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The Future Impact of Adoption of Soil Conservation Strategy at Family level in the Highlands of Ethiopia

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ABSTRACT

In the highlands of Ethiopia, soil erosion is a bottleneck to maintain land productivity. In order to mitigate the problem of land degradation, the Soil Conservation Research Project (SCRP) developed and disseminated a number of soil conservation techniques. The studies done so far dealt with the impact of these techniques on yield and profitability of farming. However, poor farmers take not only yield and profitability into consideration but also many other factors. This study was initiated to assess the future impact of adoption of bund construction on family income, external labour requirement, cash balance, credit need, and dependence on purchased food. The study was conducted using survey data collected in 1999 from 111 farm families in the Ankober district in Ethiopia. The study area was sub-divided into four sub-regions before carrying out the survey based on intensity of agriculture, the main emphasis of the farming system (crop and/or livestock), type of major crop and the altitude, which is one of the main agro-ecological factors. A multi-periodical linear programming model was applied to each of the sub-regions to assess the future impact of the strategy at household level. The model results indicated that adoption of a soil conservation strategy has positive impact on family income and the cash balance of the family in the long term. However, except in one of the sub-regions, credit must be available to make adoption of the conservation measure feasible. Adoption of the technique has mixed effect on the dependence of farm families on purchased grain.

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INTRODUCTION

The Ethiopian highlands include approximately 85-90 percent of Ethiopia's farmers, over 95 percent of the cropped area, around 66 percent of its livestock, almost 50 percent its land area and over 90 percent of the national economic activity. Soil erosion is a severe problem in sloping areas, especially in the northern and central highlands where vegetation cover is very low and soils are already very shallow (JABBAR et al., 2000). Moreover, the population is growing at an unprecedented rate. Consequently, food production has fallen short of the demand for it leading to a very low and unsustainable standard of living of farm families.

The Soil Conservation Research Project (SCRP), was initiated in Ethiopia in 1981 with main development objectives of providing the Ethiopian soil conservation efforts with necessary basic data for the proper implementation of soil conservation measures, testing the applied and planning adapted measures, and training local as well as international personnel in this field of study (SCRP, 1984). The SCRP has developed a number of soil conservation techniques and several studies have been conducted on the adoption and profitability of these techniques. The studies done so far dealt with the impact of these techniques on yield and profitability of farming. However, subsistent farmers take not only yield and profitability into consideration in making decisions but also many other factors. This study was initiated to assess the future impact of adoption of stone/soil bund construction on family income, external labour requirement, cash balance, credit need, and dependence on purchased food.

THE STUDY AREA

A study area was selected in the Ankober district in the Ethiopian highlands based on the criteria that the area is prone to soil erosion and that land is scarce. The other criterion for selecting and defining the study area was the fact that natural, man-made, and socio-economic gradients are manifested from top mountain to valley bottom and that the transect across a watershed reflects land of different levels of degradation. Before starting with the family survey the study area was

sub-divided in to four regions based on level of agricultural intensification, importance of the livestock component and the emphasis given to soil conservation practices.

The high mountain area has a relatively extensive type of agriculture with a high livestock component (Sub-region one: Kundi). The next watershed is a highly degraded and a highly overused area (Sub-region two: Lay Gorebela). The next zone is characterised by moderately intensive agriculture without a clear indication of over utilisation of land in comparison to the area located to the north of it (Sub-region three: Chefa & Kulife). At the bottom of the valley agriculture is more stable with an intensive construction of terraces and intensive production system (Sub-region four: Aliyu Amba area). Total size of the study area is about 70 sq. km out of which settled area constitutes about 35 sq. km and there are about 1200 farm families out of which 111 farm families were randomly selected for interview.

SOIL CONSERVATION STRATEGY

The type of soil conservation strategy, whose impact was tested, is the construction of soil and stone bunds based on the specifications provided by Keddeman, 1992. According to Keddeman (Table 1), assuming no intervention to combat soil erosion, yield would decline by about one percent per year. However, if bunds were constructed, grain yield would increase by about 7.5 percent after five years (average of the “Best estimate”). This would need labour input of 150 Wd/ha in the first year (the year in which bunds would be constructed) and the area lost to bund construction would be ten percent of the land. In testing this strategy, other factors determining the decision making process were assumed to remain constant.

Table 1: Specifications for the construction of soil and stone bunds

Item	Minimum	Maximum	Best estimate
Km of bund/ha	0.8	1.4	1.0
Investment: Wd/ha	94	535	150
Area lost	5 percent	14 percent	10 percent
Base year yield, Kg/ha	600	750	750
P.a. Yield loss without	1 percent	5 percent	1 percent
Yield increase after five years	5 percent	70 percent	5-10 percent

Source: Willem Keddeman, 1992

MULTIPERIODICAL MODELLING OF FARM-HOUSEHOLD

For the purpose of simulating the farming systems, multi-periodical (dynamic) linear mathematical programming models were developed for each of the four sub-regions. The basic models, built to simulate the existing farming systems were used to assess the impact of construction of soil or stone bunds on family income, external labour requirement, cash balance, credit need, and dependence on purchased food. The impact of this strategy is given by the difference between the situation with soil conservation and the situation without soil conservation.

A dynamic linear programming model has the following mathematical form.

$$Max\ Z = \sum_{t=1}^{y}\sum_{j=1}^{n}\left(P_{jt}X_{jt} - C_{jt}X_{jt}\right)$$

Subject to

$$\sum_{j}^{n} a_{ijt}X_{jt} \le bit, \qquad All\ i = 1\ to\ m$$

$$X_{jt} \geq 0, \qquad \begin{array}{l} All\ t = 1\ to\ y \\ All\ j = 1\ to\ n \\ All\ t = 1\ to\ y \end{array}$$

Where:

- Z = *Objective function*
- X_{jt} = *The level of activity j in period t*
- P_{jt} = *The price per unit of the j output activity in period t*
- C_{jt} = *The cost per unit of j input activity in period t*
- y = *Number of periods*
- n = *Number of possible activities*
- m = *Number of resources and constraints*
- a_{ijt} = *Technical coefficient (amount of ith input required to produce one unit of jth activity in period t)*
- b_{it} = *Amount of ith resource available in period t*

Construction of bunds to combat soil erosion can be accomplished in one year. However, the impacts of this kind of measures take a number of years to be observed. Therefore a static model is not adequate to capture the effect of construction of bunds. That is why single objective multi-periodical models were built to test the soil conservation strategy. The multi-periodical model has three periods and these periods are described as follows.

a) The first period is the period in which bunds would be constructed. This period consists of only one year because, given the small land holding in the area, bund construction can be done in one year.

b) The second period is the period in which bunds are already there but the yield is still at the level of the first year. This period consists of four years because during these four years (the years

which follow year one), there would be similar technical coefficients in the matrix. These technical coefficients are different from the coefficients in period one and three.

c) The third period is the period in which yield becomes higher than the previous periods by about 7.5 percent as a positive impact of soil conservation. This period consists of five years. There is no technical limitation to the number of years that can be covered during this period. This period includes five years because it is believed that it has to have at least the same length of time as the previous years (Period one + Period two) in which no benefit of bund construction could be realised.

The three periods differ from one another in labour requirement and yield level. In period 1, in which bunds are constructed, labour requirement is much higher than in the periods two and three where only maintenance is required. In period two and three, labour is needed only for bund maintenance that is about 20 percent of the labour needed for bund construction. In the first period and also in the other periods of the model for testing strategy of soil conservation, cultivable land was reduced by ten percent because of the area lost to bund construction. The multi-period models were built in such a way that it is possible to transfer surplus cash from period one to two and from period two to three.

FUTURE IMPACT ASSESSMENT

Adoption of a mechanical soil conservation technique has different impacts on and implications for the different farming systems. This section presents the impact of adoption of stone/soil bund on farm income, external labour requirement, credit need, cash balance, and dependence on purchased food in four of the sub-study regions.

Farm income

Kundi: In the "without" situation farmers would get an average yearly income of about 2697 Birr. The family income would be about 2981 Birr if the family adopts the recommended bund construction, which is an increase of about 11 percent as compared to the "without" situation. The

increase in family income is due to an increase in farm income by about 13 percent. Analysis of the change in farm income per unit of family owned resources indicates that the return on land increases by about 15 percent whereas farm income per unit of family labour (man-day) decreases by about nine percent. Off-farm income remains at similar level in the "with" and the "without" situation because of the assumption made (other factors affecting farmers' decision making remain constant). Consequently the share of farm income as a percentage of family income would increase by about three percent.

Lay Gorebela: The ten year average yearly family income in the "without" situation was found to be about 3070 Birr whereas in the "with" situation it would be about 3206 Birr. The impact of adopting the recommended soil conservation measure on family income is an increase in family income by about four percent.

The increase in the family income due to this strategy corresponds to about 4.44 percent increase in income per family member. In this sub-region, farm income both per unit of labour and per unit of land would increase. However, the increase in farm income per unit of land is higher than the increase in farm income per unit of labour. This is quite logical since bund construction increases land use efficiency and requires high labour input. The percentage share of farm income would increase by about three percent if no change occurs in availability of off-farm activities in the area and if farmers allocate the same amount of labour to off-farm activities as they were doing during the survey year.

Chefa & Kulife: Without adopting the soil conservation structure, the family would earn a yearly average income of about 1396 Birr in the next ten years. Whereas adopting the recommended measure would lead to an average income of about 1381 Birr which is slightly lower (by about 1 percent) than in the "without" situation. The decrease in family income is because of a decline in farm income. The farm income per unit of land would increase by about ten percent. However,

this increase is not sufficient to pay for the decrease in farm income per unit of labour that is about 26 percent.

Aliyu Amba: The analysis of the impact of the "with" situation on family income for the next ten years has revealed that income would remain more or less at the same level whether the family adopts the recommended soil conservation measure or not. Only a slight decrease (0.94 percent) of family income was observed.

The farm income in the "with" situation would drop by about 1 percent owing to the decrease in farm income per unit of labour that is about 12 percent which is higher than the increase in farm income per unit of land by about two percent. The percentage share of farm income in the "with" situation would remain more or less at the same level as in the "without" situation.

In general adoption of a soil conservation strategy has positive impact on family income in Kundi and Lay Gorebela area. In Chefa & Kulife and Aliyu Amaba area it would entail a slight drop in family income. Since yield continues to decline steadily in the future, if present trend continues, the impact of adopting mechanical soil conservation measure would be more pronounced in the distant future.

Labour need

In all of the sub-regions, the external labour requirement in the first period of the "with" situation was more than 100 percent higher than in the "without" situation. This has implications on the availability of cash since it is essential to have cash in order to hire external labour. Family labour alone would not be enough to accomplish the activities of bund construction.

Cash balance and credit need

In Kundi, the cash balance is worse in the case of the "without" situation as compared to periods one, two, and three of the "with" situation. In the rest of the three sub-regions, cash balance

deteriorates in the "with" situation in the beginning and improves later. The adoption of physical soil conservation measure positively affects the cash balance of the family in the long term implying improvement in the standard of living of the families.

However, except in the surroundings of the Aliyu Amba area, credit must be available to the families in order to make adoption of the conservation measure feasible. In Aliyu Amba area, the families could do with out credit because they have other sources of income, i.e. cash crops that are not available in the other sub-regions. Credit would be more greatly needed in Lay Gorebela than in any other sub-region.

Dependence on purchased food

Adoption of a mechanical soil conservation technique has mixed effect on the dependence of the farm families on purchased grain. In Kundi and Aliyu Amba area, dependence on purchased grain decreases slightly in the "with" situation. In the other two sub-regions, the dependence of farmers on purchased grain would increase in the "with" situation. This is particularly true during the short rainy season[3].

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[3] *The study area has a bimodal rainfall pattern*

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