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Economics of Integrating Local Knowledge and Practices for Sustainable Land Management: the case of smallholder farms in eastern Ethiopian Highlands

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Abstract

Degradation of land has been a subject of concern in Ethiopia since 1970s. In this study we analyse the role and economics of local conservation practices. The study is based on survey made during 1997on sample of 70 farms of which 30 were case studies. In economic analysis farmer's time preference, the opportunity costs of their resources, yield and price risks are considered.

Different conservation strategies with regards to land allocation were compared: a) existing conservation measures, b) addition of improved fodder, c) addition of 50% of household fuel energy demand by on-farm fuelwood production, d) addition of 100% of household fuel energy demand by on-farm fuelwood production, and e) addition of improved fodder combined with 50% fuelwood production. Using a risk analysis approach, it can be shown that the probability of the discounted NPV at 65% discount rate falling below zero is only 5%. This study concludes that intensive type of conservation with addition of improved fodder production is profitable for the smallholder farmers. Because of opportunity cost of land and high farmers' time preference, investments in fuel and construction wood production are found less attractive.

Keywords: smallholders, local, soil, conservation, Ethiopia.

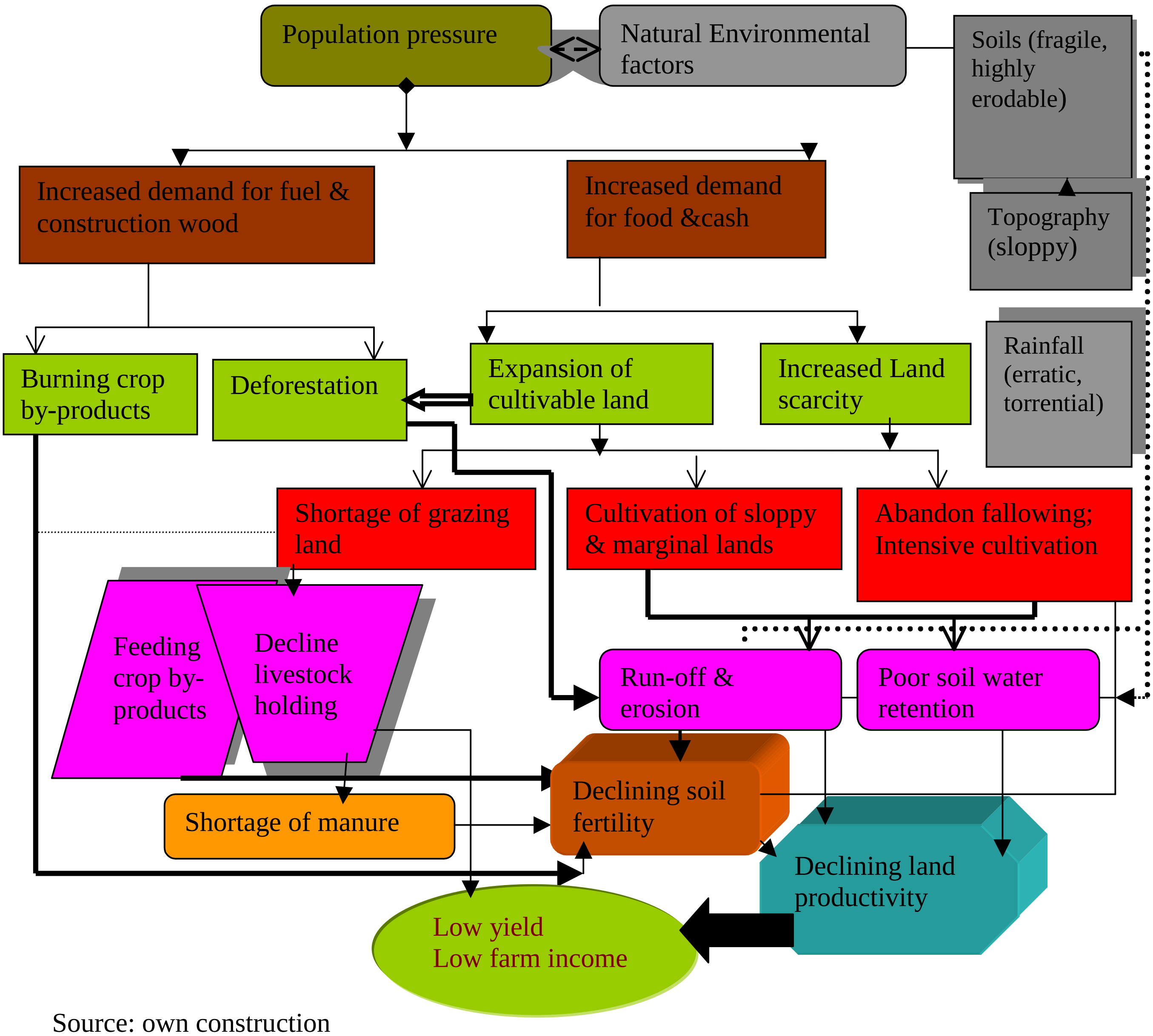
1. Background

1.1 Problem of soil degradation in Ethiopia

As in many agrarian based economies of developing countries, the peasant farm sector plays an important economic role in Ethiopia. The agricultural sector heavily depends on the natural resources and has also greatly influenced the state of condition of these productive resources and the environment. Hence, environmental degradation has been one of the major areas of concern in Ethiopia since the last few decades (Tsedale, 1998; Yohannes (1998); Herweg, 1993; FAO, 1986; Alemneh, 1990; Hurni, 1988; Keddeman, 1992). Reports indicated that Ethiopia is one of the sub-Saharan African countries where soil degradation has reached a severe stage. The problem has a magnificent national economic significance. Some places are reported to have land degradation reached a scale where further loss due to erosion can not be tolerated (FAO, 1986).

Human factors are assumed to have mainly contributed to the problem of soil degradation in the study area. At the base of the problem is the population pressure with limited carrying capacity under situation of a stagnant agricultural technology with low productivity and poor

development of non-farm rural sector that would provide off-farm employment and surplus labour absorption.
Population pressure leads to an increase in demand for food, fuel and construction wood. This results in expansion of cultivation into marginal and fragile lands on sloppy areas. As these are susceptible to erosion, the soil productive capacity declines fast. Demand for fuel and construction wood results in depletion of vegetation, deforestation, and burning of agricultural by- products. Depletion of vegetation exposes the soil to run-off erosion and waste of water resources. The Hararghe region is among one of the regions, which has depleted its biomass energy sources.



Source: own construction

Figure1: Problem Analysis: cause-effect of land degradation in Haraghe Highlands

Land scarcity and fragmentation leads to decline in fallow practices and an intensive cultivation with insufficient crop rotation. Land scarcity also leads to shortage of grazing land and consequently in dependence for livestock feed on crop by-products and decline in livestock holding and manure for field fertilisation.

The soil nutrient-imbalance is attributed to more export of nutrients than inputted due to depletion by cereals continuously planted and removal of by-products for feed and utilisation as firewood. Institutional and policy factors have definitely played role in this gradual land degradation. There is no defined private property right that guarantees resource protection and its sustainable use. Absence of private ownership in the forest areas led to free- access and depletion of trees and vegetation. Research and extension works in rural sector have not fully accessed the
peasants so as to effectively tackle the problems and impediments of improvement in farming. Policies could not give sufficient attention to the development of rural non-farm sectors that would have ease the population pressure on land and generate income-earning opportunities for rural labour force. Due to inadequate rural infrastructure like roads, markets, farmers training and demonstrations centres, remoteness in terms of poor market access and low information flow have played disincentive and negative role in resource conservation and farm development. The dominant soil types in the eastern Hararghe Highlands are Regosols inherently characterised by shallow root depth, coarse texture, less humus and OM content, low water retention capacity, instability and high erodebility. One major feature of the landscape is gully erosion, which continues encroaching into the agricultural land.

1.2. Past efforts of soil conservation and limitations

Public attention to reduce the problem of soil degradation and a massive government involvement through Food-For-Work campaigns was made since mid 1970s and 1980s. The projects assisted by World Food Program (WFP) and other agencies have spent millions U.S. dollar during1980s (Hurni, 1988). In the food-for-work programme, conservation measures on farmlands like soil and stone bunds, fanaya juu, and tree planting on mountain areas have been introduced. Inspite of tremendous effort, there was little adoption of the introduced conservation measures by the peasants in the past (Herweg, 1993; Yohannes, 1998; Alemneh, 1990; Keddeman, 1992). Failures of conservation projects and low adoption of the introduced practices is reported to be mainly attributed to the following causes:

- non-participatory nature of the conservation programme (planning not involved peasants, land taken without consent of villagers, top-down approach);
- peasants lack resources : scarce land, labour, capital, time;
- inappropriate technology: favour pets, weed, water-logging, costly;
- institutional & organisational problems: hastily designed, lack of feed-back, low trust of institutions;
- approach : local knowledge and practices largely ignored, concentration on erosion alone as main cause of degradation, lack of other aspects of farm development;
- economic: measures could not improve yield and production sufficiently.

These problems in technical feasibility and economic viability are reported to have contributed to a low acceptance of introduced conservation measures.

1.3 Research questions

This study addresses the following questions. Does the present cropping / farming system decline soil fertility? What are farmers' perceptions, conservation practices, opportunities and limitations of improving them? Is it economically justifiable to invest in soil conservation measures? Is conservation measure with technical changes involving fodder, fuel and construction wood production profitable?

1.4 Objectives

This study has the following specific objectives:

- To study farmers’ perception of soil degradation and their conservation measures;
- To study the potential of employing local conservation measures for better soil management;
- To analyse opportunities for and impacts of investment in integrated measures involving fodder and on-farm tree planting on soil improvement and sustainable farm income development.
- To analyse the role of farmers' time preference and risk in investment in soil improvement measures.

2. Methods

2.1 Location, Sampling and Data

Field survey was conducted in Kersaa district of eastern Hararghe region during 1997 with a sample of 70 smallholder peasant farms of which 30 were case studies. Farmers were randomly selected and studied during April to October 1997. Following a general survey, selected cases were closely monitored. Different farmers based on differences in location, soil type, cropping pattern, slope or topography of farmlands were studied.

Primary data was collected form the farmers. Farmers' perceptions of land degradation, their views and suggestions, their time preferences; type, costs and benefits of local conservation measures have been studied. Data for estimating the time preference rate of farmers was generated by a game conducted with farmers following a procedure used by Wesseler and Waibel (1994), Wesseler (1996), Holden et al. (1998) and Pender (1996) and others. From farmers' inter-temporal choice of hypothetical payments (benefits) to be received at present or in future estimate of their time preference has been made. Secondary data has been collected from research, extension and development institutions, reports of conservation projects, and other statistics.

2. 2 Methods of data analysis

Budgeting and investment analysis techniques incorporating risk analysis have been employed to study the economics of alternative conservation investments at farm level. Gross margin analysis helped to identify better conservation technologies from among the local practices. Regression analysis was employed for estimating opportunity cost of labour, estimating yield of crops over time due to conservation, to identify determinants of investment, and analyse factors of variation of farmers' rate of time preference.

Investment planning and analysis is made for testing and selecting suitable conservation strategy. Risk analysis has been incorporated by the use of stochastic simulation based on variation in price and yield. Comparison of alternative investments has been made following the principles of stochastic dominance (Anderson, et. al, 1977). For the stochastic simulation Risk Analysis and Simulation Add-In for Microsoft Excel or Lotus 1-2-3 Windows version 1997 has been used (Palisade, 1997). In the simulation run 1000 iterations were run or computed by a using a Monte-Carlo sampling method.

Farmer's rate of time preference has been used as discount rate in investment analysis. The reason behind use of farmers time preference is that, given the imperfect capital market in the study area, use of official capital interest rate does not reflect the peasant farms' investment decision behaviour. Estimate of an opportunity cost of farm labour has been made using an econometric approach, where farm income as a dependent variable is explained by farm inputs land, labour and capital using a Cobb-Douglas production function. Marginal returns to resources have been estimated from the resulting regression parameters.

3. Theories and Concepts

In this study relevant theoretical background and concepts are widely reviewed. These are peasant farm household theory and labour allocation; household theory and inter-temporal resource allocation (saving & investment); theories and concepts of rate of time preference, and risk and uncertainty.

4. Hypotheses

Based on the problem analysis, theoretical backgrounds and concepts, the hypotheses of this study are the following:

- There is a variation in level of soil conservation of farmers in the study area;
- Despite awareness of problem of soil degradation, the existing socio-economic and institutional factors pose constraints to farmers' effort to improve soil management;
- Economics of existing soil conservation practices can be improved by introducing some technical changes

5. Results and Discussion

5.1. Grouping of local conservation practices

The local conservation practices have been grouped into conservation 'systems' that will enable their comparison in their soil improvement and profitability. Multitude of local practices of soil and water conservation have been evolved through time in the study area. These are mechanical measures and biological measures. The mechanical measure include soil and stone bunds, and bench terraces on sloppy lands; ridges, tide-ridges and micro basins for water conservation in association with bunds or alone depending on the slope of the cultivated land. There are diversion ditches, which run through the plots and drain excess water from the cropland. They can also be constructed above or around the plots to protect farm fields from heavy flood coming from above in sloppy lands.

The biological aspects of the local conservation measures is reflected in integration of the t'chat (Catha edulis) hedgerows in the cropping system and conservation. Some grasses are also planted on the bunds/terraces. Inter-cropping of different crops to increase the vegetation cover of the soil is another aspect.

As farmers practice various number of practices and their combinations, economic evaluation of the local practices can be done only by classifying the practices into certain distinct groups. Individual practices can not be studied because of data limitations and difficulty of identifying their individual impacts in terms of conservation and production. The following features of the conservation practices were considered for grouping them. (i) Basic mechanical structures: terraces or soil bunds; absence or presence of diversion ditches; height and width of the terraces or bunds (ii) the associated biological measures: absence or presence of t'chat (Catha edulis) hedgerows on terraces or bunds; absence or presence of grasses on the terraces or bunds.

Table 1: Mean Difference Test of Construction Labor and Investment cost for Various Features of Existing Soil and Water Conservation Practices

Item	Type of Structure		Grass on structure		T'chat hedge		Diversion ditch		Height of structure (m)		Width of structure				Width of structure (meters)	
	Terrace	Bunds	With	Without	With	Without	With	Without	> 0,59	< 0,6	1-1,5	0,45-0,9	Low,	< 0,6	Wide, 1 -1,52	Narrow 0,45 - 0,9
No of (plots)	16	26	28	14	32	10	27	15	14	28	19	23	28		19	23
Labor (MD/ha)	74	50	70^{*}	37^{*}	69^{*}	27^{*}	61	56	88^{+}	44^{+}	64	55	44^{+}		64	55
Std.	62	32	51	26	48	20	53	35	57	33	53	42	33		53	42
CV (%)	84	64	73	70	70	74	87	63	65	75	83	76	75		83	76
Investment [1] (birr) (Birr/ha)[2]	725	436	650^{+}	337^{+}	638^{*}	250^{*}	581	483	851^{+}	393^{+}	630	476	393^{+}		630	476
Std.	670	305	544	275	517	229	567	321	644	307	597	385	307		597	385
CV (%)	92	70	84	82	81	92	98	66	76	78	95	81	78		95	81

* Mean difference between two groups significant at 1 % probability; + Mean difference between two groups significant at 5 % probability. [1] Cash expense plus construction labour valued at wage rate (5 birr/day); 1 US $ = 6.50 ET Birr

Mean differences in investment in terms of construction labour, and investment cost (labour and cash expenses) are used as testing the significant differences of groups of conservation measures classified by the above method. As shown in table 1, mean construction labour and total labour and cash investment cost per hectare are significantly different between structures with and without grasses, with and without t'chat hedgerows, and between higher and lower structures. This shows that classification based on the above method is reasonable. Three major systems of existing conservation practices are defined: 'complex', 'intermediate', and 'lower'. The complex system represents an intensive conservation while the lower system is the extensive type. The '*complex system' combines bunds or terraces with height of 0.6 meters and above, t'chat hedgerows, and grasses planted on bunds and terraces,* On the other hand *'lower systems' are charcterised by bunds with no t'chat hedgerows, and with no grass on them and, and height of bunds less than 0.6 meters.* The intermediate is in between the two. Study of the farm fields show that about 30% of the cultivated land is currently under intensive system while the rest, 70%, is under medium to extensive conservation system. We assume that this definition reflects the complexity of activities and the intensity of efforts inputted as measured by labour and cash inputs required for construction or establishment. 70% of the plots under intensive conservation system are well maintained while two-third of the extensive and one-third of the intermediate is poorly maintained.

Following this classification, economic analysis of investment in intensive (complex) conservation measures under different land allocation strategies is made to assess the profitability of shifting from the current extensive (lower) conservation measures to the intensive (better) ones.

5.2. Measurement of economic benefits of local conservation practices

In order to assess the economic merit of soil and water conservation measure to the farm household, quantification of their costs and benefit is essential. The incentive of soil improvement and benefits of soil conservation comparing with and without conservation situations may be presented as shown in figure 2. This concept is widely established and discussed by Stocking (1992), Calrson, et al. (1993) and others.

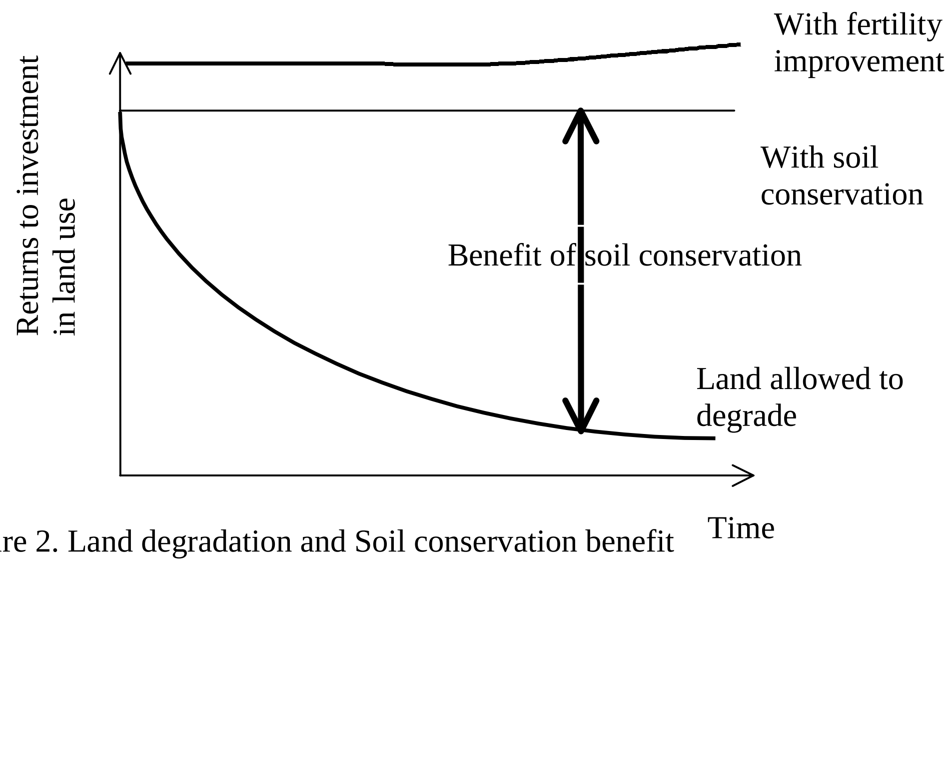


Figure 2. Land degradation and Soil conservation benefit

Source: Stocking (1992).

The benefit of conservation depends on yield increase over the situation without conservation as a result of reduced nutrient loss, water conservation and improved use efficiency, and increased productive efficiency of inorganic fertilisers and manure. Indirect benefits may also arise as a result of change in cropping pattern by a shift to high valued crops which fetch higher prices to the farmers.

In this study we have followed this principle to the estimate incremental benefit of the intensive soil conservation investment compared to the extensive conservation. In the absence of measured farm level specific soil degradation and yield declining data, rate of yield decline without conservation is assumed based on estimate made by Ethiopian Highlands Reclamation Study (FAO, 1986). It is estimated that crop yields decline by 0.5 % to maximum of 3% for the agroecological condition of the study area.

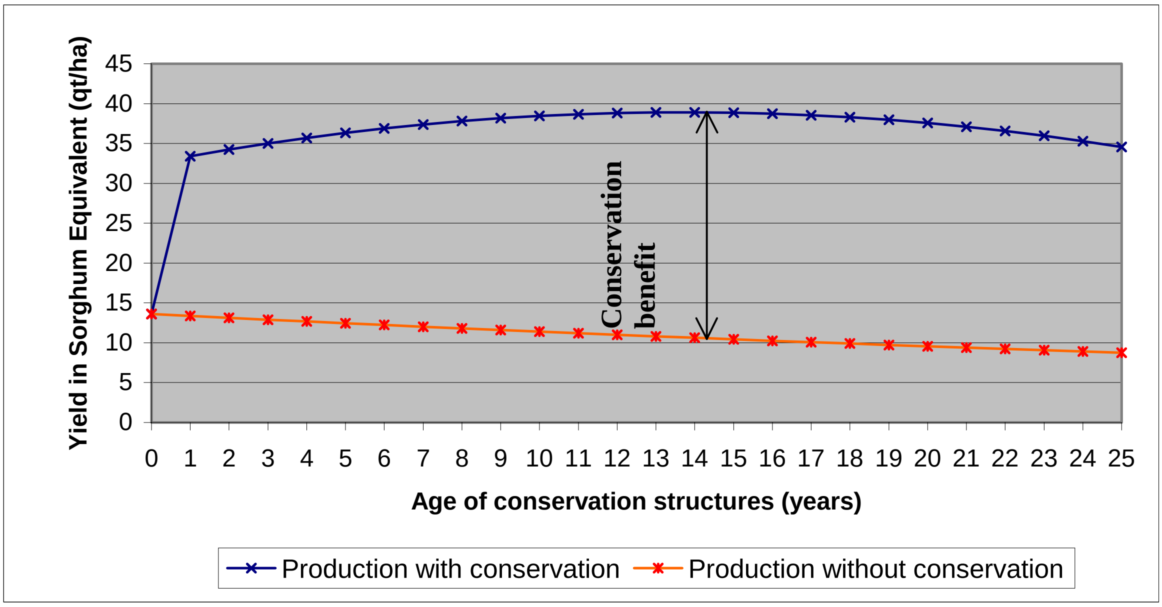
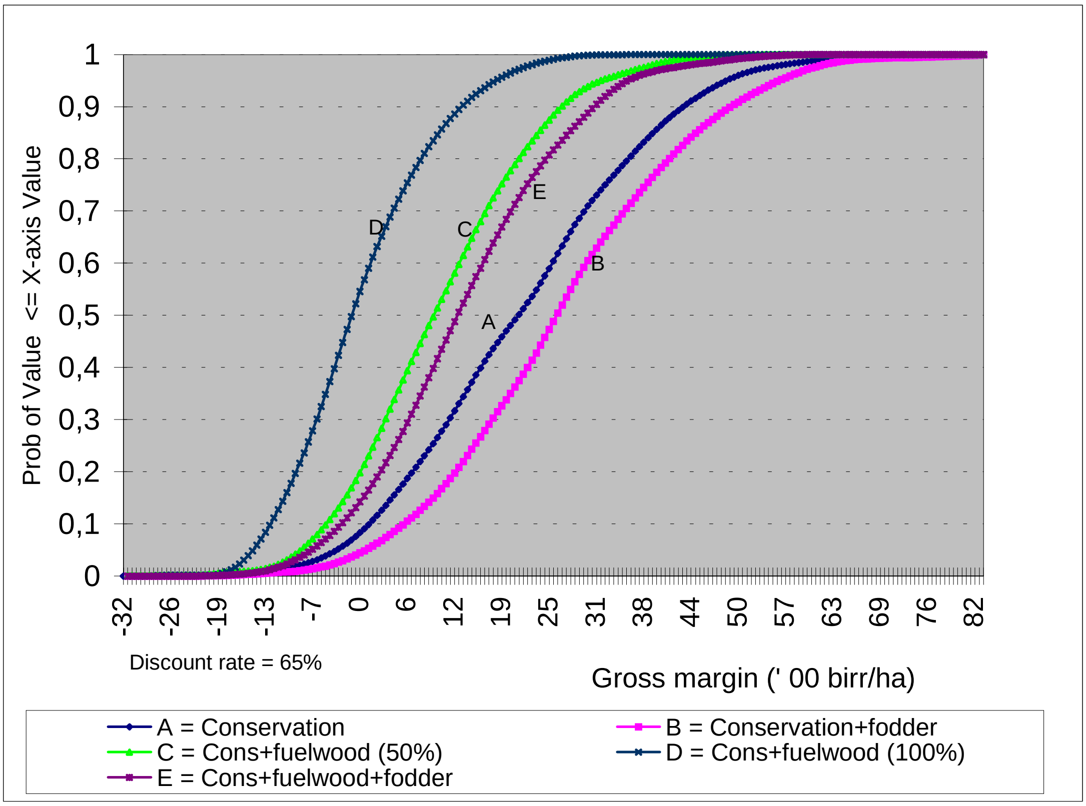


Figure 3. Yield trend with and without conservation and conservation benefit

To estimate the yield impacts of intensive conservation, first yields of individual major crops over time has been estimated (explanatory variable being age of the conservation structures). Significant parameters could be estimated only for T'chat and Sorghum. In the next step, the yield of other crops has been converted into sorghum equivalent using prices and quantities of individual crops. After estimating the yield function in sorghum equivalent, forecast of yield level over time after conservation investment has been made as shown in figure 3. The gap between the tow yield trends is a measure of benefit attributed to soil and water conservation. The production under conservation will gradually rise, and then stabilise for some years. To account for risk of variability in yield, the regression coefficients of age of conservation structures are allowed to vary from their lower to upper boundary in estimating yield function in the simulation model.

5.3 Evaluation of investment in soil improvement under alternative land allocation strategies

Alternative investments in conservation based on different land allocation strategies were analysed and compared. These are: a) investment in existing intensive conservation measures that entails a shift from the current extensive conservation, b) additional investment in land use with improved fodder production incorporated as an alley cropping or hedgerow system, c) additional investment in on-farm production of 50% of the household fuel and construction wood demand, d) additional investment in on-farm production of 100% of the household fuel and construction wood demand, and e) addition of improved fodder combined with on-farm production of 50% household fuel and construction wood demand.



Source: own result

Figure 4. Distribution for NPV of the incremental net benefit of conservation with alternative land use strategies.

Figure 4 depicts the cumulative probability distribution of the net present value of income stream discounted at 65 % discount rate for investment in intensive soil and water conservation under alternative land allocation strategies. 25 years of investment period is assumed. Following the principle of stochastic dominance (STD) I investments in conservation with addition of improved fodder production dominates all other alternatives. This investment has 50% chance of generating incremental gross margin per hectare of up to 2074 Birr. The chance loss is only 5%. Due to opportunity cost of land and delayed wood harvest, farm level fuel and construction wood production is not an attractive investment for the farm households in the study area. Investing in intensive type of conservation and addition of improved fodder production is the best alternative with minimum risk of loss for the farmers.

Conclusion

This study concludes that better soil conservation measures can be found from among the existing practices. These better /suitable practices are found economical also when some technical improvements like improved fodder production are introduced.

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