UNIVERSITY FOR DEVELOPMENT STUDIES

EFFECTS OF SOIL EROSION AND DEGRADATION ON FARMLANDS IN THE TOLON-KUMBUNGU DISTRICT OF THE NORTHERN GHANA

BY

TIIFU BABA ANAMBABI (UDS/MSWC/0005/08)

(BSc. Applied Physics with Environmental Science)

A THESIS SUBMITTED TO THE DEPARTMENT OF AGRICULTURAL MECHANIZATION AND IRRIGATION TECHNOLOGY, FACULTY OF AGRICULTURE, UNIVERSITY FOR DEVELOPMENT STUDIES IN PARTIAL FULFILMENT OF THE REQUIREMENTS FOR THE AWARD OF MASTER OF PHILOSOPHY IN SOIL AND WATER CONSERVATION AND MANAGEMENT

2015

DECLARATION

Student

I hereby declare that this thesis is the result of my own original work and that no part of it has ι presented for another degree in this university or elsewhere.

didates Signature……Bapps……………date…31/08/2015……………………………

ıe: Tiifu Baba Anambabi

ervisors'

reby declare that the preparation of the thesis was supervised in accordance with the ıelines on supervision of thesis laid down by the University for Development Studies.

ıcipal supervisor's signature:………………………………….date:8.09.2015…………………

ne: Prof. Gordana Kranjac-Bersavijevic

-supervisor's

nature:……………………………………………….date:…2/9/15………………

Name: Dr. Felix K. Abagale

ABSTRACT

Soil erosion and degradation has been a fundamental problem that has bedeviled the farming business of especially small-scale farmers across northern Ghana. The study was undertaken in four communities in the Tolon-Kumbungu District. The soil is pre-dominantly sandy, with sand content increasing with soil depth. It is easily washed away through water erosion. Soil erosion is orted to have adverse consequences on the living conditions of inhabitants. Different forms of sion are noted to be common in northern Ghana where the soil is already of low fertility. This earch was undertaken from January, 2012-May, 2013 to assess the effect of soil erosion and radation problems manifested by reduced crop yield in the Tolon-Kumbungu District. Semi-ctured questionnaire was used to gather information on socio-economic activities. Field-ed measurement of erosion forms and quantity of eroded soil were employed in the study. sults of the field study indicates an estimated amount of soil loss by rills to be 79.5 t/ha and lies of 251.9 t/ha. The average bulk density of the soils for the selected fields was 1.7g/cm^3. d clearing methods and continuous cultivation, excessive grazing, ploughing along steep pes contribute greatly to soil erosion in the study area. About 90% of the respondents icated deforestation and over-cultivation of croplands, as contributory factors to the cause of l erosion and land degradation in the area. Low infiltration rates resulting from high rates of runoff from rainfall, the texture of the soil, little or no soil cover were observed to contribute to high rates of soil loss from erosion. Farmer education on the negative effects of soil erosion on farmlands is therefore recommended as a way of conserving soil nutrients.

ACKNOWLEDGEMENTS

First of all, I will like to thank the almighty God for granting me the opportunity to be able to complete this work of mine amidst difficulties.

Special thanks specifically go to my supervisor, Prof. Gordana Kranjac-Bersavijevic, for her ·ence and dedication to this scholarly work, offering useful criticisms and motivation which immense in the successful completion of this work.

second appreciation goes to my co-supervisor, for having the time and painstakingly going ugh my work offering very important contribution to the successful completion of this work.

hermore, I will also like to thank the following in the Department of Agric Mechanization Irrigation Technology; (Head of Department), Mr. Vincent Gbedzi (Senior Lecturer), Mr. ert Yawson (Senior lecturer), Mr. Gandaa Bizoola (Senior Lecturer) and finally Dr. Abdul-ıiyu (Senior Lecturer), for their undying support and encouragement during this research.

ıo wish to send my heartfelt gratitude to, Mr. Tom-Dery Damian (Senior Lecturer, Forestry), Adongo Apusiga and Mr. Edem Aklaku Komla, for helping me with useful tools and ipment for my field measurements and laboratory analyses.

I am also very grateful to my dad and mom, Mr. and Mrs. J.K Tiifu, for their spiritual assistance through the research period.

I will like to specifically acknowledge My Uncle, Mr. J.K Jimah formerly of Savanna Agricultural Research Institute (SARI), for his contribution to the success of this work.

Finally, I will like to thank the following; Tiifu Hawa, Tiifu Faizah, Dr. Tiifu Adamu John, Adamu Mahama, Mr. and Mrs. Dr. Kofi Issah and family for their spiritual and material support and encouragement.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF PLATES

LIST OF FIGURES

ABBREVIATIONS

NEP:	United Nations Environmental Program
NDP:	United Nation Development Program
AO:	Food and Agricultural Organization
ARI:	Savanna Agricultural Research Institute
AD:	International Fund for Agricultural Development
LOSAD:	Global Assessment of Soil Degradation
PRI:	International Food Policy Research Institute
LaM:	Sustainable Land Management for Mitigating Land Degradation
NAPCD:	National Action Plan to Combat Drought and Desertification
OXFAM:	Oxford Committee for Famine Relief
AGDP:	Agricultural Gross Domestic Product
RCP:	Replacement Cost Approach

UNU: United Nations University

EEA: European Environment Agency

UP: Upstream

ISCO: International Soil Conservation Organization

UNSO: United Nations Statistics Office

R: Directory of Graduate Research

DP: Average Gross Domestic Product

S: Ghana Statistical Service

CHAPTER ONE

INTRODUCTION

1.1 Background to the Study

Approximately 40 % of the world's agricultural land is seriously degraded. Currently in Africa, if trends of soil degradation continue, the continent might be able to feed just 25 % of its ›ulation by 2025 (UNU, 2006).

dies have shown how agricultural productivity varies with differences and changes in land ılity, and that degradation-induced changes in productivity affect food security (Wiebe, 2003). ıd degradation does not threaten productivity, growth and food security at the global level. t problems do exist in some areas, especially where resources are fragile and poorly function iebe, 2003).

ıd serves as a source of raw material for industry and food for the population. This is ticularly important for the local economy of the rural areas where the bulk of food is produced local consumption by the population. In northern Ghana, increasing population growth and :d for more food coupled with the degradation of natural resource base, and low yields as in drivers put further challenges in agriculture as strategic tool for attaining policy objectives food and nutrition security and wealth creation by the people. There is the need to double efforts at increasing agricultural productivity and production in northern Ghana.

The need to rapidly transform Ghana's agriculture is further underscored by the fact that population of Ghana is expected to increase to about 30 million by 2020 (GSS, 2010).

This may reduce agricultural land availability per capita from 0.77 ha in 1996 to 0.38 ha in 2020 (Okorley et al., 2002). Surely, Agriculture will be unable to grow and be sustained if steps are not taken to ensure proper land and water conservation in improved production and utilization practices. Land and soil degradation assessments have recently become more fashionable responding to environmental concerns particularly in industrial countries, following the lead in developing countries that have claimed significant effects of land degradation on their agricultural production and food security. A review of the state of art of these assessments is made and a specific integrated approach is documented (Nachtergaele, 2003).

ıny national, regional and global assessments of soil degradation were undertaken over the last years. Of all these studies, one may conclude that many past statements were based on ;ertions that were unsubstantiated by hard evidence. In fact the influence of land degradation economic terms continues to be debated. A paper presented by Wiebe (2003) estimated the onomic effect of soil erosion globally at only 0.05 % per year of the production value. Studies Crosson (1998) in North America emphasize a similar small decline, but admit that off-site fects are often of a much higher magnitude. On the other hand, dramatic effects of land gradation are estimated by Pimentel et al. (1995) and UNEP/UNDP/FAO (1994), with figures ıching 10 % of the value of agricultural production each year.

ırsory observation has revealed, the pervasive use of fire for land clearing in the farming stems in the Guinea savannah agro-ecological zone of Ghana, and the uncontrolled late annual ıshfires which destroy forests woodland and crops over extensive land areas as the major soil erosion factors.

Several biological and mechanical soil and water conservation practices have been used to reduce the rate of soil loss such as stone bounding, contour ploughing and terracing etc,(SLaM, 2008) but erosion in the Tolon-Kumbungu district are still on the increase making the people poorer and resulting in high rate of youth migration (GSS, 2010).

1.2. Problem Statement

Soil erosion depletes soil fertility and reduces land productivity which, in turn, reduces the farm level income of households. Reduction in fertility of soil results in poor water holding capacity of the soil and vegetative growth of crop is limited as a result, particularly with additional decrease in the quantity of seasonal rain-fall. Decrease in soil fertility leads to increase in farm /el investment. The prevailing farming systems in Tolon-Kumbungu, can be described nerally as subsistence with low or minimum external input. The traditional farmers have been ltivating these soils over the years without mineral fertilizers. They maintained soil oductivity by prolonged fallow periods of more than 15 years followed by four-year cropping riods (Fugger, 1999).

ıe soil within Tolon-Kumbungu area is pre-dominantly sandy, where sand content increases ith soil depth (Hauffe, 1989). It is easily washed away through water erosion. Continuous ıltivation with little protection measures has exacerbated the level of soil erosion and hence nd productivity has declined significantly.

ıese problems severely affect the lives of the people in the study area. The principal constraints increasing agricultural production is declining soil fertility, soil erosion, lack of credit ograms and improved agronomic practices, and lack of water conservation techniques (Rudat and Mercer-Quarshie, 1993; Albert, 1996).These problems have rendered farmers in the Tolon-Kumbungu District incapable of meeting their livelihoods needs through farming.

Soil erosion depletes soil fertility and reduces land productivity, which in turn reduces the farm level income of households. Decrease in soil fertility leads to increase in farm level investment. Variation in rain-fall pattern has had adverse consequences in terms of land degradation in the low land areas of Tolon-Kumbungu District of Northern Region, resulting in internal migration or displacement. During the peak of rainy season, heavy downpours cause the removal of soil which is washed with runoff, exposing hardpans. In the peak of dry season, uncontrolled bush burning and overgrazing also causes soil deterioration.

1.3 Objectives of the Study

e main objectives of the study were to assess the effects of soil erosion and degradation ınifested by the reduced-crop yield of farmers in the Tolon-Kumbungu District.

;.1The specific objectives of the study were:

1. To identify the soil erosion forms which have greatest impact on farmers
2. To determine the major causes of soil erosion
3. To measure/estimate the amount of soil loss through rill erosion and
4. To measure/estimate the amount of soil loss through gully erosion.

4 Research questions

The study aimed to answer the following questions:

1. Which types of soil erosion affects farmland in the district most?
2. What are the major causes of soil erosion in Tolon-Kumbungu district?
3. What are the measured /estimated values of rills erosion?
4. What are the measured /estimated values of gully erosion?

1.5 Significance of the study

It is evident that soil erosion has adverse consequences on the living standards of inhabitants. Quansah et al., (1989) noted that in Ghana, 23 % of the land is subject to severe to sheet and gully erosion, 43.3% to severe sheet and gully erosion and 29.5 % to slight to moderate sheet erosion. The decreasing fertility of the soil leading to demand for chemical fertilizers to npensate for the loss of organic matter through soil erosion has been a pressing issue among al communities.

e rising cost of chemical fertilizer is particularly worsening for the farmers as many cannot ord them. Knowledge of potential negative impacts of soil erosion and deforestation on the ing standards of the farming communities is prerequisite to designing programmes and for ojects to implement sustainable land management systems nationally, to reduce the gradation of land, to ensure sustainable agriculture and to improve food security among rming communities. The study is vital because the problems relating to soil erosion negatively ect the living conditions of framers.

il erosion reduces drastically the productive potential of farms through impoverishment of the il. Tolon-Kumbungu district study sites were chosen as the study area because of the evalence of soil erosion in the area.

There are five soil series, which includes the Tolon, Nyankpala, Kpasegwu, Tongoli and the Volta series and their characteristics are that they are all very prone to soil erosion (SARI, 2010). Globally, poverty is predominantly rural phenomena. It is estimated that 62 % to 75 % of all poor people live in rural areas. More than 70 % of the world's poor live in South Asia and sub-Saharan Africa (Kwankye et al., 2003).

Despite increasing urbanization, it is estimated that in 2035 more than 50 % of poor people will remain in rural areas, most of them smallholder farmers (IFAD, 2002).

In many countries, rural poverty is more severe than in urban areas, particularly among agricultural workers (often over 60 %), women and indigenous communities (Oxfam, 2009). There is robust evidence that investments in agriculture are more effective in reducing poverty n spending in other sectors (Oxfam Novib, 2008).Also rural households rely mainly on the est products for energy.

erefore, an understanding of the impact of soil erosion as well as degradation on the elihoods of farmers will enable policy makers and development partners of the government to n and implement programmes and projects to alleviate problems thereby increasing living ndards.

; Scope of the study

terms of geographic scope, the study was restricted solely to study sites in the Tolon-ımbungu District. The results and conclusions drawn from the study are limited to the defined get population. The study focused on soil erosion and how it affects farmlands. Specifically, : study looked at the causes of soil erosion, types of soil erosion that greatly affects farmers, did some measurement of soil erosion and control measures.

1.7 Organization of the dissertation

Chapter 1, presents the background, problem statement, objectives and significance of the study. In chapter 2, relevant literature on soil erosion and degradation are reviewed.

Chapter 3, provides the methodology and research design for the study and description of the study area including demographic characteristics of the population. In Chapter 4, results obtained from the research and a discussion of the results and analysis is presented. Chapter 5, provides conclusions and recommendations based on the findings of the study.

CHAPTER TWO

LITERATURE REVIEW

2.1 Introduction to Erosion

Countless definitions can be given to soil erosion such as the wearing away of the land surface bv running water, wind, ice or other geological agents, including such processes as gravitational ep (SCSA, 1982). It is a natural process, but it is accelerated by human land use, especially ıustrial agriculture, deforestation and urban sprawl (Kotke, 2007). Other forms of soil ;radation along with soil compaction are low organic matter, loss of soil structure, poor ernal drainage, salinization and soil acidity problems (Wall, 2003). Erosion is sometimes ssified into geological (sometimes called natural or normal) which is the inexorable and ıtinuous process of evolution of the earth's surface by such geological agents as rainfall, snow :lt, stream, overland flow, etc. and accelerated which is a more rapid process that is largely luced by human practices and activities (Lal, 1995).

.1 Agents of Erosion

ıids or gravity is the principal agent of erosion. Wind, rainfall and running water are the fundamental agents of erosion on arable land in the tropics. Ice as an agent of erosion is relevant in northern latitudes and in highlands while gravity erosion is relevant with steep lands (Lal, 1995).

2.1.2 Water Erosion Process

Studies show that detachment, transport and deposition are basic processes that occur on upland areas (Foster, 1982). Detachment occurs when the erosive forces of rainfall drop impact or when flowing water exceeds the soil's resistance to erosion. Several detached particles are carried away by the splash and flow of raindrop. And for that matter, deposition of transported materials :curs when the sediment load of eroded particles exceeds its corresponding transport capacity 'oster, 1982).

'ater and wind erosion can be combined to form natural biophysical and human causes. Erosion ın cause the removal of the most fertile topsoil causing soil productivity to reduce. In most ıses where soil is shallow and land is sloping (Tamene and Vlek, 2007) this can lead to an reparable loss of soil, and for that matter land degradation. China's Loess Plateau, due to ‹tensive deforestation caused largely by population hikes over the past century, leaving the land r soil surface bare. This further led to problems associated with rill and gully erosion, as the rain 'ashed down the steep slopes, taking the soil with it (Zheng et al., 2005). Consequently, it did ot only erode the soil but caused the sedimentation of water courses (Feng et al., 2010).

'limate change conditions, excessive rainfall and drought are likely to become more common lace in some sites, with significant impacts on soil erosion, increases in water and wind erosion resulting from land use changes that changes the land's vegetative cover. Agricultural practices such as ploughing, mowing and levelling beds can all increase wind erosion and dust emissions, while the planting of windbreaks, use of cover crops and leaving plant residues in the field after harvesting can all reduce the risk of erosion (Nordstrom and Hotta, 2004).

This can disrupt soil functions and the links between soil and other ecosystem components. Recently, droughts in the horn of Africa caused inhabitants to migrate to less affected areas, in order to access sufficient food and water, which are the fundamental needs of existence. Locations in receipt of migrants, large-scale deforestation has taken place, driven by demand for fuel wood (charcoal). This has left the land exposed and prone to erosion (Terefe, 2012). The relative importance of these fundamental processes depends on whether the processes are occurring on inter-rill or rill areas and in the levels of the controlling variables. Eroded soil ıcles generally descend down slope, flowing into rills and gullies. Measuring and estimating volume of soil eroded is very important to design soil erosion control techniques (Foster, 2).

3 Types of Water Erosion

ıer erosion cannot be mentioned without paying great recognition to splash, interrill, rill and y erosion (Lal, 1995). Raindrops can be a main problem for farmers when they strike bare . With an impact of up to 9 m/s, rain washes out seed and splashes soil into the air. If the ls are on a slope, the soil is splashed downhill which causes deterioration of soil structure. ɔ, soil that has been detached by raindrops is more easily moved than soil that has not been ıched (Young, 1972).

Interrill erosion is caused by raindrops and is defined as the uniform removal of soil in thin layers from sloping land. It is the removal of the entire topsoil as a result of heavy rains (Lal, 1995).

Rill erosion occurs when soil is removed by water from little streamlets that run through land with bad surface drainage.

It is generally, caused by overland flow moving across soil and forming small streams. It is the most common form of erosion. Its effects can be easily reduced tremendously by tillage. Rills can often be found in between crop rows (Savat, 1982).

Gullies are larger than rills and cannot be fixed by tillage. Gully erosion is an advanced stage of rill erosion, just as rills in most cases result in interrill erosion. Once rills are large enough to rict vehicular access, they are referred to as gullies or gully erosion. Major concentrations of ı-velocity run-off water in these larger rills remove large deposites of soil. This results in ply incised gullies occurring along depressions and drainage lines (Zaborski, 1972).

.4 Wind Erosion Process

a matter of fact, wind erosion is the movement and deposition of soil particles by wind. It urs when soils bared of vegetation are exposed to high-velocity wind (Lal, 1995). When its ocity overcomes the gravitational and cohesive forces of the soil particles, wind will move l and carry it away in suspension. Wind moves soil particles 0.1 - 0.5 mm (fine and medium) ize in hopping or bouncing fashion known as saltation.

ıne impact of saltation causes very fine particles (less than 0.1 mm) to detach into suspension and those greater than 0.5 mm by rolling (known as soil or surface creep) after being loosened by the impact of saltating particles (Lal, 1995). Practically, wind erosion is most visible during the suspension stage, as dust storms, or subsequently as deposition along fence lines and across roads.

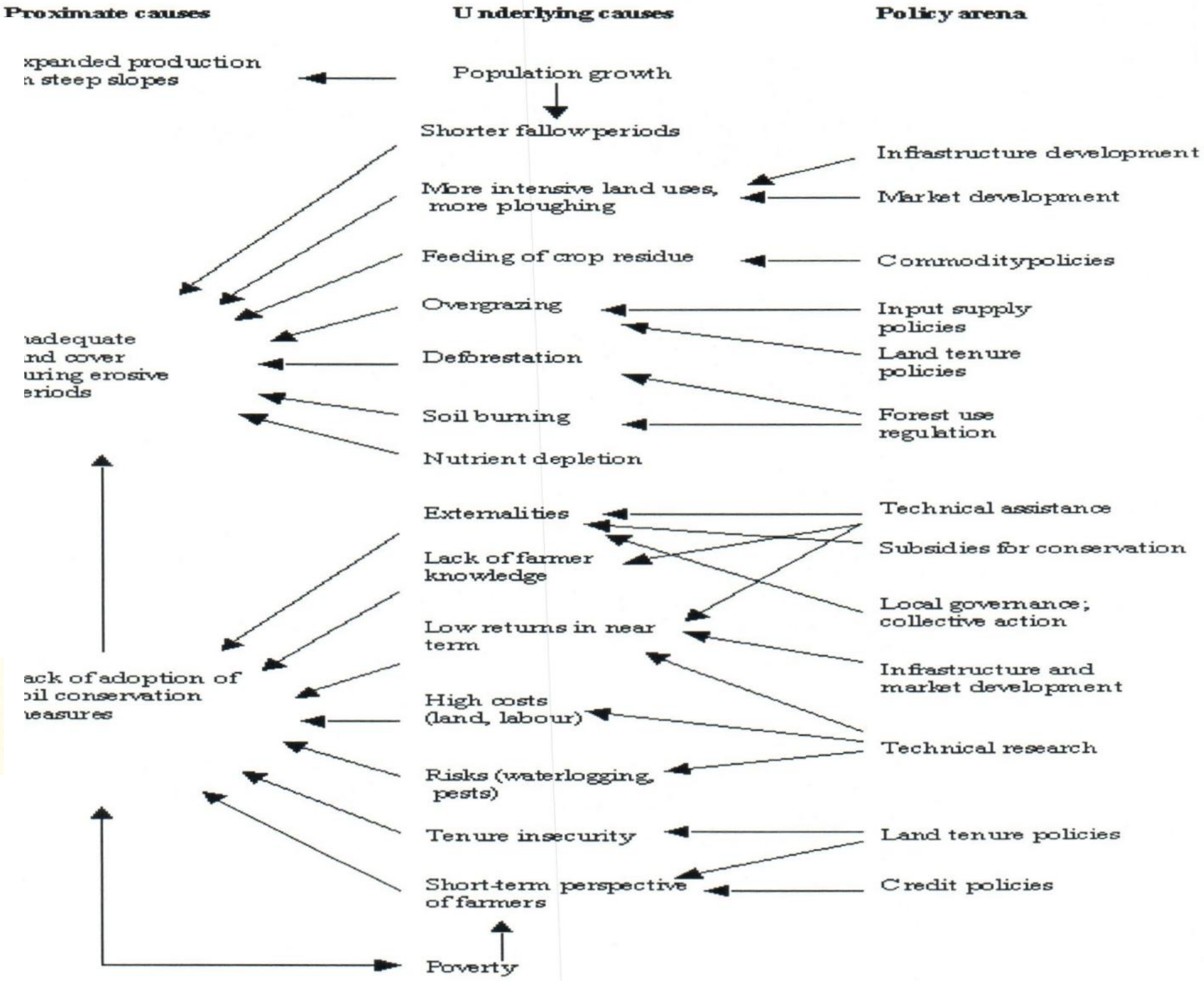
The process sorts' soil particles, detaching the finer material containing the organic matter, clay and silt through suspension and leaving the coarser, less fertile material behind thereby reducing the productive capacity of soil, as most of the nutrients plants need is attached to the smaller colloidal soil fraction. Over a longer period, the physical nature of the soil changes as the subsoil is exposed (Lal, 1995).

5 Causes of Erosion/Degradation

atural hazards are left aside, the causes of land degradation can be divided into direct and erlying causes. Direct causes are inappropriate land use and unsuitable land management ctices, such as the cultivation of steep slopes without soil conservation measures. ındermental causes are the reasons why these inappropriate practices take place, for instance slopes may be cultivated because the landless poor need food, and conservation measures not en because farmers lack security of tenure. (FAO, 1994).

l degradation is a process that leads to decline in the fertility or future productive capacity of as a result of human activity (UNEP, 1993). It occurs whenever the natural balances in the dscape are altered by human activity through misuse or overuse of soil. Degraded soils which result in poor or no production are also called poor soils. Waste lands are those which for one or the other reason have poor life sustaining ability. Out of 100 % potentially active lands only 44 % are available for cultivation and 56 % of lands are non-available for cultivation. The wasteland can be made useful by increasing productivity of land by using some useful methods as afforestation or by using bio-fertilizers (UNEP, 1994).

1. Physical factors such as loss of fertile top soil due to water or wind erosion. 2. Chemical factors including depletion of nutrients or the toxicity due to acidity or alkalinity (salinization) or water logging. 3. Biological factors which affect the micro-flora and reduce the microbial activity of the soil. These factors reduce the yield. (UNEP,1994)



(Source: Fitsum et al., 1999)

Fig. 2.1 The nature and extent of soil erosion and the proximate causes

2.2.1 Chemical Causes of Erosion/Degradation

Chemical degradation causes loss of nutrients and organic matter, salinisation, acidification and pollution. Globally, analyses are recognising that such less conspicuous changes in soil features are critical in affecting crop yields (Mueller et al., 2012) and that monitoring devices need to be developed to focus on fundamental parameters such as soil organic carbon content and integrated ient management approaches. Nutrient and organic matter losses can have an important ıence on the soil's structure, stability, water holding capacity, ecology and biodiversity. ket demands for specific commodities can lead to unsustainable land management practices, ch can play an important role in affecting soil nutrients and organic matter content, icularly when the practices are not capable to return nutrients to the soil. Intensive agriculture lead to organic matter reductions of up to 50 % following several decades of cropping ıgore et al., 2007). On farms where soya bean cultivation followed the production of wheat or ze, the practices involved burning the crop remains to clear the fields quickly and plant the a bean. This caused serious losses of soil organic matter, undermining productivity to the ent that in the 1990s, soil degradation was estimated to have affected 60 % of the farmland of entina's Carcaraña River basin (Trigo et al., 2009).

Surprisingly, the expansion of soyabean cultivation into new areas sparked confusion over land and property rights (Masuda and Goldsmith, 2009).In some parts of the world, increasing poverty can mean that farmers cannot afford to buy inputs such as fertilisers that typically supplement soil nutrients. Vitousek et al., (2009) sampled the farms of 90 smallholders in the Siaya District of Kenya and observed that the nitrogen inputs from fertilizers they could afford to vide were less than the amount harvested or output in grain and crop remains. This lead to a ıction in traditional integrated (organic and inorganic) nutrient management approaches in ch livestock manure, household compost and crop residue provide organic inputs to arable ds, in northern South Africa. (Dougill et al., 2002).

many peasant farmers, security of land tenure may be non-existent to the effect that land rs have insufficient incentive to invest in soil inputs.

s is particularly so when insecure tenure results in an absence of attachment to a particular ation; a common problem in countries where tenure irregularities lead to the adoption of fting cultivation (Whiteside, 1998). This can lead to a reduction cycle of poverty and radation. Soil degradation as a result of pollution and acidification can be local or diffuse. fuse pollution is widely reported in the Sudbury Region of Ontario, Canada, where mining l ore smelting has polluted more than 100 million tons of Sulphur dioxide over the past century, causing high concentrations of metal in the soil, acidification and damage to forests (Narendrula et al., 2012). Worldwide demand for copper is continuing to hike prices, compelling countries such as Zambia and the Democratic Republic of the Congo to construct huge copper mines to exploit their reserves of this resource. Concurrently, mining activities have caused these countries to be within the 10 most polluted areas (Banza et al., 2009).

Salinisation is as result of concentration of water soluble salts in the soil increasing. This can happen due to natural processes, Soil salinisation has had important negative effects on rice production, as well as potable drinking water availability (Minh, 2000).

In Western Australia, abundant natural salts within the soil, combined with the clearance of native vegetation, has caused critical hydrological changes and extensive salinisation, with ındwater levels increasing by more than 30 m. More than 1.8 million ha (9.4 % of cleared ıland in Western Australia) is salt affected, leaving severe repercussions on productivity and, ›me cases, has caused land abandonment (George et al., 1997).

2 Physical causes of erosion/ degradation

sical degradation causes compaction, sealing or crusting, waterlogging and subsidence. Soil ing is often a consequence of urban development and infrastructure construction, as the soil ace is covered with impervious materials such as concrete, plastics, glass and metal. The ınt to which sealing takes place links closely to the type of landuse and the population sity.

bal population growth, migration and upsurge of urbanisation throughout the world, confirms sealing, is a trend that will continue into the future. In Europe, around 9 % of the total land area is covered by an impermeable material (Scalenghe and Marsan, 2009), while in the urban areas of Germany, 52 % of the soil is sealed (EEA, 2006).

The application of technologies such as the mouldboard plough in the United States, around 1850, set in motion a long-term precedence that destroyed the soil structure and increased the soil's susceptibility to crusting, compaction and erosion (Lal et al., 2007). Furthermore, pastoral areas, such as grazing phenomenon have become less extensive and more sedentary due to policy set-up and land tenure systems. Soil compaction has caused, in accordance with other ecosystem changes such as lower pasture palatability, reduced infiltration and ultimately, soil degradation (Niamir-Fuller, 2005).

An estimate shows that as many as 2 million hectares of arable land is lost yearly to severe soil erosion (Lal, 1990) Modern technology as well as mechanized farm operations usually cause e severe erosion than manual (hoe and machete) farm operations. Risks of erosion are ıter in monocropping than rotation and mixed farming, in open row cereals than close canopy ımes, in clean cultivation than in mulch farming and in plough than zero till lands (Lal, 1990; ·gan, 1995). Gullies, pedestals, rills, sediments deposits and root exposure are indicators that ısure the extent of soil loss through erosion (Stocking and Niamh, 2001).

3 Scales for Measuring Soil Erosion

re are three basic scales of measurement: macroscale, mesoscale and microscale (Lal, 1995). macroscale deals with hundreds to thousands of square kilometres of area and deals with ams and rivers.

ılogical, ecological and regional aspects of soil erosion are studied at macroscale and the results are used to assess denudation rates of major river basins, mountain systems, continents, and ecological regions (Lal, 1995).

The mesoscale involves evaluation of sediment sources from few hectares to few hundred hectares. Results are used to evaluate the effects of farming practices, landuse systems, and topographic factors on runoff and erosion. The effects of agricultural practices on pollution of environment and eutrophication of natural waters are also measured (Lal, 1995).

The microscale deals with the study of hill slope erosion at a scale of few square metres to few hundred square meters. The basic process governing soil splash detachability and transportability, initiation of overland flow and of sediment washed by rill erosion is studied at microscale. Effects of soil erosion degradation hazard in relation to changes of soil properties are studied at this scale (Lal, 1995).

4 Soil Erosion and Food Production in the Tropics

ﾐub-Saharan Africa food staples production in 1985 was at 1.7 % a year, but population eased at 3.2 % a year (Paulino, 1986). Food production has to be increased substantially to id mass starvation in many parts of the world (Lal, 1995). Although the perpetual food deficit ıfrica cannot be entirely attributed to erosion and erosion induced soil degradation and the ılting decline in crop productivity, there is disturbing degree of correspondence between the ıs affected by severe soil erosion and those prone to gross food deficit.

ica faces the greatest challenge of breaking the vicious cycle of erosion-induced soil radation and the resulting reducing in crop productivity. Intensification of agriculture is essary to increase food production, although this also increases the risk of erosion (Lal, 1995).

2.2.5 Soil Erosion in the Tropics and Temperate Regions

Predominant soils at the humid and sub humid tropics are highly leached oxisols, ultisols and alfisols and less leached inceptisols.

Soils of the semi-arid and arid regions are not leached and include vertisols, entisols and aridisols (Lal, 1987). Severity of erosion depends on both the absolute quantity of soil eroded and the depth and quality of soil remaining. The degree of erosion or quantity of soil eroded per unit time and per unit area may not be necessarily greater in the tropics than in temperate regions.

However, the consequences of erosion are often drastic in tropical regions. The drastic erosion–ıed productivity decline in soils of the tropics is due to harsh climate and partly to low lity and poor quality sub-soils (Lal, 1987).

6 Soil Erosion and Civilization in the Tropics

erosion began with the dawn of agriculture, when people began using the land for intensive culture (Lal, 1987). It is estimated that soil erosion has destroyed over the millenia, as much ıle land as is now cultivated (Kouda, 1977). It is argued that as many as 2 million hectares of ıle land is lost annually to severe soil erosion and erosion induced soil degradation. Soil ıion caused some of the once-thriving ancient civilizations to vanish (Oslon, 1981).

he Middle East, the cradle of civilizations, deforestation of cedar forests from countries ounding the Mediterranean caused severe corrosion, toppled the Phoenicans and destroyed the granaries of the Roman empire (Eckholm, 1976).

The Phoenicians cultivated steep lands by developing stone terraces, however, severe erosion set in where erosion controls were not constructed or otherwise poorly maintained. Deforestation and overgrazing of the steep slopes were major causes of severe erosion. Agriculture that was thriving about 10000 B.C in Mesopotamia, present day Iraq, has been changed to desert and shifting sand dunes by deforestation and erosion of the surrounding hills and watersheds that nurtured its ancient irrigation system (Lowdermilk, 1953).

The ancient kingdom of what are now Syria and Lebanon also dwindled because of excessive erosion following deforestation and exposure of soils on steep slopes (Beasley, 1972).

Intensive agriculture began in the Indus valley soon after that in Mesopotamia. The extinction of Harappan-Kalibangan civilization that flourished in northwestern India, the pre-Anyan era contributed to erosion, erosion related soil degradation and desert encroachment.

Harappan culture flourished about 2000 B.C. along the fertile valleys of Ghaggar, Saraswati, shadavati, and old Yamuna in the region of what is present-day Haryana and Rajsthan in ia and Pakistan (Singh, 1982). It is estimated that in Peru, about one million hectares of land terraced, of which about 1/3 is still in cultivation today (Denevan, 1985).

liams (1987) estimated that these terraces are retained by 3 million meters m^2 or more of rock l requiring at least 4 million person-years of labour for retaining wall construction alone. The topsoil was rapidly washed away once maintenance of the terrace system was rejected.

collapse of a 1700-year-old Mayan civilization in Guatemala around 900 A.D. is also ibuted to accelerated erosion. Oslon (1981) reported that millisols developed on limestone rock were easily eroded when the forest was cleared. As the population increased, soil depletion set in and the Mayan culture paid the ultimate price (Hardin, 1968).

2.2.7 Factors Affecting Erosion by Water

Factors which affect water erosion include the following;

1. Rainfall intensity and runoff; Both rainfall and runoff factors are significant in determining water erosion problem. The effect of raindrops on the soil surface can break down soil aggregates and disperse the aggregate material (Wall, 2003).

Lighter aggregate materials such as very fine sand, silt, clay and organic matter can be easily removed by raindrop splash and runoff water; heavier raindrop energy or runoff amounts are required to move the larger sand and gravel particles. Soil movement by rainfall (raindrop splash) is usually greatest and most predominant during short-duration, high-intensity thunderstorms (Wall, 2003). Although the erosion caused by long-lasting and less-intense storms is not as spectacular or noticeable as that produced during thunderstorms, the amount of soil loss can be significant, especially when compounded over time. Runoff can occur whenever there is excess water on a slope that cannot be infiltrating into the soil or trapped on the surface. The amount of runoff can be increased if infiltration is reduced due to soil compaction, crusting or freezing.

2. Soil erodibility; Soil erodibility is an estimate of the ability of soils to resist erosion, based on the physical feature of each soil (Wall, 2003). Generally, soils with faster infiltration rates, higher levels of organic matter and improved soil structure have a greater resistance to erosion. Sand, sandy loam and loam textured soils tend to be less erodible than silt, very fine sand, and certain clay textured soils. Tillage and cropping practices which lower soil organic matter levels, cause poor soil structure and compaction increases the soils erodibility (Wall, 2003). A report revealed that decreased infiltration and increased runoff can be a result of compacted subsurface soil layers and formation of a soil crust, which tends to "seal" the surface. Previous erosion on a soil has an effect on a

soils' erodibility. Many exposed subsurface soils on eroded sites tend to be more erodible than the original soils, because of their poorer structure and lower organic matter.

3. Slope gradient and length; naturally, the steeper the slope of a field, the greater the amount of soil loss from erosion by water. Soil erosion by water also increases as the slope length increases due to the greater accumulation of runoff. Consolidation of small fields into larger ones often lts in longer slope lengths with increased erosion potential, due to increased velocity of water :h allows a greater rate of scouring (carrying capacity for sediment) (Wall, 2010).

egetation; Soil erosion potential is increased if the soil has no or very little vegetative cover lants and/or crop residues. Plant and residue cover protects the soil from raindrop impact and sh, tends to reduce the down movement of surface runoff and allows excess surface water to trate (Wall, 2003).

ially incorporated residues and residual roots are also important as they provide channels that w surface water to move into the soil. The efficiency of any crop, management system or ective cover also depends on how much protection is available at various periods during the :, relative to the amount of erosive rainfall that falls during these periods (Wall, 2003).

his respect, crops which provide a full, protective cover for a major portion of the year (for example, alfalfa or winter cover crops) can reduce erosion much more than crops which leave the soil bare for a longer period of time (e.g. row crops) and particularly during periods of high erosive rainfall (spring and summer). However, most of the erosion on yearly row crop land can be reduced by leaving a residue cover greater than 30 % after harvest and over the winter months, or by inter-seeding a forage crop (e.g. red clover) (Baldwin, 2003).

Soil erosion potential is affected by tillage operations, depending on the depth, direction and timing of ploughing, the type of tillage equipment and the number of passes. Generally, the less the disturbance of vegetation or residue cover at or near the surface, the more effective the tillage practice in reducing erosion (Baldwin, 2003).

8 Factors Affecting Erosion by Wind

: rate and magnitude of soil erosion by wind is controlled by the following factors:

- Erodibility of soil; Very fine particles can be suspended by the wind and then transported great distances. Fine and medium size particles can be lifted and deposited, while coarse particles can be blown along the surface. The abrasion that results can reduce soil particle size and further increase the soil erodibility (Wall, 2003).
- Soil surface roughness; Soil surfaces that are not rough or ridged offer little resistance to the wind. Excess tillage can contribute to soil structure breakdown and increase erosion (Wall, 2003).
- Climate; The speed and duration of the wind have a direct relationship with the extent of soil erosion. Soil moisture levels can be very low at the surface of excessively drained soils or during periods of drought, thus releasing the particles for transport by wind (Lal, 1995).
- Unsheltered distance; The lack of windbreaks (trees, shrubs, residue, etc.) allows the wind to put soil particles into motion for greater distances thus increasing the abrasion and soil erosion. Knolls are usually exposed and suffer the most (Lal, 1995).

- Vegetative cover; The lack of permanent vegetation results in extensive erosion by wind. Loose, dry, bare soil is the most susceptible; however, crops that produce low levels of residue also may not provide enough resistance. The most effective vegetative cover for protection should include an adequate network of living windbreaks combined with good tillage, residue management and crop selection (Cheng, 1984).

9 Fertility and Productivity Loss as a Result of Erosion

l erosion removes the part of the soil which is usually richest in plant nutrients. Erosion on s which are highly fertile, naturally or by fertilizer addition, results in greater fertility losses. nutrients are lost during erosion but the most economically significant losses will be that of ogen, phosphorus, potassium and lime (Frye, 1983).

:ording to some school of taught, if soil is naturally low in fertility, then erosion will cause a ; of the added nutrients and increase the fertility requirements of the soil. Erosion caused a 'erence in the fertility status of a crider soil at Kentucky which is naturally low in fertility. The ater the erosion, the more fertility that would be lost. It has been estimated that the value of ..nt available nutrients lost from a highly fertile soil in Kentucky could range from 1-4 to per acre (Frye, 1983).

A number of soil properties are affected by soil erosion. Fertility, organic matter, rooting depth, soil tilth and available water holding capacity are reduced and soil texture is changed. Collectively, these characteristics affect the yield potential of the soil. In most cases, the potential productivity of the soil will be decreased as erosion occurs. The yield decrease is usually so slight from year to year that the farmer may not realize that it is happening. As small annual losses accumulate with time, productivity is substantially reduced. The yield potential of most soils decreases with erosion, but actual yield may continue to rise on moderately-eroded soils. Yields do not rise as rapidly or as high as on similar soils with none to slight erosion (Frye, 1983).

other way to view this concept is that more technological inputs are necessary for crop yields eroded soils to equal those on uneroded soils. And more technological inputs usually mean e financial inputs as well. The maize production of a crider soil decreased over three years n 125 to 100 bushels per acre after moderate erosion had taken place. Both lower available er supplying capacity and lower fertility status probably contributed to the lower yields. ny of the soils in Kentucky have limited rooting volumes due to underlying fragipans, rocks lay pans. Loss of surface soil by erosion further decreases the already limiting volume of soil ourable for root growth and available water storage (Frye, 1983).

.10 Problems/Damages Caused by Erosion

l eroded and transported from upstream headwater catchments can be deposited at downstream points in rivers. For instance, a bridge constructed in 1919 over a torrent crossing the Dehradun-Mussoorie road, in the northern state of upstream (UP) originally had a clearance of 16.7 m below its soffit.

In 1941, when the bridge was resurveyed, aggravation of about 12.2m had taken place in the torrent bed, due to the excessive erosion / land sliding in the upstream catchment (Garde & Kothyari, 1989).

About 126 dams in India for irrigation, hydropower generation, flood control, etc. contain significant accumulations of sediment eroded from their catchments leading to a reduction in their capacity (Murthi, 1977).

Cropland, about 70 million hectares (171.8 million acres) are eroded by wind and water at rates that exceed twice the tolerance level for sustainable production (USDA, 1989).

average, wind erosion is responsible for about 40 % of this loss (Hagen, 1994), and can ease markedly in drought years (Hagen and Woodruff, 1973). In the United States, wind ion is the dominant problem on about 30 million hectares (73.6 million acres) and lerately to severely damage approximately 2 million hectares (4.9 million acres) annually DA, 1965).

ıd erosion physically removes the lighter, less dense soil constituents such as organic matter, 's, and silts. It removes the most fertile part of the soil and lowers soil productivity (Lyles, 5).

ıd erosion reduces potential soil productivity and increases economic costs. Blowing soil acting plants reduce seedling survival and growth, depress crop yields, lower the rketability of vegetable crops, increase the susceptibility of plants to certain types of stress, including diseases, and contribute to transmission to some plant pathogens (Armbrust, 1982 and 1984; Claflin, *et al*., 1973; Michels *et al*., 1995). Some soil from damaged land enters suspension and becomes part of the atmospheric dust load which obscures visibility, pollutes the air, fills road ditches where it impacts water quality, causes automobile accidents, fouls machinery, and imperils animal and human health (Skidmore, 1988). Seeds and plants can be disturbed or completely removed from the eroded site. Organic matter from the soil, residues and any applied manure is relatively light-weight and can be readily transported off the field, particularly during spring thaw conditions. Pesticides may also be carried off the site with the eroded soil (Wall, 2003).

Soil quality, structure, stability and texture can be affected by the loss of soil. The breakdown of aggregates and the removal of smaller particles or entire layers of soil or organic matter can ken the structure and even change the texture. Textural changes can in turn affect the water-ing capacity of the soil, making it more susceptible to extreme condition such a drought ll, 2003). Eroded soil, deposited down slope can occupy or delay the emergence of seeds, small seedling and necessitate replanting in the affected areas. Sediment which reaches ams or watercourses can accelerate bank erosion, clog drainage ditches and stream channels, in reservoirs, cover fish spawning grounds and reduce downstream water quality.

icides and fertilizers, frequently transported along with the eroding soil can contaminate or ute downstream water sources and recreational areas (Wall, 2003).Soil drifting is a fertility-leting process that can lead to poor crop growth and yield reductions in areas of fields where d erosion is a recurring problem. Continual drifting of an area gradually causes a textural nge in the soil. Loss of fine sand, silt, clay and organic particles from sandy soils serves to lower the moisture holding capacity of the soil. This, in turn, increases the erodibility of the soil and compounds the problem (Wall, 2003). The removal of wind-blown soils from fence rows, ditches, roads and from around buildings is a costly operation.

2.3.1 Control/Prevention of Erosion

Methods used by farmers to limit soil erosion include:

1. Increase of vegetation; When the land is covered with vegetation, the roots of the plants and trees interlock and interlace to bind the soil. Vegetation does not allow the soil particles to be ·ed away by wind or water and also prevents free flow of water over the soil. The falling :s of the plants get converted to humus by decomposing action of the soil microbes which enriches the soil and improves its structure (FAO, 1994). Several methods can be employed crease the vegetation cover of the land. Some of them are as follows;

- Crop rotation; The practice of growing different crops at different times on the same land. This keeps the topsoil covered with vegetation. Rotation of cereal crops with legumes also keeps the soil enriched with nitrogen from the legumes (Kellman, 1969).
- Properly constructed stone bunds can have a tremendous positive impact on soil properties and on crop production (Mando, 2000). For instance, it is estimated that in Burkina Faso, stone bunds alone could increase sorghum yields on very degraded soil from 350 kg/ha to 515 kg/ha and that yields could be further increased to 630 kg/ha by adding 1.7 ton/ha of 23 organic manure, to 700 kg/ha by adding 150 kg/ha of inorganic fertilizers and to 850 kg/ha by adding both (Mando, 2000).
- According to Quansah et al., (2001) cover crops such as cowpea, groundnut, and Bambara beans are crops suitable to reduce direct impact of raindrop onto the soil in northern Ghana. Also crop residue mulching on the surface protects the soil against raindrop impact, soil detachment and dispersion and maintain high soil infiltration capacity (Lal, 1984).

- Crop residue mulch of 4-6 t/ha can effectively control erosion on slopes up to 15 % and for open-row crops such as maize. In the tropics, decomposition of organic matter is rapid and good soil management including maintenance and management of organic matter (Asafo-Agyei, 1995).
- It is an aspect of the widespread deterioration of ecosystem and has diminished or destroyed the biological potential i.e. plant and animal production for multiple use purposes at a time when increased productivity is needed to help growing populations in the quest of development (Pinstrop-Anderson, 2001). This situation is important in the Northern Region of Ghana whose inhabitants live mostly in rural areas and practice subsistence farming for their survival with very low-income levels.
- There is a symbiotic relationship between poverty and desertification which is close and complicated. The rural poor depend on agriculture and hence natural resources for 40 – 85 % of their income (Pinstrop-Anderson, 2001).
- Reforestation; slopes are more subject to soil erosion by running water. Growing trees like Albizia, Cassia, Butia, etc. on lands which have lost their vegetation is called reforestation. Trees serve as windbreaks which keep high winds from sweeping across land surfaces (Gray and Leiser, 1982).
- Strip cropping; It involves growing of crops in strips. The most common method followed is the contour farming where the strips of crop are at right angles to the slope. Wind-strip cropping is when the strips of crop are placed at right angles to the direction of the wind (FAO, 1965).

- Restoring soil fertility; Fertile soil supports vegetation. Loss of fertility results in loss of vegetation and this exposes the land to erosion. Fertility of soil can be increased by addition of natural and synthetic fertilizers (FAO, 1994).
- Control of grazing; Covering the land with small plants and grasses helps the topsoil to remain in place as the roots of these plants bind with the soil particles. Cattle graze on these plants and expose the topsoil Thus, grazing should be allowed only on the land meant for the purpose and other areas should be protected from grazing (Fournier, 1972).

erracing; Fields are cut at right angles to the slope. This slows down the flowing water and ws it to irrigate the crops (Fournier, 1972).

am building; Dams are used to control the speed and amount of water flowing to control soil ion at river banks (Fournier, 1972).

2 Effects of Erosion and Degradation

ere soil erosion may lead to loss of whole topsoil making it incapable to produce biomass in cultural or natural ecosystems. Lal, (1990) stated that changes in physic-chemical properties such as fertility increases cost of production if yields are to be maintained. According to IFAD (1992) soil erosion results in reduction in productivity of land and crop yields, increased poverty, reduction in fodder for livestock and storage of fuel wood which further increases the burden on women.

2.3.3 Soil Erosion and Degradation at Global Level

Soil is one of the most cherished world's limited, non-renewable resources. Under cropland conditions, it takes between 200 and 1000 years for 2.5 cm of topsoil to form (Piementel et al., 1995). The continued maintenance of fertile soil is essential in order to meet basic human needs. It therefore, underpins the provision of ecosystem services such as food production and climate ıintenance, and provides the basis of living standards for millions of people across the world [A, 2005).

ɔsion is very synonymous to land degradation. Globally, the annual loss of 75 billion tonnes of il costs the world about US$400 billion/year (at US$3/tonne of soil for nutrients and ;$2/tonne of soil for water), or approximately US$70/person/year (Lal, 1998). It is estimated ıt the total annual cost of erosion from agriculture in the US is about US$44 billion/year or out US$247/ha of cropland and pasture (Lal, 1998).

osion causes the removal of most fertile topsoil, resulting in the decline of soil productivity. In cations where soil is shallow and land is sloping, such as in the Ethiopian highlands (Tamene d Vlek, 2007), this can lead to an irreparable loss of soil and hence land degradation.

ies (2009) indicated that soil sealing and crusting, as resulting in reduced infiltration capacity and sparse vegetation cover, lead to increased overland flow and even higher erosion rates.

Land degradation leads to a tremendous reduction of the productive capacity of land. Man's activities contribute to land degradation including unsuitable agricultural land use, deforestation, poor soil and water management practices, removal of natural vegetation, constant use of heavy machinery, improper crop rotation, and overgrazing and poor irrigation practices. Natural disasters, such as floods, droughts and landslides, also contribute to erosion.

A Global Assessment of Soil Degradation (GLASOD) was undertaken in the early 1990s (Oldeman et al., 1990; UNEP, 1992) and a land degradation assessment of drylands (LADA) was started by GEF and UNEP in 2000 and is now being developed with FAO.

o, less water infiltrates into the soil, since there is an increase in run-off rate as a result of sion. Therefore, less moisture is absorbed and more soil is carried away. One major driver of l erosion is deforestation (Stocking and Murnaghan, 2001). A sequel to deforestation is ically large-scale erosion, loss of soil nutrients and sometimes total desertification (Mingyuan al., 1998). Desertification therefore sets in where the poor lose the capacity to sustainably port themselves from their natural resource base.

sertification still remains a major problem, impeding dry land improvement. Every year, urly 17 million hectares of tropical rain forests are destroyed, thousands of irreplaceable plant ieties are lost, and million of hectares of land turn into deserts (Pinstrop-Anderson, 2001).

tural forests in the region have almost disappeared. The real causes are likely to be poverty, equal land distribution, low agricultural productivity, rapid population growth and misguided blic policies. Failure of farmers and agricultural managers to understand the significance of erosion, as well as intensive weathering under hot, humid conditions, has brought about the widespread distribution of poor, badly eroded, infertile soils all over the tropics and subtropics (Ochse et al., 1961).

The physical structure of soil suffers when organic matter from biomass is depleted. A common result is soil surface crusting, which impedes germination and increases runoff.

As a result, soils become more vulnerable to erosion. Soil erosion which may be called the 'creeping death' of the soil is a worldwide problem (Montgomery, 2007).

Erosion by water is a primary agent of soil degradation at the global scale, affecting 1,094 million hectares, or roughly 56 % of the land experiencing human induced degradation. It affects the land from which soil is washed; damages the area downstream by floods and liments and is detrimental to the economy because it lowers the overall income of the farm ripathi et al., 2008).

cording to Tripathi and Singh (2008), in India, the problem of soil erosion assumed serious ncern after the eleventh century with the destruction of forests by Mughals and grew to rming proportions by the nineteenth century. It is also estimated that nearly 2 billion hectares land worldwide (22 % of all cropland, pasture, forest and woodland) have been degraded since d-century.

me 3.5 % of the 2 billion totals are estimated to have degraded so severely that; the gradation is reversible only through costly engineering measures, (GLASOD, 1997).

st over 10% has been moderately degraded, and this degradation is reversible only through ajor on farm investment. Of the nearly 1.5 billion hectares of cropland worldwide, about 38% degraded to some degree (GLASOD, 1997).

Soil erosion is the most important limitation for the sustainable livelihood, optimal land and water management and development (IFAD, 2001). Furthermore, control of sedimentation in reservoirs requires that all the potentially significant sediment sources and sinks are known. Recent studies indicate that gully erosion is often the main source of sediments. Gully erosion has been long neglected because it is difficult to study and to predict (Lal, 1994).

Strategies to prevent soil depletion are critical for livelihood development. Worldwide, erosion on cropland averages about 30t/ha-yr, with a range of 0.5 to 400t/ha-yr (Pimental, 1993).

2.3.4 Erosion in Sub-Saharan Africa

Several studies (Smaling, 1993; Sanchez et al., 1997) have documented the significance of sion in soil functional degradation throughout sub-Saharan Africa at varied scales, which, en minimal use of soil amendments by rural farmers, has profound implications on sustained ;ional agricultural production (Lal, 1995).

ough some local success in controlling and reversing soil degradation has been documented ffen et al., 1994), the soil resource continues to decline regionally (Sanchez et al., 1997), rmingly so in some areas (Oostwoud and Bryan, 2001).

e link between soil erosion and agricultural yields has been widely cited (Lal, 1995; ılengera and Payton, 1999), with most attention paid to nutrient limitation. While the severity the erosion problem is disputed (Crosson, 1986, 1995; Stocking, 1995), it is clear that ricultural yields in Africa have failed to match improvements observed elsewhere (World nk, 1996), and that a primary constraint to improved yields is soil nutrition.

il erosion remains the world's biggest environmental problem, threatening developed and developing countries (ISCO, 2002). About 46 % of the total area of Africa is affected by desertification.

In Food and Agriculture Organization (FAO, 1992) publication concerning desertification, this process is considered an expression of socio-economic evolution and natural or man-made processes that destroy the balance between natural resources.

Soil erosion is caused by non infiltrated water that runs-off a field (Derspsch et al., 1991). Despite scientific and empirical evidence explaining these processes, many people are of the school of thought that the soil has to be loosened by tillage to increase water infiltration and reduce runoff. Soil erosion by water and runoff is often accepted as an unavoidable phenomenon associated with agriculture on sloping land (Derspsch, et al, 1991). Soil loss by erosion or runoff not an unavoidable process; occurrence of erosion damage on cultivated land is merely a nptom of land misuse for that ecological environment (Lal, 1982). It is not the topography or nfall intensity, but rather poor farming methods used by man, which are responsible for ›sion and its negative consequences.

veral biological and mechanical soil and water conservation practices have been used to luce the rate of soil loss such as stone bounding, contour ploughing and terracing amongst ıers, etc (SLaM, 2008).

:ter which contributes organic matter to the soil is burnt and the land is laid bare and :disposed to water and wind erosion. Although the ash produced through burning of the getation increases nutrients such as calcium, magnesium, potassium and phosphorus (Nye and eenland, 1964), the effect is transient. The nutrients are lost trough leaching, resulting in an :rease in soil acidity and high levels of exchangeable aluminium. This limits the range of crops that can be grown.

Failure of farmers and agricultural managers to understand the significance of erosion, as well as intensive weathering under hot, humid conditions, has brought about the widespread distribution of poor, badly eroded, infertile soils all over the tropics and subtropics (Ochse et al., 1961).

Soil erosion is not limited to the tropics alone, but also occurs in more temperate climates such as in the United States and Russia. Eroded, unproductive and abandoned lands as well as advanced signs of desertification are silent testimonies of this phenomenon all over the world. Most researchers agree that soil erosion has a serious impact on agricultural production. However, it is difficult to quantify the effect of the loss of a unit of soil on crop yield (Lal, 1987) because of lack of direct, clear-cut relationship between erosion and productivity and livelihoods. Moreover, soil is only one of the factors affecting productivity, as crop yield is a function of many variables (rrens and Trustum, 1984).

cording to Stocking and Peake (1986), an exponential relation best describes the fall in yield most cases with cumulative erosion, with the coefficient in the exponential equation ranging m 0.002 to 0.036 depending on the crop type. It has also been observed that the loss of soil by sion on unprotected land is often as much as 50 t /ha /year and may grow up to 120 t /ha /yr ipathi et al., 2008).

il is functionally a non-renewable resource; while topsoil develops over centuries, the world's wing human population is actively depleting the resource over decades, which is the basis for % of all food production (Pimentel, 1993).This has a serious impact on the world food curity in the near future. About 50 % of the earth's land surface devoted to agriculture is sceptible to erosion, because of the removal of vegetation before planting and frequent ltivation of soil (Myers, 1993).

Various sources suggest that 5-10 million hectares are being lost annually to severe degradation. If this trend continues, between 1.4 – 2.8 % of the total cropland, pasture and forestland will have been lost by 2020 (GLASOD, 1997). Young (1998) showed that increase in population on limited land resources produces land shortages, leading to small farms, low production per person, increasing landlessness and in consequence, poverty. Land shortage and poverty together lead to non-sustainable land management practices, the direct causes of land degradation. High population density is not necessarily related to land degradation but what the population does to the land that determines the extent of degradation.

Therefore, long-term programmes need to be developed to protect and enhance the quality of land sustainably, especially developing countries with high population densities.

.5 Soil erosion and degradation in Ghana

ım Nsiah-Gyabaah (1996), bushfire is one of the challenging conflicts in Ghana and its ɔacts harshly felt in the northern parts of the country which constitute more than 30% of the ıl land area of the country. Productive soil is one of Ghana's greatest natural resources. So intaining land productivity and preventing environmental degradation from soil erosion are ;h priority national goals (Bobobee et al., 2005).

cursory study revealed that, losses have reduced soil productivity, thus, leading to declining ıd production, food insecurity, reduced farm family incomes and livelihoods, slow economic ıwth against the background of increasing population and urbanization (Shetty et al., 1995).

ırthermore, Ghana, the most susceptible agro-ecological zone to degradation is the interior ..ıanna, which covers about 50% of the land area of the country (UNSO, 1986; Asiamah et al., 2000).

However, assessing poverty at the national level may underestimate the severity of the impact of soil degradation on the country's poor, as many poor rural households live in the areas with higher levels of land degradation and food insecurity compared to the national average (Aryeetey and McKay, 2004).

For this reason, evaluate on the effect of poverty at the sub-national level was done.

Also, Adama (2003), stringed the relation between soil erosion and maize crop yield on another soil type (Acrisols).Furthermore, marginal effect of soil loss on yield loss (MYL) is equivalent to 14 kg/ha for maize in Ghana, while adopting Stocking and Peake's coefficient for cowpeas in the exponential equation, the MYL is 3.86 kg/ha for cowpeas. Based on the results of Thao (2001), MYL is 39.8 kg/ha in the case of cassava with the effect of erosion on root crops in Vietnam. wever, according to Biggelaar et al., (2004), the impact of past erosion on crop yields is much aller than these estimations, whereas the impacts of present erosion on crop yields are higher n the estimations, productive soil is one of Ghana's greatest natural resources.

maintaining land productivity and preventing environmental degradation from soil erosion are ;h priority national goals (Bobobee et al., 2005). Soil erosion by water and soil degradation in ana was noticed way back in the 1930s and measures were taken to solve the problem uansah, 1990) but nevertheless in 1989, investigations done by the Soil Research Institute in ıana revealed that at least 23 % of the country was subject to very severe interrill and gully ›sion, 43.3 % to severe interrill and gully erosion and 29.5 % to slight to moderate interrill ›sion.

a result of the continued increasing pressure on the land, however, it is expected that figures may be much higher (Quansah et al., 1989). Most researchers agree that soil erosion has a serious impact on agricultural production. However, it is difficult to quantify the effect of the loss of a unit of soil on crop yield (Lal, 1987) because of lack of direct, clear-cut relationship between erosion and productivity and living standards. Moreover, the soil is only one of the factors affecting productivity, as crop yield is a function of many variables (Perrens and Trustum, 1984).

According to Stocking and Peake (1986), an exponential relation best describes the fall in yield in most cases with cumulative erosion, with the coefficient in the exponential equation ranging from –0.002 to –0.036 depending on the crop type. It has also been observed that the loss of soil by erosion on unprotected land measures up to 50 ton/ha/year and may grow up to 120 ton/ha/yr (Tripathi et al., 2008).

ana ranks amongst countries where fertilizer use is the lowest, with figures between 4.5 and kg ha^{-1}(NAPCD, 2002).

nce, per capita use was 0.73 kg/person between 1990 and 1996. The situation, coupled with low inherent fertility of the soils and absence of conservation practices, has resulted in rapid cline in the degradation in the desertification prone zone. The following factors which nstrain mineral fertilizer use and uptake of soil conservation technologies therefore contribute the land degradation problem (NAPCD, 2002).

s indicated that the 8.2 million ha of closed forest has been deforested to its current extent of to 2 million ha. Rates of deforestation have been variously estimated at 1.3 and 2 % per num.

nd clearing for agriculture using the slash and burn system accounts for the overall forestation, which leads to the loss of, soil fertility through the effect of erosion (NAPCD, 2002).

Guinea and Sudan Savannah agro ecological zones carry most of Ghana's livestock population. Densities of cattle may range from 77 to 103 animals per km².This high livestock population leads to the corresponding increases in overgrazed marginal lands. During the dry season there is grazing pressure, leaving the lands bare.

The adverse consequences of overgrazing are general deterioration and destruction as a result of soil erosion (NAPCD, 2002).

Bojo (1996) estimated that the gross annual economics loss due erosion ranged from 2 to 5 % of the Agricultural Gross Domestic Product (AGDP) in Ghana.

ble 2.1 Erosion hazard on regional basis (km²)

Region	Slight to moderate sheet erosion	Severe sheet and gully erosion	Very severe sheet and gully erosion
Northern	23,310	19,062	23,330
Upper East	4,574	3,774	964
Upper West	7,288	4,470	7,148
Brong Ahafo	10,697	20,932	5,219
Volta	6,615	7,376	2,901
Ashanti	7,115	11,826	6,017
Greater Accra	3,005	101	85
Eastern	3,090	11,015	2,852
Central	2,002	7,780	521
Western	2,745	16,913	3,675
Total	**70,441**	**103,249**	**54,712**

(Source: Asiamah, 1987)

Research conducted by Alfsen et al., (1977), clearly depicts that loss in soil productivity resulted in an economic growth decline of 1 % even with increased fertilizer use. Using the Replacement Cost Approach (RCA), Convery and Tutu (1990) assessed the cost of annual production loss through erosion and nutrient depletion in Ghana to be US$166.4 million, which was about 5 % of the AGDP.

ailable data on soil erosion (Asiamah, 1987) derived from the soil Erosion Hazard Map of ana (SRI, 1971), indicate the area/extent of the various forms of erosion as 70,441km² from ght to moderate sheet erosion,103,248km² for severe sheet and gully erosion and 54,712km² very severe sheet and gully erosion.

il erosion is one of the most potent degradation processes affecting soil productivity (Oldeman al., 1991). In Ghana, the causative agents of erosion are water and wind. Although wind osion is presently of no major consequence, it can be serious as bare land increases due to the noval of vegetation as in compound farming areas in the Sudan Savannah Zone.

e Food and Agriculture Organisation (FAO) 1983 estimated over 50 % of the country's getation cover with an annual loss of 4 % of GDP.

ı the other hand, large tracts of land have been destroyed by water erosion (Quansah et al., 91). Studies by Asiamah (1987) on the extent of erosion reveal the land area susceptible to the various forms of erosion. However, the most vulnerable zone is the northern savanna comprising the Guinea and Sudan Savanna zones, covering nearly 50 % of Ghana with the Upper East Region being the most degraded area of the country. Adu (1972) reported a loss of 90 cm of soil by interrill and rill erosion. Some severely eroded lands had lost the equivalent of 120 cm thick solum above the unweathered parent rock.

In Ghana, soil erosion and degradation will reduce agricultural income by a total of US$4.2 billion over the period 2006 - 2015, which is approximately 5 % of total agricultural GDP in these ten years.

The effect of soil loss on poverty is also significant at the national level, equivalent to a 5.4 % point increase in the poverty rate in 2015 compared to the case of no soil loss. A cursory

ervation has revealed, the pervasive use of fire for land clearing in the farming systems in the

cursory observation has revealed, the pervasive use of fire for land clearing in the farming tems in the Guinea Savannah Agro-ecological Zone of Ghana, and the uncontrolled late ıual bushfires which destroy forests woodland and crops over extensive land areas as the jor soil erosion factors (NAPCD, 2002).

cording to the studies of DGRD (1992) in Ghana, malnutrition among children between the es of 0 - 5 years in communities with severely degraded soils increased from about 50 % in 36 to 70 % in 1990. Famine also increases the need for relief programmes.

.6 Soil Erosion and Degradation in northern Ghana

pecially in the northern part of the country, erosion problems are severe and both physical and cio-economic factors have intensified, due to a combination of factors such as population pressure, poor farming practices, high erosivity and erodibility of the soils, etc (Agyepong and Kufogbe, 1994). Moreover, soil loss causes a slowdown of poverty reduction over time in the three northern regions, which currently have the highest poverty rates in the country (Xinshen and Sarpong, 2007).

In Africa, two thirds of the total land used for cultivation is affected by land degradation and each year between 5-6 million hectares suited for agricultural production are permanently lost due to soil degradation (Johnson et al., 2006).

Natural processes such as climate conditions and drought are some of the reasons behind land degradation, but also anthropogenic causes play a significant role as for instance, mining ivities, firewood harvesting and overgrazing (Johnson et al., 2006; Agyemang et al. 2007).

ıtistics show that the Northern Region of Ghana loses over 38,000 hectares of its tree cover to sertification yearly, due to the unsustainable farming practices, indiscriminate felling as well commercialization of fuel wood, high incidence of bushfires, overgrazing and extreme ploitation of the Savannah resources to satisfy the socio-economic needs of the people (GNA, 05). It is estimated that 40 % of the region's woodland is exposed to acute soil erosion which viously is alarming and threatens the long term survival of the people living in the area.

3.6 Soil Erosion and Degradation in Tolon-Kumbungu District

ıpulation pressure and the use of improper soil and crop management techniques in producing e basic necessities of life are causing serious accelerated soil erosion, a major component responsible for the loss of soil productivity (FAO, 1965). This can seriously constrain agricultural productivity, which is the spine for the socio-economic development of Ghana (Bonsu and Quansah, 1992). According to Ghana News Agency, on Oct. 18, Land degradation has become a major threat to food production and economic livelihoods of farmers in the Tolon-Kumbungu district.

About 99 % of farm households in the district have either experienced or been affected by the problem of soil infertility, soil compaction, deforestation, overgrazing and weed infestations, research has indicated.

The effects of land degradation had led to 17 % loss of productive lands, 19 % decreased in crop yields and raised production cost to 17 %, while vegetables and pastures had been reduced by 12 and 11 %, respectively. (GNA, 2005).

¡.8 Causes of Erosion and Degradation

ıdies have confirmed that productivity of African soils is endangered by rainfall erosivity and : erodibility of the soil as a result of high rainfall intensities and the ground being exposed at : beginning of the rainy season (Zegeye, 1993).

sks of erosion are accelerated by activities such as deforestation and overgrazing and are ;her in intensive arable land use than in forest or pastures and the magnitude depends on ltural practices adopted. An estimate shows that as many as 2 million hectares of arable land lost annually to severe soil erosion (Lal, 1990).

otorized farm operations usually cause more severe erosion than manual (hoe and machete) :m operations. Risks of erosion are greater in monocropping than rotation and mixed farming, in open row cereals than close canopy legumes, in clean cultivation than in mulch farming and in plough than zero till lands (Lal, 1990) and (Morgan, 1995). Gullies, Pedestals, rills, sediments deposits and root exposures are indicators that measure the extent of soil loss through erosion (Stocking and Niamh, 2001).

2.3.9 Effects of Erosion and Degradation

Extreme soil erosion may lead to loss of whole topsoil making it incapable to produce biomass in agricultural or natural ecosystems. This may result in less soil water retention and sediment deposit in riverbeds which results in flooding (Alan, 2003).

Lal, (1990) stated that changes in physicochemical properties such as fertility increases cost of ›duction if yields are to be maintained. According to IFAD (1992), soil erosion results in luction in productivity of land and crop yields, increased poverty, reduction in fodder for estock and storage of fuel wood which further increases the workload on women.

›.10 Soil Conservation and Improvement Measures

›ategies applicable for addressing soil degradation and improving fertility vary with soils, ›ographic factors, rainfall regimes and farming practices. Mechanisms of erosion require vering the soil to protect it from raindrop impact, increasing infiltration capacity so as to prove aggregate stability and increasing surface roughness to reduce velocity of run-off. ›nservation strategies are categorized as agronomic measures, soil management and ›chanical methods.

According to Quansah et al., (1987), cover crops such as cowpea, groundnut, and Bambara beans are crops suitable to reduce direct impact of raindrop onto the soil in northern Ghana. Also crop residue mulching on the surface protect the soil against raindrop impact, soil detachment and dispersion and maintain high soil infiltration capacity (Lal, 1984). Crop residue mulch of 4-6 tons/ha can effectively control erosion on slopes up to 15 % and for open-row crops such as maize.

In the tropics, decomposition of organic matter is rapid and good soil management involves maintenance and management of organic matter (Asafo-Agyei, 1995).

In Agro forestry, trees roots break through soils to enhance infiltration and also recycle nutrients for use by the food crops through decomposition of leaves. Leguminous plants such as *Parkia biglobosa* and *Leucaena leucocephala* fix nitrogen into the soil. The system conserves soil ainst erosion, provides biomass for mulching and improves soil properties (Baumer, 1990).

namic kraaling which comprises partially decomposed animal dung improves both structure d fertility of the soil favourable for crop development.

her indigenous conservation measures include stone bunds, earth bunds, mound cultivation, pit ltivation and traditional ditches (Shetto, 1999).

idespread deterioration of the ecosystem has diminished or destroyed the biological potential . plant and animal production for multiple use purposes at a time when increased productivity needed to support growing populations in the quest for development. (Pinstrop-Anderson, 01).

ie deterioration of productive ecosystems is an obvious and serious threat to human progress in ese affected areas. In general, the quest for ever greater productivity has intensified ploitation and has carried disturbance by man into less productive and more fragile land. The situation is important in Northern Region of Ghana, whose inhabitants live mostly in rural areas, and practice subsistence farming for their livelihoods with very low-income levels.

The relationship between poverty and desertification is therefore close and complicated. The rural poor depend on agriculture and hence natural resources for 40 – 85 % of their income (Pinstrop-Anderson, 2001).

CHAPTER THREE

MATERIALS AND METHODS

3.1 Study Area

The study area was the Tolon-Kumbungu District of the Northern Region (Fig 3.1). Four communities, namely Cheshegu, Dabogshie, Kpaligum and Fihini, were considered for the study, sed on the degree of land degradation was reported by SLaM (2006). The Tolon-Kumbungu strict, with the District Capital at Tolon, is about 30 km from Tamale, the capital of the rthern Region. Tolon-Kumbungu is located between latitudes 9° 20^{1}N and 10° 05^{1}N and ngitudes 1° 20^{1}W and 1° 50^{1}W. It shares borders with the West Mamprusi District in the rth, West Gonja District in the West and South, and in the East with Savelugu/Nanton District d the Tamale Municipality.

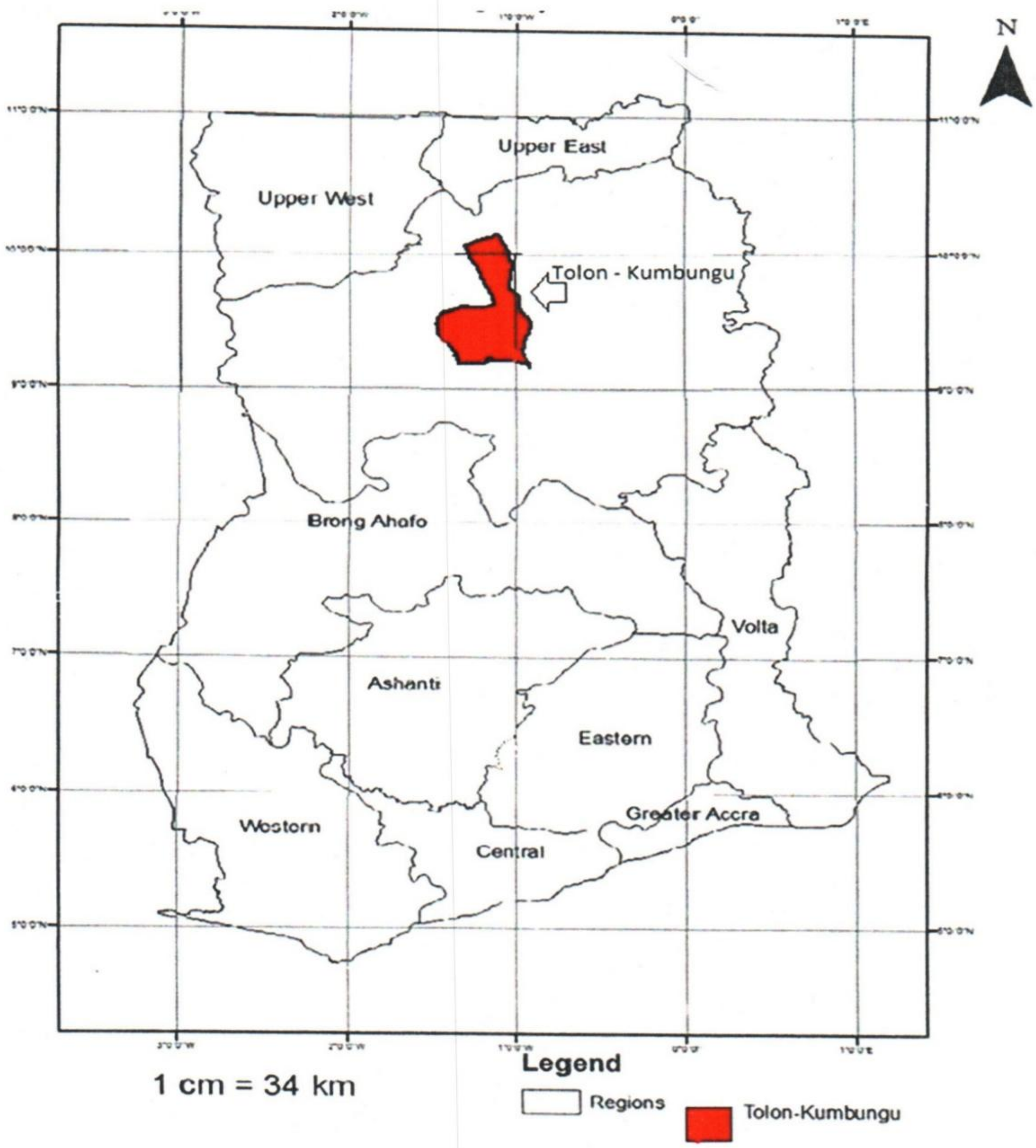


Fig.3.1 Map Showing the Study Area

3.1.1 Climate

The area has a unimodal rainfall pattern which begins from April/May to September/October. The mean annual rainfall is 1.043 mm. The mean annual daytime relative humidity is 54 %. Temperature generally fluctuates between 15°C and 45°C, with a mean annual temperature of 28°C (SARI, 2010).

1.2 Vegetation

ne vegetation is mainly woody Guinea Savannah. The common grasses include *Panicum aximum* (Guinea grass) and *Andropogon gayanus* (Gamba grass). The common trees include *zadiracta indica* (Neem), *Parkia biglobosa* (Dawadawa) and *Vitellaria paradoxa* (Shea tree) MoFA, 2010).

1.3 Population

he population of the Tolon-Kumbungu District is about 122,550 and the breakdown for the udy sites are as follows; Cheshegu has a population of 1148, Dabogshie a population of 355, paligum a population of 965 and Fihini a population of 673 (GSS, 2010).

3.1.4 Soils

The soils in the study area are made up of five main series, which are Nyankpala, Tolon, Kpalesegwu, Tongoli and finally Volta. The selection of the study sites was based on:

- How prone the area is to soil erosion and
- What soil conservations are employed by the indigenes to solve this problem.

3.1.5 Socio-Economic Activities

The people in the study area are mainly small scale livestock and crop farmers. The main crops grown are millet, maize, sorghum, groundnut, rice, yam, tomato, okro, and cowpea and soya beans. The animals kept include cattle, sheep, goats, guinea fowls, etc. In addition to farming activities, the men are also engaged in "zaana-mat' weaving, bicycle repairs and petty trading, 'hile some women also process groundnut and carry out shea butter extraction (Stephen, 2003).

.2 Materials

he following instruments/materials were used for the study:

. Core sampler (7.62 cm x 7.62 cm)

. Sharp machete

. Balance with sensitivity of 0.01 gms

. Oven capable of 105◦C

. Plastic bags

. Weighing tins

. Metal disk

. Survey sheets

9. GPS etrex

10. Metal and fibre tape measure

11. Augur

3.2.1 Research design

The study comprised the following parts:

- Selection of erosion prone sites in the study area through reconnaissance visits.
- Selection of respondents from the study area based on simple random sampling.
- Conducting interviews with community representatives, district level experts and development agents.
- Field measurements of rills, gullies and bulk density.

ese activities were carried out from January 2012-May 2013.

.2 Respondents

simple random sampling method was used to select sample households for the household vey. A total of 40 people were sampled in the study sites as well as households interviews in ay, 2012 were conducted on three levels i.e. district expert level, key informants and finally, nmunity level farmers as well as household interviews.

eld measurements were used to actually determine the areas for the data collection on erosion d degradation.

e questionnaire was developed for the work with the objective of obtaining meaningful information and views from the household members living within the study area and from the key informants. Before the actual data collection, the questionnaire was pre-tested for validity among sampled households in March 2012. During the pre-testing, the questionnaire was fine-tuned and final questionnaire is as presented in Appendix I.

The survey generated quantitative data from sampled households and key informants in the area of study, and qualitative data from focus group discussions to gather information from the community members.

Additionally, focus group discussion was used to discuss the problem with staff working in the District office of the Ministry of Food and Agriculture and development agencies working within listrict and community.

Methods

1 Measuring Instruments for Data Collection

generate information on the negative impacts of soil erosion and degradation of farmland, rviews were done for three categories. The first category entailed interviews with sample seholds living in the area. Household members for the interview were identified using simple lom sampling. The total number of households living in the study area is 366 of whom 40 seholds and 40 people were identified for the interview. A detailed questionnaire was used to ıer adequate information on soil erosion and degradation in appendix I.

second category was key informant interviews with the representatives of the communities ng in the designated area. 14 respondents in number, comprising 7 men and 7 women were interviewed to achieve gender balance, and this was carried out in November 2012.

The group comprised district level staff with professionals from varied areas of specializations in the fields of agriculture, agronomy as well as development agents who lived and worked within the area with the same professions as those of the experts. The purpose of gathering information on the negative impacts of soil erosion and degradation on the farmlands, from different sources, was two-fold. The first was to ensure a diversity of information and the second required triangulation of the information gathered.

The communities used for the study were spread over a large area; therefore five days were needed to complete the interviews of household members.

2 Data Analysis

a from field interviews with households and key informants were analyzed using SPSS 12.0 ware. The information gathered included the perception of the respondents of the existence of erosion and degradation and to determine the consequences of soil erosion and degradation ıcing land productivity through depleting soil fertility with reduced farm incomes. The lysis was also based on age categories and gender to see whether there were different udes towards the problem and perceptions of the different age groups of the problem of soil sion and degradation on the farmlands of these farmers.

a obtained from the focus group discussion, which was qualitative, was analyzed through ussions and what the focus group had to say about their perception and understanding of the blem of soil erosion and degradation on the existence of farmers within the study area was umented. The views of all the members of the focus groups (experts, and development agents were classified and analyzed after which the information was combined with the results from the interviews with households and key informants.

3.4 Method of Field Data Calculations for Field Experiments

3.4.1 Method used to determine the estimated soil loss from rills

The estimated volume of soil loss from a field was calculated by measuring the depth, width and length of rills. The average width and depth of the rills were then calculated.

$$Cross\ sectional\ area(area\ of\ triangle\ m^2)$$

$$= \frac{1}{2} \times horizontal \times depth \qquad (Equation\ 1)$$

$$Volume\ of\ soil\ loss(\ m^3)$$

$$= cross\ sectional\ area \times length\ of\ rill \qquad (Equation\ 2)$$

$$Soil\ loss\left(\frac{m^3}{m^2}\right) = \frac{Volume\ of\ soil\ loss}{Catchment\ area} \qquad (Equation\ 3)$$

$$Soil\ loss\left(\frac{tonnes}{ha}\right) = Soil\ loss\left(\frac{m^3}{m^2}\right) \times bulk\ density \times 10000 \qquad (Equation\ 4)$$

Plate.3.1 Photograph of measurement of rills (16/04/13)

3.4.2 Method used to determine the estimated soil loss from gullies

The volume of soil loss from these gullies was estimated, by measuring the width of upper lip, width of base and depth.

Gully depressions assume trapezoidal shape, across sectional area =

$$cross\ sectional\ area\ of gully = \frac{w1 + w2}{2d} \qquad (Equation\ 5)$$

$$\frac{1}{2}(Av\,Width\,w1 + Av\,Width\,w2) \times Depth \qquad (Equation\ 6)$$

$$Average\ width\ of\ lip\ (m) = \frac{sum\ of\ width\ measurements\ (m)}{Number\ of\ measurements} \qquad (Equation\ 7)$$

$$Average\ width\ of\ base\ (m) = \frac{sum\ of\ width\ measurements\ (m)}{Number\ of\ measurements} \qquad (Equation\ 8)$$

$$epth\ of\,gully\ (m) = \frac{Sum\ of\,depth\ measured\ (m)}{Number\ of\ measurements} \qquad (Equation\ 9)$$

Plate.3.2 Photograph of measurement of gullies (17/04/13)

3.4.3 Determination of Bulk Density

Soil samples were collected 48 hours after the first rain of the year at the various farmlands, for the determination of bulk density.

Samples of soil were taken using a soil augur at different depths of 0-20 cm along the upstream, midstream and downstream of farmlands. These soil samples were collected into the core samplers. The samples were then sent to the laboratory and put in empty containers for oven drying to determine the moisture content.

Soil samples of known volumes of core samplers were also collected at depths between 0-20 cm,

downstream, midstream and upstream, after which average bulk density values were then ermined. The core samplers were driven into the soil vertically until their ends flushed with soil surface inside the core at each layer thickness, and they were then covered with tight ing lid. A knife was used to dig around the core samplers to remove them from the soil. Soil s trimmed with the knife at the ends of the core samplers and covered, which were also sent to laboratory for oven-drying to determine the bulk density.

re samplers were twelve in number and were provided with a metal casing to hold the cores d permit easy removal and handling of the samples during weighing, wetting and drying. If the il core is assumed to be full its volume may be used as the volume of soil.

ie weight of the field soil plus the tin plus cylinder is recorded as Ww. Record the weight of tin and soil when dry as Wd, after drying the samples in an oven at 105°C. The time required to dry the sample varies with the amount of soil present. For core samples, longer time, used was 24 hours.

$$Bulk\ density \left(\frac{g}{cm^3}\right) = \frac{Weight\ of\ dry\ soil\ (Wd)}{Total\ volume\ of\ soil} \qquad (Equation\ 10)$$

3.4.4 Determination of Soil Texture

Purpose: To determine the ratio of clay, silt, and sand in a soil sample by testing its texture.

Materials: Soil samples

Wash bottle with water

Procedure:

A heaped teaspoonful of soil was moistened (used water from a wash bottle).

The Soil Flow Chart was used to determine the composition of the soil.

The fingers were used to feel the predominant particle of soil

A ball of soil was moulded by rubbing between the palms

The thumb and forefinger was used to flatten the ball by pressing it

A ball of soil was rolled into a thread, first a thick one (about 1 cm in diameter) and then a thinner one (about 0.5 cm in diameter)

The thin thread of soil was bent into a horseshoe shape

The soil was manipulated in between the fingers and judge the general feel of the soil

Remoistening was necessary, to make a thin thread of soil (about 0.3 cm in diameter) and bend into a horseshoe shape.

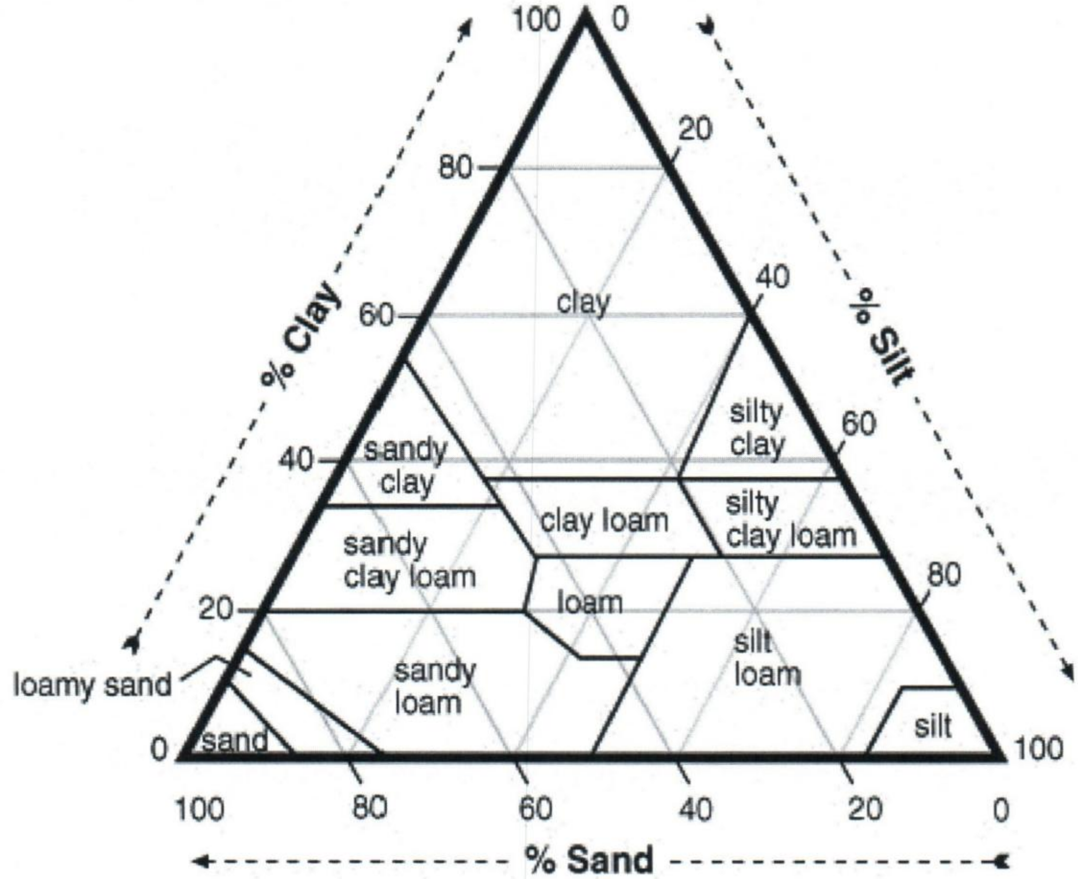
) The horseshoe was made into a thin thread of soil into a ring about 2.5 cm in diameter by joining the two ends of the thread, making sure that cracks do not form.

) The soil was moulded into a ball and rubbed between thumb and index finger to produce a smeared surface

12) The soil was manipulated between the fingers and judging the general feel of the soil

13) The soil is formed back into a ball and manipulated between the fingers to judge the general feel of the soil

The determination of texture compared to the textural triangle.



(Source: Saxton et al., 1986)

g.3.2 Textural triangle

4.5 Sampling Procedure for Soil Samples

The soil samples which were used in the laboratory tests were collected using the diagonal sampling method in order to eliminate homogeneity of the soil collected, which ensured a true representation of soils in the field and checked biases.

CHAPTER FOUR

RESULTS AND DISCUSSION

4.1 Introduction

The results and discussion centred on soil erosion as well as land degradation practices that ' /ersely and negatively affect the farmlands of people within the district.

Socio-Demographic Characteristics

ble 4.1 Total population and household data from GSS, 2010

No	Community	Total Population	Total number of Households	Households Selected for interviews
1	**Cheshegu**	1148	129	10
2	**Dabogshie**	355	47	10
3	**Kpaligun**	965	114	10
4	**Fihini**	673	46	10
Total		3141	336	40

The total number of households in the study area is 366, comprising four communities namely; Cheshegu, Dabogshie, Kpaligum and Fihini, and the breakdown per community is as presented in Table 4.1 the average household size is 8 persons. Sample households were selected through simple random selection process. All except one were male headed households.

ım Table 4.2 it was realized that 25 % of the respondents were aged between 0-19 years; while 5 % represented persons between 20-40 years, making them the majority and people above 40 ırs represented 7.5 %, making it the minimum.

ble 4.2 Age distribution of respondents during the field studies in 2012

Age (y)	No. of respondents	Percentage
0 – 19	10	25.0
20 – 40	27	67.5
>40	3	7.5
Total	40	100

Table 4.3 shows that 10 % of all respondents had secondary education, while 2.5 % had basic education. Most of the household heads (about 87.5 %) had no formal education.

Table 4.3 Distribution of respondents by level of education during the field studies in 2012

Level of Education	Frequency	Percentage
No formal education	36	87.5
Basic education	1	2.50
Secondary education	4	10.0
Total	40	100.0

ım Table 4.4 about 32.5 % of the respondents were involved in arable farming alone, with the ıe percentage of respondents engaged in mixed farming. Trading with farming was 17.5 % tty trading as well as sale of vegetables), while the same number of respondents were engaged ıll the livelihood earning activities already mentioned.

Income generating activities

ble 4.4 Income generating activities the during field studies in 2012

Activity	Frequency	Percentage
Crop farming	13	32.5
Mixed farming	13	32.5
Trading with farming	7	17.5
All combined	7	17.5
Total	40	100.0

The results showed that 15 % of respondents are involved in petty trading and therefore were not farming, 77.5 % cultivate cereals and root tubers,while 7.5 % cultivated crops as well as doing petty trading.

Table 4.5 Crops cultivated by respondents during the field studies in 2012

Crops	Frequency	Percentage
Vegetable crops	7	15.0
Cereals and root tubers	31	77.5
All	2	7.50
Total	40	100.0

ɔm Table 4.5 according to the farmers, factors affecting their farming practices include, ɪaustion of soil nutrients (72.5 %), rainfall fluctuations (10 %) and removal of soil by erosion ; %), as well as all these factors combined giving (2.5 %).

Table 4.6 Problems encountered in farming during the field studies in 2012

Factors affecting soil erosion	Frequency	Percentage
Exhaustion of soil nutrients	29	72.5
Rainfall fluctuation	4	10.0
Removal of soil by erosion	6	15.0
All factors combined	1	2.50
Total	40	100.0

ɪm Table 4.6, 85 % of respondents agreed that they use chemical fertilizer because of the uction in soil fertility, whiles 15 % responded negatively, which means that those did not use ɪmical fertilizer.

ɪ able 4.7 Chemical fertilizer use during the field studies in 2012

Are you using chemical fertilizer?	Frequency	Percentage
Yes	34	85
No	6	15
Total	40	100

From Table 4.8 one farmer did not use any form of fertiliser, while, 27.5 % used organic fertilizers, and 32.5 %indicated that they used inorganic fertilizers (chemical fertilizers). Further 37.5 % also used both organic and inorganic fertilizers.

Table 4.8 Type of fertilizer used by respondents during the field studies in 2012

Type of fertilizer used	Frequency	Percentage
None	1	2.5
Organic fertilizer	11	27.5
Inorganic fertilizer (chemical fertilizer)	13	32.5
Both	15	37.5
Total	40	100

›m Table 4.8, it can be seen that 55 % of farmers stated using chemical fertilizers during the t five years; during the last ten years there were 7.5 %, during the last fifteen years 17.5 %, ı finally, more than twenty years was 20 %.

Table 4.9 Duration of chemical fertilizer use during the field studies in 2012

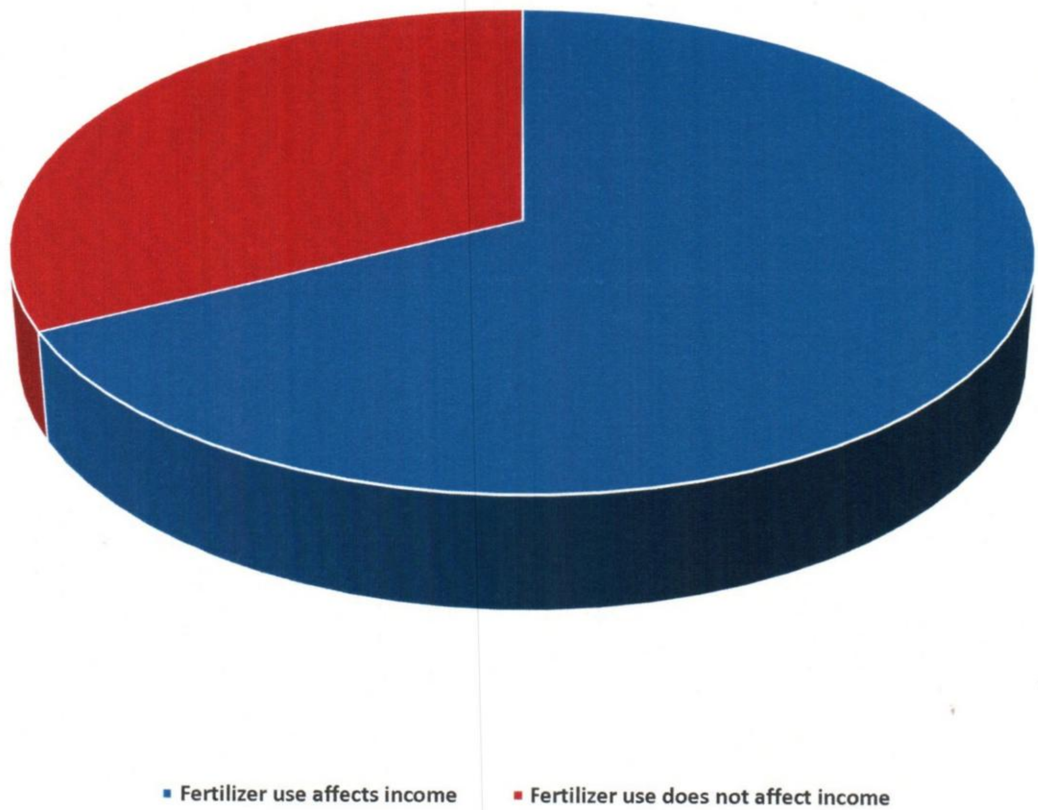
Duration of fertilizer use	Frequency	Percentage
Stated during the last five years	22	55
During the last ten years	3	7.5
During the last fifteen years	7	17.5
More than twenty years ago	8	20
Total	40	100

out 95 % of the respondents said that they use chemical fertilizers to increase yield, whiles, % said they use it to improve fertility of the soil and finally, 2.5 % said that fertilizer serves a binding material for the soil.

ble 4.10 Reasons for the use of fertilizer during the field studies in 2012

Reasons for using fertilizer	Frequency	Percentage
To increase yield	38	95
To improve fertility of the soil	1	2.5
To bind the soil together	1	2.5
Total	40	100

Response to fertilizer use and income during the field studies in 2012



'ig. 4.1 Farmers response to fertilizer use and its effect on income during the field studies n 2012

From Fig .4.1, majority of farmer's responded yes to fertilizer use and its effect on income was 77.5 % and 22.5 % of the respondents interviewed said that fertilizer use does not affect income.

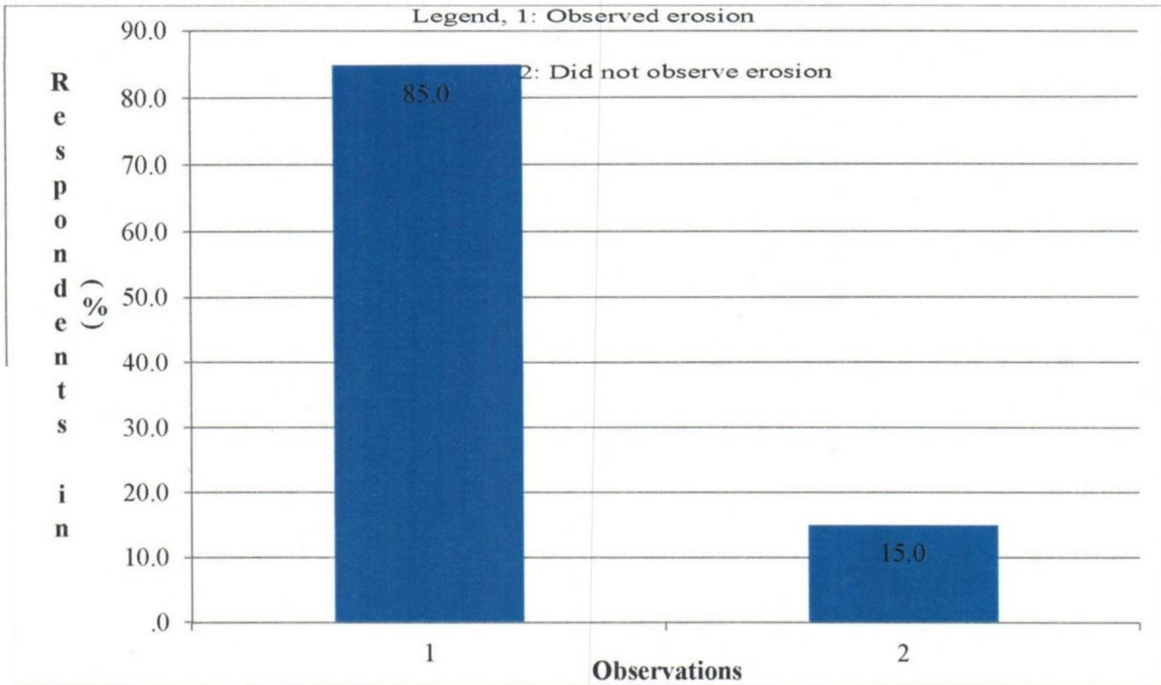


Fig.4.2 Erosion problems of respondent farmers during the field study in 2012

From Fig.4.2, responses revealed that 85 % of the farmers indicated that they have erosion problems on their farms while 15 % of the farmers responded negatively.

Regarding the problems associated with soil and land degradation, it was realized that 12.5 % of the farmers indicated that they suffer loss in agricultural production, while 7.5 % agreed that there was visible channels and gullies on farm, 25 % of respondents mentioned that there was a marked loss of soil fertility due to erosion, 7.5 % also indicated that soil erosion posed a problem, that is damaging their houses and finally, 47.5 % mentioned that they have observed all the above mentioned problems emanating from the erosion with its accompanying degradation both to farmlands and settlements.

Table 4.11 Problems associated with erosion during the field studies in 2012

Problems associated with erosion	Frequency	Percentage
Loss in agricultural production	5	12.5
Channels and gullies on farm.	3	7.5
Loss of soil fertility	10	25
Damage to houses	3	7.5
All combined	19	47.5
Total	40	100

m Fig.4.3 it was observed that 85 % of respondents adopted and used several soil servation practices to mitigate the erosion menace is very pronounced which meant that they cticed it, whiles 15 % responded negatively, meaning that they did not do soil conservation ctices.

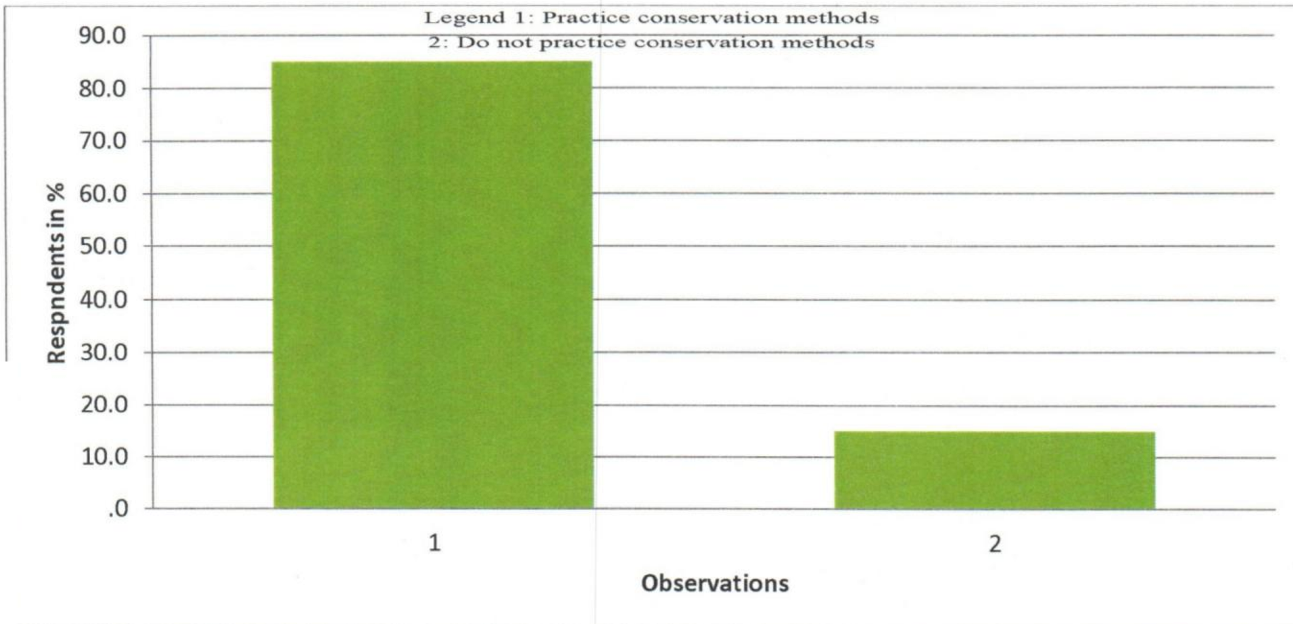


Fig.4.3 Are you practicing soil conservation protection activities on your farm? (Contour ploughing, stone bunding, planting of cover crops) during the field study in 2012

With respect to conservation practices, 80 % of repondents said that there were changes as result of conservation practices suggesting that there was a drift to using conservation techniques and methods , while 20 % disagreed with this statement that there wasn't any.

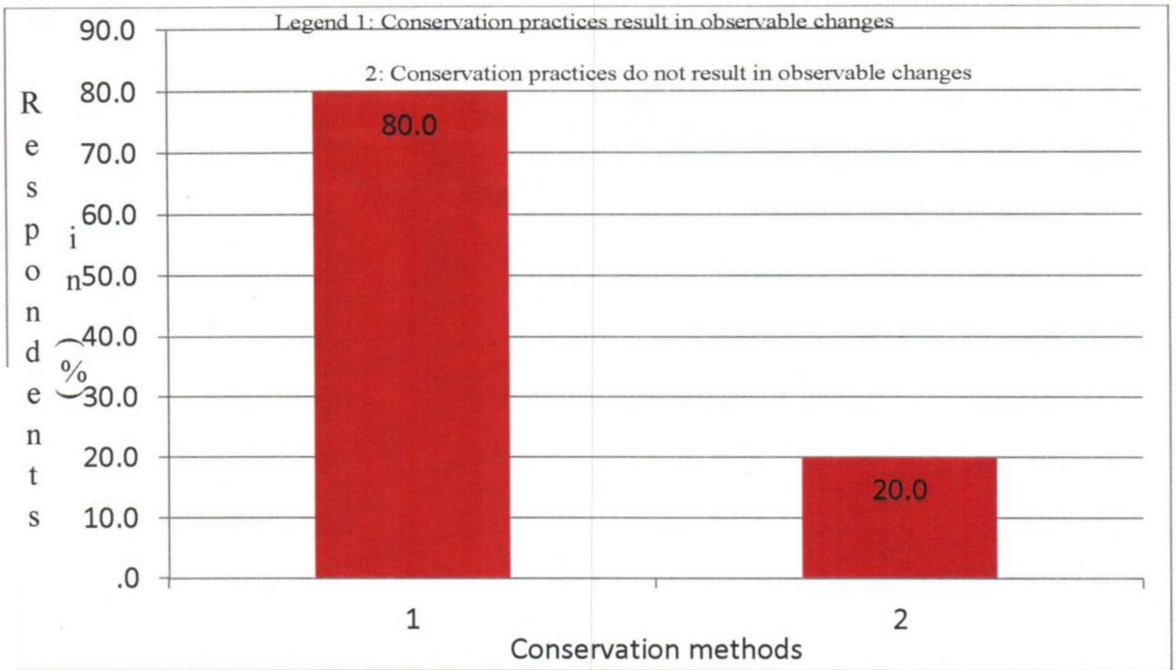


Fig.4.4 Farmers observation of conservation practices during the field studies in 2012

About 35 % of respondents thought that practicing conservation activities increases soil fertility and endowment in terms of nutrient capacity enhancement, whiles 37.5 % observed that it increases land cover, preventing the direct hitting of rainfall on the land, and finally, 27.5 % responded that it increases land productivity by maintaining the nutrient capacity or ability of the soils.

Table 4.12 Conservation practices benefits in the view of respondents during the field studies in 2012

Soil conservation practices	Frequency	Percentage
Increase in soil fertility	14	35
Increase in land cover	15	37.5
Increase in land productivity	11	27.5
Total	40	100

rom Table 4.13 the conservation practices used were largely terracing making up 27.5 %, /hiles the culture of tree planting was 45.0 %, with compost making to being the least 2.5 %, lso waterway creation was also the least with 2.5 % and finally drainage increased to 22.5 %.

'able 4.13 Soil conservation activities/practices during the field studies in 2012

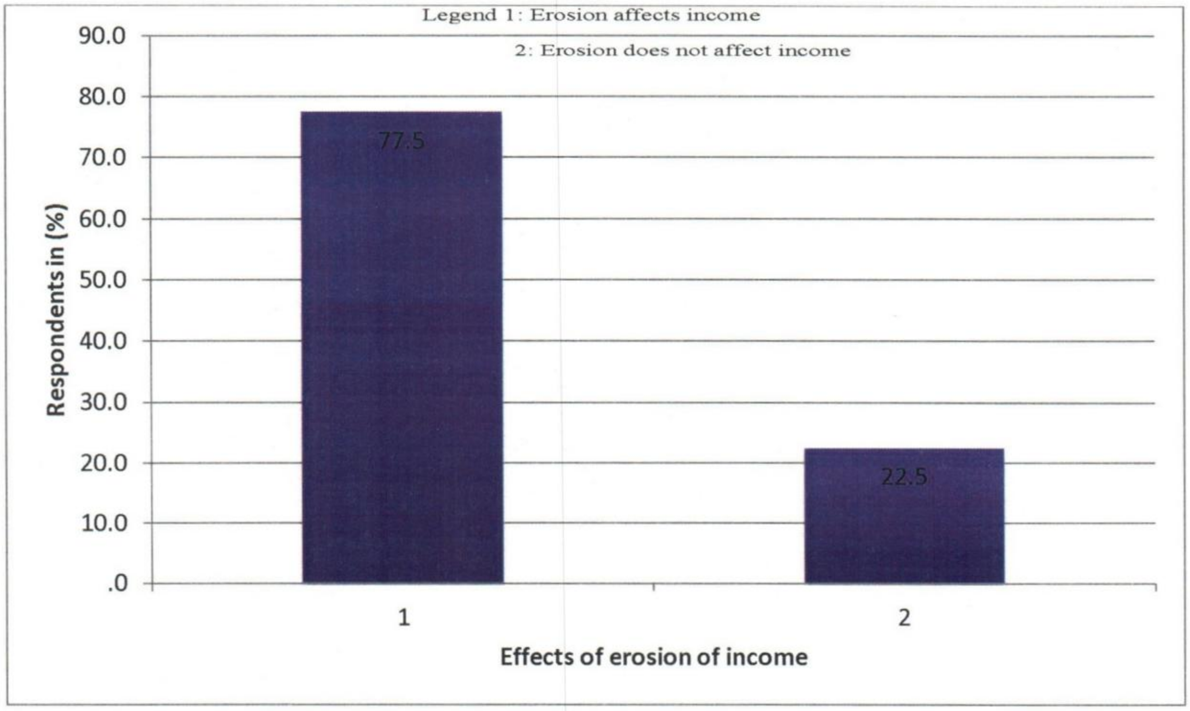
Conservation practices	Frequency	Percentage
Terracing	11	27.5
Tree planting	18	45
Compost making	1	2.5
Waterway creation	1	2.5
Drainage	9	22.5
Total	40	100

Quantifying the decrease in income based on the results from the respondents, 72.5 % of the farmers indicated that there was a decrease in production per kilogramme which was the majority, 15 % also indicated that there was a decrease in livestock production, whilst 5.0 % maintained that there was both decrease in production per kilogramme as well as the decrease in livestock production being the least.

Table 4.14 Changes in farmer's income due to soil erosion during the field studies in 2012

Observed changes	Frequency	Percentage
Decrease in production per kg	29	72.5
Decrease in livestock production	6	15
Both	2	5
Equivalent in cash per year	3	7.5
Total	40	100

The relation between erosion and income revealed that 77.5 % of the total respondents indicated that erosion affects income on a large scale since mitigating or preventing it comes with a cost, but 22.5 % of respondents disagreed with the assertion that the erosion prevention has no cost attached to it.

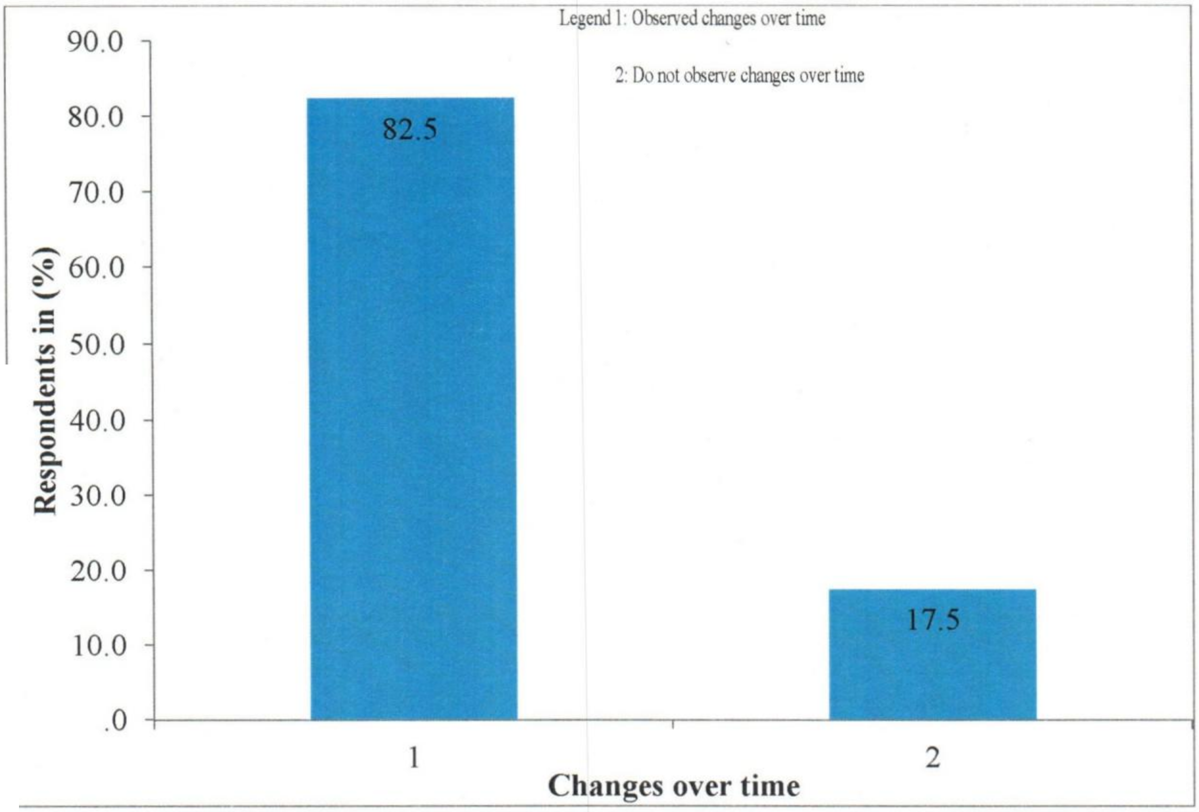


'ig. 4.5 Effects of erosion on income as revealed by the field studies in 2012

\ question followed on the consequences of the reduction of income as a result of soil erosion. ;ome respondents had indicated that it is reduced the number of meals 5.0 % of respondents had educed quantity of food per meal 2.5 %, withdrawal of children from school 17.5 %. Poor health ıs a result of low income was also observed by 20.0 %. Increase in marginal land cultivation was ılso seen as a result of the soil erosion by 2.5 % of respondents, while 52.5 % mentioned and agreed to all five conditions below which were the highest as shown in Table 4.15

Table 4.15 Consequences of reduced income as result of soil erosion during the field studies in 2012

Response on reduced income	Frequency	Percentage
Reduced number of meals	2	5
Reduced quantity of food per meal	1	2.5
Withdrawal of children from school	7	17.5
Poor health	8	20
Move to marginal land cultivation	1	2.5
All	21	52.5
Total	40	100



'ig.4.6 Effects of changes over time period during the field studies in 2012

'rom the Table 4.16 it was realized that there was a change in the environment. It was also :vident that the major physical change of the environment was manifestation of soil erosion with 7.5 %, deforestation 37.5 % and both combined, 42.5 % which was very suggestive that espondents were conscious about their environment.

Table 4.16 Environmental changes observed by respondents during the field studies in 2012

Reasons for changes	Frequency	Percentage
Soil erosion	7	17.5
Deforestation	15	37.5
Both erosion and deforestation	17	42.5
Total	40	100

The changes with respect to the environment showed that 92.5 % of respondents now lived under worse conditions than before, 2.5 % indicated a decrease in their income and 5.0 % mentioned that they also observed other changes, such as loss of vegetation within their surroundings.

Table 4.17 Changes with respect to environment and their effect on respondents during the field studies in 2012

Response	Frequency	Percentage
Poor living conditions	37	92.5
Decrease income	1	2.5
Loss of green cover/vegetation	2	5
Total	40	100

Data collected and analyzed from Dabogshie, Cheshegu, Kpaligum and Fihini revealed that, the highest estimated volume of soil loss by rill erosion at Kpaligum was 165.75 ton/ha, suggesting that the amount of soil depleted by erosion was most severe as shown in Table 4.18

Table 4.18 Estimate amount of soil loss by rill erosion in four communities within the Tolon-Kumbungu District of Ghana

Name of Community	Estimated amount in volume of soil loss by rill in t/h	Location of rills
Kpaligum	165.75	Elev. 178m, Lat. N09.49796^0, Long. W001.07518^0
Cheshegu	95.37	Elev. 171m, Lat. N09.47045^0, Long. W001.05971^0
Dabogshie	1.08	Elev. 165m, Lat. N09.49264^0, Long. W001.05333^0
Fihini	55.93	Elev. 182m, Lat. N09.46933^0, Long. W001.07122^0

Number of measurements, n = 80

Standard deviation, S.D = 47.06

On the contrary, the least severe rill erosion was at Dabogshie with the lowest estimated volume of soil loss of 1.08 ton /ha. Furthermore, the highest estimated volume of soil lost through gully erosion at Kpaligum was 355.3 ton/ha, being the most severe, and the least severe was 169.5ton/ha at Fihini. Baatuuwie et al, (2011) estimated soil loss at 2.6 ton/ha, at the study are of Kpaligum, Nyankpala, Nafrang and Kukuonaayili in the Tolon-Kumbungu District in the Northern Region of Ghana.

Table 4.2.19 Estimate amount of soil loss by gully erosion in four communities within the 'olon-Kumbungu District of Ghana

Name of Community	Estimated amount in volume of soil loss by gully in t/h	Location of gully
Kpaligum	355.3	Elev. 164m, Lat. N09.41091^{0}, Long. W001.81931^{0}
Cheshegu	250.7	Elev. 168m, Lat. N09.46998^{0}, Long. W001.05906^{0}
Dabogshie	232.33	Elev. 171m, Lat. N09.48936^{0}, Long. W001.05379^{0}
Fihini	169.5	Elev. 182m, Lat. N09.46842^{0}, Long. W001.07157^{0}

Number of measurements, n=80

Standard deviation, SD=169.1

The area is located on latitude 09° 25'N and longitude 00° 58'W and at an altitude of 183.3 m above sea level. In Fihini, the estimated amount of soil loss was 169.5 t/ha greater than 1.08 t/ha at Dabogshie.

The soil in this area is mostly loamy, which is compacted and susceptible to erosion. Which goes without saying, that the rate of erosion in the area is moderate? This is because the Potential Soil Loss (PSL) values range from less than 200 t/ha in Greater Accra, Upper West and Upper East Regions, to close to 700 t/ha/yr in Ashanti, Northern Region, and Western Region (IFPRI, 2007). The area easily becomes saturated during rainfall in a short time. This may be attributed to the deposition of clay minerals. According to Donahue (1983), soils with low permeability have hardpan, clayey subsoil or bedrock at the bottom of the soil (B-horizon) as it goes down the soil profile. Therefore, the area could easily become waterlogged when there is excess water or when the final infiltration capacity is exceeded. The soil has an average bulk density of 1.7 g/cm^3. Donahue (1983) reported that plants perform well when the bulk density is between 1.1 and 1.4 g/cm^3. At a bulk density of 1.7 g/cm^3, water movement and root development are curtailed. So, at an average bulk density of 1.9 g/cm^3, crop growth would be adversely affected. Donahue (1983) also stated that very compact subsoil may have bulk density as high as 2 g/cm^3 or even higher and thus many have no root in them. So at bulk density of 1.7 g/cm^3, the soil may be moderately compact. This compaction could be attributed to rain drop impact on the soil, since the soil has inadequate residue cover and also the cultivation of the soil at the same depth year after year, especially when wet. The use of tillage equipment for ploughing when the soil is wet enough makes it plastic and easily compressed. The compaction of the soil impairs aeration, infiltration and root growth (Donahue, 1983).

4.4 Soil Bulk Densities of Farmlands

Table 4.20 Bulk densities for four communities in the study area at 0-20 cm depth

Name of community	**Bulk density (g/cm^3)**		
	Upstream	**Midstream**	**Downstream**
Cheshegu	1.6234	1.5989	1.6183
Kpaligum	1.768	1.7334	1.7456
Dabogshie	1.7354	1.6723	1.6936
Fihini	1.6285	1.5725	1.5623

Table (4.20) shows the soil bulk densities of upstream, midstream and downstream of the agricultural fields in the area, with depths between 0 -20 cm Thus, the bulk density, from the four communities upstream recorded the highest soil bulk density of 1.77 g/cm^3 at Kpaligum while, the downstream recorded the least of 1.56 g/cm^3 at Fihini. Therefore, the average bulk density of soil in the study area is 1.66-1.7 g/cm^3.

From the study, it was realized that crop residues after harvesting were used for fuel, feed for livestock and other domestic purposes, instead of leaving them on the field to serve as mulch and help build up the nutrient requirement of the soil after decomposition has taken place. This exposes the land to heavy rain causing erosion and compaction of the soil. Also low fertility of the soil according to the farmers could be as a result of over-cultivation without replacement of the nutrients and erosion, which washed most of the soil nutrients away. Also, the farmers cultivate the soil usually with a mouldboard plough at the same depth year after year.

This increases root-restricting layers such as hardpans and traffic pans to develop, as reported by Donahue (1983). Plants with restricted roots would not reach their full potential, hence low crop yield.

ecause of the erratic rainfall pattern in the study communities, soil conservation practices such s, agroforestry practices, cover cropping, mulching and crop rotation are widely practiced. The and conservation practices employed by the farmers include contour plowing (tillage practices), ormally with a mould board plough or animal traction.

he farmers plough across the slope before planting their crops. Ploughing across the slope ncreased capture of run-off water, thereby reducing soil erosion and maintaining infiltration rate s well as increasing soil macro pores after contour plowing, as reported by Singer and Munns 2006). Manure is applied to the land after first ploughing. The second ploughing is done to mix he manure with the soil thoroughly. This helps improve the cohesiveness of the soil and ncreases its water retention capacity as reported by Hil (1987).

ome peasant farmers also prefer making ridges to plowing the land before planting. The farmers ill the ground into wide parallel ridges across the slope using simple tools like hoe. According to Bonsu (1981), surface runoff is reduced as water moves across the ridges to the furrows and then down the furrows. This reduces soil erosion, since there is reduction of volume of soil loss by erosion as surface runoff moves across the ridge.

Mounding is another conservation measure practiced by the farmers in the area. It is applied with mulch mostly in the cultivation of yams and sometimes cassava, where some weeds or crop residues are put on top of the mounds to serve as mulch. The mounds reduce runoff thereby reducing soil erosion. It also conserves moisture around the rooting and feeding zone of the crops, as reported by Kranjac-Bersavijevic et al. (1998).

The weeds (mulch) incorporated into the mounds improved the fertility of the soil when they decompose. It also protects the soil against the impact of direct rainfall and impedes runoff, as stated by Lal (1984).

his helps minimize the erosion rate in the area. it can be seen generally that in summary the ɔils on the farmlands in the Tolon-Kumbungu district, have small pore spaces, with high ıoisture content so during a heavy downpour the pore spaces easily gets filled up, and for that ıatter excess rainwater cannot infiltrate into the soil, it then result in runoffs and this washes way the top soil causing rill erosion in most cases and finally results into gullies.

ılso it was observed that the subsoil is compacted as a result of over plowing using these gricultural implements making it very difficult for rainwater to drain, this results in runoff, since ıfiltration on compacted soils is very difficult.

'inally only few farmers, applied the most common conservation practices such as ploughing cross the slope, this serves to reduce the velocity of the running water thereby reducing the load ıf soil mass it carries, at Dabogshie this was very prominent in the fields of cultivation.

4.5 Soil Texture of Farmlands

Table 4.21 Soil texture analysis at selected locations (composite samples)

Sampled Soil	% Sand	(%) Clay	(%) Silt	Texture
Dabogshie	77.52	7	15.48	Loamy Sand
Cheshegu	49.52	17	33.48	Loam
Kpaligum	77.52	9	13.48	Sandy loam
Fihini	61.52	5	33.48	Sandy loam

'able 4.21, shows the soil textural analysis of composite samples, the percentage or proportion ıf sand, clay and silt in the soil samples for the various study sites can be seen clearly; with sand '7.52 %, 7 % of clay and 15.48 % of silt at Dabogshie with texture being loamy sand, 'urthermore, Cheshegu, has sand to be 49.52 %, 17 % of clay and 33.48 % of silt, with texture being loam. Also, Kpaligum, has sand to be 77.52 %, 9% and 13.48 %, with texture sandy loam. Finally, Fihini, has sand being 61.52 %, 5 % of clay and 33.48 % of silt, with a texture of sandy loam.

CHAPTER FIVE

CONCLUSIONS AND RECOMMENDATIONS

5.1 Conclusions

The negative effects of soil erosion and degradation lead to several problems, including low ertility of the soil, which affects crop yield. However, farmers in the study area are able to onserve the soil and control erosion to some extent through some conservational methods such s ridging across the slope, contour ploughing with tractors or animal traction with organic nanure or fertilizer application and mounding with mulching, which enhances crop growth, thus ncreasing yields..

- Most of the respondents admitted that rills and gullies as well as physical damage to infrastructure, were the least perceived problems from erosion. Loss of fertility was the highest effect of erosion.
- Most (85%) of the respondents observed erosion problems in their farmlands.
- Most (85%) respondents practiced soil conservation methods, such as stone bunding, contour ploughing and planting of cover crops.
- Decrease in crop yield and corresponding income was the most observed change, due to soil erosion (72.5%)
- Only few farmers (22.5%) did not agree that erosion could affect income.
- Some (17.5%) farmers withdrew their children from school due to reduced income, as a result of erosion.
- A few respondents (2.5%) admitted that they experienced a decrease in income as a result of erosion.

- Most (92.5%) of the respondents agreed that poor living conditions resulted from changes in the environment due to erosion.
- Most (60%) of the respondents agreed that overgrazing was one of the frequently recognized main causes of soil erosion and land degradation.
- Most (90%) of the respondents also attested to the fact that deforestation and over-cultivation of cropland, was also a contributory factor to the causes of soil erosion.
- From the field measurement in rills, the highest (165.75t/ha) amount in volume of soil loss was estimated at Kpaligum, while the lowest was (1.08t/ha) at Dabogshie.
- From the field measurement to estimate the amount in volume of soil loss through gully erosion in the four communities, Kpaligum had the highest (355.5t/ha) amount of soil loss in gully, while at Fihini it was the lowest (169.5t/ha).
- Textural analysis, showed that the highest percentage, of sand was in the range of 77.52% at Dabogshie and Kpaligum, with textures of soil, being loamy sand and sandy loam respectively, whiles, Fihini showed the lowest 5% of clay, with soil texture been sandy loam.
- The results from the analysis show that, the study area has a slightly compact soil with a bulk density of 1.6-1.7 g/cm^3. The permeability of the soil is therefore low as well as infiltration rate and surface water flows rapidly causing moderate erosion on the land and land degradation.

5.2 Recommendations

A comprehensive programme of land management interventions should be enforced and implemented in the study area to avoid damage from soil erosion. This will entail mobilizing resources, experts and the community at large.

It is very imperative to assess the economic repercussions of both soil erosion as well as degradation, together with the cost components that needs to be incurred to remedy the situation. Policy makers need to be committed to making a difference and embarking on natural resource management practices, instead of merely rehabilitating degraded and derelic lands which use up scanty resources.

The following points are worth recommending:

- General awareness should be created at all levels on the negative effects of soil erosion and land degradation on the livelihoods of farmers.
- The soil should be loosened to make way for water to infiltrate easily into the soil, so as to prevent run-offs or flooding.
- The significant high values from gully erosion can be prevented by using conservation methods such as stone bunding, to prevent the escalation to a more intense and disastrous form of erosion.
- The significant high values from rill erosion can be prevented by the application of green manure, farmyard manure and compost, which serve as mulch on the surface of the exposed farmlands.
- Generally, observation revealed that the soil types in the farmlands were mainly sandy, which could not retain water and hence washed away the topsoil during heavy downpour.

- The high elevation also contributed to the increase and degree of degradation, the steeper the farmland the more intense the erosion was for some farmlands.
- The rate of soil erosion and land degradation should be quantified, as well as the associated costs.
- Community mobilization to improve soil fertility through the application of compost and dynamic kraaling should be given due consideration to reduce the rising expenses that farmers incur as a result of increasing cost of chemical fertilizers.
- Comprehensive watershed management planning for disseminating sustainable land management interventions at community level and vigorous national-level programmes should be implemented.
- Alternative and appropriate technologies in soil and water conservation measures should be explored by national research institutes tested and disseminated taking into cognizance the different agro-ecological zones of the country.
- Special emphasis should be placed on the evaluation of the rate of survival of seedlings to harness the existing initiatives in tree planting and reforestation projects.
- Community-based area closures and natural forests should be protected and managed properly.
- Alternative and environmentally friendly energy sources should be considered and information disseminated at grass roots level to protect the remaining forests.

REFERENCES

Adama, A. I. (2003). The Effect of Different Tillage Practices on Soil Erosion, Water Conservation and Yield of Maize in the Semi-Deciduous Forest Zone of Ghana. Unpublished M.Sc. Thesis, Department of Crop and Soil Science, Kwame Nkrumah University of Science and Technology, Kumasi, Ghana.

.du, S. V. (1972). Eroded savanna soils of the Navrongo-Bawltu area, Northern Ghana, Ghana. Journal *of Agricultural Science,* 5: 3-1 2. Agronomy 37: pp. 183-248.

.gyemang, I., McDonald, A. & Carver, S. (2007): Application of the DPSIR framework to environmental degradation assessment in northern Ghana. *Natural Resources Forum,* 31, pp. 212-225.

.gyepong, G. T. & Kufogbe, S. K. (1994). "Assessing the Spatial Patterns of Land Cover and Land Degradation in the Upper East Region of Ghana using satellite images", Paper presented at the inter-university seminar workshop on social science research, University of Ghana, Legon, 25th-29th July.

.lfsen, K. H., Bye, T., Glomsrod S. & Wiig, H. (1997). Soil degradation and economic development in Ghana. *Environment and Development Economics* 2: pp. 119-143.

Albert, H. 1996. Farm household systems in northern Ghana and the problem of striga. Unpublished workshop paper 1996. Savanna Agricultural Research Institute (SARI).

Armbrust, D. V. (1984). Wind and sandblast injury to field crops: Effects of plant age. Agron.Journ. 76: pp. 991-993.

Armbrust, D.V. (1982). Physiological responses to wind and sandblast damage by grain sorghum plants. Agron.Journ. 74: pp. 133-135.

Aryeetey, E. & McKay, A. (2004). Operationalizing Pro-Poor Growth: A Country Case Study On Ghana.

Asafo-Agyei, J.N. (1995). The Role of Legumes in Soil Fertility Improvement-Soil Fertility Status in Ghana. In: Proceedings of Seminar on Organic and Sedentary Agriculture.

Asiamah, R. D. (1987). Soil Resources And Their Agricultural Utilization In Ghana. Proceedings Of The National Conference On Resource Conservation For Ghana's Sustainable Development. Environmental Protection Council, Accra, 2: pp. 99-111.

Asiamah, R. D., Quansah, C. & Dedzoe, C. D. (2000). Soil degradation: Management and rehabilitation in Ghana – An overview report, 89–101. In *Proceedings FAO/ISCW Expert Consulta-tion on Management of degraded soils in Southern and East Africa (MADS – SEA), Pretoria, South Africa. 8–22 Sep. 2000.*

Baatuuwie, B.N;Kwame O.B, Abdul-Ganiyu ,S. and William. J.A.(2011).Assessment of soil and water conservation measures practiced by farmers: A Case Study in The Tolon-Kumbungu District of Northern Ghana. Journal of Soil, Soil Science and Environmental Management Vol 2(4) pp. 103-109, April.

Baldwin, C. S. (2003). Soil Erosion-Causes and Effects, Ridgetown College of Agricultural Technology ISSN 1198-712X, Queens Printer for Ontario.

Banza, C. L. N., Nawrot, T. S., Haufroid, V., Decree, S., De Putter, T., Smolders, E., Kabyla, B. I., Luboya, O. N., Ilunga, A. N., Mutombo, A. M., & Nemery, B. (2009). High human exposure to cobalt and other metals in Katanga, a mining area of the Democratic Republic of Congo. Environmental Research 109: pp. 745–752

Beasley, R. P. (1972). Erosion and Sediment Pollution Control, 1st ed., Iowa State University Press, Annes.

Biggelaar, C., Lal, R., Wiebe, K. & Breneman, V. (2004). The Global Impact of Soil Erosion on Productivity.In *Advances in Agronomy* Vol. 81.

Bobobee, E. Y. H., & Bart-Plange, A. (2005). Hunger without Frontiers. West African Society of Agricultural Engineering (WASAE).www.wasae.org.

Bojo, J. (1996). The Cost of Land Degradation in Sub-Saharan Africa.Ecological Economics. 16: pp. 161-173.

Bonsu, M. & Quansah, C. (1992). The importance of soil conservation for agricultural economic development in Ghana: The role of the soil scientists. In *Proceedings of the 12th and 13/hAnnualGeneral Meetings of Soil Science Society of Ghana. National Science and Technology Press (NASTEPJ,CSIR, Accra,* pp. 77-80.

Bonsu, M. (1981). Assessment of Erosion under Different Cultural Practices on a Savanna Soil in the Northern Region of Ghana. In: R. P. C. Morghan (ed.), Soil Conservation: Problems and prospects. Chichester, Wiley.

Claflin, L. E., Stuteville, D. L., &Armbrust, D. V. (1973). Windblown soil in the epidemiology of bacterial leaf spot of alfalfa and common blight of beans. Phytopathology 63: pp. 1417-1419.

Cheng, N.Z.,(1984).Experiments on Green Manure Crops on Fallow Land in Summer, Soil and Water Conservation,China 28, pp. 17 - 18

Convery, F, & Tutu, K. (1990). Evaluating The Costs Of Environmental Degradation: Ghana-Applications Of Economics In The Environmental Action Planning Process In Africa. Dubin, Ireland; University College Of Dublin, Environmental Institute.

Crosson, P. 1998. The On-Farm Economic Costs of Soil Erosion. In Methods of Assessment of soil degradation, edited by R. Lal, W.H. Blum, C. Valentine, and B. A. Stewart. Boca Raton, FL. CRC Press, pp. 495-511.

Crosson, P.R., 1995. Soil erosion estimates and costs. Science 269: pp. 461– 464.

Crosson, P. R., (1986). Soil erosion and policy issues. In: Phipps, T.T., Crosson, P.R., Price, K.A. (Eds.), Agriculture and the Environment.

Denevan, W. (1985). Terrace Abandonment in the Perivian Andes: Extent, Causes and Prospects for Restoration. Proc. ConsejoNationale de Genia Y Technologia, Seminario – Taller, Lina, Peru (Resumen).

Derpsch, R., Roth, C.H., Sidiras, N. & Köpke, U. (1991): Controle da erosão no Paraná, Brasil: Sistemas de cobertura do solo, plantiodireto e preparoconservacionista do solo. Sonderpublikation der GTZ, No. 245 Deutsche GesellschaftfürTechnischeZusammenarbeit (GTZ) GmbH, Eschborn, TZ-VerlagsgesellschaftmbH, Rossdorf, pp. 272. Development (CSD) on Desertification.

Donahue, R. L. (1983). Our Soils and their Management.5th Edition. Interstate Printers and Publishers, Inc., United States of America. Hil H, Anne M, Edger T (1987). Erosion Control in the Tropics.Pub. By Wageningen, April 1987, English translation: Mrs. Verheij, pp. 20-25.

Dougill, A. J., Twyman, C., Thomas, D. S. G., &Sporton, D. (2002). Soil degradation assessment in mixed farming systems of southern Africa: use of nutrient balance studies for participatory degradation monitoring. The Geographical Journal 168(3): pp. 195-210..

Eckholm, E. P. (1976). Loosing Ground, Norton, New York

EEA. (2006).European Environment Agency. Urban Sprawl in Europe: The Ignored Challenge. EEA, Copenhagen, EU16.

FAO (1992), Sustainability, accounting for natural resources and environmental degradation.

FAO. (1965). Soil Erosion by Water, FAO, Rome.

Feng X, Wang Y, Chen L, Fu B, Bai G. 2010. Modelling soil erosion and its response to land-use change in hilly catchments of the Chinese Loess Plateau. Geomorphology 118: pp. 239–248.

Fitsum H, Pender J. and Nega, G. (1999). Land degradation in the highlands of Tigray and strategies for sustainable land management: Socio economics and Policy Research Working Paper 25. International Livestock Research Institute.

Foster, G. R. (1982). Modeling the erosion process. In: Haan, Johnson and Brakensiek (eds.), Hydrologic modeling of small watershed. An ASAE Monograph No. 5. ASAE, 2950 Niles Road, P.O.Box 410, St. Joseph, Michigan 49085, USA.

ournier, F. (1972). Soil Conservation, Nature and Environment Series, Council of Europe.

rye, W.W., S.A. Ebelhar, L.W. Murdock and R.L. Blevins. 1982. Soil erosion effects on properties and productivity of two Kentucky soils. Soil Sci. Soc. Am. J. 46(5): pp. 1051-1055.

ugger, W. D. (1999). Evaluation of Potential Indicators for Soil Quality in Savanna Soils

Jarde, R. J. & Kothyari, U. C. (1989) Effects of landslides on river regime. In: Proc. 4th Int. Symp. On River Sedimentation (Beijing, China), pp. 819-831.

Jeorge, R., Mcfarlane, D.and Nulsen, B. (1997). Salinity threatens the viability of agriculture and ecosystems in Western Australia. Hydrogeology 5 (1): pp. 6-21.

Ghana News Agency, (GNA.2005). Land Degradation affecting food production in Tolon/Kumbungu District. GNA.

Gray, D. H. and Leiser, A. T. (1982).Biotechnological Slope Protection and Erosion Control, Van Nostrand Reinhold.

Hagen, L.J. (1994). Wind erosion in the United States. Proc. Of Wind Erosion Symposium, Poznan, Poland. CCLX: pp. 25-32.

Hagen, L.J. and N.P. Woodruff. (1973). Air pollution from dust storms in the Great Plains. Atmos. Environ. 7: pp. 323-332.

Hardin, G. (1968). The Tragedy of the Commons. Science 162: pp. 1243 – 1248.

lauffe, H. K. (1989). Site characterization of the West Ridge Upland Experiment Area (NAES).In: Nyankpala Agricultural Research Report, No. 6, Annual Report 1987/88, NAES, pp. 139 - 154.

Iil, D.S. (1987).Agricultural Insect Pests of Temperate Regions and Their Control.2nd edition, Cambridge University Press ,Cambridge.

FPRI, (2007). Cost Implications of Agricultural Land Degradation in Ghana: An Economy wide, Multimarket Model Assessment. IFPRI. Discussion Paper 00698. 2033 K Street, NW Washington, DC 20006-1002 USA. in Northern Ghana (West Africa). Ph.D. Thesis, University of Göttingen.

FAD. (2001).Rural Poverty Report 2001.Oxford,UK:Oxford University Press.

IFAD, (1990).Upper East Region Land Conservation and Smallholder Rehabilitation Project. Appraisal Report. Vol. II: Working Papers. Africa Division. Project Management Department. Confidential Report No. 0244-GH. November 1990. (IFAD,)Environment and Natural Resource Management.

Johnson, P. M., Mayrand, K. & Paquin. (2006): The United Nations Convention to Combat Desertification in Global Sustainable Developmnet Governanace. In P. M. Johnson, K. Mayrand and M. Paquin (Eds.) *Governing Global Desertification.Linking Environmental Degradation, Poverty and Participation.* Ashgate, England.

Kauda, V. A. (1977). Soil Loss: An Over View. Agro – Ecosystem 3: pp. 205 – 244

.ellman, M. C. (1969). 'Some Environmental Components of Shifting Cultivation in Upland Mindanao', J. Tropical Geology 28, pp. 40.

.otke, W. (2007). The Final Empire. Author House. ISBN 143433130X.

.ranjac-Bersavijevic G., Bayorbor, T. B., Abdulai, A. S. and Obeng, F. (1998). Soil and Water Conservation in Northern Ghana.(A Review Paper Prepared by the Faculty of Agriculture, UDS Tamale, Ghana in Collaboration with Overseas Development Institutes (O.D.I) London.

.wankye. S, Anarfi. J, Ofuso-Mensah. A, and Tiemoko, R. (2003): Migration from and to Ghana: A background paper. Working Paper C4. Brighton, U.K.: Development Research Centre on Migration, Globalisation and Poverty.

Lal, R. Reicosky, D. C., Hanson, J. D., (2007). Evolution of the plow over 10,000 years and the rationale for no-till farming. Soil and Tillage Research 93: pp. 1–12.

Lal,R.(1998).Soil erosion impact on agronomic productivity and environmental gravity.Critical Reviews in Science;17, pp. 319-464.

Lal, R. (1995). "Erosion-Crop Productivity Relationships for Soils in Africa."*Soil Science Society of America Journal* 59(3): pp. 661-667. May-June.

Lal,R.(1994).Water Management in Various Crop Production Systems in related to soil tillage,Soil and Tillage Research 30, pp. 169-185.

' al R (1990). Soil Erosion in the Tropics: Principles and Management. McGraw-Hill, Inc. United States of America.

.al, R., 1987: Response of maize and cassava to removal of surface soil from an Alfisol in Nigeria. International Journal of Tropical Agriculture, 5, pp. 77 – 92.

.al, R. (1984), Soil Erosion In Tropical Arable Lands And Its Control. Advances In

.al, R. (1982): Management of clay soils for erosion control. Tropical Agric., 59 (2), pp. 133 - 138.

.owdermilk, W. C. (1953) Conquest of the Land through Seven Thousand Years. SCS Afric. Inform. Bull. 99, Washington.

.yles, L. (1975). Possible effects of wind erosion on soil productivity.Journ. Soil and Water Cons. 30: pp. 279-283.

Masuda, T. and P.D. Goldsmith. 2009. "World Soybean Production: Area Harvested Yield, and Long-Term Projections." The International Food and Agribusiness Management Review. 12 (4): pp. 143- 162.

MA. (2005). Millennium Ecosystem Assessment.Island Press, Washington, DC, USA.

Mando, A. (2000). Integrated Soil Management for Sustainable Agriculture and Food Security. Country Case Study: Burkina Faso. FAO-RAF 2000/01. Masuda T, Goldsmith PD. 2009. World Soybean Production: Area Harvested, Yield, and Long-Term Projections. International Food and Agribusiness Management Review 12 (4): pp. 143-162.

Michels, K., D.V. Armbrust, B.E. Allison, and Sivakumar, M.V.K. (1995).Agron.Journ. 87: pp. 620-626.

Minh, L. Q. (2000). Environmental Governance: A Mekong Delta case study with downstream perspectives. Can Tho University, Vietnam, 15, pp.16.

Montgomery, D. (2008). Dirt: The Erosion of Civilizations (1st ed.). University of California Press. ISBN 0520258061.

Montgomery. D, (2007). Soil erosion and agricultural sustainability. Journal of Natural Academy of Sciences, 104(33):13268-13272.

Morgan, R. P. C. (1995). Soil Erosion and Conservation. 2nd Ed. Longman group UK limited.

Mueller N.D, Gerber J.S, Johnston M, Ray D.K, Ramankutty N, Foley J.A. (2012). Closing yield gaps through nutrient and water management. Nature 490: 254-257

Mulengera, M. K. & Payton, R. W. (1999). Estimating the USLE-soil erodibility factor in developing tropical countries. *Tropical Agriculture*76, pp. 17–22.

Murthi, B. N. (ed.) (1977). Sedimentation studies in reservoirs, vol. I. Central Board of Irrigation and Power, Tech. Report no. 20, New Delhi, India.

Myers, N. (1993). *Gaia;An atlas of planet Management, Garden City NY,Anchor/Doubleplay.*

Nachtergaele, F.O.F. (2003). The Future of the FAO Legend and the FAO/UNESCO Soil Map of the World. In: Thomas Rice et al (Eds). "Soil Classification: A Global Desk Reference", CRC Press, Boca Raton, FL.

Niamir-Fuller, M. (2005). Managing mobility in African rangelands. In: Collective action and property rights for sustainable rangeland management. pp. 5-7.

'ordstrom, K. F., Hotta, S. (2004). Wind erosion from cropland in the USA: a review of problems, solutions and prospects. Geoderma 121: pp. 157–167.

[APCD, (2002). National Plan of Action to Combat Drought Desertification. Prepared For The Government Of Ghana By Environmental Protection Agency.P 41.

[siah-Gyabaah, K. (1996). Bushfires in Ghana.*International Forest Fire News*: 24-29.Accessed April 16, 2011. http://www.fire.uni-freiburg.de/iffn/country/gh/gh_1.htm.

[ye, P. H. & Greenland D. J., (1964). Changes In The Soil After Clearing Tropical Forest. Plant And Soil. pp. 101 –112.

)chse, J. J., Soule Jr., M. J., Dijkman, M. J., & Wehlburg, N.C. (1961): Tropical and Subtropical Agriculture, Vol. 1. The Macmillan Company, New York, London, 760 p Of Ghana. Topics In Applied Resources Management 2: pp. 135-157.

Oldeman, L. R., Hakkeling, R. T. A, Sombroek, W. G. (1991). World Map of the Status of Human-Induced Soil Degradation: An Explanatory Note (2nd edition). International Soil Reference and Information Centre/United Nations Environment Programme: Wageningen, The Netherlands and Nairobi, Kenya.

Oldeman, L.R.,Hakkeling, R.T.A. and Sombroek, W.G. 1991.Global Assessment of Soil Degradation - GLASOD: World Map of the Status of Human-Induced Soil Degradation. An Explanatory Note. ISRIC/UNEP. ISBN 90-6672-046-8 34.

Oostwoud, D. J. and Bryan, R., (2001). Gully-Head Erosion Processes and Semiarid Valley Floor in Kenya: A Case Study into Temporal Variation and Sediment Budgeting. Earth Surface Processes and Landforms 24, pp. 585 – 603.

›slon, G. W. (1981). Archeology: Lessons on Future Soil Use. J. Soil Water Conservation 36 (5) pp. 261 – 264.

›xfam International, (2009). 'The Missing Middle in Agricultural Finance: Relieving the Capital Constraint on Smallholder Groups and Other Agricultural SMEs', Briefing Paper; available at www.oxfam.org.uk/resources/policy/trade/missing-middle-agricultural-finance.html.

›xfam Novib,(2008). 'The Right to a Sustainable Rural Livelihood. Strategies, Lessons Learned and Actions (2008–2010)', available at http://www.wemanglobal.org/documents/ON_Economic%20Justice.pdf

Okorley EL, Kwarteng J.A. (2002). Current status of the use of pesticides in urban and peri-urban vegetable production in the central region of Ghana. Paper presented at a workshop on the Sustainable Food Production Project, Accra, Ghana, January 30, 2002.

Okorley, E.L.Mensah,,A.O and Al-hassan,I.S.1996.Transfer and adoption of soil and water conservation technologies in the Tolon-Kumbungu Districts of Northern Region of Ghana.

Paulino, L. A. (1986). Food in the Third World. IFPRI Res. Rpt. 52, Washington

'errens, S. J. and Trustum, N. A. (1984). Assessment and evaluation of soil conservation policy.Report, Workshop on Policies for Soil and Water Conservation, 25-27 January 1983, East West Center, Honolulu, Hawaii.

'imentel, D., Harvey. C, Rasosudarmo. P, Sinclair. K, Kurz. D, Macnair. M, Crist. S, Shpritz. L, Fitton. L, Saffouri. R, And Blair. R, (1995). Environmental And Economic Costs Of Soil Erosion And Conservation Benefits.Journal Of Science, 267: pp. 1117-1121.

'imentel, D. (1993). World Soil Erosion and Conservation. Cambridge University Press, Cambridge, UK World Bank, 1996. African Development Indicators. World Bank, Washington, DC.

'instrup-Andersen, P. (2001). Feeding the world in the new millennium: Issues for the new US administration. *Environment*43(6): pp. 22-31.

Quansah, C., Drechsel, P., B.B. Yirenkyi, & Asante-Mensah, S. (2001). Nutrient Cycling in Agroecosystems 61 :205-213. Research Institute, Kwadaso. Kumasi, Ghana.

Ries Jr, R.A., Monnerat P.H (2001).Exportacao de nutrients nos tuberculos de batata emfancao de doses de sulfato de potassio Hortii.Bras.19(3): pp. 360-364.

Quansah et al. (1990). "Soil Erosion and Conservation in the Northern and Upper Regions of

Quansah, C. (1990). Soil erosion and Conservation in the Northern and Upper Regions of Ghana. Topics in Applied Resources Management 2: pp. 135 - 157.

Quansah, C. (1996). Soil, water and nutrient management needs for sustainable crop production. Proceedings of DSE International Seminar on Tools for Analysis and Evaluation for sustainable Land use in Rural Development, DSE, Zscortan, Germany, pp. 38-46.

Quansah C, Baffoe-Bonne E, Aslmmah, R. D. (1989). "Soil erosion in Ghana and strategies for conservation", A country paper presented at the African ministerial conference on environment. Regional coordination unit of the soils and fertilizers network for Africa.Seminar on soil conservation strategy for Africa, Accra, 2-30th August.

Reis,Jr R.A,Monnerat P.H.(2001).Exportacao de nutrients nos tuberculos de batata em funcao de doses de sulfato de potassio Hortic.Bras.19(3): pp. 360 - 364

Rudat, H., Mercer-Quarshie, H. (1993). Proceedings of the 2nd Workshop on improving farming systems in the interior savanna zone of Ghana.24 - 26 April, 1990, Nyankpala, Ghana.

Saxton, K.E. and Rawls, W.J. (1986). Soil Water Characteristic Estimates by Texture and Organic Matter for Hydrolytic Solutions.

Sanchez, P. A., Shepherd, K. D., Soule, M. J., Place, F. M., Buresh, R. J., Izac, A .N., Mokwunye, A .U., Kwesiga, F. R., Ndiritu, C. G., & Woomer, P. L. (1997). Soil Fertility Replenishment in Africa: An Investment in Natural Resource Capital. In: Replenishing Soil Fertility in Africa, Soil Science Society of America Special Publication #51, Soil Science Society of America, Madison,

ARI. (2010), W. Stephen (2003) Prospects and Constraints of Forage Production in Tolon/Kumbungu District. B.Sc. Dissertation, University for Development Studies-Tamale. Unpublished.

avat, J. (1982) Common and Uncommon Selectivity in the Process of Fluid Transportation Field Observation and Laboratory Experiments on Bare Surfaces. Canteria suppl. 1, pp 139.

CSA, 1982. Soil erosion by water in the Tropics S.A El-Swaify, E.W.Dangler and C.L.Armstrong. College of Tropical Agriculture and Human Resources University of Hawaii Honolulu, Hawaii.

calenghe, R. and Marsan, F. A. (2009). The anthropogenic sealing of soils in urban areas. Landscape and Urban Planning 90: pp. 1–10.

Shetto, R.M (1999). Indegineous Soil Conservation tillage System and risks of animal traction and land degradation in Eastern and Southern Africa. In P.G Kaunbutho ,and T.E. Sima leaga (Eds),Conservation Tillage with Animal Traction. A resource book of Animal Traction Network for Eastern and Southern Africa (ATNESA). Harare, Zimbabwe. French Cooperation Namibia.

Shetty, S. V. R., Debrah S. K. & Renard C. (1995). Technology development, testing and transfer: An overview of ICRISAT's Experience in semi-arid Africa. In *Proc. of Workshop on Moist Savannas of Africa: Potentials and constraints for crop production. Cotonou, Benin. Sept 19–23, 1994.*

Singer, M. J. and Munns, D. N. (2006). Soil an Introduction, 6th edition. University of California, Davis. Pearson Prentice – Hall, Upper Saddle River, New Jersey, Columbus, Ohio.07458, pp. 354 - 365

ingh, H. P. (1982) Management of Desertic Soils. In: Review of Soil Research in India, Pp. 676 – 699, ICAR, New Delhi, India.

kidmore, E.L. (1988). Wind Erosion. In R. Lal (ed.) Soil Erosion Research Methods, 2nd ed., Soil and Water Conservation Soc., Ankeny, IA. pp. 265-293.

maling, E. (1993). An Agro-Ecological Framework for Integrated Nutrient Management With Special Reference to Kenya. Landbouw universiteitTeWageningen,Wageningen, Neitherlands.

RI. (1971). Erosion Hazard Map Of Ghana. Survey Department, Accra.

Stephen, W. (2003) Prospects and Constraints of Forage Production in Tolon-Kumbungu District. B.Sc. Dissertation, University for Development Studies-Tamale. Unpublished

Stocking, M. and Murnaghan, N. (2001).Handbook for the field assessment of land

Degradation .Earthscan Publications Ltd, UK/USA. pp 1-35.

Stocking, M. (1996). Soil erosion: Breaking new ground. In: Land degradation and societies (ed. P. Blaikie and H. Brookfield), pp. 49-63. London: Viliers Publication.

Stocking, M., Peake, L., (1986). Crop Yield losses from the erosion of Alfisols. Tropical Agriculture (Trinidad). January, 63(1): pp. 41-45.

ustainable Land Management for Mitigating Land Degradation (2008): Lessons from the SLaM Project Experience in Ghana.

amene, L., Vlek, P. L. G. (2007). Assessing the potential of changing land use for reducing soil erosion and sediment yield of catchments: a case study in the highlands of northern Ethiopia. Soil Use and Management 23(1): pp. 82-91.

'ripathi, S.K., Singh, K.P. (2008). Role of active components in carbon and nutrient cycling of bamboo ecosystems in Indian dry tropical region. J. Bamboo Rattans7: No. 1& 2, pp. 141-150.

'erefe, H. A. (2012). People in Crises: Tackling the Root Causes of Famine in the Horn of Africa. Discussion paper 2012-1.Norwegian Agricultural Economics Research Institute.

'iffen, M.,M.Mortimore, and F,Gichucki, (1994). More people less erosion; Environmental recovery in Kenya. Nairobi Acts Press.

Thao, T. D. (2001). On site Costs and Benefits of Soil Conservation in the mountainous region of northern Vietnam.EEPSEA publications www.eepsea.org.

Trigo, E, Cap, E., Malach, V., & Villarreal, F. (2009).The case of zero-tillage technology in Argentina. IFPRI Discussion Paper. Washington D.C.: International Food Policy Research Institute.

UNEP/FAO/UNDP, 1994: Land Degradation in South Asia: Its severity, Causes and effects upon the People NEP/FAO/UNDP. FAO World Soil Resources Report 78 FAO, Rome.

'nited Nation Environmental Programme UNEP, 1992; GEO: Global Environment Outlook

'NSO. (1986). Essentials of the Problems of Desertification and Review of on-going and proposed activities to implement the Plan of Action to Combat Desertification in Ghana. (United Nations Sudano – Sahelian Office).

Jnited Nations University UNU. (2006). Measuring Vulnerability to Natural Hazards; Towards Disaster Resilient Societies.

JSDA, (1989).The second RCA Appraisal Soil, Water, and Related Resources or Nonfederal land in United States. Analysis of Conditions and Trends. Washington DC, US Department of Agriculture.

/itousek, P. M., Naylor, R., Crews, T., David, M. B., Drinkwater, L. E., Holland, E., Johnes, P. J., Katzenberger, J., Martinelli, L. A., Matson, P. A., Nziguheba, G., Ojima, D., Palm, C.

A., Robertson, G. P., Sanchez, P. A., Townsend, A. R., & Zhang, F. S. (2009). Nutrient Imbalances in Agricultural Development. Science 324: pp. 1519-1520.

Wall, G. (2003). Soil Erosion-Causes and Effects, Ontario Institute of Pedology; ISSN 1198-712X, Queens Printer for Ontario.

World Bank. 1996. Tunisia's Global Integration and Sustainable Development: Strategic Choices for the 21st Century. Washington DC: World Bank Press.

Whiteside, M. (1998). Living farms: encouraging sustainable smallholders in Southern Africa. Earthscan, London.

Viebe. K. (2003). Linking land quality, Agricultural Productivity and Food security, Resource Economics Division, Economic Research Service, U.S Department of Agriculture. Agricultural Economic Report No.823.

Young, (1998). Land Resources; Now and for the future, Cambridge. Cambridge University Press.

Zheng,C., & Tang, K.(2005). Effects of erosion patterns on nutrients loss following deforestation on the Loess Plateau of China. Agriculture, Ecosystems and Environment 108.

Zingore,S.,Murwira,H.K.,Delve,R.,Giller, K.E. (2007). Influence of nutrient management strategies on variability of soil fertility, crop yields and nutrients balances on smallholder farms in Zimbabwe. Agriculture, Ecosystem and Environment 119: pp. 112-126.

APPENDIX (I)

The essence of this research is to collect data for the purpose of my MPhil thesis, Effects of soil erosion and degradation on farmlands in the Tolon-Kumbungu District of northern Ghana. My hope is that the information that will be given will be treated with the necessary confidentiality it eserves.

Iousehold Questionnaire

. Background

Iame of researcher-----------------

Date of interview--------------------

Code of the respondent------------

Iame of the respondent------------

Physical address--------------------

. General

.1. Name of head of household----------------------------------

.2. Sex: Male------------Female--------------------

.3. Age: (1) 0 – 19, (2) 20 – 40, (3) 41+

1.4. Name if different from head of household

1.5. Sex: Male-----------Female--------

1.6. Age-----------------

1.7. Education level, please specify------

Z. farming activities

2. Size of the household--------

2.1. Land holding in hectares----------------

2.3. How do you make your income? A. farming alone----------------- b. farming and livestock

ːaring------------- c. trading------------------ d. all------------- e. Other (specify)-------------

.4. How long have you lived in this area? ----------------years

.5 What type of crops do you grow? a. Vegetables crops b. cereals and roots tubers c. all

.6. Have you experienced any decline in land productivity during the last five years? A. Yes---

. No---

.7. If yes, what do you think is the reason? a. Loss of soil fertility b. rainfall fluctuation c.

ɜmoval of soil by erosion d. loss of forest resources e. all

2.8. Do you use fertilizer for crop production? a. yes--- b. no---

2.9. If yes, which type of fertilized are you using? a. organic---b. inorganic --c. both---

2.10. If you use fertilizer, when did you first started using it? a. During the last five years…b. during the last 10 years---- c. during the last 15 years---- d. more than 20 years ago

2.11. If you use fertilizers, why do you use it for that long? Please explain----------------

.12. If you have been using fertilizers, is there any change in the quantity of fertilizer you are sing? a. yes--- b. no---

.13. If yes, what do you think is the reason? a. reduction in soil fertility-- b. the fertilizer is vashed away---- c. both----

.14. As a result of increase in use of fertilizer, has your income reduced? a. yes----- b. no--- c. emained the same----

.15. If yes, can you quantify in terms of cash------

I. Soil erosion

. Do you know what soil erosion is? Yes---------------No---------------

.1. If yes; what are the problems associated with it? a. Loss in production-------b. Land dissection--------- c. gully formation----------- d. loss of soil fertility---------------- e. damage in infrastructure -------------

3.2. Have you ever practiced soil conservation activities? Yes-----------No-----------

3.3. If yes, what are the major activities you have practiced? a. Terracing b. Tree plantation c. compost making d. Check dam e. waterway f. Cutoff drain

3.4. Have you observed changes as a result of the practiced activities? a. yes------- b. No------

3.5. If yes, what are the changes? (mark all that apply) a. increase in soil fertility---- b. increase in land cover----- c. increase in land productivity-----

N. Changes in income as a result of erosion

4. As a result of erosion problems, has your income decreased? Yes------------ No-------------

4.1.How do you quantify the decrease in your income? a. decrease in production per hectare------Kg b. decrease in livestock production ------ c. both--------d. Equivalent in cash per year-----

4.2. As a result of these problems, what is the level of the problem you have encountered in relation with your livelihood? a. low ------ b. medium------- c. high------- d. no change-------

4.3. What are the consequences of the reduction in your income? Mark all that apply. a. reduced umber of meals------- b. reduced quantity per meal------- c. withdrawal of children from school-------- d. poor health--------- e. marginal land cultivation----- f. all--------

ey Informant questionnaire

ieneral points of discussion, community members who have been trained on land degradation nd conservation.

. Do you know land degradation? a. yes……. b. no……..

. If yes, what are the major causes of degradation…………

. Do you know climate change? a. yes….. b. no………

. If yes, please explain the major causes

. Do you observe physical change in your environment? a. yes……. b. no………

5. If yes, what do you think are the main reasons? .a. soil erosion--------- b. deforestation--- c. both--------

6. Do you observe social instability as a result of these problems? a.. yes……… b. no……

7. Do you observe livelihood change in your community from what has been 10 years ago? a. yes…….. b. no………

8. Have you realized any vegetative change in your community? a. yes…… be. No…….

9. If there are any changes in relation with your environment and livelihood patterns, can you describe/explain?..

....

'ocus group discussion

:indly tell the problem that soil erosion and deforestation are causing on the survival of farmers ı the study area………………………………………………………………………………..

……………………………………………………………………………………………..

……………………………………………………………………………………………..

APPENDIX (IIa)

Field Assessment Form: Rill (Triangular cross-section)

Site: Farm of Mr.Naporo Nabila, Kpaligun-Tolon/Kumbungu

Date: 2nd April, 2013

Coordinates: Elev. 178m, Lat. N09.49796^0, Long. W001.07518^0

leasurement lumber	Width (mm)	Depth (mm)		Measurement Number	Width (mm)	Depth (mm)
	260	80		***13***	530	130
	700	90		***14***	470	146
	760	80		***15***	550	138
	650	290		***16***	603	260
	500	140		***17***	540	140
	590	100		***18***	489	160
	480	150		***19***	437	128
	540	170		***20***	450	145
	470	140		***Sum of all measurements***	10309	2913
0	440	150				
1	460	120		***Average(mm)***	515.45	145.65
2	390	156		***Average (m)***	0.52	0.15

(Source: Field measurement, 2013)

Length of rill (m): 26

Contributing (catchment) area to rill (m^2): 104

APPENDIX (IIb)

Field Assessment Form: Gully (Trapezoidal cross-section)

Site: Farm of Mr Nabila Abukari, Kpaligum-Tolon/Kumbungu

Date: 2nd April, 2013

Coordinates: Elev. 164m, Lat. N09.41091^{0}, Long. W001.81931^{0}

leasurement umber	Width at lip **W1** (m)	Width at base **W2** (m)	Depth (m)
	2.20	1.10	0.44
	2.30	1.25	0.61
	2.90	1.57	0.47
	5.00	4.00	0.80
	2.65	1.37	0.60
	4.80	2.54	0.67
	2.20	1.50	0.57
	4.10	2.00	0.45
	4.06	1.60	0.76
10	3.55	1.30	0.51
11	7.00	3.20	0.51
12	5.00	3.20	0.69

Measurement Number	Width at lip **W1** (m)	Width at base **W2** (m)	Depth (m)
13	5.90	3.40	0.95
14	6.10	3.10	0.65
15	4.70	2.80	0.90
16	3.30	2.10	0.54
17	2.70	1.50	0.50
18	2.90	1.40	0.47
19	2.30	1.20	0.57
20	4.70	2.80	0.67
Sum of all measurements	78.36	42.93	12.33
Average(m)	3.92	2.15	0.62

(Source: Field measurement, 2013)

Length of gully (m): 518

Contributing (catchment) area to gully (m^2): 46620

APPENDIX (IIc)

Field Assessment Form: Rill (Triangular cross-section)

Site: Farm of Mr. AliduYakubu, Cheshegu, Tolon/Kumbungu

Date: 3rd April, 2013

Coordinates: Elev. 171m, Lat. N09.47045^0, Long. W001.05971^0

Measurement Number	Width (mm)	Depth (mm)		Measurement Number	Width (mm)	Depth (mm)
1	290	50		***13***	540	130
2	320	45		***14***	580	110
3	300	53		***15***	490	120
4	260	58		***16***	500	160
5	700	130		***17***	340	115
6	630	125		***18***	365	99
7	710	100		***19***	470	124
8	700	110		***20***	484	109
9	550	120		***Sum of all measurements***	10279	2138
10	680	140				
11	600	90		***Average(mm)***	513.95	106.9
12	770	150		***Average (m)***	0.51	0.11

Length of rill (m): 30

Contributing (catchment) area to rill (m^2): 150

APPENDIX (IId)

Field Assessment Form: Gully (Trapezoidal cross-section)

Site: Farm of Mr. AliduYakubu, Cheshegu-Tolon/Kumbungu

Date: 3rd April, 2013

Coordinates: Elev. 168m, Lat. N09.46998^0, Long. W001.05906^0

Measurement Number	Width at lip **W1** (m)	Width at base **W2** (m)	Depth (m)	Measurement Number	Width at lip **W1** (m)	Width at base **W2** (m)	Depth (m)
	1.5	0.75	0.55	***13***	2.00	1.00	0.51
	1.20	0.80	0.43	***14***	1.70	1.10	0.38
	1.30	1.00	0.78	***15***	1.40	0.90	0.34
	4.60	2.10	0.73	***16***	2.40	0.95	0.25
	2.10	1.20	0.54	***17***	2.60	1.10	0.30
	2.80	1.60	0.51	***18***	3.50	1.50	0.49
	2.70	1.70	0.45	***19***	2.70	1.20	0.25
	1.80	1.40	0.32	***20***	2.80	1.64	0.50
	2.40	1.23	0.33	***Sum of all measurements***	45.3	24.97	8.8
10	2.10	1.10	0.40				
11	1.70	1.60	0.42	***Average(m)***	2.27	1.25	0.44
12	2.00	1.10	0.32				

Length of gully (m): 245

Contributing (catchment) area to gully (m^2): 12863

APPENDIX (IIe)

Field Assessment Form: Rill (Triangular cross-section)

Site: Farm of Mr Iddrisu Musah, Dagboshie-Tolon/Kumbungu

Date: 2nd April, 2013

Coordinates: Elev. 165m, Lat. N09.49264^0, Long. W001.05333^0

Measurement Number	Width (mm)	Depth (mm)	Measurement Number	Width (mm)	Depth (mm)
1	650	100	***13***	510	95
2	670	112	***14***	480	67
3	400	80	***15***	660	100
4	700	110	***16***	710	85
5	390	100	***17***	650	50
6	460	70	***18***	500	60
7	500	80	***19***	490	80
8	600	95	***20***	400	90
9	440	85	***Sum of all measurements***	10520	1029
10	420	80			
11	430	79	***Average(mm)***	526.00	51.45
12	460	83	***Average (m)***	0.53	0.05

Length of rill (m): 165

Contributing (catchment) area to rill (m^2): 37125

APPENDIX (IIf)

Field Assessment Form: Gully (Trapezoidal cross-section)

Site: Farm of Mr. Iddi Issah, Dagboshie-Tolon/Kumbungu

Date: 2nd April, 2013

Coordinates: Elev. 171m, Lat. N09.48936^0, Long. W001.05379^0

Measurement Number	Width at lip **W1** (m)	Width at base **W2** (m)	Depth (m)
1	1.30	0.50	0.25
2	1.90	1.20	0.20
3	3.00	1.30	0.21
4	2.50	0.90	0.20
5	2.20	1.60	0.30
6	3.00	1.40	0.28
7	2.60	1.20	0.34
8	4.50	2.10	0.23
9	2.00	1.00	0.30
10	2.10	0.70	0.33
11	3.20	0.80	0.15
12	3.40	1.20	0.27

Measurement Number	Width at lip **W1** (m)	Width at base **W2** (m)	Depth (m)
13	4.70	1.99	0.46
14	2.80	1.20	0.52
15	3.50	1.50	0.35
16	2.90	1.80	0.32
17	2.80	1.50	0.35
18	3.30	1.60	0.38
19	3.50	2.10	0.27
20	2.90	1.60	0.32
Sum of all measurements	54.9	27.19	6.03
Average(m)	2.74	1.36	0.30

Length of gully (m): 578

Contributing (catchment) area to gully (m^2): 26010

APPENDIX (IIg)

Field Assessment Form: Gully (Trapezoidal cross-section)

Site: Farm of Mr. AliduYakubu, Cheshegu-Tolon/Kumbungu

Date: 3rd April, 2013

Coordinates: Elev. 168m, Lat. N09.46998^0, Long. W001.05906^0

Measurement Number	Width at lip **W1** (m)	Width at base **W2** (m)	Depth (m)	Measurement Number	Width at lip **W1** (m)	Width at base **W2** (m)	Depth (m)
	1.5	0.75	0.55	***13***	2.00	1.00	0.51
	1.20	0.80	0.43	***14***	1.70	1.10	0.38
	1.30	1.00	0.78	***15***	1.40	0.90	0.34
	4.60	2.10	0.73	***16***	2.40	0.95	0.25
	2.10	1.20	0.54	***17***	2.60	1.10	0.30
	2.80	1.60	0.51	***18***	3.50	1.50	0.49
	2.70	1.70	0.45	***19***	2.70	1.20	0.25
	1.80	1.40	0.32	***20***	2.80	1.64	0.50
	2.40	1.23	0.33	***Sum of all measurements***	45.3	24.97	8.8
10	2.10	1.10	0.40				
11	1.70	1.60	0.42	***Average(m)***	2.27	1.25	0.44
12	2.00	1.10	0.32				

Length of gully (m): 245

Contributing (catchment) area to gully (m^2): 12863

APPENDIX (IIh)

Field Assessment Form: Rill (Triangular cross-section)

Site: Farm of Mr. Mohammed Fuseini, Fihini-Tolon/Kumbungu

Date: 3rd April, 2013

Coordinates: Elev. 182m, Lat. N09.46933^0, Long. W001.07122^0

Measurement Number	Width (mm)	Depth (mm)		Measurement Number	Width (mm)	Depth (mm)
[illegible]	460	100		***13***	420	70
[illegible]	530	55		***14***	430	78
[illegible]	670	78		***15***	510	57
[illegible]	730	80		***16***	350	80
[illegible]	500	46		***17***	415	60
[illegible]	490	50		***18***	370	68
[illegible]	450	100		***19***	395	70
[illegible]	460	90		***20***	440	85
[illegible]	390	90		***Sum of all measurements***	9456	1497
10	480	85				
11	600	70		***Average(mm)***	472.8	74.85
12	366	85		***Average (m)***	0.47	0.07

Length of rill (m): 20

Contributing (catchment) area to rill (m^2): 100

APPENDIX (IIi)

Field Assessment Form: Gully (Trapezoidal cross-section)

Site: Farm of Mr. Fuseini Alidu, Fihini-Tolon/Kumbungu

Date: 3rd April, 2013

Coordinates: Elev. 182m, Lat. N09.46842⁰, Long. W001.07157⁰

Measurement Number	Width at lip **W1** (m)	Width at base **W2** (m)	Depth (m)
	2.00	0.80	0.12
	2.50	1.00	0.19
	3.10	2.30	0.18
	4.10	2.00	0.15
	2.30	1.60	0.13
6	2.10	1.10	0.10
	2.60	0.90	0.14
	1.40	0.80	0.30
	1.70	0.90	0.27
10	2.20	1.00	0.20
11	3.50	1.70	0.35
12	2.30	1.30	0.23

Measurement Number	Width at lip **W1** (m)	Width at base **W2** (m)	Depth (m)
13	2.40	1.10	0.28
14	2.20	1.00	0.14
15	2.50	1.10	0.10
16	2.30	1.30	0.20
17	3.60	2.10	0.25
18	2.50	1.50	0.22
19	2.50	0.90	0.20
20	2.70	0.70	0.15
Sum of all measurements	50.5	25.1	3.9
Average(m)	2.53	1.26	0.20

Length of gully (m): 120

Contributing (catchment) area to gully (m^2): 4560