ECONOMIC ANALYSIS OF SOIL CONSERVATION PRACTICES IN NORTHERN GHANA

BY

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DECLARATION

I do hereby declare that, except for references cited which have been duly acknowledged, this research work presented in this thesis was carried out by me as a student at the Department of Agricultural Economics, University of Ghana, Legon. This work has never been presented anywhere either in part or whole for the award of any degree.

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ABSTRACT

This study was carried out in some parts of the Northern and Upper East regions of Ghana with the objective of identifying the traditional soil conservation options available to farmers in the area. The study subsequently assessed the economics of the use of stone bunds as a conservation technology.

To achieve the above objectives structured questionnaires were administered in selected villages from the East and West Mamprusi districts in the Northern region and the Bolgatanga district in the Upper East region. Descriptive statistics and a partial budget analytical tools were employed here. In Northern Ghana high intensity rains, extensive land clearing and tree felling for fuel wood, overgrazing, uncontrolled burning of bush, poor farming practices and population pressures have resulted in severe erosion problems. The gradual soil degradation has affected crop productivity. Stone bunding, Ridging, and Crop residue management are some techniques that farmers have adopted to check soil erosion. Among the numerous fertility restoring methods, Composting, mulching, crop residue management and shifting cultivation are those currently being used by farmers. Others include the use of crop rotation, household refuse, animal/farmyard manure and fertilizer. Results of the partial budget analysis for the use of stone bunding indicate that an additional benefit of ¢3,122,860.00 was realised by putting in 35 extra man-days at a total cost of ¢374,150.00. In other words, it is worth adopting this strategy where possible since the profitability ratio of 9.3 is substantial. A more participatory approach to extension programme formulation and implementation is therefore recommended since farmers are already aware of the problems.

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CHAPTER ONE

INTRODUCTION

Background

Land is an important natural resource of every country, and particularly for a developing country like Ghana, where agriculture is the main source of livelihood to the majority of the people. Since the dawn of time, soil has been on the move. Rain and wind have transported soil particles from place to place, resulting in loss of fertile topsoil from agricultural lands. This problem of land degradation through soil erosion has been a major concern to mankind but still continues to pose a threat to food production. Again, attempts to achieve rapid increase in food production in many African countries including Ghana have basically relied on the extension of the area of land under cultivation. The cleared lands have continuously been exploited through various ecologically unfriendly and unproductive systems. Considering these, and increases in the rate of use of new agricultural lands, it is imperative that adequate attention be focused on arresting the situation.

Ghana is richly endowed with natural resources such as land and forests and the growth of the economy is to a large extent linked to the utilization of these resources. However, current production technologies are in conflict with conditions for sustainable development. The most pressing environmental issues in Ghana today are soil degradation, deforestation and pollution from mining industries. Studies in Northern Ghana have revealed that high intensity rains, extensive land clearing and tree felling for fuel wood, overgrazing, uncontrolled burning of bush, poor farming practices and population pressures have resulted in severe erosion problems.[1] These problems include drastic decline in soil productivity, drying out of streams, depletion of soil water reserves and pollution of natural waters.[2] Research shows that the causative agents of soil degradation in Northern Ghana are water and wind. Wind erosion becomes serious as the area of bare land increases as a result of vegetation degradative processes. Agricultural production in the area, characterized by small farm units and relying almost solely on land and labour as factor inputs, have been suffering from the hazards of low rainfall and poor soils. Livestock rearing, mainly cattle and small ruminants, which constitute vital sources of income to farmers, equally suffer.

Problem Statement

Soils are more vulnerable than is generally thought. Yet they remain the very basis of human existence and the foundation of our food chain.[3] Traditionally, farm household production strategy has revolved mainly around extensive shifting cultivation, which allows the farmland to fallow in order to improve its quality. In other words, the traditional production strategy is a way of reducing pressure on the land and therefore averting soil degradation. According to Boserup,[4] when demand for agricultural products rise as a result

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[1] Adu, S.V. , Soils of the Navrongo-Bawku area, Upper Region, Ghana. Kumasi: Soil Research Institute, *Memoir No.* 5, (1969): pp. 4, 11, 20, 54. ;Bonsu, M. (1981): Assessment of erosion under different cultural practices on a Savannah soil in the Northern Region of Ghana - In Morgan, R.P.C. (ed.), Soil Conservation:Problems and Prospects. Chichester, U.K, John Wiley & sons, pp. 247 – 53.; Garbrah, B.W., and Gyampoh, A. A.: A URADEP Report on Draught and Desertification in Ghana:- Proceedings of Workshop on Combating Draught and Desertification, EPC, Accra. (1985)

[2] Adu, S.V.: Eroded Savannah Soils of Navrongo - Bawku area, Northern Ghana; - *Ghana Journal of Agricultural Science* 5, (1972) pp.3 - 12.; Abu, A.: The Problem of Desertification in Northern Ghana - Proceedings of Workshops in Combating Draught and Desertification, E.P.C., Accra (1985); Garbrah, B.W., and Gyampoh, A. A. , ibid.

[3] Sheng, T.C.:. Soil Conservation for small farmers in the humid tropics. FAO Soils Bulletin, No. 60 FAO Rome. (1989).

[4] Boserup, E.: Economic and Demographic Relationships in Development. (Essays selected and introduced by T. Paul Schultz), John Hopkins University Press, Baltimore (1990).

of population growth and economic development, there are two ways to raise output to meet it. The first is to apply more labor to land by: (a) bringing forest and wasteland under cultivation; (b) reverting to fallow and natural grazing land (and) producing fodder for the livestock; (c) reducing the fallow period; (d) extending the use of multiple cropping system. The second way is to increase the use of industrial and scientific inputs such as fertilizers, insecticides, improved seeds and mechanized equipment. Options such as cultivation of marginal lands and reducing fallow periods, which farmers have already adopted increase pressure on the land. Al-hassan et al[5] indicate in a study of household food security that, unless agricultural land use becomes more intensive in terms of frequency of cultivation, and the use of productivity enhancing factors such as fertilizers and irrigation, as well as adoption of improved soil management practices, the contribution of own food production to the attainment of household food security may reduce. Adoption of improved productive techniques and soil management practices will therefore be essential for achieving sustainable and increased agricultural production. Sheng[6] defines soil conservation as the scientific use and protection of land, including wise choice of land use and pursuits of necessary measures of soil management and erosion control. This definition reemphasizes the fact that conservation is a resource and time consuming activity with apparently little or no long-term benefits to the private interest. Therefore the attitude of the small farmer towards its adoption is likely not to be encouraging. It was therefore

[5] Al-hassan, R., J.A. Famiyeh and A. de Jager 'Farm household strategies for food security in Northern Ghana: a comparative analysis of high and low population farming systems'. In: W.K Asensu-Okyere, G. Benneh and W. Tims (eds.) Sustainable food security in West Africa. Kluwer, Boston. (1997).

[6] Sheng, T.C., *op cit.*

observed rightly that the short-term goals of small farmers (private returns) heavily outweigh that of long-term social benefit of soil conservation[7].

Agricultural officers (working in the area of soil conservation) several years ago noticed the potentially damaging consequences of land degradation in Northern Ghana.[8] Despite the long-standing concern about these problems, little evidence exists on their magnitude. Conservation measures were meanwhile adopted to deal with the problems. However, the non-sustainable nature of these measures in post-independent Ghana has resulted in considerable damage to the soils. The use of the slash and burn method of cultivation with low or no use of fertilizer especially nitrogen and phosphorus negatively affects crop yields. As soil is degraded and crop yields decline, any attempt at restoring productivity will mean higher levels of input utilization (and hence cost). The present situation could degenerate further if adequate and sustainable measures are not put in place to ensure effective soil conservation.

In spite of the numerous constraints facing farmers with regard to practicing soil conservation on their farms, it is observed that some farmers still commit some resources into the practice while others do not. This study therefore seeks to find out what factors directly or indirectly influence farmer's decision to or not to invest in soil conservation. It is necessary to, (a) investigate whether the problem of soil erosion on farmlands has anything to do with cultural practices on the farms (b) find out what soil conservation

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[7] ibid

[8] Lynn, C.W. Agriculture in North Mamprusi:- Dept. of Agriculture, *Gold Coast Bulletin* 34 (1937), pp. 5-6.

means to farmers (c) research the yield implications of soil conservation , and (d) inquire about what needs to be done to enable farmers to invest in soil conservation.

The farm household decision-making is primarily directed towards crop and livestock production with the purpose of satisfying its different goals. By letting farm households pursue their own objectives, society expects that our common interest of environmental sustainability will is promoted as well. However in soil and water conservation, private and public interest may differ considerably. It is possible that even in situations where the soil erosion problem exists, farmers will not perceive the need to conserve the soil. It has however been argued that if erosion will impose serious on-site productivity effects, it would be in the interest of the farmer to conserve his resource.[9] In situations where farmers are seen to under-invest in conservation, it is not unusual for governments to try and redress the problem by introducing intervention packages based on the premise that conservation technology works. This approach generally sets out to persuade and/or coerce farmers into adopting soil conservation. Persuasion and/ or coercion alone, on the grounds of environmental concern was never likely to be effective, in the face of private costs.[10] Thus by trying to address the research issues above, it is possible to find a better alternative to the traditional approach whereby persuasion and coercion become participation and cooperation respectively.

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[9] Crosson, P.: Will erosion threaten agricultural productivity? *Environment* 39(8): 4-9 (1997) pp. 29-31.

[10] Nowak, P.J.: The costs of excessive soil erosion. *J. Soil and Water Cons.* 43(4) (1988) pp. 307-10; Sanders, D.W. :Food and Agriculture Organization Activities in Soil Conservation. In W.C. Moldenhauer and N.W. Hudson (eds.), *Conservation Farming on Steep Lands.* Ankeny, SWCS, (1988) pp. 54-62.

Objectives of the Study.

The main objective of this study is to identify the traditional soil conservation options available to farmers in Northern Ghana and to investigate the yield implications i.e. whether the practice is beneficial or otherwise in terms of crop yields.

The study has the following specific objectives.

1. To identify the major causes of soil erosion on farm lands.
2. To investigate the extent to which farmers use these conservation and fertility maintenance techniques on their farmer.
3. To analyse the yield implications, hence the profitability of use of these measures.
4. To make recommendations on how to encourage the adoption of conservation methods among small-scale farmers who may for some reasons not use them.

Justification of the study.

The performance of Ghana's agricultural sector has generally influenced the performance of the economy as a whole. Since the soil serves as a very important medium for crop production (supplying vital micro and macronutrients), its destruction poses a serious threat to maintaining agricultural production and national development. Given Ghana's need for food and fuel, current rates of soil degradation jeopardize the soil's life supporting potential, and hence, its capacity to provide the present and future population with the essential food requirements. This study is therefore relevant in the light of the existing problems relating agriculture and soil fertility maintenance. For soil conservation programs to be effective, it is important to be clear whether farmers see erosion as a serious problem and know what they could do about it. By so doing, certain fundamental factors that influence farmer's decisions comes to light and also make provision for measures that fall within their means, in terms of acceptability and affordability. Three of such reasons are referred to below.

Firstly, it has been documented that farmer's inability to adopt modern technologies is a result of high input costs and subsidy removal which have contributed to a declining trend in domestic food supply.[11] Since the end of the 1970s the frequent failure of soil conservation interventions is increasingly noted.[12] It has again been reported by most performance measures that conventional conservation programmes have seen remarkable failures[13]. These failures have been attributed to an inefficient/ineffective mode of intervention, especially in developing countries. Secondly, although the disastrous effects of soil degradation/erosion were noticed decades ago, little empirical analysis has so far been carried out on the causes and severity of these problems and on the best ways to address them. Thirdly, it has become obvious that future planning of soil conservation strategies need to draw on past experiences so as to ensure its effectiveness and sustainability.

Scope of study

The study covered small scale food crop farmers in two Guinea savanna zones of Ghana. These are the Northern and Upper East administrative regions, which are located in the

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11 Nyanteng, V.K.: Policies and Options for Ghanaian Economic Development. ISSER, Accra. (1993).

12 Roose, E.: Water and Soil Fertility Management- A New Approach to Fight Erosion and Improve Land Productivity. In: E. Baum, P. Wolff and M.A. Zobish (eds.), *Acceptance of Soil and Water Conservation. Strategies and Technologies.* Witzenhausen, DITSL. (1993) pp. 129-64.

13 Pretty, J.N. and Shah, P.: Making soil and water conservation sustainable: From coercion and control to partnerships and participation. *Land degradation & development* 8: (1997) pp. 39-58.

northeastern section of Ghana. The Upper East Region lies between longitude 0° and 10° 4′ west and latitude 10° 15′ to 11° 10′ north, with a total area of 8,842 sq. km. (see Appendix 1). The region is bordered to the north and east by Burkina Faso and Togo respectively, to the west by Upper West Region and to the south by the Northern Region. The total area of the Northern Region, which also lies between longitude 8° and 11° north, is 70,384 sq. km. It is bounded to the east by Togo and the south by Brong Ahafo Region. Even though the two regions receive an average of about 1100mm of rainfall (mono-modal), the distribution is erratic, rainfall intensities are high (>80mm^{-1}), with an unpredictable onset and termination. On the other hand, the two regions have a comparative advantage for the production of cereals and legumes. Described as the "cereal basket" of the country, Northern Ghana produces all the national supply of sorghum and millet as well as groundnuts and cowpea.[14] About 56%, 45% and 23% of yam, rice and maize are also produced, respectively.

The topography of the study area is undulating and low in relief with slopes of 3 to 4 per cent dominating. The highest hills are around 397m and most of the area lies between 153m and 244m above sea level. Soils of the Guinea savanna are predominantly savanna ochrosols and oxysols. Upland soils, mainly developed from granite rocks are low in inherent soil fertility and poor in organic matter content. Valley soils range from sandy clay loam to silt clays, which have higher natural fertility. According to Food and Agricultural

[14] Langyintuo, A.S., Abatania, L., Asare, E. and Albert, H. : The economics of alternative methods of soil fertility improvement in the guinea savanna zone of Ghana. Proceedings of seminar on Organic and sedentary agriculture organized in Accra, Ghana. 1-3rd November (1995), pp. 295-315.; PPMED: Statistical information from the Ministry of Food and Agriculture, Ghana (1994).

Organization of the United Nations (FAO), a large part of the region has class IV soils, mostly well drained, red to reddish brown with some patches of shallow soils and concentrations.

The northern regions of Ghana could be climatically described as semiarid savannah with humidity that lasts on the average up to seven months in a year. The predominant tree species of economic value commonly found growing on farmlands are *Parkia filicoides* (dawa-dawa) and *Butyrospermum parkii* (shea nut) with more localized areas of *Faidhabia albida*. Grass species commonly found are *Andropogon*, *Hyparrehnia* and *Heteropogon spp*. On highly eroded soils *Aristida*, *Cymbopogon* and *Imperata spp*. are found.[15]

Organization of the Study.

Chapter Two reviews the relevant literature. In it, literature on definitional concepts of conservation, evidence of degradation and conservation policies are reviewed. Chapter Three deals with the methods employed in data collection and analysis. In Chapter Four the empirical results of the study and discussion of results are presented. The final Chapter presents the summary, conclusions and policy recommendations.

[15]Dogbe, E.G.K. : Report on Inception Workshop on Savannah Resources Management Programme for Opinion Leaders in the Upper East Region 9th – 11th September (1998).

CHAPTER TWO

LITERATURE REVIEW

This chapter reviews the relevant literature related to land degradation and conservation. It provides a brief overview of the general definition of the two concepts: land degradation and soil conservation. The review specifically concerns findings of the factors that have contributed to the process of degradation in the northern parts of the country, their effects and the efforts that have gone into salvaging the situation.

Definitional Concepts.

Land degradation

Land degradation is among the most frequently named global environmental problems because it threatens food production, especially in developing countries. The World Resource Institute estimates that 1.2 billion hectares or 11 percent of the earth's vegetated surface have been moderately or severely degraded since 1945.[16] Biot[17] has defined land degradation as an environmental process, which occurs when the ability of the land to produce the goods and/or services people demand from it is declining. In other words, it is the reduction in soil's productivity that may result from breakdown in soil structure, salinization, water logging, nutrient loss, and pollution from toxic substances. Most of these processes are the result of agricultural activities such as misuse of chemicals and tillage with heavy implements. The thought of soil conditions are what basically comes to

[16] World Resources,: World Resources 1992-1993. Toward sustainable development. New York, Oxford University Press (1992).

[17] Biot, Y. "Quantifying sustainability " Paper presented at the *International Workshop on evaluation for sustainable land management in the developing world.* Chiang Rai, 15 - 20/9/9. (1991)

mind when the expression "land degradation" is used. It is however important to note that the vegetation growing on the land, such as trees, bushes or grasses are also included. Among the several overlapping environmental processes involved in land degradation is soil degradation, of which soil erosion is a key contributor.

Soil conservation

In a wide sense, soil conservation includes "all forms of human action to prevent and treat soil degradation".[18] The objective of conservation, according to Sheide,[19] is to ensure that the soil functions for long-term use of humans and nature. In the sense used here, conservation aims at protecting the ability of the soil to produce crops and to reduce soil erosion. Soil conservation on agricultural lands includes mechanical and biological measures. Mechanical conservation measures are referred to as "hard" measures because they involve changes of the landscape to slow runoff and guide water safely from fields. Popular methods include contour ridges or bunding for gentle slopes and terraces for steeper slopes. The biological measures rely on vegetative cover for soil protection. Examples include the use of crop covers like trees, intercropping to reduce the time the soil is bare, and covering the soil with mulch or stubble. Sheng[20] also classified soil conservation practices into four categories,

[18] Oosten, van A.M. and E.J. Cahill, "Towards integrated soil conservation" *Land Use Policy*, April, (1986) pp. 127-140.
[19] Scheide, W: Entwicklung eines wissensbasierten Systems zur Unterstützung der Beratung im Erosionsschutz. Unveröffentlichte Diplomabeit, Hohenheim (1990).
[20] Sheng, T.C.: Soil Conservation for small farmers in the humid tropics. FAO Soils Bulletin, No. 60 FAO Rome (1989).

- Structural or Mechanical erosion practices which is composed of terraces, ditches, windbreaks, earth dams, irrigation dams, controlled land smoothing and land grating.
- Agronomic practices such as multiple cropping, strip cropping, mulching, cover cropping and crop rotation.
- Soil management practices like deep ploughing, composting/farm manure, green manuring, and use of fertilizer.
- Cultivation practices such as minimum/conservation tillage, zero tillage and conventional tillage.

Evidence of degradation

Soil erosion has been described as the most potent degradative process affecting the productivity of agriculture in Ghana[21]. However, soil nutrient mining and depletion which starts off productivity diminishing processes leading to the loss of vegetative cover contributes immensely to the exposition of the top soil to erosion.

Various types of soil erosion caused by water namely sheet and gully are common in most parts of the country particularly in the areas where the vegetation has been disturbed in the savannah zones, hilly areas and steep slopes. Annual water erosion is widespread in many parts of Ghana (Table 2.1).

[21] Asiamah, R.D. Soil resources and their agricultural utilization in Ghana. Proceedings of a National Conference on Resource Conservation for Ghana's sustainable development. Environmental protection agency. Accra, (1987).

Table 2.1. Erosion hazard on regional basis (km^2)

Region	Slight to moderate sheet erosion	Severe sheet and gully erosion	Very severe sheet and gully erosion
Northern	23310	19062	23330
Upper East	4574	3774	964
Upper West	7274	4470	7148
Brong Ahafo	10697	20930	5219
Volta	6615	7376	2901
Ashanti	7115	11826	6017
Greater Accra	3005	101	85
Eastern	3090	11105	2852
Central	2002	7780	521
Western	2745	11913	3675

Source: Asiamah (1987)

About 29.5 per cent of the country is subject to moderate sheet erosion, 43.3 per cent to severe sheet erosion and 23 per cent to very severe and gully erosion in hilly areas and steep slopes depending on the amount of rain received. In areas with vegetation cover such as the forest zone, erosion is not a problem[22]

Brammer[23] indicated that soil erosion is not a serious problem in Ghana except in very densely populated and intensely cropped areas around major towns. While it has been generally claimed that an increasing population would accelerate land degradation, some

[22] Ofori, F.. Enhancing the supportive capacity of land resources for agriculture in Ghana. *World Resource Review*, 4 (3), (1992) pp.469-479.
[23] Brammer, H.: Soil erosion and Conservation in Agriculture and Land use in Ghana.(Wills, J.B. ed.) London, UK: Oxford university press (1962).

cases have been reported where a reverse development took place: more people, less erosion.[24]

Much of the concern about soil degradation in Northern Ghana is beset by uncertainty due to lack of concrete evidence about the amount/rate of soil erosion in the area, hence its productivity consequences. The few available studies on absolute quantities of soils eroded however reveal alarming losses. On the other hand, some of these findings may be limiting in the sense that references as to the time frame during which those losses occurred were not made.

Adu[25] found that, in the Upper East Region the Tanchera series (Chromic cambisol), consisting of 90 to 120cm of brown loamy coarse sand, has lost an estimated amount of 90cm of soil by sheet and rill erosion, leaving about 30cm of coarse sandy loam and gravel above the parent material. In other severely eroded areas, the Pusiga series (Dystric leptosol) had lost all its solum of about 120cm. Soil losses of 2.24ton/ha have been recorded in the course of a season on a bare one per cent slope.[26] In Northern Region, Bonsu[27] found that between July and October in 1977 and 1978, soil loss from a bare fallow run-off plot with a 2 per cent slope ranged from 0.19 to 1.83ton/ha.

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[24] Tiffen, M., Mortimore, M. and Gichuki, F. : *More people, less erosion; environmental recovery in Kenya*. Wiley, Chichester (1993)

[25] Adu, S.V, Eroded Savannah Soils of Navrongo - Bawku area, Northern Ghana; - *Ghana Journal of Agricultural Science* 5, (1972) pp.3 - 12.

[26] Bonsu, M.: Soil erosion studies under different cultural practices within the various ecological zones of Ghana.- Lecture notes, FAO Training Course in Soil Conservation and Management, Kwadaso, Kumasi (1979).

[27] Bonsu, M., *ibid.*

Land use

Over the years, shifting cultivation has been the dominant system in Ghana[28]. Soil fertility was maintained by leaving the land from 5 to 15 or more years for fertility to be rejuvenated[29] However, the bush fallow system is no longer available and soil fertility has to be improved and maintained through the use of inputs and appropriate land/crop management systems for the realization of increased growth in the agricultural sector.

In recent years, increasing population pressure on land and food requirements have led to the extension of cropped areas and the lengthening of cropping periods. Consequently, long fallow periods traditionally associated with shifting cultivation have been reduced to about 2 to 3 years.[30]

Cereals (millet and guinea corn), the main crops grown, do not provide adequate cover to protect the soil against the forces of raindrop and runoff. Moreover, the common practice of clean weeding by hoe and the use of stems as fuel leaves the soil bare at the onset of rains. Farming along streams has enhanced erosion along stream banks and large-scale paddy rice cultivation has transformed thousands of hectares of swampy bush-land into virtually treeless plains.[31]

[28] Bonsu, M. K., K. Yerfi Fosu and P. K. Kwakye. :Soil Management Action Plan for Ghana. Final technical Report Prepared for the World Bank, Washington D.C., U.S.A. (1996)

[29] Benneh, G., G.T. Agyepong and J. A. Allotey. Land Degradation in Ghana. Commonwealth Secretariat, London-University of Ghana, Legon (1996).

[30] Schmidt, G. and Frey, E.: Crop rotation effects in savanna soils.-Nyankpala Agricultural Report, Vol. 4. (1988) ; Runge-Metzger, A.: Variability in agronomic practices and allocative efficiency among farm households in Northern Ghana.-Nyankpala Agricultural Report, Vol. 2. (1988)

[31] Abu, A.: The Problem of desertification in Northern Ghana - Proceedings of Workshops in Combating Draught and Desertification, E.P.C., Accra (1985). ; Garbrah, B W. & Gyampoh, A. A.: A URADEP report on Draught and Desertification in Ghana: - Proceedings of Workshop on Combating Draught and Desertification, EPC, Accra (1985).

Livestock rearing

Overstocking of grazing land (cattle being the most important here) is a common feature in the three northern regions, where most of Ghana's cattle population is found. Cattle population density was reported to be 103 per sq. km. in Navrongo and Bolgatanga districts and 77 per sq. km. in the Bawku and Lawra districts with an estimated stocking rate of 1.3 ha/cow (*ibid.*). This, as observed by Asare[32] was far in excess of the recommended carrying capacity of 10 to 20 ha/cow. These areas are overgrazed during the prolonged dry season creating bare patches, which are subject to erosion. Annual recurrence of uncontrolled bush burning further worsens the situation. The Upper East Region for example recorded a total of 149 incidents of fire outbreaks during the 1997/98 dry season.[33]

Conservation Policies in Northern Ghana.

The recognition of the severity of erosion in Northern Ghana, and the need for proper land use planning, led to the establishment of a Land Planning Organization about four decades ago. This organization was charged with the responsibility of allocating land between forestry, farming and pastureland to protect/develop natural resources in the area.[34] With the statutory backing of the Land Planning and Soil Conservation Ordinances of 1952, seven land planning areas, each with a Project Committee and a Central Co-ordinating

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[32] Asare, E.O.: Conservation of forests and savannahs of Ghana for sustainable development: problems and strategies. - Proceedings of the 11th Annual General Meeting of the Soil Science Society of Ghana, University of Ghana, Accra (1988).

[33] Dogbe, E.G.K. : Report on Inception Workshop on Savannah Resources Management Programme for Opinion Leaders in the Upper East Region 9th – 11th September (1998)

[34] Billes, D.J.: The planning of land-use and soil and water conservation in the Northern Territories of Gold Coast - 2nd Inter African Soils Conference, Leopodville 90, (1954) pp.1143 - 1155.; Pitman, J. and Ramsey, J.M.: Land Planning, Soil and Water Conservation in Northern Ghana. A review of progress in the past ten years (1949 - 1959) Third Inter-African Soils Conference, Dalaba (1959) pp. 797- 804.

Committee were set up. They were to see to the implementation of conservation measures such as establishment of forest reserves, controlling run off on arable lands by narrow-based graded terraces, among others. With a regular flow of inputs and extension services, considerable progress was made with respect to appropriate land-use and conservation of natural resources.

Unfortunately, the above measures could not be sustained in post independence Ghana. As noted by Asem,[35] a major problem of the planning was that, it was difficult for the people to continue after the technical advisors left. This was due to the non-participatory nature of the program planning and implementation. Nevertheless, the need to re-introduce soil and water conservation measures is recognized at all levels.

The National Soil Fertility Management Action Plan

The continuous decline in soil nutrients and organic matter in most soils in Ghana have been of great concern in recent times. In order to accelerate growth in the agricultural sector the Ministry of Food and Agriculture (MOFA), with financial assistance from Sasakawa Africa Association (SAA), in conjunction with Ministries of Environment, Science and Technology (MEST), Lands and Forestry (MLF), the University of Cape Coast (UCC) and the International Fertilizer Development Center (IFDC) -Africa Division, based in Lome-Togo organized a 4-day stakeholders' workshop at Cape Coast in July 1996. The stakeholders (i.e. policy makers, farmers, private agricultural business firms, university professors, researchers, extension workers, donors, non-governmental organizations and

[35] Asem, A.K.: The Problem of Teaching Soil Conservation in the Villages of Ghana,- Third Inter–African soils conference. Dalaba, 2, (1959)pp. 713-719.

international development agencies) in the country dialogued on the constraints affecting soil fertility restoration and maintenance for increased food production. The workshop, which examined broad areas of soil fertility management, formulated guidelines for the development of National Soil Fertility Management Action Plan[36], a document launched by the Ghana Government in December 1998[37]

The document laid emphasis on measures to be adopted to increase the productivity of smallholder farmers who form the bulk of agricultural production in the country, after consideration of ongoing soil fertility maintenance work being undertaken by various institutions. In the Northern, Upper East and Upper West Regions, coverage areas of the project focused on the use and promotion of organic manure for soil fertility maintenance in agriculture. To ensure successful implementation of the Action Plan, some policy action programmes such as land tenure, land use policy and land management programmes are to be adopted by government ministries, district assemblies and relevant institutions for the smooth execution of programmes/projects of the plan with the active involvement of farmers and rural communities.

Effects of soil degradation (erosion)

Accelerated erosion is the most serious form of soil degradation in many developing countries (eg. Nigeria and Ghana). However, one of the problems of soil erosion - and for

[36] Ofori, F. and E.Y. Safo. :Proceedings of the National Workshop on Soil Fertility Management Action Plan for Ghana (Eds.) held at Cape Coast, Ghana, from 2nd to 5th July 1996 organized by MOFA, conjunction with Ministry of Environment, Science and Technology... *et al.*, (1996) p. 226.

[37] Ministry of Food and Agriculture. National Soil Fertility Management Action Plan. Government of Ghana. (1998) 159 pp.

that matter soil degradation is the invisibility of the problem itself.[38] According to Rickson *et al.*,[39] most forms of soil erosion are subtle. The process is slow and unobtrusive at first yet the effects accumulate over time.[40] It was thus rightly noted that, farmers consistently underestimate the extent of erosion in the early stages, and their misperceptions are common.

Off-site effects.

Soil erosion by water is basically a redistribution of soil. Its deposition elsewhere generally has both positive and adverse effects. Clark II divides these into in-stream and off-stream effects[41]. In-stream impacts include adverse effects on navigation, water storage, water conveyance, recreation and water ecology. Off-stream impacts include flood damages and adverse effects on water use for human consumption, industry and agriculture (in terms of water quality loss and water treatment costs). Deposition elsewhere may also have positive effects. For example, whereas Herodutus called the fertile silt deposit by seasonal floods in the Nile delta a 'gift from the gods', a more recent view is that it was a

[38] Chisholm, A.: Abatement of Land Degradation: Regulations versus Economic Incentives. In A. Chisholm and R. Dumsday (eds.), *Land Degradation: Problems and Policies.* Cambridge, Cambridge University Press, (1987a) pp.223-47.; Camboni, S.M. and Napier, T.L: Socioeconomic Barriers to Adoption of Soil conservation Practices in the United States. In: T.L. Napier, S.M. Camboni and S.A. El-Swafi (eds.), *Adopting Conservation on the Farm.* Ankeny, SWCS, (1994) pp. 59-74.; de Graaff, J.: The price of soil erosion: An economic evaluation of soil conservation and watershed development. Monsholt Studies No. 3. Wageningen, WAU. (1996)

[39] Rickson, S.T., Rickson, R.E. and Nowak, P.J.: Farmer's Response to Land Degradation: Dialemmas in Sustaining Land Resources in Tropical Agriculture. In E. Baun, P. Wolff and M.A. Zobisch (eds.), *Acceptance of Soil and Water Conservation. Strategies and Technologies.* Witzenhausen, DITSL, (1993) pp.77-102.

[40] Biot, Y. and Xi, L.X.: Assessing the Severity of the Problem and the Urgency for Action. In E. Baun, P. Wolff and M.A. Zobisch (eds.), Acceptance *of Soil and Water Conservation. Strategies and Technologies.* Witzenhausen, DITSL, (1993) pp.165-92.

[41] Clark II, E.H. .Soil Erosion: Off-Site Environmental Effects. In: J.M. Harlin and G.M. Berardi (eds.), *Agricultural Soil Loss: Processes, Policies and Prospects.* London, Westview Press, (1987) pp.59 - 89.

gift from Ethiopia.[42] Soil erosion is viewed as the removal of soil and water from areas of low valued use (upland) to high valued use (lowland) where both can be utilized more efficiently.[43]

On-site effects.

The large-scale effects of erosion on the productivity of soils are not well known.[44] Crop yields are a function of many variables, including biophysical conditions, crop management and the crop itself.[45] However, it is clear that fertility decline affects crop production directly. To ensure a good harvest, farmers use expensive chemical fertilizers (usually unaffordable), which when over utilized further degrades soils low in organic matter. In other words, sole use of chemical fertilizers destroys soil structure. Meanwhile, the explanatory power of the erosion-productivity relationship is generally limited – that is, soil erosion rates by themselves are poor indicators of the loss in productivity.[46] Bush burning is the number one contributing factor to the shortage of feed for livestock in degraded areas. Poor quality of the soil affects the supply of vegetative material for feed leading to overgrazing of crop lands.

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[42] Sanders, J.H., Southgate, D.D. and Lee, J.G.. *The economics of soil degradation: technological change and policy alternatives.* Technical Monograph Soil Management Support Services No.22. West Lafayette, USA, Purdue University. (1995)

[43] Seckler, D.: Issues in the Economic Evaluation of Soil and Water Conservation Programmes. In: P. Blaikie and H. Brookfield (eds.), *Land Degradation and Society.* New York, Methuen & Co, (1987) pp.84 - 96.

[44] Pierce, F.J.: Erosion Productivity Impact Prediction. In: R. Lal and F.J. Pierce (eds.), Soil Management for Sustainability. Ankeny, SWCS, (1991)pp. 35-52

[45] Lal, R.: Effects of Soil Erosion on Crop Productivity. *CRC Critical reviews in Plant Sciences* 5(4): pp.303-67. Bishop, J. and Allen, J., (1989): *The On-Site Costs of Soil Erosion in Mali.* Environmental Working Paper No. 21. Washington, D.C., The World Bank (1987a); Rabbinge, R. and van Ittersum, M.K.: Tension Between Aggregation Levels. In: L.O. Fresco, L. Stroosnijder, J. Bauma and H. van Keulen (eds.), *The Future of the Land: Mobilising and Integrating Knowledge for Land Use Options.* Chichester, John Wiley and Sons Ltd, (1994) pp.31 - 40.

[46] Larson, W.E., Pierce, F.J. and Dowdy, R.H.: The Threat of Soil Erosion to Long-Term Crop Production. *Science* 219: (1983) pp. 458-65.

Effects of some Fertility restoration/Conservation methods

Animal Manure

Owing to the high cost of fertilizers, farmers in the study area use manure in their efforts at restoring/maintaining soil productivity. However, the several constraints to the efficient utilization of dung and other forms of manure include difficulties in collection, processing, storage and the mode of application preclude their intensive use in crop production in Ghana. In northern Ghana, large quantities of cow dung are available in some farms, but this is not used extensively due to the limited available information on nutrient content and crop yields.

Agroforestry

Agroforesry provides the possibility of growing woody perennials (trees and shrubs) in association with crops and/or animals in either spatial or sequential arrangements on farms. Since its introduction in 1988, farmers have adopted various types of agroforestry interventions in crop production. These include alley cropping, woodlots and contour planting with multiple purpose trees (MPTs). The commonest MPT familiar to farmers is *Leucaena leucocephala*, which is known to increase the soil nitrogen content, and organic matter levels and the restoration of topsoil fertility. In a trial conducted with the prunings of *Leucaena leucocephala* and fertilizer on maize, it was observed that while yields declined in the control (no fertilizer and no mulch), maize yields increased with mulch and in combination with half-rate of fertilizer (Table 2.2).

Table 2.2. Response of maize to fertilizer and mulch

Treatment	Maize yield (kg/ha)				
	1992	1993	1994	1995	Mean
No mulch, no fertilizer	1808	1415	552	nd*	1258
Full rate of fertilizer	2250	2400	908	2120	1920
Mulch only	2100	2500	1860	2600	2265
Mulch + ½ rate of fertilizer	3050	2800	1296	2700	2687

Source: Annual Report of Agroforestry Unit, MOFA (1995).
*'nd' indicates ' no data'

Fertilizer use

Research has clearly demonstrated that fertilizer is an important component in the technology required to increase crop production in Ghana. Fertilizer use can increase crop yields and biomass for conservation in most deficient soils of the tropics[47]. Results from field trials show that annual food crops respond positively to N, P and K fertilizers and these responses vary according to agro-ecological zone (Table 2.3).

[47] Bumb, B. L and Baanante.: The role of fertilizer in sustaining food security and protecting the envionment to 2020. IFPRI Food, Agriculture and Environment Discussion Paper 17, Washington D. C., U.S.A. (1996).

Table 2.3. Responses of some food crops to fertilizers in regions of Ghana

Crop	Region	*Yield (kg/ha)
Maize	Eastern	2257
	Central	2020
	Volta	3160
	Ashanti	2531
	Brong Ahafo	1381
Cassava	Volta	14493
Groundnut	Volta	1082
Rice(LL)	Volta	2708
	Northern	2781
Cowpea	Central	740
	Volta	1015
	Ashanti	706
Soybean	Ashanti	771
Sorghum	Brong Ahafo	1345

**Yield increase due to fertilizer;*
Source: Bonsu et al[48].,

Determinants of soil conservation

Decisions with regard to long term conservation measures concern investment and usually require a whole farm analysis. Given that farmers will choose to adopt soil conservation techniques if the economic and non-economic benefits exceed the costs, the determinants of soil conservation are those factors that affect these benefits and costs.

Among the numerous economic and non-economic factors found to be of importance in the decision structure of farmers and which are likely to induce transition towards sustainable land use, Burger and Oostendorp[49] distinguished between two types of evidence. These are Statistical and Transitional evidences. From a statistical point of view, evidence shows that

[48]Bonsu et al, *op cit.*
[49]Burger, K. and Oostendorp, R.,: Towards a Transitional Indicator Model. A working paper on the research program "*The agricultural transition towards sustainable tropical land use*". NWO Program *Environment and the Economy.* (1999).

certain factors are relevant but not that they necessarily have a major effect on the transition process. For example, ethnicity of the farmer may contribute to the adoption of soil conservation, but even the largest change possible in ethnicity may have a small effect on the eventual adoption. Transitionally significant factors are those that can by themselves change enough to have large significant effect on transition. Some factors found to be of transitional significance include the land tenure system, credit markets, off-farm income of farmers, their age, education and knowledge of conservation techniques. The rest are farm size, soil type, erosion and soil depth, population density, prices, labor markets, risk, village-level effects and the effectiveness of soil conservation technique adopted.

Land tenure

The incentive to invest in soil conservation can be affected by the functioning of the land market. If the tenure is less secure, a tenant farmer faces lower expected return from investment into soil conservation because of the risk of being evicted before realizing all benefits. Even if tenure is secure, the return to soil conservation will be lower if the land sales market is not functioning well, because farmers will not be able to recover land improvement investments through sales.[50]Imperfect land markets may also affect soil conservation by limiting the access to (formal) credit.[51]

[50]Pender, J. and J. Kerr: "Determinants of farmer's indigenous soil and water conservation investments in India's semi-arid tropics", EPDT Discussion paper no. 17, IFPRI, Washington D.C. (1996); Clay, D., F. Byiringiro, J. Kangasniemi, T. Reardon, B. Sibomana and L. Uwamariya "Promoting food security in Rwanda through sustainable agricultural productivity: Meeting the challenges of population pressure, land degradation and poverty". Department of Agricultural Economics Staff Paper No. 95-08, Michigan State University (1995).

Credit markets

The incentives to invest in soil conservation may be affected by the wealth of the farmer if credit markets do not function well due to the short-run costs of construction expenses and long-run benefits of increased productivity that often characterise the investment. According to Reardon *et al.*[52], realization of agricultural progress and adequate soil management in West Africa (and several less-developed countries) requires the meeting of certain conditions. In the agricultural sector in Ghana for example, there is very limited assess to financial services and credit. In view of the risks associated with agriculture, inadequate funds are channeled for lending to farmers. The high interest rate and bank charges due to inflation drastically increase the prices of fertilizers, which serve as disincentive for farmers to invest in soil fertility restoration and maintenance. In general if farmers are liquidity constrained, for example, because of borrowing problems, capital-poor farmers will be less able to invest than their rich counterparts.[53] Consequently, in addition to restoring competitive conditions and remedying structural constraints, support of farm incomes may be needed to encourage farmer investment.

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[51] Feder, G., T. Onchan, Y. Chalamwong and C. Hongladaron: *Land Policies and Farm Productivity in Thailand.* Baltimore: John Hopkins University (1988).

[52] Reardon, T., V. Kelly, E. Crawford, B. Diagana, J. Dioné, K. Savadogo and D. Boughton 'Promoting sustainable intensification and productivity growth in Sahel agriculture after macroeconomic policy reform'. *Food Policy*, vol. 22 nr. 4, (1997) pp. .317-327.

[53] Clay, D., F. *et al. op cit.*; Barbier, E.: "The farm-level economics of soil conservation: the uplands of Java", *land Economics* 66 (2) (1990); Kerr, J. and N. Sanghi: "Indigenous soil and water conservation in India's semi-arid tropics", Gatekeeper Series No. 34, Sustainable Agriculture Program. London: International Institute of Environmental Development (1992); Pender, J. *et al., op cit.*

Off-farm income

The effect of off-farm income on soil conservation is ambiguous. On the one hand it might induce conservation indirectly through the type of crop it induces[54], and on the other hand off-farm income is sometimes seen as decreasing conservation by reducing the landowners' interest in farming and limiting labor availability.[55] Off-farm income may also affect soil conservation activity through its effect on the rate of time preference or risk aversion.

Education

A study carried out in two villages in India[56], found out that education has transitional significance effect on soil conservation as well. In both villages, one additional year of education implied an increase in soil and water conservation investment of about 25% of the average investment level.

Age

Shiferaw *et al.*[57] found age of the household head to be of transitional significance, i.e. the elasticity of the probability of adoption of level bunds at the plot level with respect to the age of the household head (in years) was –0.94. Age effect could however change in the long run given that farms will eventually be transferred from the older to the younger generation which may be more inclined to adopt new techniques.

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[54] Barbier, E., *ibid.*
[55] Kerr, J. and N. Sanghi, *op cit.*
[56] Pender, J. et al., *op cit.*
[57] Shiferaw, B. and S. Holden: "Resource Degradation and Adoption of Land Conservation Technologies in the Ethiopian Highlands: A Study in Andit Tid, North Shewa", discussion paper #D-31/1996, Agricultural University of Norway (1996).

Knowledge of conservation techniques

It has been found out that awareness of soil conservation techniques is of transitional significance[58]- the elasticity of the probability of adoption of level bunds at the plot level with respect to the number of techniques known was 0.74.

Farm size

Soil and water conservation at the plot level was reported to be much lower for larger farms than for smaller farms[59] (elasticities –2.5 and –3.0). Reports of positive effects of farm size also exist. Farm size has been found to be of transitional significance - the elasticity of the probability of adoption of level bunds at the plot level with respect to farm size was 0.87[60]

Soil type

Pender *et al.*[61] finds out that soil type is another factor of transitional significance. In their sample of three villages, the village with deep black heavy clay soils (vertisols) and high water retention capacity shows the greatest level of soil and water conservation investment. The village with the lowest level of investment has shallow to medium red soil (alfisols) and low water retention capacity. Red soils are difficult to work when dry, so conservation investments in such soils take place during the rainy and post-rainy seasons, when soils are moist and labor scarce. In contrast, plots with black soils allow conservation work in the dry season when labor is cheap.

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58 Shiferaw, B. *et al. ibid.*
59 Pender, J. *et al., op cit.*
60 Shiferaw, B. *et al. op cit.*
61 Pender, J. *et al., op cit*

Slope

The steepness of the plot has been found to be of transitional significance. Results pooled for three villages showed that if the slope of the plot is more than 3%, conservation investment increases by 781 rupees[62] (average investment 581 rupees).

Erosion and soil depth

The presence or perception of severe erosion on the plot is sometimes found to be a transitionally significant factor in farmer's decision and is likely to induce transition towards sustainable land use.[63] This was found not to be always so for the reason that there may be a simultaneity problem however, plots that have conservation structures tend to have less erosion, thus creating a downward simultaneity bias. Another reason given for the lack of a clear relationship between erosion and investment may be that yields do not fall because soil erosion does not lead to soil depth below the critical level where yields are reduced.

Population density

The land/man ratio has been found to be of transitional significance for sustainable land use[64]- the elasticity of the probability of adoption of level bunds at the plot level with

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[62] Pender, J. *et al., op cit.*

[63]Sengalawe "Household adoption behaviour and agricultural sustainability in the Northeastern mountains of Tanzania. The case of soil conservation in the North Pare and West Usambara Mountains", PhD. Dissertation, Wageningen Agricultural University (1998); Shiferaw, B. *et al. op cit.*; Pender *et al- op cit.*

[64] Shiferaw, B. *et al. op. cit.*

respect to the land/man ratio was 0.57. Barbier *et al.*[65], using a calibrated dynamic linear programming bioeconomic model at the micro watershed-level in the hillside of Honduras, simulate the effect of increasing immigration on the adoption of soil conservation techniques. The results of two population simulations showed that when population density is relatively low, population pressure has negative effects on natural resources. However, when population reaches higher density and when the productivity of the resource base is threatened, farmers start to improve their natural resource management practices.

Increasing the population by a factor 3 has only a small short- and medium-run effect on the adoption of conservation techniques (terraces, life barriers, grass strips). The inflow of immigrants leads to erosion increases from an estimated 5 tons per ha to 25 tons per ha over a period of 15 years. After 15 years farmers are motivated to invest in soil conservation techniques because then it becomes profitable and erosion starts to fall. Population is therefore a transitionally significant factor for sustainable land use induction, but only in the long run.

Prices of output

Conservation investments often decrease current output levels because of a reduction in the effective farming area or because of adjustments in farming practices.[66] An increase in the output price will therefore make soil conservation investment less attractive by increasing

[65] Barbier, B. and G. Bergeron "Natural Resource Management in the Hillsides of Honduras": *Bioeconomic modeling at the micro-watershed level.* EPTD Discussion Paper No.32. IFPRI, Washington D.C. (1998) pp. 34-36.
[66] La France, J. "Do increased commodity prices lead to more or less degradation?", Australian Journal of Agricultural Economics, Vol. 36, No. 1, (1992) pp. 57-82.

the opportunity cost of forgone output. On the other hand, because soil conservation leads to higher future output levels due to lower rate of soil degradation, higher output prices will increase the future benefits of soil conservation investments. It is sometimes suggested that lack of transport and market imperfections make national prices of little importance to farmers.[67]

In less-developed countries, low population densities have hampered the development of markets and raised cost of physical and social infrastructure per head. Lack of infrastructure has increased the difference between agricultural product prices in rural and urban markets[68], augmented farmers' transaction cost (eg. time involved in headloading of output), and raised the cost of inputs.[69] This, according to LaFrance leaves the price effect ambiguous. The effect of increase in the price of a conservation input is ambiguous as well, because it makes conservation in the current period more expensive, but also reduces the future cost of additional inputs applied to compensate for soil loss.[70]

Labor market

If the labor market function perfectly and costlessly (and household labor and hired labor are perfect substitutes), then the incentive to invest in soil conservation will be independent

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[67] Alcántara, S.H. de (ed.). *Real markets: social and political issues of food policy reform*. Frank Cass, London and Portland. (1993).

[68] Ahmed, R. and N. Rustagi. 'Marketing and price incentives in African and Asian countries: a comparison.' In: D. Elz (ed.), *Agricultural marketing strategy and pricing policy*. World Bank, Washington, D.C. (1987).

[69] Heerink, N., M. van der Lubbe and K. Y. Fosu. 'Public extension services and agricultural production in Ghana.' In: T. Bierschenk, P.-Y. Le Meur and M. von Oppen (eds.), *Institutions and technologies for rural development in West Africa*. Margraf Verlag, Weikersheim (Germany) (1997).

[70] Walker, D. "A damage function to evaluate erosion control economics", *American Agricultural Economics Association*, November, (1982) pp. 690-98.

of the household size or composition. In reality the labor market is rarely perfect, because of transaction costs, adverse selection, moral hazard problems, and discrimination. Hired labor and household labor are therefore not perfect substitutes. In this case the availability of household labor will have a positive impact on soil conservation adoption.[71] Availability of hired labour on the other hand may not necessarily impact positively on conservation, but even if it does, it will be to a lesser extent.

Village-level effects

It has been established[72] using regression analysis, that village characteristics are a transitional factor for the total conservation investment (grass strips, anti-erosion ditches, hedgerows and radial terraces) at the plot-level in the highland areas of Rwanda. These village characteristics include social and administrative conditions, imitation effects and externalities of neighbors undertaking land protection measures. They estimate the elasticity of soil conservation with respect to village-average level of conservation to be 1.00. This unitary elasticity suggests a simultaneity problem with their estimation.

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[71] Childress, M. "Capital Investments on Smallholder Coffee Farms: An Empirical Study from Honduras", in *Economic and Institutional Analysis of Soil Conservation Projects in Central America and the Caribbean*, (E. Lutz. S. Pagiola and C. Reiche, eds.), World Bank Environment Paper No.6, The World Bank, Washington D.C. (1994); Clay, D., *et al. op cit.*; Pender, J. *et al. op cit.*

57 Clay, D., F. Byiringiro, J. Kangasniemi, T. Reardon, B. Sibomana and L. Uwamariya "Promoting food security in Rwanda through sustainable agricultural productivity: Meeting the challenges of population pressure, land degradation and poverty". Department of Agricultural Economics Staff Paper No. 95-08, Michigan State University (1995).

Effectiveness of soil conservation technique

The effectiveness of soil conservation techniques has also been found to be a transitional factor. In a cost-benefit analysis of soil conservation in Honduras, Valdes[73] performs a sensitivity analysis of the returns to conservation to percentage change in yield with and without conservation for a village in Honduras. Without the construction of diversion ditches protected with life barriers, the average yields of corn are estimated to fall by 5.5% per year. With the construction of these conservation measures, the average yields are estimated to increase by 7.4% per year. The average yield over the period 1986-90 is 1.95 metric tons per ha with conservation measures. If the increase in yields due to soil conservation investment fall from 7.4% to 3.7% per year, the net present value of the investment in soil conservation falls from L4, 910 to L2, 667 per ha for a period of 100 years (20% discount rate). If soil conservation did not lead to any improvement in yield but simply halted its decline, the net present value will only be equal to L234 per ha (L, the unit of the currency is Lempira). Because diversion ditches protected by live barriers are relatively low cost measures, the internal rate of return of these investments remain high even if soil conservation only stabilizes the yield. The sharp fall in the net present value shows, however, that for more costly conservation measures adoption will be affected by small changes in estimated yield changes.

[73]Valdes, P. "Economic analysis of soil conservation in Honduras", *in Economic and Institutional Analysis of Soil Conservation Projects in Central America and the Caribbean*, (E. Lutz, S. Pagiola and C. Reiche, eds.), World Bank Environment Paper No.6, The World Bank, Washington D.C. (1994).

Risk

Holden *et al.*[74] argue that in a low income rural setting crop insurance markets will be either highly imperfect or simply nonexistent. Problems of moral hazards, lack of collateral, covariate risk, and fixed costs make it unlikely to have well-functioning crop insurance markets other than for every specific risk.[75] Weather and yield risks are therefore likely to affect the incentives to invest in soil conservation given that farmers are risk averse.[76]

Risk is often assumed to form a disincentive to soil conservation investment, particularly in soil-conserving structures or perennial crops with long lead times, but theoretically the effect of risk is often ambiguous and depends on the particular farming system.[77] Clay *et al.* using regression analysis, found evidence to support the fact that risk is a transitional factor for total conservation investment at the plot- level, with an elasticity of output price variation of 0.52 at the mean[78]

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[74] Holden, S., B. Shiferaw, and M. Wik "Poverty, market imperfections and time preferences: of relevance for environmental policy?" Environment and Development Economics, 3, (1998) pp. 105-130.
[75] Hazell, P., C. Pomereda and A. Valdes :*Crop Insurance for Agricultural Development: Issues and Experience*. Baltimore: Johns Hopkins University Press (1986, eds.).
[76] Wik, M. and S. Holden "Experimental Studies of Peasant's Attitude towards Risk in Northern Zambia", Discussion Paper #D-14/1998, Agricultural University of Norway (1998).
[77] Grepperud, S. "Soil Depletion Choices under Production and Price Uncertainty", Discussion Paper No. 186, Statistics Norway, Oslo (1997a) ; Ardilla, S. and R. Innes "Risk, Risk Aversion, and On-Farm Soil Depletion", *Journal of Environmental Economics and Development*, 25, S-27-S-45 (1993).

[78] Clay et al op.cit.

CHAPTER THREE

METHODOLOGY

Method of Data collection

The study which was carried out in 4 major districts of the Northern and Upper East regions of Ghana is based on survey data collected in the 1999 cropping season and secondary data from the Ministry of Food and Agriculture. The districts are the East and West Mamprusi districts in the Northern region and Bawku East and Bolgatanga districts in the Upper East region. Selection of the areas was done purposely to fit into an on-going research study on land degradation and migration, sponsored by the Economic and Social Institute of the Free University of Amsterdam.

Sampling Procedure

Thirty villages (see Appendix 2) were purposively selected based on their historical and documented information on environmental and land degradation issues in the study regions. Five households were randomly selected from each of the villages. The selection of the households was done using house numbers from the recent population and housing census held in the country. After the first house has been selected, subsequent ones are identified by adding three(3) to the first and for that matter the preceding house number. The household head, representative or an adult member of each of the households was interviewed using structured questionnaires. A total of one hundred and fifty households were thus used in the study.

Types of Data

Questions were formulated in such a way as to throw more light on soil conservation and fertility maintenance information, crop yields, household information and plot characteristics. Others included farmer's perception on causes of soil erosion on farm plots, need for soil conservation, the reasons for engaging (or not) in soil conservation practices, among others (see Appendix 3).

Methods of Data analysis

Descriptive statistical tools such as percentage distribution was used to describe the extent to which farmers use these conservation and fertility maintenance techniques on their farms. Prevalence and popularity of different soil conservation techniques as well as fertility restoration methods at the plot level were analysed using the same tool plus charts. The causes of soil erosion in the area were also analysed.

Given that extra resources are required (financial and labour) for the construction of conservation structures and improve upon crop yields, a partial budget analysis was used to compare the extra benefits as against extra costs incurred in construction of stone bunds. In order to compare benefits of bunding (yield implications), the net profit per hectare for typical crop mixtures was used as a cost-effective measure.

The cost of construction of stone bunds per hectare per growing season were analysed using,

$$Cc = \mathrm{Lcj} + \mathrm{Mcj}; \qquad (1)$$

where, Cc is the total cost of bund construction /ha/growing season.

Lc_j is the labor cost involved in bund construction.

Mc_j is the cost of purchase or hiring of materials such as pick axes, shovels and wheel barrows used in bund construction.

Incremental yields obtained as a result of bunding were computed as

$$Y_{in} = \sum_{i=1}^{N} (Y_{ic} - Y_{inc}) \qquad (2)$$

where Y_{in} is the incremental yield in kg/ha.

y_{ic} is the mean of yield of crop i from bunded fields in kg/ha.

y_{inc} represents mean yield of crop i from non-bunded fields in kg/ha.

The following relation expresses household incremental income from crop production;

$$I_{in} = Y_{in} * P_i \qquad (3)$$

with I_{in} denoting incremental farm income (¢)

Y_{in} is the incremental yield of crop i (kg/ha)

P_i is the price (¢) (average farm-gate price in 1999)

Incremental profit per hectare is given by

$$N_p = I_{in} - C_c/A, \qquad (4)$$

where Np represents the incremental profit (¢/ha)

Cc is the cost of bund construction (incremental) (¢)

'A' is the area measured in hectares.

In order to determine the profitability of the method, the input/output (profitability) ratios were used. given by the expression:

$$\pi = \frac{I_{in}}{C_c} \qquad (5)$$

Where π is the profitability ratio for the technique.

The technique is considered profitable if π is greater than one, (i.e. $\pi > 1$).

Based on the findings of the study, conclusions and recommendations will be made for improving upon the current farming practices that have the potential of worsening the erosion problems on farms and hence the associated negative yield effects.

CHAPTER FOUR

RESULTS AND DISCUSSION

Causes of erosion on farming fields.

The first objective of the study is to identify the causes of soil erosion in Northern Ghana. In this section the causes of soil erosion on fields are presented as obtained from interviews using structured questionnaire.

Household heads or representatives were interviewed generally on what they observe as the major factors that contribute/facilitate the process of soil erosion on their individual plots. The result is as presented for the two regions in the Table 4.1 below.

Table 4.1. Causes of erosion on respondents' plots

	Upper East		Northern	
	Frequency	% Distribution	Frequency	% Distribution
Land preparation	37	33.0	29	30.9
Burning	33	29.5	13	13.8
Tree felling	10	8.9	3	3.2
Heavy rainfall	17	15.2	18	19.1
Sloppy lands	13	11.6	25	26.6
Farming on water ways	2	1.8	6	6.4
Total	112	100.0	94	100.0

Source: Field Survey June, 2000.

Farming and other human activities contribute immensely to the erosion problem. Land preparation was mentioned as the most important remote cause of erosion in both regions. In the Upper East, erosion on thirty-seven out of 122 plots (33 %) was attributed to bad land preparation methods and twenty-nine out of 94 plots (31%) for the Northern Region. Farmers indicated ploughing along slopes and the use of heavy equipment for farm work when the soil is dry as the remote causes. Burning and heavy rainfall came second and third in the Upper East as against sloppy lands and burning in the Northern Region.

These findings confirm the assertion of Asiamah[79] that the various types of soil erosion caused by water become common in areas where the vegetation has been disturbed. All forms of land clearing result in the destruction of vegetative cover depriving the soil of its cover and enhancing the erosive action of water. The problem is aggravated further when the exposed soil is worked during the dry season.

Common Erosion Control Techniques

With their knowledge of the primary causes of erosion on their farms, the strategies adopted by farmers to control the situation are those directed at reducing the velocity of run-off water and hence soil loss. Ridging across slopes, stone bund construction and the use of grass strips are some of these strategies. Ridging is the most common among farmers in both the Upper East and Northern Regions as shown in Figures 4.1 and 4.2. below

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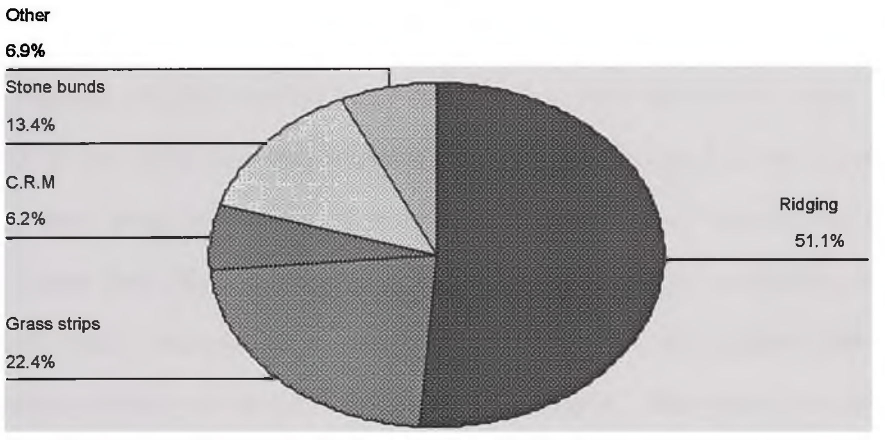
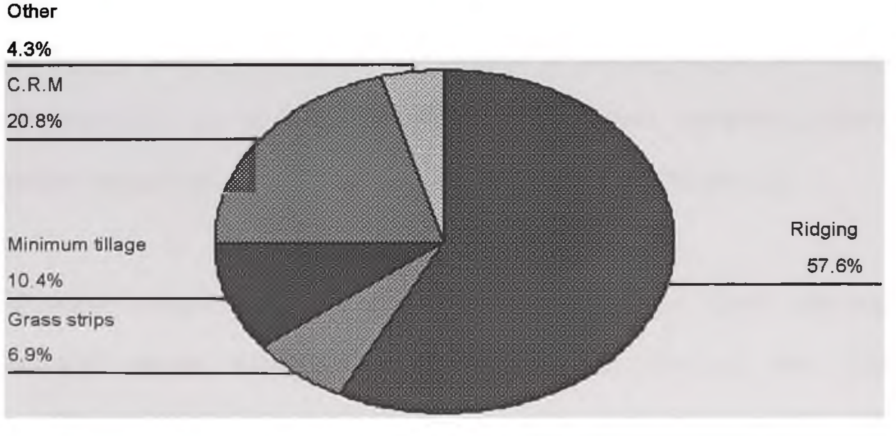
[79] Asiamah, R.D.: Soil Resources and their Agricultural utilization Ghana, - Proceeding of the National Conference on resource conservation for Ghana's sustainable development, EPC, Accra, 2, (1987) pp. 99 - 111.

Fig. 4.1.Erosion control techniques(Upper East Region)



Source: Field Survey Data, 2000

Fig. 4.2. Erosion control techniques(Northern Region)



Source: Field Survey Data, 2000

These ridges are basically constructed on plots in areas of moderate slope. Fifty-seven (57) percent of farm plots in Northern Region use ridging as against 51 percent in the Upper East Region.

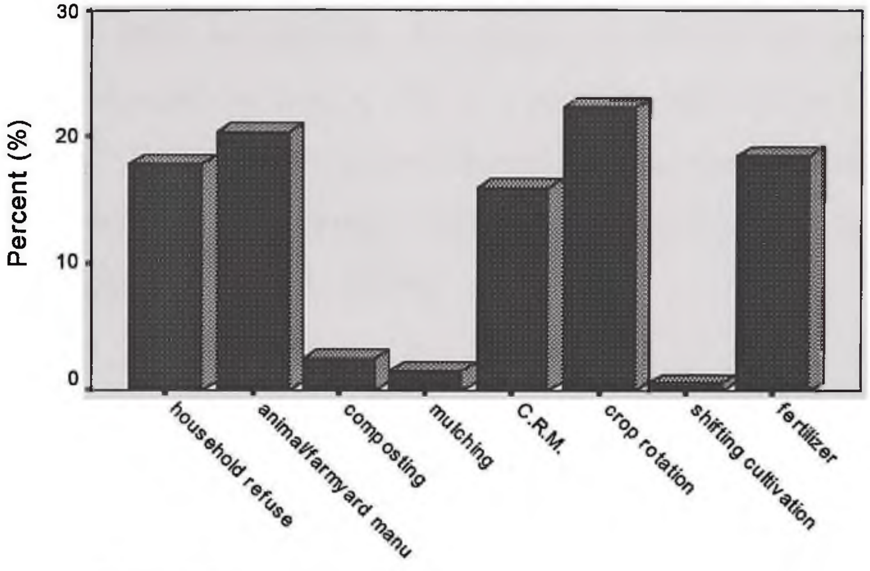
Stone bunding (13.4%) featured as the next popularly used method after grass strips (22.4%) in the Upper East Region while in the Northern Region less than 4 percent of plots have stone bunds (captured in the area labeled other %). Use of stone bunds in the Upper East Region is limited to those areas where stones are readily available (Nangodi areas). Incorporation of crop residues is the next most popular technique after ridging adopted by farmers in the Northern Region. The rather low level of crop residue use in the Upper East could be attributed to the higher incidence of bush fires and fuel wood scarcity.

Fertility restoring methods

Figures 4.3 and 4.4 below show the frequency of utilization of these methods in the two regions. Techniques being used by farmers to maintain/restore the fertility of the soil include the use of household refuse, animal manure, composting, mulching, crop residue management, crop rotation, shifting cultivation and fertilizer use.

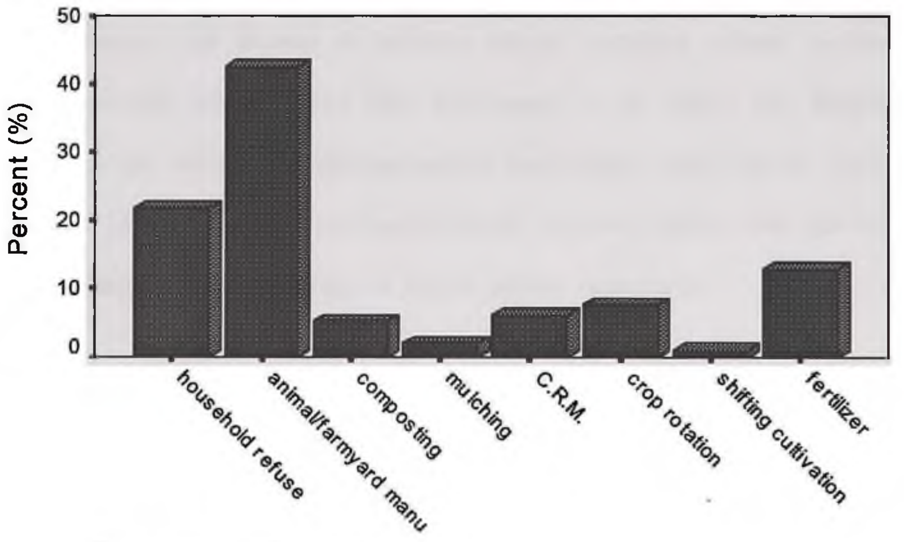
Use of animal manure is the most prevalent practice in the Upper East Region representing 43 percent, followed by household refuse use (22%) and then fertilizer (13%). Although farmyard manure is highly used by farmers, the high labour required for its collection, preservation and transportation make it quite unattractive.

Fig. 4.3. Fertility Restoring methods(Northern Region)



Source: Field Survey Data, 2000

Fig. 4.4. Fertility Restoring methods(Upper East Region)



Source: Field Survey Data, 2000

*C.R.M represents crop residue management

Despite the fact that yield response to recommended levels of fertilizer is better and quicker than the other methods, its use is rather low, confirming the fact that farmers cannot afford the high cost. This problem of low/nonuse of mineral fertilizers was observed way back in 1995 in a survey of over 4000 fields in northern Ghana[80]. In the survey, it was observed that only 16 percent of fields used some mineral fertilizers. The continuous existence of this trend poses a serious threat to increased agricultural productivity in Ghana.

Although farmers are aware of the use and benefits of composting, mulching and crop residue management, the level of practice is low due to constraints such as high labour requirements, inadequate quantities of residue produced and most importantly farmer's high demand for residues as animal feed, fencing and for fuelwood.

Apart from composting, mulching and shifting cultivation whose prevalence are very low in both regions, the farmers in Northern Region frequently utilized fertilizer and the crop rotation technique than their counterparts in the Upper East Region. Crop rotation is the commonest technique used in the Northern region (22%). On 20 percent of the plots in the Northern Region, animal manure is applied with fertilizer and household refuse utilization taking 19 and 18 percent respectively.

Reasons attributed to the low level of utilization or non-use of some of these fertility restoring methods are as presented in Table 4.2 below.

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[80] Albert, H. :Farm household systems in Northern Ghana and the problem of *Striga*. Unpublished Manuscript. Savanna Agricultural Research Institute, Ghana (1995).

Table 4.2. Problems with the use of some fertility maintenance techniques (% of farmers).

Reason	*CRM (n=70)	Composting (n=82)	Mulching (n=70)	Crop Rotation (n=40)	Fertilizer (n=40)
High labour demand	40	81	50	12	0
No/little knowledge	3	0	1	0	0
Expensive(cash)	2	34	10	0	88
Unavailable materials	75	78	80	0	0

*CRM represents Crop residue management.
Source: field survey data, 2000

Most (88%) of the farmers interviewed from both regions who did not use fertilizer on their fields (40 framers) attributed their non-use to the expensive nature of the input while a few said they actually have no need for fertilizers. Out of a total of 82 farmers who did not practice composting, 81 percent said it is labour intensive while none claimed no knowledge of the technique. 78 percent of them, again mentioned non-availability of composting materials as the reason.

Only 1 percent of non-users of mulching claimed no knowledge of the technique. Again, lack of mulching materials and high labour involvement dominated (80% and 50% respectively) as reasons for not using the technique. The story was not different in the case of crop residue management as 75 percent of farmers indicated lack of residue as mulch material. Apart from the mere 12 percent of farmers who attributed their non-use of crop rotation to its labour demands, majority could not explain why they do not use the technique.

Farmer's response on yield trends

Farmer's perception of yield changes over the years is one of declining output. Responding to structured questions, farmers gave varying reasons for what they perceive to be the immediate cause of the general decline in the yields. Prominent among the reasons is unfavorable rainfall pattern. Others include continuous cropping, *Striga* infestation and deforestation as shown in Table 4.3 below.

Unfavorable rainfall featured highest in both the Upper East and Northern Regions, (51.7% and 21.3% respectively). The area, situated in the one-maximum rainfall zone has the rains commencing in April and extending to October.

Table 4.3. Farmer's response on reasons for declining yield trends

	Northern Region		Upper East Region	
	Number of farmers	Percentage	Number of farmers	Percentage
Continuous cropping	16	18.0	10	11.2
Striga infestation	19	21.3	8	9.0
Soil erosion	6	6.7	4	4.5
Bush burning	10	11.2	8	9.0
Lack of fertilizer	6	6.7	5	5.6
Deforestation	10	11.2	1	1.1
Unfavourable rains	19	21.3	46	51.7
Bad seed variety			7	7.9
Pests and diseases	3	3.4		
Total	89	100.0	89	100.0

Source: field survey, June 2000.

The rainfall pattern is erratic, coupled with lengthy drought periods thus rendering the plant environment fragile. Next to this is the issue of *Striga spp*. Infestation and continuous cropping. Interestingly, these two move together in the sense that as the land is cropped continuously without adequately replacing the lost nutrients (declining fertility), *Striga spp*. begins to thrive. Surprisingly, only six out of 89 farmers (6.7%) from Northern Region and five out of 89 (5.6%) from Upper East attributed the problem to lack/rising cost of fertilizer. Issues like poor seed varieties and pests/diseases did not matter among farmers in the study area.

Table 4.4. Response of maize/groundnut mixture to stone bunding.

Crop	**Crop yield (kg/ha)**		**□ *Yield**	**□ Yield**	**Percentage**
	Bunded	Non bunded	**(kg/ha)**	**(bags)**	**increase**
Maize	4,500	2,910	1,590	32	54.6
Groundnut	5,000	2,505	2,495	50	99.6

**Yield increase due to stone bunding*;
Source: computed from TRAX field data, 1999.

Table 4.5. Response of maize to mulch

Treatment	**Maize yield (kg/ha)**					**Yield**
	1992	**1993**	**1994**	**1995**	**Mean**	**(bags)**
No mulch	1808	1415	552	nd*	1258	25
Mulch	2100	2500	1860	2600	2265	45

Source: Annual Report of Agroforestry Unit, MOFA (1995).
*'nd' indicates ' no data'

Table 4.4 shows the result of an on-farm trials in which mean yields from stone bunded fields were compared with those of non-bunded fields in a typical mixed maize/groundnut farms. The table shows marked changes (increase) in crop yield as a result of bunding; 1,590kg/ha for maize and 2,495kg/ha representing approximately 32 bags and 50 bags respectively. In other words, bunding yielded a 54.6 per cent increase in maize output while that of groundnut doubled (99.6 per cent).

A 43.7 per cent (approximately 20 bags) increase in maize yield was realised as a result of mulching with *Leucaena leucocephala* (Table 4.5).

Cost-effectiveness of Adopting Stone Bunding

The labour-related implications of stone bunding for the farm household are paramount here since all activities draw on labour for production. In general, well constructed stone bunds tend to be labour saving in that it spare farmers the ordeal of having to construct less permanent soil conserving structures such as ridges every cropping season. In other words, avoidance of such seasonal demands on labour invariably frees capital (cash) for alternative uses (*e.g.* to finance the purchase of mineral fertilizers and for other non-agricultural activities).

The average farm gate prices of maize, millet, sorghum and groundnuts computed from field survey data for the 1999 cropping season is as presented in Table 4.6.

Table 4.6. Average (nominal) farm gate price for the 1999 cropping season.

Crop	Price (¢)/Bag of 50kg.			
	Northern	Upper East	Mean	Price (¢/kg)
Maize	46,000	50,600	48,300	966
Millet	44,789	42,273	43,531	871
Sorghum	38,000	62,062	50,031	1,001
Groundnut	32,694	45,903	39,299	786

Source: Field Survey Data, 2000.

At a mean cost of ¢10,690.00 per head, an average of 12 persons are required for the construction of 'standard' numbers and sizes of bunds (dimensions and number of bunds per hectare which is dependent on the slope is unavailable) on a hectare of land. This data was computed using the field survey data i.e. the mean cost of hiring labour and the average number of persons needed for the task. Thus the incremental cost due to bund construction is ¢128,280.00.

At the going farm gate price for maize and groundnut (Table 4.6) and the incremental yields obtained in the typical maize/groundnut mixture (Table 4.4), the net incremental profit is presented in Table 4.7 below.

Results of the partial budget analysis indicate that it is worth committing resources into the adoption of stone bunding for the purpose of conserving soil and also improving upon crop yields. This is so because the basic materials needed (stones) for the bund construction are obtainable at no cost, provided the labour for haulage is available.

Table 4.7 A partial budget of adopting Stone bunding in maize-groundnut production.

Extra benefits/ Extra costs	Quantity (kg)	Unit price (¢)	Total value (¢)
Extra benefits			
Extra output of maize	1,590	966	1,535,940
Extra output of groundnuts	2,495	786	1,961,070
Total extra benefits			**3,497,010**
Extra costs			
*Materials	–	–	–
Extra labour	35 man days	10,690	**374,150**
Extra benefits less extra costs			**3,122,860**

*Materials needed are stones (no costs)
Source: Field survey data 1999.

By putting in 35 extra man-days at a total cost of ¢374,150.00 additional benefits of ¢3,122,860.00 was realised. From the result it can be seen that additional benefits far exceeded additional costs. In other words, it is worth adopting this strategy where possible since the profitability ratio of 9.3 is substantial. Also farmers can improve upon their revenue targets for maize up to about ¢972,762.00 from a hectare of land by simply making use of crop residues for mulching.

CHAPTER FIVE

SUMMARY, CONCLUSIONS AND RECOMENDATIONS.

Summary

The land use pattern in the study area suggests that the traditional farm household production strategy that has revolved mainly around extensive shifting cultivation with the aim of improving the soil quality is no more. Other husbandry methods, which were able to cope with the past, are equally ineffective due to rapid increase in population. In the face of the low resource/capital base of most farm households, much could still be done with improvement in the use of crop residues, crop rotation and cultivation practices to maintain or improve fertility, reduce run-off and thereby enhance crop yields. Again, improvement on the use of such traditional methods will also mean some form of replacement of the existing over reliance of artificial inputs, the price of which cannot be afforded by the farmer.

Conclusions

One major factor that has exacerbated land degradation and for that matter erosion is the wanton destruction of vegetation through bush burning. Apart from destroying soil nutrients, bush burning destroys small seedlings and big trees thus making it difficult for forests to re-establish themselves thereby exposing the soil to erosion. The recurrence of the bush burning problem could be partially attributed to some socio-cultural practices of the people. The people of Nangodi for example, have an annual practice of sacred bush burning called *Gog* during which the youth hunt game. Other groups in the Bolgatanga district have similar practices. The important issue here is the effect such practices has on the youth rather than the festival itself. They are taught (unconsciously though) to burn and destroy without any sense of guilt[81]

Virtually all farmers in the study area are aware of the need for soil conservation. Four main erosion control techniques and seven fertility maintenance techniques are known and are being practiced by farmers. Of the four anti-erosion techniques, ridging is the common practice in both the Upper East and Northern regions (51 percent and 58 percent respectively). Under normal terrain conditions ridging across the slope is enough to check soil erosion. The next fairly prominent technique is the use of grass strips and crop residue management. Strip cropping is basically used to reinforce ridges.

Household refuse utilization, animal manure, composting, crop residue management, crop rotation, shifting cultivation and fertilizer are the seven fertility maintenance techniques used. Pressures from rapidly rising population have virtually eliminated the age-old system of shifting cultivation. Apart from animal/farmyard manure and household refuse use, the remaining five methods of fertility maintenance are poorly patronized in the study area especially the Upper East Region.

Non-use or poor patronage of composting, mulching and crop residue management as these fertility maintenance techniques is mainly the result of bush burning which consumes every organic residue on the field. Even though extensive use of stone bunding, as a soil conservation measure is limited to some areas in the Upper East Region (Bongo area), it is worth committing resources into programmes that will

[81] Korem A.: Bushfires and Agricultural Development in Ghana. Ghana Publishing Corporation, 1985.

encourage its adoption elsewhere. With its high profitability ratio of 9.3 and the more permanent nature of stone bunds, farmers stand to gain eventually.

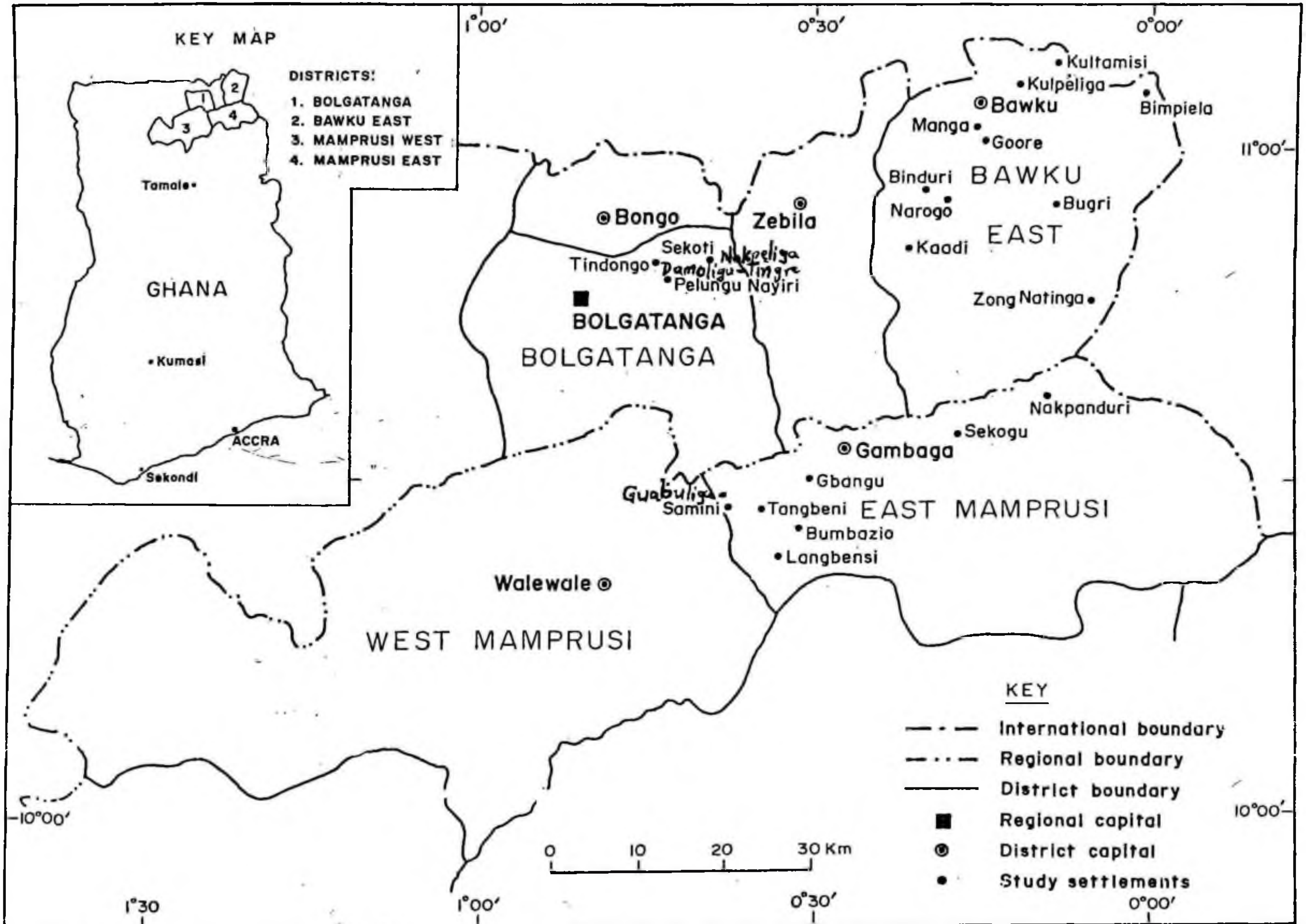
Recommendations.

Prolonged drought certainly tips the balance in favour of desertification, which aggravates the already bad situation created by misuse of the land. Misuse of the land is however likely to be a result of the high incidence of drought in the area. An ecosystem that is fragile and which is only capable of supporting limited range of crops and livestock for example, leaves the people with no other option than to continue producing with little regard to the carrying capacity of the land.

In view of the above situation, there is an urgent need for an articulate soil conservation policy for the Northern and Upper East Regions of Ghana. Techniques used for maintaining soil fertility and preventing erosion on continuously cropped lands are already known to farmers. What is required presently is a more participatory approach to programme formulation and implementation. In other words, farmers/farming communities should be made to feel responsible for the sustenance of their land's productivity. Enforcement of laws on bush fires should be entrusted in community leadership with strong support from government.

Control of water erosion with the use of contour ploughing and maintenance of field cover is vital. Farmers should be given the necessary institutional support (a reformed extension effort) in the area of education on effective conservation. Conservation practices involving trees species, should be included in extension packages to farmers. Pastureland development should also feature prominently in future government policies on agriculture as well as financial assistance (various forms of subsidy) to farmers.

APPENDIX 1 MAP OF THE STUDY AREA



Source: Base map: Survey of Ghana / Field survey by the author.

APPENDIX 2: List of villages covered

Districts covered in Northern Region	Village(s)	Districts covered in Upper East Region	Village(s)
East Mamprusi	Langbensi	**Bawku East**	Gotulis
"	Samini	"	Kultamisi
"	Tangbeni	"	Zong-Natinga
"	Bowku	"	Bimpiela
"	Gbangu	"	Kugasegu-Bugri
"	Namango	"	Binduri
"	Bumbazio	"	Narogo
"	Sakogu	"	Kaadi
"	Nakpanduri	"	Goore
		"	Manga
West Mamprusi	Guabuliga	***Bolgatanga**	Asonge
		"	Sekoti-Baadabog
		"	Pelungu Nayiri
		"	Tindongo
		"	Tasoo/Kulpeliga
		"	Madina/kulpeliga
		"	Ndanboug/Nyogbari
		"	Gaagin/Dagliga
		"	Damoligu-Tingre
		"	Nakpeliga

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APPENDIX 3: QUESTIONNAIRE

1. CHARACTERISTICS OF RESPONDENT/HOUSEHOLD

Household Number.	Name of respondent	Relationship to household head (a)	Age	Sex 1=M 2=F	Education (c)
1					
2					
3					
4					
5					

(a)
1= Head
2= Wife/Husband
3= Son/Daughter
4= Father/Mother
5= Sister/Brother
6= Others (specify)

(c)
1= Illiterate
2= Primary
3= Secondary
4= Others (specify)

2. How many people are living in your household?

Men ☐

Women ☐

Children above 5 years ☐

3. CHARACTERISTICS OF THE PLOTS.

Plot No.	*Slope (code a)	Plot characteristics in 1999				Plot characteristics in 1989			
		Fertility status (code b)	Extent of erosion	No. of trees on plot	Extent of striga attack	Fertility status (code b)	Extent of erosion	No. of trees on plot	Extent of striga attack
01									
02									
03									
04									
05									
06									
07									
08									

*Ask respondent to describe slope as compared to the whole village farms.

(a)
1= Flat
2= Gentle slope
3= Steep slope

(b)
1= Very low
2= Low
3= Moderate
4= High
5= Very high

4.USE OF SOIL AND WATER CONSERVATION TECHNIQUES.

Technique	Do you know about this technique? Yes = 1, No=2			If yes, do you use it on your farm? Yes=1, No=2			If no why? (code x)		
	Household			Household			Household		
	hh 1	hh 2	hh 3	hh 1	hh 2	hh 3	hh 1	hh 2	hh 3
Hedgerows/Grass strips									
Ridging across slope									
Stone bunds									
Mulching									
Household refuse									
Minimum tillage									
Crop residue management									
Animal/farmyard manure									
Shifting cultivation									
Compost									
Use of fertilizer									
Crop rotation									

(x)
1= it involve too much work
2= it require a lot of money
3= the technique is not convenient on my farm
4= the materials needed are not available /scarce
5= land is scarce
6= others (specify)

5.What do you see as the major cause(s) of erosion? (List and rank in order of importance: 1= most important cause in that order)

....
....
....

6. HOUSEHOLD FERTILITY MAINTENANCE AND EROSION CONTROL MEASURES ON PLOTS.

Plot No.	Method of restoring fertility (code a)		Erosion control/conservation technique (code b)		How do you rate the completeness of the conservation work?(code c)	If not complete, what do you think is needed to make it complete? (code d)
	Type(s)	Since when?	Type(s)	Since when?		
01						
02						
03						
04						
05						
06						
07						

(a)
1= Animal manure
2= Composting
3= Crop rotation
4= Shifting cultivation
5= Fertilizer

(b)
1= Ridging across slope
2= Grass strips
3= Minimum tillage
4= Crop residue management
5= Stone bunds
6=Hedge rows
7=None

(c)
1= Complete
2= Not complete

(d)
1= education
2= materials/equipment (specify)
3= labour
4= financial assistance
5= others (specify)

7. In general, how will you rank the need to practice soil conservation on farmlands?

1= low
2= moderate
3= high

☐

8. COST OF IMPLEMENTING CONSERVATION TECHNIQUE FOR THE 1999 SEASON

Technique name	Size/Length of land conserved/ Units (e.g length, area)	Number of people	Number of days	Daily wage per person (¢)	Month (s) of implementation in 1999
Ridge across slope					
Terracing					
Minimum tillage					
Crop residue management					
Hedge rows					
Stone bunds					

9. Which one of the following two systems is dominant on your fields?

1= sole cropping ☐
2= mixed cropping

10. Provide an estimate of your household's total production of the following crops during the last (1999) cropping season.

Crop	Quantity-actual (bags/bowls)	Quantity-expected (bags/bowls)	Equivalence in kg.		Price per unit (¢)
			actual	expected	
Maize					
Millet					
Sorghum					
Groundnut					
Cowpea					
Soybean					

11. Generally, do you consider crop output from your farm plots in the last 10 years as;

1= increasing ☐
2= decreasing
3= uncertain

12. If crop output are decreasing, what do you think are the reasons for that?

....
....

....
....

13. What do you think about the future of crop production if nothing is done about the erosion problem? (indicate yes=1, no=2, uncertain=3)

1= further yield decline ☐
2= remain as it is
3= uncertain