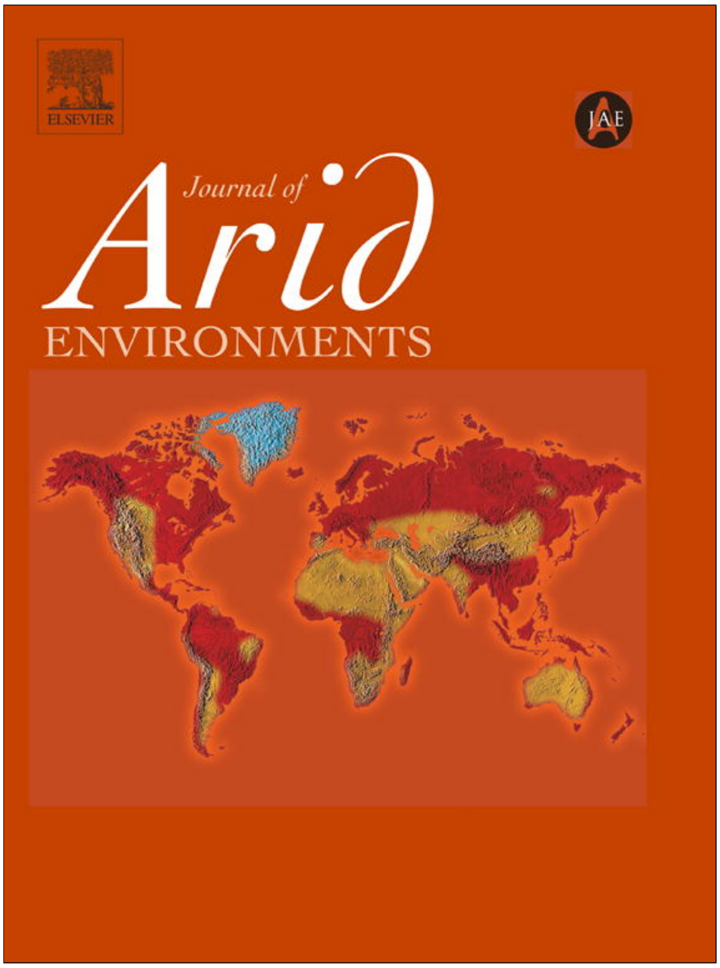
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Manage or convert *Boswellia* woodlands? Can frankincense production payoff?

T. Dejene [a], M. Lemenih [b,c,*], F. Bongers [c]

[a] Forestry Research Center, P.O. Box 30708, Addis Ababa, Ethiopia
[b] International Water Management Institute (IWMI), P.O. Box 5689, Addis Ababa, Ethiopia
[c] Forest Ecology and Forest Management group, Wageningen University and Research Center, P.O. Box 47, 6700 AA, Wageningen, The Netherlands

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ABSTRACT

African dry forests provide non-timber forest products (NTFPs) of high commercial value, such as frankincense and gum arabic. Nonetheless, their deforestation and conversion to croplands is intensifying. Expected higher financial return from crop production is a main driver of conversion, but research supporting this underlying claim is scarce. We compared the financial returns for two crop production options (sesame and cotton) and forest use, in a dry forest area known for its frankincense production in northern Ethiopia. Net revenue was highest for sesame and lowest for cotton agricultural use. The forest based revenue was intermediate. The revenues from the crop production options were more sensitive to a range of uncertainties than the forest land use. Our results show that forest land use that includes commercial NTFPs is financially competitive to some commercial crop options and offers returns of better reliability. The hypothesis that forest based revenues are lower than crop based ones is not supported by our results. Therefore, the continued deforestation of dry forests cannot be explained by lower returns alone, but other factors such as awareness, market access, property right and institutional issues may also play a role to drive deforestation and conversion of dry forests to croplands.

1. Introduction

Dry forests in Africa represent an important resource base for livelihoods and economic development of millions of poor households (Paumgarten and Shackleton, 2009; Shackleton et al., 2008; Suderland and Ndoye, 2004). If managed wisely they have the capacity to provide a sustainable stream of income and subsistence products while supporting other economic activities through the provision of a bundle of ecosystem services (Chikamai et al., 2009; Lemenih and Teketay, 2004). However, dry forests are among the least managed and protected ecosystems (Bongers and Tennigkeit, 2010; Dirzo et al., 2011; Murphy and Lugo, 1995), and are suffering severe degradation due to anthropogenic pressures leading to their continuous shrinkage by the expansion of agricultural lands and human settlement (Bongers and Tenningeit, 2010; Miles et al., 2006).

In Ethiopia, dry forest is the largest remaining forest vegetation and covers 55 million ha (Lemenih and Bongers, 2011; WBISPP, 2004). These forests are distinctly rich in *Acacia*, *Boswellia* and *Commiphora* species (Abiyu et al., 2010; Eshete et al., 2011; Lemenih, 2005), that provide important export commodities such as gum arabic, frankincense and myrrh (Abiyu et al., 2010; Lemenih, 2005; Lemenih and Kassa, 2011). The production, export volume and foreign currency earnings from the dry forest products are growing in Ethiopia (Lemenih and Kassa, 2011).

Concomitant with the world trend, also in Ethiopia dry forests are subject to increasing pressure from competing land uses (Lemenih et al., 2007, 2011, 2012). Rapid population growth and the consequent clearance of dry forests for cropland expansion and overgrazing drive deforestation of Ethiopian dry forests (Lemenih et al., 2007, 2011, 2012). It is postulated (Lemenih et al., 2011) that the main reason for the high clearance rate to cropland is the assumption that crop production provides better income to farmer households and agri-investors than managing the dry forest for a range of Non-Timber-Forest-Products (NTFPs) such as frankincense, honey and fuelwood production even in combination with to-a-certain-extent-forest-compatible-uses such as livestock grazing (e.g. Eshete et al., 2005; Lemenih and Kassa, 2011; Lemenih et al., 2007). For example in Tigray, one of the largest frankincense producing areas in Ethiopia, about 170,000 ha dry forest has been deforested and converted to croplands since the 1970s (Gebrehiwot et al., 2003). Similarly croplands and settlements are expanding in Metema district and surrounding regions at an estimated annual rate of 0.49% (1855.3 ha) (Lemenih et al., 2012).

* Corresponding author. International Water Management Institute (IWMI), P.O. Box 5689, Addis Ababa, Ethiopia. Tel.: +251 911 863214; fax: +251 11 6172001.
E-mail addresses: m.lemenih@cgiar.org, elerohi@yahoo.com (M. Lemenih).

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The sustained production of frankincense and conservation of the dry forests for their biodiversity and other ecosystem services appear to depend largely on the financial benefits that the rural households receive compared to alternative land use options. A study from Tigray, for instance, showed that managing dry forests for frankincense production is a competitive land-use and provides a higher net financial return than crop production alternatives (Tilahun et al., 2007). Similarly, the financial return from NTFP in Indian dry deciduous forests was significantly higher than the returns from alternative land uses (Mahapatra and Tewari, 2005).

However, financial feasibility of a forest land use option depends highly on site specific factors, and will therefore vary from site to site. In the present study we evaluate the financial feasibility of forest use in north western Ethiopia, currently a major frankincense producing area. We compare the financial benefit of conserving the dryland forests for the production of wood (fuelwood) and other non-wood forest products, with those of agricultural land-use options based on sesame and cotton.

2. Materials and methods

2.1. Study area

The study was conducted in Metema district, north-western Ethiopia, which is located between 12°39′ and 12°45′N and 36°17′ and 36°48′E. Metema district covers an area of 399,500 ha at an altitude ranging between 550 m and 1608 m a.s.l. The area receives an uni-modal rainfall, *ca* 955 mm, from June to September. Annual mean minimum and maximum temperatures are 19.1 °C and 35.6 °C, respectively (Eshete et al., 2005). The district is inhabited by a total population of 83,000 (CSA, 2007), most of which are sedentary agriculturalists who practice mixed crop-livestock production system. Large part of the district is covered with woodlands but land cover/land use is changing rapidly. The population is ethnically diverse, including Amhara (80%), Tigre (10%), Oromo (5%), Gumuz (2%) and others (3%) (Lemenih et al., 2011). Except for the Gumuz, who are considered native to the area, inhabitants of Metema are migrants that arrived through either spontaneous migration or government sponsored resettlement. Metema district is receiving a large number of formally resettling households (Lemenih et al., 2012).

Until recently, the Gumuz were hunters and gatherers, with a very limited crop cultivation, mainly sorghum and finger millet (Mekonnen, 2004). Extensive crop and livestock farming was introduced to the area along with the highland settlers and commercial farmers (Lemenih et al., 2012, 2007). Settlers and commercial farmers in the district cultivate sesame, cotton and sorghum and raise goats and cattle. Thus, agriculture is expanding in area and economic importance at the expense of the dry forests (Lemenih et al., 2007). Three crops namely sorghum, sesame and cotton predominate, and cover about 90% of the cultivated area in the district (Lemenih et al., 2012, 2011). Livestock production is extensive and involves year round free grazing in the dry forests (Desalew et al., 2010).

The vegetation type in Metema belongs to the *Combretum–Terminalia* broad-leaved deciduous woodland and wooded grasslands (Friis et al., 2010). *Boswellia papyrifera* is the dominant species in the vegetation (Eshete et al., 2011). Due to its historical remoteness and sparse population Metema has still major resources of *B. papyrifera*, and therefore is currently one of the districts with the largest frankincense production in Ethiopia (Lemenih and Kassa, 2011). Until now the production is entirely controlled by gum companies (state and private). The production takes place through a concession system providing gum companies the right to extract frankincense from the dry forests subject to annual lease payment. Gum companies acquire short term (usually one to two years) concession rights from the regional Bureau of Agriculture. Since local farmers in Metema are not involving in the frankincense collection and production (Eshete et al., 2005; Lemenih et al., 2011, 2007) conflict of interest over the woodlands is growing. Conflicts raise mainly related to cropland expansion by the community and commercial farmers on one hand, and Gum companies for collecting and marketing frankincense on the other (Lemenih et al., 2011). Farmers generally perceive the woodlands as economically less productive and attractive compared to alternative land use options such as the production of cash crops like sesame and cotton (Lemenih and Kassa, 2011; Lemenih et al., 2007; Woldeamanuel, 2011). As a result, the woodlands and their frankincense resources are increasingly converted into farmlands (Lemenih et al., 2012, 2007; Woldeamanuel, 2011). Yet, the dry forests continue providing the farmers with major grazing areas (forest grazing) supporting livestock production and a variety of wood and non-wood products, mainly fuelwood, honey and grass for local consumption and sale to augment household income (Lemenih et al., 2012).

Since the radical land reform in Ethiopia in 1975, land and natural resources such as forests and woodlands are classified as public property and therefore belong to the state. Farmers have no use right over natural trees and woodlands for extracting commercial products, be it timber or commercially important non-timber (e.g. frankincense), unless official permission is given by the concerned government agency. However, farm households are allowed to freely harvest minor forest products such as firewood, collect grass or graze their animals in the woodlands and can hang bee hives for honey production. With respect to farm lands farmers hold the usufruct right subject to payment of annual land tax to the government.

In Metema individual farm households combine sesame, cotton, livestock production and to some extent forest use (except frankincense tapping) as livelihoods portfolio. For this study, we combined all of the forest related activities practiced by the gum companies (frankincense production) and the collection of other forest products by farm households (honey, grass and firewood) into the forest land use system.

2.2. Data collection

Economic revenue from the three alternative land uses was based on monetary values of the various physical inputs and outputs involved in their production systems. Data for the physical inputs and outputs and their prices were collected through a combination of socio-economic survey and field inventory. The socio-economic survey involved various data collection techniques such as informal discussion, household questionnaire survey and focus group discussion (FGD). For the household questionnaire survey 54 sample households were purposively selected (David, 1997) using the criteria of having farm field cleared out of Boswellia woodland mainly for sesame and cotton production as well as residing still nearby woodlands that are tapped for frankincense production. A structured questionnaire was developed, pre-tested and used to interview the sample households. Reconnaissance survey and informal discussion was conducted across the site covered by the study to gather essential information to be incorporated into the structured questionnaire for the household interview. Based on the information gathered from the reconnaissance survey the structured questionnaire was designed to capture information on history of land use, farm size ownership, crop types cultivated, size of land used for each crop, amount of annual inputs and outputs for farm activities by crop type (mainly for cotton and sesame), types and quantities of forest products collected from the nearby woodlands, types of forest products and proportions sold and consumed at household level, costs and price of inputs and outputs and production constraints. The questionnaire was pre-tested on 5 randomly selected households and the necessary adjustments were made before being used in the main data collection procedure. Interview was conducted by the researchers using the local language (Amharic). Besides, focus group discussion (FGD) was conducted with two groups each consisting of 6–8 individuals. The check list questionnaire used for the FGD also sought information related to labour cost, price and amounts of inputs, work norms per hectare and the like. The information obtained from the FGD was used to triangulate, check and confirm the data collected through the household interview.

Moreover, to obtain reliable estimate of cotton and sesame annual yield per hectare the farm plots of the 54 sample households were surveyed using measuring tapes and their respective area calculated. Then cotton or sesame yield harvested in that specific year from the respective plot was obtained from the households through interview. The quantity of harvested yield (kg) was divided by the plot size (ha) to obtain estimate of crop yield per ha and year.

For estimating frankincense yield per hectare and year the mean stem density (stem number per hectare) and yield per tree and year were determined. Mean stem density was obtained from vegetation inventory in the woodlands using a systematic transect sampling procedure. Five parallel transects that run in North-South direction (along the topographic gradient) were laid out at 500 m apart. A total of 32 plots of 20 × 20 m size were laid along the transects at 250 m apart following an established procedure (Eshete et al., 2005; Ogbazghi et al., 2006). In each plot the number of *B. papyrifera* trees with diameter at breast height (DBH) ≥ 10 cm, which is the productive size for frankincense, were counted. From the data, the mean *B. papyrifera* stem density was calculated by taking the average stem density from the 32 plots inventoried and converting it to a hectare base (Equation (1)).

$$\text{Stem density} = \left(\left(\sum_{i=1}^{n} \boldsymbol{d}\right) \Big/ \boldsymbol{n}\right) {*}25 \quad (1)$$

where: d = stem number/plot and n = number of plots.

Frankincense yield (kg) per hectare and year was computed by multiplying the mean stem density per hectare calculated above with the mean yield per tree (kg/tree/year) (Equation (2)). The latter was obtained from previous studies in the same woodland (e.g. Eshete et al., 2012; Tadesse et al., 2004), which was 0.3 kg/tree/year.

As indicated in the section above, the local community is allowed to collect dried wood material for firewood for free from the woodlands. The tradition is that firewood is collected and piled once every year, at the end of the dry season. This is also the time during which the survey was conducted. All dry wood material, including dried branches from standing trees were collected, piled and weighed for the 32 inventory plots. The mean weight per plot was computed and converted to a per hectare basis to provide estimate of firewood production per hectare and year. With respect to the annual grass production, five sub-sample plots of 1 m^2 within each of the 32 main plot, were established and available grass during the survey was harvested and weighed. However, as livestock production in the area is free roaming, it was expected to have affected the grass available at the time of survey in these plots. To compensate for this effect, grass harvested from 15 same size plots from within enclosed research plots that were protected against grazing was used as a correction factor to adjust for grazed quantity of grass. The mean value of the grass weight from the enclosed 15 plots and the mean values from the inventory plots were computed and the ratio of the enclosed to the non-enclosed grass weight was used to correct the grass weight harvested from the inventory plots. The mean of the corrected grass weight per plot was converted to a hectare base to estimate the average annual grass production per hectare. Furthermore, the number of beehives was counted in five 1-ha Boswellia forest sample plots that were 200 m apart and averaged per ha. Mean honey production in kg per hive was obtained from the household interview.

$$\text{Frankincense yield (kg/ha.yr)} = \left(\left(\sum_{i=1}^{n} \boldsymbol{d}\right) \Big/ \boldsymbol{n}\right) {*}25{*}\boldsymbol{y}(\text{kg/tree.yr}) \quad (2)$$

where: d = stem number/plot, n = number of plots and y = mean frankincense yield per tree and year.

For prices of inputs and outputs we used two market prices. A farm gate price, which is the price at the village, was determined through direct survey of the market for prices and costs of outputs and inputs respectively following the norms in the area. The market price, which is the price and costs for inputs and outputs in the nearby major town, Shehidi in this case, was determined by conducting a market survey. The types and quantities of inputs for the three land use options were obtained from the information gathered through household survey and FGD. The total monetary values of the outputs or inputs on a per hectare and year basis were computed by multiplying quantity of outputs or inputs per hectare and year with the corresponding unit price of each of the output or input, respectively.

2.3. Data analysis and decision criteria

The financial efficiency of each land use option was evaluated using Equation (3), following Godoy et al. (1993) and Camille (2003). The estimated net revenue (NR) from the alternative land uses on a per-hectare and year base was calculated by summing the net values of selected products following the annual enterprise budgeting system and subtracting the total cost from the gross revenue of each alternative.

$$NR = (Q{*}P) - C \quad (3)$$

Where, NR = Net Revenue, Q = quantity of products harvested, P = unit price of the products (in ETB[1]), C = total cost of production (in ETB) all on a hectare base. For the forest land use option, the NRs obtained for the four products (frankincense, grass, fuelwood and honey) were added together.

Outputs of each option are annual. The establishment and management cost for the forestry option was set to zero as collection of the products were from natural stands with no ongoing management activities. Sensitivity analyses were conducted to evaluate the reliability of the net revenues from the three options using those variables that are likely to have greater influence on their net returns. The selected variables were yield, prices of products and costs of input, and we assumed that, compared to the base year, costs of inputs could increase up to 80%, prices of products could decrease up to 50%, and sale prices of products could decrease up to 50%.

3. Results

3.1. Socio-economic characteristics of the respondents

All respondents were farmers that practice a mixed crop-livestock production system for their livelihoods. They practice

[1] ETB stands for Ethiopian Birr, which is the local currency in Ethiopia. The exchange rate of ETB to USD = 1: 17.2.

long fallow to maintain land productivity: they leave lands to rest for about six years after cropping for three to four consecutive years. The average landholding was 3.22 ha per household. All of the respondents (100%) were households that resettled from the highlands through either a government sponsored resettlement program (57.4%) or self-initiated migration (26%), and 16.6% were born to the resettled households. About 37% of the respondents lived shorter than 10 years in the area. Average family size was 6, and the range was between 2 and 12. Illiteracy rate was very high: 57.4% of the respondents could neither read nor write; 35.2% had attended school up to grade 4, the rest attended school beyond grade 4. About 81.5% of the respondents were between 15 and 50 years of age, and 18.5% were older than 50 years.

None of the respondents were engaged in frankincense production related activities, not even as daily laborer. Frankincense is solely produced by companies that lease land from the regional government. The gum companies rely entirely on labor force from outside the district mainly from Tigray. Local farmers benefit from the forest in the form of honey production, grass for fodder and fuelwood for consumption as well as sale. The reasons for the lack of involvement of farmers in the frankincense business are many, and include: lack of awareness and experience in the business (89%), policy constraint that restrict individual household production (68%), the arduous nature of tapping (76.5%) and market access (67%). In fact, the Amhara regional policy prohibits individual farmers from producing and selling frankincense, unless they are organized into cooperatives. Such farmer-producer cooperatives are recently emerging in the area.

3.2. Physical inputs and outputs of production

The two crop land use options (sesame and cotton) show large differences in terms of their input requirements (Table 1). The production of cotton is more labor intensive than that of sesame. Chemical fertilizers were not used in the crop production system in Metema. Estimated yields of sesame and cotton were 0.532 and 1.192 tons/ha/yr, respectively (Table 2). Production inputs and outputs for the forest land use are presented in Tables 1 and 2. In the forest vegetation of Metema *B. papyrifera* stems predominate the standing vegetation accounting for 53.1% of the total stem density per hectare. A total of 18 other tree species were recorded associated with *B. papyrifera*. The mean *B. papyrifera* stem density was 225 stems/ha. With a mean frankincense production of *ca.* 0.3 kg/tree/yr, the mean frankincense yield expected was *ca.* 67.5 kg/ha/year. Honey production was also estimated at *ca.*105 kg/ha/yr and fuelwood production was estimated at *ca.* 4.5 loads/ha/yr. Similarly the average grass yield was estimated at *ca.*132 loads/ha/yr (Table 2).

The labour cost differed for peak season and slack season. For instance, cost for one man-day at slack season is 20 ETB, while the same labour costs up to 30 ETB during peak season depending on the type of farm activity accomplished. However, the respondents put together these differences when reporting the annual cost of labour per hectare and year for the agricultural land use options.

Table 1
Production inputs, their quantity per hectare and year, unit price and total cost for the three land use options in Metema, Ethiopia.

Land use	Inputs	Unit	Quantity/ha/yr	Cost (ETB)/unit	Total cost/ha/yr (ETB)
Forest	Mingafe	Piece	4	10	40
	Basket	Piece	4	6	24
	Beehives	Piece	5	20	100
	Labor	Man-days	15	20	300
	Land lease for frankincense	–	–	50	50
	Transport to Shehidi (fuelwood)[a]	Load	3	5	15
Sesame	Labor	Man-days	30	20	600
	Land tax	ETB	50	50	50
	Transport to Shehidi	ETB	15	125	125
	Traction power (pair of oxen)	Pairs	2	200	400
	Seed	Kg	5	40	200
Cotton	Labor	Man-days	42	20	840
	Land tax	ETB	50	50	50
	Transport to Shehidi	ETB	15	180	180
	Traction power (pair of oxen)	Pairs	2	200	400
	Seed	Kg	10	30	300

[a] Transport cost here refers to the transportation of fuelwood to the nearby market. For the other forest products, particularly frankincense, the transport is not relevant since this is included in the labour cost of the tappers.

Table 2
Types of outputs and their unit price (in ETB) at both farm gate and in the nearby town of Shehidi for the three land use options in Metema, Ethiopia.

Product type	Unit of measurement	Mean annual yield per ha	Price (ETB)/Unit	
			Farm gate	Shehidi
Frankincense	Kg	67.5	12	15
Fuelwood	Load	4.5	6.50	8
Grass	Load	132	3.50	5
Honey	Kg	105	12	15
Sesame	Kg	532	8	8.50
Cotton	Kg	1192	2.80	3.20

3.3. Financial comparisons of the land-use options

Prices of the outputs differed between the two market-places: farm gate and Shehidi town market. At Shehidi most products are sold at 12–20% higher prices compared to the farm gate (Table 2). The computed annualized net revenue from the three options showed that sesame production yielded the highest revenues, and cotton the lowest, both at farm gate as well as in Shehidi market. Forest use yielded a net revenue in-between the two crop productions. At Shehidi market net revenue per hectare per year of sesame production exceeded forest land use revenue by 552 ETB and that of cotton by 992 ETB, while at farm gate the sesame production net revenue exceeded that of forest option by 1069 and that of cotton production by 1158 ETB (Table 3).

How reliable are these revenues under various assumptions? The net revenue of the three land use options is sensitive to changes in input costs (Fig. 2), but the sensitivity differed among land use with cotton showing the strongest decrease in net revenue (Fig. 1). An 85% increase in production cost (costs of inputs) may reduce the net revenue from cotton, sesame and forest options with 54%, 31% and 16% respectively (Fig. 1). Reduction in the prices of outputs similarly affects the net revenue of all the options, with again the cotton option showing the strongest decrease (Fig. 2a). A reduction in the prices of the products with 50% of the base year may reduce

Table 3
Revenue generable for the three land use options in Metema, Ethiopia (values are in ETB/ha/year).

Land-use option	Gross revenue		Total cost of production		Net revenue	
	Farm gate	Shehidi	Farm gate	Shehidi[a]	Farm gate	Shehidi
Sesame	4256	4522	1140	1215	3116	3307
Cotton	3337	3814	1380	1500	1957	2314
Forest	2561	3283	514	529	2047	2754

[a] The total cost of production at Shehidi is computed by adding the cost of production at farm gate with the transport cost to Shehidi.

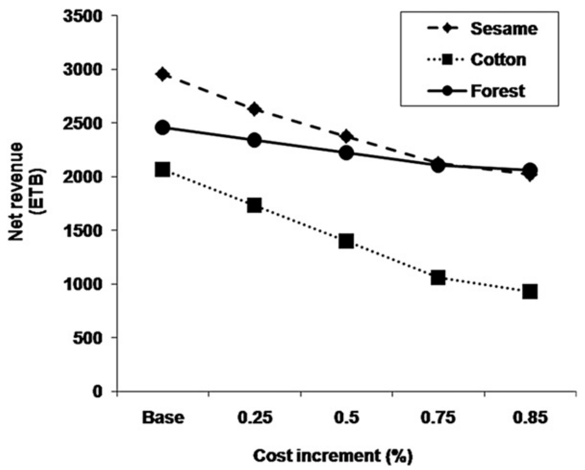

Fig. 1. Sensitivity of the net revenue from the three alternative land use options under increasing cost of inputs (up to 85% over the base year) in Metema district, Ethiopia.

the net revenue by 68%, 82% and 59% for sesame, cotton and forest options, respectively (Fig. 2a). A 50% reduction in yield of products may reduce the net revenue by 68.4, 82.4% and 59.6% for the sesame, cotton and forest uses respectively (Fig. 2b). Hence, under all assumptions the net revenue of the cotton land use option is the most sensitive, while the net revenue of the forest option is least sensitive.

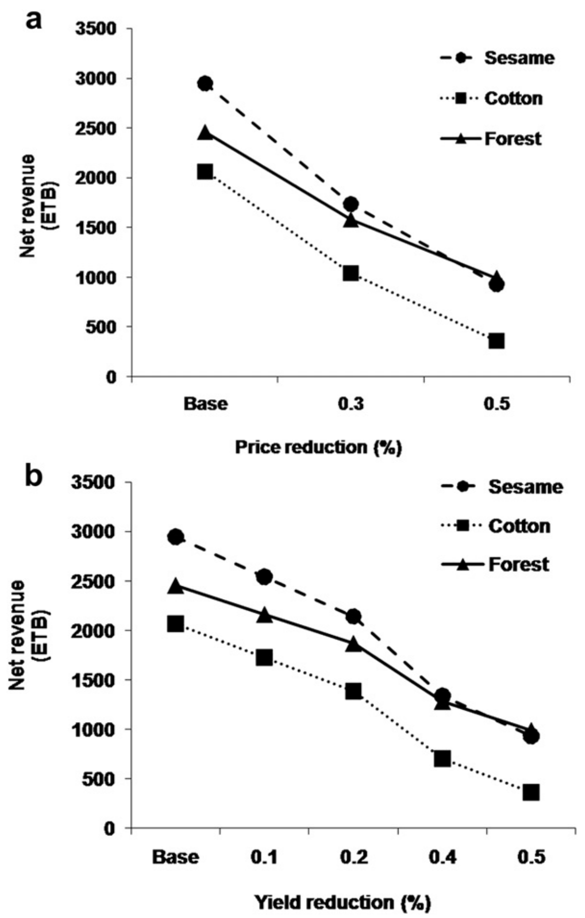

Fig. 2. Sensitivity of the net revenue from the three alternative land use options under decreasing prices of outputs (a) and reduction of yield (b). Reductions are percentages of the base values.

4. Discussion

This study shows that forests richly endowed with commercial NTFPs like frankincense may compete in financial terms with some of the cash crop based agricultural land uses that are replacing them, for instance cotton. The rapid conversion of frankincense woodlands observed today therefore is not driven by economic returns only. Factors that may affect the decision to convert dry forest to agricultural land include lack of awareness regarding realistic possible economic returns of the alternatives, and the short term (for farmers) economic return advantage of agricultural crops compared to the economic (for companies) and ecological returns of the forest use option. In Ethiopia these two elements reflect the fact that rural development and food security issues disproportionately preoccupy the political agenda through the 'market oriented agricultural based rural development and poverty reduction' policy framework of the government (e.g. PASDEP, 2006). This agenda has led to conversion of thousands of hectares of dry forests into agri-business land, as well as to human resettlement programs whereby food insecure households from degraded lands are translocated to dry forest ecosystems including those in the study area (Lemenih and Kassa, 2011; Lemenih et al., 2007, 2012).

The economic returns attached to the forest land-use option is not directly enjoyed by the farmers, unlike those of the agricultural land use option. Agricultural produce of smallholder farmers is directly sold at the market and converted into cash for the farmer. Frankincense production, on the other hand, is mostly run by companies that mobilize large capital and hire external labour for tapping. At individual farmers level this in fact is impossible, because of the concession construction (Woldeamanuel, 2011). In addition, legally farmers have stronger access right to land as farmland than as forest land. Constitutionally, natural forests such as the woodlands in Metema are property of the Government in Ethiopia. However, once it is converted to farmland, legally or illegally, farmers obtain a legal use right as farmland with an indefinite period. This situation thereby becomes an incentive to convert the forest into farmland as it leads into a legal claim over the land (Lemenih et al., 2012). An additional argument is that frankincense, the main forest product from the area, is little traded on the local market. Nearly the whole production is transported to Addis Ababa, from where it is distributed again over the country or exported. Farmers, therefore, have to rely on long distance traders to be able to use the product. These information, policy and trading organisation factors, in addition to the pure economic factor, contribute to the continued clearance and conversion of the woodlands into cropland. This conforms to other studies that argue that combinations of factors such as higher income, market access and policy constraints are likely to drive forest conversions (e.g. Cavendish, 2000; Chipika and Kowero, 2000; Woldeamanuel, 2011).

Unexpectedly, our results contrast with those of a similar study conducted in Tigray, Ethiopia. Tilahun and coworkers (2007) showed that management of frankincense tree dominated forests generates a higher Net Present Value (NPV) (6468–8622 ETB/ha/yr) from frankincense and grass combined than crop based alternatives (maize and sorghum cultivation) in which both grain and residue are valued, respectively by a minimum of 2005 ETB/ha/yr. This contrast may result from regional differences. First, in Tigray the crop options considered (maize and sorghum) are not commercial types, resulting in generally lower market prices for the crops compared to the high prize for sesame in Metema. Second, the biophysical potential (soil, temperature, rainfall) of Metema leads to a generally higher productivity than in Tigray. Third, while more or less comparable quantities were obtained in both studies for grass and fuelwood, the quantity of frankincense yield was higher in Tigray (0.5 kg/tree/yr) compared to Metema (0.3 kg/tree/yr). This resulted in an annual frankincense yield per hectare in Tigray being twice that of Metema (127 vs 67.5 kg/ha/yr). Recent studies in both forests suggest that the earlier yield estimate (Tilahun et al., 2007) may be the result of a more intensive tapping (e.g. Eshete et al., 2012).

On the other hand, our study conforms to other studies. For instance, Mahapatra and Tewari (2005) found that the net revenues from NTFP from dry deciduous forests in India were significantly higher than the returns from alternative land uses as timber, agriculture and livestock.

Most interestingly, the present study shows that the forest based income was less sensitive to increases in cost, and decreases in prices and yield of the produce than the crops based incomes. Forest based investments are thus less risky, which should attract investments into sustainable forest use. Additionally, forests provide several benefits other than timber and non-timber that are not directly traded on regular product-based markets. These benefits are part of the ecosystem services, the benefits that humans obtain from ecosystems that contribute to their (human) wellbeing (Kareiva et al., 2011; MA, 2005). Some of the ecosystem services include watershed protection, biodiversity conservation, climate regulation, carbon storage, water flow regulation, and cultural and spiritual values. Most of these ecosystem services are not directly traded or marketed, impeding the easy translation of their values through traditional market assessment techniques into the monetary systems (Kareiva et al., 2011). In this study we ignored the valuation of these additional services, that otherwise could have increased the total economic value of the forest land use by several fold to make it much higher than the total economic values expected from agricultural land uses (e.g. Yaron, 2001). Until very recently, most economic decisions did not take these ecosystem services, and their values, into account, but increasingly this aspect of natural ecosystems are getting the attention it deserves (e.g. Bishop, 1999; Campbell and Luckert, 2002; MA, 2005). Therefore, we here argue that the total economic return of the dry forest land use option in fact is much higher than we calculated and reported here, and could even exceed the sesame production option.

Our findings show that forest based land-use options including commercial NTFPs can offer a better investment opportunity than agricultural land use options, even when cash crop based. The result of the study presents an interesting paradox. If the value of NTFPs exceeds alternative land uses, one would expect that dry forests being preserved well or even frankincense tree domesticated and enriched in the landscape, which is not the case in reality. There are several reasons for this not happing. First, lack of awareness, agriculture biased policies, inappropriate forest institutions, and poor market access for the forest products are acting as an incentive for continues forest conversion. Second, the potentials of forest land uses are often overlooked by policy makers leading to their vote in favour of investments and resettlement programs that instigate cropland expansion (Lemenih et al., 2011). In this context we recommend that policy makers critically evaluate their decision making processes related to resettlement and agro-business investment programs in frankincense woodlands.

5. Conclusions

In this study we analyzed and compared net revenue generated from two crop land use options and dry forest management for NTFPs. Unlike the usual assumption that NTFPs are safety net products, the results of this study show that even without considering timber and other ecosystem services provided by the dry forests, the net revenue it generates from NTFPs can offer a competitive investment opportunity compared to agriculture in which cash crops involve. Nonetheless, deforestation of dry forests persists and this is because farmers are not supported by market development supports to make forest incomes as easily accessible as the crop incomes. The general lack of awareness among policy makers and associated institutional constraints (e.g. property rights over forests and their products) are negatively affecting an optimal economic use of dry forests for livelihoods. In general, the potentials of forest land uses are often overlooked by policy makers leading to their conversion and deforestation through investments and resettlement programs that instigate cropland expansion. Based on the results from this study, we recommend that policy makers should critically evaluate their decision making processes related to resettlement and agro-business investment programs in frankincense woodlands.

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