Trade-off between forest conservation and agricultural expansion in Gura-ferda district, Southwest Ethiopia

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A B S T R A C T

Agricultural expansion is one of the main drivers of deforestation in Ethiopia. This study was therefore carried out to examine the trade-off between forest and agricultural land uses in Guraferda district, southwest Ethiopia. Data to estimate economic values of land use were derived from the household surveys, key informant interviews, and focus group discussions. The household surveys were carried out in four purposively selected kebeles. Within the selected Kebeles, a total of 186 sample households were selected randomly. In addition, this study used Remote Sensing (RS) to detect and quantify LULC changes that occurred in the district throughout a thirty-year study period. The study employed by Excel 2013 for solving a cost –benefit analysis and ERDAS Imagine 9.1 for image processing. The finding revealed that an expansion of agriculture/settlement and shrinkage of forest and shrub land over the last thirty-year. The forest and shrub land use decreased by 0.43 and 2.42% ha year^{-1}, respectively, whereas agriculture/settlement and grassland increased by 9.1 and 0.64% ha year^{-1}, respectively over the same period. The deforestation rate is estimated at 425 ha year^{-1} in the study area. Analysis of trade-off provides estimated forgone earnings of about ETB 79,138 ETB (1665.3 USD ha^{-1}) and ETB 258,298.10 (5,435.5 USD ha^{-1}) from forest conservation and crop production, respectively assuming a 20-year planning horizon and a 10% discount rate. The 425 ha of annual deforestation entails a loss of ETB 33,633,650 (707,779 USD year^{-1}) from forest conservation and a gain of 109,776,692.5 ETB (2,310,115.5 USD) agricultural activity.

Keywords: ERDAS, Gain-Lose, Landsat imagery, Land use/land cover change, Trade - off

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Introduction

Global demand for agricultural products such as food and feed is currently a major driver of agricultural area expansion across much of the developing world. Whether these new agricultural lands replace forests, shrub land, and/or grasslands greatly influences the conservation values of expansion (Gibbs *et al.*, 2010). Trade-offs between agricultural expansion and nature conservation are usually analyzed as a matter of competing uses of ecosystem services. Ecosystems provide direct provisioning for humans, through processes of cultivation or extraction of food and fiber. The Millennium Ecosystem Assessment broadly defines ecosystem services as the benefits people

obtain from natural ecosystems (MEA, 2005). Agricultural production is a provisioning service (food) and nature conservation provides a mix of all four types of ecosystem services (provisioning, regulating, supporting, and cultural services) (Franks *et al.*, 2017). These services are mutually exclusive (Tscharntke *et al.*, 2005; Brussaard *et al.*, 2010).

In Ethiopia, agricultural expansion is the most significant economic driver of deforestation and biodiversity loss as is in most other countries in Africa. According to Ethiopia's forest reference level submission to the United Nations Framework Convention on Climate Change (UNFCCC), 53% of the deforestation in the

country is associated with conversion to agriculture and grassland (FDRE, 2016). A closer analysis of the geography of deforestation in Ethiopia shows that the highest rates of conversion of natural forests to other land use are found in the southwest of the country where there is 1.7 million ha of forest. This is mainly due to large-scale commercial agriculture over the period 2002–2012 (Franks *et al.*, 2017). In Ethiopia, between 1973 and 1999, the forest cover change reduced to about 2.36% (Reusing, 2000). The current data on forest resources of Ethiopia reported in (FAO, 2010), the forest cover decreased from 15.11million ha in 1990 to 12.2 million ha of forestland in 2010. Thus, in two decades, 2.65% of forest cover has been deforested (Moges *et al.*, 2010).

Southwestern Ethiopia was almost completely land-covered by montane rainforests at the beginning of the 19th century (Chaffey, 1979; Reusing, 1998; Reusing, 2000). In 1967 the proportion of natural forest (35%) and wooded grassland (30%) diminished to 7% and 6%, respectively, in 2001 whereas 19% of the cultivated and settlement land in 1967 increased to 75% in 2001 (Mekuria, 2005). Large areas of forest have been usual for tea, coffee, soapberry, rubber tree, black pepper, and cereal crop production investment in the region, which has resulted in a rapid decrease of forested land (Dereje, 2007; Tadesse and Woldemariam, 2007).

Economic studies have been conducted on the effect of land-use change on forest ecosystem services (Reichhuber and Requate 2012; Rojahn's, 2006; Sutcliffe, 2009; Sutcliffe, *et al.*, 2012). Studies have been conducted on trade-offs between income and tree cover when incorporating trees into food-crop based agricultural systems by comparing economic return of provisioning ecosystem services (Rahman et.al, 2016). In addition, Silva et.al (2016) estimate trade-off between forest and agriculture commodity in Amazon using a directional distance function to estimate a production possibility frontier. This study is different, selecting crop-dependent and forest-user groups separately, using GIS satellite image analysis rather than secondary data, combining economic gain of land use and image analysis to determine trade-off. Some studies focused on exploring impact of deforestation on biodiversity (Kassa *et al.*, 2017), sediment yield at southwest Ethiopia's forest frontier (Kassa *et al.*, 2019), while land use/land cover change and its drivers (Gessese, 2017). Studies investigated on the poverty reduction and tropical forest

conservation through sustainable management of non-timber forest products (Worku, 2014). The local people have developed traditional forest management practices based on customary tenure rights and religious believes managing the forests in order to meet their needs for a variety of timber and non-timber forest products for household use and their income generation (Zewdie, 2007). However, the current land use/ land cover change that has resulted in deforestation is caused by agricultural expansion in the usage of open farmlands, settlement, and investment in commercial farming (Mekuria, 2005; Dereje, 2007).

In Guraferda district, the benefits/gain derived from agriculture is in contrast to the forest provisioning ecosystem services benefits that provides to humans. This the expansion of agricultural land due to the rapidly growing domestic food demand and large-scale plantation of coffee, rubber, black pepper, and cereal crop at the expense of the natural forest (Kassa *et al.*, 2017). This implies serious trade-offs between agricultural land-use objectives (food production), which certainly leads to a negative change in forest land-use objectives (forest conservation) in the area. However, have either been less frequently studied or completely overlooked trade-offs i.e. gain from the expansion of agricultural land and loss of benefits from the forest due to agricultural expansion in a form of deforestation in Gurafeda. Therefore, the present study aims at analyzing trend of land use/land cover change and issues associated with gain from the expansion of agricultural land and loss of benefits from the forest due to agricultural expansion in a form of deforestation in Guraferda district, southwest Ethiopia.

Methodology

Description of study area

The study was conducted in Guraferda District in southwestern part of Ethiopia, in Bench Sheko administrative zone of Southern Nations, Nationalities, and Peoples' Region. Located 635 Km Southwest of Addis Ababa, the capital of Ethiopia and 42 Km away from Mizan-Teferi city (Fig. 1). Geographically, it is positioned between 6°29'5" to 7°13'20" N and 34°55'59" to 35°26'13" E. The agro-climatic zones of study area were lowland and midland, which constitute 78.25% and 21.75%, respectively. The altitude ranges from 700 to 1995 meters above sea level (Belay, 2009). The mean annual rainfall is between 1500 and 2400 mm. The average monthly temperature of the district is 29.5°C.
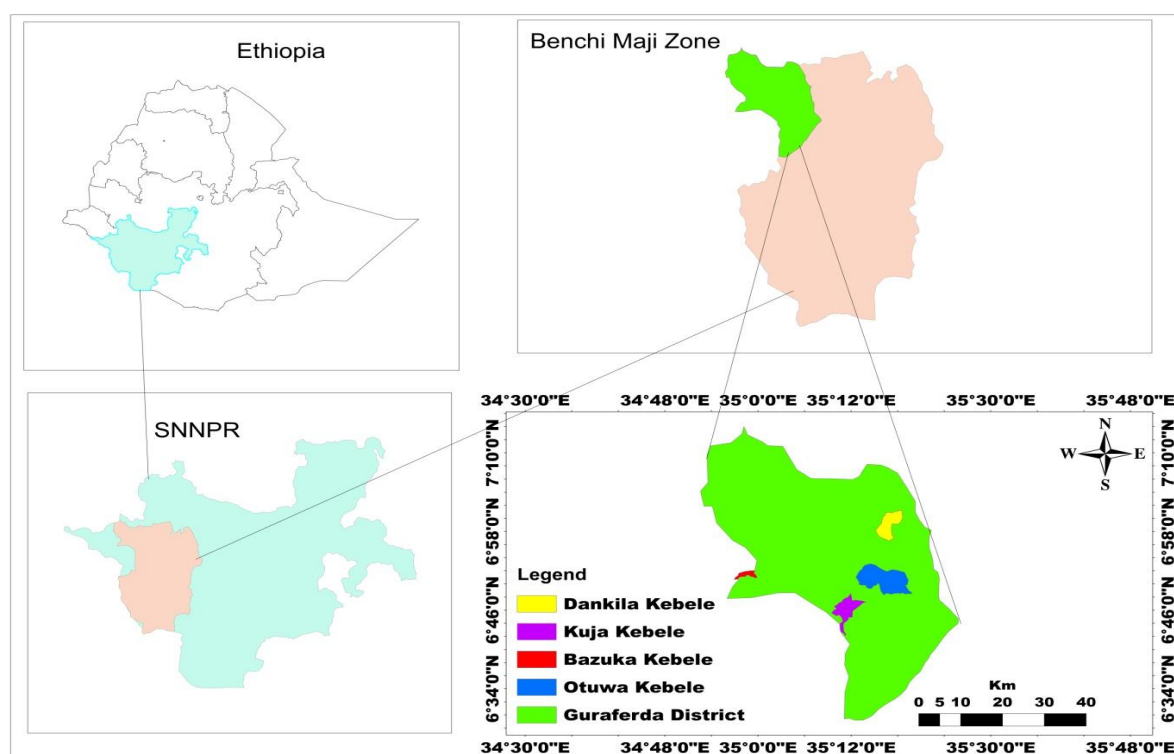
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Fig. 1. Study area map.

Sampling techniques

Guraferda district was selected purposely because of high conversion of forest to alternative land use, particularly to agriculture. Two kebeles[1] (Kuja and Otuwa) where people's livelihood dominantly depends on crop production and two kebeles (Dankila and Bazuka) where there are forest users that economically depend on forest products were selected to analyze the trade-off between land uses. A simple random sampling technique was used to select respondent households from selected kebeles. A total of 186 households was selected randomly. The total sample size was distributed to each sample kebele based on the proportion of total number of households in each selected kebeles.

Data collection

Household surveys, key informant interviews and focus group discussions

Primary data were collected from field using GPS measurement, household surveys, key informant interviews and focus group discussions. The secondary data were collected from satellite images, relevant published material (books, articles and review papers) and unpublished materials (District land administration, Forest and Environmental and agricultural offices). The survey was conducted in the agricultural dependent sites (Kuja and Otuwa) mainly on crop production and forest user groups' (Dankila and Bazuka). The widely applied guideline of the Poverty and Environment Network (PEN-CIFOR) was applied for the definition of income in the household surveys. Accordingly, household income is the return to the labour and capital owned, used in own production and income-generating activities, or sold in a market (https://www.cifor.org/publications/pdf_files/posters/6553-infographic.pdf). All price and product quantities for sold and consumed products were obtained from the respondents' individual reports. The field data collection was done from March-May 2020 using questionnaires.

Twenty key informants' interviews were conducted in all selected kebeles. In forest user the key informants who are native community in-depth interviews were carried to get clear data on existing LU/LC type, the historical trend of LU/LC, type of forest product, and changes in forest use over time. In agricultural dependent areas, detailed interviews were carried about the current land use, crop production and input used for crop production.

Four group discussions were undertaken (two forest user groups and two crop producer groups (one at each selected kebeles). They were selected purposively based on knowledge on environmental and social settings of the study area. As well as individual who have good experience in crop production and forest products were selected to discuss on specific issues related to the purpose of study by forming

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[1]The smallest administrative unit of Ethiopia similar to a ward, a neighborhood or a localized and delimited group of people.

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8-10 of participants with homogenous composition and member sharing similar background and experience on the subject in study. In forest user groups, the focus issues of discussion were the type of benefits derived from the forest, household dependence on forest, cause of forest loss, LULC type and the trend of LULC were discussed within the group. The main discussions points in agricultural dependent kebeles, were about the livelihood of agricultural dependent people, major crop type, payment of wages, inputs of production and crop productivity in the study area.

Satellite images

Secondary data of remotely sensed Landsat Thematic Mapper (TM) and Operational Land Imager (OLI) images of 1990, 2000, 2010, and 2021 have been downloaded from the United States Geological Survey (USGS) website, https://earthexplorer.usgs.gov, for analyzing and detecting the trends of land use and land cover (LULC) changes in the study area. These periods include the major political and social changes that occurred in the study area in the recent past. These are the 1990/91 collapse of the Derg regime, the major resettlement program organized by the FDRE government in 2000, and the occurrence of large-scale agricultural investments in 2010. Finally, in order to identify the current LULC changes, preferred to use image of the 2021 as a reference. To reduce the effect of cloud cover and seasonal variation, the dry season was selected to acquire satellite images so that a clear image can be obtained for the study area (Table 1).

Table 1. Descriptions of the Landsat images used for the land cover classification.

Satellite/ Sensor	Path/ Row	Acquisition date (yyyy/mm/dd)	Spatial resolution (m)
Landsat-5/ TM	170/055	1990/03/03	30
	170/056	1990/12/16	30
	171/055	1990/11/21	30
	170/055	2000/03/14	30
	171/055	2000/03/21	30
	170/055	2010/02/06	30
	171/055	2010/01/28	30
Landsat-8/ OLI	170/055	2021/03/08	30
	171/055	2021/01/10	30

Data analysis

Land use change analysis

The multi-dated Landsat images were imported into the ERDAS Imagine 9.1 software to evaluate the change between the land use and land cover. The pre-processing on the raw image was carried out which consider band selection and stacking, image mosaicking, enhancement, clipping of the imageries, image classification, and accuracy assessment were performed. The Landsat images are already corrected of the geometric and radiometric errors.

The second step is the processing. In this step, the pre-processed images were classified in to land use and land cover classes to forming thematic layers. For doing this, supervised classification technique was used to categorizing the image pixels into identified map classes, namely, agriculture/settlement, natural forest, shrubs, grass, and plantation coffee. Based on district land administrative office, key informants, and site visit, different land cover classes were identified on the ground and compared with the image data so that the image pixels are categorized accordingly.

In the third step, the post-processing steps were applied on the processed images. This involves ground truth data collection and accuracy assessment processes. A ground truth points, 41 from agriculture/settlement, 50 from forest, 48 from plantation coffee, 36 from grassland and 30 from shrub land were collected from the field using (GPS). The ground truth data were distributed randomly for each image under study. For the years 1990, 2000, and 2010, the data was interpreted on the original images of the respective years, using Google earth, and interviewing of KI during the field visit. For 2021, GPS navigation system in combination with KI was carried out to find the locations of the points within the study area and recording of the LULC types found on the locations. These reference data were then cross-tabulated with the classification maps to determine and quantify the amount of errors made during the image classification. The rate of land cover change was calculated for the four periods from 1990-2000, 2000-2010, 2010-2021 and 1990-2021 using following formula:

$$r = \frac{Q^2 - Q^1}{t}$$

Where,

r is rate of change,
Q^2 is recent year LULC in hectare
Q^1 is initial year LULC in hectare,
t is interval year between initial and recent year, respectively.

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Economic analysis

Monetary valuation methods analyze trade-offs by comparing economic gains to ecological goals as net present values based on cost-benefit valuations/analyzes (Chen *et al.*, 2016). Economics analysis is one tool for measuring the value of the trade-offs (Godsey, 2000). To estimate trade-offs between competing land uses, all direct benefits and costs were quantified across the production 2019/2020 years. To compare economic gain of land-use conversion from forest to new land use, which was estimated from crop production and household loss by means of deforestation, estimates were obtained from forest data collected by the household survey. Measuring the costs and benefits of non-extractive and preservation values is difficult (Sutcliffe, 2009). Therefore, the focus of the study was on the direct use value of forest products. Many crops and forest products are sustainably harvested every year and thus provide a stream of benefits into the future. In order to capture the total net present value of these products over a long period of time, it is necessary to discount the future net income. Therefore, 20 years period was assumed for analysis of land use with 10% discount rate. This rate was sourced from the Ministry of Finance and Economic Development (MoFED) and it has been used in other national economic valuations (WFP, 2005; Reichhuber and Requate, 2012). The NPV of land use was calculated using the following formula:

$$NPV = \sum_{t=0}^{n} \frac{B_t - C_t}{(1+r)t}$$

Where: NPV is the present value of all benefits, discounted at the appropriate discount rate, minus the present value of all costs discounted at the same rate. B_t is benefits flow at time t, C_t is costs of production at time t, t is a year, and r is the discount rate.

Results and Discussion

Land use /land cover change detection

The land use/ land cover change analysis was conducted for four periods (1990, 2000, 2010 and 2021). In the district, five major land uses/land cover classes were identified, namely: agriculture/settlement, forestland, shrub land, grazing land and plantation coffee (Table 2). Land-use/land-cover patterns in the study area have indicated a significant change between the 1990 and 2021 periods (Fig. 2). In comparison, the area of forest and shrub land showed a decreasing trend whereas agricultural land/settlement and plantation coffee has shown increasing trend, respectively. On the other hand, grassland showed a fluctuating trend between the study periods. The error matrix overall accuracy and kappa statistics were used to explain the classification accuracy. Therefore, an overall accuracy of 87.32%, 84.88%, 84.88% and 86.34% was achieved for the Landsat TM of 1990, 2000, 2010 and OLI 2021 with kappa statistics of 0.809, 0.774, 0.789 and 0.814, respectively.
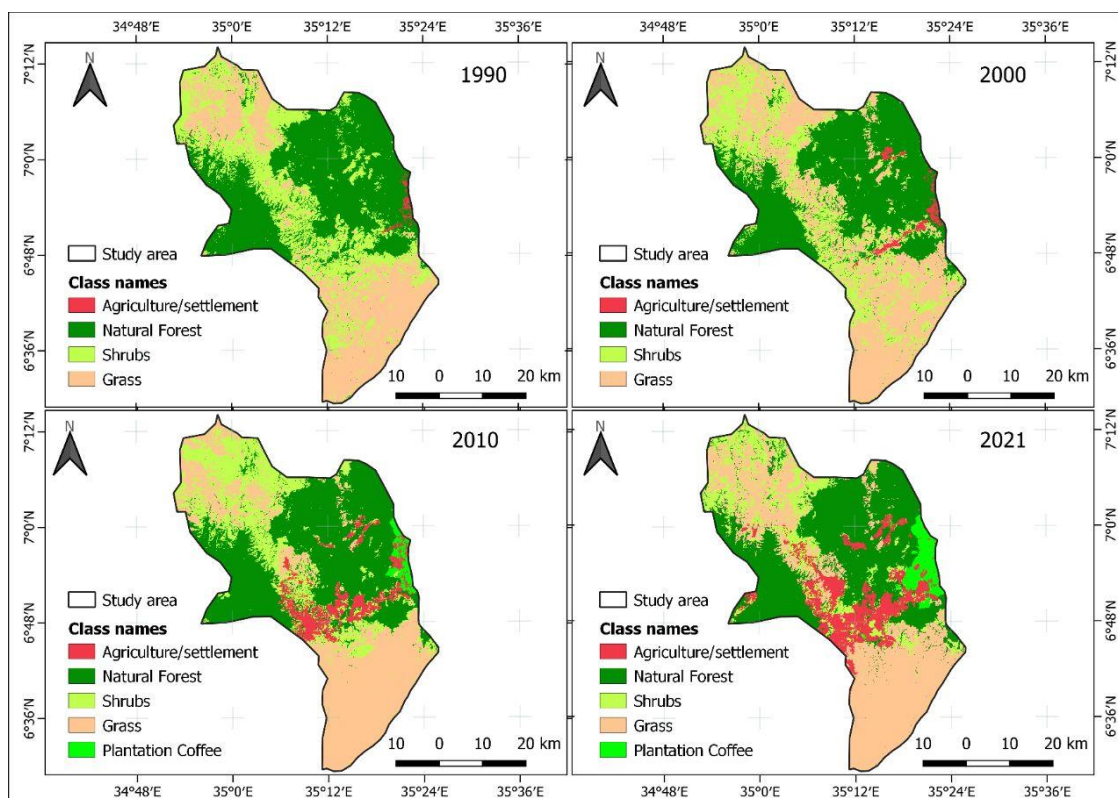

Fig. 2. Land use/cover maps of Guraferda district 1990, 2000, 2010 and 2021.

As shown in Table 3, between 1990 and 2000, there was an increment in grassland and agricultural land/settlement while forest and shrub land declined in the study area. Within this period interval, agricultural land/settlement increased at the higher rate of 229.05 ha or 8.9% per year followed by grassland 1,632 ha or 2% per year. For the same period, natural forest and shrub lands were decreasing at a rate of -448 ha or -0.44% per year and -1413 ha or-2.24% per year, respectively.

In the period between 2000 and 2010, the land under forest and shrub land show decreasing trend of 0.12% and 0.86%, respectively, while agriculture/settlement increased by 13.8%. However, grassland showed a reversed trend from the first period decreased by 1.13% per year.

Within this period, plantation coffee land use/ land cover system emerged and increased at a rate of 10% per year (Table 3).

The result for the period 2010-2021 indicated that the land under agriculture/settlement and plantation coffee increased by a high rate of 1,054.5 ha (5.1%) and 459.4 ha (7.6%), respectively followed by a slow increment rate of grassland 849.4 ha (1.0%). On the other hand, shrub land and forestland continued with a decrement, which declined by 1,675 ha (4.0%) and 757.1 ha (0.73%), respectively (Table 3). This implies that shrub land has a higher rate of decline, shrub land was originally forestland degraded to shrub land, and then people easily convert it to agriculture.

Table 2. Areas of LULC types in Guraferda district (1990-2021).

Years	1990		2000		2010		2021	
LULC Classes	Area (ha)	%	Area (ha)	%	Area (ha)	%	Area (ha)	%
Agriculture/ settlement	1590.66	0.64	3881.16	1.56	15401.07	6.18	27000.18	10.84
Forest	103693.41	41.63	99214.2	39.84	98076.24	39.38	90505.35	36.34
Shrubs	70528.14	28.32	56396.43	22.64	51750.09	20.78	33326.19	13.38
Grass	73245.33	29.41	89565.75	35.96	79965.09	32.11	89308.08	35.86
Plantation Coffee	-	-	-	-	3865.05	1.55	8917.74	3.58
Total	249057.54	100	249057.54	100	249057.54	100	249057.54	100

Table 3. Rate of land use/land cover change in Guraferda District.

LULC Classes	1990-2000		2000-2010		2010-2021		1990-2021	
	Rate (ha yr^{-1})	% yr^{-1}	Rate (ha yr^{-1})	% yr^{-1}	Rate (ha yr^{-1})	% yr^{-1}	Rate (ha yr^{-1})	% yr^{-1}
Agriculture/settlement	229.05	8.90	1,152.00	13.80	1,054.50	5.10	820.00	9.15
Forestland	-448.00	-0.44	-113.80	-0.12	-757.10	-0.73	-425.00	-0.43
Shrub land	-1413.00	-2.24	-464.60	-0.86	-1,675.00	-4.00	-1,200.00	-2.42
Grassland	1,632.00	2.00	-960.00	-1.13	849.40	1.00	518.20	0.64
Plantation Coffee	-	-	386.50	10.00	459.40	7.60	287.70	3.23

Generally the LULC image (Fig. 2) and result (Table 3) of four periods indicate both conversion and modification of LULC types. The area under forest land and shrub land declined by 425 and 1200 hectare per annual, respectively, during the period 1900−2021, whereas agriculture/settlement land and grazing land expanded by 820.0 and 518.2 hectares per annual, respectively Similarly, the newly emerged land use cover plantation coffee showed increased by 287.7 hectares per annum (Table 3). Focus group discussion and key informant conducted in the district also support this trend showing an increase in land under agriculture/settlement and coffee plantation over time at the expense of other LULC (forest, shrub, and grazing land) in the district is increasing as population, area under settlement are rising, and large scale commercial investments. The main finding in this study shows that there is a major

decline in forest cover particularly natural forests. In agreement with the finding of this research, studies conducted in central rift valley, Ethiopia, Gebreslassie (2014) and Gessese (2017) in southwest Ethiopia, documented a reduction of area under forest and shrub land and conversely increase in area under agricultural land. Rapid reduction in woodland and forest and increase in agriculture/settlement was also reported by Zeleke and Hurni (2001) in the Dembecha area of Gojjam, and Nigussie (2016) in Bale eco-region, Ethiopia. However, this funding opposing the study of Alemayehu (2015) who reported expansion of forest land between 1973 and 2015 with the corresponding reduction of cultivated land in Fagita Lekoma Woreda, Awi Zone, Northwestern Ethiopia.

Forest and agricultural land use trade-off

This section presents results of the trade-off between agricultural production and forest conservation, which consider crop production (maize, sorghum, and rice) in agriculture land use, timber and non-timber forest products in forestland use. The cost-benefit analysis was conducted based on the input used/cost and outputs produced/benefits from land-use across 2019/2020 production years were used to compare gain/loss situation (Table 4). The total revenue, cost, and profit of each land use were divided by the total land area under the cultivation of crops and forest cover to obtain per hectare economic value of land use in the study area. The annual deforestation rate was 425 hectares obtained from land-use change analysis.

The households earned different revenues from forestland use as forest provisioning services. In the study area, households gained the highest revenue from honey and forest coffee product. Estimated to be 3589 ETB (75.53 USD ha⁻¹) of annual profit the households gain from honey. The net present value per hectare of the forest of the sustainable supply of honey was ETB 30,554 (643 USD ha⁻¹) in the district using a 10% discounting rate whereas the household lost an amount of 12,985,577 ETB (273,265.5 USD year⁻¹) total annual value of honey services due to deforestation of 425 hectare of forest (Table 4 and 5). Sutcliffe (2009) who conducted a cost-benefit analysis of forest and agriculture land uses in southwest Ethiopia can compare these figures to other study. It found that 118.62 ETB (118.62 USD ha⁻¹) of annual profit from honey production and the net present value of 1,076.76 ETB (119.64 USD ha⁻¹) for honey over 20 years at a 10% discounting rate. Which is lower than the figures in this paper because of the current value of honey is high at the time of this study and the author reported that the community lost 31,135,592 ETB (655,210 USD year⁻¹) from honey production through deforestation with 28,916 hectare annual deforestation rates. Sutcliffe *et al.* (2012) revealed that the net value of honey was 960.49 ETB (64 USD ha⁻¹) of the forest after deduction 40% of total cost from total production in southwest Ethiopia. Reichhuber and Requate (2012) also reported that the annual profit from NTFP was 144.48 ETB (16.8 USD ha⁻¹) and the net present value of NTFP was 1,548 ETB (180 USD ha⁻¹). Using 10%, discounting rate over 40 years conducted in the same land uses in Sheko southwest Ethiopia.

Annually, the household was gaining 3492 ETB (73.5 USD ha⁻¹) profits from coffee inside the forest. The net present value per hectare of the forest coffee was 29,732.8 ETB (625.7 USD ha⁻¹). On another side, the local community lost 12,636,440 ETB (265,918.3 USD year⁻¹) of the total annual value from forest coffee due to 425

hectare of deforestation (Table 4 and 5). This finding was much lower than the findings of Rojahn's (2006) which reported that the net present value of forest coffee was 96,586 ETB (11,231 USD year⁻¹) at a 10% discounting rate over 24 years in southwest Ethiopia. Similarly, Reichhuber and Requate (2012) also found that the net present value of forest coffee was 105,530.6 ETB (1,250 USD ha⁻¹) at 10% discounting rate over 40 years in the montane rain forest in Ethiopia. According to focus group discussion and key informants, the reductions of income from forest coffee were the decline of forest coverage. However, the finding was significantly higher than the study of Sutcliffe (2009) which found that the net present value of forest coffee was 31.05 ETB (3.45 USD ha⁻¹) and also 897,842 ETB (99,760 USD year⁻¹) as the loss of the community from forest coffee services due to the increasing rate of deforestation in southwest Ethiopia.

The total economic value households gain from spices collected from the forest was 989 ETB (20.8 USD ha⁻¹), and giving the net present value of spices per hectare of the forest was 8,416 ETB (177 USD ha⁻¹) at a 10% discounting rate. However, with an annual deforestation rate of 425 hectare, the households' loss of 3,576,672 ETB (75,267 USD year⁻¹) benefits from the spices products (Table 4 and 5). This finding significantly is higher than a study by Sutcliffe (2009) because of the current market value of was high. They found that 6.21 ETB (0.69 USD ha⁻¹) benefit from spices whereas the net present value of spices including miscellaneous forest goods was 56.34 ETB (6.26 USD ha⁻¹) using a 10% discounting rate over 20 years, nevertheless the community was losing 1,629,127 ETB (181,015 USD year⁻¹) from the forest due to deforestation for agricultural activity in southwest Ethiopia. Rojahn's (2006) also found that a very small amount of profit from spices which is 6.02 ETB (0.7 USD ha⁻¹), providing a net present value of 13.65 ETB (1.6 USD ha⁻¹) in montane rain forest Ethiopia.

The household gained 632 ETB (13.3 USD ha⁻¹) annual net economic returns from fuel wood services. The net present value per hectare of the forest, fuel wood services was 5,377 ETB (113 USD ha⁻¹) conversely households lose 2,285,225 ETB (48,090 USD year⁻¹) from the forest because of deforestation in the study area (Table 4 and 5). The local community benefited from timber services from the forest with an annual gain of 351 ETB (3.4 USD ha⁻¹) profit from hectares of forest. The net present values per hectare of the forest of the sustainable supply of timber were 2,986 ETB (63 USD ha⁻¹) at a 10% discounting rate. With an average annual deforestation rate of 425 hectare, the households' loss is 1,268,922 ETB (26,703 USD year⁻¹) value of timber production (Table 4 and 5).

Table 4. Economic value of land use per hectare.

Land use	Revenue ha⁻¹ (ETB)	Cost ha⁻¹ (ETB)	Profit ha⁻¹ (ETB)
Forest land use			
Forest coffee	4190.9	698.5	3492.4
Honey	4306.7	717.8	3588.9
Spice	1186.2	197.7	988.5
Fuel wood	737.0	105.4	631.6
Timber	438.4	87.7	350.7
Charcoal	292.1	48.7	243.4
Total	11,151.2	1,855.7	9,295.5
Agriculture land use			
Crop production	40,958.5	10,618.9	30,339.6

The local households harvest charcoal from the forest and generate net profit 243 ETB (5.1 USD ha⁻¹). The net present values per hectare of forest of the sustainable supply of charcoal were 2,072 ETB (44 USD year⁻¹) over 20 years. The below analysis indicated that low amount of monetary losses in a year was recorded from charcoal harvesting with the value of 880,685 ETB (18,533 USD year⁻¹) (Table 4 and 5).

The total economic value of wood product (fuel wood, timber and charcoal) were 1,226 ETB (26 USD ha⁻¹) and net present value was 10,435 ETB (220 USD ha⁻¹) from the forest conservation at 10% discounting rate over 20 years. However 4,434,833 ETB (93,326 USD year⁻¹) is the total economic value loss to the households from the wood product services with 425 hectare of annual deforestation rate (Table 4 and 5). In consistent with these findings, a study conducted in southwest part of Ethiopia reported that net present value of wood product was 14,949 ETB (1,738 USD ha⁻¹) with annual profit of 6,395 ETB (744 USD ha⁻¹) at 10% discounting rate over 24 years (Rojahn's,2006). However, the finding of the study was lower than a net present value of 101,844 ETB (2,143 USD ha⁻¹) over 40 years which has 6,795 ETB (143 USD ha⁻¹) of annual profit in southwest Ethiopia (Reichhuber and Requate, 2012). This finding was also significantly lower than the figure of Sutcliffe (2009), which reported that the annual profit of wood product was 10,890 ETB (1,210 USD ha⁻¹) whereas net present values per hectare of forest of the sustainable supply of wood products were 98,874 ETB (10,986 USD ha⁻¹) at 10% discounting rate over 20 years over year. According to the author, the community lost 2,859 million ETB (USD 317.7 million year⁻¹) from wood products due to deforestation, which is a new land use in Baro-Akobo Basin in southwest Ethiopia.

Table 5. Result of net present value and annual gain-lose per hectare of land use.

	Land use							Agriculture land use
	Forest land use							
	Forest coffee	Honey	Spice	Fuel wood	Timber	Charcoal	Total	Crop production
NPV	29,732.8	30,554.3	8,415.7	5,377.0	2,985.7	2,072.2	79,138.0	258,298.1
Gain-lose	12,636,440	12,985,577.5	3,576,672.5	2,285,225	1,268,922.5	880,685	33,633,650	109,776,692.5

Generally, 9,296 ETB (196 USD ha⁻¹) total economic values gained the forest user households from sustainable forest conservation mostly, from honey and forest coffee in study area (Table 4). Using 10% discounting rate, net benefits over 20 year can be combined into a single aggregate figure or net present value forestland use were 79,138 ETB (1665.3 USD ha⁻¹). Agricultural expansions were the main drivers of forest cover changes/deforestation based on information of focus group discussion. However, the loss of total economic value to the local community because of the expansion of agriculture (425 ha year⁻¹) into the forest is 33,633,650 ETB (707,779 USD year⁻¹) (Table 5). In line with Sutcliffe (2009), a study conducted in the Baro-Akobo River Basin, southwest Ethiopia reported that the total extractive values of forest was 11,050 ETB (1,228 USD ha⁻¹), which has a net present value of 100,322 ETB (11,147 USD ha⁻¹. However, 28,916 hectare of annual deforestation rate, the forest user community loss 2,901 million ETB (USD 322 million year⁻¹) from the forest over 20 year in southwest Ethiopia. Peter (2012) also reported that 83 million Naria economic value losses from the forest due to different deforestation activities a study conducted in Enugu State, Nigeria.

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In agricultural land use, food is the main services in the study area. The most frequently occurring new land use resulting from deforestation in the district was agriculture dominated by maize, sorghum and rice crop production. The household gain the total net economic return from agricultural uses were 30,340 ETB (638 USD ha^{-1}), which has a net present value of 258,298 ETB (5,435.5 USD ha^{-1}) over 20 years at 10% discounting rate. The crop producers gain 109,776,692.5 ETB (2,310,115.5 USD year[-1]) total economic values because of agricultural expansion (425 ha year^{-1}). The net present value of agricultural activities were 3.16 times more than when compared with net present value of forest conservation land use (Table 5). This implies that land-use allocation of agricultural expansion is taking place at the expense of the loss of forest ecosystem services. Accordingly, the gain from agricultural land use is 109,776,692.5 ETB (2,310,115.5 USD) while the resulting loss from forestland use becomes 33,633,650 ETB (707,779 USD) in the district.

This finding compares with the study of Sutcliffe (2009) is higher because of higher crop yield the use of commercial fertilizers and the current value of the crop. The author reported that the annual profit from crop production was 2,008 ETB (223 USD ha^{-1}) with a net present value of 18,227 ETB (2,025 USD ha^{-1}) over 20 years at a 10% discounting rate in Baro-Akobo River Basin, southwest Ethiopia. However, the crop producer community was gaining 527,040,944 ETB (58,560,104 USD year[-1]) from 28,916 hectare of annual deforestation rate in Southwest Ethiopia. Furthermore, study of Rojahn's (2006), who conducted a cost– benefit analysis of agriculture land uses dominated by maize production result, shows that 1,013 ETB (118 USD ha^{-1}) profit from maize production in improved management which has a 30,573 ETB (3,555 ha^{-1}) net present value over 24 years at 10% discounting rate in southwest Montane rain forest Ethiopia.

Conclusion

Land use/land cover dynamics in southwest Ethiopia, Guraferda district has revealed that there was significant conversion of forest, shrub land and grassland to agricultural use. The proportional changes in area were determined for the total land use/land cover types in four different periods. The multi temporal analyses of satellite image data clearly indicated that forest and shrub land have decreased; in contrary agricultural/settlement and plantation coffee have showed a subsequent expansion in the district. Grassland shows fluctuation trends. These changes are driven by agricultural expansion strategies of the government, which support conversion of forestland to large-scale commercial agricultural, such as coffee plantation. On the other hand, changes was driven by the choices of farmers, due to low productivity of land community believe to compensate the yield reduction right solution were expanding their arable land by clearing natural vegetation.

This land use land cover change resulting trade-offs between forest conservation and agricultural land use was evaluated by using cost benefit analysis of their provisioning services. The study finding show that there is present win-lose situation between forest and agricultural land uses that the local economic value of forest provisioning services generated from the forest conservation was 79,138 ETB (1665.3 USD ha^{-1}) assuming 20 year and 10% discounting rate. However, the loss of total economic value to the local community because of the expansion of agriculture (425 ha year^{-1}) into the forest is 33,633,650 ETB (707,779 USD year[-1]). On the other hand, the economic value of crop production was estimated at ETB 258,298.10 (5,435.5 USD ha^{-1}) assuming a 20-year and 10% discounting rate and 109,776,692.5 ETB (2,310,115.5 USD year[-1]) gain from 425 hectare of annual deforestation of agricultural activity. This implies that land-use allocation of agricultural expansion is taking place at the expense of the loss of forest ecosystem services. Accordingly, the gain from agricultural land use is 109,776,692.5 ETB (2,310,115.5 USD) while the resulting loss from forestland use becomes 33,633,650 ETB (707,779 USD) in the study area. Therefore, allocation of agriculture and forestland use should optimize trade-offs between forest conservation and agriculture in order to maximize food security benefits while reducing injury to the forest ecosystem. Further research could focus on trade-off analysis of non-extractive or indirect use values and preservation values related to expansion of agriculture.

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