

## **Policies for Poverty Reduction, Sustainable Land Management, and Food Security: A Bioeconomic Model with Market Imperfections**

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**E**thiopia is one of the poorest countries in the world, and its population of more than 70 million people lives mostly in the highlands. The food security of these people is threatened by land degradation and droughts that cause declining and highly variable land productivity. Changes in the global climate may also have caused an increase in the incidence of drought that has occurred recently in areas that were not affected by the earlier droughts. Along with a history of social conflict and unrest in the country, poor governance and misplaced government policies have contributed to the vicious spiral of poverty, land degradation, and food insecurity. There is a strong need for peace, better governance, and improved policies that can help break the Malthusian development path and put communities onto more sustainable development pathways where poverty is reduced and food security is improved. Especially, there is an urgent need for pro-poor alternative development strategies that address land degradation and food insecurity in less-favored areas where drought risk is higher and/or market access is poorer.

Market imperfections tend to be severe in rain-fed tropical agriculture because of the basic material and behavioral conditions, including spatial dispersion, seasonality, covariate risk, poor infrastructure, and moral hazard (Binswanger and Rosenzweig 1986) as well as because of policy distortions and social unrest. Policy reforms aiming at improving the functioning of markets may therefore be one important element in a new policy for sustainable development. Still, there is no

guarantee that piecemeal improvements of some markets will lead to economic growth and more sustainable land use. It is even possible that improved access to some markets can lead to more land degradation. This is also consistent with the theory of second best (Lipsey and Lancaster 1956).<sup>1</sup> Both the mixture and sequencing of policies may matter for the outcomes.

Policymakers and technology development institutions have for a long period of time neglected less-favored areas. The International Food Policy Research Institute (IFPRI) has challenged the conventional wisdom that public investments in developing countries should emphasize investment in favored areas because of diminishing returns to investments in these areas and high concentration of poverty and natural resource degradation problems in less-favored areas (Fan and Hazell 2000; Pender and Hazell 2000; Hazell et al. 2002). Based on a comparative advantage argument, Pender, Place, and Ehui (1999) argue that certain types of agricultural and nonagricultural activities can give high returns and contribute significantly to poverty reduction and improved natural resource management in less-favored areas. More research is, however, necessary to investigate how big this potential is.

Stimulation of crop production through provision of credit for adoption of fertilizer has not been very successful in less-favored areas of Ethiopia, however (e.g., see Chapters 5 and 9). This has led to increased interest in alternative activities, including development of livestock production, tree crops, forestry, small-scale irrigation, and nonfarm activities.

We have in this chapter developed a bioeconomic model for a less-favored, severely degraded, densely populated area with fairly good market access in the Ethiopian highlands. The study area was chosen because of the unusual availability of biophysical empirical data on land degradation and the effect of alternative conservation technologies from the research carried out by the Soil Conservation Research Project, beginning in the early 1980s. Combined with our own household panel data from three survey rounds in 1994, 1998, and 2000, including very detailed farm plot-level data, we had a very good basis for developing bioeconomic models for the area. We use the models to assess the effects of alternative policies to reduce poverty, increase food security, and promote more sustainable land use in the study area. Specifically, we assess the (1) effect of improved access to off-farm income and credit for fertilizer, (2) effect of access to food-for-work (FFW), and (3) effect of promoting planting of eucalyptus on land unsuitable for crop production on household welfare, agricultural production, conservation investments, and soil erosion.

In the second part of the chapter we give a brief description of the case study area. The structure of the bioeconomic model is briefly described in the next part,

and the results of the model simulations are presented and discussed in the fourth part, followed by the conclusions.

### **Description of the Case Study Area and Data**

Andit Tid is located approximately 60 kilometers east of Debre Berhan, along the main road between Addis Ababa and the Tigray Region, in East Shewa in the Central Ethiopian Highlands. This implies that the market access is fairly good. The area is classified as belonging to the low-potential cereal–livestock zone and is severely degraded. It is a high-altitude area (> 3,000 meters above sea level). The land is located in two altitude zones: *dega* zone (< 3,200 meters above sea level) and *wurch* zone (> 3,200 meters above sea level). The average rainfall is 1,336 millimeters per year distributed over two growing seasons, the *meher* season from June to November and the *belg* season from January to May. Droughts have not been common in the area until very lately when the *belg* rains have failed in two consecutive years (1999 and 2000). Hailstorms and frost have, however, commonly damaged crops.

Yohannes (1989) estimated 75 percent of the land to be on steep slopes (>25 percent slope). Soil erosion rates in the area are very high, and a large share of the land has shallow soils, causing reduction of soil depth to affect crop rooting depth and thus yields (Shiferaw and Holden 2001). Holden and Shiferaw (2000) estimated 21 percent of the land to be shallow (<30 centimeters soil depth) and 48 percent to be of medium depth (30–60 centimeters).

Various forms of conservation technologies are common in the area. They have partly been introduced through external FFW programs. Some of the exogenously introduced conservation structures have later been removed by the farm households. Shiferaw and Holden (1998) found that human population pressure (land scarcity) increased the probability that conservation structures were partly or fully removed. The reasons for this were thought to be that the conservation structures did not contribute to increased yields in the short run, they occupied some land and therefore reduced the effective planting area, and they collected fertile soils that could be used to increase short-run production by dismantling the structures and spreading out the soil collected there. The structures could also harbor rats that may damage the crops.

The main crop in the area is barley, followed by wheat, horse bean, and field pea. Lentils and linseeds are also commonly grown. Most of the crop production takes place in the *dega* zone, but barley is also grown in the *wurch* zone in the *belg* season.

Cattle and sheep are the dominant types of livestock, but goats, equines, and chickens are also common. The animal population density is very high in the area: Yohannes (1989) estimated it to be 1.48 TLU (tropical livestock units) per hectare against 0.36 as the average for the Ethiopian highlands. We found this density to

have increased to 2.03 TLU per hectare in 1998, but it declined to 1.71 by the end of 1999 as a result of the drought (Holden and Shiferaw 2000).

The human population density was estimated to be 145.5 persons per square kilometer in 1986 against the average of 61 persons per square kilometer for the Ethiopian highlands (Yohannes 1989). The population density was 230 persons per square kilometer of cultivable land. The population growth rate was estimated to be 3.0 percent per year, indicating high and increasing population pressure in the area.

Production of crops and livestock are well integrated in the area. Oxen are the dominant source of traction power. Hand cultivation is used only on very steep slopes inaccessible by oxen. Animal manure is used for fuel or as fertilizer on crops. Sale of animals is an important source of cash income. Crop residues are used as animal fodder. Fodder is otherwise obtained from fallow land and grazing land, but only a small share of this (5 percent) is from communal land. Fodder shortage is an important constraint, and purchase of fodder and use of a cut-and-carry system are the main strategies to overcome this problem besides limiting the number of animals kept (Holden and Shiferaw 2000).

The land resources are fairly evenly distributed in the area because of land reform and frequent land redistributions in Ethiopia, where land was allocated to households based on household size. Livestock wealth is therefore a better indicator of household wealth and wealth differentiation than land ownership. Particularly, ox ownership signifies the farming capacity of households because the rental market for oxen for plowing is highly imperfect (Holden and Shiferaw 2000; Holden, Shiferaw, and Pender 2001). It also leads to the typical pattern in which households without oxen rent out land to households with two oxen or more, whereas households with one ox exchange oxen among themselves. Land renting typically takes place in the form of share tenancy, where the share to the owner varies between 0.5 and 0.25, depending on land quality. Households may have access to credit in kind for purchase of fertilizers but are reluctant to take this kind of credit even though it appears profitable to do so. Risk and high aversion to this type of risk cause households to be reluctant to buy fertilizer on credit.

Households have limited access to off-farm income sources; crop production is highly subsistence oriented, but the trend during the last 20 years has been from households being net sellers of food grains to now being net buyers. The recent droughts have even made the area dependent on food aid (Holden and Shiferaw 2000).

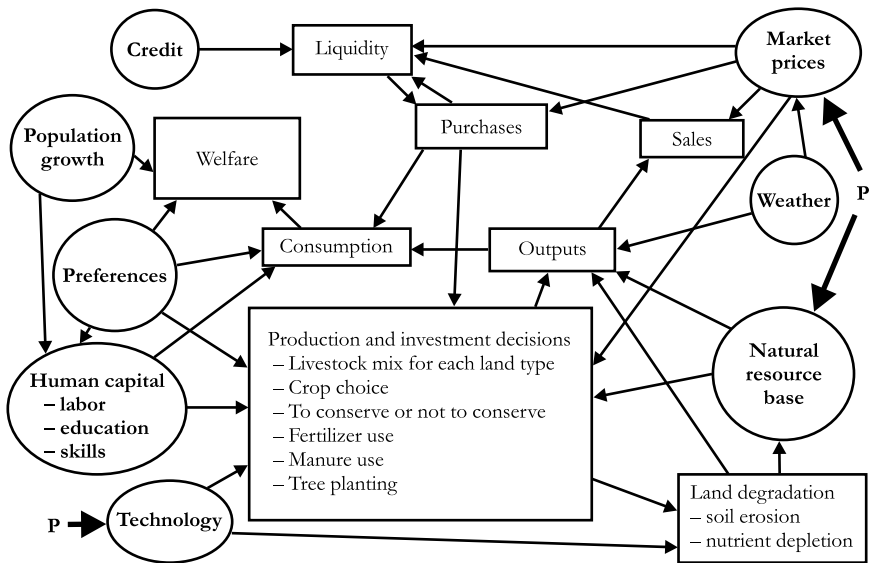
The development trend in the study area appears to be similar to that in other parts of the less-favored Ethiopian highlands, although it was less severe in the past than in South Wollo, for example (which has lower elevation and lower and more erratic rainfall than our study area) (Ege and Aspen 2003). Ege and Aspen find that

households with oxen are generally poor, and even if they manage to sharecrop in land, this does not lead to wealth accumulation. Ege (2003a) finds that ox owners are usually poor and likely to grow poorer. Ege (2003b) finds that ox owners can be able to obtain extra land through sharecropping, but the costs of keeping oxen and the costs of renting land are so high that these “rich” households remain poor by any normal standard. Aspen (2003) also finds that informal sources of credit exist among close relatives and friends and semiprofessional money lenders, but he finds no evidence of money lending leading to accumulation of wealth by richer farmers. Devereux and Sharp (2003) have also found that the incidence and severity of poverty are increasing over time in Wollo, indicating a deepening livelihood crisis in this part of Ethiopia. Various studies in Wollo confirm the similarity in terms of limited off-farm employment opportunities and low income-generating potential (Holt and Dessalegn 1999; Devereux 2000; RESAL Ethiopia 2000; Yared et al. 2000). According to Devereux and Sharp (2003), there are some improvements in off-farm opportunities as a result of greater freedom of trade and population movement, improved roads, and new construction work on government offices, schools, and clinics. However, they find that the supply of labor far exceeds the demand.

### **The Bioeconomic Model**

This model is an extension of the model developed by Holden and Shiferaw (2004) that was used to analyze the effects of land degradation, drought, and price risk and the suitability of the standard fertilizer-credit extension approach in the study area. The main expansion of the model presented here is that it looks at alternatives to the traditional fertilizer-credit development strategy in the form of off-farm income, FFW, and tree planting. Whereas the previous models were run for a simulation period of 5 years, these new models were run for a 10-year period. A detailed technical description of the model can be found in Holden, Shiferaw, and Pender (2005). Other published papers based on the model include Holden, Shiferaw, and Pender (2004) and Holden, Barrett, and Hagos (2006). Holden et al. (2003) provide a more detailed analysis of policies and poverty effects of investments in on-farm tree planting.

A simple conceptual representation of the model is presented in Figure 14.1. Households are maximizing their welfare (measured as utility of certainty equivalent full income) subject to many constraints. The model is a dynamic, nonlinear optimization model. For example, land degradation in the form of soil erosion and soil nutrient depletion is endogenous in the model, as it is affected by household production and investment decisions. Furthermore, soil erosion affects soil depth that affects yields and output in succeeding years, which affects income and welfare

**Figure 14.1 Main components of bioeconomic household group model**

in future years.<sup>2</sup> Weather risk affects production as well as prices, and this may again affect production decisions. Households make production decisions based on expectations about prices and output and the risk involved. Imperfections in markets<sup>3</sup> affect production decisions and cause nonseparability of production decisions from consumption decisions. Households in the study area were divided into groups based on ox ownership because oxen are used for land cultivation and represent a very important wealth indicator.<sup>4</sup> Population growth affects both the labor force and household welfare as more people have to share the outcome of a constant land area that also is affected by land degradation. This leads to a Malthusian development path when technology, prices, and other exogenous factors are constant. This poverty-environment trap can be broken only through availability of new technologies, improved access to markets, and better investment opportunities.

## Results and Discussion

### Effect of Improved Access to Off-Farm Income

Ten-year models were developed to explore the effect of better access to off-farm employment on household welfare, agricultural production, conservation incentives,

and soil erosion. The results are presented in a set of graphs in Figure 14.2. The risk of drought in these models was low (10 percent), and so was the level of risk aversion. Higher risk and risk aversion caused infeasibilities when the time horizon was expanded much beyond five years.<sup>5</sup> Because of population growth, the land constraint, and land degradation, income per capita would fall by 8 percent over a five-year period when there is access to credit and by 16 percent when there is no access to credit. We did not manage to get the bioeconomic model to solve for a period of 10 years when access to both wage employment and credit are restricted at very low levels. This is indicative of the precarious situation faced by households in the study area. The income per capita would be lower and decline much faster than for the scenario with access to credit, given in Figure 14.2. This illustrates the severity of the combined effects of land degradation, increasing population pressure, stagnant technology, and drought risk in the study area. Households are becoming increasingly dependent on better market access for off-farm employment, selling of crop–livestock products, or assistance from the outside in case of adverse conditions.

We see furthermore that the hypothetical case of unconstrained access to wage employment at the going wage rates in Andit Tid would have substantially improved household income in the area. The fact that households have low levels of off-farm income (Table 14.1) demonstrates that there are insufficient local employment opportunities and entry barriers<sup>6</sup> in relation to getting wage employment in distant areas. Otherwise, households in the study area would have worked much more outside the farm given their small farms and the risks of agricultural production. Provision of better employment opportunities for unskilled labor (at low wages) may substantially improve household income.

We now look at how different market access conditions affect the agricultural production over time. Households without access to off-farm wage employment cultivate more of their land because they have a lower opportunity cost for family labor. Unconstrained access to credit but not to off-farm employment creates more incentives for land cultivation than both having access to credit and off-farm employment. Agricultural production is continued on a larger area for a longer period of time when households have access to credit only. The effect on livestock capital of households under the different market access conditions is such that households with access to credit only build up and hold more livestock than households with access to off-farm employment (with or without credit constraint). There is a downward trend in livestock capital over the 10-year period, however, and this may partly be explained by a decline in fodder production.

Households with unconstrained access to credit (but not to off-farm employment) remain net sellers of crops in years with good rains for most of the 10-year time period. The surplus declines over time, however, and turns into a net deficit in

**Figure 14.2 Effects of improved access to credit, off-farm employment, and both credit and off-farm employment**

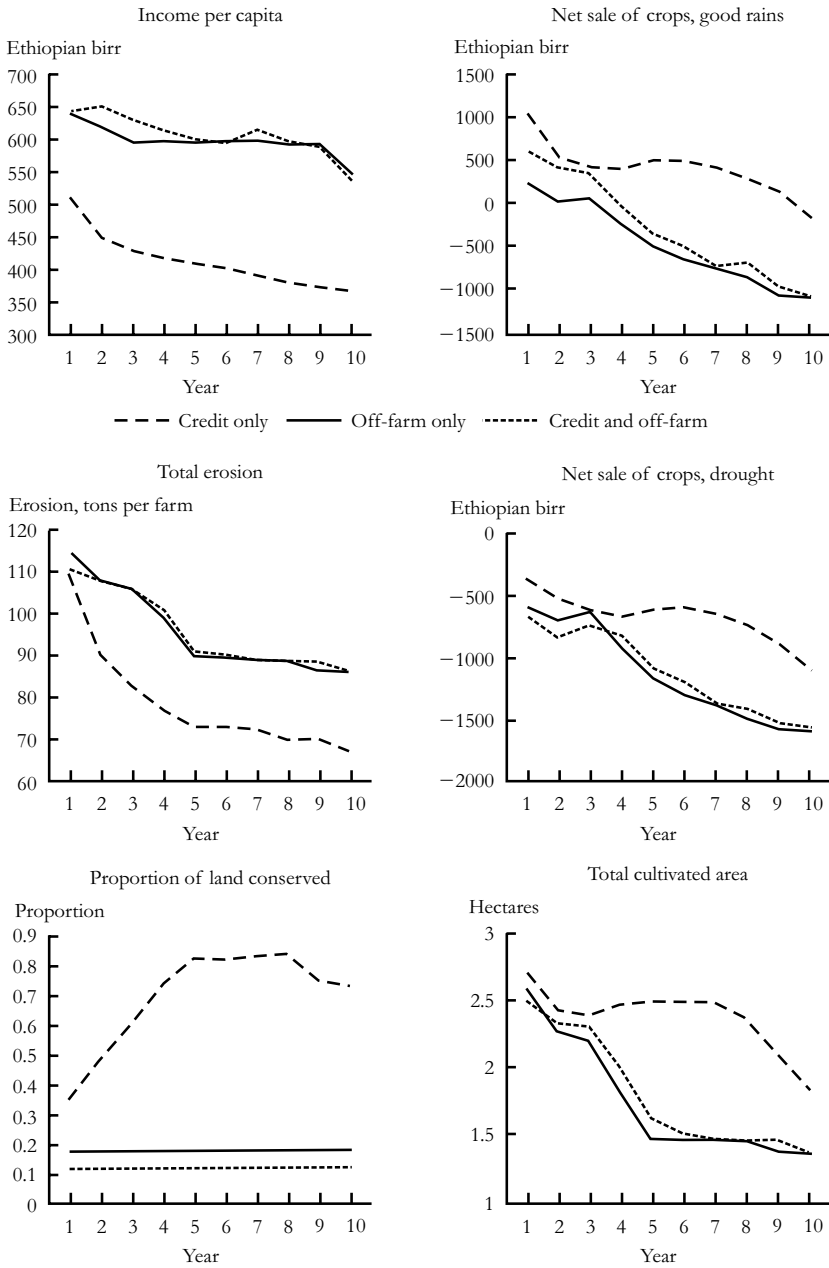
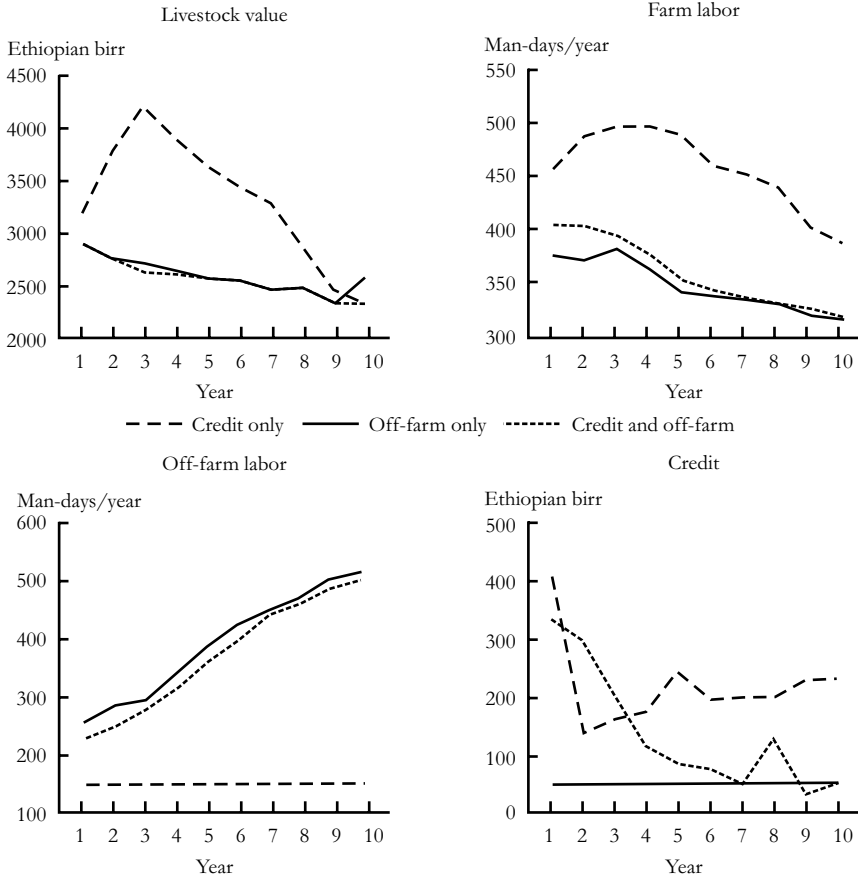


Figure 14.2 (continued)



the last year. Households with access to off-farm income gradually become deficit producers of food crops even in years with good rainfall, and the deficit grows to more than 1,000 kilograms of grain per household by the 10th year. Unconstrained access to off-farm income also reduces the demand for credit for purchase of farm inputs over time.

Households with unconstrained access to both credit and off-farm wage employment also gradually become deficit producers of food crops. They produce more food grain in the initial years than households with unconstrained access to off-farm wage employment only, but they have a more rapid decline in food grain production and have after 10 years a deficit as large as those with unconstrained

**Table 14.1 Average income by source and household group in Andit Tid, 1999**

Income source	Number of oxen in household		
	0	1	2 or more
Wage income	152	15	85
Remittance income	38	38	37
Common property resource income	44	25	35
Business income	80	60	44
Food aid	463	586	547
Farm income <sup>a</sup>	458	402	509
Total income	1,236	1,125	1,244

**Note:** Values in Ethiopian birr.

<sup>a</sup>Cash income only. It does not include the value of crops or livestock products that were produced and consumed by the household during the year. The year 1999 was a drought year, causing total failure of crop production during the *belg* season.

access to off-farm income only. Better access to off-farm income therefore reduces incentives to produce crops and produce a surplus or be self-sufficient in food grains. The pattern is very similar in drought years (net sale with drought), but then all households are deficit producers. The deficit increases from about 400 to above 1,000 kilograms of grains for households with unconstrained access to credit over the 10-year period, whereas it increases from 600 to above 1,500 kilograms for households with access to off-farm wage employment (with or without access to credit).

Households with unconstrained access to credit put much more labor into farming than households with unconstrained access to off-farm income. Access to credit does not help much for the incentives to work on the farm when there is unconstrained access to off-farm wage employment, showing the higher relative returns to family labor off-farm. The demand for off-farm employment increases steadily with the growth in the family labor force and the fall in agricultural productivity and thus labor input into agriculture.

Households with unconstrained access to credit had more incentives to conserve their land and conserved proportionally much more of it than households with unconstrained access to off-farm wage employment. Households with unconstrained access to credit and off-farm wage employment conserved even a smaller share of their land than households with unconstrained access to off-farm wage employment but not credit.

The consequences of this for land degradation on the typical farm was that even though households with off-farm employment cultivate small land areas (have less intensive agricultural production), their activity causes more erosion than that of households with access to credit because they conserve a much smaller proportion

of their farmland. It appears, therefore, that provision of better off-farm employment opportunities does not necessarily provide win-win benefits, as the natural resource base may degrade as a result of neglect.

### **Effect of Introducing FFW Programs**

Food-for-work (FFW) programs have been widely used to target food insecure people and to promote development in various parts of Ethiopia. FFW was also used to establish conservation structures in Andit Tid in the early 1980s. This was done through a top-down approach that did not involve local people in planning or organization. The farm households themselves therefore had no say with respect to choice of conservation technology or how it was fit into the landscape on their farms. This caused many to reject the technologies, and many were found to have partly or fully removed these technologies on their farms (Shiferaw and Holden 1998). This may also have been caused by choice of inappropriate or nonprofitable conservation technologies (Shiferaw and Holden 2001).

The effect of new FFW programs in Andit Tid aimed at providing food security through provision of seasonal employment at a low wage rate (in food) was assessed using the model. The effect of three alternative scenarios was evaluated (1) when FFW employment is provided outside agriculture and (2) when FFW employment is provided for conservation investment on-farm. In both these cases we assume that access to off-farm employment is constrained and that conservation investment does not reduce initial yields. The third case (3) is like case (2) but with unconstrained access to off-farm employment and with conservation investment reducing initial yields (both these changes reduce incentives for farm production and conservation investment). In cases (2) and (3) we assume that the investment is taking place on-farm. In all cases, the “wage rate” is defined as 3 kilograms of wheat per day of work, the standard rate mostly used in FFW programs in Ethiopia.

One of the criticisms of FFW programs is that they undermine farmers’ incentives to produce their own food and to take care of their own farms, partly because FFW activities compete with farming activities of households. Arguments against this are that if FFW is provided outside the main agricultural season, such competition may be reduced, thereby enhancing the synergies with agricultural production. In Andit Tid there are two growing seasons. It is most relevant to provide FFW after the short rains, that is, in the period March to May.<sup>7</sup> However, FFW may compete with households’ own conservation activities in this period, as these are typically carried out in the slack season.

In our first simulation, case (1), presented in Figure 14.3, we look at the effects of provision of FFW when FFW is not used for conservation on-farm, when

**Figure 14.3 Effect of introducing food-for-work (FFW) when FFW is not used for conservation, because of constrained access to the labor market or for land conservation, and FFW does not reduce initial yields**

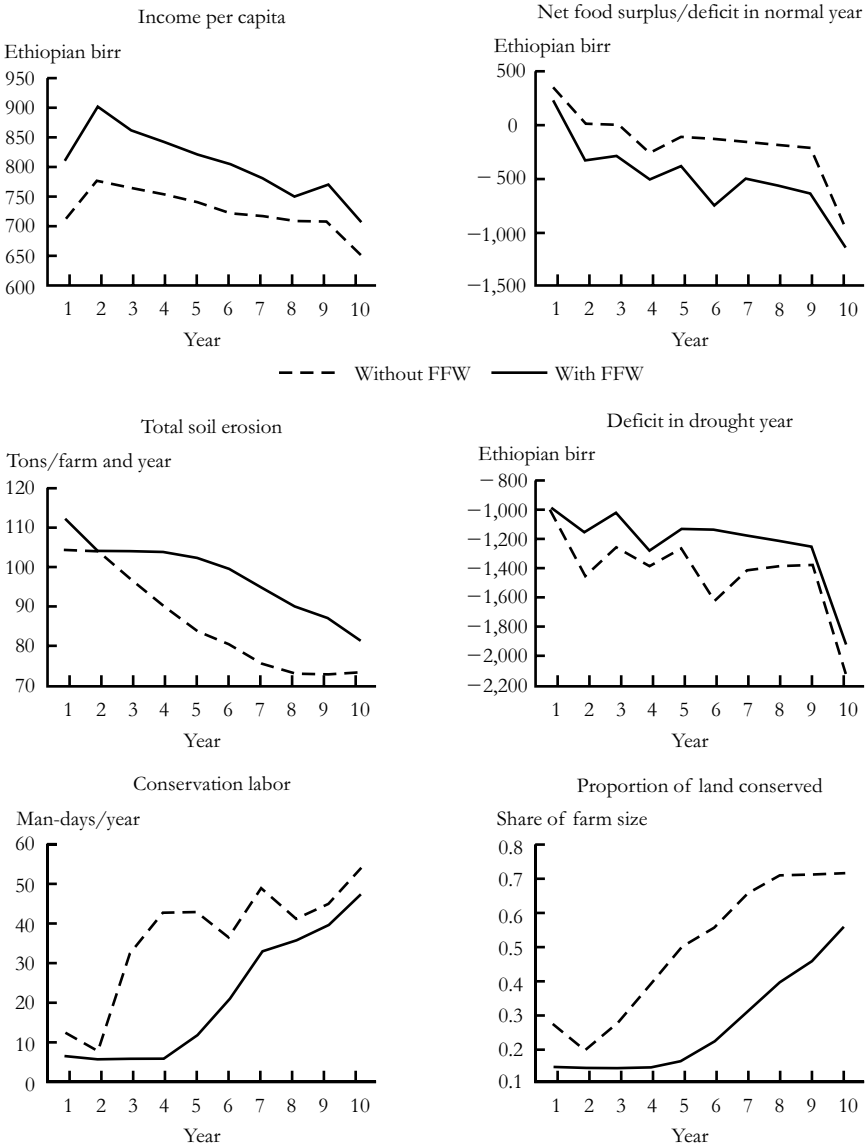
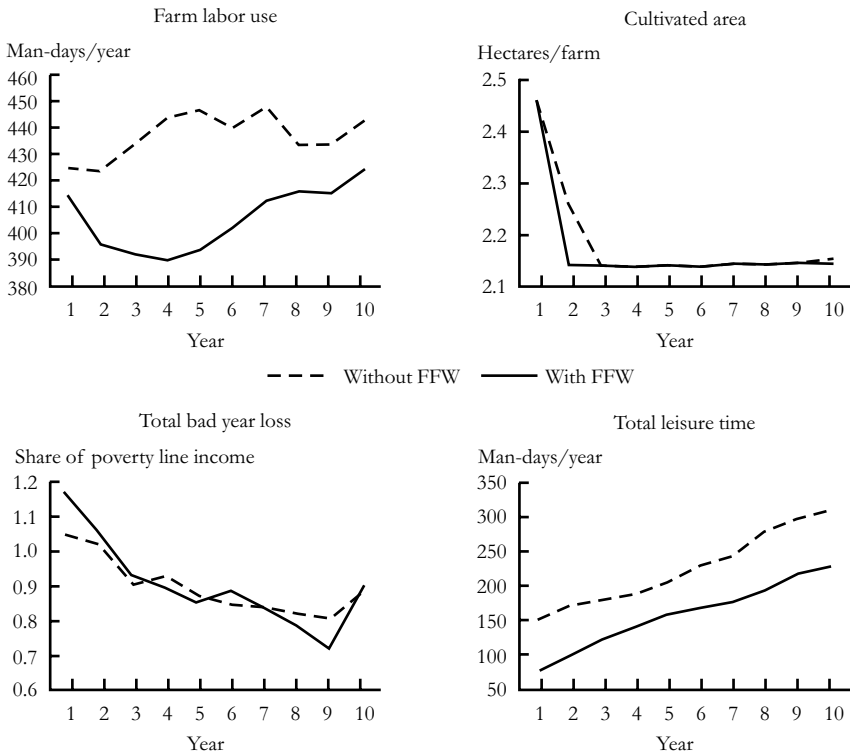


Figure 14.3 (continued)



households have constrained access to the labor market, and conservation technologies do not reduce initial yields. We see from Figure 14.3 (containing 10 graphs) that FFW increases income per capita compared to the baseline condition without access to FFW. We also see that own food production is reduced in normal as well as in drought years for households with access to FFW (excluding the food obtained through the FFW activity). We see that farm labor use, including conservation labor use, is reduced when opportunities for off-farm employment through FFW are provided. This causes a smaller proportion of the farm to be conserved and total soil erosion to be larger compared to cases where such employment opportunities do not exist. Total leisure time is reduced, indicating that FFW has substituted not only for farm labor but also for leisure time. This indicates clear costs of providing FFW for poverty reduction and food security, as it reduces incentives for own food production and conservation and increases the dependency on assistance from outside.

**Figure 14.4 Effect of food-for-work (FFW) when FFW is used for land conservation, because of constrained access to the labor market, or for conservation, and FFW does not reduce initial yields**

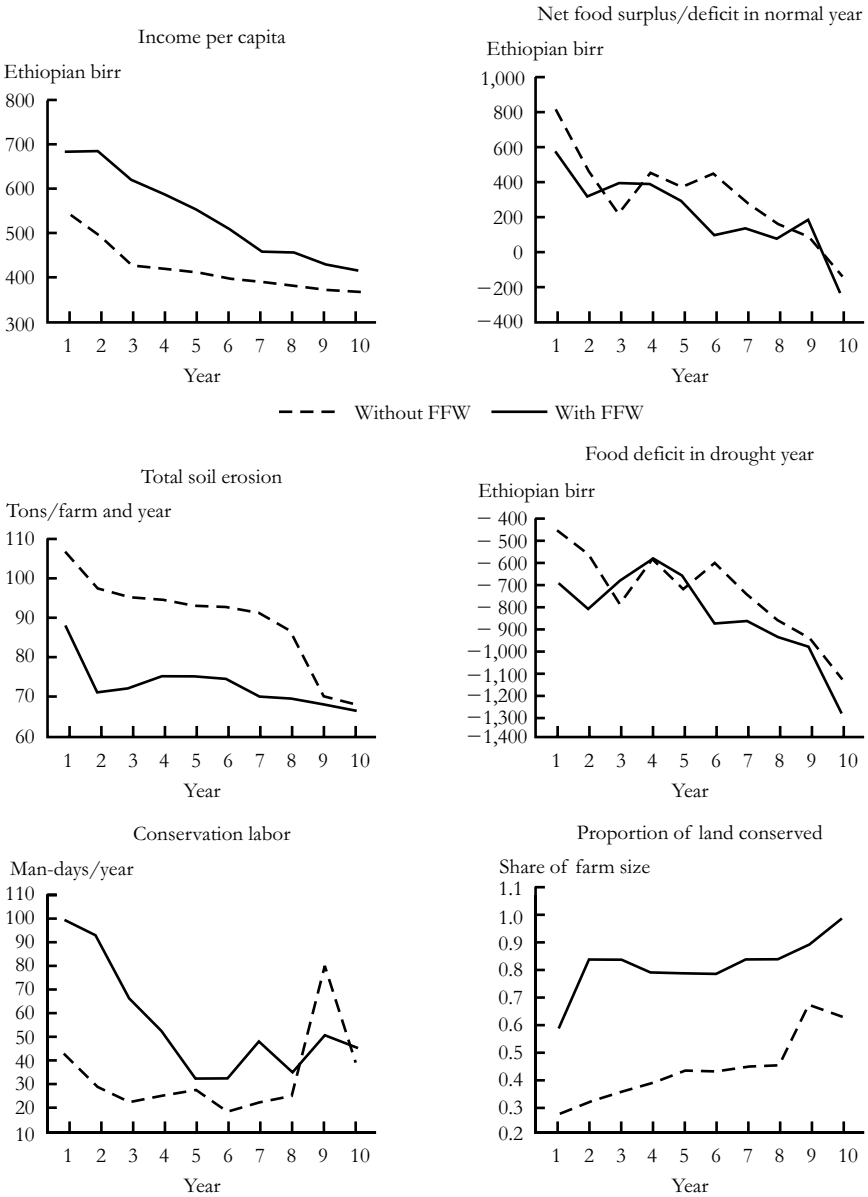
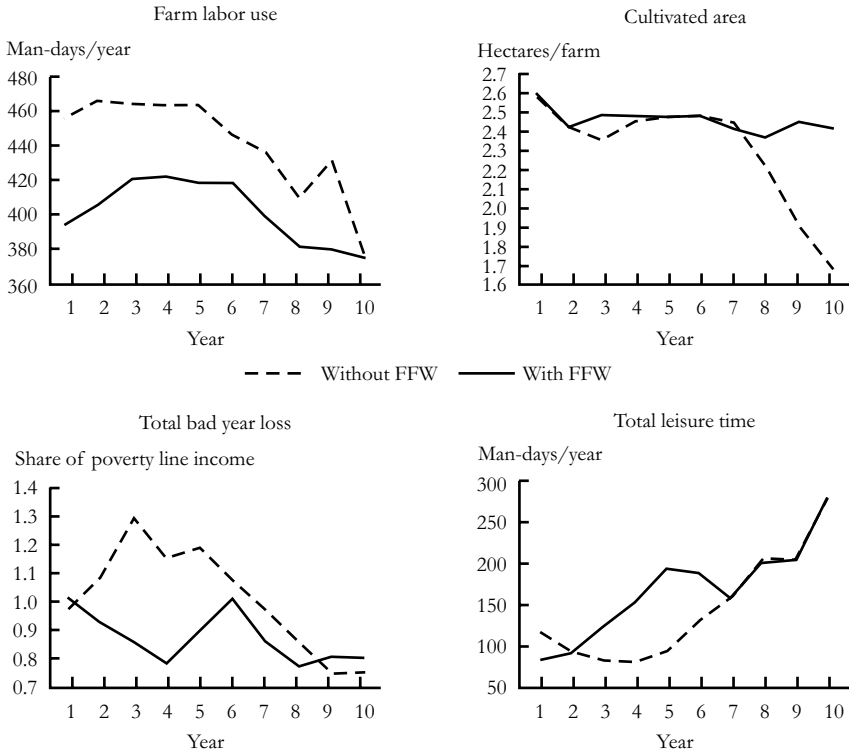


Figure 14.4 (continued)



In our second simulation, case (2), we look at the effects of FFW when it is used for conservation on-farm, when farmers have constrained access to the labor market, and conservation does not reduce initial yields. The results are presented in Figure 14.4.

We see from Figure 14.4 that household income per capita is increased when opportunities for on-farm employment are available through local FFW interventions. We also see that, as expected, conservation-linked FFW stimulates land conservation, and this leads to less soil erosion. The effect on household surplus food production is small (i.e., the food surplus is relatively lower with FFW than without it).

In the third simulation, case (3), we have altered two of the initial assumptions and look at the effect of FFW when FFW is used for conservation, when households have unconstrained access to the labor market (better nonfarm employment

opportunities), and conservation technologies reduce initial yields (lower incentives to conserve land). The results of the model simulations are included in Figure 14.6. Household income per capita is increased for households with access to FFW in this case also, but less so than when access to the labor market was constrained. This implies that the payment from FFW (3 kilograms of wheat per day) is higher than that in the labor market. We also see that FFW substitutes for other off-farm work in this case. On the other hand, FFW stimulates own food production and reduces food deficits in normal as well as drought years, and particularly so toward the end of the 10-year period for which the models have been run. This is largely because FFW is used for land conservation, and this makes farm production more sustainable. Without FFW, households do not invest in conservation in this case because conservation reduces initial yields and because they have alternative off-farm employment opportunities.

We see that the effects of FFW on food production and conservation of land can be highly different depending on how and for what activities FFW is used, the wage rate, the level of access to off-farm cash employment, and the effect of conservation technologies on short-term yields. When FFW competes with labor used for conservation, FFW may reduce incentives to conserve land where such incentives exist without intervention. On the other hand, FFW may be used to stimulate conservation when there are insufficient incentives to conserve land. This illustrates that care has to be taken when such programs are designed to avoid unwanted disincentive effects and to achieve the social, economic, and/or environmental objectives of the programs. Good knowledge about the local farming systems, about the local market characteristics and prices, and about the distribution of resources and welfare are needed to avoid design failures. Those who have designed such programs in the past may not have had such knowledge, and this may also explain the mixed experiences with such programs (Barrett, Holden, and Clay 2004).

### **Effect of Stimulating Tree Planting**

Planting of trees, especially eucalyptus, may be a promising option for farm households in marginal areas of Ethiopia where rainfall is adequate (Jagger and Pender 2003). In the past, most tree planting took place on government land and community woodlots. However, some tree planting also took place on privately controlled land. Jagger and Pender (2003) suggest that tree planting is most likely to be profitable in areas with low population density, low agricultural potential, good market access, market outlet for tree products, access to long-term credit, and secure access to the benefits from the investments. Holden and Yohannes (2002) found that resource poverty in land, livestock, and basic education may undermine planting

of perennials in southern Ethiopia, whereas Gebremedhin and Swinton (2003a) found that tenure insecurity may undermine tree planting in the Tigray Region. If farm households adopt short planning horizons because of poverty and tenure insecurity, they may not adopt tree planting, as it may take 8–15 years before they can harvest the benefits of their investments. It may, under such conditions, be socially optimal to intervene to stimulate private tree planting because the benefits from intervention may be higher than the costs.

Interventions may take alternative forms depending on local circumstances, and various approaches should be tested. Direct regulation is one alternative, as has been recently done in Tigray, where planting of eucalyptus on land suitable for crop production was prohibited in 1997 (Jagger and Pender 2003). More recently, the regional government allowed private planting of eucalyptus on community wasteland and steep hillsides. In the Amhara Region distribution of state-owned communal lands on long-term lease contracts for private tree planting has started.

Our case study area has high population density, no access to long-term credit, and farmers may not feel secure that they will be getting the benefits from their tree-planting efforts (Holden and Shiferaw 2000). The land redistribution in 1997 may have undermined the feeling of tenure security and reduced the incentives to plant trees. Poverty, credit constraints, and lack of access to tree seedlings may be other reasons for underinvestment in tree planting compared to what would be socially optimal. Our survey showed that farm households in the area are not willing to plant trees on land suitable for crop production but are positive toward tree planting on land unsuitable for cropping. The potential of this option to improve household welfare is, therefore, what we explore with our bioeconomic model. We also want to explore the indirect effects on agricultural production and incentives for conservation, considering the income effect and possible competition between alternative uses of family time for agricultural production, including conservation, tree production, nonfarm employment, and leisure. We do not here explore alternative ways of promoting tree planting but rather assume that the constraints to tree planting have been removed and that a stable tree rotation has been established, given that it is profitable. We therefore try to assess the potential contribution of trees to household income and the influence such production may have on other production and conservation activities.

The model allows tree planting only on steep slopes and shallow soils unsuitable for crop production. Almost all land in densely populated Andit Tid has been distributed to individual households. The average area of steep lands with shallow soils is 0.45 hectare per household. The average area planted with trees on the farms was only 0.09 hectare per household. If trees are relatively more profitable, it should

therefore be possible in principle to increase the area planted with trees from 3.3 percent to 18.2 percent of the average farm size without using land that is suitable for crop production.

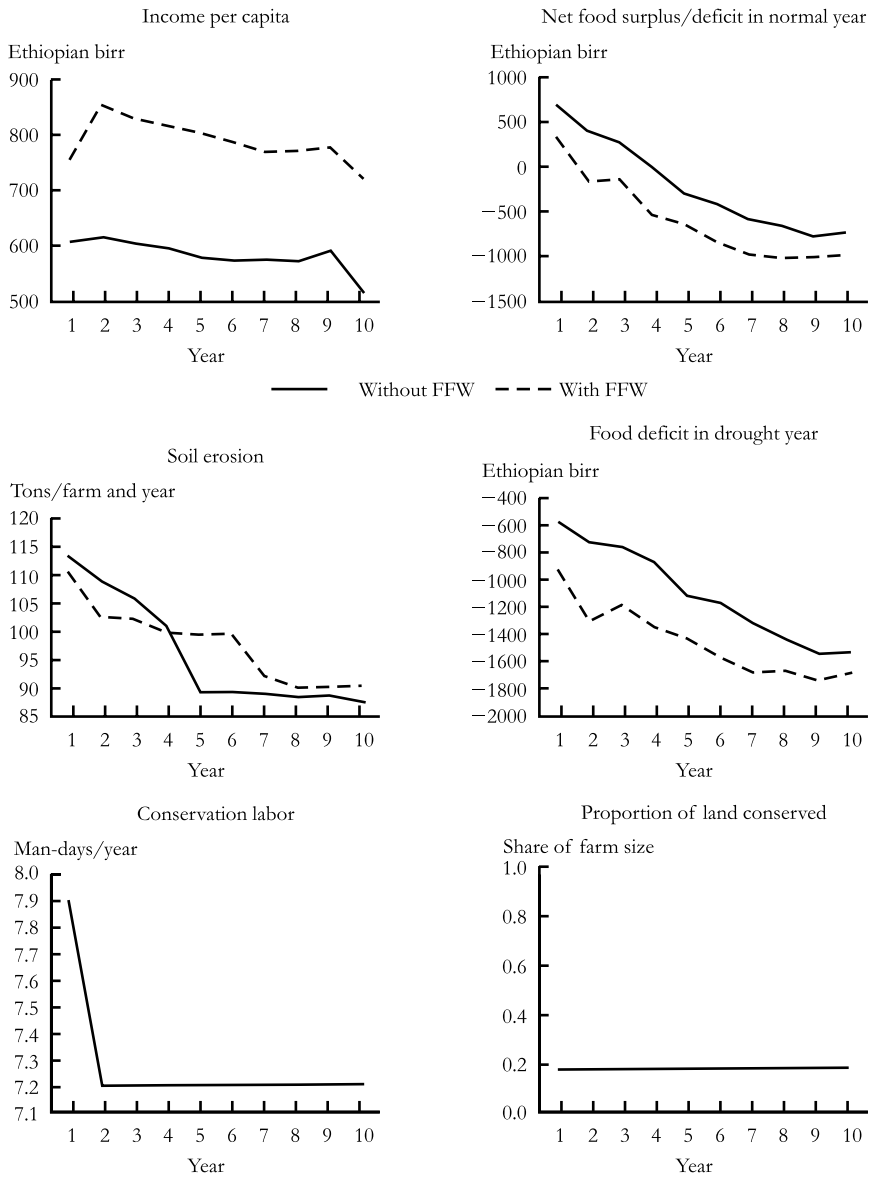
The high elevation in Andit Tid causes the time from planting to harvesting of eucalyptus to be as long as 12 years. The average price of harvested trees was 12 birr in 1998. This is substantially below the lowest price of 17 birr used by Jagger and Pender in their study in Tigray, suggesting higher scarcity of trees in Tigray compared to North Shewa, even though Andit Tid is located along the main road between Addis Ababa and the Tigray Region. We also assume away marketing constraints in our analysis and assume that farm households may sell all the trees they produce at the 1998 price. However, we included a small transportation cost for trees of 0.5 birr per tree. We used a planting density of 5,000 trees/hectare and a survival rate of 60 percent. We have not included additional ecological benefits and costs of eucalyptus planting in the model because these are highly uncertain and complex, and it is not clear whether the net effects are positive or negative (Jagger and Pender 2003).

Figure 14.5 illustrates the potential effects of planting of a stable rotation of eucalyptus trees on land unsuitable for crop production in Andit Tid. We have in this case assumed that households have unconstrained access to off-farm employment and that conservation investment reduces initial yields. We see that planting of eucalyptus on land unsuitable for crop production can increase household income substantially. This is in line with what has also been found in other studies (Okumu et al. 2002; Jagger and Pender 2003). We see that although land for crop production is not used for tree planting, food deficits are increased after tree planting has been stimulated. This is primarily because of higher demand for food when income is higher but to some extent also because of less food production. Planting of trees had little effect on incentives for conservation of land used for crop production and therefore also had little effect on total soil erosion on farms. Growing of trees reduced the demand for off-farm employment, indicating that the relative return to family labor in on-farm tree plantations was higher than the return to available cash employment for unskilled labor off-farm.

It appears that stimulation of on-farm trees may be a promising policy option for degraded drought-prone areas in the Ethiopian highlands provided that market outlets can be identified or developed. Interventions may be necessary to promote this through stimulation of seedling production, mobilization of labor, and identification of suitable areas.

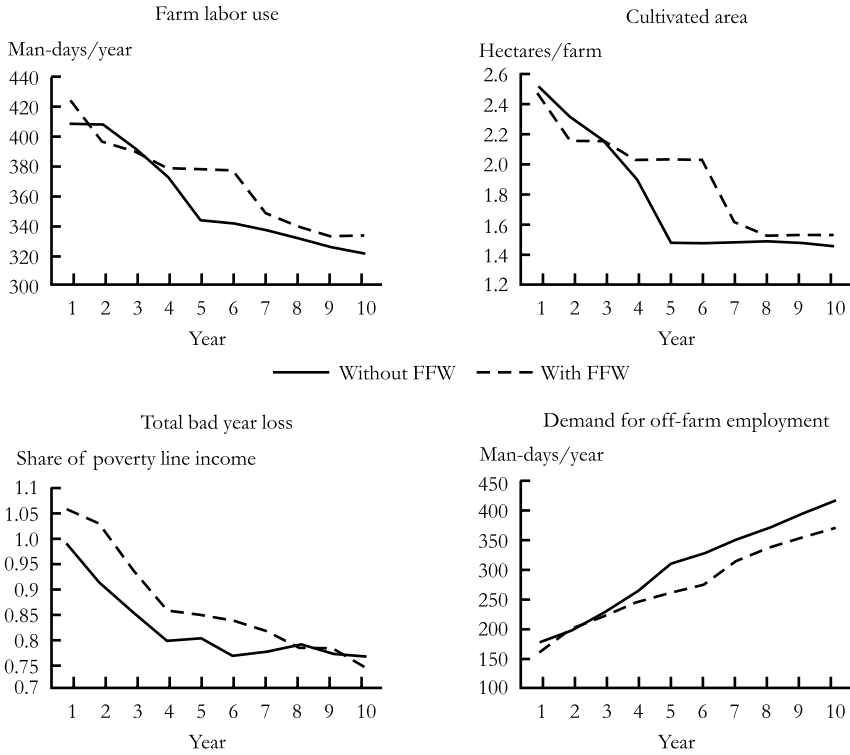
Finally, we looked at the combined effects of planting of eucalyptus and FFW employment to promote land conservation, in the case with unconstrained access

**Figure 14.5 Effect of planting of eucalyptus when off-farm employment is unconstrained and conservation investment reduces initial yields**



(continued)

Figure 14.5 (continued)

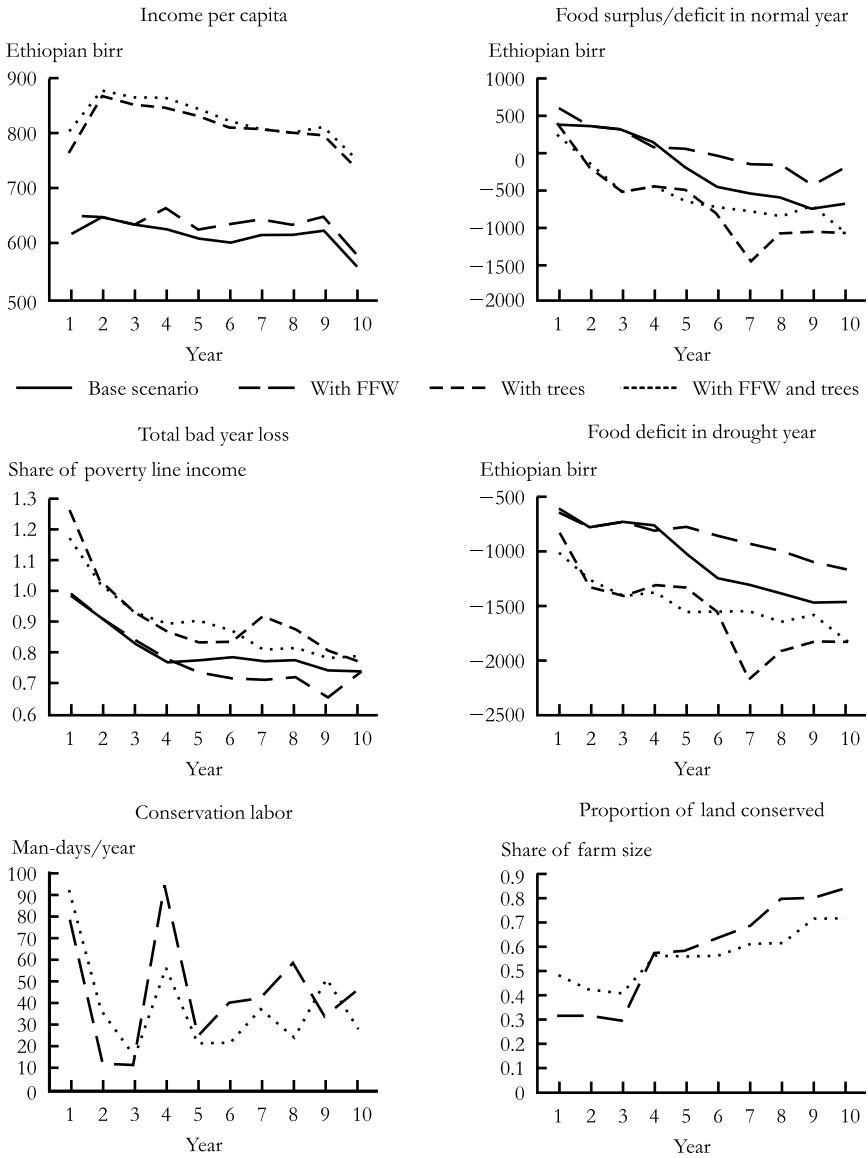


to off-farm employment, and when conservation investment reduces initial yields. The results are presented in Figure 14.6.

The influence of FFW on income is small compared to the planting of trees (when access to off-farm income is unconstrained). However, FFW stimulates land conservation and reduces soil erosion even when tree planting on shallow soils and steep slopes is included as an alternative livelihood strategy. The combination of tree planting and FFW for conservation therefore appears to produce superior outcomes, and substantial increases in household income are achieved while the erodible cropped lands are also conserved. We have, however, not taken into account the external costs of stimulating tree planting and using FFW. That has to be done to make a social cost-benefit analysis of the alternative policies.

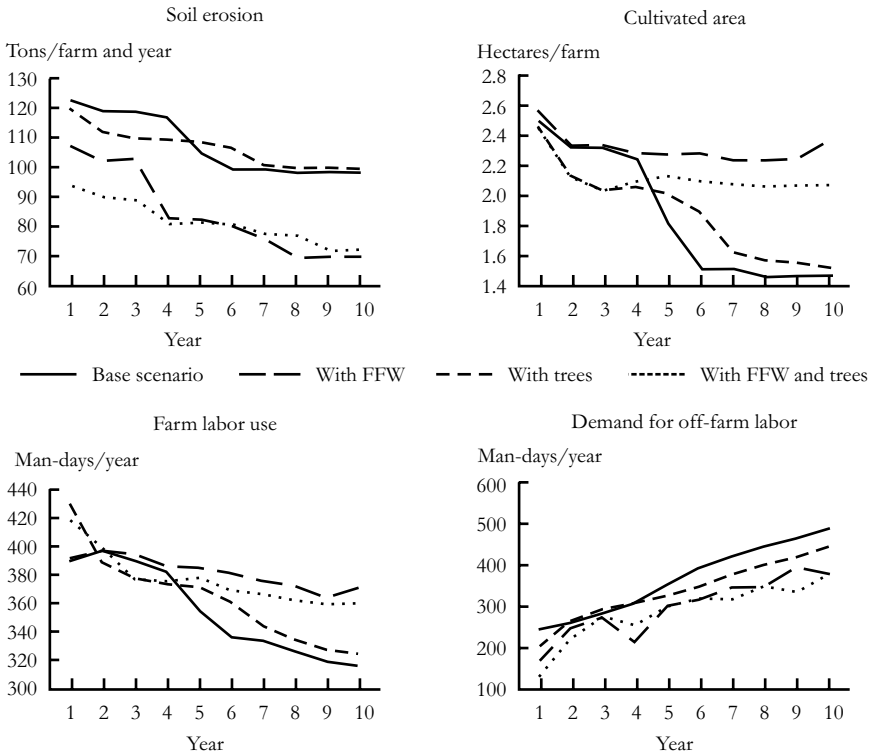
We refer to Holden et al. (2003) for a more comprehensive analysis of the potential of tree planting for poverty reduction in less-favored areas of the Amhara Region.

**Figure 14.6 Impact of tree planting and food-for-work for land conservation when off-farm employment is unconstrained and conservation investment reduces initial yields**



(continued)

Figure 14.6 (continued)



**Conclusions**

We have developed bioeconomic models for a severely degraded area with high population density and fairly good market access in the Ethiopian highlands (building on the model by Holden and Shiferaw 2004).

The simulations indicate that there are limited off-farm employment opportunities in the local economy and entry barriers against wage employment in other areas. Better (unlimited) access to off-farm income at the low seasonal wage rates that are typical in the study area had a considerable positive effect on household income but also increased the need to import basic food grains to the area. We find that better access to off-farm income reduces farm households' incentives to invest in conservation and that this leads to more overall soil erosion and more rapid land degradation. Conservation investments require only labor inputs and are not limited by financial constraints. This is the case even though total agricultural production (crop and livestock production) and farm input use are reduced when

access to off-farm employment is improved. There is therefore a need to complement a policy focusing on the development of the non-farm sector with a policy that ensures conservation of the natural resource base.

We find that FFW programs may be used to improve household food security and to promote more sustainable land management. There is a danger that such programs may undermine private incentives for food production and land conservation. By linking FFW to conservation investments, negative side effects may be minimized. However, local participation and commitment are important to ensure lasting effects of the investments.

Stimulation of planting of trees is a promising policy alternative. If land unsuitable for crop production is planted with trees and market outlets for the trees can be found, this can provide substantial increases in household incomes. This may not have large effects on incentives to conserve cropland.

FFW may be used to stimulate tree planting as well as cropland conservation. Policies combining promotion of tree planting and conservation through FFW may have the potential to achieve win-win benefits in terms of poverty reduction and more sustainable land use. Careful design and implementation are required to maximize such benefits.

## Notes

This work is part of the IFPRI/ILRI project "Policies for Sustainable Land Management in the East African Highlands." ILRI and IFPRI have provided funds and logistical support for the work. The Norwegian Ministry of Foreign Affairs has provided funds for this research in the Amhara Region in Ethiopia. We also draw on earlier work funded by The Research Council of Norway. The first author claims senior authorship.

1. Starting from a point with many market imperfections and removing one of them does not guarantee that the new solution is closer to the social optimum.

2. Shiferaw and Holden (2001) provide a production function analysis based on experimental data that is used as basic input for the bioeconomic model. Households may decide to conserve their land by introducing conservation structures (graded soil or stone bunds). Only labor is needed as an input for this. The conservation technologies maintain yields better in the long run by reducing erosion and maintaining soil depth.

3. These market imperfections include limited access to off-farm employment, price bands for outputs and labor, a constrained rental market for land through share tenancy, ox rental market through exchange with labor only, and constrained access to formal credit in kind (for fertilizer) or to informal credit at a high interest rate. There is also no insurance market.

4. The model results presented are for the household group with two oxen (a pair of oxen is required for cultivation). This group cultivates 70 percent of the land in the case study area.

5. The households were operating close to their minimum subsistence level. Continued land degradation, population growth, stagnant technology, drought, and poor market access contribute to the infeasibilities.

6. Entry barriers are defined to include lack of information, uncertainty, risk aversion, and costs of obtaining information and moving to areas where wage employment could be obtained.

7. This is to minimize the crowding-out effects of FFW. In this period opportunity cost of family labor is at its lowest.