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Assessing Soil Nutrient Depletion to Household Food Insecurity in the Smallholders Farming System in the Western Hills of Lake Abaya, Ethiopia

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Abstract
Soil nutrient depletion is major environmental problems that threaten food security in Ethiopia, especially in the study area. It can be regarded as a direct result of the past agricultural practices in the area. In the study, an attempt has been made to examine the adverse effect of soil nutrient depletion to the household livelihood situation in the western hills of Lake Abaya, Ethiopia.
To assess the research data methodologies such as soil analysis, food balance sheet, per capita food availability in kilocalories and multiple regression models were utilized. The laboratory analysis of soil had shown that organic matter, cation exchange capacity (CEC), available phosphorus and potassium content of the soil is progressively decreasing away from the homestead. The study further revealed that 61 percent of the household's feed themselves for not more than nine months in a year against 28.2 percent, those from low-lying areas are self-sufficient. An analysis of this kind would help the local government to take timely intervention and help planners and donor agencies to include the problems as a priority area of intervention in their program.
Keywords: Soil nutrient depletion, Food insecurity, Food balance sheet, Per capita food availability.

1. Introduction

1.1 Background to the problem

The unique topography, soil type, intensive rainfall, poor land management and deforestation all have resulted in heavy runoff that induced soil degradation and are considered to be some of the major problems threatening agricultural development and food security in Ethiopia (Tadesse, 2001; Sonneveld and Keyzer, 2003; Holden and Shiferaw, 2004). A research document on the cause and impact of soil degradation in Ethiopia had viewed that natural and human factor as the short term causes of degradation (Wischmeier and smith 1978). Several other researchers have discussed about the anthropogenic factors, especially the underlying socio-economic conditions, such as population pressure, poverty, land rights and market access (FAO, 1994; Kerr, 1998; and Anand, 2003).
It is observed that soils in the Ethiopian highlands are severely eroded. In some localities it reached to an extent that it will never be restored in a short period even with the application of organic manure and modern farm inputs (Lal, 1994). Erosion adversely affects crop productivity by reducing the availability of water, nutrients and organic matter content. Organic matter is important for water retention, soil structure, and cation exchange capacity of soil and is the source of a large portion of the nutrients needed by plants. As noted by Alexander (1977), after water, shortages of soil nutrients (nitrogen, phosphorus, potassium, and calcium) are the most important factors limiting crop production. Thus, Soil erosion by water must be considered the most important of all degradation processes, and therefore the extent of damage is taken here as the sole indicator of the present status of soil resource in the region.
In a predominantly agrarian society like Ethiopia, soil nutrient depletion is a severe threat to food supply and is estimated that food productivity is declining at a rate of 2-3 percent annually (Lemenih et al. 2005). This poses a serious problem to the national food supply. The mountainous topography, extensive cultivation and heavy population pressure make the study area vulnerable to soil nutrient depletion and food shortage. With the declining soil infertility, farm income, land scarcity and lack of development intervention youth and adult population are prone to out-migration in search for alternative source of income in the major cities of the country. Due to the aforementioned constraints agricultural production cannot meet consumption need of the households and making the people food insecure. Hence, studies on the on-going nutrient depletion and the resultant effect on food supply become important to take remedial measures before the situation became severe. This investigation has assessed the status of soil nutrients depletion and thereby treats severity of household food shortage in the western hills of Lake Abaya, Ethiopia.

1.2 Site Description

Covering an area of 189 km2, the study area is located in the South- western part of Ethiopia, at about 495 km

south of Addis Ababa. It is located in between 60 7' 30"N to 60 19' 00"N latitude and 370 31' 30"E to 37o 40' 30"E longitude. The region encompasses 20 rural villages (figure 1).

The area enjoys cool humid climate in the upland and dry sub humid climate in the downstream. It has great geographic diversity, with high and rugged terrain, flat topped plateaus, deep gorges and rolling plains. Soils in the upland area are volcanic in origin, such as cambisols and nitisols. While, in the lake area and river plains deposited fluvisols are dominant. Except in a few remote localities, the area is devoid of forest cover. However, bamboo, poducarpus, acacia, eucalyptus tree and thickets are seen in some pocket localities. The study area is among a few densely populated parts of Ethiopia, with population density of 408 persons per sq.km.

2. Data sources and Methodologies

2.1 Soil Sampling and analysis

Soil samples were collected from the surface layer (0-30cm) of different land-use types and analyzed for its physical and chemical properties, following the standard procedure of Jackson, (1967) to compare differences in soil nutrient content across the land-uses. One-way analysis of variance (ANOVA) was used to test the difference in soil properties across the land use type.

2.2 Socio-economic data

Household survey was conducted between September and February, 2011 to obtain Socio-economic data pertaining to household income, size of farm production, off-farm income, etc. Two hundred fifty five households from three agro-ecologies were interviewed using structured survey questionnaire on household food variables. To quantify household food variables methodologies such as food balance sheet (Negatu, 2005) and multiple regression models was utilized.

3. Results and Discussion

The nature of soil and physical properties such as color, structure and depth are the main determinants of soil fertility in an area. As field identification of soil color at dry state has shown that in the study area, especially in homestead plot the color of soil sample was dusk red. The dusky red color is due to the presence of high humus content in the area. On the other hand, in the outfields red color soils were observed, indicating that there is high concentration of ferrous minerals. This is resulted from the leaching processes, which is due to heavy rainfall situation in the area. In addition, soil texture is the other important permanent attributes of soil. It indicates the potential rate of infiltration, water-holding capacity, degree of leaching and erodibility of the soil.

Laboratory analysis of soil had shown that average size of sand, silt and clay fraction in the homesteads were 36.6 percent, 40 percent and 23.4 percent, respectively, while in the outfields the proportion of sand, silt and clay were 17.7 percent, 22 percent and 60.3 percent, respectively. These show that the soil textural classes in the homestead and outfields were loam and clay, respectively. From laboratory result of soil analysis it is possible to suggest that due to high application of organic manure in homestead plots soil textural class was dominantly became loamy compared to poorly manured distant plots. In the study area, the soil reaction varies between 7.6 and 5.5 in homestead and outfields, respectively. Organic matter content of soil varies between 0.34 percent and 3.2 percent in the out fields and homestead fields, respectively. This is due to farmer's management practices in the homestead plot, where they enrich it with manure and crop residue, as such fields did not face labor shortage compared to the outfields. As revealed in Fig. 2, there is significant decrease in organic matter content of the soil in the outfields by 31.6 percent compared to the homesteads; suggesting that farm fields are depleted with distance from the main dwellings.

Laboratory result of soil analysis further revealed that available phosphorus and potassium exhibited significant variation between the land-use types. The decrease in the outfields was 6.2 percent and 6.7 percent for available phosphorus and potassium, respectively. The analytical result indicated that average cation exchange capacity, CEC concentration was found to be highest in both land use types, which is more than 30.5 mill-equivalents per 100 gram soil (Fig. 2).

This is due to the presence of large amount of clay particles in the soil. However, at land use level similar to the concentration of soil organic matter, the proportion of CEC in the outfields were decreased by 76 percent compared to the homestead fields, suggesting that the concentration of CEC is influenced by source of animal manure which is dominantly available near the main dwellings.

Further, what was currently observed in the study area is that there is continuous cultivation of crop without using any conservation measure. This practice leads to soil erosion and soil nutrient depletion hazards, which further enhanced the plots for declined crop productivity. Therefore, from the discussion given above, organic matter and nutrient content of soil in varying land-uses are severely depleted and is one of the major causes for the currently declined crop productivity and increasing food shortage in the study area.

The major food types used in the study area are cereal, enset and root crops, while animal products and

vegetables are rarely consumed. As shown in Table 1, farmers in the study area had access to food from three sources, namely own farm production, food purchased from market and grains obtained from Food for Work schedule (FFW). In the study period between March 2010 and February 2011, of the total food availability, purchased food from market contributed the highest proportion (60.3 percent) followed by own production (33.5 percent) and food for work schedule (6.2 percent).

At village level, the contribution of purchased food to the total households' food availability was found to be 86.6 percent, 24.3 percent and 20.9 percent in Lante, Damoze and Dallo, respectively. This simply reveals that in semi arid lowlands, households are shifted to cultivate high value cash crops instead of cereal crops that worth low price and purchased cereals from market.

Food grain production per capita decreased significantly in the study area. For instance during the study year, yields of some of the major cereal crops, such as barley, wheat and maize were 870 kg, 900 kg and 1340 kg per hectares, respectively. However, as revealed in Central Statistical Authority (CSA, 2008) that at the national levels the yield of similar crops was 1380, 1630 and 2120 kg, respectively. When consider the per hectare yield of these crops, it is less than 40 percent of the national yield estimate. This means that, production of barley, wheat and maize is below the minimum amount that a hectare of farm can yield even at the sub-Saharan level. In such a circumstance, in the absence of other sources of income, it is improbable that agricultural production alone can cover the household's means of subsistence. To confirm the aforementioned analysis households in the study area were requested regarding their perception on food production in the last ten years. Accordingly, more than 82 percent of the respondents reported that the crop production on their farm is continuously decreasing for the last ten years, while the remaining 18 percent replied an increase in production. From soil analysis it was ascertained that the declined agricultural production was resulted from the cumulative effect in the reduction of organic matter and other nutrient content of soil. Thus at present in the study area, due to progressive depletion of soil and decline in farm size farm production cannot cover household annual food requirement.

To confirm the situation socio-economic data was collected through household survey and food balance sheet for the year 2010/11 was computed as presented in Table 2. As can be seen from the table among the three sample villages, Dallo and Damoze has a per capita food availability of 1112 cal. and 1665 calories, respectively. Medically allowed per capita minimum daily dietary intake for adult person is equivalent to 2100 calories (Ethiopian Nutrition Institute, 1990). Thus, the study result indicates a high level of food insecurity among the households in the highland villages. However, Lante village with the per capita food availability of 2560 calories was found to be relatively food secure part of the study area. The foregoing analysis clearly reveals that food energy deficiency in Dallo village was more than 47 percent compared to 21.9 percent self sufficiency in Lante village, suggests that there is marked regional imbalances exist in food availability among the studied villages. At the study area level, the estimated average daily per capita food available was 1785.6 calories (which is 85 percent of the minimum recommended allowance). Thus, food data reveals the prevalence of under-nourishment as 62.4 percent compared to 46 percent under-nourishment for Ethiopia in 2007/08 (UNDP, 2008). However, in one of the most food insecure village (Dallo) the prevalence of under- nourishment rate was 100 percent. Most of the population in the area is below poverty line of 0.5 kg daily per capita consumption requirement. Therefore, taking consumption of less than 0.62 kg of cereal food per adult equivalent per day as an indicator of food insecurity, daily per capita requirement of 0.5kg makes the study area in a severe situation of food shortage.

Further investigation of the data depicts that variation of food availability among the households with in villages seems very wide as shown by the computed coefficient of variation in table 2. The coefficient of variation for Dallo, Damoze and Lante was 32.4 percent, 72.6 percent and 44.9 percent, respectively.

Among others the followings are influential factors that affect household livelihood in the study area. In traditional community like the lake region, numerous farm variables do influence household food production and availability. For instance, size of farm and labor, number of oxen, livestock, and the use of modern farm inputs are critical factors that strongly influences households' livelihood. The findings from multiple regression models reveals statistical relationship as presented in table 3.

In the finding, multiple correlation (the correlation between per capita food availability and eleven independent variables) is R = 0.742. The R-value of 0.742 suggests that there exists a strong positive relationship between the variables considered in the analysis. The percentage of eleven independent variables (that is due to a combination of factors such as farm size, fertilizer use, crop harvest, etc) is then R2 = 0.550. Hence, in this study, 55 percent of the variance of per capita food availability is explained by eleven independent variables. Because 1-R2 is 0.45, 45 percent of per capita food availability may be explained by weak infrastructural development, unstable market situation, errors in data collection, and etc.

Similarly, food availability variation with an ANOVA (analysis of variance) F-ratio of 19.481 was also statistically significant. In the study area among the independent variables, size of harvest, livestock population, farm oxen, use of improved seed, fertility of the farmland, and education of household heads were found to be the

main factor that affects food availability at household level (see the significance of 't' in table 3).

However, contrarily the increase in food availability has resulted in a similar increase in family size. Furthermore, the inverse relationship between independent variables (such as farm size, chemical fertilizer, and use of off-farm activities) and food availability was unexpected situation, because it was expected that these variables can have a positive contribution to the household food availability.

4. Conclusion

This study, which set out to examine the adverse effects of soil depletion on the livelihood of the households in the western hills of Lake Abaya has revealed that there was a substantial depletion of soil nutrients and decline in the humus content of soil. Landlessness and food shortage are the main problems, which force subsistence farmers to expand their cultivation on to erosion-prone marginal lands. Thus, such practices may further aggravate the condition of soil erosion, particularly in the up stream area.

Soil nutrient depletion, acidity, decline in the organic matter content, reduced permeability, etc are among others major production constraints in the area that requires due attention from the agronomists and extension agents. However, recently what was observed in the study area is with the increasing deforestation and surface run-off, soil depletion has further becoming worse. This suggests the need for conservation and reforestation measures especially in the mountainous areas to make farming sustainable and productive.

As revealed in the study that household factors played an immense role in determining food security status of the study area. The analysis of food shortage showed that the household food production during the survey period, especially in the two highland villages is lower than annual food requirement as revealed in the food balance sheet, implying that there is a considerable stress of food insecurity in those localities. The argument made in this study was that if sustainable policy measures are not taken in areas such as population pressure, environmental protection, soil depletion and household income diversification, food shortage in the hilly villages will persist.

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Table 1. Total food available for consumption at household level

Village	Source of food available (%)			Total net food in kilogram
	Own production	purchase	food for work	
Dallo	62.8	20.9	16.3	94080
Damoze	62.5	24.3	13.2	54240
Lante	13.4	86.6		214620
total	33.5	60.3	6 .2	362940

Source: Author`s field work

Table 2. Average Net Food Available for Consumption (2010/11)

Village	Mean total kg/ Household/ year	Mean total Kcal/ household/ year	Daily per capita food available in calories per individual					
			Mean	percent of MRA	minimum	maximum	SD	CV
Dallo	1039	3927.4	1112	53	509.4	1939.3	358.1	32.2
Damoze	895	3482.9	1665	79.3	624.9	5488.6	1208.4	72.6
Lante	1774	7174.5	2560	121.9	752.3	5729.7	1149.5	44.9
Average	1236	4861.6	1785.6	85	509.4	5729.7	1138.9	63.8

Source: Author`s field work

Note**:** SD, stands for standard deviation and MRA, for minimum required allotment, while CV, for coefficient of variation

Table 3. Result of multiple regression analysis

Independent Variables	Betta(B)	t	significance
Chemical fertilizer use	-0.013	0.198	0.843
Education of household head	0.176	3.218	0.001
Family size	0.019	-0.343	0.732
Farm credit	-0.22	-0.467	0.641
Farm oxen	0.170	2.288	0.023
Farm size	0.034	0.692	0.530
Fertility of farmland	0.164	3.406	0.001
Size of crop harvest	-0.658	-8.005	0.000
Size of livestock	0.178	2.171	0.031
Off-farm activities	0.040	0.678	0.499
Improved seed	0.194	3.255	0.001
Constant	1.575		
R	0.742		
R square	0.550		
Adjusted R square	0.522		
F change	19.481		

Source: Author’s field work

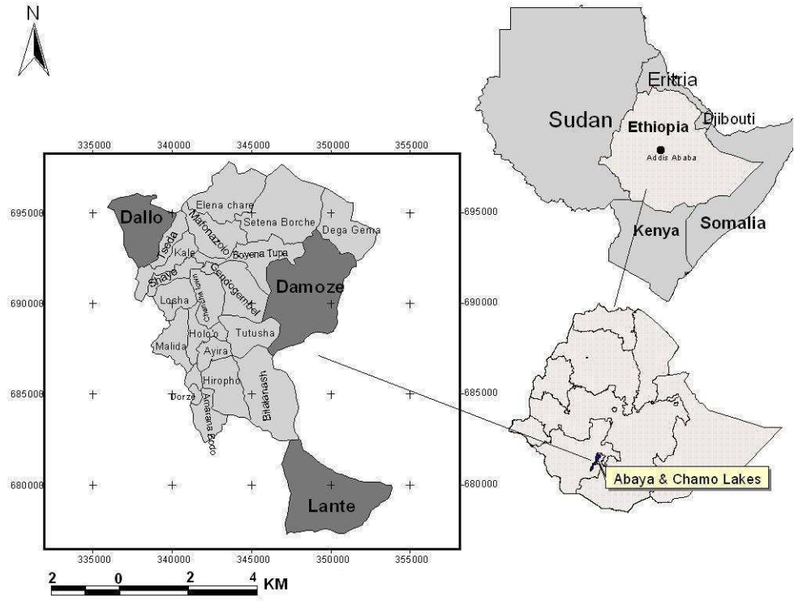

Fig. 1: Location Map of the Western Hills of Lake Abaya, Ethiopia

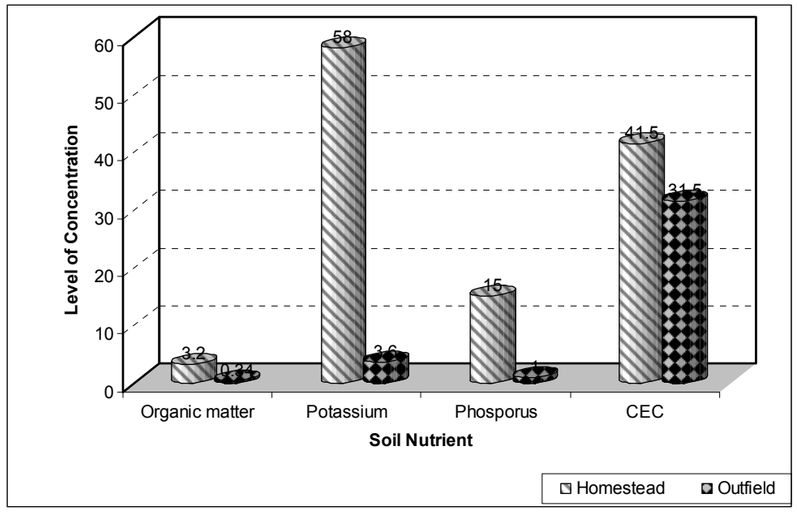

Fig. 2: Concentration of Soil Nutrients between farms