Poverty and natural resource management in the Central Highlands of Eritrea

Araya Tesfamicael, Bereket

Publication date:
2005

Chapter 9

Discussion of Model Results: Scenario Analysis

9.1 Introduction

Considering the biophysical and socio-economic diversity of the villages in the Central Highlands of Eritrea on the one hand, and the nature and causes of land degradation discussed in Chapter two on the other, different policy, technological and institutional strategies may be required to reduce rural poverty and control land degradation. Ehui and Pender *et al*. (1999) have suggested that different pathways are needed to escape from the downward spiral of resource degradation, low agricultural productivity and poverty in sub-Saharan Africa and that no "one-size-fits-all" approach can be successful given the enormous socio-economic and agro-ecological heterogeneity of villages and households in the region (also see Pender *et al.,* 1998; Fitsum *et al.,* 2002). A successful strategy for sustainable development in a given situation depends on the comparative advantage of a given region, which in turn depends, among other things, on agricultural potential, access to markets and population pressure.

We will use the village-level models to analyse various scenarios (see Table 9.1). The justifications for the choice of a village-level model have been discussed in Chapter four. The comparison of village and household level models in Chapter eight shows that, despite obvious limitations, the use of village level model is a useful tool of analysing land use decisions of farmers and the conditions under which various technologies may or may not be adopted. Moreover, the household model, which takes into account household level resource limitations and interactions among rural households, could not take into account resource sharing and cooperation among rural households which are not driven by economic interests.

In the following sub-sections, we will study the effectiveness of alternative technological and policy interventions for the study villages and compare outcomes in light of differences in village characteristics. We will focus on economic factors in our scenario analysis. However, the theories from the sociological models of technology adoption will also be used in explaining results.

Table 9.1 Brief description of the different scenarios

Serial number	Model scenario (Abbreviation used)	Distinguishing characteristic
1.	Base	Existing data
2.	PFERT	Removal of fertilizer subsidy: price of chemical fertilizers increased 5 times
3.	NEWSTOVE	Energy-saving stoves are introduced
4.	MECHNIZ	The possibility of hiring tractors is introduced
5.	IRRIG	Limited possibility of cultivating potatoes on irrigated land is introduced
6	FFWSC	A FFW program where farmers receive cereals for participating on the construction of stone bunds is introduced
7	FFWTP	A FFW program where farmers receive cereals for participating on tree planting activities is introduced

9.2 Scenario 1. Removal of subsidy on fertilizer (PFERT)

Fertilizer is highly subsidized in Eritrea and such high levels of subsidies cannot be sustained in the long run. It is important to explore how the removal of subsidies will influence land use decisions and investments on fertilizer and other inputs and thereby study the impact of removing fertilizer subsidy on rural income and the environment. It has been noted that efforts to improve farming systems with only little use of external inputs (termed as the low external input sustainable agriculture, LEISA) were not able to make a wide impact in developing countries (Sanders *et al*., 1996). Improved use of chemical fertilizers was therefore considered as a necessary prerequisite to poverty alleviation and circumventing land degradation in SSA. This has led to an extensive subsidy of fertilizer. Despite such higher levels of subsidy, however, the level of fertilizer use in Eritrea, as in most SSA countries, remains very low. We therefore explore how the removal of subsidies impacts on the optimal level of fertilizer use.

The price of the two major types of fertilizer used in Eritrea, Urea and DAP is Nakfa 110 (USD 7.33) and 145 (USD 9.67) per 100 kg. Although this obviously is a highly subsidized price, estimates of the level of subsidy were not available. Thus we estimate the level of subsidy by comparing the above prices to the prices in the region. The unsubsidized farm gate price of DAP in the Tigray region of Ethiopia in 1996 was USD 40.51 per 100 kg (MEDC, 1997). This shows a subsidy level of more than 76 percent. These figures are, of course, only rough estimates of the level of magnitude of subsidy because, 1) transport costs may be lower in Eritrea due to access to ports and 2) the market exchange rate in Eritrea is much higher than the official exchange rate[53].

To reflect the price of fertilizer when subsidies are removed, therefore, we consider a scenario (PFERT) in which current fertilizer prices are increased five times. The effects on income, land use, soil erosion and nitrogen balance varies considerably among the study villages. In Embaderho the model responds by reducing the cultivated land by 18.8%, but the level of fertilizer application (per hectare of cropland) remaines the same. This results in a 24 percent decline in net per capita income[54]. Surprisingly, compared to the base results, soil erosion and nitrogen loss declines under the PFERT scenario. This is due to different farmers' responses that reinforce each other's effect. With an increase in fertilizer price, the productivity of crop production relative to other activities declines leading to an increase in tree planting and livestock activities. Tree planting increases by 15 percent and grazing land expands by 12.2 percent. This led to a decline in soil loss, as soil loss from croplands is much higher than from other land use categories. In addition, since farmers cultivate less land under this scenario, more labour is available for soil conservation activities. Stone bunds are constructed on 44.6 percent of the croplands, compared to 25 percent in the base case. Finally, less of the steeper-slope land types are cultivated, leading to a decline in soil and nutrient loss.

As farmers in Maiaha entirely depend on agriculture, the effect on income is the highest. Net per capita income declines by 85 percent (or by 17% of the net full per capita income). Total cultivated area in Maiaha remains the same. However, there are some changes in land management. The proportion of cropland where chemical fertilizer is applied declines from 100% of the cultivated land in the base case to 80 percent in the PFERT scenario. Manure and crop residues (mulching) are applied on 20 percent and 6 percent of the cultivated lands respectively compared to none in the base case. In addition, stone bunds are constructed on 33.3 percent of the croplands compared to 29 percent in the base case.

Tree planting in Maiaha declines considerably under this scenario, with only 69 ha of land planted during the planning period compared to 219 ha in the base case. Grazing land, on the other hand increases substantially and the number of cattle in the village is higher by about 10 percent compared to the base case. The changes in land use and land management under this scenario have mixed effects on soil and nutrient loss. As stated above, relatively more land is treated

---

[53] In March 2005, the official and parallel market exchange rates were USD 1 = Nakfa 15 and USD 1 = 22.5 respectively.

[54] This refers only to the supernumerary income. The decline in full annual per capita income is only about 6.9 percent.

with soil conservation activities and all manure and some mulch are applied as fertilizer when the price of inorganic fertilizer increases. These changes reduce soil and nutrient loss. On the other hand, the declines in woodlands and in the use of inorganic fertilizer have the opposite effects. Thus soil and nutrient losses from croplands slightly decline while total soil loss increases by 6.2 percent.

In Zibanuna, the removal of fertilizer subsidies does not affect the allocation of land among different activities. However, the level of fertilizer application declines compared to the base results. More than 20 percent of the croplands are cultivated without fertilizer in the first three years under the PFERT scenario compared to none in the base scenario. As a result average soil and nutrient losses from croplands increase by 100% and 45% respectively. Total soil loss from all land increases by nearly 60 percent. Total crop production declines by 1.2 percent and net per capita income declines by 19 percent (8.2 percent of full income).

In summary we observe that higher fertilizer prices have a negative impact on income in all cases but the impact on soil erosion and nitrogen balance is mixed. In addition, the extent of the decline in income varies considerably among the study villages depending on the availability of alternative sources of income and the initial level of income. The responses to removal of subsidy are different and include, reduction in cultivated land, reduction of fertilizer application, shift to organic fertilizer and changes in the extents of soil conservation and tree planting. As a result, the impact of higher fertilizer prices on environmental indicators such as soil loss, nutrient loss and total areas of woodlands is not uniform in all the study villages

Another interesting result in this scenario is that despite a five-fold increase in the prices of fertilizer, simulated levels of fertilizer application remaines very high in all cases. While this suggests the limitation in our model arising from aggregation problem in the village model (because capital is not as binding at the village level as at household level), the results nevertheless indicate that if farmers can afford it, fertilizer is profitable even at such high levels. Consequently, policies that improve farmers' access to fertilizer such as wider distribution, extension services as well as access to credit are likely to have more impact on the adoption of this technology than subsidies.

9.3 Scenario 2. Introduction of energy saving stoves (NEWSTOVE)

As discussed in Chapter two, Eritrea is experiencing a rural energy crisis. Biomass, including wood, dung and crop residues constitutes for more than 80 percent of energy consumption in rural areas and this is primarily used in the household. The average efficiency of biomass use is very low - estimated at about 10 percent (MOE, 2000). The combination of high demand and low levels of efficiency has contributed to deforestation and aggravated rural poverty. However, the current low levels of energy use also provide an opportunity for improvement. A recent stove efficiency research found that the efficiency of wood stoves could be approximately doubled through improvements in the design of traditional stoves (EERTC, 2000).

However, the adoption of higher efficiency stoves in Eritrea may be hindered by the need of special training in the design of the new stove as well as the costs involved in acquiring it. The cash costs of improved stoves are estimated at about USD 30 or about Nakfa 450 per stove (EERTC, 2000). The new stove scenario (NEWSTOVE) requires that each household in the village buys one improved stove at the beginning of the planning period. Additional expenditures are incurred annually proportional to population growth. Per capita energy requirement when new stove are adopted is 50 percent of the energy requirements when the less efficient traditional stoves are used.

The introduction of new stoves increases net per capita income in all the three villages. All the benefits to the households in the three villages are due to less cash expenses on fuels (purchased wood and kerosene). This implies villages that depend more on the market for fuel benefit more from the use of the new energy saving stoves. As a result, the benefit from the adoption of improved stove is highest in Embaderho (Nakfa 129/person/year) followed by Zibanuna (Nakfa 103/person/year) and Maiaha (Nakfa 83/person/year). There are no changes on land use and land management decisions of the households in all the three villages.

It can be noted from the above discussion that the introduction of the new stoves is economically attractive in all cases but its contribution to the environment in the form of sustainable land use practices is not evident in all cases. We observe two key points here. The environmental benefits from the adoption of energy saving stoves were to come in the form of less wood collection (less deforestation), less burning of manure which can then be used as organic fertilizer (improving nutrient balance) and less time for the collection of fuel wood and that labour can be used for soil conservation. However, these effects are not observed in any of the study villages for the following two reasons:

First, in two of the three villages (Embaderho and Zibanuna), biomass fuels from local sources are not sufficient to meet household energy needs such that households partly depend on purchased fuels. This means that if energy requirements due to the adoption of energy saving stoves decrease, households cut on expenses on fuel; but the amounts of wood and manure used as fuel from local sources remain unaltered. In Maiaha, local biomass resources are sufficient to satisfy the present domestic energy need of all households. But when energy requirements decrease due to the adoption of energy-saving stoves, households still harvest same amount of fuel wood and increase the sales of fuel wood. Thus, energy-saving stoves ease neither deforestation nor nutrient depletion.

Second, and partly related to the above reason, the adoption of improved stoves does not save labour needed for fuel collection, as the amount of biomass used from local sources does not decrease. Moreover, while soil conservation activities are traditionally done by adult males, fuel collection is done by all males and females. Thus, even when the adoption of improved stoves saves labour needed for fuel collection, the construction of stone bunds may not necessarily increase.

The use of improved stoves could, however, have positive impacts on the environment in areas where rural households entirely depend on local biomass sources and where harvesting of fuel wood for commercial purposes is not allowed (as is the case at present). In this situation, the economic benefits and hence the adoption of the technology, are likely to be lower. But improved stoves also have other benefits, not taken into account here, like health effects and more free time and their use should be encouraged in both situations. The adoption of this technology, however, is likely to be hindered by initial financial costs and the need for training in producing the stoves. While the benefits of saving energy are realized over time, the cost of the new stove is incurred at the beginning of the planning period. As a result, net per capita income in the first year under the improved stove scenario is lower than in the base case in all the three villages. Poor farmers may not afford the initial decline in income and hence may not adopt this technology. Financial and technical assistance will be needed to encourage rural household to shift to the use of improved stoves.

9.4 Scenario 3. Mechanization (MECHNIZ)

It has been discussed that draft power is a crucial component of the farming system in the Central Highlands of Eritrea (Chapter five). However, the number of livestock in the region has declined due to the combined effects of war and drought. Large numbers of oxen were reported to have died in recent years and many farmers sold oxen and other livestock not only because they needed cash to survive the successive droughts but also because they had no feed for their livestock (FAO, 2005).

The Ministry of Agriculture provides tractor service to farmers. The tractors, which are mostly provided by bilateral donors, are made available to farmers either directly or through a farmer (contractor) who buys the tractors on credit and provide a service to the farmers. There are also some farmers who rent tractors at commercial rates. For use of these tractors MOA/Contractor charges 150 to 200 Nakfa/hr. Commercial hire is more expensive, ranging from about 250 to more than 350 Nakfa/hr. One hour is generally considered sufficient to plough half a hectare of land (FAO, 2005).

The use of tractors for land preparation instead of oxen may affect both crop yield and soil erosion. This is due to the fact that mechanization can help farmers to undertake farming activities, particularly sowing, in time. The effect of this on crop yield in areas where rainfall is a major constraint to crop production is often very significant. Moreover, the extent of disturbance of the soil differs with different tillage practices. Tillage is defined as "physical, chemical or biological manipulation of the soil to optimize conditions for germination, seedling establishment and crop growth" (FAO, 1993). Although reduced tillage is generally believed to reduce erosion, conserve moisture and increase crop yield, these effects are not considered in this study due to lack of data. Only the saving of labour and animal power is taken into account. This may affect the allocation of land and labour among different economic activities as well as the composition of livestock held by farmers, which, in turn, will affect rural income and the environment.

The use of tractors eases draft power and labour constraint at times of land preparation and sowing. However, oxen and male labour are still required for threshing. This limits the extent to which cultivated land could be extended with the introduction of tractors. Moreover, expansion of cultivated land by hiring tractor services can be economically feasible only when there exists good quality land that guarantees sufficient returns. Due to the above reasons, the level of adoption of this technology and its impact on income and the environment differ among the study villages.

The simulated cultivated lands in Embaderho and Zibanuna under the mechanization scenario are 2.5 and 6.7 percent higher respectively than the base case. Simulated cultivated land in Maiaha is the same as the base results. The proportion of land cultivated by tractor varied from 2.5 – 10 percent of total cultivated land in Embaderho and Maiaha to 33-70 percent in Zibanuna. The higher level of adoption of this technology in Zibanuna is mainly a result of the availability of good-quality land the suitability of climate and soils in the village to the cultivation of taff, a valuable cash crop that makes crop production more profitable compared to the other two villages. As a result, simulated net per capita income increases by 34 percent in Zibanuna. The increase in the other two villages is, however, very small with 3 percent in Maiaha and less than one percent in Embaderho.

Access to tractor services also affects differently the simulated soil conservation and tree planting activities of farmers in the study villages. Both total conserved area and the percentage of croplands where stone bunds are constructed increase in Zibanuna compared to Embaderho, where total conserved land increases but the percentage of land treated with stone bunds slightly declines, and to Maiaha where there is no change in soil conservation practices of the farmers. Compared to the base result, the simulated area of woodlands at the end of the planning period does not change in Maiaha and Zibanuna but are 16.4 percent higher in Embaderho. Due to the different impacts of mechanization on land use and land management, the impacts on soil loss also differ among the villages. Total amount of soil loss declines by 22.5% percent in Zibanuna and by less than 2 percent and 1 percent in Embaderho and Maiaha respectively. As there are no changes in fertilizer application in the higher mechanization scenario, there are only very small improvements in nitrogen balance resulting from a decline in soil loss in all the study villages.

9.5 Scenario 4. Irrigation (IRRIG)

It has been discussed in Chapter two that insufficient and erratic rainfall is one of the major bottlenecks for agricultural development in Eritrea. The country has no perennial rivers or streams and knowledge of availability of ground water is limited (World Bank, 1994). However, it is generally believed that the total irrigated land in the country is much lower than the potentially irrigable area. In the Central Highlands minor irrigation schemes using water from small dams or wells are practised at present. It is believed that small-scale irrigation can be expanded in this region from shallow ground water in the valleys and from the large number of micro-dams constructed before and after independence (World Bank, 1994; FAO, 2005). However, this potential is not yet fully utilized.

In terms of its environmental suitability and highly appreciated food value, potato is the main vegetable crop cultivated in the rural areas of the Highlands of Eritrea. The major potato growing zones are Maekel, Debub, Anseba and Semienawi Keih Bahri. The total area of irrigated land in the Central Highlands is estimated at about 9,000 hectares. There are about 200 micro-dams in the Central Highlands but only about 30 dams are used for irrigation. Thus most of the irrigation activities in this region depend on underground water.

As in most parts of Eritrea, there is too little surface water in the study villages to support irrigated agriculture and water from the dams in Embaderho and

Zibanuna have limited capacity that they are only used for domestic use and for watering livestock. Thus the Irrigation scenario refers to the cultivation of potatoes using pumped underground water. Digging a well and purchasing a pump are the two major initial costs required. One well and a pump are assumed to be sufficient to irrigate one ha of land and that irrigated lands will be harvested twice a year. As water is likely to be the most limiting factor in irrigation activities, it is assumed that a maximum area of 160 m^2 per household can be irrigated. Other costs include expenditures on seed, fertilizer, fuel and transport. The average yields under farmers' conditions for potatoes vary from 8 to 10 tons/ha under rain-fed conditions to 15 t/ha under irrigation (FAO, 1995).

Despite high initial costs, simulated net per capita income in the three villages increases substantially in the IRRIG scenario. The average increase in annual per capita income is Nakfa 250, 187 and 238 in Embaderho, Maiaha, and Zibanuna respectively. This difference is attributable to distance of the villages from Asmara and the resulting difference in transport costs. The increase in income is substantial considering the small size of land considered for irrigation. The results clearly show that small-scale irrigation schemes have high potential in raising rural income. However, due to high initial costs that are not affordable to the majority of rural households, and institutional constraints relating to communal land ownership, this opportunity is yet to be exploited.

The introduction of irrigation also results in changes in land use and land management practices of the farmers. Initially, the total cultivated land in Embaderho and Zibanuna under the IRRIG scenario declines substantially. However, the gap between the cultivated land in the base case and the IRRIG scenario declines over time as more labour is available with population growth. In Embaderho and Maiaha fewer trees are planted in this scenario thus the total area of woodlands are slightly lower. There is not significant change in the level of soil conservation in both Embaderho and Maiaha but due to the decline in woodlands the total level of soil loss slightly increases. Conversely, compared to the base results, more trees are planted in Zibanuna under this scenario. This is because, with a decline in the cultivated land, the number of oxen required declines making some land available for tree planting. Stone bunds are also constructed on all croplands. Due to the combined effects of higher levels of tree planting, a decline in cultivated land and higher levels of soil conservation, soil erosion declines substantially under IRRIG scenario.

9.6 Scenario 5. Food aid for soil conservation and tree planting

Food For Work programs have become increasingly popular over the past few decades not only as a means of ensuring short-term food security of the poor but also as a means of undertaking long-term investments that will enhance the productive base of the resources on which the rural poor depend for their livelihoods. Holden *et al*. (2004) identify three distinct channels through which the long-term development objectives of FFW programs can be realized. First, by relieving short-term liquidity constraints FFW programs may enable farmers to invest in soil conservation and to purchase inorganic fertilizers. Second, FFW programs can create new public goods such as roads and irrigation and soil conservation structures that can increase future productivity. Finally, FFW programs provide insurance against transitory income shocks that may force farmers to employ themselves in activities that have long-run costs such as sale of productive assets, soil and nutrient mining and excessive forest clearing.

Empirical evidence on the efficacy of FFW programs regarding the above stated contributions are limited (Barret *et al.,* 2004). However some studies show that FFW programs indeed relieve binding liquidity constraints and that the benefits associated with participation exceed the value of food received. The benefits from lower constraints are reflected either on higher investment on improved inputs or production technologies or reduced disinvestments (Bezuneh *et al.,* 1988; Barrett, 1999; Barett *et al.,* 2001).

On the contrary, FFW programs are thought to crowd out private investment. It may divert productive resources away from private activities and thereby have negative impacts on current production and long-term resource sustainability. Holden *et al*. (2004), in a survey in northern Ethiopia, found out that a considerably high proportion of farmers participating in FFW programs believed that participation gave them less time to look after their farms and animals and reduced their need to produce their own food compared to farmers who stated the opposite effects.

As discussed in Chapter eight, the base-run results show that all soil conservation activities are made on croplands. Since land types with relatively gentle slopes are generally used for crop cultivation, lands with steeper slopes and hence higher risk of soil erosion remain without any conservation. On the other hand, trees are planted on steeper slopes without the construction of stone bunds. In the following two sub-sections we explore how FFW programs for soil conservation and tree planting activities influence farmers' land use and land management decisions and thereby rural income and land degradation in the study villages.

9.6.1 Scenario 5.1 FFW for soil conservation (FFWSC)

We consider a FFW program in which farmers receive cereals for stone bunds constructed on soil types s_3 and s_4. In this scenario, 3 kg of wheat is provided per person per day for participation in FFW activities. Although men and women participate in FFW programs, traditionally only men engage in soil conservation activities on their own croplands. Thus we assume in this scenario only men can participate.

Because of the differences in village characteristics, the impact of FFW projects on land use, income and soil and nutrient loss vary among the three study villages. In Embaderho, simulated area of croplands treated with soil conservation increases from 25.1 percent in the base case to 35.6 percent and the total annual soil loss declines by 11.2 percent (from 27010 tons/ha/year in the base case to 23990 tons/ha/year). The decline is not only a result of the higher level of soil conservation but also due to changes in land use. Compared to the base case, the simulated area of cropland at the end of the planning period declines from 995 ha to 908 ha and woodlands increase from 164 ha to 275 ha. The average net per capita income in Embaderho increases only modestly from Nakfa 345 per year in the base year to Nakfa 360 per year.

Net per capita income in Maiaha increases from Nakfa 330 per year in the base scenario to Nakfa 397 under when FFW programs are introduced. The proportion of croplands where stone bunds are constructed increases slightly from 29 percent in the base case to 31.2 percent in the FFWSC scenario. As a result, soil erosion and nutrient loss from croplands decline slightly as well. However, the total amount of soil loss in the village increases from 13,714 tons/ha/year in the base scenario to 13,986 tons/ha/year. This is because the area under woodlands declines by 26 percent compared to the area under woodlands in the base scenario. Cultivated land and crop production in Maiaha remains the same as in the base scenario.

Since there is only very small area of land types s_3 or s_4 in Zibanuna, the scenario of FFW for soil conservation is not considered for this village. As discussed above, the provision of FFW for the construction of stone bunds results in higher income increase in Maiaha than in Embaderho. Two factors contribute to such a difference. First, since there is limited area of soil type s_1 or s_2 in Maiaha, even before the introduction of FFW program (in the base scenario), farmers cultivate and construct stone bunds on steeper slopes. Thus when the FFW program is introduced, they receive payments for an activity they were undertaking even without payment. In Embaderho, on the other hand, more land of type s_1 and s_2 are available. Thus in the base scenario, farmers construct stone bunds only on these land categories. The introduction of FFW induces the farmers to build stone bunds on steeper slopes, but less area of gentle-slope croplands are now treated with soil conservation structures. This offsets the benefits farmers receive in terms of FFW for the construction of stone bunds.

Second, while participation on FFW programs in Embaderho results in a decline in cultivated land, total cultivated land in Maiaha remains the same. Since farmers in Embaderho have better access to off-farm employment, participation in FFW programs comes at the expense of farm activities. Due to the decline in cultivated land, the simulated average annual crop production in Embaderho declines by 8 percent compared with the base results.

While the contribution of FFW programs for soil conservation activities is higher in Maiaha, the environmental benefits in terms of total area of woodlands, and the reducing the level of soil erosion are higher in Embaderho. Compared to the base results, total area of woodlands in Maiaha declines, proportion of cropland on which stone bunds are built increases only slightly and as a result total soil loss are higher. Conversely, When FFW programs are introduced in Embaderho, total area of woodland increases, and stone bunds are constructed on substantially higher proportion of croplands that both soil and nutrient losses decline compared to the base results.

9.6.2 Scenario 5.2 FFW for tree planting (FFWTP)

Similar to the above scenario, FFW program for tree planting in which participating farmers receive 3 kg of wheat per day is considered. Most tree planting programs in the Central Highlands of Eritrea have a primary objective of reversing on reducing land degradation and involve the construction of stone bunds, and tree planting on steep slopes. For this reason we assume that farmers receive the payments only for trees planted on steep slopes with the application of stone bunds. Trees may be harvested five years after planting and may be used for fuel or sold in the market.

Surprisingly, the total area of woodlands in Maiaha decreases by 10% compared to the base results. Stone bunds are now constructed on 30.8 percent of the woodlands; however, no stone bunds are built on croplands compared to about 30 percent in the base scenario. As a result, soil and nutrient loss from croplands as well as total level of soil loss are higher under FFWTP scenario than in the base case.

Net per capita income in Maiaha increases from 330 per year in the base case to 398 in the FFWTP scenario. However, the increase in income is much lower than the value of crops received for participating in the FFW program (net per capita income increases by Nakfa 68 per person per year while the value of crops distributed is Nakfa 262.35 per person per year). This clearly shows that participation in FFW programs is coming at the expense of other economic activities.

In Embaderho simulated area of woodlands under the FFWTP scenario increases by 35% and simulated cultivated land declines by about 13 percent compared to the base case. Stone bunds are constructed on 62.4 percent of the woodlands compared to none in the base case but no stone bunds are constructed on croplands. Total annual soil loss declines by 7.5 percent. Even average soil and nutrient losses from croplands decline slightly despite lower levels of soil conservation on croplands. This is because with a decline in the cultivated land the croplands with steeper slopes go out of cultivation.

Average annual net per capita income increases from 345 to 369. As the case with Maiaha, however, this increase is much lower than the value of food aid distributed in the program, which is Nakfa 150.60 per person per year. This is caused by the decline of cultivated land and lower yields due to less soil conservation activities.

The above results show that the way FFW programs are designed do in fact crowd out farmers' investment on their own land. However, it is important to remember that women also participate in most FFW programs and the disruption in private farming activities caused by the FFW programs may be of much lower magnitude.