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Alternative Use Systems for the Remaining Cloud Forest in Ethiopia and the Role of Arabica Coffee - A Cost-Benefit Analysis

by Anke Reichhuber and Till Requate

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Alternative Use Systems for the Remaining Cloud Forest in Ethiopia and the Role of Arabica Coffee - A Cost-Benefit Analysis

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Abstract

This paper presents a cost-benefit analysis of three different use systems for the remaining cloud forests in Ethiopia which at present are being depleted at a rate of 8% per year. These use systems are traditional conversion to crop land, sustainable management of the forest (e.g. by growing high-quality semi-forest coffee), and strict protection. We find that conversion to cropland yields the highest net present income value for the local population, and at discount rates of 10% is even in the best interests of the country. For discount rates of at 5% or lower, sustainable forest use is in the best interests of the country. Taking into account the global benefits of biodiversity conservation and carbon storage, sustainable forest management yields the highest total economic value.

Keywords: cost-benefit analysis, biodiversity, coffee, Ethiopia.

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1 Introduction

Although a considerable part of the highlands of south-west Ethiopia are still covered by cloud forests, these are being depleted at the alarming rate of 8% per year (FAO [a]). This loss is of global importance as the east African mountains are among to the most biologically diverse regions in the world. Cloud forests are generally considered to be concentrations of biodiversity with high levels of endemism. A special feature of the cloud forests in Ethiopia is that they provide a habitat to the last wild populations of Arabica coffee. Arabica Coffee originates from Ethiopia, and these wild plants represent its genetic base. During the 13th century a few trees were taken to Yemen and they spread out from there across the globe. As a consequence, the genetic make-up of the coffee plants growing on plantations in other coffee-producing countries is very similar. This renders them vulnerable to new pests and diseases. By contrast, the populations growing in Ethiopia's cloud forest are characterized by high genetic diversity as a result of evolutionary processes which have been taking place for centuries. The information stored in the wild coffee genes is therefore a valuable resource for breeding purposes.

To prevent further deforestation and conversion to arable land, an initiative by the Ethiopian government and the European Commission has transformed the cloud forests into protected parks. This initiative conflicts with the interests of the local communities, half of their territory being covered by forest which they use notably to produce so-called semi-forest coffee. The collection of non-timber forest products and fuel wood generates additional income and provides a safety net for the extremely poor. The people living around the forests are subsistence farmers. As arable land is scarce, farmers are sometimes forced to extend their agricultural fields into the forest.

The situation described here is not unique to Ethiopia. Similar developments can be

observed in several sub-Saharan countries. The main drivers of biodiversity loss have been identified by Perrings [2000] as growth in demand induced by population expansion and economic development, market and policy failure, and a distribution of assets that often leaves people with little choice but to use natural resources in an ecologically unsustainable way.

The literature on the environmental Kuznets curve initiated by Grossman and Krueger [1995], suggests that environmental degradation displays an inverted U-shaped pattern over time. In the course of economic development it is high but it decreases when income reaches a certain level and society attributes greater importance to the environment. The inference from this relation is that economic growth may eventually take care of one of the main drivers of biodiversity loss.

A different view suggests that both conservation and the use of biodiversity are integral parts of, and necessary for, sustainable development. This strand of the literature inquires into local win-win options and synergies between environmental conservation and poverty alleviation (e.g. see Wunder [2001]). For instance, Collins and Qualset [1998], Buck et al. [1998], Lee and Barret [2001] discuss the potential of agro-forestry systems in combining environmental objectives with the aspirations of local communities. Pearce et al. [2003] highlight the role that sustainable forest management can play in maintaining forests and biodiversity. A number of case studies investigate the role of non-timber forest products for household incomes, as well as the conditions for, and the impacts of, their commercialization (see Shanley et al. [2002], Byron and Arnold [1999]). Ruiz-Pérez et al. [2004] observe that income potential and the successful commercialization of these products depend crucially on the existence of an appropriate infrastructure and access to skills and services.

Having recognized that the economic needs of the local population often lead to deforestation, several organizations are looking for innovative ways of compensating local communities for their conservation efforts. Markets for environmental services are being created, where consumers pay premiums for "green" products identified by eco-labels. In general, Payments for Environmental Services (PES) induce farmers to take account of the external environmental effects associated with their activities. With respect to poverty, Wunder [2005] and Pagiola et al. [2005] argue that the question of the extent to which PES can contribute to poverty alleviation has yet to be answered satisfactorily.

Sunderlin et al. [2005] summarizes the theory behind, and the available evidence connected with, two questions: To what extent can forests serve as an income basis to support poverty alleviation in developing countries? Is the way forests are used for the sake of poverty alleviation compatible with conservation efforts? With respect to the first question, the authors emphasize that forests play an important role in mitigating extreme poverty by providing essential services like medicinal plants and food, especially in remote areas. Their role in rescuing people from poverty is, however, less clear and depends on supporting institutions like markets for environmental services and non-timber forest products. With respect to the second question the authors conclude that more local research is needed, which should at the same time be integrated into a society-wide perspective. This study can be regarded as a contribution towards fulfilling this requirement.

The objective of our study is to analyze whether the interests of the global community, the Ethiopian government, and local farmers can be reconciled. Three competing use systems stand out as possible scenarios for forest use: conversion to arable land, sustainable use of the forest with production of semi-forest coffee, and strict conservation of the forest as currently directed by the Ethiopian government. We calculate the income associated

with each of the three alternative use systems to illustrate the private economic incentives for the local communities. Subsequently, we undertake an economic analysis of the three systems, taking national and global values into consideration.

Our main findings are that, taking a high discount rate of about 50% of the local population as given, conversion of the forest to cropland is rational for the local population, and yields a higher net present income value than sustainable forest management. But even for a discount rate of 10%, as recommended for the evaluation of projects by the Ethiopian Ministry of Economic Development and Cooperation, conversion to cropland would be in the best interests of the Ethiopian nation. Only for discount rates of 5% and lower is sustainable forest management the best alternative, while strict protection yields a negative net national income values due to the cost of maintenance. Taking into account global environmental services of the forest such as biodiversity, in particular as a gene pool for coffee Arabica, and carbon storage, sustainable forest management yields the highest total economic value.

Combining the financial incentives of the local population and the total economic value of the forest, we finally discuss the potential of price premiums for semi-forest coffee achieving both the conservation of the cloud forests and the alleviation of poverty.

The paper is organized as follows: The next section describes the main characteristics of the three competing forest use systems. Section 3 presents the income analysis. In section 4 we provide an analysis of total economic value from a local, national, and global perspective. In section 5 we wrap up our results and present some policy conclusions.

2 The Competing Forest Use Systems

In this section we describe the three competing use systems: maize production, strict conservation of the forest as currently directed by the Ethiopian government, and the sustainable use of the forest with production of semi-forest coffee. Our study areas are the two districts of Sheko and Yayu (see Table (I)). In the preparations for this study, primary and secondary data were collected in Yayu, Sheko and the capital of Ethiopia, Addis Ababa in 2003 and 2004. The respective data sources are indicated in the text. A list of experts consulted in the course of the field research is given in the appendix. In Sheko and Yayu several experts from the local departments of agriculture and the administration were interviewed and provided us with access to data. These sources are indicated by "DoA."

2.1 Maize Production

Farmers in Yayu and Sheko practise low-input, rain-fed subsistence farming. On average they cultivate 1.5 ha of land in Sheko and 1 ha in Yayu (DoA). In Ethiopia 1 ha is the average amount of land per household and is regarded as the absolute minimum for providing sufficient food for one household (Berhanu et al. [2002], p. 58). The current cultivation practices are considered ecologically unsustainable. In the face of a rising population and the scarcity of arable land, farming communities largely employ two coping strategies.

	Sheko	Yayu
Number of households	4,454	17,127
Number of villages	17	37
Total area	50,000 ha	163,000 ha
Total forest	25,042 ha	80,420 ha
Protected forest	9,025 ha	10,000 ha

Table I: The study areas Yayu and Sheko in 2003, source: DoA

They reduce fallow periods by cultivating continuously, and they cultivate unsuitable land with steep slopes of up to 50%. Only 10% of the farmers use fertilizer. This practice results in serious land degradation involving a high degree of soil erosion and nutrient mining. The concomitant annual productivity losses on croplands in the south-western highlands of Ethiopia are estimated to be 10% (Denboda [2005]).

To achieve an ecologically sustainable increase in production that would offset both the population growth of 2.3% and the negative effects of land degradation, farmers would have to intensify their land management and to adopt soil conservation measures. Intensification involves using fertilizers and improved seeds. The profitability of these new technologies is, however, severely constrained by imperfect input and output markets and a poor infrastructure (Techane [2001], Demeke [2001]).

Conservation of the production basis requires both biological and physical measures to prevent, or at least significantly reduce, soil erosion and land degradation. Of course there are schemes that are widely accepted among agricultural and development professionals, but their dissemination among farmers is difficult. The main obstacle to sustainable land use is the ill-defined allocation of property rights induced by the land tenure system in Ethiopia. According to the country's constitution, the ownership of land rests with the state and the people of Ethiopia. Private ownership and land markets are not permitted. Instead, the government allocates land use rights to the farmers. Repeated land redistribution practices in Ethiopian history have led to a high degree of uncertainty concerning the tenure rights of the farmers' holdings. During a nationwide survey on tenure rights and farmers' reactions, only 3.5% of the households believed that they could retain their current holdings for over 20 years, while the overwhelming majority of households did not believe that their claim to their existing holdings would last more than five years (Berhanu

et al. [2002], table 19). This uncertainty reduces incentives to invest in the maintenance of land.¹ To take account of the two possible forms of maize production, the traditional but ecologically unsustainable method, on the one hand, and the improved but rather unrealistic method, on the other, we will calculate income, costs, and benefits for each of the two in sections 3 and 4.

2.2 Strict Forest Conservation

The polar strategy for converting forest to farm land is strict conservation. In the distant past, one third of Ethiopia was covered by forest, but currently only 2% of the former forest is left. The northern and central highlands have been deforested completely. The remaining forests of Ethiopia are currently under the special protection of the government, which has demarcated 58 national forests as National Forest Priority Areas (NFPA) (EFAP [1994]). By law, no encroachment on the NFPA is tolerated and cutting down trees is frequently punished by prison sentences. In practice, the enforcement of this policy in most of the NFPA is difficult and expensive. The forests of Yayu and Sheko, however, receive special attention due to the remaining populations of wild coffee still growing there. The Coffee Improvement Project financed by the European Commission aims to conserve this coffee gene pool for future breeding activities (Agrisystems [2001]).

One reason why it is difficult to conserve coffee germ plasm *ex situ* in seed gene banks is that its seeds do not stay viable for very long. Another option is to store genes in a field gene bank, where live plants are stored. These collections are not very secure, however, as the plants might succumb to diseases and pests. They are also expensive to maintain.

¹The Ethiopian government is determined to keep this land legislation anchored in the constitution (Berhanu et al. [2002], Teklu [2003]) and has no intention of fundamentally changing the current system. On the contrary, the government claims that the system promotes equity among farmers, prohibits speculation on land, and prevents migration to the towns.

By contrast, coffee plants conserved *in situ* are kept in their natural forest ecosystem. Its main advantage is that the evolutionary process can continue as the plants adapt to changes in environmental conditions (Gole et al. [2002]).

The conservation authorities in Ethiopia suspect that permitting the local communities to enter the demarcated areas would entail further disturbance in the form of illegal logging and harvesting of wild coffee. Therefore guards patrol the demarcated areas in Yayu and Sheko, which cover areas of 10,000 and 9,000 hectares respectively.

2.3 Sustainable Forest Management

Between the two polar strategies, i.e. complete conversion and strict conservation, sustainable use strategies may be considered as a viable alternative. In this particular case the use strategy consists in growing coffee in the forest and in harvesting renewable resources such as honey, plants for medical purposes etc. from the forest.

Coffee accounts for 60% of the country's exports and the government estimates that about 15 million households depend either directly or indirectly on coffee for their livelihood. 94% of Ethiopia's coffee is produced by 700,000 smallholders growing coffee either in their gardens or in nearby forests as so-called semi-forest coffee (Oxfam [2002]). The remaining 6% is produced on plantations.

Semi-forest coffee is organically produced and grown in the forest under the canopy of shade trees. The forest is thinned out in order to give the coffee plants more space. As the agronomic conditions are near optimal, only some minimum husbandry practices are needed to produce very fine Arabica coffee.

It is important to note that the production of semi-forest coffee is different from harvesting wild coffee that grows completely uncontrolled deep inside the less accessible re-

gions of the forest. The practices of semi-forest coffee production definitely damage the natural forest system to a certain extent. A vegetation study conducted by Gole [2003] in the Yayu forest finds that the diversity of higher plants in the semi-forest coffee areas is only half as high as in the natural forest. Nevertheless, the managed coffee forest can still be considered a relatively intact forest ecosystem serving as an eco-support system and providing a variety of services such as the regulation of both the quality and quantity of water and the conservation of soil.

Management can affect the diversity of coffee populations in several ways. Farmers can increase diversity by planting coffee trees from different parts of the forest and introducing land races.² Removing weaker races achieves the opposite. An overall effect of management on the diversity of coffee populations has not been observed so far. The genetic diversity of coffee populations growing in semi-forest areas is similar to the diversity of coffee populations growing wild in the natural forest (pers. com. T. Borsch).

In order to bypass low world commodity prices for coffee and to capture price premiums, a minority of Ethiopian farmers have managed to enter the niche market for differentiated and organic coffee³ with price premiums amounting to anything up to 100%.⁴ However, these markets are still small. Mainstream qualities, including Robusta coffee, account for a estimated 85%-90% of world coffee consumption, while the share of high-quality coffee makes up 10% - 15% of the world market (ITC [2002]). The share of differentiated coffee is however increasing in Western countries.⁵ Therefore we will consider both sce-

²Land races are varieties deriving from a process of selection by the farmers themselves. They are usually found in gardens and on plantations.

³Differentiated coffee can be clearly distinguished from mainstream brands by origin, defined processing, or exceptional characteristics such as superior taste or zero defects (see Lewin et al. [2004]).

⁴Most niche market suppliers in Ethiopia are represented by the Oromiya Coffee Farmers Cooperative Union (OCFCU), which exports certified organic fair-trade coffee. In 2002 and 2003 the price paid to farmers was double the price for conventional coffee (pers. com. T. Meskela (OCFCU)). However, due to transaction costs only a minority of farmers manage to sell their coffee as certified.

⁵For organic coffee the industry predicts future sales growth rates of up to 20% per year (Lewin et al. [2004]).

narios for the income analysis: farmers selling differentiated coffee and farmers selling conventional coffee.

In summary, there are three main use systems competing for the forest resource: (1) the conversion to arable land and the cultivation of food crops, notably maize, in two different ways, (a) the traditional system, which is ecologically unsustainable and which provides low yields, and (b) a modern sustainable mode of production, the skills for which, however, are not yet disseminated in the area under investigation; (2) the sustainable use of the forest, including harvesting of renewable resources and the production of semi-forest coffee; (3) strict protection for the sake of biodiversity conservation.

3 Income Analysis from the Perspective of the Local Population

We now proceed to estimate the private income generated by the three use systems using a time horizon of 24 years. We assume that strict conservation does not generate any income. Conversion to farm land yields returns from logging and maize production, while the sustainable use of the forest is characterized by a variety of income sources such as coffee, wood products, and several non-timber forest products. The monetary flows will be expressed in US\$ per hectare⁶. To evaluate intertemporal income streams, discounting is necessary. Due to distorted capital markets and ill-defined property rights, the market interest rate does not accurately reflect the local farmers' time preference rate.

Few studies exist on time preference rates in developing countries. Holden et al. [1998] use a stated preference method to measure rural households' annual discount rates for

⁶We use an exchange rate of 1\$:8.6 Ethiopian birr, which was the average exchange rate from 2003 to 2005 (NBE [2005]).

money in Indonesia, Zambia, and Ethiopia. Assuming that time preferences are characterized by a constant exponential discount function, they estimate mean annual discount rates of 93% in Indonesia, 105% in Zambia, and 53% in Ethiopia. These high rates are in line with an earlier study conducted in India (Pender [1996]), which established median discount rates of over 50%.⁷

Despite the distortion capital and financial markets, local market interest rates are also influenced by time preference rates. Farmers in Sheko and Yayu have access to formal and informal financial services. In the informal sector, financing is obtained from family and friends, rotating savings and credit associations, and commercial money-lenders. Interest rates and repayment terms for commercial money-lending are often quite flexible, but they can be as high as 100%. Credit associations are traditional institutions through which group members meet each other's financial needs. But their capacity is limited (Aredo [2001]). Formal financial services in Yayu and Sheko are offered by two micro-finance institutions, which are public entities with the objective of delivering micro-loans and micro-savings to resource-poor but productive people. Credits are group-based and require group guarantees. The main characteristics of these schemes are indicated in Table (II).⁸ We take 30% as an approximation of the average interest rate in both the formal and the informal sector.

Given the limitations of the local financial system, we apply a discount rate of 30% as a lower bound and 53% as the upper bound.

⁷It is often argued that high time preference rates reflect the high-risk environment faced by the farmers, the main risk factors being frequent droughts, coffee and maize price fluctuations, and health risks such as malaria and HIV/Aids. As private and public risk management strategies are often ineffective, farmers are especially vulnerable to these risks (c.f. World Bank [2005]).

⁸Farmers use these credits in order to buy fertilizer, seeds, and livestock. However, not all farmers are willing to form a group because of transaction costs and the risk involved, and not all of them are informed of this possibility.

Terms of small credits	Sheko	Yayu
Amount of credit (ETB)	50 - 1200	1000 - 5000
Interest	15%	12,5%
Farmers per group	5	4-6
Collateral	group members, house, livestock	group members
Payback period	variable	1 year

Table II: Micro finance in Yayu and Sheko

3.1 Maize

3.1.1 Traditional Land Management

The local departments of agriculture in Yayu and Sheko report an annual maize production of 1800kg per hectare where traditional techniques are employed. A recent study investigating the consequences of deforestation in the south-western Ethiopian highlands on soil erosion finds that the productivity of maize cultivated on deforested lands in the traditional way declines by 10% per year due to nutrient mining and erosion (c.f. Denboda [2005]). We incorporate this productivity decline in our calculations on future output.

The farm gate price for 100 kg lies at US\$ 4.7 during the harvesting period, and US\$ 7 in Sheko and US\$ 10.5 in Yayu later in the year. As farmers sell half of their produce immediately after the harvest, when the price is the lowest, we use a price of US\$ 6 in Sheko and US\$ 7 in Yayu.

Labor input has been assessed by the Ethiopian Agricultural Research Organization. According to the respective cropping calendars, farmers work approximately 4 months on their fields for tillage, sowing, and harvesting (c.f. Shibru et al. [2002]). We estimate the opportunity costs of rural labor, based on the value of agricultural production and labor input, to be US\$ 0.4 per man and day.⁹ Thus we arrive at labor costs for maize production of 48 US\$/ha. In accordance with these calculations, one hectare of maize leads to net

⁹The details of the calculation are given in the appendix.

returns of US\$ 60 and US\$ 78 in the first year.

3.1.2 Improved Land Management

For improved land management we assume the application of fertilizer and biological measures against erosion. Under these conditions, the average production of maize in Yayu and Sheko is 3200 kg per hectare (DoA).

Input costs include fertilizer costs, labor, and investment in soil conservation. Fertilizer costs are around US\$ 50 per ha (DoA). The additional costs associated with soil conservation are approximated by the investment in biological measures to prevent erosion. A biological soil boundary of Vetiver grass is a popular technique in the region of Yayu and Sheko, because it can also be used for other purposes (DoA). Hence its planting generates additional benefit. Here only the planting material will be included on the cost side. As the farmers are willing to plant the grass if they are provided with the planting material, it is assumed that the labor cost associated with planting is less than, or equal to, the additional benefit of the grass. The planting material costs US\$ 13.5 for one hectare. Labor costs and farm gate prices are the same as for traditional land management.

To sum up, maize produced in an ecologically sustainable way on one hectare of land generates a net annual income of US\$ 80.5 in Sheko and US\$ 112.5 in Yayu.

3.2 Semi-Forest Coffee

In semi-forest coffee systems, about 450 kg/ha of coffee can be harvested per year (Agrisystems [2001]). In 2003 the average price for conventional Arabica coffee as mostly produced by Ethiopian farmers was 0.64 US\$/lb (1lb=450g). Despite a decline in commodity coffee prices over the last 30 years (price in 1970: 1.80 US\$/lb), and taking into account shifts in global demand and supply, the World Bank has forecasted that the price of Arabica coffee

(Lewin et al. [2004]) will rise to 0.95 US\$/lb in 2015. We use these forecasts to calculate income generated by the production of semi-forest coffee sold as conventional commodity coffee.

For certified organic fair-trade coffee a minimum current price of 1.35 US\$/lb and lasting for several years is set by the fair-trade market. Moreover, the price of differentiated coffee is largely independent of the commodity price fluctuations. This is due to different marketing channels characterized by closer relationships and long-term contracts between producers and buyers (see Lewin et al. [2004]). According to a random sample of more than 2000 actors in the North-American coffee industry, 9 out of 10 firms expect the price premiums for organic, fair-trade, and shade-grown coffee to continue (Giovannucci [2001]). For this reason we assume in our calculations that the price for organic coffee will stay constant over time.

Based on information provided by the Coffee and Tea Authority (a federal regulatory institution), OCFCU, and our own calculations,¹⁰ the costs of production, processing, and export amount to 0.1 US\$/lb. The net return on differentiated coffee production is therefore 1250 US\$/ha per year. The net return on conventional coffee was 540 US\$/ha in 2003 .

3.3 Non-Timber Forest Products

The valuation of NTFP in Sheko and Yayu builds on earlier research by the Institute of Biodiversity Conservation and Research (IBCR), Addis Ababa, (IBCR [a], IBCR [b]), and the FAO (Deffar [1998]). The IBCR conducted both participatory rural appraisals and focus group discussions in Yayu and Sheko to determine the status and use of the forests and their products. The author then carried out a market survey and interviewed

¹⁰Details of the cost calculation are given in the appendix.

traditional health practitioners in the study areas.

The NTFP are classified into 3 main groups: honey, medicinal plants, and miscellaneous goods. The miscellaneous goods are: brown cardamom ("kororima"); "gesho," a condiment used in making a local drink; "desha," used to clean the oven; "ensosela," used for decorating the skin with color; mats and baskets made of lianas and baskets made of bamboo. The three groups of NTFP take different channels from the forest to the farmers. Hence the appropriate valuation methods differ. They are explained in more detail in the following paragraphs.

To calculate net income production costs have to be deducted. To assess the value of timber and non-timber forest products from the Amazon, Peters et al. [1998] estimate production costs to be 40% of the product value. Using a survey Batagoda et al. [2000] estimate production costs of 50% in Sri Lanka. These figures are likely to overestimate such costs in Yayu and Sheko, where capital and processing hardly figure. For most of the NTFP the time spent on collection is modest as these products are gathered "en route" or during work in the semi-forest. Only the production of honey, mats, and baskets requires more time. Thus for the area under study a more reasonable estimate of production costs as a share of total product value is 20% for all products except honey, mats, and baskets. For the latter 40% of gross value is deducted for production costs. To arrive at a per-hectare income for NTFP, we divide the estimated values by the areas used for collection, which approximately correspond to the semi-forest coffee areas.¹¹

3.3.1 Miscellaneous Goods

The miscellaneous goods are only collected to a small degree by the farmers themselves. Most tend to buy them at local markets. To value the miscellaneous NTFP we conducted

¹¹The semi-forest coffee areas amount to half the total forest areas given in Table I.

a market survey¹² by visiting the five local markets in the Sheko district.¹³ The survey was carried out at the peak of activities, around midday. Since there is a distance of 90 minutes on average between the villages and the nearest road, these markets are relatively small, and hardly any professional traders are present. Most of the traders are farmers selling their garden products. Despite the simplicity of the event, no barter trade was observed, only the exchange of goods for money.

The vendors of NTFP were asked how much of the respective product they sell and at what price, differentiating between a "good" and a "bad" day. On the basis of this information we calculated an average income per seller of NTFP. Multiplying this figure by the number of traders present at the market, we arrive at the total value of products per market per day. Summing up all these figures across markets and multiplying by the number of market days, we arrive at the annual value. After deducting of the production costs, we arrive at a value for miscellaneous NTFP amounting to US\$ 0.70 per hectare and year. The results from Sheko were then transferred to Yayu.

3.3.2 Honey

Ethiopia has a long tradition of beekeeping. Although production is rather old-fashioned, Ethiopia was fourth in beeswax and tenth in honey production on a world level in 1998 (c.f. Deffar [1998]). Honey is almost exclusively used for local consumption, in particular for the brewing of a species of mead called *tej*. In Sheko and Yayu beeswax is regarded as a by-product of *tej*-making and is not used. Though the honey is sufficient for local demand, its quality does not meet international standards. The productivity of honeybees is low, and an average of only 5 kg of honey can be cropped annually per hive in

¹²Due to the sporadic fashion in which farmers collect these products, a household survey did not appear to be very reliable.

¹³The Sheko district consists of 17 villages, but only 5 of them host markets.

Sheko and Yayu. However, in areas where improved technology has been introduced an average of 15 kg/hive/year has been recorded (DoA). The average number of beehives per household (10) was multiplied by the average output per beehive and the total number of households.¹⁴ The figures from honey production using modern beehives were then added. Total production was valued at the average local price of 0.9 US\$/kg (DoA) and production costs of 40% were deducted. Accordingly, annual production in Sheko and Yayu is worth US\$ 14.6 and US\$ 11.6 per hectare, respectively.

3.3.3 Medicinal Plants

Medicinal plants are mostly collected by traditional health practitioners (THP) and then used for curing patients.¹⁵ For the valuation of medicinal plants we conducted interviews with THPs in Yayu and Sheko. Villages for the survey were selected randomly. The survey revealed that on average there are 2 THPs per village.¹⁶ Using guides to contact the local THP in each village, we managed to talk to 80% of all THPs. We asked them about the illnesses they attempt to cure, the average number of patients asking for such treatment, and the prices for the different kinds of treatment.

We found that on average a THP is familiar with four different kinds of treatment costing US\$ 2.40 each. The illnesses most often treated are tuberculosis, haemorrhages, snake and dog bites, and skin and liver diseases. The average number of patients per treatment is 12 per month. This provides each THP with an annual income of US\$ 1382.40. Multiplying this figure by the number of THPs per district and adjusting for the collection costs for medical plants, we arrive at a total income related to medicinal plants

¹⁴The number of modern beehives in Sheko is 6910, in Yayu it is 346. Note that 4,454 households live in Sheko, while 17,127 live in Yayu.

¹⁵THPs are normal farmers who have learned how to prepare medicines from medicinal plants. This knowledge is usually kept secret within the family.

¹⁶This number was confirmed by the local health office.

of US\$ 3 and US\$ 1.80 per hectare for Sheko and Yayu respectively.

3.4 Fuel Wood and Timber

The stock of the Ethiopian natural high forest ranges from $30m^3/ha$ to $300m^3/ha$, depending on the level of incursion (c.f. EFAP [1994]). For semi-forest coffee, the average stock is $200m^3/ha$ with an incremental yield of $4m^3/ha$. Gole [2003] carried out a vegetation survey in Yayu and assessed the volume of timber trees. We draw on his results for both districts. In each case the difference to the total volume is the amount of fuel wood that can be harvested¹⁷.

According to the local department of agriculture, the local price for $1m^3$ of timber is approximately US\$ 23. We deduct two labor days for production and arrive at a value of $US\$22.2/m^3$.¹⁸

The price of fuel wood is more difficult to determine because quantities are measured in local units such as "women's load" or "donkey load". A survey undertaken by the German Technical Development Cooperation in 2000 estimates the price of rural fuel wood to be $US\$20/m^3$ (GTZ [2000]), and we have used this estimate in our calculation. Deducting labor costs of 2 days we arrive at a value of $US\$19.2/m^3$.

Based on these data, the income gained from producing timber and fuel wood in converting one hectare of natural forest into farm land amounts to US\$ 6174. One hectare of forest converted to semi-forest coffee production results in a one-time income of US\$ 2022 from fuel wood and timber and a recurrent flow income of US\$ 76.8 per year from fuel wood production.

¹⁷For further details see appendix.

¹⁸We assume that the opportunity cost of labor is the same as for the production of maize.

3.5 Results

The results of the income analysis for Sheko are summarized in Tables (III) a and b. The figures for Yayu are similar and can be found in the appendix (Table (IX) a and b). The results indicate that at discount rates of 30 to 50% maize production is more profitable than sustainable forest management. Although the harvesting of non-timber forest products represents an additional source of income, and despite the fact that coffee generates a stable and relatively high income, the high discount rates favor the immediate returns from sales of timber and fuel wood preceding maize production. In the near future, the superiority of conversion is likely to increase as the prices for timber and fuel wood are expected to rise sharply.¹⁹

(a) Net income discounted at 53%

Good	Sustainable forest management		Maize production	
	differentiated coffee	conventional coffee	improved	traditional
NTFP	37	37	0	0
Fuel wood (once)	1267	1267	3110	3110
Fuel wood (annually)	154	154	0	0
Timber	755	755	3064	3064
Maize	0	0	161	100
Coffee	2499	1743	0	0
Total	4712	3956	6335	6274

(b) Net income discounted at 30%

Good	Sustainable forest management		Maize production	
	differentiated coffee	conventional coffee	improved	traditional
NTFP	61	61	0	0
Fuel wood (once)	1267	1267	3110	3110
Fuel wood (annually)	256	256	0	0
Timber	755	755	3064	3064
Maize	0	0	268	150
Coffee	4159	2764	0	0
Total	6498	5103	6442	6324

Table III: Discounted net income in US\$/ha per use system in Sheko.

¹⁹GTZ [1998] observes that the price of fuel wood increased by 70% every ten years between 1970 and 1995.

Comparing the two systems of maize production, the revenues from improved maize production exceed those arising from traditional practices. Nonetheless, under the current conditions it seems unlikely that improved management will become the dominant farming system.

Despite price premiums for certified organic coffee (over US\$ 1000 per hectare) those are not sufficiently high to ensure that sustainable forest management will be regarded by farmers as the most profitable land use option. To tip the balance, the price would have to rise to a level of about US\$2/lb. Moreover, many farmers still sell their coffee as a simple commodity since switching requires investments in new marketing channels and certification. Cheaper and more reliable access to credit would therefore not only raise the profitability of sustainable forest management by lowering farmers' discount rates, it would also facilitate switching to differentiated coffee production.

4 Total Economic Value

In this section we calculate the total economic values (TEV) of the alternative use systems from the perspective of Ethiopia as a whole. The TEV consists of direct use values, indirect use values, option values, and non-use values.

Prior to identification of the relevant costs and benefits, we reviewed empirical studies and surveys on the economic values of forests and other land use systems (see Pearce and Pearce [2001], Bishop [1999], Pearce et al. [2002], Chomitz and Kumari [1998], Yaron [2001]). In most studies, the highest values are attached to direct uses, like timber extraction, or the indirect use of the carbon storage capacity of forests.

Here we first present estimates of the values arising at global, national, and local levels. We then undertake a cost-benefit analysis to establish the best possible use of the forest

areas from the Ethiopian perspective. This procedure allows us to compare and contrast the global and national interests involved.

Except for the economic value of the genetic diversity of Arabica coffee, all values are expressed in per-hectare terms. This is consistent with the income analysis.

As in standard CBA practice, market prices are used whenever markets are functioning well (Squire and van der Tak [1995], Dinwiddy and Teal [1996]). As a reasonable approximation, the semi-forest coffee in Sheko and Yayu is valued in terms of its premium price. The NTFPs included in the income analysis are only traded and consumed locally. These prices can be safely regarded as representing the actual willingness to pay on the part of the consumers, because the goods are traded competitively on local markets²⁰. If markets are not functioning well, values are estimated by using the replacement cost method, the avoided cost method, benefit transfer, or the opportunity cost. In the following we examine these cases in more detail before presenting the overall results.

4.1 Direct Use Values: Timber and Fuel Wood

Ethiopia is a net importer of wood products. Since the local market is distorted by state intervention, which deters private investment in the forestry sector (see Yemshaw [2002], Bekele [2001]), we did not rely on local market prices for the valuation of timber and fuel wood. Instead we chose the replacement cost method for fuel wood. Its value is approximated by the cost of a eucalyptus plantation supplying the equivalent amount of wood. According to Pohjonen and Pukkala [1990] the expected annual yield of eucalyptus plantation is $20m^3/ha$. Wirtu and Gong [2000] estimates the average cost of production

²⁰To be more precise, we value the flow of NTFP and assume it to be sustainable. The figures for medicinal plants include the value of the traditional knowledge at health practitioners' disposal. But as this knowledge would invariably vanish with the loss of the forest it can be regarded as an additional benefit.

to be $US\$205/ha$.²¹

By contrast, timber is valued by its border price. According to ITTO [2002], the average prices for logs imported to Africa in 2001 and 2002 were $US\$251/m^3$ and $US\$252/m^3$ respectively. Similarly, the average value of sawn wood imported to Ethiopia in 2002 was $US\$241/m^3$ (see FAO [b]). Accordingly, we assume the price of timber to be $US\$245/m^3$. In 2003 the Sawmill and Joinery Enterprise reported processing and transport costs of $US\$163/m^3$ (for a sawmill based in Addis Ababa). We deduct this figure from the gross value of the timber. Accordingly, the unit value of timber is $US\$82/m^3$. For the volume of wood the same data as in the income analysis are applied.

4.2 Direct Use Value: Maize

In Ethiopia, 5 million people are chronically dependent on food aid. Varying from crop year to crop year further emergency assistance is provided by international donor organizations. Grain markets in Ethiopia function through a limited number of small traders who buy surpluses from farmers and sell them at the nearby markets at relatively small profit margins. These markets are segmented, and grain movements from surplus to deficit areas are constrained by high transport costs due to poor road infrastructure, limited competition in the transport sector, and weak market information systems. The donor organizations rely on imports to meet the food requirements.²² For this reason we value the direct use value of maize by its import parity price. According to OECD estimates, the world price for maize will be about $US\$113/t$ in the next 10 years²³. We use their estimation and add ocean freight and insurance costs of $US\$ 40 /t$ for transport from Gulf

²¹Costs include establishment, weeding, guarding, thinning, harvesting, and land rent. For example, to replace $162m^3$ of the fuel wood associated with 1 ha of maize production, 8.1 ha of eucalyptus plantation would have to be established, leading to a cost of $US\$ 1660.5$ per ha of maize.

²²For further information on food assistance for Ethiopia see FAO [c].

²³Price for No2 yellow maize, US f.o.b. Gulf Ports, see OECD [2004].

ports to Djibouti.²⁴ To estimate the import parity price of maize in Addis Ababa we have to add transportation costs from Djibouti. However, due to the same distance (ca. 600 km) and a similar road infrastructure, these are approximately equal to the transportation costs from Yayu and Sheko to Addis Ababa, which will then be deducted from the import parity price. Thus we arrive at a unit value of US\$153 /t for maize.

Here again, we distinguish maize produced in a sustainable way and maize produced under traditional management, using the same data as in the income analysis for production costs and yields. Thus the per-hectare value of maize produced under traditional management is US\$ 227.4 in the first year. Improved maize production leads to annual benefits of US\$ 378.1 per hectare.²⁵

4.3 Direct Cost: Wild Animals

Farmers in Sheko and Yayu incur substantial losses due to wild animals inhabiting the forest and looting their fields. These losses are seen as costs associated with the forest. Bonger et al. [2002] value these costs by taking the average amount of time farmers require to guard their fields multiplied by the opportunity cost of labor. Following their results for different areas (US\$ 10 to US\$ 73) we assume annual losses of US\$ 40 per household due to wild animals. This takes into account the proximity of the forest to the fields in Sheko and Yayu. Multiplying the cost per household by the number of households and dividing it by the number of hectares of forest we arrive at a cost of US\$ 7.4 per hectare of forest in Sheko and US\$ 7.6 in Yayu.

²⁴US\$40/t is an estimation based on freight rate data obtained from FAO [d].

²⁵Traditional: $1800\text{kg}/\text{ha} \times \text{US}\$153/\text{t} - \text{US}\$/48\text{ha} = \text{US}\$227.4/\text{ha}$ Improved: $3200\text{kg}/\text{ha} \times \text{US}\$153/\text{t} - \text{US}\$/48\text{ha} - \text{US}\$50/\text{ha} - \text{US}\$13.5/\text{ha} = \text{US}\$378.1/\text{ha}$.

4.4 Direct Cost: Implementation of Strict Conservation

Strict conservation of the forest requires investment in infrastructure and the employment of personnel to ensure the protection of the forest and to facilitate the exploration of plant and, especially, wild coffee diversity. Our calculation of these costs is based on project documents of the European Commission for the conservation of the forest in Sheko and Yayu (see Agrisystems [2001]). These provisions include guards, forest management offices, and one person per district responsible for conflict prevention. Initial investment costs are US\$ 79/ha and US\$ 3/ha of labor costs accrue arise annually.²⁶

4.5 Indirect Use Value: Watershed Services

Typically, watershed services resulting from upstream land uses subsume services such as the regulation of water quantity and quality and erosion control. Their magnitude and direction completely depend on local conditions and, in the case of conversion, on the subsequent land use system (Calder [1999]). Unfortunately there are no reliable studies investigating these services for the south-western highlands of Ethiopia and the forest in particular (pers. com. "Ethiopian Nile Basin Project", Ministry of Water Resources, Addis Ababa). We were thus unable to calculate the potential costs and benefits relating to the watershed. Nevertheless they do deserve attention. The montane forest in the study areas belongs to the class of cloud forests. Tropical montane cloud forests are frequently covered in clouds or mist. Therefore, in addition to rainfall, they capture water droplets condensing on the vegetation. Cloud water interception generally lies within the range of 5-20% of ordinary rainfall in wet tropical locations but can be much higher in certain exposed locations (see Bruijnzeel [2004]). This results in stream flows from cloud forest

²⁶A detailed list of costs is given in the appendix.

areas that are greater than can be attributed to rainfall. Another aspect is the magnitude of stream flows in dry periods. There is a growing body of evidence from Latin America that cloud forest clearance for pasture or annual cropping may lead to decreased flows in the dry season. Several capital cities in Latin America benefit from the augmented water supply provided by cloud forests: Quito (Ecuador), Mexico City (Mexico), and Tegucigalpa (Honduras) (Bubb et al. [2004]). We therefore add a non-quantifiable benefit, which we will call 'watershed services' to the use systems strict conservation and sustainable forest management.

4.6 Non-Use Values

The stated preference method is the usual tool employed to estimate non-use values. Despite methodological progress in CVM in the last decades, according to Carson et al. [2001] stated preference techniques are still extremely sensitive to language and the cultural environment.²⁷ As the authors are not Ethiopian, we refrained from conducting a CVM among the local population. Unless forests have unique features like rare beauty or fascinating fauna (Pearce and Pearce [2001]), the literature reports modest non-use values for forests for developing countries hardly exceeding 1% of household income (see in particular Bishop [1999]). Anecdotal evidence from interviews with farmers in Sheko confirms the view that they greatly appreciate the various useful products they can obtain from the forest. This view was expressed earlier by IBCR [a] and IBCR [b]. Due to the evidence suggesting that non-use values are quite low, we did not include it in the analysis.

²⁷Whittington [2002] describes the most common mistakes made in administering contingent valuation studies in developing countries.

4.7 Indirect Use Value: Carbon Storage

By storing carbon, a process known as sequestration, forests can slow down global warming. This is a benefit that accrues to the world as a whole. Obviously, more carbon can be stored with agro-forestry than with conversion of the forest to farm land for maize production. For a valuation of the carbon stored in the trees and other forest plants one can either estimate the marginal damage avoided or use the market price for tradable CO_2 emission permits.

With the avoided cost method, the value of a tonne of carbon is approximated by the global warming damage a tonne of carbon would contribute to. Estimates by the Intergovernmental Panel on Climate Change suggest that the marginal damage of a tonne of carbon would hardly exceed US\$ 50 /tC (Smith et al. [2002]).²⁸

Current market prices for emission reductions vary depending on the possibility of registration under the Kyoto protocol. Average prices lie between US\$ 1 and US\$6/tCO₂ (1tC = 3,667 tCO₂). For projects not intended for Kyoto compliance, the average price is \$ 1.34/tCO₂ (World Bank 2004b). Avoided deforestation is currently not admissible under the Kyoto protocol.

Since the Ethiopian government does not have any data on the amount of carbon stored in its land uses (pers. com. Ministry of Agriculture, Addis Ababa), we have borrowed our data from a study conducted by Gockowski et al. [2001]. These authors compare dense cocoa agro-forest, primary forest, and intensive farming in southern Cameroon with respect to their time-averaged carbon stocks. The primary forest stores 307 tons of carbon per hectare. The amount of biomass and, hence, the amount of carbon stored in the agro-forestry system is reduced. With an average tree stock age of 25 years 132 tons of carbon

²⁸This result was confirmed recently by Tol [2005], who reviewed 22 marginal cost studies containing 88 estimates.

are stored. By contrast, the most intensive farming system with a fallow period of 1.5 years stores 82 tons of carbon. Since further conversion of forest to farm land is very likely to happen in the absence of policy measures, we take this as the reference point, assuming a carbon storage value of zero. Accordingly, the global value of the carbon stored in the untouched rainforest protected by strict conservation ranges somewhere between US\$ 11,250 /ha and US\$ 1,106/ha, depending on the price attached. The carbon stored by the semi-forest-coffee system has a global value between US\$ 2,500 /ha and US\$ 246 /ha based on avoided marginal cost and market price respectively.

4.8 Indirect Use Value: Biodiversity

An inventory of fauna and flora in Ethiopia suggests a high degree of biodiversity.²⁹ Cloud forests are in general focal points of biodiversity. 86% of the worldwide cloud forest sites identified by a UNEP-WCMC inventory (Bubb et al. [2004]) are found on the list of priority forests defined by Olson and Dinerstein [1998].³⁰

To place a global value on the amount of biodiversity in the study areas, we consider its option value, represented by its value for future pharmaceutical research and coffee breeding. As the level of general plant diversity is significantly reduced in the semi-forest coffee areas, the value for pharmaceutical research is only attached to the use system of strict conservation.

²⁹An inventory indicates that there are 277 species of terrestrial mammals, 862 species of birds, 201 species of reptiles, 63 species of amphibians, 150 species of fish, and 7000 species of higher plants. Among these, 11% of the mammals, 3.3% of the birds, 4.5% of the reptiles, 38% of the amphibians, and 12% of the higher plants are endemic (EFAP [1994]).

³⁰These authors selected priority forests based on the following set of parameters: species richness; species endemism; higher taxonomic uniqueness; unusual ecological or evolutionary phenomena (such as migrations); global rarity; keystone habitats.

4.8.1 Pharmaceutical Research

Up to now three generations of studies have dealt with the informational value of biodiversity for pharmaceutical research. Most of them approximate the informational value by estimating private values of biodiversity for respective companies. These companies are assumed to prospect plant material or animals for substances that are suitable for pharmaceutical products. The approaches of the first and second generation multiply the probability of discovering a commercially valuable substance by the value of the substance itself (based on sales values of pharmaceutical companies and estimates of plant based drug sales) to estimate the average value of a species for pharmaceutical research (e.g. Principe [1989], Mendelsohn and Balick [1992]).

More refined models of the third generation, as proposed by Simpson et al. [1996], Rausser and Small [2000] estimate the values of the marginal species rather than the average values of all species. In order to describe the willingness of pharmaceutical firms to pay for the right to "bioprospect" a certain area, these authors value marginal species on the basis of their incremental contribution to the probability of making a commercial discovery. This is a consequence of the probability of redundancy among research leads. Various leads may bring about the same innovation, just as caffeine can be found both in coffee and tea. This redundancy feature causes the relatively small values for marginal species and the respective areas for bioprospecting. Employing this method, Simpson et al. [1996] find values ranging between US\$ 0.2 and US\$ 20.6 per hectare for 18 hot-spot areas as defined by Myers [1988].

Rausser and Small [2000] claim that these low values are related to the way the search process is modeled. They introduce a targeted search process contrasting with the random search assumed in the earlier models. According to this method prospecting firms take into

account existing information on different sites and their anticipated research quality. Then they rank potential research sites according to their quality. If promising sites are examined first, research costs decline, and the values for the same 18 hot-spot sites range between US\$ 231 and US\$ 9,000 per hectare. These high values are largely due to information rents resulting from prior existing information on the quality of these hot-spots.

Ethiopia did not appear on the list of 18 hot-spots. Recently, Myers et al. [2000] presented new information on biodiversity hot-spots. They enlarged the list to twenty-five areas worldwide. Their basic analysis is driven by two criteria: species endemism and degree of threat. Ethiopia is still not on their list because they find that the Ethiopian highlands "appear to feature exceptional plant endemism and exceptional threat, but are not sufficiently documented to meet the hot-spot criteria." Considering this apparent absence of precise information on the Ethiopian highlands, but taking into account its position as a "near hot-spot", we have assumed a fairly modest value of US\$ 20 per hectare.

4.8.2 Agronomic Research

The option value of biodiversity for agronomic research is approximated by the value of the diversity of Arabica coffee growing in the forest. As mentioned above, Arabica coffee originates from Ethiopia. Since, according to Ferwerda [1976], the spread of Arabica coffee across the world was based on only a few original trees, the coffee plantations in producer countries possess an extremely narrow genetic base, which makes the coffee vulnerable to diseases and pests.³¹ Coffee production in Ethiopia is still possible despite endemic leaf rust and the outbreak of a new disease called coffee-berry disease in 1971. This fact is

³¹The occurrence of coffee leaf rust in Sri Lanka in 1869 forced that country to abandon coffee production and shift to tea.

attributed to the availability of genetic diversity and its ability to release resistant varieties in a very short space of time (see Demel [1999]).

For the economic value of this diversity we draw on the results of the study by Hein and Gatzweiler [2005]. They use the potential of genetic resources to enhance the value of coffee production to establish an economic benefit. Specifically, coffee genetic resources are valued on the basis of three main aspects: their potential use for breeding disease-resistant varieties (thus avoiding cost of damages), the potential for breeding a caffeine-free coffee cultivar (avoiding the costs of decaffeination), and their potential to increase coffee yield (increased profit). Hein and Gatzweiler [2005] obtained estimates on the potential costs and benefits of a breeding program for enhanced coffee by conducting an extensive survey of the literature and by interviewing experienced coffee breeders. They find that the total net benefits of coffee genetic diversity in Ethiopia amount to US\$ 1458 million at a 5% discount rate over a period of 30 years and US\$ 420 million at a discount rate of 10%.

Hein and Gatzweiler [2005] argue that their estimates represent minimum values because they do not include all the potential benefits that can be obtained from genetic coffee resources. They mention the potential for resistance to other diseases than those included in his study. The study, however, suffers from the assumption of constant prices over the coming decades. The precondition for this would be a sufficient increase in global demand for coffee over the next few decades that would absorb the increased supply resulting from higher yields and the reduction of disease-induced losses.

A further important issue for our analysis is the availability of Ethiopian coffee accessions in coffee collections around the world and in field gene banks. Table IV (page 32) shows the major field gene bank collections of Arabica coffee.

Naturally decaffeinated coffee varieties were recently found in Ethiopian accessions

Country	Institute	No of accessions
Brazil	Centro Nacional de Recursos Geneticos	275
Colombia	Centro Nacionales de Investigaciones de Café Pedro Uribe Mejia	886
Costa Rica	Centro Agronomico Tropical de Investigacion y Ensenanza	1498
Côte d'Ivoire	Orstom Institut Français de recherche scientifique pour le développement et coopération	1787
Ethiopia	Institute of Biodiversity Conservation and Research	4000
Ethiopia	Jimma Research Station	679
India	Central Coffee Research Institute, Kamataka	329
Kenya	Coffee Research Foundation	592
Madagascar	Recherche Agricole à Madagascar	329
Tanzania	Tanzanian Agricultural Research Organization	42
USA	US Department of Agriculture	292

Source: Gole et al. [2002]

Table IV: Major C. Arabica field gene bank collections

maintained in Brazil (Silvarolla et al. [2004]). Apparently, part of the economic value of the coffee diversity generated by Ethiopia has already been transferred to other countries and cannot be attributed to our study regions. The above estimates must therefore be regarded as very rough indicators of the value of coffee diversity. They are attributed to strict conservation and to sustainable management of the forest areas as a whole.

4.9 Results

In this section we first present the results of the cost-benefit analysis conducted from the Ethiopian perspective. These findings are then combined with our assessment of the global values of the forest. All future costs and benefits are discounted by rates of 10%, 5%, and 2%. A discount rate of 10% is recommended for the evaluation of projects by the Ethiopian Ministry of Economic Development and Cooperation (GoE [1998]). Here we only report the figures for Sheko. Those for Yayu convey the same picture and are presented in the appendix (table (X)).

According to the available data and the aforementioned calculations, only two of the three use systems achieve positive net present values. These are maize production and the sustainable use of the forest (Table V, page 34). The negative net present value of strict conservation is very probably due to the lack of data on the local benefits of watershed services provided by the forest, i.e. the regulation of the water quantity and quality in the region. Nevertheless, the conservation initiative by the government of Ethiopia and the European Commission is, at least according to these estimates, not in the best interests of Ethiopia.

At discount rates of 2% and 5%, the sustainable use of the forest is the most profitable option, while maize production is associated with the highest benefits at a discount rate of

(a) **Maize production, traditional management**

Value	Present value per ha discount: 10%	Present value per ha discount: 5%	Present value per ha discount: 2%
Maize	1,123	1,469	1,770
Fuel wood	1,661	1,661	1,661
Timber	14,490	14,490	14,490
Total	17,274	17,620	17,921

(b) **Maize production, improved management**

	Present value per ha discount: 10%	Present value per ha discount: 5%	Present value per ha discount: 2%
Maize	3,397	5,217	7,151
Fuel wood	1,661	1,661	1,661
Timber	14,490	14,490	14,490
Total	19,548	21,368	23,302

(c) **Strict forest conservation**

	Present value per ha discount: 10%	Present value per ha discount: 5%	Present value per ha discount: 2%
(Watershed services)	n.a.	n.a.	n.a.
Wild animals	-67	-102	-140
Implementation	-106	-120	-136
Total	-173	-222	-276

(d) **Sustainable forest management**

	Present value per ha discount: 10%	Present value per ha discount: 5%	Present value per ha discount: 2%
(Watershed services)	n.a.	n.a.	n.a.
NTFP	164	253	346
Fuel wood	716	716	716
Timber	3,570	3,570	3,570
Coffee	11,231	17,249	23,643
Wild animals	-67	-102	-140
Total	15,614	21,686	28,135

Table V: Results of CBA for Sheko

10%. Unfortunately it is not possible to establish whether the maximum difference between maize production and sustainable forest management - US\$ 4,000 /ha - is outweighed by the benefits of the watershed services provided by the forest.

The high net present value of maize production highlights two points. First, it reflects the timber value stored in Ethiopia's forests. Second, it calls attention to the value of food in this drought-stricken and aid-dependent country. Regarding maize output only, the improved version is 2 to 3 times more profitable than the traditional one.

The high positive value of sustainable forest management is the sum of mid-range benefits like timber and non-timber forest products combined with the returns from coffee production. Over and against the pure income analysis, the long-term benefits of continuous high income generated by coffee here receive more weight due to lower discount rates.

From a global perspective, which adds the indirect values of biodiversity conservation and forest carbon storage to the direct use values, sustainable management of the forest is the most beneficial use option. From a national perspective, sustainable forest management is only the most beneficial solution at a discount rate of 5% or lower. It follows that, if the Ethiopian farmers were to switch from their dominant use system, which is maize production, to sustainable use of the forest, they could rightfully claim compensation from the global community, especially the coffee-producing countries, for their efforts to provide global environmental services.

It remains to be said, though, that sustainable management of the forest is associated with a trade-off, as part of the forest biodiversity will be irreversibly lost.

5 Conclusions

We analyzed three alternative use systems for the remaining montane rain forest in southwest Ethiopia with respect both to their financial returns and their total economic costs and benefits. These use systems are conversion to crop land, strict conservation, and sustainable use of the forest. The objective was to investigate whether conservation of biodiversity can be compatible with poverty alleviation in the Ethiopian highlands.

The cost-benefit analysis shows that from a global perspective sustainable forest management is the most beneficial land use option. From the national viewpoint, sustainable forest management produces the highest net benefits at discount rates of 5% or lower. It generates high benefits in terms of income from coffee production and other forest products, which largely accrue to Ethiopia. It also provides global environmental services like the conservation of coffee genetic diversity and the storage of carbon. We therefore argue that, from a theoretical viewpoint, conservation is compatible with local economic development. However, this involves a trade-off as management of the forest will reduce forest biodiversity. By contrast, the results of the income analysis confirm what the annual deforestation rate of 8% already painfully illustrates: maize and timber production generate the largest cash flow to the farmers. Current incentives and institutional constraints induce farmers to continue to convert forest to cropland. Note, however, that current distortions on the maize and timber market reduce the financial profitability of conversion and will thus prevent further deforestation. The local price for timber is about one quarter of its economic value. Likewise, due to a segmented market, the farm gate price for maize lies at 25% of its estimated value.

Some farmers receive premium prices for certified organic fair-trade coffee and thus take into account the positive external environmental effects associated with sustainable

forest management. The price premium raises the financial profitability of sustainable use of the forest to some extent, but the current monetary incentive is not sufficiently high to make this form of use interesting to farmers. According to our estimates, a premium price of US\$ 2 /lb, as opposed to the current US\$ 1.35 /lb, would be necessary to tip the balance. Such a price is hardly conceivable, but it would be justifiable on environmental grounds. It would amount to a transfer payment of US\$ 1350 /ha, which adds up to US\$ 26 million annually for the currently protected forest areas. Recall that the discounted net benefit of coffee genetic diversity lies between US\$ 1458 million and US\$ 420 million, depending on the discount rate.

Can coffee save Ethiopia's cloud forest and alleviate poverty? We conclude that it could help doing so. It would serve as a vehicle for transfer payments from consumers to farmers with the objective of protecting global environmental benefits. Moreover, at its current level it already raises the incomes of those farmers who have successfully entered the niche market for differentiated coffee. To prevent further conversion, however, timber plantations are necessary. In addition, better conditions for private investment would facilitate entry to niche markets and increase the profitability of sustainable forest management in general by lowering discount rates. This could be achieved by improving the local financial infrastructure and tenure security.

Finally, one point deserves emphasis. Forest-based poverty alleviation can be reconciled with conservation in Ethiopia. The sustainable use of biodiversity should be an integral part of economic development in the forest areas. But a deforestation rate of 8% per year calls for quick action.

6 Appendix

6.1 Income from timber and fuel wood

(a) Sustainable forest management

	A) Natural forest	B) Sustainable forest management
1. Stock	$300m^3/ha$	$200m^3/ha$
2. Volume of standing timber	$138m^3/ha$	$104m^3/ha$
3. Volume of fuel wood (1.-2.)	$162m^3/ha$	$96m^3/ha$
4. Incremental annual yield	n.a.	$4m^3/ha$
5. Value of timber	-	$[2A) - 2B)]22.2US\$/m^3 = 754.8US\$/ha$
6. Value of fuel wood	-	$[3A) - 3B)]19.2US\$/ha = 1267.2US\$/ha$
7. Value of fuel wood annually	-	$4m^3/ha \times 19.2US\$/ha = 76.8US\$/ha$

(b) Maize production

	A) Natural forest	C) Maize production
1. Stock	$300m^3/ha$	0
2. Volume of standing timber	$138m^3/ha$	0
3. Volume of fuel wood (1.-2.)	$162m^3/ha$	0
5. Value of timber	-	$[2A) - 2C)]22.2US\$/m^3 = 3063.6US\$/ha$
6. Value of fuel wood	-	$[3A) - 3C)]19.2US\$/ha = 3110.4US\$/ha$

Table VI: **Income out of timber and fuel wood** (Price of fuel wood: $19.2US\$/m^3$, price of timber: $22.2US\$/m^3$), Source: DoA, GTZ [2000], EFAP [1994],

6.2 Opportunity cost of rural labor

A Value of agricultural production in 2003 (US\$'000)	2,800,600
B Labor cost relative to A (60%)(US\$'000)	1,680,360
C Economically active rural population in 2003	23,360,100
D Adult equivalent to C (75%)	19,629,721
E Agricultural opportunity cost (B/D) in 2003 (US\$)	143
Opportunity cost of rural labor per day (ETB)	3

Table VII: **Opportunity cost of rural unskilled labor in Ethiopia** The opportunity cost of rural unskilled labor was estimated on the basis of the value of agricultural production and the number of full-time adult equivalent workers. 60% of the value of agricultural production is a return to labor. Source: GoE [1998] updated with World Bank Development Data

6.3 Cost of semi-forest coffee

A Production costs ETB/ha (450kg of green coffee)^a	
Weeding, 60 man-day a 3 ETB	180 ETB
Pruning, 30 man-day a 3 ETB	90 ETB
Harvesting, 60 man-day a 3 ETB	180 ETB
A Total	450 ETB
A Total/kg	1 ETB
B Processing costs ETB/kg of green coffee^b	
Transport from producer to hullery	0.07 ETB
Hulling costs	0.23 ETB
B Total	0.3 ETB
C Marketing and export expenses^c	0.3 ETB/kg
A + B + C	1.6 ETB/kg

^aData provided by Coffee and Tea Authority, Addis Ababa

^bData provided by Coffee and Tea Authority, Addis Ababa

^cData provided by Oromiya Coffee Farmers Cooperative Union, Addis Ababa

Table VIII: Cost of semi-forest coffee

6.4 Results of income analysis for Yayu

(a) Net income discounted at 53%

Good	Sustainable forest management		Maize production	
	differentiated coffee	conventional coffee	improved	traditional
NTFP	28	28	0	0
Fuel wood (once)	1267	1267	3110	3110
Fuel wood (annually)	154	154	0	0
Timber	755	755	3064	3064
Maize	0	0	225	130
Coffee	2499	1743	0	0
Total	4703	3947	6399	6304

(b) Net income discounted at 30%

Good	Sustainable forest management		Maize production	
	differentiated coffee	conventional coffee	improved	traditional
NTFP	47	47	0	0
Fuel wood (once)	1267	1267	3110	3110
Fuel wood (annually)	256	256	0	0
Timber	755	755	3064	3064
Maize	0	0	374	195
Coffee	4159	2764	0	0
Total	6484	5089	6548	6369

Table IX: Discounted net income in US\$/ha per use system in Yayu

6.5 Results of cost-benefit analysis for Yayu

(a) Maize production, traditional management

Value	Present value per ha discount: 10%	Present value per ha discount: 5%	Present value per ha discount: 2%
Maize	1,123	1,469	1,770
Fuel wood	1,661	1,661	1,661
Timber	14,490	14,490	14,490
Total	17,274	17,620	17,921

(b) Maize production, improved management

	Present value per ha discount: 10%	Present value per ha discount: 5%	Present value per ha discount: 2%
Maize	3,397	5,217	7,151
Fuel wood	1,661	1,661	1,661
Timber	14,490	14,490	14,490
Total	19,548	21,368	23,302

(c) Strict forest conservation

	Present value per ha discount: 10%	Present value per ha discount: 5%	Present value per ha discount: 2%
(Watershed services)	n.a.	n.a.	n.a.
Wild animals	-75	-105	-144
Implementation	-106	-120	-136
Total	-181	-225	-280

(d) Sustainable forest management

	Present value per ha discount: 10%	Present value per ha discount: 5%	Present value per ha discount: 2%
(Watershed services)	n.a.	n.a.	n.a.
NTFP	127	195	257
Fuel wood	716	716	716
Timber	3,570	3,570	3,570
Coffee	11,231	17,249	23,643
Wild animals	-75	-105	-144
Total	15,569	21,625	28,042

Table X: Results of CBA for Yayu

6.6 Implementation cost of strict conservation

I Investment	ETB '000
A Infrastructure	
Office	410
Stores	450
Houses	3120
Vehicle shelter	7.5
Fire break	760
Fire towers	6
Nursery fencing	10
Water wells	180
Water tank	30
Subtotal infrastructure	4970
B Vehicles, Machinery & Equipment	
Double cabin pick-up 4x4	350
Tractor	570
Motorcycles	120
Electric generator	290
House furniture kits	320
Office furniture kits	30
Office equipment	140
Water pump	10
Water hose	3
Forest inventory equipment	30
Subtotal Vehicles, machinery & Equipment	1860
Total investment cost	6830
II Recurrent cost	ETB/month
A Salaries and wages	
Project site manager	2500
Conservation officer	2000
Community development officer	2000
Assistants (2)	1000
Secretary/cashier	1000
Pick-up driver	600
Tractor driver	500
Nursery foreman	400
Storekeeper	500
Guards (10)	150
Subtotal salaries and wages	13000
B Operating cost	8330
Total recurrent cost	21330

Table XI: Estimated costs of implementation of strict conservation, Yayu forest (Agrisystems [2001])

6.7 List of Interviewed Experts per Topic

6.7.1 Forest

Pierric Fraval, Ethiopian Nile Basin Project, Ministry of Water Resources, Addis Ababa

Jean B. Laffitte, UNDP, Environment Unit, Addis Ababa

Stefano Latella, UNDP, Environment Unit, Addis Ababa

Abebe Tadege, National Meteorological Services Agency, Addis Ababa

Million Bekele, forester, Ministry of Agriculture, Addis Ababa

Nicholas Petit, European Commission, Addis Ababa

Ben Irvin, Farm Africa, Addis Ababa

Ato Mesfin, Institute for Biodiversity Conservation and Research (IBCR), Addis Ababa

Ato Taye, Institute for Biodiversity Conservation and Research (IBCR), Addis Ababa

Martin Neumann, Gesellschaft für Technische Zusammenarbeit (GTZ), Addis Ababa

Trudy Koenemund, Gesellschaft für Technische Zusammenarbeit (GTZ), Addis Ababa

6.7.2 Maize production

Dr. Tasfa Bogale, agronomist, Jimma Agricultural Research Center, Jimma

Volli Carucci, World Food Program, Addis Ababa

Dr. Abiye Astatke, agronomist, International Live Stock Research Institute (ILRI),
Addis Ababa

Dr. Kai Sonder, agronomist, International Live Stock Research Institute (ILRI), Addis
Ababa

Dr. Legesse Dadi, agricultural economist, Ethiopian Agricultural Research Organiza-
tion, Addis Ababa

6.7.3 Coffee

Ato Assefa, Coffee and Tea Authority, Addis Ababa

Martin Grunder, Menschen für Menschen, Yayu

Tadesse Meskela, general manager, OCFCU, Addis Ababa

Dr. Demel Teketay, director general, Ethiopian Agricultural Research Organization, Addis Ababa

Dr. Tadesse Gole, Forestry Department, Ethiopian Agricultural Research Organization, Addis Ababa

Dr. Thomas Borsch, botanist, University of Bonn, Germany

Dessialo Fantai, forester, DoA in Sheko

Ibrahim Mohammed, extension officer, DoA in Sheko

Lako Asrat, coffee agronomist, DoA in Sheko

Abebe Diori, agronomist, DoA in Yayu

Bely Legesse, extension officer, DoA in Yayu

Dinga Amente, forester, DoA in Yayu

References

Agrisystems. Coffee improvement project, revised draft formulation report, 2001.

D. Aredo. Informal financial institutions: The economic importance of iddr, iqub, and loans. In M. Demeke, A. Mekonnen, A. Admassi, and D. Aredo, editors, *Technological Progress in Ethiopian Agriculture*. Department of Economics, University of Addis Ababa, 2001.

B.M.S. Batagoda, R.K. Turner, R. Tinch, and K. Brown. Towards policy relevant ecosys-

- tem services and natural capital values: Rainforest non-timber products. CSERGE Working Paper 6, 2000.
- M. Bekele. Forestry outlook studies in Africa: Country report Ethiopia. Food and Agriculture Organization of the United Nations, 2001.
- N. Berhanu, A. Berhanu, and G. Samuel. Land tenure and agricultural development in Ethiopia. Research report, Ethiopian Economic Association/Ethiopian Economic Policy Research Institute, 2002.
- J. Bishop. Valuing forests: A review of methods and applications in developing countries. International Institute for Environment and Development, London, 1999.
- T. Bongor, E. Gebre-Madhin, and S. Babu. Agricultural technology diffusion and price policy. In *2020 Vision Network for East Africa Report 1*. International Food Policy Research Institute (IFPRI), 2002.
- L.A. Bruijnzeel. Hydrological functions of tropical forests: not seeing the soil for the trees? *Agriculture, Ecosystems and Environment*, 104:185–228, 2004.
- P. Bubb, I. May, L. Miles, and J. Sayer. Cloud forest agenda. UNEP-WCMC, Cambridge, UK, 2004.
- L.E. Buck, J.P. Lassoie, and E.C.M. Fernandez. *Agroforestry in sustainable agricultural systems*. CRC Press, Boca Raton, 1998.
- N. Byron and J.E.M. Arnold. What futures for the people of the tropical forests? *World Development*, 27(5):789–805, 1999.
- I. Calder. *The Blue Revolution: Land Use and Integrated Water Resource Management*. Earthscan, London, 1999.

- R.T. Carson, N.E. Flores, and N.F. Meade. Contingent valuation: Controversies and evidence. *Environmental and Resource Economics*, 19:173–210, 2001.
- K.M. Chomitz and K. Kumari. The domestic benefits of tropical forest preservation: A critical review emphasizing hydrological functions. *World Bank Research Observer*, 13(1):13–35, 1998.
- W.W. Collins and C.O. Qualset. *Biodiversity in Agroecosystems*. Boca Raton: Lewis Publishers, CRC Press, 1998.
- G. Deffar. Non-wood forest products in Ethiopia. Food and Agriculture Organization of the United Nations, Rome, 1998.
- M. Demeke. *Technological progress in Ethiopian agriculture*, chapter The profitability of crop production technologies in selected sites: Implications for poverty alleviation in Ethiopia, pages 87–106. Department of Economics, University of Addis Ababa, Ethiopia, 2001.
- T. Demel. History, botany, and ecological requirements of coffee. *Walia*, 20:28–50, 1999.
- A.M. Denboda. *Forest conversion, soil degradation, farmers' perception nexus: implications for sustainable land use in the south-west of Ethiopia*. PhD thesis, University of Bonn, 2005.
- C. Dinwiddy and F. Teal. *Principles of cost-benefit analysis for developing countries*. Cambridge University Press, 1996.
- EFAP. Ethiopian Forestry Action Plan, Government of Ethiopia, 1994.
- FAO. The state of the world's forests. Food and Agriculture Organization of the United Nations, FAO, 2003a.

- FAO. Faostat forestry statistics database. Food and Agriculture Organization of the United Nations, FAO, 2003b.
- FAO. FAO/WFP crop and food supply assessment mission to Ethiopia. Food and Agriculture Organization of the United Nations, FAO, 2005c.
- FAO. Food outlook. Food and Agriculture Organization of the United Nations, FAO, 2005d.
- F.P. Ferwerda. *Evolution of Crop Plants*, chapter Coffees *Coffea* spp. (Rubiaceae), pages 257–260. Longman, London, 1976.
- D. Giovannucci. Sustainable coffee survey of the North American specialty coffee industry. Specialty Coffee Association of America, California, 2001.
- J. Gockowski, G.B. Nkamleu, and J. Wendt. *Tradeoffs or Synergies? Agricultural intensification, economic development and the environment*, chapter 11, pages 197–217. CAB International Publishing, 2001.
- GoE. National economic parameters and conversion factors for Ethiopia. Ministry of Economic Development and Cooperation, Government of Ethiopia, Addis Ababa, 1998.
- T. Gole. *Vegetation of the Yayu forest in South-West Ethiopia: impacts of human use and implications for in situ conservation of wild coffee *Arabica* L. populations*. PhD thesis, University of Bonn, 2003.
- T.W. Gole, M. Denich, T. Demel, and P.L.G. Vlek. *Managing plant genetic diversity*, chapter Human impacts on the coffee arabica gene pool in Ethiopia and the need for its in situ conservation, pages 237–247. IPGRI, Rome, 2002.

- G.M. Grossman and A.B. Krueger. Economic growth and the environment. *Quarterly Journal of Economics*, 110(2):353–377, 1995.
- GTZ. Profile of household energy in Ethiopia. Gesellschaft fuer technische Zusammenarbeit, Addis Ababa, Ethiopia, 1998.
- GTZ. Household energy project brief. Gesellschaft fuer Technische Zusammenarbeit, Addis Ababa, Ethiopia, 2000.
- L. Hein and F. Gatzweiler. The economic value of coffee (*coffea arabica*) genetic resources. *Ecological Economics*, 2005.
- S.T. Holden, B. Shiferaw, and M. Wik. Poverty, market imperfections and time preferences: of relevance for environmental policy? *Environment and Development Economics*, 3(1): 105–130, 1998.
- IBCR. PRA report on Sheko national forest. Forest Genetic Research Conservation Project IBCR/GTZ, Addis Ababa, 2000a.
- IBCR. PRA report on Yayu national forest. Forest Genetic Research Conservation Project IBCR/GTZ, Addis Ababa, 2000b.
- ITC. Coffee, an exporter’s guide. International Trade Center, Geneva, Switzerland, 2002.
- ITTO. Annual review and assessment of the world timber situation. International Tropical Timber Organization, Yokohama, Japan, 2002.
- D.R. Lee and C.B. Barret. *Tradeoffs or synergies? Agricultural intensification, economic development and the environment*. CAB International, 2001.
- B. Lewin, D. Giovannucci, and P. Varangis. Coffee markets: new paradigms in global

- supply and demand. Agriculture and rural development discussion paper 3, The World Bank, 2004.
- R. Mendelsohn and M.J. Balick. Assessing the economic value of traditional medicines from tropical rain forests. *Conservation Biology*, 6(1):128–130, 1992.
- N. Myers. Threatened biotas: Hotspots in tropical forests. *The Environmentalist*, 8(3): 1–20, 1988.
- N. Myers, R.A. Mittermeier, C.G. Mittermeier, G.A.B. Da Fonseca, and J. Kent. Biodiversity hotspots for conservation priorities. *Nature*, 403:853–858, 2000.
- NBE. Quarterly bulletin. National Bank of Ethiopia, Addis Ababa, Ethiopia, 2005.
- OECD. Agricultural outlook 2004 - 2013. OECD, Paris, 2004.
- D.M. Olson and E. Dinerstein. The global 200: a representation approach to conserving the earth's most biologically valuable ecoregions. *Conservation Biology*, 12:502–515, 1998.
- Oxfam. Crisis in the birthplace of coffee. Oxfam International Research paper, 2002.
- S. Pagiola, A. Arcenas, and G. Platais. Can payments for environmental services help reduce poverty? An exploration of the issues and the evidence to date from Latin America. *World Development*, 33(2):237–253, 2005.
- D. Pearce and C.G.T. Pearce. The value of forest ecosystems - a report to the secretariat. Convention on Biological Diversity, 2001.
- D. Pearce, C. Pearce, and C. Palmer. *Valuing the Environment in Developing Countries*. Edward Elgar Publishing Ltd., 2002.

- D. Pearce, F.E. Putz, and J.K. Vanclay. Sustainable forestry in the tropics: panacea or folly? *Forest Ecology and Management*, 172:229–247, 2003.
- J.L. Pender. Discount rates and credit markets: Theory and evidence from rural India. *Journal of Development Economics*, 50(2):257–297, 1996.
- C. Perrings. *The economics of biodiversity conservation in Sub-Saharan Africa*, chapter 1, pages 1–45. Edward Elgar Publishing Ltd. UK, 2000.
- C.M. Peters, A.H. Gentry, and R.O. Mendelsohn. Valuation of an amazonian rainforest. *Nature*, 339:655–656, 1998.
- V. Pohjonen and T. Pukkala. Eucalyptus globulus in Ethiopian forestry. *Forest Ecology and Management*, 36:19–31, 1990.
- P. Principe. The economic value of biodiversity among medicinal plants. OECD, Paris, 1989.
- G.C. Rausser and A.A. Small. Valuing research leads: Bioprospecting and the conservation of genetic resources. *Journal of Political Economy*, 108(1):173–206, 2000.
- M. Ruiz-Pérez, B. Belcher, R. Achdiawan, M. Alexiades, C. Aubertin, B. Caballero, C. Campbell, C. Clement, A. Cunningham, A. Fantini, H. Foresta, C.G. Fernandez, K.H. Gautam, P. Hersch, W. Jong, K. Kusters, M.G. Kutty, C. Lòpez, M. Fu, M.A. Martínez Alfaró, T.R. Nair, O. Ndoye, R. Ocampo, N. Rai, M. Ricker, K. Schreckenberg, S. Shackleton, P. Shanley, T. Sunderland, and Y. Youn. Markets drive the specialization strategies of forest people. *Ecology and Society*, 9(2), 2004.
- P. Shanley, A.R. Pierce, S.A. Laird, and A. Guillén, editors. *Tapping the green market*. Earthscan Publications Ltd., 2002.

- A. Shibru, A. Girma, and T. Kufa. Characterization of the farming system of Metu woreda. Research Report 45, Ethiopian Agricultural Research Organization, 2002.
- M.B. Silvarolla, P. Mazzafera, and L.C. Fazuoli. Plant biochemistry: a naturally decaffeinated arabica coffee. *Nature*, 429(826), 2004.
- D.R. Simpson, R.A. Sedjo, and J.W. Reid. Valuing biodiversity for use in pharmaceutical research. *Journal of Political Economy*, 104(1):163–185, 1996.
- J.B. Smith, H.J. Schellnhuber, M.Q. Mirza, E. Lin, S. Fankhauser, R. Leemans, L. Ogallo, R.G. Richels, U. Safriel, R.S.J. Tol, J.P. Weynant, and G.W. Yohe. Synthesis. IPCC Third Assessment Report, Cambridge University Press, Cambridge, 2002.
- L. Squire and H.G. van der Tak. *Economic analysis of projects*. John Hopkins University Press, 1995.
- W.D. Sunderlin, A. Angelsen, B. Belcher, P. Burgers, R. Nasi, L. Santoso, and S. Wunder. Livelihoods, forests, and conservation in developing countries: An overview. *World Development*, 33(9):1383–1402, 2005.
- A. Techane. *Technological progress in Ethiopian Agriculture*, chapter Fertilizer use and marketing in Ethiopia: the case of major cereal producing sites, pages 241–259. Department of Economics, University of Addis Ababa, Ethiopia, 2001.
- T. Teklu. Rural lands and evolving tenure arrangements in Ethiopia: Issues, evidence, and policies. Discussion paper 10, Forum for Social Studies, Addis Ababa, 2003.
- R.S.J. Tol. The marginal costs of carbon dioxide emissions: an assessment of the uncertainties. *Energy policy*, 33(16):2064–2074, 2005.

- D. Whittington. Improving the performance of contingent valuation studies in developing countries. *Environmental and Resource Economics*, 22:323–367, 2002.
- D. Wirtu and P. Gong. The economics of growing Eucalyptus Globulus L. on the highlands of Oromiya, Ethiopia. *Ethiopian Journal of Natural Resources*, 2(2):203–225, 2000.
- The World Bank. Ethiopia risk and vulnerability assessment. World Bank, Report 26275-ET, 2005.
- S. Wunder. Payments for environmental services: some nuts and bolts. CIFOR Occasional Paper 42, Center for International Forestry Research, 2005.
- S. Wunder. Poverty alleviation and tropical forests: What scope for synergies? *World Development*, 29(11):1817–1833, 2001.
- G. Yaron. Forest, plantation crops or small-scale agriculture? An economic analysis of alternative land use options in the mount cameroon area. *Journal of Environmental Planning and Management*, 44(1):85–108, 2001.
- Y. Yemshaw. Overview of forest policy and strategy issues in Ethiopia. In D. Teketay and Y. Yemshaw, editors, *Forests and Environment*, volume 4. Forestry Society of Ethiopia, 2002.