DOI number: 10.5027/jnrd.v3i0.10

JOURNAL OF NATURAL RESOURCES AND DEVELOPMENT

Indigenous perceptions of soil erosion, adaptations and livelihood implications: the case of maize farmers in the Zampe community of Bole in the Northern region of Ghana.

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Article history

Received 26.02.2013
Accepted 23.05.2013
Published 07.10.2013

Abstract

Soil is an important natural resource which when effectively managed, could increase the livelihoods of households in sedentary agricultural communities. Soil erosion is however an emerging challenge as a cause of environmental degradation and this paper sought to ascertain the nature of soil erosion on maize farms, the effects of soil erosion on maize crop farmers and the effectiveness of local control measures on output levels and the livelihoods of the farmers. A cross-section of the community was taken and participants were selected non-probabilistically by snow-balling for questionnaire administration and focus group discussions. The study revealed that the local farmers perceived soil erosion as the wearing away of the top soil and nutrients, under the influence of running water during rainy periods and the slope of the land. The major effects of soil erosion were found to be the loss of fertile soils, reduction in the cultivable land area, the reduction in the crop yield and a fall in the living standards of farmers' households. The findings also indicated that some of the adaptive strategies to reduce the effects of soil erosion include shifting cultivation, ridging across slopes, planting on raised mounds and avoidance of deep ploughing. It was further revealed that farmers who successfully applied the traditional methods improved upon their output levels per land area and the standards of living of their families It was recommended that modern agricultural extension services were needed, not to replace, but to complement the local knowledge systems in order to ensure sustainability.

Keywords

Local farmers
Food crop farming
Soil erosion
Adaptive strategies

Introduction

The rising need for local Ghanaian farmers to advance themselves beyond subsistence economic system is creating the awareness of soil loss through erosion and the adoption of soil management practices as important aspects of traditional agriculture. This situation however, varies from one part of the country to another on the basis of climate, vegetation and topographical characteristics.

The Bole District in the Northern Region of Ghana which is ethnically dominated by the *Gonjas*, is located in the tropical continental climatic belt and savanna vegetation zone. Apart from the single maximum and inadequate rainfall with less denser vegetation, human activities

such as deforestation, over cultivation, overgrazing and bush burning are occurring at increasing rates in the area due to rapid population growth in the midst of poverty (Gyabaah, 1994; GPRS, 2002-2004). The situation is worsened by other natural factors such as the impact of rainfall and the slope of the land, which increase the susceptibility of the soil to erosion, especially by water and subsequent fall in crop yields (Wischmier and Smith, 1965).
In the face of these environmental problems and the associated negative effects on the livelihoods of the farmers, it became necessary to determine the indigenous adaptive strategies and their degree of relevance in solving the problem of soil erosion, with maize farming in the Zampe community of Bole as a case study.

Objectives of the Study

The main objective of the study was to ascertain how local farmers perceive soil erosion and adopt strategies to solve the problem.

The Sub-Objectives of the study are:

1. To examine the nature of soil erosion on maize farms
2. To identify the effects of soil erosion on maize crop farmers
3. To assess the effectiveness of local control measures on output levels

Theoretical perspectives

The study adopted a mixed theory approach, and the relevant ones are discussed below.

Theory of Plant Tolerance

"Tolerance is the ability of an organism to withstand harmful conditions within its cell tissues" (Acheampong, 2006: 120). The theory of plant tolerance is built mainly on the principle that, in any environment a given plant has the minimum, maximum and optimum requirements for growth (Acheampong, 2006). This study sought to examine how soil erosion by water affects the tolerance level of the maize crop in particular, and how local farmers respond to the situation.

The Erosion and cultivated Crop Sustainability Theory

The researcher emerged with this grounded theory after field observation of the local maize farmers. As illustrated in Figure 1, soil erosion leads to the depletion of soil fertility as the top soil is removed. Farmers observe the level of tolerance of the crops to the soil erosion and declining soil fertility by using crop yields per land area as the indicator (all other farm practices assumed to be constant). In response to negative indicators, farmers adopt control mechanisms, involving soil loss control and the improvement of the soil fertility.

The theory concludes that the sustained cultivation of the crop by a farmer depends on the effectiveness of the adaptive control mechanisms. Thus, the paper examined how soil erosion causes soil loss, poor soil fertility and declining crop yields, as well as what farmers do to solve the problems for sustained cultivation and livelihood improvement.

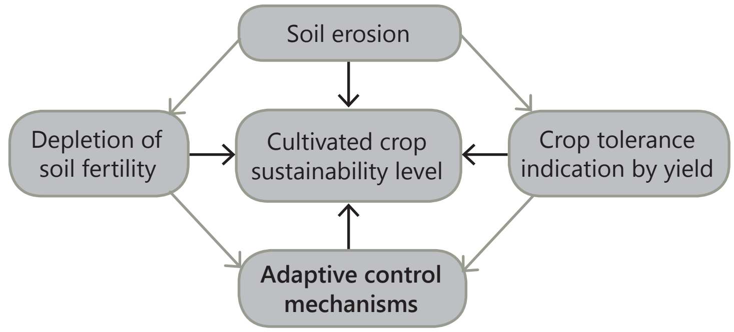

Figure 1. The Erosion and Crop Sustainability Theory in Diagram (Self-designed)

Methodology

This paper resulted from a mixed research design involving the cross-sectional and the before-and-after study designs and qualitative and quantitative approaches. Maize farmers in the Zampe community of the Bole District constituted the sample frame, and a sample size of 100 was chosen using the non-statistical method. Respondents were reached by snow-balling, for primary data collection using questionnaire, focus group discussion (FGD) and observation by transect walk along cultivated areas. Retrospective and one-short types of questions were used in the instruments, and the face-to-face interview technique was used to administer the tools.

Results and discussions

This section presents the interpretation, analysis and synthesis of the results of the study in relation to the objectives set.

Indigenous Perceptions of Soil Erosion by water

The survey revealed that all the maize farmers of Zampe experienced soil erosion by water on their farmlands, while almost half of them perceived it as a threat to productivity. Below is a presentation of how the indigenous farmers define soil erosion by water.

Indigenous Definitions of Soil Erosion by Water

1. *"During or after rain, running water carries top fertile soils in the direction in which it is moving"*

Implied in this definition is that running water is a major cause of the loss of top fertile soils from cultivated lands, and that the running water has a direction depending on the nature of the land. Thus the loss of soil fertility is the cause of worry to this particular farmer.

2. *"Soil erosion by water is the carrying away of top soil by running water along slopes"*

This definition is a complement of the first one, as it specifies the exact nature of the land that facilitates the phenomenon of erosion, namely sloping land. With this awareness, such a farmer can predict the fate of crops cultivated along slopes, and hence what practices he should adopt to control the situation. This farmer shares the same views with another who said "Soil erosion occurs on sloping farm lands".

3. *"Soil erosion is the washing away of the top soil which contains most of the plant nutrients by running water "*

This farmer's view rates slightly higher than the first ones because he does not just understand the concept of soil fertility, but that there are several elements in the top soil that collectively make soil fertile, and which are lost from their original places due to running water.

4. *"Soil erosion by water is the mixing of original soils with different ones due to the transfer and deposition of soil on farm lands by running water"*

This definition simply points out that soil erosion causes conditional instabilities in cultivated soils since this process of mixing of soil can never allow a permanent texture to develop. In order words erosion by water does not permit the development of a soil with unique characteristics on the affected portion of a piece of farm land.

5. *"Running water carrying top soil away and resulting into the creation of gullies"*

This is the view of a typical farmer who experiences water erosion as one in which running water concentrates on some specific spots, especially along steep slopes, and cutting deep grooves into the land. The main cause of worry to this farmer is how the process renders the portions of the land changed into gullies uncultivable. This farmland is obviously located along the alluvial fan zone of a high land area (Beaumont, 1993).

6. *"Water erosion is the process by which running water carries top soil from a highland and deposits it at an end"*

This is what happens when a farmland is located between the alluvial plain (gentle sloping part of highland area) and the salt desert (flat land area) (Beaumont, 1993). Here the gentle sloping nature of the land may not give rise to gullies, but rill erosion which is between gulley and sheet erosion may occur. The energy of the running water soon terminates as it gets to the more level or flat land area and the soil is deposited. The implication is that a portion of this farm land would be fluvial (erosive) while another portion would be depositional. This would lead to a contrast between crop yields from the different areas; those on the fluvial zone would have less fertile soils, possibly displaced by running water and so have lower yields, while those at the depositional zone would have an accumulation of finer and more fertile soils with little fluvial distructabilities, and so have higher yields (Beaumont, 1993).

7. Finally, another intelligent middle-aged farmer defines soil erosion by water as a process whereby

"running water caries soil from where it has a greater energy, to where its energy ends"

This particular definition is the experience of a farmer who holds all other things constant, and concludes that the ability of running water to continue carrying soil along depends on the intensity and duration of rain and the length of slope factors, as implied in the universal soil loss equation (Wischmier and smith, 1965). I now compare these indigenous views of soil erosion to two classical definitions of the concept.

Comparison of Indigenous Knowledge with Classical Definitions of Soil Erosion

For the assessment of the relevance of the indigenous knowledge of soil erosion to the contemporary scientific world, it is worth restating some of the classical definitions of the concept for the purpose of comparison. According to Sumner (2000: 171), "Soil erosion is a series of processes leading to soil depletion in situ and the export of sediments towards downstream areas". Bunnett and Okunrontiffa (1983: 50) also defined soil erosion as "the breaking up and wearing away of exposed rocks by moving water (rivers and waves), the wind and moving ice".

These classical notions of erosion are nothing different from the indigenous knowledge displayed above. The local participants explained the phenomenon based on how they experienced it on their farmlands (based on topography and specific cultural practices), which also influenced the type of erosion they were exposed to. Table 1 shows the types of soil erosion according to participants' perceptions and experiences.

Table 1. Common types of soil erosion in Zampe

Type of soil erosion by water	Frequency	Percentage
Sheet erosion	68	68%
Gully erosion	30	30%
Rill erosion	2	2%
Total	**100**	**100%**

Though not the most popular type as indicated by the response rates in Table 1, the local farmers expressed the worry that after heavy rains, amounting to 1050 mm (40 inches) per annum in the Bole area (GhanaDistricts.com, 2013), gully erosion in particular, destroys significant portions of their farmlands. They added that on uniform and gentle sloping farmlands, gullies resulting from exposed tunnels caused by decaying roots of trees felled for land reclamation, also promote gully erosion. A later part of the article examines the actual effects of soil erosion as known to the farmers.

Cultural Practices that Increase the Erodibility of Soil

Figure 2, shows how the local farmers rated cultural practices according level of impact on soil erosion. The farmers explained that over-cultivation loosens soil particles, deforestation and overgrazing expose soils to the direct impact of rain drops to facilitate the break-up of soil particles. Additionally the removal of the natural vegetation for land reclamation reduces the roots that hold the particles together. These make the soil easily eroded by running water.

Bush burning (for hunting and land clearing purposes) and over-grazing have rated low in Figure 2 because, according to the farmers, over-grazing in the community usually occurs only with the coming of Fulani herdsmen (See Bunnett and Okunrontiffa, 1983; Pickering and Owen, 1994).

The Effects of Erosion on Maize Farming

Figure 3 shows the estimated portions of farmlands affected by soil erosion, for respondents who said they experienced the phenomenon. The effects of this high level of soil erosion according to the farmers include the removal of the fertile top soils which support the growth and development of the maize crops; the development of badlands which reduce the cultivable land area; reduction in the capacity of the soil to store water for crop use; and the dislocation of the crops, causing livestock to graze on the fallen stalks and buds. The combined result of these effects is low output per land area, according to the farmers (See Barnett et al, 1972; Stocking, 1984; Russell and Russell, 2003; Hutchinson, 2008).

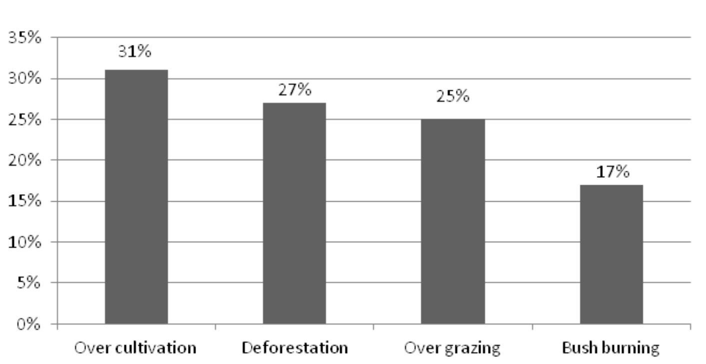

Figure 2. Cultural Practices that Influence Erosion by water

Figure 3 shows that a greater number of farmers (61%), have about ½ of their farmlands eroded by water, and some of them (48%) considered the phenomenon to be very serious, in view of the associated low output per land area.

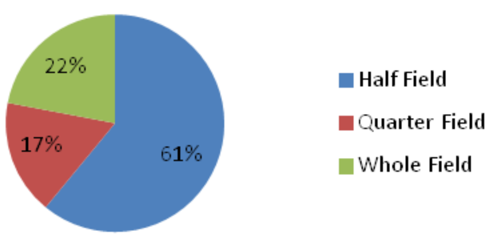

Figure 3. Portions of land area eroded by water

This reveals the application of the Erosion and Crop Sustainability Theory in a negative direction (stopping cultivation), as the maize crops become increasingly intolerant to the erosive effects (Acheampong, 2006). The next section discusses how the local farmers try to address the situation.

Adaptive Strategies to Reduce Soil Erosion by Water

In response to the negative effects, the indigenous farmers of Zampe device and adopt strategies to reduce soil erosion on their maize farms. Figure 4 shows how the Zampe farmers perceived the nature of their farm lands, which also influence water erosion and hence, the nature of adoptive control measures. It shows that 90% of the respondents had gentle sloping farm lands while 10% had steep sloping lands. Topographically therefore, the area is generally undulating. According to Wischmier and Smith (1965), the slope of land is contributory to soil erosion, and focus group discussion results with the farmers indicated that ridging across slopes is one of the ways of minimizing the effects of slope on soil erosion. The maize crops are then planted on and in some cases, between the ridges. This checks the speed of running water and effectively prevents the transportation of soil particles and nutrients.

Reduced ploughing is another common practice among the farmers of Zampe. Most farmers prefer to clear land with the hoe or cutlass, to reduce disturbance to the natural compactness of the soil particles. This practice however, goes along with mixed cropping to increase the resistance to erosion, such as cassava, pigeon peas, millet, maize and vegetable crops cultivated on the same farmland. This increases the soil cover while crops with stronger stems and deeper root systems protect weaker ones like maize, against water erosion and rain storms.

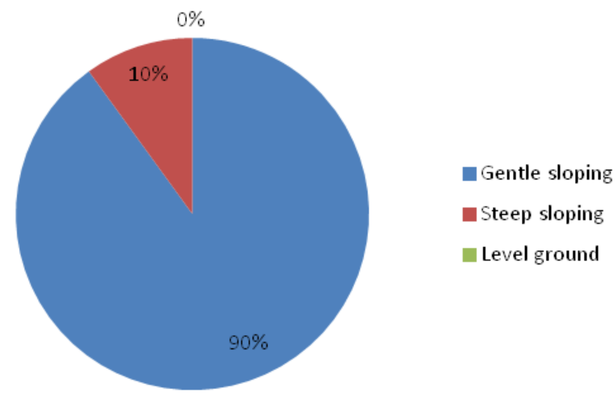

Figure 4. Topographical distribution of maize farmlands

On less sloping lands, farmers allow the maize crops to attain considerable heights after which they raise small mounds around individual plants to prevent root exposure and subsequent falling of plants due to erosive activity. This is accompanied by a weeding method involving cutting lumps of soil and capsizing them with special broad-bladed hoes, thus creating a rough land surface. This method of weeding is known as 'Kimutɛ' in the Gonja language.

This takes place at the last weeding before harvesting (a period rather associated with heavier rainfalls between August and early September). At this stage the crops are close to maturity or at the later stage of budding ("Kipige"), during which period maize crops easily fall due to their weight and combined effects of rain storms and running water. Kimutɛ is therefore suitable for the protection of the crops against both wind and water erosion.

Though quite classical, shifting cultivation and bush fallowing are also local practices among the farmers of Zampe. They use the development of rills, gullies and decline in crop yields as indicators to shift to virgin or previously fallowed lands. Farmers who do so are therefore subject to the application of the negative consequences of the Erosion and cultivated Crop Sustainability Theory and the Theory of Plant Tolerance, which they try to avoid.

Effectiveness of the Adaptive Strategies

About 93% of the farmers saw their practices as being capable of maintaining the tolerance level of the crops and hence sustaining their interests to continue cultivation, based on output levels (a positive application of the Erosion and Cultivated Crop Sustainability Theory- Figure 1). The remaining 7% who failed to see the relevance of their own control methods in reducing the impact of soil erosion are those threatened by declining yields per land area, and hence are allocating portions of the maize field to crops that are more tolerant to the prevailing conditions, such as cassava, potatoes, pigeon peas and agro- forestry related practices. In this regard, it is clear the willingness or ability of the farmer to sustain the cultivation of the maize crop declines.

Possible Innovations Due to Access to Extension Services

Figure 5 shows the accessibility of the farmers to agricultural extension services. About 45% of them have access to extension services while 55% do not. The extension services are mostly provided by the Agricultural Extension Department of the Ministry of Food and Agriculture (MoFA). The activities of the extension officers usually include demonstration of modern techniques of farming using modern equipment and fertilizers; introduction of improved breeds of seeds; erosion prevention and control methods and the prevention and treatment of livestock diseases.

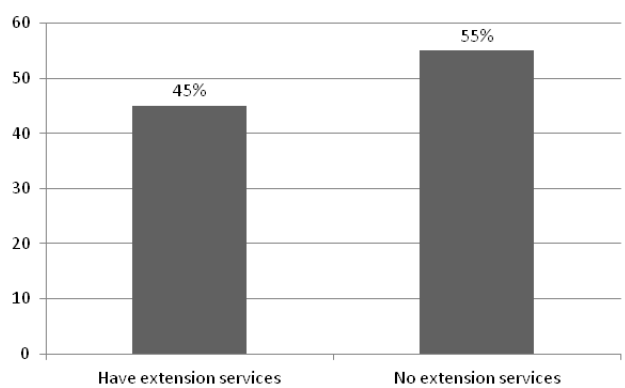

Figure 5. Accessibility to extension services

These usually take place through field visits, home visits (by expressed need of the farmers) or organized meetings in the community.

Level of Adaptation of Extension Services

Figure 6 shows the level of responsiveness of the farmers to the methods of the extension officers. It indicates that most farmers are conservative to the traditional farming practices and so do not respond easily to the technical advice of extension officers.

It is not at all bad to maintain traditional farming practices, provided the prevailing environmental conditions still respond to the effectiveness of such practices. In line with this, however, the World Bank (1994) advices that for best results, there is the need to combine conservatism with modernity in order to ensure the sustainability of an innovation. The next section reveals the outputs of the farmers in periods when they were highly conservative in their farming methods (before), and periods when they combined traditional with modern methods of soil management (after).

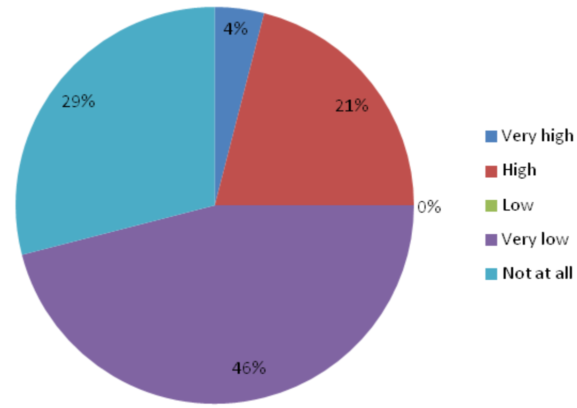

Figure 6. Levels of adaptation to extension services

Estimated Outputs of Farmers before and after Adaptation of Traditional and Modern Erosion Control Strategies

There was 100% response rate that the adaption of traditional and modern strategies in the control of soil erosion is effective. The comparison of Tables 3 and 4 confirms the contention. With an average farm size of 3.45 acres, the average output per acre before adaptation measures was 2.2 bags, while that after adaptation was 4.7 bags. This showed an increase of 100% over the output level before adaptation, which was quite a significant improvement.

Table 2. Sizes of maize farmlands

Farm size (x) in acres	Absolute Number of Farmers (F)	Absolute number (f) multiplied by farm size (fx) (in acres)
0.5	10	5
2	40	80
5	45	225
7	5	35
	∑f= 100	∑fx= 345

Average farm size = ∑fx/∑f = 345/100= 3.45 acres

Table 3. Output of maize farmers before erosion control measures

Output level in bags (x)	Absolute number of farmers (f)	(fx) in bags
4	20	80
7	10	70
8	40	320
9	30	270
Total	∑f=100	∑fx= 740

Source: Field survey, 2009

Average output per farmer before erosion control= ∑fx/∑f= 740/100= 7.4 bags

Average output per acre before erosion control= 7.4 / 3.35 = 2.2 bags

Table 4. Outputs of maize farmers after adaption of erosion control measures

Output level in bags (x)	Number of farmers (f)	(fx)
4	5	20
9	10	90
15	40	600
20	45	900
Total	**∑f=100**	**∑fx=1610**

Source: Field survey, 2009

Average output per farmer after erosion control = ∑fx/∑f= 1610/100= 16.1 bags

Average output per acre after erosion control= 16.1/ 3.35 = 4.7 bags

However, if the local maize farmers were more responsive to extension services by technical officials, the situation could have been better. This is because, according to the Ministry of Food and Agriculture (MoFA, 2009), maize farmers in Northern Ghana could harvest about 8 to 9 bags per acre with training and input support from extension officers, but without intervention the output level could be 7 to 8 bags per acre. This also reveals the negative effects of some of the traditional soil loss control measures like mixed cropping, on the output of maize by the Zampe farmers (who are also in Northern Ghana), hence the relatively lower yields per acre both before and after adoption of control measures.

Local Farmers' Perception of Climate Change and the Impact on Soil Erosion

This section presents the outcome of a focus group discussion with a chief and five elderly maize farmers on indigenous perceptions of climate change, and how it affects soil erosion. The results showed that a major problem caused by climate change is the inability of the local farmer to predict the right time for planting; that during their childhood, farmers could use the position of the stars and the arrival of certain bird species to predict weather and the right time for specific farming activities.

Erosion is a common phenomenon associated with farming, the farmers said, but the severity of erosion on the maize plant also depends on the stage of development they reach during the period of maximum rain and erosive activity. Accurate timing is however difficult today because of increasing variations in rainfall patterns from year to year.

They also observed that in the past, the land was more wooded, and the thick vegetation constituted a check to the impact of running water, thereby reducing soil erosion, and linked rapid deforestation to modern population pressure:

"*There were no many houses as you see today, to call for the felling of trees to make homes, instead structures were constructed under trees to provide shade and fresh air*". The chief recalled (Source: Focus Group Discussin with Maize farmers in Zampe-Bole, 09/09/09).

The discussion also related deforestation to reducing rainfall, as well as low organic matter content of the soil, which also causes desertification and the associated effect of low crop yield (see Arku & Arku, 2010).

The Effects of Soil Erosion on Farmers' Livelihoods

Table 5 shows respondents' perceptions of the effects of soil erosion on their livelihoods.

Table 5. Effects of soil erosion on farmers' livelihoods

Effect	Frequency	Percentage
Low output	30	30%
Food insecurity	10	10%
Low income	20	20%
Low savings	20	20%
Low investment capital formation	20	20%
Total	**100**	**100%**

Source: Field survey, 2009

In the focus group discussion with the maize farmers, the participants identified low output, low income, low savings, low capital for investment and food insecurity as being the effects of soil erosion on their livelihoods. On low output, a participant elaborated:

"*The wind and running water do not just remove the soil. You see, if the soil were removed and our crops are still in place and doing well, we should have no reason to worry. But during certain times of the growing season, there are heavy rains and wind storms. These cause the removal of the soil by running water and our maize stalks are also uprooted and broken down all over the field. At the end, we have the problem of how to provide our families with food for the rest of the year*". (Source: Focus Group Discussin with Maize farmers in Zampe-Bole, 09/09/09).

Another farmer added his voice to the above contribution by saying that:

"*Sometimes we manage to transplant some of the damaged crops if they are still at the early stages of development. But still, the good part of the soil is often carried away and we experience poor outputs. This affects our income and the ability to save for the following farming season, so that some farmers are not even able to farm again, or their farm sizes are reduced*".

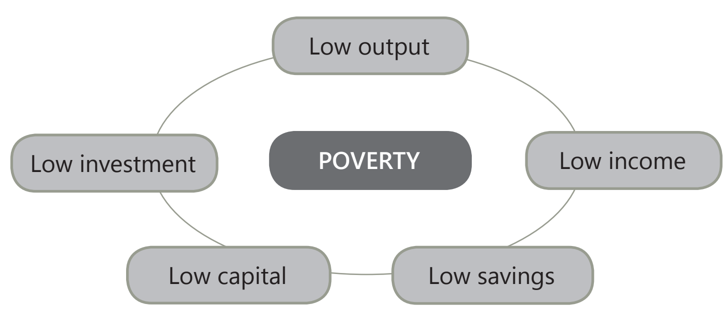

Figure 6. The vicious cycle of poverty (Self-designed)

The contributions of the participants contained the factors that are responsible for the vicious cycle of poverty, that is low output; low income; low savings; low capital formation; and low investments in farming, which is the predominant occupation. These among others, are contributory to poverty; a condition of lack of the basic needs of life (Todaro and Smith, 2006).

Conclusion

The study revealed that local farmers perceive soil erosion as the wearing away of the top soil and nutrients, under the influence of running water during rainy periods. The phenomenon is known to all farmers, but the severity of the impacts felt depends on the nature of the individual farmer's land, as well as the cultural practices.

Soil erosion also reduces soil fertility, affects the physical development of food crops and consequently reduces crop yields. Traditional farmers adapt strategies such as ridging across slopes, planting on raised mounds, shifting cultivation and mixed cropping to control the phenomenon.

Farmers, who effectively combine traditional methods with the services of extension officers, are able to reduce the effects of soil erosion for better crop yields, improved household livelihood and reduce poverty.

Recommendations

Though the traditional notions of soil erosion are quite comprehensive, they have technical limitations. For instance none of the traditional definitions could identify weathering or the fractional decomposition of soil as a precondition for soil erosion. Adequate education on the meaning and processes of soil erosion through extension services, could improve upon the farmers' understanding of the phenomenon and hence their ability to develop and practice better preventive methods. For example an understanding of fractional decomposition or the break up of soil particles by rain drops and other mechanical processes, would inform farmers on the need to ensure adequate soil cover during and after the farming season.

Extension officers educating farmers on the prevention of soil erosion should not impose new technologies or ideas on their clients. They should rather involve them first in the identification of the weaknesses of the existing practices, and then in the development of improved or better methods of doing so, otherwise the acceptance and sustainability of the innovations could be doubtful.

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