Land Degradation and Adoption of Conservation Technologies in the Digil Watershed Northern Highland of Ethiopia

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2. GENERAL CHARACTERISTICS OF THE STUDY AREA

2.1 The Physical Environment

A. Location

The Digil Watershed is located in Gozamen Woreda (district), East Gojjam Zone, Amhara Regional State (Fig. 1). Situated at some 308 km northwest of Addis Ababa, the watershed forms part of the northwestern highlands of Ethiopia. The watershed is from amongst the headstreams of the Blue Nile. As studies indicate, 90% of the Blue Nile basin was originally covered with forests (El-Swaify 1993); today the forest coverage is insignificant (Mengistu 1997). The basin is remarkably degraded and is following a trend of environmental deterioration (Mengistu 1997). The Digil watershed is part of this degraded and degrading basin, which will be representative of the conditions in large parts of the temperate (locally known as *dega)* climatic and agro-ecological belts of the northwestern highlands. Besides, the watershed is part of the highlands that are considered surplus producing regions of the country, but presently threatened by resource degradation and impending food insecurity (Gete 2000).

B. Geology, physiography and soils

In terms of geology, the Digil watershed is part of the highlands that have derived the greatest proportion of their heights from the uplifting of the Arabo-Ethiopian landmass and the subsequent outpouring of basaltic lava flows during the Tertiary period, commonly known as the Trappean lava. This thick basalt layer is underlain by sedimentary rocks of the Mesozoic age, which is in turn underlain by the basement complex rocks of the Precambrian (Mohr 1971). The physiography of the watershed reflects its geology and geological history. The uplifting force created an initial elevated landmass, and the subsequent outpouring of basaltic lava provided a thick protective cap and added on to the elevation. The resulting landmass within the bounds of the watershed has now an elevation ranging from 2420m to 2500m a.s.l. This structural landscape has been subjected to geomorphic processes over the geologic time to be significantly re-shaped. Currently, steep slopes and undulating topography characterise the study watershed.

Physiography can create both opportunities and constraints to development. For instance, around the study area, the higher elevation influences air movement and contributes to the occurrence of higher orographic rainfall. The elevation gradient and the associated climatic conditions allow cultivation of a wider range of crops and the high altitude offers a favourable environment for human habitation, which is free from tropical pathogens. On the other hand, the irregular surface created by frequent and deep dissection constitutes a major barrier to communication and impedes, in one way or another, agricultural and infrastructural development. Also, the steep slopes and rugged terrain constitute natural hazards with respect to soil erosion. Under such physiographic conditions, even rains of moderate intensity are enough to cause massive erosion and make soils shallow and stony.

The soils of the study watershed can be classified into two groups based on colour: reddish soils and greyish soils. The reddish soils occur on steeper slopes, which are well-drained. They are derived from complete decomposition of the volcanic lava flows by deep tropical weathering in situ. These soils have been deeply leached and are moderate to low in natural fertility and with some level of acidity. The greyish soils occupy alluvial valley floors. These are deep, grey to dark in colour, and largely fluvial sediments or washed down from upland areas. They are apparently fertile soils. The nature and properties of soils such as texture, aggregate stability, shear strength, infiltration capacity and organic matter and chemical contents, which are interacting in a complex manner, constitute an important factor affecting the susceptibility to detachment and transport (erodibility) of the soils by the forces of erosion (Morgan 1995). Organic matter content and textural composition can be considered the most important, as these influence all the other soil properties.

C. Climate

According to the simplified traditional agro-climatic classification system, which considers only temperature and altitude, the study watershed lies within *dega* (temperate) zone. The climatic condition is generally humid. As measured at Debre-Markos ($10^0$20'N, $37^0$40'E and elevation 2411 m a.s.l.), mean annual temperature is 14.5^0C with a range from 13.2^0C in July and August to 17.3^0C in March. Average annual total rainfall is 1300 mm. The rainfall pattern is unimodal, with a rising limb starting in May and reaching to a peak between July and August. More than 75% of the total rain falls in June, July, August and September (locally known as *kiremt* season) (Fig. 2). It is in this season that the major agricultural activities such as ploughing, sowing and weeding are carried out in the study area. At the national level as well, some 85 to 90% of the harvests are due to the *kiremt* rains (Woldeamlak 1998). The dry months are November, December, January and February (locally known as *bega* season), when less than 5% of the annual total rainfall occurs. Since the watershed lies at a higher elevation than Debre-Markos, temperatures must be slightly lower and rainfall higher than these values. Average annual total potential evapotranspiration (PET), as estimated by the Thornthwaite's (1948) method, is 855.7 mm. It reaches a peak in March, matching with the temperature pattern, but generally with a very low monthly variation. The monthly rainfall exceeds the calculated PET only in June, July, August and September. In the rest of the months, PET exceeds the rainfall. The uneven distribution of the rainfall gives rise to a serious shortage of water even for domestic consumption purposes during the dry season.

Fig. 2. Long-term average monthly rainfall (RF), potential evapotranspiration (PET) and temperature (Temp.)

2.2 The Human Environment

A. Demographic profile

Table 1 shows the demographic composition of the sample households. The total population of the 64 households was 326, of which 169 were males and 157 were females. The male population outnumbered the female population giving a sex ratio of 107.6%. The average household size was 5.1. But this average cannot be an indicator of the gross fertility levels of the population. The average household size refers to the number of individuals who were living under one roof; thus, it excluded children of some households who had established their own households. Nearly all the households were found to be nucleated families.

Table 1. Demographic composition of the sample households

Age group	Male	% of total	Female	% of total	Total (male + female)	% of total
0-14	84	49.7	78	49.7	162	49.7
15-64	76	45.0	76	48.4	152	46.6
≥ 65	9	5.3	3	1.9	12	3.7
Total	169	100.0	157	100.0	326	100.0

The overwhelming majority of the population was young. The population segment under the age of 15 years was around 50% of the total. The number of individuals whose age was above 64 was only twelve. The working age population, following the conventional categorisation, was 152. The age-dependency ratio was 114.5%, which was composed of 106.6% young-age dependency ratio and 7.9% old-age dependency ratio. The fact that the majority of the population was young implies that the pressure on environmental resources is on the increase and that effective measures are required to control the problem. Viewing it from another angle, it may perhaps be stated that it is also a force that can be deployed for environmental rehabilitation and conservation works. Better environmental conditions were observed in some places with growth in population numbers (e.g., in a Kenyan district as reported by Tiffen, Mortimore, and Gichucki 1994).

B. Land holdings

The distribution of farm sizes among the surveyed households is depicted in table 2. The average holding was 1.22 ha. Taking the average household size of the sample households, the per capita holding was 0.24 ha. There was a significant variation in the size of holdings among householders. Of the sampled households, the majority (56.2%) possessed between 0.6-1.0 ha of land. Only 9.4% had more than 2 ha and some 14.1% had ≤ 0.5 ha. The pattern is similar to the national level reality. According to CSA (1995), some 80% of the Ethiopian farmers in the highlands (>1500 m) cultivate less than 1 ha of farmland. Even worse, the number of households with small landholdings will increase with time owing to the increasing rural population and limited land resource. Resettlement of people from the densely populated and degraded highlands to the relatively sparsely populated lowlands may be a short-term alternative. Nonetheless, the current administrative regionalisation, which is based on ethnic-linguistic grouping, will pose constraints to be overcome for such a purpose.

Table 2. Household size and landholdings of households

Total land held (ha)	% of total
≤ 0.5	14.1
0.6 - 1.0	56.2
1.1 - 1.5	9.4
1.6 - 2.0	10.9
>2.0	9.4

Nearly all of the interviewed farmers (93%) stated that agricultural lands were becoming scarcer in their communities. The decrease in landholdings was attributed to the increased population in the area (85.9% of the respondents). Only few (9.4%) mentioned land degradation and consequent abandonment as a reason, and still fewer (4.7%) reported that land was not scarce. The farmers were also asked whether their current holdings were adequate to support their families. About 48.4% responded that their holdings were insufficient. Still, the majority (66.1%) stated that they would not like to resettle elsewhere even if they were to be taken to new areas where land may be abundant.

The quality of farmlands varies considerably within villages and within farms. This is taken into consideration during land redistribution and readjustment activities. The result is that farmers operate more than one parcels of land, which can be located long distances apart. The farmers included in the survey operated, on average, 3.53 plots. As it is often argued, fragmentation has negative effects on the intensity with which land can be utilised and crops managed. For instance, fragmentation causes croplands to be reduced to narrow corridors running down slope. Such land strips will be inconvenient to apply structural soil and water conservation measures. Moreover, the “linear” shapes will dictate ploughing to be carried out along the slope rather than across, which will significantly increase the magnitude of “tillage erosion”. Thus, these very small and fragmented holdings are, generally, conducive neither to optimisation of agricultural practices nor to the application of land management measures. However, in view of the majority of the surveyed farmers, the advantages of fragmentation outweigh the disadvantages.

C. Crop production

Crop production is the major source of income for the farmers in the watershed. Barley (*Hordeum vulgare*), oats (*Avena sativa*), wheat (*Triticum vulgare*), *tef* (*Eragrostis tef*) and maize (*Zea mays*) are the important crops cultivated. All the crops are produced only once a year because of the unimodal rainfall distribution. Mixed cropping is virtually unknown to the farmers. The types of crops grown and the cultivation practices have important implications on soil erosion and land degradation processes.

Table 3 shows estimated incomes of the sample households from crop production at average *bega* and *kiremt* prices for the year 2001/2002. The produce is expressed in terms of monetary equivalents to enable comparisons and provide a universal yardstick for better understanding. The average price for the different crops varies between the seasons. Generally, it is low in the *bega* season and high in the *kiremt* season, a few weeks after harvest. Barley and oats accounted for the largest share of the total annual income of households from crop production, followed by wheat and *tef*. Maize accounted only for a small proportion of the total household incomes. The farmers grow the different crops as a strategy to avert any risk, to spread out food availability and to adjust for local agroecological conditions.

Nearly all the farmers (98.4%) stated that they had witnessed a decrease in productivity of their plots over the past 10 years. As reasons for the decline in productivity, “ageing of the land”, which must mean nutrient depletion, and the high price of chemical fertilisers were repeatedly mentioned (92.2% of the respondents). Other reasons given by the farmers included drought, soil erosion particularly by landslide, and other more household-specific problems.

Table 3. Estimated average households’ incomes from crop production, 2001/02

Crop type	Income (Eth. Birr)	% of total
Barley & oats	295.00	39.0
Wheat	217.85	28.8
Tef	211.50	28.0
Maize	31.56	4.2
Total	755.91	100.0

D. Livestock tending

As in all other parts of the Ethiopian highlands, livestock are an integral part of the sedentary life of the people in the study area. Table 4 shows the number and types of farm animals kept by the surveyed households. The total number of farm animals of the surveyed households was 495, including cattle, sheep/goats and equines. This represents 7.73 farm animals per household. There were also 21 poultry, which is 0.33 per household. The composition of the farm animals was such that cattle accounted for 59.4%, sheep and goats for 31.7% and horses and donkeys for 8.9%. Oxen provide the draught power needed for the farming. Sheep and poultry are very important sources of cash and food. The contribution of livestock as cash sources of the farmers is significant. For instance, sales of livestock, livestock products, chicken and eggs contributed to 19.9% of the cash income of the surveyed households in 2001/02. Farmers usually sell farm animals to cover bigger expenses such as land taxes and other government obligations. The horses and donkeys transport people and goods.

As elsewhere in the country, livestock ownership is used as a measure of wealth of households in the communities studied. That is, livestock ownership is the main differentiating factor between the wealthier and poorer households as the farmers cannot be differentiated based on their land holdings about which they are insecure. Thus, there is a social standing attached to the number of livestock owned regardless of the feed shortage. There is a serious shortage of animal feed. In *kiremt*, the livestock are dependent on heavily degraded (overgrazed) communal lands and on some crop residues collected in *bega*. In *bega*, crop residues are the main feed. Residues of wheat, barley and oats are, however, also used as roof covers, thus sometimes an absolute choice to be made is whether to use the residues as animal feed or as part of own shelter. The shortage of feed is due to both decreased productivity of available grazing lands and shrinkage of the grazing lands due to encroachment by cultivation.

Table 4. Total number of livestock owned

Livestock	Total number
Calves	55
Cows	88
Heifers	31
Horses	14
Oxen	96
Sheep	147
Goats	10
Donkeys	30
Young bulls	24
Poultry	21

The causes for the shortage of livestock feed were drought, human population pressure and land degradation. Some farmers also stated that the common property nature of the grazing lands contributed to its degradation and shrinkage in the area. On the other hand, the majority of the farmers expressed that they would not suggest distribution of the grazing lands amongst community members for a privatised use. As a lasting solution to the problem of feed shortage, the farmers suggested increasing of grazing land areas, introduction of controlled grazing systems and reduction of livestock numbers. Regarding the trend in livestock numbers, it was learned from the farmers that there had been an overall increase at the village levels, while per capita holdings had been decreasing. The reasons for the decrease in the number of livestock per household include drought, feed shortage and inadequacy of veterinary services. The increase in the overall livestock population implies a growing pressure on the land resource base.

Oxen are the engines of the subsistence crop production activities in which the households are engaged. In deed, they constitute an important factor of production in many subsistence cultures elsewhere. In the Ethiopian highlands where cereal producing farmers perform their farming activity by ox power, lack of this main resource determines the vulnerability status of a household to food insecurity and famine. Oxen determine the efficiency of cropping. Thus, oxen ownership among the surveyed households is shown separately in table 5.

Table 5. Number of oxen owned per household

No. of oxen	% of total
0	18.8
1	25.0
2	45.3
3	9.4
4	1.6

Nearly 19% of the households did not possess an ox; some 25% owned only a single ox; 45.3% had a pair of oxen; 9.4% had 3 oxen and only 1.6% had 4 oxen. At the national level as well, some 30% of highland farmers were found to be without an ox in 1994/95 (CSA 1995). To have no ox or even have only one is a serious constraint on farming. The farmers without oxen try to overcome this problem and get their pieces of land ploughed through several arrangements. These include leasing out their lands for crop sharing or for money, using ox pairing with others, exchanging human labour for oxen, pairing an ox with a horse and using a pair of horses.

E. Expenditures

Table 6 shows items of expenditure and amounts of expenses which were incurred by the sample households in the year 2001/02. The largest item of expenditure was that for purchasing chemical fertilisers. Purchase of food items such as salt, edible oil, coffee, sugar, etc., which are not produced by households, constituted the second highest item of expenditure. Religious festivities, such as commemoration days of the Saints and *mahber* (a social/mutual aid association which involves festivities), constituted the third major item of expenditure.

The other important items of expenditure were for purchase of clothing, land use fees, purchase of kerosene, purchase of seeds, contribution for community works such as for the church, and expenses for the schooling of children. There were also wedding-related and death-related expenses. Since these were not recurrent items of expenditure, they were excluded from the analysis of the households' expenditure patterns.

Table 6. Items of expenditure and average amounts of expenses, 2001/02

Items of expenditure	Expense (Birr)	% of total
Clothing	91.61	14.7
Community contribution	15.33	2.5
Fertilisers	176.89	28.4
Food items	130.16	20.9
Kerosene	31.33	5.0
Land use fee	30.44	4.9
Religious festivities	110.00	17.7
Schooling children	12.73	2.0
Seeds	24.50	3.9
Total	622.99	100.0

F. Income-expenditure balances

Annual income-expenditure balances of the sample households are given in table 7. Both the income and expenditure figures are as estimated by the farmers themselves. For the calculation of the annual incomes of the surveyed households, three activity categories were identified: crop production, livestock rearing and sales of wood and wood products. No household was engaged in off-farm or non-farm works and also none had received any remittance. From all of these activities, annual incomes of the households were generally low and households were found to be highly vulnerable to seasonal food shortages. The average annual income from crop production was estimated at only Birr 755.91 on average (of *bega* and *kiremt*) prices. Income from sales of livestock and livestock products including poultry was estimated at Birr 207.06. There would be a difference of about Birr 300, on average, in annual incomes from crop production comparing the *bega* and *kiremt* prices, the higher being the *kiremt* prices. However, the farmers are required to pay land tax and other governmental and social obligations (e.g., religious festivities) in the *bega* season; hence, they are deprived of the chance to exploit the raised market prices of the *kiremt* season.

Table 7. Income-expenditure balances, 2001/02

Activity	Birr
Crop production*	755.91
Livestock raising including poultry	207.06
Sale of trees and wood products	75.70
Total income	1038.67
Total expenditure	622.99
Income-expenditure balance	415.68

*Computed at average prices (of *bega* and *kiremt*) for each crop.

No income was reported from any off-farm or non-farm activity and also from remittances. Hence, although land has become degraded and productivity has declined over time, it seems that the farmers lacked flexibility or the opportunity to move away from their age-old practices and engage in other income-generating activities. This indicates the need for an effective external intervention along this direction so that part of the population will be taken off the land. The other important (third largest) source of income was from sale of wood and wood products. This contributed to 7.3% of the total income of the surveyed households. About 50% of all the households covered by the survey responded that they generated some income by selling trees and/or fuel wood. Most of them sold trees planted by themselves, but a few others sold wood from natural woodland areas and forests, which may be rather a threat to the remaining meagre natural vegetation cover in the watershed.

According to table 7, the net balance between total annual incomes and expenditures being positive might suggest that incomes were well above expenditures. However, the income-expenditure balances show the proportion of households' produce used for household consumption purposes; therefore, they don't indicate household level savings and capital formation. Because the households have no other sources of cash income, it is from sale of farm products that they meet their cash requirements to cover all their expenses. In addition, not all food produced is available for consumption as allotments should be set aside for seeds.

Generally, the people of the study area, like those elsewhere in the country, are very poor and entirely dependent on nature. The use of chemical fertilisers is very low. Almost everyone heavily complains that the price of fertilisers is too high and prohibitive, contributing to growing food insecurity in their communities. Other modern agricultural inputs such as herbicides and pesticides are simply unknown to the farmers. The vulnerability of the households is such that, in any year, rainfall amount and temporal pattern determine the amount of food that would be available at the households' disposal. A shift in rainfall pattern of a cropping season easily translates into a period of food shortage. If shortage of rain extends for two consecutive cropping seasons, these subsistence farmers can become helpless victims of mass starvation.

3. LITERATURE REVIEW

3.1 Introduction

Ethiopia is one of the poorest countries in the world. The agricultural sector contributes disproportionately much to the national economy. It accounts for some 80% of employment, 85% of export revenue and 45% of the GDP (FAO 1993). Most of the total national agricultural produce is generated by the subsistence-oriented farmers, who are cultivating micro-holdings with impoverished soils on sloping and marginal lands. These smallholders constitute the poorest and largest segment of the population whose livelihoods directly depend on the exploitation of natural resources. They operate with obsolete agricultural technologies and with livestock playing the key role in the production process. The basic nature of the agricultural production is thus exploitative without sufficient use of ameliorative inputs, which is undermining the sustainability of the life support systems.

The pressure on the land resource is more severe in the highlands (> 1500 m.a.s.l) of the country, constituting some 45% of the total area. The highlands accommodate some 88% of the human and 75% of the livestock populations, and constitute about 95% of the regularly cultivated lands (FAO 1986). These highlands have, in deed, been settled for millennia, and agriculture has a matching history. Currently, the highland farming population grows with a rate of around 3% per annum, and correspondingly the livestock population is increasing. These place more demand on more marginal land for cultivation and grazing uses, leading to more de-vegetation and degradation. The de-vegetation and degradation of the grazing lands create shortages of fuel wood and animal feed, forcing the rural poor to divert dung and crop residues from their traditional roles as soil nutrient to burning for fuel and feeding livestock. Coupled with many other physical, socio-economic and political factors, these conditions are leading to degradation of the natural resource base. Of the forms of resource degradation, expansion of cultivation into steepland areas at the expense of natural vegetative covers and soil erosion by water are the most damaging.

Many empirical studies conducted in different parts of the country have reported that croplands expanded into marginal areas at the expense of natural vegetation covers. For instance, a significant increase in cultivated land at the expense of forestland was found to have occurred between 1957 and 1995 in the Dembecha area, northwestern Ethiopia (Gete and Hurni 2001). Kebrom and Hedlund (2000) have reported increases in open areas and settlements at the expense of shrublands and forests between 1958 and 1986 in the Kalu area, north-central Ethiopia. A rotational land cover/use involving cultivation and vegetation (forest and bush) was found to have occurred between 1957 and 1982 in the Metu area, southwestern Ethiopia (Solomon 1994). Increases in the farming compounds were reported for the Mafud escarpment around Debre-Sina, central Ethiopia, between 1957 and 1986 (Wøien 1995). Belay (2002) has reported a significant increase in the cultivated land at the expense of natural vegetation cover between 1957 and 1986 in the Derekolli microwatershed in south Welo, north-central Ethiopia. Such expansions of cultivation, commonly into steepland marginal areas without putting in place necessary soil and water conservation measures, lead to loss of soils due to erosion.

Soil erosion by water is by far the biggest problem in Ethiopia. According to Hurni (1993), national average soil removal is around 1493 million tones per annum, but with magnitudes as high as 300 t/ha/year measured at individual fields. On cropped lands, the same study has estimated the average soil loss rate at 42 t/ha/year or 4 mm of soil depth, which is sufficient to wear away the total soil profile within 100-150 years (assuming average soil depth of 60 cm in the highlands). In economic terms, soil erosion is estimated to lead to productivity loss of 1 to 2% per annum; while use of crop residues and dung, by contributing to biological degradation of the soil, is estimated to lead to a further 1% per annum decline in agricultural productivity (Hurni 1993). Erosion and biological deterioration of soil has implications on the country's structural food insecurity problem. With shallow and degraded soils, rainfall infiltration is severely reduced, moisture and nutrients storage capacity is strongly depleted, growth of vegetal cover becomes poor and the resistance to erosion significantly decreases – the process thus becoming self-accelerating. These conditions simply exacerbate effects of droughts and amplify variations in crop yields, thereby contributing to the famines.

The issue of land degradation and conservation was given a serious attention following the change of government in the early 1970s. Since then, considerable efforts have been made to tackle the problem. The largest of all was that carried out between 1976 and 1988 with assistance from the international community, particularly the World Food Program. Over this period, 800,000 km of soil and stone bunds and 600,000 km of terraces were installed; 500 million tree seedlings were planted; 100,000 ha of degraded lands were closed for natural regeneration; and check dams were constructed along gullies of tens of thousands of kilometres long (Daniel 1988; Wood 1990). This environmental rehabilitation endeavour was described as "impressive" by some and "astonishing" by others (Daniel 1988; Wood 1990). Yet, the area covered by these rehabilitation and conservation works was estimated at only 7% of the total that needed treatment. With this rate, it was estimated that all the area awaiting treatment could take some seven decades (Berhe and Chadhokar 1993).

Even worse is, however, that the reported achievements were later evaluated as ineffective, insufficient and unsustainable (Stahl 1990; Yeraswork 2000). The whole effort was, therefore, largely a failure due to a number of factors. The most important factor is said to be the top-down policy approach pursued in the implementation processes, which made the conservation works unattractive on the part of the farmers. That is, due consideration was not given to understand locale-scale factors that would affect farmers' acceptance and adoption of conservation measures at the farm level. In the study area also, as in the rest of the country, there was an extensive attempt for land conservation with a similar implementation process, which was then unsuccessful. A lasting solution to the problem evidently requires a new approach in which there is a genuine involvement of the direct-land users, i.e., the subsistence farmers. Thus, a clearer understanding of the magnitude of land degradation and local-specific socio-economic and institutional factors influencing farm-level conservation decisions is necessary.

3.2 Theoretical Framework

Land degradation has been defined in several ways. Some of the definitions are very general and address to all types of processes leading to a negative change in productivity of land under all types of uses. An example of these types of definitions is that given by Dudal (1981) who describes it as a loss of land productivity, quantitatively or qualitatively, through various processes such as erosion, salinisation, water logging, depletion of nutrients, deterioration of soil structure, and pollution. Others are restricted in spatial coverage. For instance, the UNCCD (1994) defines land degradation as reduction or loss, in arid, semiarid, and dry subhumid areas, of the biological or economic productivity and complexity of rainfed cropland, irrigated cropland, or range, pasture, forest and woodland. The multiplicity and generality of the definitions are partly to overcome the problem that the term “land degradation” is a value-laden one. As such, what one land user may consider as beneficial changes in land quality may be considered as detrimental by another. Hence, it becomes a matter of perception dependent on one’s preferences, production objectives, and value systems at large. In this study, the definition by Blaikie and Brookfield (1987) is favoured. Accordingly, land degradation is a decline in the productive capacity of the land in relation to actual or possible uses and hence a problem for those who use the land. The definition is comprehensive and, more importantly, views land degradation from the perspective of the direct stakeholders – the land users. Land degradation is a process that frustrates economic development, which in turn can have a strong causal impact on the incidence of the degradation process.

Land degradation is sometimes taken as synonymous with soil degradation. Strictly speaking, however, land degradation is more than degradation of the soil, as the preceding definitions indicate. Soil degradation is just an aspect of land degradation; in agrarian countries such as Ethiopia, it is certainly the most important one. The term soil degradation is also far from simple because there are so many types. It stands for all the processes that can lead to the lowering of current and/or future capacity of the soil to support human life. Hence, it is a sweeping concept for the deterioration in soil quality in terms of its physical, chemical and/or biological attributes as well as its removal by the process of erosion. Of these, the removal of soil by water is the most widespread and critical problem in Ethiopia. In fact, soil erosion is the most serious form of land degradation at the global scale (El-Swaify 1994). In accordance with this, SWC technologies have always occupied a central role in solutions to the land degradation problems.

In the degradation-conservation discourse, three major perspectives have recently emerged: classic, populist and neo-liberal (Biot *et al*. 1995). According to the classic approach, the problem of land degradation can be overcome by technocratic solutions, thus tending to ignore the socio-economic side of the problem. On the other extreme, the populist approach puts emphasis on the role of local knowledge and land management practices and underscores the importance of stakeholder participation in conservation activities. In this perspective, the link between poverty and land degradation is critical; policy formulation and action towards conservation should base itself on local peoples' knowledge and land use practices. Taking a middle-ground position, the neo-liberal approach draws from both the classic and the populist approaches. It acknowledges the classic approach in its view that technology is available to control land degradation that can be adopted or adapted wherever and whenever required. Acknowledging the populist view, the neo-liberal approach puts emphasis on empowerment of the people for their adoption or adaptation of the technologies at the farm level. In other ways, the argument on major causes of land degradation incorporated in this neo-liberal view is centred on institutional failures and lack of adequate incentives for the adoption/adaptation of conservation technologies among the land users. This study employed the neo-liberal approach as its theoretical backdrop. Therefore, it holds the view that there is a plethora of land conservation technologies. The problem lies in the acceptance and adoption of the technologies by the land users. That is, the problem of land degradation persists in Ethiopia, and elsewhere for that matter, not because of lack of technical fixes to the problem but due to lack of sufficient consideration of socio-economic and institutional factors in solution prescriptions.

4. RESEARCH DESIGN

4.1 Data Sources and Methodology

4.1.1 Appraising Land Degradation

One of the problems in the land degradation/conservation issue is the determination of the extent and rate of the degradation process. What to measure and how to measure present a formidable challenge given the value-laden nature of the concept of land degradation. Generally, however, dynamics in land cover/use (specifically de-vegetation), soil erosion and soil nutrient depletion are the most commonly used indicators. Following this customary practice, land cover changes and rates of soil erosion by water were used as indicators and evaluated in this study.

4.1.2 Assessment of Land Cover Changes

The materials used to create the spatial databases needed for the evaluation of land cover changes were two sets of panchromatic aerial photographs taken in December 1957 and January 1982. Both sets of photographs have base scales of about 1:50,000 and were obtained from the Ethiopian Mapping Authority (EMA). The establishment of the databases involved the following procedures: i) scanning the aerial photographs with 600 dots per inch scanner; ii) geo-referencing the photo mosaics according to the Universal Transverse Mercator (UTM) system using 1:50,000 topographic map of the area, and iii) delimiting and cutting out the study watershed by first tracing it from 1:50,000 topographic map and digitising this separately in Arc View 3.1, and then superimposing the view on the spatial databases created from the photos.

The identification and classification of land cover types on the aerial photos required intensive use of mirror stereoscopes for visual verification because the photos were black and white. To avoid errors that would occur as details increase, the classification scheme was kept simple as follows: forests, woodlands, shrublands, open grazing lands, croplands and settlements. Arc/Info version 3.5.1 was used to analyze the spatial databases created. Finally, two land cover maps were produced using Arc View 3.1, corresponding to the two years of reference, and temporal changes in the land cover were determined. Due to the absence of aerial photographs of a recent year, maps could not be produced for the present land cover. It was also not possible to update the 1982 land cover/use map through field surveys due to the time constraint. However, only little change would be expected between 1982 and the present time.

4.1.3 Measurement of Soil Erosion

The evaluation of soil erosion was undertaken through measurement of visible erosion features – rills – in some selected and representative fields within the watershed. Rill erosion constitutes one of the mechanisms of soil loss by water. Rills are very shallow channels that are formed by the concentration of surface runoff along depressions or low points in sloping lands. The shearing power of the water can detach, pick up and remove soil particles making these channels the preferred routes for sediment transport. Soil erosion that occurs in areas between rills by the action of raindrops (causing splash erosion) and surface runoff (causing sheet erosion) is called interrill erosion. Rills differ from gullies in that they are temporary features and can be easily destroyed during ploughing, whereas gullies are more permanent features in the landscape (Stocking and Murnaghan 2000).

Rill erosion is probably the most important form of soil loss in cultivated fields because in the absence of these channels, which serve the purpose of transporting detached materials, interrill erosion will be negligible. Hence, assessment of soil loss by surveying rill erosion gives a good understanding of the process of land degradation due to erosion. Rill erosion survey is a semi-quantitative method for assessing the extent of erosion damage under field conditions, without involving expensive instrumentation, long lead times or/and sophisticated modelling (Herweg 1996). It is a more conservation-oriented method of soil erosion assessment than the plot and watershed level studies (Herweg 1996). Some researchers also argue that good field surveys of erosion produce results fairly comparable with test plot derived data (Govers 1991; Evans 1993). According to Herweg (1996), results from erosion survey are within 15% accuracy for careful applications. Obviously, however, being a semi-quantitative and qualitative assessment, survey results cannot be taken as reliable estimations of soil loss. Still, the low cost and the ease of application under natural conditions somehow compensate for the precision and the high cost that test plot and watershed levels command. Generally, erosion survey is currently accepted as a good alternative approach to soil erosion research for it has multiple advantages (fastest, cheapest and under actual on-farm situations) (Turkelboom and Trébuil 1998).

For this study, ten representative fields (with a total area of 42,457 m^2 or 4.25 ha) were selected for the rill erosion survey. The topographic position of the fields was such that they represent the cultivated slopes in the study area. The fields were in the slope angle range of 10 to 12%. All of the surveyed fields were linear in slope shape. The types of crops cultivated in the surveyed fields were barley, oats, wheat and *tef*. Oats was the dominant crop type (36.5% of the total area surveyed) closely followed by wheat (35.6% of total area). *Tef* had the least area coverage (12% of total area). Excepting *tef*, all of the crops have very similar canopy characteristics and cropping calendars (table 8). Hence, they have similar implications on the erosion process. According to Hurni (1985a), the annual average crop cover factor (C-factor) of the Universal Soil Loss Equation (USLE) is 0.20 for barley, oats and wheat. *Tef* has a C-factor of 0.25. For sowing barley and oats, ploughing started with the first rains; and for wheat and *tef*, ploughing started before the first rains. Ploughing was done repeatedly before sowing because the farmers believed that it controls weeds, giving better crop yields. The frequency of ploughing varied with crop types. The *tef* fields were ploughed 5 to 7 times; for the other crops, the fields were ploughed only 3 to 4 times. The ploughing created a very rough surface, which provided a large storage space for the rainwater, thereby contributing to the protection of the soil from erosion. However, the roughness got smoothened over time mainly due to raindrop and surface runoff impacts as the amount of the rain increased. The only SWC measures applied by the farmers were traditional ditches known locally as *feses*, which were meant for a safe disposal of surface runoff. Generally, the differences amongst the surveyed fields in terms of land use and management practices were negligible.

Table 8. Cropping calendars for the different crops cultivated in the study site

Crop type	Ploughing	Sowing	Weeding	Harvesting
Barley	April – June	June	September	Nov. – Jan.
Oats	April – May	June	Aug.– Sept.	Nov. – Dec.
Wheat	Jan. – July	June	July – Aug.	Nov. – Jan.
Tef	Jan. – July	July	Aug. – Oct.	Nov. – Jan.

Each field was intensively monitored for rill erosion over a wet season, between June and August, of the year 2002. The survey involved repeated visiting of the fields. Once the emergence of the rills was noticed, measurements could be taken. Each rill was carefully measured for its dimensions of length, width and depth. The length of a rill was measured from its starting point up to the place where sedimentation occurred. In cases of rills that come laterally and merge with a main rill, the length was measured from the starting point up to the confluence with the main rill. Some of the rills were not following the direction of the steepest slope, in which case the lengths were measured following their shape. The width of a rill varies across its depth and length. Depending on the depths and lengths, therefore, widths were measured at two or three depths at a point and at several points along the length. Likewise, depth measurements were taken at two or three sites at a point and at several points along the length. These measurements allow determination of rill volumes, which in turn allows obtaining average magnitudes and rates of soil erosion for the fields with an acceptable margin of error. The development of the rills was observed to be a dynamic process. Some of the rills form at the beginning of the wet season and grow in size throughout much of the wet season, while others disappear soon after their formation. In almost every field, maximum development of rills, both in number and dimension, was attained towards the end of the wet season. This maximum value is analysed in this paper as it presents the total soil loss due to rills.

During the survey, some on-field observations were made on field characteristics for a qualitative description of the erosion process. It is recognised that the estimated soil loss rates remain not only best approximations of erosion due to the rills but also exclude soil loss by the inter-rill erosion processes. Hence, the reported figures ought to be understood with due caution. No attempt was made to measure the damage caused by siltation of eroded materials, as the more important process in the monitored cultivated fields was erosion.

4.1.4 Farmers' Acceptance and Adoption of Newly Introduced Conservation Technologies

The data for this objective were generated by employing multiple methods of social research. The techniques employed include formal household survey and informal discussions with individual farmers and an extension worker, officially called development agent (DA), working at the site. For the formal household survey, a sample of 64 farm households who possessed fields treated with the introduced SWC technologies were randomly selected and interviewed, of which only one was female-headed. This represented more than 31% of the total number of households owning farm fields in the treated microwatershed. As sample size depends on variability of a population to be sampled and given the homogeneity of the subsistence farmers of the study area in many respects, the sample size was sufficiently representative. The survey questionnaires comprised closed- and open-ended questions.

The questionnaires generated information on the extent of the farmers' acceptance and adoption of the introduced conservation technologies in reference to their awareness and perception of erosion hazard, labour supply and the land tenure system constraints, effectiveness of the technologies in arresting erosion, fitness of the technologies to the farming system circumstances and the approach followed in the planning and implementation of the technologies. In addition to this, information was collected on household demographic and socioeconomic characteristics, as they are relevant for explaining the perception of the soil erosion problem and the adoption of conservation measures. The interviews were conducted by going to each interviewee's homestead. Each respondent was informed about the purpose of the survey before starting the interview. Attempt was also made to crosscheck responses of the farmers on such questions as landholding sizes and number of livestock owned from records of the DA, as farmers sometimes understate these fearing that land use fees and other government obligations might be increased.

The other method of data collection was informal discussion with individual farmers and the DA. This informal dialogue with the farmers provided a forum where they openly expressed their opinions and views. The issues raised during the informal discussions were similar to those covered by the structured survey questionnaires. The rationale of obtaining information about the same fact from multiple methods is to increase validity and reliability of data.

The data generated by the structured questionnaires was analysed using the frequencies and descriptive procedures of the SPSS release 10 (Bryman and Cramer 2001). Sample means and variations were calculated for attributes that are parametric, and sample proportions were calculated for the attributes that are categorical. The qualitative data generated by the informal discussions was used to substantiate and augment the quantitative results from the structured questionnaires.

4.2 Data Analysis and Interpretation

4.2.1 Land Degradation

A. Changes in land cover/use

Land cover maps of the watershed for the two years of reference derived from interpretation of the remotely sensed images are depicted in Figs. 3 and 4. For clarity, a brief definition of the various land cover/use types is given in table 9, and statistical summaries of the land cover types for the two years of reference are given in table 10.

Table 9. Description of the land use/cover classes identified in the Digil Watershed

Land use/cover	Description
Forest	Areas covered with dense growth of trees that formed nearly closed canopies (70-100%). This category included plantation forests, mainly eucalyptus and junipers, mixed with regenerating “indigenous” species of trees and bushes.
Woodland	Areas with sparse trees mixed with short bushes, grasses and open areas; less dense than the forest.
Shrublands	Areas covered with shrubs, bushes and small trees, with little useful wood, mixed with some grasses. Some riverine trees were also included in this category
Grazing lands	Open grassy areas used for communal grazing, as well as bare land that has very little or no grass cover (exposed rocks) but with the same tone on the air photos.
Croplands	Areas used for crop cultivation, mainly annuals.
Settlements	The scattered rural settlements. Some trees, mainly eucalyptus, which are commonly found around homesteads, were also included in this category.

1957: Most of the area was occupied by croplands (36%), followed by woodlands (28%) and open grazing lands (25%). Forest and shrublands covered some 1.6 and 9.5% of the total area of the watershed, respectively.

1982: The largest proportion of the watershed remained under croplands by 1982 as well. But it had shown an increase, by more than 9.7 ha per annum between 1957 and 1982, to account for 65% of the total area of the watershed by 1982. The increase of cropland area was corresponding to the growth in population numbers. Areas of woodlands and open grazing lands showed a decrease over the same period. The decrease was very high for the open grazing lands; it decreased from nearly 25% of the total area of the watershed by 1957 only 1.3% by 1982. This represents a rate of decrease of nearly 8 ha per annum. In addition to the growth of population, the decrease in the area of grazing lands was possibly due to the national level land reform of the 1975, which should have allocated a good part of the grazing lands for landless peasants. Areas under forest and shrublands increased between 1957 and 1982. The rate of increase was much higher for the shrublands than for the forest; the area of shrublands increased by 60% while that of the forest increased by only 5.2%. Human settlements emerged as a land cover type in the watershed between 1957 and 1982, and accounted for 2.4% of the total area.

Over the twenty-five years considered, the major changes were the increase of the cropland and shrubland areas at the expense of the open grazing and woodland areas. Unexpectedly, the forest cover showed an increase, but only very slightly. This increase is attributable to the reforestation and afforestation activities during the *derg* regime and the planting of trees at the household level. As in many places throughout the country, there existed some afforestation undertakings by the community during the *derg* regime. The little success achieved by this contributed to the increased area coverage of the forests. Much of the tree species planted by then were junipers and eucalyptus varieties. The most important factor for the increased area coverage of forests is, however, the household level planting of trees, as a response to the growing scarcity of natural forests for various uses. By 1957, the entire forest area was under indigenous species; whereas by 1982, almost all the forest area was of eucalyptus species.

Table 10. Land cover changes in the Digil watershed between 1957 and 1982

Land cover	Area in ha (1957)	% of total	Area in ha (1982)	% of total	Change between 1957 and 1982 (%)
Forest	13.5	1.62	14.2	1.70	+ 5.2
Woodlands	234.7	28.11	118.6	14.21	- 49.5
Shrublands	79.6	9.53	127.7	15.30	+ 60.0
Croplands	300.4	35.98	543.5	65.09	+ 80.9
Grazing lands	206.7	24.76	10.9	1.31	- 94.7
Settlements	-	-	20.0	2.39	+ 100.0
Total	834.9	100.00	834.9	100.00	-

B. Causes of the land cover changes

Land cover changes are caused by a number of driving forces spanning from natural to human (Meyer and Turner II 1994). While impacts of the natural driving forces such as climatic change are felt only over a long time period, impacts of the human drivers are immediate and radical. Of the human factors, growth in population numbers is the most important under the Ethiopian setting (Hurni 1993) and generally in the underdeveloped countries (Hurni 1993; Mortimore 1993). For the study watershed, it was not possible to obtain population figures because such socioeconomic data are organised along administrative structures. But the population growth rate at the national level shows that there has been an increasing population pressure on the land resource base. Along with the growth in human population, increase in the livestock population is to be expected. Hence, the growing human population had certainly been the most important factor to the observed land cover changes through greater demands it imposes on land for cultivation and settlement and on trees for fuel and construction purposes.

C. Implications of the land cover changes

i. Implications for soil degradation

Land cover is one of the factors that determine the rate of loss of soils due to erosion. It influences both factors of erosivity of the eroding agents and erodibility of the eroding subject (Morgan 1995). From the point of view of land exposure to erosive storms, typical of the area, the land cover types in the watershed can be classified into two classes: i) the bare lands by the time of erosive rains; and ii) lands under good vegetative cover by the time of erosive rains, thus largely free from the threat of erosion. Cultivated fields and part of the open grazing lands constitute the first category, while the rest of the land cover types can be included in the second. Accordingly, part of the watershed vulnerable to possible maximum soil loss accounted for around 60 and 76% of the total area in 1957 and 1982, respectively. At the same time, the slightly increased forest cover in the watershed cannot imply a lessened severity of erosion because most of these were areas under eucalyptus plantations, which would not reduce erosion due to the sparse canopies (FAO 1988).

ii. Implications on hydrological balance of the watershed

Land cover changes are interference in the land phase of the hydrological cycle. Land under little vegetative cover is subject to high surface runoff and low water retention. The increased runoff causes sheet erosion to intensify and rills and gullies to widen and deepen. The masses of sedimentary materials removed from hill slopes accumulate downstream, and there create problems of water pollution, reservoir in-filling and sedimentation of important agricultural lands. Following the above grouping of the land cover types into two, the total area of possible maximum runoff had increased between 1957 and 1982. Also, the increased area under plantations cannot imply a salutary condition from the point of view of regulating hydrological balance of the watershed, because the tree species widely planted was eucalyptus, which has a reputation of being heavily thirsty.

4.2.2 Soil Erosion

A. Magnitude and rate of soil loss by rilling

Table 11 shows the total length and volume of rills in all of the surveyed fields. The total number of the rills was 34 with a total length of 861m. This figure represents rill density of 202.8 m/ha. The total volume of all the rills was 98.5m^3 (23.2 m^3/ha). This is equivalent to 25.52 t/ha of soil loss given the soil bulk density of 1.1 g/cm^3. Because of the exclusion of the interrill erosion, the measured rill erosion rates underestimate the actual rate of soil loss. According to Govers (1991), the contribution of interrill erosion can be more than 30% of the total soil loss in fields where rills are present. Assuming that the measured rill erosion rate underestimated soil loss by 30%, the actual soil loss rate was around 36.5 t/ha.

The estimated soil loss rate in the Digil microwatershed was lower than the average rate estimated to occur from cultivated fields in the country (42t/ha/year). But it is within the range of soil erosion rates measured in a nearby experimental microwatershed, the Anjeni, located about 45 km northwest of this site. In a five-year monitoring, soil erosion from cultivated fields under the traditional land use practices in the Anjeni ranged from 17 t/ha to 176 t/ha per annum (Herweg and Ludi 1999).

Table 11. Total length and volume of the rills and damaged area

Rill parameter	Measured quantity
Length (m)	861.00
Volume (m^3)	98.50
Damaged area (m^2)	432.70
Damaged area out of total area (%)	1.02

The total area of actual damage, the surface area covered by the rills themselves, was 432.7m^2 (table 11). These areas show the direct impact of rill erosion on productivity of the cultivated fields via reduction of the total areas. However, the impact of rill erosion is much more than just a reduction in the area of productive land. Rill erosion is a result of surface runoff and associated sheet wash, which is a process that selectively removes fine material and organic matter that are very important determinants of land productivity. On the other hand, the area of actual damage as a proportion of the total land area can give a clue as to the type of SWC that will be required. That is, the quantity of soil lost can be the same while the total area damaged is different, as in the case of several small rills and a single large gully. In the case of the former, SWC measures should be covering the whole field like mulching; whereas in the case of the latter, measures against the single gully will suffice.

Soil loss showed stronger and more significant correlation (at $P < 0.01$) with rill depths ($R^2 = 0.400$) than widths, which are having important implications on the SWC types that can be recommended. Depth was, hence, used to classify the rills into size categories. Accordingly, three classes of rills were identified: small (shallow) (≤ 20 cm), medium (21-25 cm) and large (≥ 26 cm). Following this classification, 35% of the total rills were in the small and 50% in the medium size classes. The large rills were the least in number (15% of the total) (table 12). Many of the small rills ended within individual fields and caused sedimentation problems. Though the sediments were left within field boundaries, fine materials and organic matter, which play vital roles in soil productivity, were obviously leaving fields suspended by surface runoff.

The medium rills contributed the largest share to the total soil loss, matching with the number of the rills. However, the contributions of the small and medium rills to the total soil loss and total area of actual damage were less than their proportionate contribution to the total number of the rills. On the other hand, the contribution of the large rills to total soil loss and area of actual damage by far exceeded their proportionate contribution to the total number of the rills. This reveals the existence of a positive and significant relationship between the depth and, width and length dimensions of the rills. Obviously, it is easier to control soil erosion by the fewer but larger-sized rills than the small but numerous rills as it will be requiring, say, construction of check dams and a single grassed waterway.

Table 12. Soil erosion caused by the different categories of rills

Size of rills	No. of rills	Total soil loss (m^3)
Small	12	26.81
Medium	17	40.80
Large	5	30.89
Total	34	98.50

B. Processes and immediate causes of rill initiation and development

Rill formation starts at the beginning of the rainy season. The beginning of the rains is the end of the long dry season over which all cultivated fields have stayed as communal grazing grounds and the soil has been exposed to the vigorous sun. This means that the soil is largely bare by that time, which increases its vulnerability to erosion. The monthly distribution of the rainfall in the area as observed at the meteorological station of Debre-Markos (close to Digil) is shown in Fig. 2. The rainfall is unimodal, extending from early February to end of September with a peak in August. It shows high concentration, more than 75% of the total falling in the four months of June, July, August and September. This concentration has important implications on runoff generation, erosion and SWC.

Both total amounts and few erosive storms were observed to be important in the process of rill erosion. Rills were initiated mostly by few destructive storms, but their continued growth throughout much of the wet season was the effect of the accumulative total rainfall. As was observed during the fieldwork, once they were initiated, most of the rills grew in length, depth and width throughout much of the wet season. This growth of the rills, while the land cover was improving, was a result of protection from being damaged by sheet wash and subsequent sedimentation by the cover itself. However, some of the rills, without sufficient protection to maintain their structures and sustain their flow, disappeared soon after their formation due to sedimentation. On the other hand, new rills continued to form throughout the wet season until the crops grew to heights that could effectively cover the ground surface and protected the soil. The formation of new rills in the later periods of the wet season was an effect of the higher antecedent moisture condition that contributed to generation of more runoff. The net effect was that maximum number and length of the rills was attained towards the end of the wet season in almost every field.

As was observed in the field, the immediate causes of the rill formation and development could be classified into three categories: within-field concentration of runoff, runoff from upslope areas and breaking or overflowing of traditional ditches meant for soil conservation, locally known as *feses* However, it was not possible to precisely determine the number of rills formed and/or the quantity of soil lost attributable to only one of the three causes due to the interaction with one another. For instance, runoff from upslope was, in some of the cases, the cause for the destruction of the *feses* and subsequent formation of rills. Within field concentration of runoff caused formation of rills, and in some other cases, it was a cause for the destruction of the *feses*. Therefore, these three factors were interacting in complex ways, finally leading to a common consequence – loss of the soil.

In cases where the within-field concentration of runoff was apparently the most important cause, the rills formed were small and ended within the fields themselves. Practically, these small rills simply translocated soil material within a single field, which will be redistributed by ploughing during the next agricultural season. Nonetheless, the within transfer of soil material also causes losses in land productivity by the erosion in a part of the field and by the deposition in another. Thus, it causes both the on-site and off-site costs of the process. The within-field concentration of runoff was accompanied by large volume of flow from upslope areas; all of the fields received runoff from fields in the upslope position. The sources of the runoff were cultivated fields.

The runoff generated within-field combined with that coming from upslope areas not only formed a network of rills, but also was a major cause for the overflowing or breaking of the *feses*, which in turn was observed to be a major cause of rill formation. The breaking or overflowing of the *feses* was basically a result of ill-designed dimensions, siltation and in-filling of the *feses* and total absence of maintenance of these structures after initial damages. The construction of the *feses* considers only land slope and not any other factors. Hence, breaking or overflowing of the *feses* was a rather common phenomenon after every high intensity storm. Once overflowing occurs along a *feses*, the energy released caused the destruction of many others in the downstream position. The siltation and in-filling of the *feses* was more common in lower ends of fields, where the runoff spreads out over a larger surface and forms a deposition fan (crop damage). The overflowing water was in turn a cause of damage in downstream fields.

4.2.3 Land Management Activities with Conventional Measures

Land management activities focusing on conventional measures were underway in the Digil watershed beginning from January 1999. The *woreda* office of the agricultural ministry was carrying out the work with financial support from SIDA. It was a five-year resource management and development project where the watershed was serving as a trial site for the SIDA on-farm research program in the Amhara Regional State. The approach pursued in was an integrated watershed management (IWM) type, where SWC was given a central place. The components of the project include SWC, promotion of afforestation and agroforestry practices, crop production improvement through variety and agronomy trials and small-scale irrigation development, and forage and livestock development. Table 13 shows the total cost (budget) of the project over the 5 years. The largest sum was for forage and livestock development (37.6%), followed by that for the establishment of a nursery (27.5%). The budget for the construction of the physical SWC structures accounted for 13.6%. But it can be said that it had also a share in the establishment of the nursery because some of the seedlings produced were to be planted on the physical SWC structures (agroforestry). The study focused on the SWC component of the project.

The trial site did not cover the whole of the Digil Watershed. It is only part of the watershed, one side of the stream channel, which was within the trial boundary. The total area of the watershed within the boundary of the trial site was only 360 ha. This total land area was cultivated by a total of 205 households, who also had some additional plots of land elsewhere outside of the trial site's boundary. The total population accommodated by these households was 722, which was constituted of 354 males and 368 females. This gives an average household size of 3.5 members. The average land holding of the households using lands within the watershed was 1.54 ha.

All the farmers living in the *Melit* village, wherein the watershed is located, who possessed plots of land within the boundary of the watershed delimited for the trial as well as those outside were involved in the implementation of the conservation measures. There were only few households who were exempted from the work. This group of people included clergymen, the elderly and female-headed households without working-age children. As an incentive to the farmers whose plots were treated, spades and shovels had been given by the beginning of the project (in 1999). Giving of these farm implements as indirect incentives was preferred to giving direct incentives, such as food-for-work payments, to increase the willing participation of the farmers by avoiding dependency mentality among the farmers.

As was learned from discussions with the development agent (DA) working in the site, the local people were initially opposed to the idea of the watershed management intervention. Their resistance stemmed from the fear that the watershed was to be set aside for a community forestry development. Convincing them about the whole purpose of the program took a great deal of time and involved repeated meetings and thorough discussions. The final option was to take a few influential farmers, who were selected by the local people themselves to one of the experimental watersheds of the soil conservation and research project (SCRP), the Anjeni, to see outcomes of a watershed management undertaking. Reportedly, after hearing from these influential farmers, the local people agreed to undertake the watershed management activities. Thus, it is believed that the farmers' participation in the watershed management project was ensured right from the very start and before the beginning of any actual work on the ground.

The task of facilitation in the implementation of the planned intervention works was a responsibility given to the DA, whose wage was paid by SIDA. A "Development Committee" was formed and made available to assist the DA, particularly concerning non-compliance and absenteeism during conservation working days. The Development Committee together with the DA ensured that each household came for the conservation work on the specified dates and times. If a household failed to come for the work for non-serious reasons, he/she would be fined Eth. Birr 3.00 for each day of absenteeism. But if one could present a valid reason, he/she was simply made to do the work in another day. The strictness with the agreed-up-on days was simply meant to make sure that each household accomplished its share of the conservation structures. Once the structures were constructed, all the maintenance work was the responsibility of the individual land users. However, by the time of fieldwork for this study, there was also a guard who protected the conserved areas from destruction by the free-grazing livestock. His payment was on food-for-work basis, which was 50 kg of wheat per month. The grain was purchased with money from SIDA through the *woreda* office of agriculture. The community excused the guard from attending such social events and obligations as *mahber* and *iddir*.

Table 13. Total cost for resource management and development activities, 1999-2003

Activity	Cost (Birr)	% of total
Soil conservation	62,823.00	13.6
Nursery establishment	127,014.00	27.5
Crop improvement and irrigation	98,490.00	21.3
Forage and livestock development	174,155.00	37.6
Total	462,482.00	100.0

4.2.4 The SWC Measures under Implementation

The conservation measures that were under implementation and planned to be implemented are described below.

A. Graded soil, stone and *fanya juu* bunds

These structural measures are generally meant to break slope length and angle. By shortening the slope length and reducing the slope gradient, these measures suppress the velocity of runoff and thereby the kinetic energy (erosive power) of the overland flow. The soil bunds are earth embankments constructed across the slope with the ditch on their upslope side and the earth material excavated thrown down slope. The stone bunds are stone embankments constructed across the slope to act as a barrier to runoff and to retain sediments on their upslope side. *Fanya juu* is a Swahili term meaning “throwing up slope”. Thus, these are structures made by digging a ditch and throwing the excavated earth material upslope to form the embankment. Upslope of the embankment acts as a barrier to runoff and provides storage space for soil sediments and nutrients. The trench in the down slope position of the embankment impounds any runoff that may spill over the embankment to safely drain it off the agricultural fields. *Fanya juu* bunds are sometimes called converse terraces. By the time of this study (first and second years of the project), no stone bund was constructed. But a total of 60 ha was covered by the soil (4 ha) and *fanya juu* (56 ha) bunds. The design of these bunds was such that they were graded 0.5-1.0% and the vertical intervals were 1.0-2.0 m, depending on the slope of individual fields. The ditches had a width of about 75 cm and a depth of around 50 cm.

B. Cut-off drains

The cut-off drains are open and graded diversion channels with a supporting embankment on their down slope position. These structures are constructed across a slope so that they intercept runoff coming from up slope, which is finally safely conveyed into a natural or artificial waterway. The embankment in the down slope position is meant to protect the runoff from spilling over the ditch and damaging fields located down slope. A total of 0.665 km of cut-off drains was constructed above fields located on steep slopes, in the first and second years of the project.

C. Artificial waterways

The artificial waterways, also called drainage ways, are man-made channels meant for collecting runoff from hill slopes, cut-off drains and bunds, and evacuate it safely into natural drainage systems, where it can empty into streams or rivers. The general technical requirement of artificial waterways is that it should possess sufficient dimensions to carry the runoff that will be generated from the prevailing rainfall conditions. Also, the channel needs to be stabilised by planting grasses or paved with stones so as to protect its development into gullies. A total of 0.375 km of artificial waterway was constructed in the first and second years of the project.

D. Check-dams

Check-dams are structures that are established across gullies to provide a physical barrier for the flowing water and initiate the process of sedimentation. They can be made of stone or tree shrubs. Check-dams encourage the growth of vegetative cover in the gully floors, providing protection against further erosion and stabilising it. Check-dams can eventually raise the floor up to the level of the surrounding and original ground. The slope of fields and runoff amounts that are generated during rainfall events determine the dimensions and spacing of these structures. That is, the length of check-dams depends on the width of the gullies to be checked (or stabilised and rehabilitated), and the width should not exceed from 1.0 m and its height. The horizontal spacing depends on the gradient of the gully talweg. The total length of check-dams constructed during the first and second years of the watershed management intervention in the Digil watershed was 0.268 km, and the overall plan was to build a total of 0.40 km over the five years.

E. Agroforestry practices to stabilise the structural measures

Agroforestry is the practice of planting and management of trees or shrubs in croplands and/or pasturelands to get economic and/or ecological benefits from the interaction between crops or livestock and the trees or shrubs. In agroforestry systems, the trees or shrubs can be grown with crops at the same time and in the same field or at the same time in adjoining fields or in the same field at different times. In the Digil watershed, the agroforestry practice was designed to involve planting of shrubs and trees along the SWC structures, mainly meant to stabilise the bunds. Planting of trees and shrubs of multipurpose species on the *fanya juu*, soil and stone bunds, on the bunds of cut-off drains, along the sides of artificial waterways and on check-dams was a component of the watershed management activities. This agroforestry and afforestation component involved establishment of one nursery with a physical expanse of 0.25 ha and a capacity of 200,000 seedlings. In the first and second years of the project, a total of 535,345 seedlings were produced and a total area of 29 ha was covered by agroforestry plantations along the SWC structures.

In addition to SWC and soil fertility maintenance, the seedlings produced at the nursery were also meant for meeting the fuel and construction wood demand of the population and production of animal fodder. The species being tried were, therefore, multipurpose. The seedlings produced were of many species: sesbania, different species of acacia trees, junipers, eucalyptus and others. A total of 860,000 seedlings were planned to be produced in the five years and to be planted in the watershed. The total area expected to be under plantations in the watershed was 160 ha. Appropriate sites for planting of the trees, added to that along the SWC measures, were identified to be homestead compounds, farm boundaries, road sides, river banks and bare lands.

4.2.5 Planning of the SWC Works and Actual Implementation

Tables 14 and 15 show the five years' plan for the construction of physical SWC measures, and afforestation and agroforestry components of the project. The *fanya juu* bunds were the most preferred structures. The rationale behind the preference was that *fanya juu* bunds take less space than soil bunds and also transform into bench terraces over a shorter period of time. A total of 150 ha of land was planned to be treated with *fanya juu* and soil bunds over the five years' period, consisting of 95 ha *fanya juu*, 50 ha soil and 5 ha stone bunds. The task of constructing the physical measures was equally divided among the five years. According to the planning, maintenance of the bunds was to be carried out every year.

The agroforestry and afforestation works form integral parts of the SWC measures. A total area of 160 ha was expected to be under plantations by the end of the five years. Unlike the construction of the physical SWC measures, the production of seedlings and the agroforestry and afforestation works were not equally distributed among the five years (table 15). The number of seedlings that were planned to be produced was 300,000 in the first and second years of the project, 360,000 seedlings in the third and fourth years and 200,000 seedlings in the last (fifth) year. Correspondingly, the areas that were planned to be under plantations were 20 ha in the first year, 60 ha in the second and third years and 80 ha in the fourth and fifth years of the project.

Table 14. Plan for the construction of the various SWC structures

Activity	Unit	Yearly plan	Total quantity
Soil bunds	ha	10.00	50.0
Fanya juu bunds	ha	19.00	95.0
Stone bunds	ha	1.00	5.0
Cut-off drains	km	0.60	3.0
Artificial waterways	km	0.40	2.0
Check-dams	km	0.08	0.4
Maintenance of the bunds	ha	30.00	150.0

Table 15. Plan for the production of seedlings and afforestation and agroforestry activities

Activity	Total quantity	Plan for the five years				
		*1st year	2nd year	3rd year	4th year	5th year
Seedling production	860, 000	150,000	150,000	180,000	180,000	200,000
Afforestation and agroforestry	160 ha	20 ha	30 ha	30 ha	40 ha	40 ha

*The 1st year of implementation is 1999/2000.

The actual implementation of the plan during the first and second years of the project is shown in table 16. In both years, the actual implementation exceeded what was planned to be achieved in some of the activities, but fell below the planned in some others. In the first year, the construction of *fanya juu* bunds and check-dams, and the production of seedlings and the agroforestry works were accomplished at higher levels than planned. The actual implementation exceeded the planned by 42.1% in the *fanya juu* bunds construction, by 135% in the check-dams construction, by 109.7% in the production of seedlings and by 45% in the agroforestry works. On the other hand, in the same year, the actual implementation of the construction of soil and stone bunds, cut-off drains and artificial waterways was below planned. Actual implementation of these works was 20% of the planned for soil bunds construction, 41.7% for the cut-off drains construction, 78.7% for the artificial waterways construction and none for the construction of stone bunds. The total labour input for the works accomplished in the first year of the project was 612 working days, estimated at Eth. Birr 4, 284.00.

Table 16. Actual implementation of the SWC plans

Activities		1999/2000		2000/2001	
	Unit	Planned	Implemented	Planned	Implemented
Soil bunds	ha	10	2	10	2
Fanya juu bunds	ha	19	27	19	29
Stone bunds	ha	1	-	1	-
Cut-off drains	km	0.06	0.25	0.60	0.415
Artificial waterways	km	0.04	0.315	0.40	0.060
Check-dams	km	0.08	0.188	0.08	0.080
Maintenance of the bunds	ha	30	-	30	60
Seedling production	no.	150,000	314,581	150,000	220,764
Affor. and agroforestry	ha	20	*29	30	-

*The plantations are on the SWC bunds.

In the second year of the project, construction of the *fanya juu* bunds and production of seedlings were accomplished at higher levels than the planned. The actual implementation exceeded the planned by 52.6% in the construction of the *fanya juu* bunds and by 47.2% in the production of tree seedlings. On the other hand, the construction of the soil bunds, stone bunds, cut-off drains and artificial waterways and agroforestry works were below the planned levels. The actual implementation was 20% of the planned for the construction of soil bunds, 69.2% for the construction of cut-off drains, 15% for the construction of artificial waterways, and none for both the construction of stone bunds and the planting of trees for the agroforestry. The construction of check-dams was carried out as planned. Besides, maintenance works were done for all the bunds constructed in the two years (60 ha coverage) in the second year of the project. The total labour input for the works accomplished in the second year of the project was 1704 working days, estimated at Eth. Birr 5,112.00.

4.2.6 Observed Changes in the Land Condition since the Watershed Management Intervention

Generally, effects of SWC works require a long period of time to be appreciable by the farmers. Yet, farmers can easily notice if there have been any visible changes in a short time as well. The farmers were asked during informal discussions to mention any changes in the land condition they may have observed since the watershed management intervention. The farmers responded that they had witnessed changes in the land cover condition, level of soil erosion and better growth of crops along the SWC structures due to the entrapped sediments. The land cover condition improved, according to the farmers, for two reasons: i) the watershed was closed and protected from encroachment by livestock, hence natural vegetation was returning in lands that were uncultivated for being too degraded, or gully sides and valleys, and ii) the trees planted on the SWC structures (agroforestry) increased the vegetative cover of the land. The farmers stated that they were using twigs of the plantations to feed their oxen, by the cut-and-carry system; hence, the change in the land cover condition had improved livestock feed availability.

The other changes the farmers mentioned were the decreased magnitude of soil erosion and the better growth of crops along the SWC structures. As stated by the farmers, the better performance of crops along the conservation structures was a result of the improved soil fertility status due to the decreased magnitude of soil erosion, which was the result of the conservation works. However, the improved crop yields were most likely due to the soil moisture conserved by the SWC structures rather than the conserved soils, as the time the SWC measures stayed in place was too short to effect significant improvements in the soil fertility status.

4.2.7 Farmers' Acceptance and Adoption of the Introduced SWC Technologies

Accelerated soil erosion is primarily caused by farmers' land use practices. Likewise, the success of any SWC intervention depends on the extent to which the introduced conservation technologies are accepted and adopted by the farm households. In other words, acceptance and farm-level adoption of the newly introduced conservation technologies by the farmers is the decisive element for the success of the watershed management intervention, which envisages improved livelihood for the farmers through conservation-based agriculture. Table 17 shows the farmers' evaluations of the introduced SWC technologies in terms of their effectiveness in arresting soil loss and their potential to improving land productivity. These evaluations are good indications to gauge the level of acceptance of the introduced SWC measures by the direct beneficiaries – the farmers.

As it can be seen in table 17, more than 98% of the respondents confirmed that the technologies were effective in arresting soil erosion. Similarly, the majority of the respondents (94%) believed that the new SWC technologies had the potential to improve land productivity and lead to increased crop yields, as they had already observed a better growth and development of crops particularly along the structures where fertile sediments were trapped. Based on this information, it can be stated that the newly introduced SWC technologies had generally obtained recognition on the part of the farmers as effective measures to combat soil erosion and improve land productivity.

Nevertheless, acceptance of the technologies as effective measures for controlling soil loss and as having potential to improve land productivity cannot warrant its adoption on the farm. While acceptance depends more on the design characteristics of the technologies as related specifically to effectiveness, farm level adoption of the measures depends also on several socio-economic and institutional factors. The factors affecting adoption also determine the sustainable utilisation of the measures by the farmers. Adoption of SWC technologies is a difficult concept to measure. Generally, newly introduced SWC measures can be considered as adopted if the land users (farmers) continue to utilise them as a part of their production system after the external assistance is withdrawn.

Table 17. Indicators of farmers' acceptance and adoption of the introduced SWC technologies

Perception and opinion	% of total
A. Indicators of acceptance	
Did you know the introduced SWC technologies before? Yes No	17.2 82.8
Are the newly introduced SWC technologies effective in arresting erosion? Yes No	98.4 1.6
Do you believe that the new SWC technologies have the potential to improve land productivity? Yes No	93.8 6.3
B. Indicators of adoption	
Do you have plan/ intention to maintain the constructed structures after the project is finished?	42.2 57.8

Yes No	
Do you have plan/ intention to implement the new technologies in the rest of your plots currently untreated? Yes No	21.9 78.1

Although adoption of the SWC technologies can be effectively appraised only after the termination of the project, it can also be assessed by analysing the farmers' attitudes, objectives and aspirations of whether they would like to use the introduced technologies as a part of their farming enterprise. Accordingly, the farmers were asked what their intentions were regarding using the introduced SWC technologies in the future (table 17). Some 42% of the respondents expressed their commitment to continue maintaining the established structures after the support ends. On the other hand, 58% stated that they would not maintain the structures as they were by then. Of the latter group, some argued that they would destroy every other structure so as to reclaim the "lost land" for cultivation; and some others stated that they would destroy some of the structures in order to use the fertile sediments retained behind. In addition to this, the farmers were interviewed whether they would like to apply the SWC technologies in the rest of their farm fields (plots that were not treated by that time). Some 78% of the respondents responded negatively, while only 22% expressed willingness, but only so long as they could be provided with labour assistance for the implementation of the measures.

In summary, it can be stated that the introduced SWC technologies were widely acknowledged and accepted as effective measures against soil erosion and as having the potential to improve land productivity. Nonetheless, their sustainable adoption on the farm level appears to be less likely.

4.2.8 Factors Affecting Farm-level Adoption of the Introduced SWC Technologies

The farm-level adoption of SWC technologies depends on several interrelated factors. Effectiveness of the technologies in arresting soil loss is only one consideration. As discussed above, the majority of the surveyed households acknowledged the introduced SWC measures to be effective in controlling soil erosion and as having the potential to improve land productivity. On the other hand, the majority of the respondents did not appear to have intentions or plans to continue maintaining the structures established by the mass work. Similarly, the majority of the respondents stated that they had no intentions of applying the technologies in their farm plots that were not treated by that time; this also implied that there was a very little chance for the farmer-to-farmer diffusion of the improved technologies.

Accepting the technologies as effective measures to control soil loss and improve land productivity on the one hand and showing disinterest to adopt them on the farm on the other might appear surprising. Yet, it is in agreement with findings of some research works elsewhere (e.g., Semgalawe 1998). According to Semgalawe (1998), farmers rather frequently reject newly introduced SWC technologies even when they are aware that adoption of the measures protects and improves productivity of their lands. This suggests that the newly introduced SWC technologies need to be evaluated not only for their technical efficacy but also for the chances of their sustainable adoption and utilisation by the land users. The latter requires identification of barriers to and facilitators of adoption of the technologies. Once the barriers and facilitators are identified, recommendations can be made on appropriate steps that need to be taken to enhance the adoption of the technologies and to effect sustainable land use. In this section, some personal, socio-economic and institutional factors that are affecting a sustainable adoption of the introduced SWC measures by the farmers are discussed.

A. Perception of soil erosion as a menace to crop production

Perception of soil erosion as a hazard to crop production and sustainable agriculture is the most important determinant of effort at adoption of conservation measures. Understanding and recognition of soil erosion as a problem in own farm plots and its causes and impacts on crop yields is the first step towards searching for and adoption of remedial measures. According to Osgood (1992), public awareness of the soil erosion problem and the need for SWC is generally low. The underlying reason for this is the fact that the process of erosion is gradual, which goes on unnoticed and is recognisable only after reaching some threshold levels. This is usually a point where it is very difficult for the subsistence farmers to arrest it with their meagre resources and technical capabilities. As Hurni (1985a) argues, when the public awareness and perception of the problem seems widespread, it must be that degradation has reached critical proportions. According to Hurni (1985a), farmers in northern Ethiopia seem to have realised that their land is being degraded after centuries of farming, when it had already become a severe problem to food production.

Once farmers perceive soil erosion as a problem having negative impacts on soil quality and land productivity and expect positive returns from soil erosion control, it is highly likely that they will decide in favour of adopting available conservation technologies. On the other hand, when farmers do not acknowledge soil erosion as a problem, they cannot expect benefits from controlling the erosion process and it is highly likely that they will decide against adopting any conservation technologies.

In Ethiopia, there are some studies that deal with the farmers' perception of soil erosion. The results are apparently contradictory. According to Hurni (1985b), "low perception of local peasants" about the problem of land degradation is a problem that needs to be circumvented to SWC efforts in the country. On the other hand, Belay (1992) concludes that farmers have a good perception of the problem of soil erosion. Berhe and Chadhokar (1993) also believe that there has been some level of awareness of the problem of land degradation throughout the country and, that a range of traditional conservation measures are in place now. More recently, a study by Omiti *et al*. (1999) shows that farmers are well aware of the problem of land degradation, stating that 85% of the households covered in their survey (n = 892) mentioned erosion as an important economic problem. Table 18 shows the farmers' awareness and perception of the erosion problem in the study watershed.

As shown in table 18, the majority of the surveyed farmers (98.4%) acknowledged that soil erosion was a problem in their own farm. Regarding signs with which it can be identified, they rightly mentioned visible erosion features, rills, gullies and landslides. The causes to the soil erosion problem mentioned by the farmers included: the slopes were very steep (40.6% of the respondents) and the soils were very erodible (20.3% of the respondents). Runoff from up-slope areas and up-slope lands being too degraded were also mentioned by some of the respondents. Concerning the intensity of the problem, the ratings were “severe”, “moderate” and “minor” by 78.1%, 17.2% and 4.7% of the respondents, respectively. The majority of the respondents (84%) also witnessed that they observed an increasing trend in the severity of soil erosion over the past ten years. On the other hand, some 14.1% of the respondents believed that soil erosion has become less and less severe over the same time period, while the rest of the respondents replied that they did not observe any change.

The farmers were also asked to rate the impact of soil erosion on crop yields. The ratings were “severe”, “moderate” and “has no impact at all” by 51.6%, 46.9% and 1.6% of the respondents, respectively. Comparing the number of respondents who rated the impact of erosion on crop yields as “moderate” to the number of respondents who rated the intensity of erosion as “severe”, it can be stated that the link between soil erosion and decline in land productivity is possibly obscure to the farmers. Additional evidence to this assumption is the explanation given by the farmers during informal discussions about decline in fertility levels of their lands. They generally agreed that there had been a decreasing trend in fertility levels of their plots of land, but they attributed this to “ageing of the land” due to overuse.

Table 18. Farmers’ perception of erosion hazards

Perception on erosion	% of total
Whether erosion was perceived as a problem in own farm Yes No	98.4 1.6
Severity of the problem, if yes to the above question Severe Moderate Minor	78.1 17.2 4.7
Observed change in erosion intensity over the last 10 years Has become more severe	84.4 14.1 1.6

Has become less severe No change	
*The perceived major cause of soil erosion Slopes being very steep Rainfall being too much Soil being too erodible Runoff from up-slope areas Uplands being too degraded	40.6 14.1 20.3 4.7 3.1
Extent of impact of erosion on crop yields Severe Moderate Has no effect	51.6 46.9 1.6
Believe that erosion can be controlled Yes No	96.9 3.1

*The total does not add up 100% because some of the respondents gave a combination of factors as equally important; e.g., slopes being very steep and rainfall being too much (6.3% of respondents).

In general terms, it can be concluded that the farmers were well aware of the problems of soil erosion and land degradation. Also, the farmers generally believed that erosion could be controlled (97% of the respondents). Hence, their lack of interest to adopting the introduced SWC measures cannot be explained by lack of awareness about the problem. This finding also suggests that correct perception of soil erosion as a problem is a necessary but not sufficient condition for the farmers to adopt improved SWC technologies. Indeed, awareness about and correct perception of soil erosion as an economic problem is only the initial step in the adoption-decision making process. After the perception of erosion as a threat to crop production and the willingness to adopt conservation measures, the ability of the farmers to do so becomes the most important factor. The ability of farmers to adopt SWC technologies is related to their labour supply and economic status.

B. Households' labour supply

In the Digil watershed, like in any other subsistence economies, household members are the suppliers of labour needed for the implementation of the SWC measures, and indeed for the whole farming operation. The SWC measures under implementation were physical structures that are labour-intensive. In fact, all types of SWC measures require a lot of labour. As Stocking and Abel (1989) estimate, 40 working days will be required to install simple biological measures per ha; construction of bench terraces on one ha of steeply sloping land will require 1800 working days. The household labour supply, therefore, determines its ability to maintain the SWC measures already established and to construct new ones. Household size in reference to landholding sizes was taken as an indictor for labour availability in this study (table 19). Obviously, farm households with fewer labour constraints can be more able and willing to adopt SWC measures while households with more labour constraints will be unable and less willing to do so.

As can be seen in table 19, the majority of households seem to have adequate supply of labour that would be needed for the SWC works in their small holdings. Some 54.7% of the total households had 4 to 6 members and some 21.9% had 7 to 9 members. In contrast, 56.2% of the households possessed only 0.6 to 1.0 ha of land. Only 9.4% of them owned more than 2 ha. Taking the average household size and the average land holdings of the households, the per capita holding was 0.24 ha. From the land holding patterns and family sizes, it might be inferred that labour availability could not be a constraint for the farmers to implement the introduced SWC measures. To substantiate the inference, the farmers were explicitly asked whether labour shortage was a problem for them to apply the introduced SWC measures. The answers failed to reinforce what seemed to be a logical inference from household size and land-holding patterns. Unexpectedly, the majority of the households (81.3%) responded that shortage of labour was one of their major problems to maintain the SWC structures established in their plots by the mass work and also to plan to implement the technologies in the rest of their plots.

Table 19. Household size, landholding and labour condition of households

Factors	% of total
Household size (no.)	20.3
≤ 3	54.7
4-6	21.9
7-9	3.1
≥10	
Total land held (ha)	14.1
≤ 0.5	56.2
0.6-1.0	9.4

1.1-1.5 1.6-2.0 >2.0	10.9 9.4
Facing labour shortage to apply the introduced SWC measures Yes No	81.3 18.8

Hence, an explanation to the fact that the farmers were disinterested in adopting the introduced SWC works is to be found in the problem of labour shortage. This finding is in agreement with the argument by Semgalawe (1998) that farmers will refrain from adopting new SWC technologies if the labour required for the implementation is thought to be too high relative to capacity of the household. At the same time, it is contrary to the general belief that labour availability is not a major problem to subsistence farmers in developing countries to apply improved SWC measures. The latter view stems from the assumption that disguised unemployment is rather rampant as many people are accommodated by small land holdings. Because of this, labour availability is the factor generally considered available at the planning stage, and undervalued at the stage of evaluation of SWC projects (Stocking and Abel 1989). The finding in this section adds to the existing little evidence in the Ethiopian situation that such a view on labour availability to SWC works is rather wrong.

C. Land tenure security

Land tenure security has been shown to be an important factor, besides farmers' awareness and labour availability, affecting subsistence farmers' decisions whether to adopt introduced SWC measures. The general agreement is that the land users must have secure property ownership rights of the lands they cultivate if they are to invest in SWC works in anticipation of long-term benefits. That is, in a situation where the farmers are not certain to capture the benefits of investment in SWC on their lands, they will not be willing to devote much effort to SWC. In other words, secure ownership of the land operated increases the sense of responsibility and lengthens the farmers' planning horizon and thus they will be more concerned about the proper use and management of the land.

In Ethiopia, land has been under state control since the 1975 land reform. The land users (farmers) have been given only usufructory rights. It is believed that this property ownership regime has been a source of insecurity for the farmers to invest on their small plots of land for long-term benefits. Studies in different parts of the country have tried to show empirically that land tenure insecurity significantly influences farmers' decisions on land management practices. For instance, Kebede (1989) mentions that the absence of clear and unambiguous property ownership rights was one of the reasons for the failure of past attempts of environmental rehabilitation and conservation works, specifically that on communally held hillsides. The destruction of those hillsides closed for natural regeneration in the northern highlands of the country during the change of government in 1991 was attributed to uncertain land ownership system (Yeraswork 2000). In his study in a West Shewa Oromo community, Mirgissa (1994, 123) concludes that “due to ownership insecurity, people nowadays have no concern about resource conservation”. Belay (2000) has identified the insecure land tenure system as having contributed to the accelerated soil erosion from cultivated fields in the south Welo highlands of Ethiopia.

Despite this information that seems convincing, land redistribution was conducted in the study region (Amhara Regional State) at the beginning of 1997 with no form of compensation to the losers for long-term investments such as building terraces. Therefore, would it also be because of the insecure land tenure that the majority of the surveyed farmers were disinterested to adopt the newly introduced SWC technologies?

The questions in table 20 were meant to see to the influence of security of land tenure on farmers’ decisions to invest in the SWC works. As it can be seen, 58% of the respondents expected land redistribution in the future, 39% did not expect land distribution, while the rest reserved themselves from giving any prophecy on the subject. The majority of the respondents (around 41%) reported that they lost held plots during the 1997 land redistribution. On the other hand, a considerable number of the respondents (32.8%) reported that they had no land before and gained by then, while a few households (9.4%) also gained additional plots. Only 14% of the respondents reported that their holdings remained unaffected. Given this dynamics of land holdings, it can be argued that the unstable land tenure system must be partly responsible for the disinterest shown by the farmers to adopt the introduced SWC measures, which inherently have long gestation periods.

More explicitly, the farmers were asked about whether the periodic redistribution of land could in any way affect their decisions to adopt the introduced SWC measures. More than 73% of the respondents asserted that it discourages them from adopting the measures. The rest of the farmers responded that it does not affect their decisions to adopt or not to adopt the technologies. Therefore, with this empirical information, it can be concluded that the insecurity of tenure over the lands they operated was one factor towing back farmers from making efforts to adopt the introduced SWC measures. It was also learned during informal discussions with farmers that security of tenure was an important factor given the labour input required to implement the measures. One farmer (who had lost a plot of land during the 1997 redistribution) compared the plot of land in his possession to a rented house, where the landlord can dislodge the tenant at any time he wants his house vacated.

This finding is in agreement with several empirical studies carried out in different parts of the country (e.g., Kebede 1989; Mirgissa 1994; Yeraswork 2000). The implication is that securing land rights will be an incentive for the farmers to adopt improved SWC technologies.

Table 20. Effect of the 1997 land redistribution on individual holdings and farmers’ opinions on aspects of land tenure

Question	% of total

Do you expect land redistribution in the future? Yes No Can't know	 57.8 39.1 3.1
Can periodic land redistribution in any way affect your decisions on adopting SWC measures? It discourages me It does not have any effect	 73.4 26.6
How did the 1997 readjustment affect your holding? Held plots lost Additional plots gained Previous holding remained unaffected Had no land before and gained by then Some plot taken but same size replaced	 40.6 9.4 14.1 32.8 3.1

D. Fitness of the technologies to farmer requirements and farming system circumstances

The farmers' decisions on whether to adopt SWC technologies at the farm level also depend on the fitness of the technologies to their needs and requirements. Some of the most important characteristics of conservation technologies or techniques that influence the farmers' adoption decisions are effectiveness in controlling soil loss, benefits to be obtained from adoption, the ease of adoption and appropriateness to the farming system circumstances. If newly introduced SWC technologies do not appear to be relevant to the farmers in view of these criteria, it is highly unlikely that they will be adopted and, indeed, should not be expected to be adopted.

In the study site, the SWC technologies under implementation were physical structural measures. These measures were acknowledged by the farmers to be effective in controlling soil loss and also as having the potential to improve productivity of land. Hence, they fulfil the requirements of effectiveness and of generating benefits, which is in this case the potential to improve crop yields. The perception of benefits in the short-term in particular can be a good source of motivation for the farmers to make more efforts to adopt the new SWC technologies. However, the farmers also mentioned problems associated with the technologies that were discouraging them from planning to maintain the structures after the end of the project and for not intending to apply the measures in the rest of their farm plots that were not treated by the time (table 21).

As can be seen from table 21, the majority of the farmers (83%) believed that the newly introduced SWC technologies had very difficult designs, which they would be unable to apply without external assistance. The other aspect mentioned as a problem was the land space these physical measures occupy. Nearly 94% of the respondents believed that the technologies put too much land out of production. As was learned during informal discussions, the shortage of land had made the farmers abandon even their age-old practice of fallowing leave alone putting a part of a plot of land out of production. According to the farmers, the introduced SWC technologies will only be adopted if they can generate balancing benefits in terms of increased crop yields. During the first and second years of the study project, the increases in crop yields were not large enough to compensate for the "lost lands", according to the farmers. Furthermore, the farmers had much complaint about the inter-structure spacing. According to them, the spacing of the bunds was too narrow, which made it land-consuming, a problem for ploughing with oxen and more labour-demanding for construction as well as maintenance. In their opinion, it was sufficient to preserve every other bund and destroy the middle ones.

The labour required for the construction and maintenance of the conservation structures was the other factor the farmers mentioned as a hindrance to adoption. More than 92% of the respondents expressed that the technologies were too labour-intensive for them to implement in their plots of land. Similar views were also stressed during informal discussions. The farmers frequently described the conservation structures as "back-breaking". From their point of view, the SWC structures had the potential to improve land productivity and increase crop yields, but that benefit would remain incommensurate with the physical work required for their implementation.

The farmers further added that the construction of the SWC structures was only in level and moderately sloping lands, while their major problem was the occurrence of landslides on steeper slopes. Thus, in their opinion, the watershed management intervention was not addressing the priority and preference of the local people. The same was also learned during informal discussions. The preference transpired by the majority of the farmers was the treatment of steeper slopes, which were still under cultivation but were left unattended by the project and suffered from severe damage due to mass movements.

Table 21. Farmers' evaluations of the introduced SWC technologies

Perception and opinion	% of total
The newly introduced SWC technologies have very difficult designs to implement by myself	
Yes	82.8
No	17.2

The new technologies require too much labour to implement Yes No	92.2 7.8
The new technologies put too much land out of production Yes No	93.8 6.3

The other concern the farmers expressed was the lack of fitness of the introduced SWC technologies to the local farming system circumstances, particularly their being in conflict with the traditional free-roaming grazing system. By the time of fieldwork for this study, the treated lands were being guarded from encroachment by livestock. The wage for the guard came from the organisation that sponsored the watershed management activities. The end of the program would thus bring the job of the guard to an end. When this happens, the farmers felt certain that the free-roaming grazing of livestock would resume in these protected areas as well and cause destruction of the SWC structures and the trees and shrubs planted on the structures.

The findings reported in this section generally tally with findings of a previous study in southern Ethiopia by Belay (1992) and elsewhere by other researchers. Belay (1992) has found out that the farmers were willing to conserve their soils and lands but demanded for more appropriate technologies. Other studies elsewhere have also concluded that farmers fail to adopt or adapt SWC technologies not for lack of concern to sustainable land use but for inappropriateness of the technologies provided. For instance, Kerr and Sanghi (1992) have reported that in India's semi-arid tropics, farmers failed to maintain or even intentionally ruined introduced SWC measures because the measures were not suitable to their small farms.

E. The approach followed in implementing the SWC measures

Earlier policies and strategies of SWC were generally similar over many countries of the world, including Ethiopia. Local farmers were seen as problems to efficient and sustainable utilisation of the land resource. The objective of conservation was then resource protection from destruction by the farmers who tend to exploit with no restraint (Pretty and Shah 1999). From this perspective, it would be logically convincing to adopt top-down planning and imperious implementation of SWC measures. Most of the decisions were thus made in offices far removed from problem areas and with the people most appropriate least involved. Evaluation reports of such conservation undertakings more commonly than not contained some failure stories as well as stories of farmers' reluctance to continue with the introduced "scientific" practices as the coercive force withdrew (Pretty and Shah 1999). The same experience is found in Ethiopia. The following of top-down approaches and lack of genuine involvement of the farmers were some of the major reasons for the failure of past conservation initiatives.

So, putting aside the conventional view that the farmers are part of the problem of resource degradation, it is today acknowledged that they rather have basic and beneficial roles to play in sustainable land use and management (see Hinchcliff *et al*. 1999). This new thinking is what is popularly referred to as “bottom-up” or “participatory” approach in the SWC and development literature. The need to involve local farmers in all the processes of SWC activities, or broadly in watershed management, is at the present widely accepted. The same is also endorsed in the environmental policy document of the Ethiopian government (FDRE 1997).

The problem lies, however, in defining and understanding what a participatory approach really means and in actually putting it into practice. Farmers are often said to participate while they indeed are involved only in the implementation of the SWC measures engineered for them by subject-matter experts elsewhere. This is not participation in the real sense. Participation should mean the genuine involvement and co-operation of the farmers beginning from the identification of the soil erosion problem to the selection, designing, implementation and evaluation of effectiveness and efficiency of the conservation technologies. In short, for a SWC initiative to be regarded as truly participatory, the farmers should be convinced, as much as the experts and organisations involved, of the need for erosion control and the types of technologies to be applied to that effect. The types and designs of the technologies ought to be determined based on consensus or on the majority opinion of the people. Table 22 presents responses of the farmers about the nature and extent of their involvement in the SWC venture in the study watershed.

Table 22. The farmers’ participation in the SWC undertakings

Question	% of total
How are you participating in the newly introduced SWC activities?	
Voluntarily	43.7
Forced to participate	56.3

As shown in table 22, nearly 44% of the surveyed households asserted that they were participating in the SWC activities, at their own conviction and voluntarily. On the other hand, more than 56% of the respondents reported that they were participating because they were forced to do so. Given that the majority felt coerced to be involved in the conservation works, it is difficult to enunciate that the watershed management project had followed real participatory processes.

As it was also disclosed during informal discussions, the farmers felt that their involvement was largely limited to the implementation of the measures brought in by the experts. According to informal discussions, less chance was given to the farmers to decide on the types and designs of the SWC technologies, i.e., at the planning stage. The chance the farmers acknowledged as having been given was to comment on the SWC structures only during a field day organised by the *woreda* office of agriculture, after the structures were implemented, on which they have lodged complaints particularly about the inter-structural spacing.

In addition, the watershed management project appears to have ignored the farmers' time-honoured knowledge in dealing with the soil erosion problem. Some 83% of the farmers reported that the SWC technologies introduced were totally new and unknown to them. As Chambers, Pacey, and Thrupp (1993) argue, if success is to be achieved, the farmers' indigenous knowledge should be at the foundation of a "modern" technology to be introduced. The argument is that building upon indigenous knowledge systems will boost farmers' self-reliance and the feeling of empowerment as determinants of their own course towards an improving livelihood and sustainable land use. However, the farmers did not even seem to be clear about whom the conservation works belonged to. For instance, many of the farmers believed that the employment of the guard should be permanent so that the conserved lands remain protected from encroachment by livestock. Otherwise, the free-grazing livestock would cause destruction of the structures as well as the trees and shrubs planted on the structures. This shows that the farmers did not feel obliged about the maintenance and sustainability of the SWC measures.

The finding in this section does not corroborate what was learned from the DA working in the site. According to the DA, the farmers were willingly participating in the watershed management activities, and their participation was ensured right from the very start and before the beginning of any actual work on the ground. However, the farmers stated that their involvement was largely limited to labour contribution, and what was done in the name of participation was more of community consultation.

The approach pursued in implementing the watershed management practices was, therefore, closer to the conventional approach by which SWC works – mostly structural measures were constructed in many countries of the world including Ethiopia. Experience has shown that structures constructed without involvement of farmers out of their veritable commitment eventually end up failures – the very reason that justifies a participatory process. As the pressure recedes, farmers will fall back on to their traditional practices, land will continue to be degraded and food insecurity will grow. Therefore, for the conservation structures implemented in the study watershed to be maintained in the fields, it appears that steps remained towards a real participatory process in their construction.

5. CONCLUSIONS AND RECOMMENDATIONS

5.1 Conclusions

In the study watershed, as is the case in much of rural Ethiopia, the people are very poor, living on an average annual income of Birr 1038.70 per household, which has 5.1 members on average. Crop production and livestock rearing contribute to 92.7% of the total annual income of the households and 7.3% was secured from sale of trees and wood. Only very few households were found to be engaged in off-farm activities as additional sources of income, indicating the heavy dependence on the land. Land and livestock are the bases of livelihood for the people. On the other hand, land has become scarce and land holdings per household have been declining because of the increasing population. Moreover, productivity of croplands has declined over time due to "ageing of the land", drought, soil erosion and inability to use chemical fertilizers because of its high cost. The scarcity and decrease in productivity of croplands has thus contributed to lower production of crops. There has also been a decreasing trend in the number of livestock owned by households, contributing towards poverty of the people. On the other hand, increase in the human population has caused an overall increase in the total livestock population in the communities, creating pressure on grazing lands and shortages of feed. The shortage of feed was identified to be one of the main reasons, the other being drought, for the decrease in the number of livestock owned by the households. Not only does the heavy grazing affect clearing of vegetation and the subsequent effects on the grazing lands but also affects cultivated lands, in much the same way, because free-roaming feeding on crop residues takes place after harvesting. The people in the study area are, therefore, facing problems of poverty and resource degradation, which require prudently composed solutions that integrate development and conservation measures.

The study has attempted to empirically establish the magnitude and rate of land degradation and identify factors affecting farmers' acceptance and adoption of land management technologies introduced to them by external development agents. Changes in land cover/use and magnitudes and rates of soil loss due to rills were used as measures of the land degradation process. The results of the investigation of land cover change indicate that over the twenty-five years considered, there have been some changes in the land cover, but the main type remained agricultural use. The major changes observed were the increase in cropland and shrubland areas at the expense of the open grazing and woodland areas. The increase in the area of croplands has implications on runoff generation, erosion, flooding and sedimentation problems. The results of the rill erosion survey indicate that, assuming a 30% contribution from interrill erosion, soil loss was around 37 t/ha/year. This estimate, which is well in agreement with results obtained by intensive measurements in a nearby experimental microwatershed, shows that soil erosion is a threat to agricultural production and that conservation measures are needed.

There have been a range of land management and development works underway in the watershed since January 1999, of which this study focused on the SWC measures. The introduced SWC measures have generally received acceptance by the local farmers. They are widely acknowledged as being effective measures in arresting soil erosion and having the potential to improve land productivity. Notwithstanding, the sustainable adoption and widespread replicability of the introduced SWC measures seem less likely. The majority of the surveyed farmers have stated that they have intentions to maintain the conservation structures as part of their regular farming practices once the external intervention is withdrawn. Also, the majority of the farmers stated that they would not like to apply the conservation measures in their plots of land that were not treated by that time. The major factors that were discouraging the farmers from adopting the introduced SWC technologies on their farms were found to be labour shortage, land tenure insecurity and problem of fitness of the technologies to the farmers' requirements and to the farming system circumstances.

The problem of fitness of the technologies to the farmers' requirements and the farming system circumstances is partly a reflection of a problem in the approach followed in the planning and implementation of the technologies. Though it was claimed that participatory procedures were followed, facts on the ground did not seem to support this. For instance, the farmers' time-honoured knowledge and preferences were ignored in dealing with the soil erosion problem, as shown by the fact that 83% of the surveyed farmers reported that the introduced SWC technologies were totally new and unknown to them. Instead, the involvement of the farmers was limited to labour contribution. Real participatory processes were, thus, not followed. In a real participatory process, the farmer is the starting point. It starts with analysis of farmers' circumstances, problems, indigenous knowledge and preferred solutions to problems (Chambers, Pacey, and Thrupp 1993). Conservation experts and facilitators of implementation are expected to fine-tune conservation technologies to the needs of the people, and not the otherwise. As Chambers, Pacey, and Thrupp (1993, 182-83) succinctly write, "[In a participatory approach], the main objective is not to transfer known technology, … what is transferred by outsiders to farmers is not a package of practices to be adopted but a basket of choices from which to select".

5.2 Recommendations

The rural households in the Digil watershed are very poor, living on very meagre annual incomes. Land and livestock are their fundamental bases of livelihood. On the other hand, land degradation, particularly soil erosion from cultivated fields, is a threat to their agricultural production, and conservation measures are needed. There have been a range of land management and development activities underway since January 1999, of which this study focused on the SWC measures. The introduced SWC have generally obtained acceptance by the farmers in terms of being effective in soil erosion control and potentially improving productivity of croplands. Nonetheless, few things need to be reoriented to ensure sustainable adoption and widespread replication of the technologies by the farmers, as findings of the study suggest.

i. The high labour requirement for construction and maintenance was one of the reasons given by the farmers for intending to dismantle some of the introduced SWC structures after the external intervention comes to an end. The farmers expressed that the SWC structures have the potential to improve land productivity and increase crop yields, but they fear that the benefits might remain incommensurate with the physical work required for their implementation. Hence, reducing the labour requirements will contribute towards enhancing the adoption of the conservation technologies. The labour required would be reduced by increasing the spacing between the structures, which reduces the total number, length and area of these structures. In addition to reducing the labour requirement, increasing the inter-structural spacing also reduces the total area of land that would be put out of production due to the structures, which was one source of complaint by the farmers. Increasing the inter-structural spacing will also ease the problem of ploughing with oxen, caused by the narrow spacing. However, this technical solution has disadvantages as well. That is, the measures will be less effective in terms of controlling soil erosion. In this regard, considering alternative technologies such as minimum tillage methods and putting greater emphasis on biological measures, instead of the physical ones, will help in reducing labour requirements without compromising the erosion control effectiveness.

ii. Insecurity of tenure on lands operated was identified to be one of the constraints for the farmers to adopting the conservation measures. Therefore, secure rights on land should be granted to the people to enhance adoption of the conservation technologies. Granting tenure security does not necessarily mean privatising land. It suffices to give the farmers assured use rights over sufficiently long periods of time during which they could reap the benefits to be derived from their conservation investments.

iii. The problem of fitness of the technologies to the farmers' requirements and the farming system circumstances was one of the barriers to the adoption of the introduced SWC technologies. The ease of adoption and appropriateness to the farming system circumstances are some of the most important characteristics of conservation techniques that influence farmers' adoption decisions, in addition to effectiveness in controlling soil loss and benefits to be obtained from the adoption. The majority of the surveyed farmers believed that the newly introduced SWC technologies have very difficult designs that they were be unable to apply the structures in the absence of external assistance. Hence, training should be given to the farmers on the designing of these measures. The farmers should also be provided with the necessary equipment such as A-frames and water levels with which to align the structures.

iv. The other concern of the farmers was the incompatibility of the introduced technologies to the traditional free-roaming grazing system. During the time of fieldwork for this study, the treated lands were closed off from livestock by a guard employed by the project. But when the employment of the guard comes to an end with the ending of the project, the farmers were certain that free-roaming grazing of livestock would resume and cause destruction of the established structures as well as the trees and shrubs planted on the structures. Hence, the local people should be convinced, before the project ends, on taking the responsibility of protecting the treated areas from destruction by livestock. As much as possible, livestock grazing should be limited to the grazing lands. The stall-feeding system should also be introduced to the farmers.

v. There was also lack of addressing the priority and preference of the local people by the project as related to the soil conservation works. As noted by the farmers, the construction of the SWC structures was carried out in level and only moderately sloping lands, while their major problem was the occurrence of landslides on steeper slopes. Thus, the watershed management intervention was not addressing the priority and preference of the people. Their preference was the treatment of the steeper slopes, which were still under cultivation but left unattended and suffered from severe damage due to mass movements. There is, therefore, the need to address this priority of the farmers. Landslides can be prevented by afforestation of hillsides (sources of the direct runoff) and by construction of cut-off drains that divert the runoff from entering into cultivated fields by coming from the up-slope source areas. Tackling priorities of the farmers will serve as an effective doorway to the willing and committed participation of the farmers in the conservation undertakings.

vi. The problem of fitness of the technologies to the farmers' requirements and the farming system circumstances is partly a reflection of a problem in the approach followed in the stage of planning of the conservation intervention. The approach followed was more of a top-down type where the participation of the farmers was limited mainly to labour contribution during implementation of the technologies. For a SWC initiative to be regarded as truly participatory, the farmers should be convinced, as much as the experts and organisations involved, of the need for erosion control and the types of technologies to be applied to that effect. The types and designs of the technologies ought to be determined based on consensus or on the majority opinion of the people. Hence, a thorough reassessment and reorientation of the approach being followed towards real participatory processes is important to ensure the sustainable utilization of the technologies by the land users.

vii. By the time of the fieldwork for this study, the watershed management trail site did not cover the whole of the watershed. It was only part of the watershed that was included. This needs to be corrected, i.e., the whole of the watershed should be taken as the land management unit because conservation in a part of the watershed will have little effects if the other parts particularly in higher positions are not conserved. For instance, it was noted during the rill erosion survey that the formation of rills was basically a result of surface runoff and the associated sheet-wash processes. Much of the surface runoff was either entering into the fields from upslope areas or/and generated by processes of within-field concentration of runoff. The runoff leaving fields, in turn, caused erosion and/or sedimentation problems in fields located downstream. This physical interdependence clearly shows that conservation in one farm will do little if the other farms in a higher position are not conserved. Thus, the problem of erosion and SWC needs to be tackled in the watershed context and the watershed management activities should cover the remaining part of the watershed. The fact that watersheds are logical units for an integrated approach to natural resources management is also underscored by Hurni (1985b) and Sivamohan, Scott, and Walter (1993).

viii. Finally, lasting solutions to the problem of resource degradation and rural poverty should include easing population pressure on the resources, technological improvements in agriculture and development of the other sectors of the economy. Involvement of the local people is essential in all initiatives of resource management since they are the direct users and managers of the resources.

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LAND DEGRADATION AND FARMERS' ACCEPTANCE AND ADOPTION OF CONSERVATION TECHNOLOGIES IN THE DIGIL WATERSHED, NORTHWESTERN HIGHLANDS OF ETHIOPIA

Woldeamlak Bewket

Abstract: Land degradation has become a critical problem in many parts of highland Ethiopia. There is great need for rehabilitation and conservation works in such areas. The aim of this study is to empirically determine the magnitude and rate of land degradation and identify factors affecting farmers' acceptance and adoption of newly introduced land management technologies, with emphasis on SWC measures, in a typical microwatershed in the northwestern highlands of Ethiopia. Changes in land cover/use and magnitudes and rate of soil loss due to rills were used as measures of the land degradation process. The analysis of land cover/use changes involved interpretation of available aerial photographs of the area (taken in 1957 and 1982). For the assessment of soil loss due to erosion by water, rill erosion surveying was undertaken at the scale of cultivated fields. Multiple methods of social research were employed to generate the data required for the investigation of the farmers' acceptance and adoption of the introduced conservation technologies.

The results of investigation of land cover/use changes indicate that over the twenty-five years considered, the main type of land use remained agriculture. The major changes observed were the increase in cropland and shrubland areas at the expense of the open grazing and woodland areas. This has implications on runoff generation, erosion, flooding and sedimentation problems. The results of the rill erosion survey indicate that, assuming a 30% contribution from inter-rill erosion, the rate of soil loss was around 37 t/ha/year, exceeding the rate with which soils could be formed in the area. The people of the study area are, therefore, facing problems of poverty and resource degradation, which require prudently composed solutions that integrate development and conservation measures.

The newly introduced SWC measures have generally obtained acceptance by the local farmers. They were widely acknowledged as being effective measures in arresting soil erosion and as having the potential to improve land productivity. Still, their sustainable adoption and widespread replication by the farmers seem less likely. The major factors discouraging the farmers from adopting the introduced SWC technologies on their farms were found to be labour shortage, land tenure uncertainty and problem of fitness of the technologies to the farmers' requirements and the farming system circumstances. The last was partly a reflection of the problem in the approach followed in the planning and implementation of the technologies. Though it was claimed that participatory procedures were followed, facts on the ground did not seem to support this. The study concludes by suggesting some measures that should be taken to enhance adoption and widespread replication of the conservation technologies by the farmers and ensure sustainable land use in the area.

1. INTRODUCTION

1.1 Background

The population of the world is dependent on land resource for food and other necessities. More than 97% of the total food for the world's population is derived from land, the remaining being from the aquatic systems (Pimentel 1993). The world's population is growing, leading to increased agricultural production for the increased food requirement. This increase in agricultural production can be achieved by bringing more land into cultivation, increasing productivity of land already under cultivation or a combination of the two. Because nearly all of the cultivable land is already under use, the option of "pushing into the extensive margin" seems less feasible. Hence, increasing productivity of the land already in use remains the best available option to increase food production and feed the world's population. On the other hand, degradation, which can be physical, chemical and/or biological and erosion by water and wind, is claiming six million hectares of the global agricultural land per annum (Pimentel 1993).

Of all the processes leading to land degradation, erosion by water is the most threatening. It accounts for 56% of the total degraded land surface of the world (Oldeman, Hakkeling, and Sombroek 1990). However, the process being extremely variable in space and time, this figure is only an estimate; actual environmental, economic and social consequences of soil erosion are not yet precisely known (Lal 1994). Obviously, erosion is a more serious problem to developing countries because their dependence on the soil resource is more direct. Therefore, soil and water conservation (SWC) is a requisite in the developing countries for their sustainable economic development.

In Ethiopia as well, soil erosion by water constitutes the most widespread and damaging process of land degradation. According to a national level study carried out in the 1980s, 3.7% of the highlands were already extremely degraded to cultivate and additional 52% were under conditions of moderate to serious degradation mainly due to erosion by water (FAO 1986). Erosion reduces rootable depth, removes soil organic matter and nutrients and decreases water-holding capacities. All these undermine agricultural production and frustrate economic development in such countries as Ethiopia where there is an extreme dependence on the land resource. More than 80% of the 64 million Ethiopians live in rural areas and derive livelihoods from agricultural activities.

1.2 Statement of the Problem

Over the past few decades, the agricultural sector has failed to keep pace with the growing demand for food. This is partly attributable to erosion-induced degradation of croplands. On the other hand, efforts of SWC made over more than two decades ended up with disappointing results. The problem has therefore persisted and will persist as a serious threat to the food security and development envisioned in the country's policy documents. Thus, SWC is fundamental to the future of the Ethiopian economy. This is more so in view of the overall economic development strategy the country is currently pursuing: Agriculture Development Led Industrialisation (ADLI).

Failure of previous attempts of SWC, or land rehabilitation activities in general, was largely because of the misguided nature of interventions: it disregarded local level biophysical and socio-economic realities. This is essential because land degradation as a process varies from one area to another, and farmers' conservation behaviour varies across socioeconomic groups. In other words, the planning of effective and efficient land management technologies that will be accepted by farmers requires empirical understanding of the extent, magnitude and rate of land degradation, and the diverse socioeconomic variables affecting farmers' conservation decisions. This study was set out to assess the magnitude and rate of land degradation, and analyse the local farmers' acceptance and adoption of newly introduced conservation technologies in the Digil microwatershed in the northwestern highlands of Ethiopia. The Digil microwatershed is located in East Gojjam Zone of the Amhara Regional State, in the Blue Nile River basin system. The watershed typically represents the temperate agro-ecological zone in the northwest highland Ethiopia. By the time of the study, there was intensive SWC intervention in the watershed by the local agricultural office with financial support from the Swedish International Development Agency (SIDA). The intention of the intervention was not only to rehabilitate the degraded landscape, but also to use it as a representative experimental and demonstration site from which the farmers in the surrounding would adopt/adapt conservation technologies. On the other hand, in this part of the country, there is dearth of information on resource degradation and farmers' circumstances.

1.3 Objectives of the Study

Determining the extent and rate of land degradation with empirical evidence has to underlie any conservation endeavour. This is because dimensions and rates of degradation vary with time and space, and hence empirical and local-scale studies are more revealing. In addition to a grounded understanding of the dimensions of degradation, knowledge of the socio-economic setting of the locality is also necessary for designing appropriate conservation technologies and intervention strategies. The general objectives of this study are, therefore, to assess the extent of land degradation and analyse the local farmers' acceptance and adoption of newly introduced conservation technologies in a representative microwatershed in the northwestern highlands of Ethiopia. Specifically, the study sets out to:

i. Describe the physical and human environmental settings of the study area as having implications on land degradation processes;

ii. Measure and analyse the magnitude and rate of land degradation using some measurable indicators; and

iii. Examine the local farmers' acceptance and adoption of land conservation technologies and identify factors affecting their decisions.

1.4 Significance of the Study

The dependence of the Ethiopian economy on land resource is evident from the disproportionately high contribution of the agricultural sector. The sector is also given particular emphasis for the overall future transformation of the national economy. Presently, the pillar strategy of economic development is Agriculture Development Led Industrialisation (ADLI). The success of this strategy depends, among other things, on the sustainable utilisation of the land resource. Thus, the current trend of land degradation is a menace to the viability of the national economy. The need for its reversal is, hence, very important. Accordingly, studies pertaining to evaluation of processes, extent, causes and cures of land degradation are significant. The study is hoped to make a contribution along this line. An underlying premise of the study is that there is insufficient empirical and local-scale understanding of land degradation and land users' conservation behaviour, leading to providing only partial solutions and subsequent failures. By clarifying the severity and rate of land degradation and identifying factors affecting farmers' land conservation decision-making processes, the study hopes to highlight more promising approaches to intervention and appropriate conservation technologies. The study also has a wider relevance of revealing some policy implications. The fact that the study site is in the part of the country where there is scant information on resource degradation further substantiates the study significance.