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The Contribution of Forests to National Income in Ethiopia and Linkages with REDD+

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Executive Summary

Main findings

- **Contribution of forests to national income in Ethiopia**: This report concludes that Ethiopian forests generated economic benefits in the form of cash and in-kind income equivalent to 111.2 billion Ethiopian Birr (ETB) (USD16.7 billion) or 12.86% of Gross Domestic Product (GDP) in 2012-13[1], considerably larger than previously thought. Of this, 6.09% of GDP is attributed to forest industries. The contribution of forest ecosystems to other sectors, particularly agriculture, is valued at 6.77% of GDP. In addition, 2.4 billion ETB was attributed to non-market benefits based on Ethiopians' willingness to pay to maintain forests.[2]

- **Important forest goods and services:** The largest market income benefits were associated with flows of wood fuel (firewood and charcoal) and livestock fodder from forests. Together, these accounted for 62% of forest use benefits (69.0 billion ETB, USD10.3 billion). Wood fuel and fodder are so valuable because their use is widespread in Ethiopia and, in the case of fodder, because agriculture is economically very important in the country. In addition, roundwood supply (11.4% of use benefits); forest coffee production (10.8%); control of cropland erosion (6%); pollination of crops by forest insects (4.5%); forest honey/beeswax production (1.5%); and collection of wild medicinal plants (1.1%) were all important sources of forest-derived income.

- **Undervaluation of the economic contribution of forests in national accounts**: All valuation methods used in this report are compatible with the System of National Accounts, which means that the valuation results can in principle be reflected in GDP. The findings suggest that current GDP estimates undervalue the contribution of the forestry sector to national income by about 38%, as official statistics show the sector's contribution to be 3.8% (Ministry of Finance and Economic Cooperation (MOFEC, 2015) whereas the assessment here estimates the contribution to be 6.09%. In addition, as mentioned, forest-derived income in terms of cash and in-kind from other sectors, particularly agriculture, are estimated to be 6.77% of GDP.

- **Options for policy making**: These findings can help strengthen the national REDD+ process in Ethiopia by, among others, permitting the Ministry of Finance and Economic Cooperation (MOFEC, the Central Statistical Agency and the Ministry of Agriculture to better understand the extent to which Ethiopia's forests underpin the economy. This could provide the basis for updating Ethiopia's System of National Accounts (ESNA) with a more accurate account of forest-derived benefits in GDP and by developing a satellite forest account. In addition, the results and recommendations could be incorporated in the REDD+ National Strategy and potentially also in Ethiopia's Growth and Transformation Plan 2 (GTP2).

[1] All major findings of this assessment are reported for the Ethiopian fiscal year 2012-13, as this is the year for which reliable estimates of all important forest ecosystem goods and services could be made.
[2] Non-market benefits are not conceptually consistent with GDP estimates. For this reason, they are reported separately here.

Project objectives

In 2014, the Government of Ethiopia requested the UN-REDD Programme to support the country in assessing the contribution of forest ecosystems to national income in the context of the national REDD+ process. The primary objective of the project was to establish the contribution of Ethiopian forests to national income[3] (GDP) by assessing the following.

- **Value added of the forestry sector**: The annual contribution of the production of forest ecosystem goods and services to GDP attributed to the forestry industry in the Ethiopian System of National Accounts (ESNA).
- **Contribution of forest ecosystems to other sectors**: The annual contribution of the production of forest ecosystem goods and services to GDP attributed to other industries in the ESNA (for example, the contribution of forest-based insect pollinators to the value added of the agriculture industry or the contribution of protected areas to the tourism industry).
- **Non-market benefits**: the annual contribution of forest ecosystems to non-market income in Ethiopia (which is conceptually beyond the scope of national accounting and therefore not included in GDP).

The contribution of forest ecosystems to national income is seen as a vital element of the case for forest conservation in Ethiopia. Prior to this study, no full assessment of the income derived from forest-derived goods and services had been undertaken in the forestry sector or other sectors. The only figure available had been the official ESNA estimate (MOFEC, 2015) of the contribution of the forestry industry to GDP (3.8% in 2012-13). By assessing the full contribution of forests to market and non-market income, a more complete picture of their economic importance emerges.

Context

With more than 90 million inhabitants, Ethiopia is the most populous nation in Eastern Africa and the second most populous in all Africa after Nigeria. Annual population growth is above 2%, meaning that Ethiopia's population could grow to 120 million people by 2030. Most people live in rural areas. Only about 17% of Ethiopians live in urban centres and nearly half of these live in the capital, Addis Ababa.

Ethiopia is a land of natural contrasts. It stretches over more than 1.1 million km^2 and has a wide variety of climate zones and soil conditions. Forests cover some 162,000 km^2 of the country's landmass, with woodland and shrubland accounting for another 492,000 km^2, according to the 2013 land cover map of Ethiopia (Ethiopian Mapping Agency, 2013) (see Figure 1 below).

The Government of Ethiopia launched a *Climate Resilient and Green Economy Strategy* (CRGE Strategy) in 2011 with the goal of achieving middle-income status for the country by 2025 while

[3] "Income" is defined here in its national accounting sense as value added associated with production activities. "Value added" and "GDP" are also used here to refer to the same income concept.

following a carbon-neutral growth path. REDD+ implementation[4] is one of the pillars of the CRGE Strategy (Federal Democratic Republic of Ethiopia, 2011).

According to the strategy, Ethiopia's greenhouse gas emissions were about 150 megatonnes CO_2 equivalent in 2010. Under a business-as-usual development strategy, these emissions are projected to more than double to 400 megatonnes CO_2 equivalent by 2030. REDD+ implementation is expected to significantly aid the country in reaching its development goals while maintaining greenhouse gas emissions at close to current levels.

The impacts of human activities on forests contribute significantly to Ethiopia's emissions. Forest-related emissions amounted to almost 55 megatonnes CO_2 equivalent in 2010, driven by deforestation for agricultural land (50% of all forestry-related emissions) and forest degradation due to firewood consumption (46%) as well as formal and informal logging (4%). These are among the main direct drivers of deforestation and forest degradation.

The CRGE Strategy recognizes that deforestation and forest degradation must be reversed if the country is to meet its development goals. Wood fuel accounts for more than 80% of household energy supply in Ethiopia and is particularly important in rural areas. Beyond wood fuel, forests provide other timber products and a host of valuable non-timber products, including livestock fodder, coffee and honey. Forests are also the source of essential ecosystem services, including carbon sequestration, crop pollination, conservation of agricultural soils and control of water discharge to streams and rivers.

Despite their economic and ecological importance, Ethiopian forests are under threat today and the country's growing population will require more wood fuel and food in the future. These demands, in turn, could significantly accelerate deforestation and forest degradation. Projections in the CRGE Strategy indicate that without action to change the country's development path, 90 thousand square kilometers (56% of total forest area) might be deforested between 2010 and 2030. Over the same period, annual wood fuel consumption could rise by 65%.

[4] REDD (Reducing Emissions from Deforestation and Forest Degradation) is a multilateral mechanism that emerged in 2008 to provide financing for developing country activities that lead to verified reductions or removals of greenhouse gas emissions resulting from deforestation and other forms of forest degradation. REDD+ is an enhanced version of the mechanism that includes sustainable management of forests, conservation and enhancement of forest carbon stocks. In 2013, the international community agreed to the details of REDD+. Under what is commonly known as the Warsaw Framework, procedures for implementation of REDD+ activities, including results-based payments are now in place.

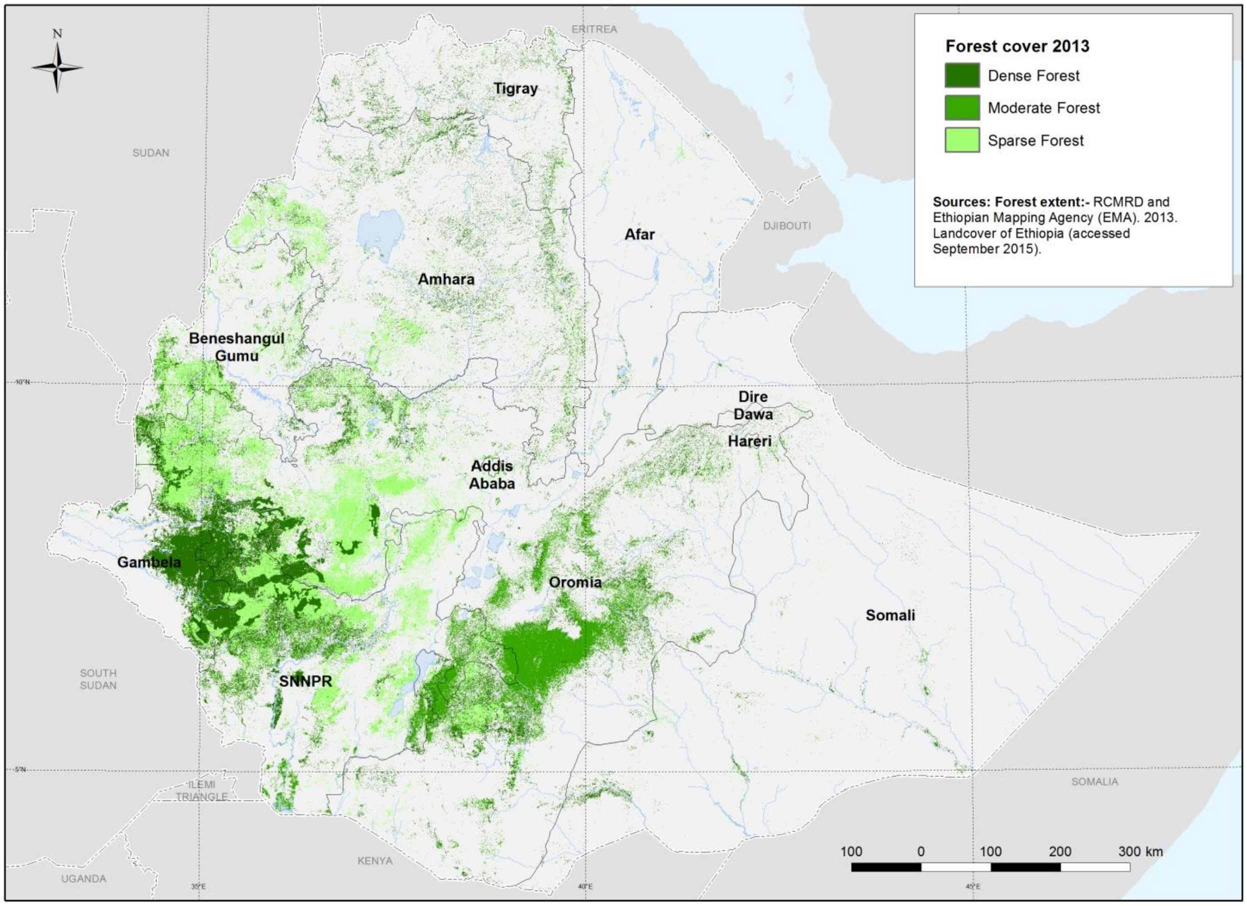

Figure 1: Forest cover of Ethiopia

To avoid these negative consequences, the CRGE Strategy prioritizes several initiatives to develop more sustainable forestry and agricultural practices.

- Intensification of agriculture through use of improved inputs and better management of crop and animal residues, resulting in a decreased requirement for additional agricultural land that would be taken primarily from forests.
- Expand agricultural activities on degraded lands through increased irrigation.
- Reduce demand for wood fuel through dissemination of more efficient wood and/or alternative-fuel stoves.
- Promote afforestation, reforestation and improved forest management activities to increase carbon sequestration in forests and woodlands.

Scope and methodology of the assessment

The assessment of forest-derived income was carried out for Ethiopia as a whole. No effort was made to compile sub-national estimates. The focus was on all forests within the country and on all important ecosystem goods and services they provide. The following forest ecosystem goods and services were assessed:

- **Provisioning goods and services**
  - Timber products
  - Firewood/charcoal
- **Regulating services**
  - Carbon sequestration
  - Pollination

- Non-timber forest products
  - Livestock fodder
  - Coffee
  - Honey
  - Beeswax
  - Medicinal plants
  - Gums and resins
  - Spices
  - Thatch
  - Wild meat
  - Wild edible plants
  - Civet musk
  - Silkworm cocoons
  - Dyes and tannins

  - Water flow control
  - Soil erosion control
  - Reservoir sedimentation control

- **Cultural and recreational services**
  - Protected-area tourism
  - Trophy hunting
  - Non-use benefits

The economic value measured in the assessment was, as noted above, the annual contribution of forest ecosystem goods and services to market and non-market income flows. No effort was made to calculate the stock value of Ethiopia's forests as natural assets. Nor was any effort made to assess the sustainability or distribution of current income flows and it is possible that some forest-derived income today is based on unsustainable or inequitable production of forest ecosystem goods and services.

The assessment was carried out mainly via desk research by an international team of research consultants. Previously existing data were used exclusively. The assessment benefited, however, from the results of a large household survey that assessed the importance of forest ecosystem goods and services to rural Ethiopian households conducted in parallel with this project (Yimer, 2016). The assessment also benefited from modelling of forest pollination and soil erosion control services undertaken by the UNEP World Conservation Monitoring Centre (UNEP-WCMC).

Ethiopian experts also contributed to the analysis through corroboration of assumptions made in the assessment. Access to experts was facilitated by the Ministry of Environment and Forests and by the national consultant responsible for the above-mentioned rural household survey (Dr. Tesfaye Yimer). Advice on the methods, data and assumptions used in the assessment was also gained during a project scoping workshop held in Addis Ababa in April 2015.

The concepts and methods used in the assessment were consistent with the established literature on ecosystem valuation and with the standards for national economic and environmental accounting set out by the United Nations in the *System of National Accounts 2008* (European Commission *et al.*, 2009), the *System of Environmental-Economic Accounting – Central Framework* (United Nations *et al.*, 2014a) and the *System of Environmental-Economic Accounting – Experimental Ecosystem Accounts* (United Nations *et al.*, 2014b).

Overall, the assessment faced no serious limitations and the results are felt to be reliable given the level of accuracy that can reasonably be expected of ecosystem valuation.

Discussion of results

Overall, the results of the assessment show that Ethiopian forests generate greater economic benefits than previously thought. Until now, the common understanding, based on measured GDP statistics, had been that about 4% of national income was attributable to forests (the exact share was estimated (MOFEC, 2015) to be 3.8% in 2012-13). The more comprehensive assessment undertaken here shows that this figure is about 12.9% (not counting the non-market benefits associated with forest preservation). The gap between these two figures is explained by several factors.

- **Attribution of forest-derived income to non-forest industries in GDP**. Forests provide benefits to economic activities that appear in the national accounts as income in non-forest industries. In particular, forests are the source of major income flows that are attributed in GDP to the agriculture industry. The fodder that livestock farmers obtain freely by allowing their animals to graze on forest land is particularly important in this regard. Since animal feed is the only major intermediate input into livestock rearing and this input is obtained free of charge by many Ethiopian farmers, the value added of the livestock agriculture industry is considerably larger than it would be in the absence of forest-derived fodder.[5] The value added of forest-derived fodder estimated here for 2012-13 (29.9 billion ETB; USD4.5 billion) equates to 36% of the value added of livestock agriculture as reported by the Ethiopian Ministry of Finance and Economic Development (MOFEC, 2015). Other important income flows found in this assessment to be attributed to non-forest industries are:
    - the value added of forest soil erosion control (6.6 billion ETB; USD996 million; attributable to crop agriculture)
    - the value added of forest pollination services (5 billion ETB; USD752 million; attributable to crop agriculture), and
    - protected area tourism (850 million ETB; USD127 million; attributed to hotels and restaurants, travel and communications and public administration).

- **Underestimation of forest-derived benefits in GDP** – A considerable portion of forest income benefits are in-kind benefits associated with the subsistence use of forest goods and services. The value added of wood fuel production, for example, provides very large in-kind income benefits because many households collect wood fuel themselves rather than purchasing it in the market. MOFEC's estimate of the value added of wood fuel in 2013-13 is 25.5 billion ETB (USD3.82 billion) compared with an estimate of 39.1 billion ETB (USD5.9 billion) here. The majority of this difference is due to the exclusion of in-kind income from subsistence use of fuel wood in MOFEC's estimate.

  In other instances, MOFEC's figures understate forest income because they are unable to include estimates for production that takes place outside of the observed economy (for example, illegal harvesting of wood). This is particularly the case with roundwood production, where MOFEC estimates value added in 2012-13 to have been 4.1 billion ETB (USD615 million) compared to 12.7 billion ETB (USD1.9 billion) here. A substantial (but unmeasurable) portion of this difference is due to the inclusion of an estimate of illegal production (the remainder is due to underestimation of in-kind household income benefits from roundwood production).

- **Gaps in GDP** – In a few cases, the income flows associated with forests goods and services are not captured at all in GDP as currently measured. However, none of these is economically important.

[5] If livestock farmers had to pay crop farmers for fodder, it would be considered an intermediate input to livestock farming and its cost would be deducted from the value added of livestock agriculture. The value added of crop agriculture would be higher in this instance.

Figure 2 below summarizes the findings of the assessment in terms of the contribution of forests to various types of income in 2012-13. The blue bar on the left represents the contribution of forests to national income attributed to the forest industry, estimated here to be 6.09% of measured GDP (52.8 billion ETB; USD 7.9 billion). Of this, about 27% is estimated to have been cash income to producers in the forest sector (including households that produce forest products such as fuel wood). The remaining 73% is in-kind income to households that produce and consume their own forest products.

The dotted bar on the left represents the official MOFEC (2015) figure for the value added of the forestry sector of 3.8% of GDP (30.4 billion ETB; USD4.6 billion), which is presented here for comparison's sake. As can be seen, the results of the assessment undertaken here suggest that MOFEC's estimate is considerably too low. The reasons for this are discussed further below.

The red bar in the middle represents the income associated with production of forest ecosystem goods and services but attributed in the ESNA to non-forest industries, the vast majority of which is income associated with the agriculture industry. This income is estimated here to equal 6.77% of measured GDP. It includes income that is measured directly in GDP (such as the value of forest coffee production, which is part of measured value added of the crop agriculture industry) and that measured implicitly in GDP (such as the value of forest-derived fodder production and crop pollination services). Most of the income represented by the red bar is already included (explicitly or implicitly) in MOFEC's official estimate of GDP, though the results of the assessment undertaken here suggest that MOFEC's estimates of the value added of medicinal plant and thatch production are too low. In addition, MOFEC makes no estimate at all for the value added of wild spice, meat or plant production.

The sum of the blue plus red bars represents the total estimated value added of forest-ecosystem goods and services production. In 2012-13, this production is estimated to have contributed 111.2 billion ETB (USD 16.7 billion), or 12.86% of measured GDP, to the Ethiopian economy.

The green bar on the right represents the non-market income benefits associated with Ethiopian's willingness to pay to preserve the nation's forests. The green bar is not directly comparable with GDP due to conceptual differences and therefore is presented separately.

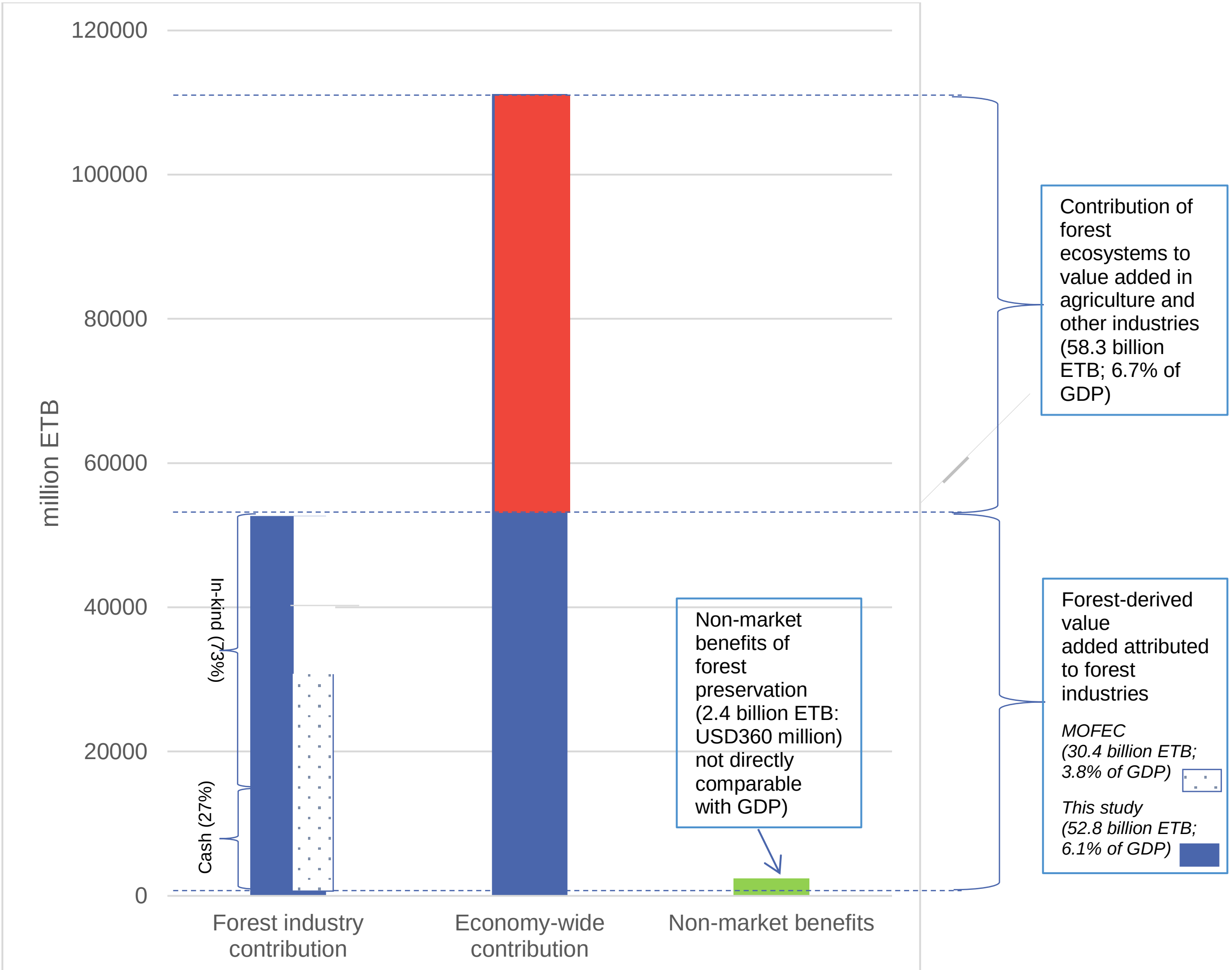

Figure 2: Summary of forest contributions to the national economy, 2012-13

The overall results of the assessment are summarized in Table 1 below.

Table 1: Summary of results

Good/service	Contribution to national income, 2012-13			Currently measured in Ethiopian SNA?				Income type			
				Yes		No		Direct		Indirect	Non-market
	million ETB	million USD	Share	Directly	Implicitly	Data gap	Out of scope	Cash share	In-kind share		
1. Provisioning goods and services											
1.1. Timber forest products											
1.1.1. **Wood fuel**	39,078	5,858	4.52%	Forestry				18%	82%		
1.1.2. **Roundwood**	12,700	1,904	1.47%	Forestry				53%	47%		
1.1.3. **Bamboo**	172	26	0.02%	Forestry				15%	85%		
Total, timber forest products	51,950	7,788	6.01%								
1.2. Non-timber forest products											
1.2.1. **Livestock fodder**	29,900	4,482	3.46%		Livestock agriculture					X	
1.2.2. **Coffee**	12,060	1,808	1.39%	Crop agriculture				99%	1%		
1.2.3. **Honey**	1,400	210	0.16%	Livestock agriculture				77%	23%		
1.2.4. **Beeswax**	191	29	0.02%	Livestock agriculture				100%	0%		
1.2.5. **Medicinal plants**	1,230	184	0.14%	Crop agriculture				44%	56%		
1.2.6. **Gums and resins**	175	26	0.02%	Forestry				91%	9%		
1.2.7. **Spices**	310	46	0.04%	Crop agriculture				56%	44%		
1.2.8. **Thatch**	706	106	0.08%	Forestry				12%	88%		
1.2.9. **Wild meat**	461	69	0.05%			X		9%	91%		
1.2.10. **Wild edible plants**	257	39	0.03%			X		22%	78%		
1.2.11. **Civet musk**	0.4	0	<0.01%			X		100%	0%		
1.2.12. **Silkworm cocoons**	0.5	0	<0.01%	Livestock agriculture				n/a	n/a		
1.2.13. **Dyes and tannins**	n/a	n/a	n/a			X		n/a	n/a		
Total, non-timber forest products	46,691	7,000	5.40%								

Total, provisioning goods and services	***98,641***	14,788	11.41%								
2. Regulating services											
2.1. **Carbon sequestration**	2.8	0	<0.01%			X		100%	0%		
2.2. **Pollination**	5,013	752	0.58%		Crop agriculture					X	
2.3. **Water flow control**	n/a	n/a	n/a		Crop agriculture, electricity and water					X	
2.4. **Soil erosion control**	6,647	996	0.77%		Crop agriculture					X	
2.5. **Reservoir sedimentation control**	n/a	n/a	n/a		Crop agriculture, electricity and water					X	
Total, regulating services	***11,663***	***1,748***	***1.35%***								
3. Cultural and recreational services											
3.1. **Protected-area tourism**	850	127	0.10%		Hotel and restaurant, travel and communication, public administration			100%	0%		
3.2. **Trophy hunting**	19	3	<0.01%		Hotel and restaurant, travel and communication, public administration			100%	0%		
Total, cultural and recreational services	***869***	***130***	***0.10%***								
Grand total, forest-derived goods and services	***111,173***	***16,666***	***12.86%***								
Non-use forest benefits*	*2,400*	*360*	*n/a*				*X*				*X*

*Non-use benefits are not included in the total because they are conceptually inconsistent with the other values reported. Non-use benefits were measured using the results of willingness-to-pay surveys that result in the inclusion of consumer surplus in the estimate. All other values were measured on the basis of market prices, which exclude consumer surplus.

The results of the assessment show that, of the goods and services considered here, the provision of forest-derived products made the greatest contribution to national income in 2012-13. The most important forest product was wood fuel (39.1 billion ETB; USD5.9 billion; 4.5% of GDP), followed very closely by livestock fodder (29.9 billion ETB; USD4.5 billion; 3.5% of GDP). The importance of these products results from their widespread use in the economy and, in the case of fodder, the importance of agriculture as a component of GDP. The income associated with fodder is not currently measured directly in GDP, though it is implicitly included as part of the value added of the livestock agriculture industry. The value of wood fuel production, on the other hand, is directly measured as part of GDP, though the findings here suggest that it is substantially undervalued due to an incomplete accounting of subsistence use by households in the GDP estimate prepared by MOFEC. MOFEC estimates the value added of wood fuel production in 2012-13 to have been 25.5 billion ETB, or 65% of the value estimated in this study.

Following fodder and wood fuel, roundwood production made the next most important contribution to income (12.7 billion ETB; USD1.9 billion; 1.5% of GDP). Roundwood is used by households to meet needs for construction materials, tools and furniture. It also serves as a raw material for the production of processed wood products like sawn lumber and plywood. About half of the income derived from roundwood is in-kind income resulting from subsistence use by households. A sizeable (but unmeasurable) share of this income is the result of illegal and/or unreported harvesting of roundwood. As with wood fuel, the findings here suggest that MOFEC's estimates of roundwood value added are too low due to incomplete accounting for illegal/unreported roundwood production and household subsistence use of it. MOFEC estimates the value added of roundwood production in 2012-13 to have been 4.1 billion ETB, or 31% of the value estimated in this study.

The next most important forest-derived product is coffee, which is estimated here to have generated 12 billion ETB of income in 2012-13 (USD1.8 billion; 1.4% of GDP). Nearly all coffee income is cash income to the farmers that produce it; just 1% is in-kind income associated with subsistence consumption of coffee. Coffee is directly measured in GDP, though no estimate is produced by MOFEC specifically for forest-derived coffee.[6] Rather, it estimates the value added of coffee in general (forest-derived plus non-forest) and reports this as part of the value added of "stimulants". Though it is not possible to compare the estimate of forest-derived coffee value added with any of MOFEC's published figures, none of the results of this assessment suggest that MOFEC's estimates of coffee value added fail to capture forest-derived income.

Of the remaining forest products considered in this assessment, honey/beeswax, wild medicinal plants and thatch for roofing on traditional houses are the most important. Together, they accounted for about 3.5 billion ETB in income in 2012-13 (USD530 million; 0.4% of GDP). When compared with MOFEC's estimates, forest-derived honey appears to be fully captured in GDP as currently measured. Thatch appears to be somewhat undervalued in GDP currently and wild medicinal plants appear to be significantly undervalued in MOFEC's estimate. It is worth noting that none of these products contributes significantly to national income overall, so any errors in their estimation in the ESNA will not have major consequences for the size of measured GDP or its growth rate.

[6] Though the majority of coffee produced in Ethiopia is considered forest-derived, some coffee plantations exist outside of forested areas.

The remaining forest-derived products (gums and resins, spices, wild meat and edible plants, civet musk, silkworm cocoons, and dyes and tannins) are all estimated to make small contributions to national income. Combined, they are found here to have generated about 1.2 billion ETB in income in 2012-13 (USD174 million; 0.1% of GDP). Except in the case of gums and resins (which are mostly sold for cash income), these products result mainly in in-kind income from subsistence use by households.

After forest products, forest regulating services made the next largest contribution to national income. The control of soil erosion on cropland (6.6 billion ETB; USD996 million; 0.8% of GDP) and pollination of agricultural crops by forest insects (5 billion ETB; USD752 million; 0.6% of GDP) both made significant contributions. Neither the value of the forest water-flow control service nor the value of sedimentation control in reservoirs could be estimated based on available data. MOFEC does not estimate the value of any of these services directly in GDP, though their values are implicitly included in the value added of the agriculture and utility industries that use them.

Cultural and recreational services are estimated to have made the smallest contribution overall to national income. Tourism to Ethiopia's protected areas is estimated to have generated 850 million ETB in 2012-13 (USD127 million; 0.1% of GDP), all of which is cash income flowing to the hotel and restaurant, travel and communications, and public administration industries. The contribution of Ethiopia's small trophy hunting industry is found to be negligible.

In addition to these recreational benefits, the value of preserving Ethiopia's forests as a source of well-being for its citizens is found to have benefits equivalent to 2.4 billion ETB (USD360 million). This benefit is not conceptually coherent with GDP and therefore is treated as a separate category here.

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List of Acronyms

CO_2	Carbon Dioxide
CDM	Clean Development Mechanism
CRGE	Climate Resilience and Green Economy (Strategy)
CSA	Central Statistical Agency (of Ethiopia)
EEPCo	Ethiopian Electric Power Corporation
EMA	Ethiopian Mapping Agency
ESNA	Ethiopian System of National Accounts
ETB	Ethiopian birr
EWCA	Ethiopian Wildlife Conservation Authority
FAO	UN Food and Agriculture Organisation
FSR	Forest Sector Review
GDP	Gross Domestic Product
GTP2	Growth and Transformation Plan 2
ITC	International Trade Centre
ICO	International Coffee Organization
MEFCC	Ministry of the Environment, Forest and Climate Change of Ethiopia
MOFEC	Ministry of Finance and Economic Cooperation of Ethiopia
NGPME	Natural Gum Processing and Marketing Enterprise
NTFP	Non-Timber Forest Products
REDD+	Reducing emissions from deforestation and forest degradation and the role of sustainable management of forests, conservation and enhancement of forest carbon stocks
SNA	System of National Accounts
SNNPR	Southern Nations, Nationalities, and People's Region
SPAM	Spatial Production Allocation Model
UN	United Nations
UNDP	UN Development Programme
UNEP	UN Environment Programme
UN-REDD	United Nations collaborative initiative on Reducing Emissions from Deforestation and forest Degradation (REDD) in developing countries
WBISPP	Wood Biomass Initiative and Strategic Planning Project (World Bank)
UNEP WCMC	UNEP World Conservation Monitoring Centre
USD	United States Dollars

1 Introduction

1.1 Context

With more than 90 million inhabitants, Ethiopia is the most populous nation in Eastern Africa and the second most populous in Africa after Nigeria. Annual population growth is above 2%, meaning that Ethiopia's population could grow to 120 million people by 2030. Most people live in rural areas. Only about 17% of Ethiopians live in urban centres and nearly half of these live in the capital, Addis Ababa.

Ethiopia is a land of natural contrasts. It stretches over more than 1.1 million km^2 and has a wide variety of climate zones and soil conditions. Forests cover some 162,000 km^2 of the country's landmass, with woodland and shrubland accounting for another 492,000 km^2, according to the 2013 land cover map of Ethiopia (Ethiopian Mapping Agency, 2013). See Figure 3, Annex 1 – Definition of forest in Ethiopian land cover mapping, and Section 1.4 for further details on forestland area.

The Government of Ethiopia launched a *Climate Resilient and Green Economy Strategy* (CRGE Strategy) in 2011 with the goal of achieving middle-income status for the country by 2025 while following a carbon-neutral growth path. REDD+ implementation[7] is one of the pillars of the CRGE Strategy (Federal Democratic Republic of Ethiopia, 2011).

According to the strategy, Ethiopia's greenhouse gas emissions were about 150 megatonnes CO_2 equivalent in 2010. Under a business-as-usual development strategy, these emissions are projected to more than double to 400 megatonnes CO_2 equivalent by 2030. REDD+ implementation is expected to significantly aid the country in reaching its development goals while maintaining greenhouse gas emissions at close to current levels.

The impacts of human activities on forests contribute significantly to Ethiopia's emissions. Forest-related emissions amounted to almost 55 megatonnes CO_2 equivalent in 2010, driven by deforestation for agricultural land (50% of all forestry-related emissions) and forest degradation due to firewood consumption (46%) as well as formal and informal logging (4%). These are among the main direct drivers of deforestation and forest degradation.

The CRGE Strategy recognizes that deforestation and forest degradation must be reversed if the country is to meet its development goals. Wood fuel accounts for more than 80% of household energy supply in Ethiopia and is particularly important in rural areas. Beyond wood fuel, forests provide other timber products and a host of valuable non-timber products, including livestock fodder, coffee and honey. Forests are also the source of essential ecosystem services, including carbon sequestration, crop pollination, conservation of agricultural soils and control of water discharge to streams and rivers.

Despite their economic and ecological importance, Ethiopian forests are already under threat today and the country's growing population will require more wood fuel and food in the future. These demands, in turn, could significantly accelerate deforestation and forest degradation.

[7] REDD is a multi-lateral mechanism that emerged in 2008 to provide financing for developing country activities that lead to verified reductions or removals of greenhouse gas emissions resulting from deforestation and other forms of forest degradation. REDD+ is an enhanced version of the mechanism that focuses on the roles of conservation and sustainable management of forests, forest restoration and reforestation in reducing emissions. In 2013, the international community agreed to the details of REDD+. Under what is commonly known as the Warsaw Framework, procedures for implementation of REDD+ activities, including results-based payments are now in place.

Projections in the CRGE Strategy indicate that without action to change the country's development path, 90 thousand km^2 (56% of total forest area) might be deforested between 2010 and 2030. Over the same period, annual wood fuel consumption could rise by 65%.

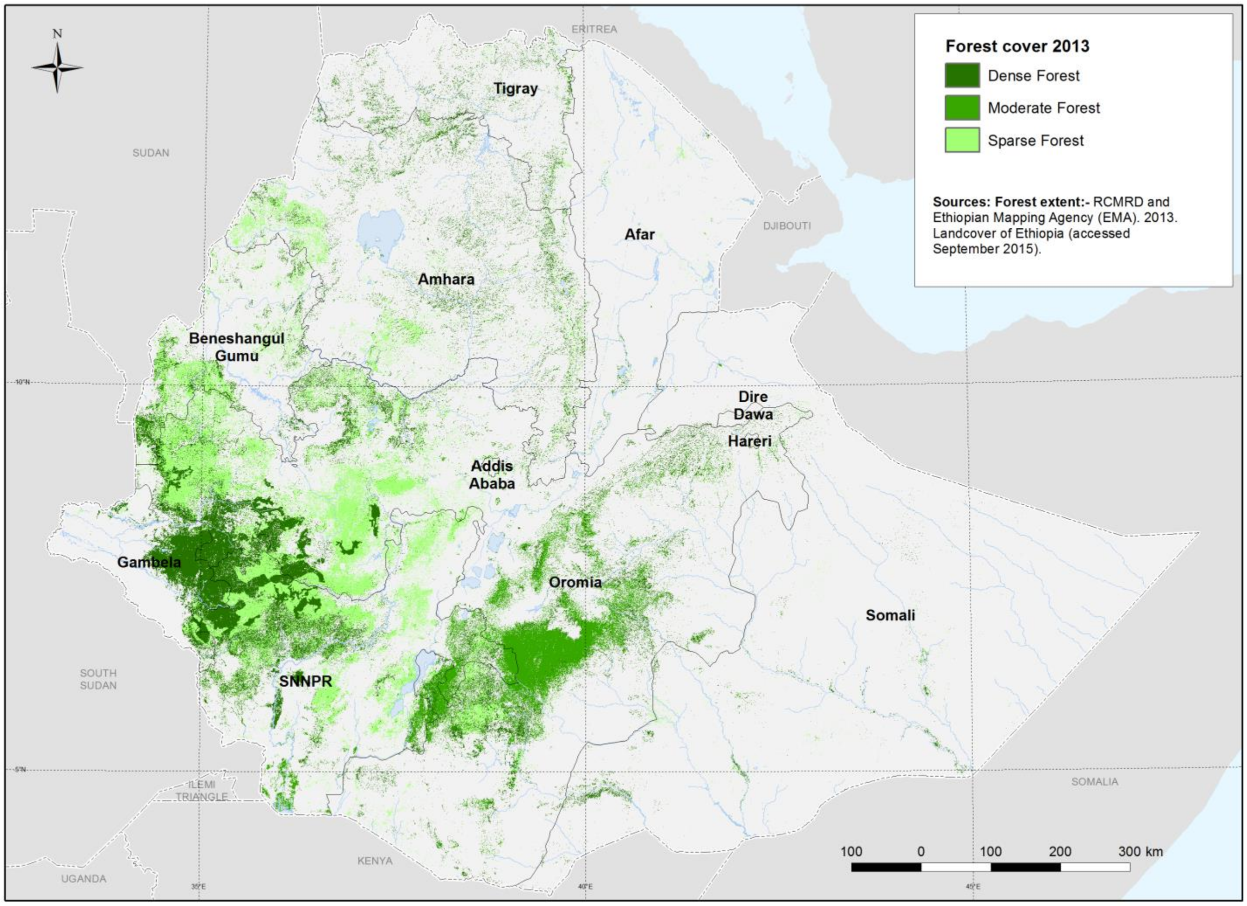

Figure 3: Forest areas of Ethiopia

To avoid these negative consequences, the CRGE Strategy prioritizes several initiatives to develop more sustainable forestry and agricultural practices.

- Intensification of agriculture through use of improved inputs and better management of crop and animal residues, resulting in a decreased requirement for additional agricultural land that would be taken primarily from forests.
- Expand agricultural activities on degraded lands through increased irrigation.
- Reduce demand for wood fuel through dissemination of more efficient wood and/or alternative-fuel stoves.
- Promote afforestation, reforestation and improved forest management activities to increase carbon sequestration in forests and woodlands.

1.2 Project background and objectives

In 2014, the Government of Ethiopia requested the UN-REDD Programme to support the country in assessing the contribution of forest ecosystems to national income[8] (GDP) in the context of the national REDD+ process. The primary objective of the project was to establish the contribution of Ethiopian forests to national income by assessing the following.

- **Value added of the forestry sector**: The annual contribution of the production of forest ecosystem goods and services to the national income attributed to the forestry industry in the Ethiopian System of National Accounts (ESNA).
- **Contribution of forest ecosystems to other sectors**: The annual contribution of the production of forest ecosystem goods and services to the national income attributed to other industries in the ESNA (for example, the contribution of forest-based insect pollinators to the value added of the agriculture industry or the contribution of protected areas to the tourism industry).
- **Non-market benefits**: the annual contribution of forest ecosystems to non-market income in Ethiopia (which is conceptually out of scope in national accounting and therefore not included in GDP).

The contribution of forest ecosystems to national income is seen as a vital element of the case for forest conservation in Ethiopia. Prior to this study, no full assessment of the income derived from forest-derived goods and services had been undertaken in the forestry sector or other sectors. The only figure available had been the official ESNA estimate (MOFEC, 2015) of the contribution of the forestry industry to GDP (3.8% in 2012-13). By assessing the full contribution of forests to market and non-market income, a more complete picture of their economic importance emerges.

Beyond this primary objective, the project also set out to:

- establish a methodology for the economic valuation of forests that could be adopted in future studies in Ethiopia and elsewhere, and
- train Ethiopian experts in this methodology.

The project was undertaken under the supervision of UNEP's REDD+ Green Economy Advisor in collaboration with the UNDP National Climate Change Specialist and UNEP Liaison Office in Ethiopia and the Ethiopian Ministry of Environment and Forests.

The results of the project are to feed into the development of the Ethiopian national REDD+ strategy and inform the government's on-going development planning.

1.3 Scope and methodology of the assessment

The assessment of forest-derived income was carried out for Ethiopia as a whole. No effort was made to compile sub-national estimates. The focus was on all forests within the country and on all important ecosystem goods and services they provide. The following forest ecosystem goods and services were assessed:

[8] "Income" is defined here in its national accounting sense as value added associated with production activities. "Value added" and "GDP" are also used here to refer to the same income concept.

- **Provisioning goods and services**
  - Timber products
  - Firewood/charcoal
  - Non-timber forest products
    - Livestock fodder
    - Coffee
    - Honey
    - Beeswax
    - Medicinal plants
    - Gums and resins
    - Spices
    - Thatch
    - Wild meat
    - Wild edible plants
    - Civet musk
    - Silkworm cocoons
    - Dyes and tannins
- **Regulating services**
  - Carbon sequestration
  - Pollination
  - Water flow control
  - Soil erosion control
  - Reservoir sedimentation control
- **Cultural and recreational services**
  - Protected-area tourism
  - Trophy hunting
  - Non-use benefits

The economic value measured in the assessment was, as noted above, the annual contribution of forest ecosystem goods and services to market and non-market income flows. No effort was made to calculate the stock value of Ethiopia's forests as natural assets. Nor was any effort made to assess the sustainability or distribution of current income flows and it is possible that some forest-derived income today is based on unsustainable or inequitable production of forest ecosystem goods and services.

The assessment was carried out mainly *via* desk research by staff of Midsummer Analytics in Ottawa, Canada. Previously existing data were used exclusively; no primary data collection was undertaken. The assessment benefited, however, from the results of a survey of the importance of forest ecosystem goods and services to rural Ethiopian households conducted concurrently with this project (Yimer, 2016). The assessment also benefited from modelling of forest pollination and soil erosion control services undertaken by the UNEP World Conservation Monitoring Centre (UNEP-WCMC).

Ethiopian experts also contributed to the analysis through corroboration of assumptions made in the assessment. Access to experts was facilitated by the Ministry of Environment and Forests and by the national consultant responsible for the above-mentioned rural household survey (Dr. Tesfaye Yimer). Advice on the methods, data and assumptions used in the assessment was also gained during a project scoping workshop held in Addis Ababa in April 2015.

The concepts and methods used in the assessment were consistent with the established literature on ecosystem valuation and with the standards for national economic and environmental accounting set out by the United Nations in the *System of National Accounts 2008* (European Commission *et al.*, 2009), the *System of Environmental-Economic Accounting – Central Framework* (United Nations *et al.*, 2014a) and the *System of Environmental-Economic Accounting – Experimental Ecosystem Accounts* (United Nations *et al.*, 2014b).

1.4 Limitations of the assessment

Overall, the assessment faced no serious limitations other than data gaps in some areas (see "Data availability and relevance" below). Where it was possible to estimate the value of forest-derived income, the results are felt to be reliable given the level of accuracy that can reasonably be expected of ecosystem valuation in the context of limited data availability.

The main limiting factors faced were related to data quality[9]; in particular:

- **availability and relevance**: the degree to which required data were available and met the needs of the study
- **accuracy**: the degree to which the data correctly described the phenomena they were intended to measure
- **accessibility**: the ease with which the data could be accessed
- **interpretability:** the availability of supplementary information and metadata needed to interpret and properly utilize the data, and
- **coherence**: the ease with which data from various sources could be combined.

Data availability and relevance

The absence of data specific to Ethiopia for some variables necessitated the adaptation of data collected elsewhere to make them relevant to the Ethiopian context. The main need was the conversion of data measured in other currencies (usually U.S. dollars) to Ethiopian currency. Except in the case of actual foreign payments to Ethiopia (for example, payments for purchases of carbon emission reduction credits), currency conversion was done using purchasing power parity adjusted exchange rates obtained from the World Bank. For details of the exchange rates applied, see Annex 2 – Inflation and currency conversion rates used.

Some out-of-date data were used in the assessment due to lack of more recent figures. In cases of monetary data, old figures were brought up to date by adjusting for inflation as measured by the Ethiopian Central Statistical Agency (CSA). In cases of biophysical data, these were simply assumed to be relevant to the current time period. In no case was data from earlier than the year 2000 used in the assessment.

Some data required for the assessment were not available at all. The most significant instances of this were with respect to the role of forests in regulating water flows and controlling the sedimentation of water reservoirs. These services are highly context specific and available data for Ethiopia were not sufficiently detailed to permit their valuation.

It was also not possible to estimate the value of natural dyes and tannins with existing data. The income associated with production of these non-timber forest products is likely very small, so its absence is assumed not to materially impact the results.

It is worth noting that several more important non-timber forest products (in particular, livestock fodder but also wild edible plants, wild meat and thatch) could not have been valued if not for the results of the above-mentioned survey of rural households (Yimer, 2016). Livestock fodder turned out to the be the non-timber forest product with the greatest value, so its exclusion from the results would have significantly impacted their quality.

Data accuracy

Many of the data used in the assessment were derived from secondary sources such as consultants, academic researchers and non-governmental organizations. The accuracy of such data is difficult to assess but it is assumed that secondary data are, in general, less accurate than data from the Ethiopian CSA and other primary data collectors. To deal with possible

[9] These are standard attributes of data quality in the domain of official statistics (Statistics Canada, 2003).

inaccuracies introduced by reliance on secondary data, the assessment results have been presented in most cases only to the nearest million Ethiopian birr (ETB). Precision beyond this was not felt to be justified.[10]

The Spatial Production Allocation Model (SPAM) spatial data on area of cropland by crop type used by UNEP-WCMC for the analysis of the forest pollination service had a resolution of only 10 km (MAPSPAM, no date). Though not highly detailed, these data offer "a robust database with crop production data for more crops and smaller administrative units than any single global collection of subnational production data currently available (MAPSPAM, no date)".

The Ethiopian Mapping Agency (2013) land cover data used by UNEP-WCMC is an interim version that requires further refinement. Nevertheless, they were the best available data available for use at the time of the analysis.

Data accessibility

For the most part, the data required for the assessment were readily accessible *via* the Internet. In some cases, however, special requests to Ethiopian experts and institutions were necessary. These requests were successful in all cases except a request to the Ethiopian Wildlife Conservation Authority for updated data on trophy hunting. This was addressed by using older data adjusted for inflation and assumed growth in the number of trophy hunters visiting the country.

Some difficulties were encountered in obtaining up-to-date and detailed spatial data required for the project. This led to, for example, the need to make use of a draft version of the Ethiopian Mapping Agency (2013) land use cover dataset that was still undergoing refinement.

Data interpretability

Like accuracy, interpretability is a challenge associated with reliance on secondary data sources. As a rule, secondary sources include few metadata, leaving users with only limited information on which to base an understanding of the data they are using. It is possible, therefore, that some data derived from secondary sources for this assessment were not perfectly suited to the use they were put to. The impact of this was limited to the extent possible by restricting use of secondary data to those from credible sources: peer-reviewed literature, multi-lateral organizations, and recognized international and Ethiopian non-governmental organizations.

Data coherence

The main issue with respect to coherence was the availability of several somewhat conflicting sources of forest cover data. Each source arrives at a different value for the area of forestland and for wooded land overall.

A commonly cited source is the World Bank's *Woody Biomass Inventory and Strategic Planning Project* (WBISPP, 2005a). More recent sources are the *Ethiopian Forest Resource Assessment* of the UN Food and Agriculture Organisation (FAO, 2010) and an Ethiopian forest sector review carried out for the World Bank in 2013 (UNIQUE Forestry and Land Use and Conscientia, 2015). In addition to these, UNEP-WCMC carried out analysis for this project using the most recent Ethiopian land cover data available from the Ethiopian Mapping Agency (2013). The estimates from these various sources are summarized in Table 2: .

[10] This level of precision is typical in studies of national income. Statistics Canada, recognized as the one of the best statistical agencies in the world, only measures value added by industry to the nearest million Canadian dollars.

Much of the variability in the estimates is accounted for by differences in the definition of forest. The age of the data used is another reason for the variation, as Ethiopia's forests are rapidly evolving due to human pressures. The WBISPP and the 2013 World Bank review both used restrictive forest definitions, placing much more land area in the "woodland" category and less in "forestland". FAO and the Ethiopian Mapping Agency (EMA) used more inclusive definitions that resulted in higher estimates of forestland and, in the case of the EMA data, the highest area of wooded land overall.

The decision was made to adopt the EMA estimates for this project because they are the most recent land cover data available.

Table 2: Summary of Ethiopian wooded area estimates

<table>
<tr><th></th><th>EMA</th><th>WBISPP</th><th>FRA</th><th>FSR</th></tr>
<tr><td></td><td colspan="4">km^2</td></tr>
<tr><td>Forestland</td><td>162,200</td><td>46,600</td><td>123,000</td><td>29,000</td></tr>
<tr><td>Woodland</td><td>23,800</td><td>295,500</td><td rowspan="2">406,300</td><td>215,000</td></tr>
<tr><td>Shrubland</td><td>467,700</td><td>264,000</td><td>201,000</td></tr>
<tr><td>Total</td><td>653,700</td><td>606,100</td><td>529,300</td><td>445,000</td></tr>
<tr><td colspan="5">Notes:
EMA – 2013 Ethiopian Mapping Agency land cover database
WBISPP - Estimates prepared for the World Bank's Woody Biomass Inventory and Strategic Planning Project (WBISPP, 2005a)
FRA - Estimates prepared for the Ethiopian Forest Resource Assessment (FAO, 2010)
FSR - Estimates prepared for the World Bank's Ethiopian Forest Sector Review (UNIQUE Forestry and Land Use and Conscientia, 2015)</td></tr>
</table>

The other challenge with respect to coherence was the fact that Ethiopian data are sometimes presented using the Ethiopian fiscal year (July 1 – June 30) as the reference period and sometimes using the calendar year. Both sorts of data were used in this study, sometimes in the assessment of the same ecosystem good or service. Where possible, efforts were made to make calendar year-based data consistent with fiscal year-based data. This was not always possible however, and calendar year data were in some cases treated as though they reflected fiscal years (for example, data for the year 2012 were in some cases taken to reflect the 2011-12 fiscal year). While this introduced a degree of inaccuracy into the results, other sources of uncertainty are of greater consequence.

1.5 Report structure

This report is divided into four main sections, including this introduction. In addition, an Executive Summary presents an overview of the overall findings of the assessment.

The findings are discussed in detail in sections 2 through 4, each of which begins with a summary of the overall results for a given category of forest ecosystem goods/services. Section 2 discusses the value of provisioning goods and services. The value of regulating services is treated in Section 3, and cultural/recreational services are dealt with in Section 4.

Individual good/services are discussed in sub-sections, each of which begins with a summary of the findings and a comparison with the relevant estimates from the ESNA as compiled by the Ministry of Finance and Economic Cooperation (MOFEC). Each sub-section also includes a summary of the valuation method and data sources and any assumptions used in the valuation.

Annex 1 provides the definition of forest land used in the assessment.

Annex 2 presents the inflation and current conversion rates used.

Annex 3 presents pollination dependence ratios.

Annex 4 presents details of the soil erosion modelling.

Annex 5 lists the protected areas of Ethiopia.

2 The economic value of forest provisioning goods and services

Summary of results

Table 3 summarizes the estimated value added of forest provisioning goods and services. In total, these services contributed about 96.6. billion ETB to national income in 2012-13[11] (USD14.8 billion; 11.41% of GDP).

The most important product was wood fuel (39.1 billion ETB; USD5.9 billion; 4.5% of GDP), followed closely by livestock fodder (29.9 billion ETB; USD4.5 billion; 3.5% of GDP). The importance of these products results from their widespread use in the economy and, in the case of fodder, the importance of agriculture as a component of GDP. The income associated with fodder is not currently measured directly in GDP, though it is implicitly included as part of the value added of the livestock agriculture industry. The value of wood fuel production, on the other hand, is directly measured as part of GDP, though the findings here suggest that it is substantially undervalued due to an incomplete accounting of subsistence use by households in the GDP estimate prepared by MOFEC. MOFEC estimates the value added of wood fuel production in 2012-13 to have been 25.5 billion ETB, or 65% of the value estimated in this study.

Following fodder and wood fuel, roundwood production made the next most important contribution to income (12.7 billion ETB; USD1.9 billion; 1.5% of GDP). Roundwood is used by households to meet needs for construction materials, tools and furniture. It also serves as a raw material for the production of processed wood products like sawn lumber and plywood. About half of the income derived from roundwood is in-kind income resulting from subsistence use by households. A sizeable (but unmeasurable) share of this income is the result of illegal and/or unreported harvesting of roundwood. As with wood fuel, the findings here suggest that MOFEC's estimates of roundwood value added are too low due to incomplete accounting for illegal/unreported roundwood production and household subsistence use of it. MOFEC estimates the value added of roundwood production in 2012-13 to have been 4.1 billion ETB, or 31% of the value estimated in this study.

The next most important forest-derived product is coffee, which is estimated here to have generated 12 billion ETB of income in 2012-13 (USD1.8 billion; 1.4% of GDP). Nearly all coffee income is cash income to the farmers that produce it; just 1% is in-kind income associated with subsistence consumption of coffee. Coffee is directly measured in GDP, though no estimate is produced by MOFEC specifically for forest-derived coffee.[12] Rather, it estimates the value added of coffee in general (forest-derived plus non-forest) and reports this as part of the value added of "stimulants". Though it is not possible to compare the estimate of forest-derived coffee value added with any of MOFEC's published figures, none of the results of this assessment suggest that MOFEC's estimates of coffee value added fail to capture forest-derived income.

Of the remaining forest products considered in this assessment, honey/beeswax, wild medicinal plants and thatch for roofing on traditional houses are the most important. Together, they

[11] All major findings of this assessment are reported for the Ethiopian fiscal year 2012-13, as this is the year for which reliable estimates of all important forest ecosystem goods and services could be made.
[12] Though the majority of coffee produced in Ethiopia is considered forest-derived, some coffee plantations exist outside of forested areas.

accounted for about 3.5 billion ETB in income in 2012-13 (USD530 million; 0.4% of GDP). When compared with MOFEC's estimates, forest-derived honey appears to be fully captured in GDP as currently measured. Thatch appears to be somewhat undervalued in GDP currently and wild medicinal plants appear to be significantly undervalued in MOFEC's estimate. It is worth noting that none of these products contributes significantly to national income overall, so any errors in their estimation in the ESNA will not have major consequences for the size of measured GDP or its growth rate.

The remaining forest-derived products (gums and resins, spices, wild meat and edible plants, civet musk, silkworm cocoons, and dyes and tannins) are all estimated to make small contributions to national income. Combined, they are found here to have generated about 1.2 billion ETB in income in 2012-13 (USD174 million; 0.1% of GDP). Except in the case of gums and resins (which are mostly sold for cash income), these products result mainly in in-kind income from subsistence use by households.

Table 3: Summary of results - Provisioning goods and services

Good/service	Contribution to national income, 2012-13			Currently measured in Ethiopian SNA?				Income type			
				Yes		No		Direct			
	million ETB	million USD	Share	Directly	Implicitly	Data gap	Out of scope	Cash share	In-kind share	Indirect	Non-market
Timber forest products											
Wood fuel	39,078	5,858	4.52%	Forestry				18%	82%		
Roundwood	12,700	1,904	1.47%	Forestry				53%	47%		
Bamboo	172	26	0.02%	Forestry				15%	85%		
Total, timber forest products	51,950	7,788	6.01%								
Non-timber forest products											
Livestock fodder	29,900	4,482	3.46%		Livestock agriculture					X	
Coffee	12,060	1,808	1.39%	Crop agriculture				99%	1%		
Honey	1,400	210	0.16%	Livestock agriculture				77%	23%		
Beeswax	191	29	0.02%	Livestock agriculture				100%	0%		
Medicinal plants	1,230	184	0.14%	Crop agriculture				44%	56%		
Gums and resins	175	26	0.02%	Forestry				91%	9%		
Spices	310	46	0.04%	Crop agriculture				56%	44%		
Thatch	706	106	0.08%	Forestry				12%	88%		
Wild meat	461	69	0.05%			X		9%	91%		
Wild edible plants	257	39	0.03%			X		22%	78%		
Civet musk	0.4	0	<0.01%			X		100%	0%		
Silkworm cocoons	0.5	0	<0.01%	Livestock agriculture				n/a	n/a		
Dyes and tannins	n/a	n/a	n/a			X		n/a	n/a		
Total, non-timber forest products	46,691	7,000	5.40%								
Grand total, provisioning goods and services	***98,641***	14,788	11.41%								

2.1 Timber products

Ethiopia's forests are an important source of timber products. Harvested wood is used primarily as an energy source (wood fuel) for households and by small businesses, either directly as firewood or after conversion first into charcoal. In addition, wood is harvested for use for:

- construction materials
- raw materials for sawn lumber and other processed wood products (chipboard, fibreboard and plywood)
- furniture manufacturing, and
- production of utility poles to carry utility power and telecommunications cables (UNIQUE Forestry and Land Use and Conscientia, 2015).

Forests in Ethiopia fall into one of five management/ownership categories (Bekele, 2011; UNIQUE Forestry and Land Use and Conscientia, 2015).

- **Natural forests** – All natural forests are owned by the government and are the main source of wood used for firewood and charcoal. Natural forests account for about 91% of forest area.
- **Privately owned plantations and woodlots** – Commercial plantations and small-scale woodlots that are legally recognized by the government. Owners have the right to harvest wood from the plantations and/or sell the plantations themselves. Plantations are mostly planted with non-native species, particularly eucalyptus. They are used mainly as a source of wood for construction and raw material inputs to processed wood products. About 5% of forests fall into this category.
- **Participatory management forests** – Forests that are jointly managed by local communities, regional governments and international non-governmental organizations. About 2% of forests are managed this way.
- **Publicly owned forest plantations** – A small area of forest (about 1%) is made up of larger publicly owned plantations. Plantations are mostly planted with non-native species, particularly eucalyptus. They are used mainly as a source of wood for construction and raw material inputs to processed wood products.
- **Community woodlots –** Small areas of natural forests or plantations managed by local communities. They are used mainly as a source of wood for fuel or materials for local construction. About 1% of forests are under community management.

2.1.1 Wood fuel

Summary of results and comparison with MOFEC estimates

The estimated value added associated with wood fuel production in Ethiopia is presented in Table 4. In 2012-13, wood fuel value added is estimated to have been 39.1 billion ETB (USD5.9 billion; 4.5% of GDP). Of this, 32.0 billion ETB is estimated to have been in-kind income for households that collect and use their own wood fuel. The remaining 7.1 billion ETB represents cash income to households that sell wood fuel products (firewood or charcoal).

MOFEC estimates the value added of wood fuel production in 2012-13 to have been 25.5 billion ETB, or 65% of the value estimated in this study. MOFEC's estimate is derived from data on household wood fuel expenditures and, as a result, does not include the value of subsistence use of wood fuel (Metaferia, 2015). Given that collection of wood fuel from forests for subsistence use is common in Ethiopia, it is to be expected that MOFEC's estimate would be considerably lower than that arrived at here.

Table 4: Value added of wood fuel production

Year	Value added		Share of GDP
	million ETB	million USD	per cent
2011-12	30,855	4,781	4.1%
2012-13	39,078	5,858	4.5%
2013-14	46,827	6,419	4.5%

Valuation method

Wood fuel (firewood and charcoal) is the most important forest product consumed in Ethiopia, with a total volume of consumption of about 116 million m^3 in 2013 (UNIQUE Forestry and Land Use and Conscientia, 2015). Based on a recent survey of 4,500 rural households, Yimer (2016) estimates that about 80% of rural household energy consumption needs are met by firewood (78.2%) or charcoal (1.6%). Both natural forests and plantations are sources of wood fuel. Non-native eucalyptus is an important wood fuel species, as are the native species *Cordia Africana, Hygenia Abyssinica* and *Juniperus Procera (*Yimer, 2016). Even though these native species are protected from harvest in principle, they often find their way into firewood bundles sold at markets (Bekele, 2011).

Two recent studies have estimated the value of wood fuel production in Ethiopia. A *Forest Sector Review* conducted for the World Bank (UNIQUE Forestry and Land Use and Conscientia, 2015) carried out a top-down assessment of wood fuel use, estimating its value on the basis of observed market prices for wood fuel. Yimer (2016) conducted a bottom-up survey of 4,500 rural households for the Ministry of Environment, Forest and Climate Change to collect data on consumption of wood fuel and other timber and non-timber forest products. Each of these studies and their results are discussed below.

The *Forest Sector Review* (FSR) based its estimates of wood fuel consumption on the results of an earlier World Bank study of biomass energy (WBISPP, 2005a). The results were updated to reflect changes since 2003 in the use of electricity for household lighting and cooking and for the use of improved wood fuel stoves. Based on these updates, the FSR estimated wood fuel consumption *per capita* to be 1.35 m^3/year in 2013, or about 116 million m^3 in total. This figure includes wood harvested for direct use as firewood (110.6 million m^3) and for conversion into charcoal (5.2 million m^3). The review notes that the majority (93%) of this wood fuel is sourced from natural forests and that 35% of the harvest from natural forests is unsustainable. The remaining 7% of wood fuel is harvested from public and private plantations and woodlots.

To value wood fuel use, the FSR applied a market price to the quantities of wood fuel consumed. Using prices of 240 ETB/m^3 and 1,840 ETB/m^3 for firewood and charcoal respectively, the FSR estimates the gross value of wood fuel production to be about 35.5 billion ETB in 2013 (the FSR does not make an estimate of value added). The CSA reports a national average monthly price for firewood of 257 ETB/m^3 in 2013[13], suggesting that the price used in the FSR may be slightly low. The CSA reports a national average monthly price for charcoal of 6.1 ETB/kg, which is difficult to compare with the FSR price, as it is reported in ETB/m^3. The density of charcoal implied by the FSR and CSA prices is about 302 kg/m^3, which falls in the middle of the range of published figures for the density of charcoal (The Engineering Toolbox, no date). Given this, the FSR charcoal price would appear to be reasonable.

[13] Ethiopian Central Statistical Agency, *Monthly retail prices*.

Yimer's rural household survey collected data on consumption of wood fuel from about 4,500 respondents spread across the country using a questionnaire administered directly in the household. Based on this, he found that an average rural household collected 11.7 m^3 of wood annually for fuel use. The average household in his survey had 6.2 members, translating to *per capita* wood fuel use of 1.89 m^3/year. This is considerably higher than the FSR estimate of 1.35 m3/year. Yimer found as well that the average rural household produced 141 kilograms/year of charcoal. The wood used to produce this charcoal is not included in his estimate of wood collected for fuel use.

It is to be expected that the FSR *per capita* consumption estimate should be lower than Yimer's since the FSR figures reflect use by all Ethiopian households, rural and urban, whereas Yimer's reflect only rural use. Urban households have greater access to alternative energy sources like electricity and kerosene and, therefore, would be expected to use less wood fuel *per capita* than those in rural areas.

Yimer converts his estimates of the quantities of wood fuel consumed to values by applying prices derived from the household survey. Where possible, price information obtained directly from households was used. Where this was not available, prices from local markets were substituted. The prices used correspond reasonably well to CSA prices for firewood (with Yimer's average price being 350 ETB/m^3 and the CSA national retail price for firewood in August 2015 being 324 ETB/m^3). Yimer's average price for charcoal (1.03 ETB/kg), on the other hand, is much lower than CSA's figure for August 2015 (7.95 ETB/kg). Part of the reason for the discrepancy in charcoal prices is certainly the fact that Yimer's survey considered only charcoal use in rural areas whereas the CSA figure reflect both urban and rural use. Urban charcoal prices are much higher than those in rural areas; the average price in Addis Ababa in August 2015 according to the CSA was 13.58 ETB/kg, nearly double the national price.

Based on the prices derived from his survey, Yimer estimates the gross value of rural wood fuel production in 2015 to be 34.2 billion ETB, which is very similar to the FSR's estimate of 35.5 billion ETB for 2013. He finds intermediate costs to be equal to 3.4% of gross production, giving a figure of 33.5 billion ETB for value added.

The fact that results of the analyses by the FSR and Yimer are very similar in spite of the significant differences in approach suggests that their findings are robust. For the purposes of this study, the FSR's estimate of 1.35 m^3 of wood fuel production *per capita* in 2013 (95% firewood and 5% charcoal) has been adopted as the basis for valuation, since it better reflects overall national conditions than Yimer's rural-focused survey. Population data from the CSA have been used to convert the *per capita* figure into an annual time series of consumption estimates for firewood and charcoal. Price data for firewood and charcoal from the CSA have been used to estimate the gross value of production corresponding to this consumption. Yimer's finding that intermediate costs are equal to 3.4% of gross production has been applied to gross production to estimate value added. The results of these calculations are summarized above in Table 4.

Wood fuel production contributes to both cash and in-kind income for collectors. The share of in-kind income is estimated to be about 82% of the total based on data from Yimer on subsistence use of wood fuel.

2.1.2 Roundwood for construction and industrial use

Summary of results and comparison with MOFEC estimates

The estimated value added associated with roundwood production in Ethiopia is presented in Table 5. In 2012-13, roundwood production value added is estimated to have been 12.7 billion million ETB (USD1.9 billion; 1.5% of GDP). Of this, 6.7 billion ETB is estimated to have been in-kind income for households that collect and use their own roundwood. The remaining 6.0 billion ETB represented cash income to households and industries that sell roundwood.

MOFEC estimates the value added of roundwood production in 2012-13 to have been 4.1 billion ETB, or 32% of the value estimated in this study. MOFEC's estimate makes no allowance for illegal harvesting of roundwood or the under-reporting of legal harvests. Both are acknowledged as weaknesses in their estimates (Metaferia, 2015). A large (but unknown) portion of the difference between the estimate here and MOFEC's is accounted for by this exclusion from MOFEC's estimates. The remainder may be the result of an underestimate of the subsistence use of roundwood by households in MOFEC's estimates.

Table 5: Value added of roundwood production

Year	Value added		Share of GDP
	million ETB	million USD	per cent
2011-12	11,100	1,720	1.5%
2012-13	12,700	1,904	1.5%
2013-14	14,800	2,029	1.4%

Valuation method

As with wood fuel (see preceding section), the FSR (UNIQUE Forestry and Land Use and Conscientia, 2015) and Yimer (2016) both provide recent estimates of the value of the production of roundwood for use in construction and as raw material input into the production of sawn timber, furniture and utilities poles.

The FSR puts the gross value of roundwood production at 10.1 billion ETB in 2013, which includes an estimated 4.9 billion ETB in production from "unspecified" sources, including illegal harvesting from protected forests. According to the FSR, expert estimates suggest that between 30 and 50% of Ethiopian construction and furniture timber production is based on illegal harvesting.

Yimer estimates the gross value of roundwood production by rural households to be 15.0 billion ETB in 2015. This includes roundwood used to produce farm implements, wooden utensils, houses and other buildings and furniture. It does not include the value of roundwood harvested as a raw material input into industrial wood products like sawn timber.

Of the 10.1 billion ETB the FSR estimates gross roundwood production to be worth, about 2.4 billion ETB is associated with the use of roundwood as raw material inputs into the formal industrial wood processing industries. The remainder is associated with use of roundwood by households for traditional construction and other needs.

It is assumed here that Yimer's survey is a more reliable source of information on the household use of roundwood, so it has been chosen as the basis for that estimate here. The FSR results for the formal wood processing industry are added (after adjustment to account for the different base year) to Yimer's results for households to arrive at the total value of roundwood production. The results are summarized above in Table 5.

Roundwood production contributes to both cash and in-kind income for producers. The share of in-kind income is estimated to be about 53% of the total based on data from Yimer on subsistence use of roundwood. Some of what is considered in-kind income here is, in fact, income that flows to those undertaking illegal harvest of roundwood. This income will be in the form of cash but, since the amount is unknown, it is treated as though it is in-kind income.

2.1.3 Natural bamboo

Summary of results and comparison with MOFEC estimates

The estimated value added associated with natural bamboo production in Ethiopia is presented in Table 6. In 2012-13, forest-derived bamboo value added is estimated to have been 172 million ETB (USD26 million; <0.1% of GDP). Of this, 146 million ETB is estimated to have been in-kind income for households that collect and use their own bamboo. The remaining 26 million ETB represents cash income to households and industries that sell bamboo.

MOFEC estimates the value added of bamboo production but combines it with the value added of thatch (see Section 2.2.8) and “other” non-timber forest products, which is attributed to the forestry industry. In total, MOFEC’s estimated value added for these products in 2012-13 is 464 million ETB, which is considerably lower than the combined value added of bamboo and thatch estimated here (172 million ETB + 706 million ETB = 878 million ETB). MOFEC’s estimate of bamboo value added is acknowledged to require improvement (Metaferia, 2015), as it is compiled indirectly using data on an assumed number of people with access to bamboo resources times an estimated average annual consumption per person.

Table 6: Value added of natural bamboo production

Year	Value added		Share of GDP
	million ETB	million USD	per cent
2010-11	114	23	0.02%
2011-12	127	20	0.02%
2012-13	172	26	0.02%
2013-14	216	30	0.02%
2014-15	239	n/a	n/a

Valuation method

Ethiopia has an estimated one million hectares of natural bamboo forest, the largest in the African continent. Natural bamboo forests grow in various regions. *Yushania alpina* (highland bamboo) grows in the northwestern, western, southern, and central part of the country, whereas *Oxytenanthera abyssinica* (lowland bamboo) is widely distributed in western and northwestern lowlands of the country (Mekonnen *et al.*, 2014).

Mekonnen *et al.* (2014) found that harvesting bamboo contributed 11% on average to the income of households harvesting it. Average annual rural household income (cash and in-kind) in 2005 was 3016 ETB according to Bluffstone *et al.* (2008). Adjusted for inflation, this suggests an annual average rural household income in 2013-14 of 12,800 ETB. Applying Mekonnen’s figure of 11% as the contribution of bamboo to rural household income, 2013-14 income from bamboo for those households that collect it is about 1,404 ETB.

In his survey of rural households, Yimer (2016) found that households collecting bamboo generated the equivalent of 500 ETB on average from their subsistence use and sale of bamboo. For the purposes here, the average of these two estimates (952 ETB per year) is used as the estimate of bamboo income for collecting households.

Yimer found that bamboo collecting households collected on average 73.3 culms per year. This implies an average price per culm of 6.8 ETB, which falls within the range of 2011 prices reported by Mekonnen *et al.* (2014) of 1.4 ETB/culm to 14.3 ETB/culm (adjusted for inflation).[14]

Yimer, using a sample of 3,360 households intended to be representative of all rural households in the country, found that 2% of surveyed households reported bamboo income. Applying this share to his estimate of total rural households dependent on forests (11.7 million[15]) suggests that some 234,000 rural households in Ethiopia derive income from bamboo harvesting. Using a smaller sample (345 households) that was explicitly focused on regions with high bamboo harvesting potential, Mekonnen (2014) found that 53% of households reported bamboo income. The estimated 2014 rural population of the zones in which Mekonnen *et al.* sampled[16] is 8,636,202 million (Central Statistical Agency, 2013). Using Mekonnen *et al.*'s estimate of average household size (6 persons), their results suggest that about 760,000 rural Ethiopian households derive income from bamboo production.

It is likely that the figure of 234,000 bamboo-harvesting rural households based on Yimer's results underestimates the number of rural households that derive income from bamboo. Yimer's sampling strategy was not designed to target bamboo harvesting households in particular, so it is likely that woredas (administrative districts) where bamboo harvesting is highly prevalent were under-sampled in the survey. The figure of 760,000 bamboo-harvesting households derived from Mekonnen *et al.*'s results is, on the other hand, likely an overestimate since there are likely woredas in the zones where Mekonnen *et al.* sampled where bamboo collection is not prevalent. For the purposes here, the average of these two estimates (497,000) is used as the estimate of the number of households deriving income from bamboo harvesting.

Mekonnen *et al.* do not report the quantity of bamboo produced by the households they surveyed, so Yimer's estimate of 73 culms per household is used here. Applying that figure and Yimer's estimated average price of 6.8 ETB/culm (which was noted above to fall within Mekonnen *et al.*'s range) to the estimated number of bamboo-harvesting rural households (497,000) gives a figure of about 247 million ETB as the gross value of bamboo production in 2014-15.

Yimer reports average intermediate costs for rural household production of non-timber forest products of 3.4% of the gross value of production. Applying this to the gross value of production gives an estimate of value added associated with natural bamboo production of 239 million ETB in 2014-15. The time series in Table 6 has been derived by adjusting the 2014-15 figure for inflation and data on changes in rural population from the Ethiopian Central Statistical Agency (2013).

Bamboo production contributes to both cash and in-kind income for collectors. The share of in-kind income is estimated to be about 85% of the total based on data from Yimer on subsistence use of bamboo.

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[14] The actual values report by Mekonnen et al. (2014) were 1 – 10 ETB/culm.

[15] Yimer estimates that the average rural household has 6.2 members and that 72,503,772 Ethiopians are dependent on forest resources, which equates to an estimated 11.7 million forest-dependent families.

[16] The zones in which the sample Woredas are located are: Awi (Amhara), Bahir Dar (Amhara), West Shiwa (Oromia), Gamo Gofa (SNNPR), Sidama (SNNPR), Sheka (SNNPR) and Asossa (Benishangul-Gumuz).

2.2 Non-timber forest products

Non-timber forest products (NTFPs) can be defined as biological materials, excluding timber, that are removed from forested areas for human use (de Beer and McDermott, 1996). In Ethiopia, the major NTFPs are:

- livestock fodder
- coffee
- honey and beeswax
- medicinal plants
- gums and resins
- spices
- thatch
- wild meat
- wild edible plants
- civet musk
- silkworm cocoons, and
- dyes and tannins.

The contribution of each of these to national income in Ethiopia is addressed below.

2.2.1 Livestock fodder

Summary of results and comparison with MOFEC estimates

The estimated value added associated with forest-derived livestock fodder in Ethiopia is presented in Table 7. In 2012-13, this non-timber forest product is found to have generated value added of about 29.9 billion ETB (USD4.5 billion; 3.5% of GDP). Forest fodder production does not result in direct cash or in-kind income. Rather, the associated income is generated when farmers sell livestock products (cash income) or consume those products themselves for subsistence purposes (in-kind income).

As an indirect income source, MOFEC makes no estimate of value added from forest fodder. However, this income is captured implicitly in MOFEC's estimate of the GDP of the livestock agriculture industry. The value added of fodder estimated here for 2012-13 accounts for about 36.3% of livestock value added in that year. However, as noted next in the discussion of the valuation method, MOFEC's estimate of livestock GDP may be too low.

Table 7: Value added of forest-derived livestock fodder

Year	Value added (million ETB)	Value added (million USD)	Share of GDP (per cent)
2010-11	16,600	3,400	3.2%
2011-12	24,100	3,700	3.2%
2012-13	29,900	4,500	3.5%
2013-14	33,400	4,600	3.2%
2014-15	38,900	n/a	n/a

Valuation method

Forest grazing is a major source of livestock fodder in Ethiopia (Teketay *et al.*, 2011; Nune *et al.*, 2010; Yimer, 2016). Forest-derived fodder contributes importantly to value added because

Ethiopia has one of the largest inventories of livestock in Africa, the majority of rural households keep livestock, and livestock farmers rely heavily on forests as a source of feed. About 5% of forestland, plantation and bamboo, and 24% of woodland, bush land and shrub land are subject to livestock grazing (WBISPP, 2005b).

Yimer (2016) further found that:

- 92% of rural households keep livestock
- the average rural household keeps about 12.3 head of livestock of various sorts and has an annual feed (dry material) requirement for all livestock of 3.35 tonnes, and
- the average market cost of dry animal feed is 1,292 ETB/tonne.

Based on these findings and the latest rural population estimate from the Ethiopian CSA (72,617,000), Yimer estimates the value added of forest-derived fodder to be 57.8 billion ETB in 2014-15. This figure can be tested for plausibility by comparison with a figure derived using CSA and MOFEC data on time use, wages and GDP in the livestock industry.

According to the *2013 Time Use Survey* (Central Statistical Agency, 2014a), 37% of males aged 10 and above participate in livestock rearing, spending 207 minutes per day doing so. For females, the corresponding figures are 28% and 126 minutes. Assuming that the average Ethiopian rural family is equally split between males and females and that 2 members of the average family are younger than 10 (leaving 2.1 working-age males and 2.1 working-age females out of the average household of 6.2 members reported by Yimer), the average daily time spent on livestock rearing per rural family is estimated to be 3.9 hours.[17]

The *2013 Time Use Survey* further reports that the average rural wage for paid agricultural workers in 2013 was 617 ETB/month. After adjusting for inflation and assuming a five-day working week [21.7 working days/month] and 8 working hours/day on average, this equates to an average agricultural worker hourly wage rate of 3.8 ETB/hour in 2014-15.

If this average wage rate is used to value livestock farmers' labour and farmers (as opposed to paid workers) are assumed to work seven days/week and 3.9 hours/day rearing livestock (see above), the average rural family's livestock rearing labour was worth 5,434 ETB in 2014-15. Multiplying this by Yimer's estimated number of rural families dependent on forest resources (11.7 million) yields a value of 63.6 billion ETB as the total value of the labour devoted by rural families to livestock rearing in 2014-15.

According to the Ethiopian *Labour Force Survey* (Central Statistical Authority, 2014), only about 1.7% of the rural workforce is made up of paid workers in private enterprises. It is therefore reasonable to assume that the 63.6 billion ETB in labour devoted to livestock rearing by households represents all of the labour inputs associated with livestock rearing (in other words, no workers other than household members are assumed to take part in livestock rearing).

Livestock rearing is largely a traditional practice in Ethiopia, with few inputs other than labour and animal feed. Given this, an estimate of the total value added attributable to fodder obtained freely from the environment (from either grazing in forests or on grasslands) can be made by deducting the value of household labour devoted to livestock rearing (63.6 billion ETB) from total value added for the livestock sector. MOFEC (2015) reports a figure for 2014-15 livestock GDP of 107.1 billion ETB. Deducting the estimated value of household labour devoted to livestock rearing from this leaves 43.4 billion ETB as the value added of the fodder freely obtained from the environment.

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[17] [(0.37*2.1*207) + (0.28*2.1*126)]/60

Yimer found that 33% of farmers' needs for fodder are met by forest grazing; the remainder is met by grazing on grasslands (38%), crop residues (25%) and purchases (4%). Thus, of the fodder obtained freely from the environment (that is, from forest and grassland grazing), 46% comes from forests and 54% from grasslands. Applying these shares to estimated value added of 43.4 billion ETB attributable to fodder obtained from the environment suggests the value of forest-derived fodder was about 20.0 billion ETB in 2014-15.

This estimate is considerably lower than Yimer's estimate of the value added of forest-derived fodder (57.8 billion ETB). Yimer's estimate may, however, be too high. If his estimate of the split between fodder derived from forests and from grasslands (46% and 54% respectively) is correct, then his results for the value of forest-derived fodder would require an additional 68.9 billion ETB in value added to be associated with fodder obtained from grasslands. This would mean a total of about 126.7 billion ETB in value added was attributable to fodder obtained from the environment. This figure, which is greater than MOFEC's estimate of total livestock GDP (107.1 billion ETB), is plausible only if MOFEC's estimate of livestock GDP is too low, a possibility that is explored next.

A study conducted for the Livestock Policy Initiative of the Intergovernmental Authority on Development (Behnke, 2010) found reason to believe that MOFEC's estimate of livestock GDP was, indeed, too low in 2009. Behnke noted several reason why this might have been the case (some of which, it should be noted, rested on misunderstandings of GDP and what it measures), including gaps in livestock statistics produced by the Ethiopian CSA and outdated livestock production (or "off-take") coefficients. In particular, he noted that "CSA surveys cover only 2 of the 5 Zones in Afar Region and 3 of the 10 Zones in Somali Region, leaving out pastoral Zones with high numbers of livestock. The CSA does not attempt to estimate livestock populations in these pastoral Zones, which are completely excluded from national estimates." Behnke went on to suggest revised livestock figures that would reflect all parts of the country and not just those surveyed by the CSA.

In a follow-up review of Behnke's findings (Metaferia *et al.*, 2011), a team of experts from MOFEC charged with improving the official methodology for Ethiopia's livestock GDP estimate concluded that Behnke's revised figures were accurate for sheep, goats and camels and suggested their adoption. They also recommended that Behnke's suggestion to use an updated set of off-take coefficients be adopted.

It is unclear to what extent the recommendations of Metaferia *et al*. were actually taken into account during the official revision of the ESNA methodology conducted in 2014. According to the updated handbook of ESNA concepts, sources and methods (MOFEC, 2014; Appendix 6.1), the revised ESNA methodology for livestock GDP continues to rest upon CSA livestock statistics. No indication is given that these statistics are adjusted to account for the undercoverage of pastoral zones. On the other hand, it does appear (Appendix 6.3 in the handbook) that updated off-take coefficients are now being used (though not, apparently, the ones recommended by Metaferia *et al*.).

Given this, it seems reasonable to conclude that MOFEC's estimate of livestock GDP might still be too low even following the revision to the ESNA methodology. By how much it might be too low could not be determined without access to more complete documentation and information regarding MOFEC's methodology than was available for this study.

Yimer's results suggest that livestock GDP should have been about 190 billion ETB[18] in 2014-15. This is significantly different than MOFEC's estimate of 110.1 billion ETB. Though it seems unlikely that MOFEC's estimate would be that much too low, the possibility that Yimer's estimate is correct cannot be ruled out.

The true value of forest-derived fodder lies somewhere between the figure estimated above (20.0 billion ETB) and that put forward by Yimer (57.8 billion ETB). For the purposes here, the average of those values (38.9 billion ETB) is taken as the estimate of forest-derived fodder value added in 2014-15. The time series in Table 7 has been derived by applying the 2014-15 ratio of fodder value added to livestock value added (0.33) to livestock value added for the years back to 2010-11.

2.2.2 Coffee

Summary of results and comparison with MOFEC estimates

The estimated value added associated with forest-derived coffee production in Ethiopia is presented in Table 8. In 2012-13, forest-derived coffee value added is found to have been about 12 billion ETB (USD1.8 billion; 1.4% of GDP). Of this, about 72 million ETB was in-kind income to households that produce and consume their own coffee. The remaining 11.9 billion ETB represented cash income to coffee producers.

MOFEC makes no estimate of forest-derived coffee value added. Rather, it estimates the value added of coffee in general (forest-derived plus non-forest) and reports this as part of the value added of "stimulants"[19]. Stimulants, in turn, are included as part of the crop agriculture industry. In 2010-11, the valued added of stimulants was estimated to be 21 billion ETB (MOFEC, 2014). Based on data from Metaferia (2015), the share of coffee in stimulant value added is around 80%, which equates to 16.8 billion ETB in 2010-11 as compared to the 8 billion ETB estimated here for forest-derived coffee. The difference between these figures is partly explained by the fact that MOFEC measures all coffee while the estimate here is for forest-derived coffee. Other likely sources of differences are data on prices, production and intermediate consumption and calenderisation.

Table 8: Value added of forest-derived coffee production

Year	Forest coffee value added	Garden coffee value added	Plantation coffee value added	Total Value-Added		Share of GDP
	million ETB			million ETB	million USD	per cent
2004-05	2,110	671	376	3,157	1,472	2.9%
2005-06	1,396	444	249	2,089	900	1.6%
2006-07	1,881	599	335	2,815	1,062	1.6%
2007-08	2,036	648	361	3,044	899	1.2%
2008-09	2,103	669	369	3,142	753	0.9%
2009-10	2,768	881	489	4,138	989	1.1%
2010-11	5,378	1,711	956	8,045	1,635	1.6%
2011-12	11,052	3,517	1,980	16,549	2,564	2.2%

[18] Yimer's estimate of forest-derived fodder (57.8 billion ETB) implies another 68.9 billion ETB for grassland fodder. When added to the figure of 63.6 billion ETB calculated here as the value of the household labour used in livestock rearing, the total comes to about 190 billion ETB.

[19] Stimulants include coffee, chat, tea, hops as well as suret and gaya (traditional tobacco-like plants).

2012-13	8,064	2,566	1,431	12,060	1,808	1.4%
2013-14	6,539	2,080	1,149	9,768	1,339	0.9%

Valuation method

Coffee production in Ethiopia is classified into three categories: forest coffee (which can be divided into true forest and semi-forest types), garden coffee and plantation coffee.

Forest coffee is harvested from naturally growing wild plants. Semi-forest coffee is harvested from managed forest coffee systems in which plants are cultivated under existing forest canopy and agronomic practices are used to enhance productivity (Abebaw and Virchow, 2003). Garden coffee is harvested from plants cultivated on farmers' properties. Plantation coffee is mainly grown by government and large, privately owned enterprises and some smaller commercial growers. It is harvested from plants grown under more intensive management regimes that include seedling selection, proper plant spacing, mulching, application of manure, weeding, shade-regulation and pruning (Policy Analysis and Economic Research Team, 2008).

According to Tadesse Gole, Director of the Ethiopian Environment and Coffee Forest Forum (personal communication, 2015), forest coffee, garden coffee and plantation coffee account for 55%, 35% and 10% of total coffee production respectively. Gole suggests that 100% of forest coffee, 100% of plantation coffee and 50% of garden coffee production should be considered to derive from forests. Applying these shares to total Ethiopian coffee production from the International Coffee Organization (no date), forest-derived production in physical units for each of the three categories was estimated (Table 9).

Table 9: Forest-derived coffee production

Year	Forest coffee	Garden coffee	Plantation coffee	Total forest-derived coffee production
	tonnes			
2004-05	135,102	67,551	24,564	227,217
2005-06	145,002	72,501	26,364	243,867
2006-07	172,029	86,015	31,278	289,322
2007-08	94,397	47,199	17,163	158,759
2008-09	132,815	66,408	24,148	223,371
2009-10	150,370	75,185	27,340	252,895
2010-11	143,132	71,566	26,024	240,721
2011-12	146,008	73,004	26,547	245,559
2012-13	203,813	101,907	37,057	342,777
2013-14	207,253	103,626	37,682	348,561

Reichhuber and Requate (2007) established the transportation and processing (hulling) costs of semi-forest coffee to be 0.3 ETB per kg in 2006. The transportation and hulling costs for garden and forest coffee were assumed to be similar to those of semi-forest coffee. According to Gole (personal communication, 2015), this figure is a reasonable estimate of total intermediate costs for forest and garden coffee. Typically, no agro-chemical inputs such as chemical fertilizers are utilized in forest or garden coffee production systems (Blakeney *et al.*, 2012). In contrast, plantation production systems require chemical inputs such as chemical fertilizers, herbicides and fungicides (Amamo, 2014).

To estimate intermediate costs for plantation coffee, estimates of total intermediate inputs used in coffee production between 2010 and 2011 were taken from the Central Statistical Agency (2011). These included fertilizers and pesticides (insecticides, herbicides fungicides and other chemicals to control pests) used in large- and medium-scale plantation coffee production.

The CSA data divide fertilizers into two types: urea and diammonium phosphate. Ethiopian unit prices for each type of fertilizer from Rashid (2009) were adjusted for inflation to calculate total fertilizer costs for plantation coffee in 2010, the most recent year for which data were available.[20]

Data on the prices of pesticides for Ethiopia are difficult to obtain. Based on the average price of pesticide inputs in the United States (United States Department of Agriculture, no date), an average pesticide input price in 2010 of 89 ETB/kg was assumed.[21] This value is comparable to the figures reported by Williamson (2003) for Ethiopian farmers in the early 2000's taking inflation into consideration.

The estimated fertilizer and pesticide prices were applied to data on the quantities of fertilizer and pesticides used as inputs in medium and large-scale coffee farming (CSA, 2011) to establish intermediate costs of chemical inputs for planation coffee in 2010-11. Dividing this figure by the quantity of plantation coffee grown in 2010-11 (Table 9: Forest-derived coffee production gave a unit intermediate cost for chemical inputs of 0.58 ETB/kg in 2010-11. Transportation and hulling costs for plantation coffee were assumed to be identical to those for forest and garden coffee taken from Reichhuber and Requate (2007). Adjusting the intermediate input unit cost for chemicals for inflation to bring it to 2012-13 and then combining it with the unit intermediate input cost for transportation/hulling (0.97 ETB/kg in 2012-13) gave an estimated unit intermediate cost for plantation coffee in 2012-13 of 1.92 ETB/kg.

Prices used in the value added calculation (Table 10) were taken from the Central Statistical Agency (2011a) for 2005-2006 and from the International Coffee Organization (no date) for other years, as CSA data were not up to date. Since intermediate costs were calculated to including hulling, prices that reflected the value of the coffee bean itself, not the whole coffee fruit, were used.

Forest-derived coffee production contributes to both cash and in-kind income for coffee producers. The share of in-kind income is estimated to be about 0.6% of the total based on data from Yimer (2016) on subsistence use of coffee.

Table 10: Ethiopian coffee prices

Year	ETB/kg
2005	15.05
2006	14.46
2007	13.89
2008	15.20
2009	19.51

[20] Rashid (2009) reports unit prices for urea and diammonium phosphate in 2008 of 7,439 ETB/tonne and 4,053 ETB/tonne respectively (8,725 ETB/tonne and 4,753 ETB/tonne respectively in 2010 after adjustment for inflation).

[21] The US Department of Agriculture reports that 899 pounds (399 kg) of pesticide active ingredients were applied to US farms in 2007 at a cost of USD7.9, for an average price per kg of active ingredient of USD19.82. Converted to ETB (based on purchasing power parity) and adjusted for inflation, this gives a figure of 89 ETB/kg of active ingredient in 2010.

2010	26.98
2011	54.12
2012	40.18
2013	31.38

2.2.3 Honey

Summary of results and comparison with MOFEC estimates

The estimated value added associated with forest-derived honey production in Ethiopia is presented in Table 11. Estimates have been made for production of honey from wild (unmanaged), modern, transitional and traditional hives. Due to uncertainties in data[22], low and high value added estimates have been calculated (except in the case of wild hives). In 2012-13, forest-derived honey value added is estimated to have been between 1.2 and 1.6 billion ETB. The average of 1.4 billion is taken as the estimate here (USD211 million; 0.16% of GDP). Of this, about 320 million ETB represented in-kind income for households that produce and consume their own honey. The remaining 1.1 billion ETB represented cash income to honey producers.

MOFEC makes no estimate of forest-derived honey value added. Rather, it estimates the value added of honey in general (forest-derived plus non-forest) and reports this as part of the value added of the livestock agriculture industry. In 2010-11, MOFEC estimated that honey accounted for 2.8% of the total gross output of livestock agriculture and that the total value added of livestock agriculture was 45.806 billion ETB. These estimates give a value of about 1.3 billion ETB for honey value added, as compared to the 1 billion estimated here (average of the high and low estimates for 2010-11 from Table 11). The difference between these figures is partly explained by the fact that MOFEC measures all honey while the estimate here is for forest-derived honey only. As well, MOFEC includes the value of beeswax along with its estimates for honey. Other likely sources of differences are data on prices, production and intermediate consumption and calenderisation.

Table 11: Value added of forest-derived honey production

	Wild	Modern		Transitional		Traditional		Total value added		Total value added*	Share of GDP*
		High	Low	High	Low	High	Low	High	Low		
	million ETB									million USD	per cent
2004-05	13	0	0	0	0	431	217	445	231	158	0.31%
2005-06	16	2	1	1	1	509	347	528	366	192	0.34%
2006-07	19	2	2	2	2	633	533	657	557	229	0.35%
2007-08	20	5	4	4	3	662	448	691	477	172	0.23%
2008-09	27	8	7	5	5	871	547	911	586	179	0.22%

[22] Uncertainties were present in the following variables: the number of beehives in Ethiopia; the share of beehives located in forests; the intermediate costs of honey production.

2009-10	33	10	9	7	7	1,067	705	1,117	754	224	0.24%
2010-11	33	11	10	5	5	1,063	927	1,112	975	212	0.20%
2011-12	41	17	15	7	7	1,293	810	1,358	873	173	0.15%
2012-13	48	21	19	20	18	1,536	1,100	1,625	1,185	211	0.16%

*Based on the average of the high and low estimate of value added.

Valuation method

In Ethiopia, the majority of honey is produced by **traditional beekeeping** methods, which include both forest and backyard beekeeping (Yadeta, 2015). In 2012-13, the forest-derived value added of traditional honey production is estimated to have been between 1.1 and 1.54 billion ETB. Our low value (1.1 billion ETB) is based on data for traditional honey production from the CSA. The high value (1.54 billion ETB) is based on an estimate of traditional honey production that assumes Ethiopia has just under 7.5 million traditional beehives[23] and that each hive yields 8 kg annually.[24]

In less forested areas of the country, traditional beehives may be placed in backyards and bee colonies may forage on agricultural crops or other non-forest flora. Such honey cannot be considered forest derived. Nune *et al.* (2010) assumed that 70% of traditional honey production is forest derived; that share has been used here as well.

Traditional beekeeping harvests are achieved with minimal costs. Those intermediate inputs that are used are taken from what is available in the surrounding environment and are typically not purchased (Belie, 2009). Transportation costs are low because farmers transport honey to local markets themselves or with animal labour. Some producers may sell honey directly to collectors in small villages (Agonifer, 2005). For these reasons, the assumption was made that only 20% of traditional honey production requires intermediate inputs. In 2012-13, the intermediate costs associated with traditional beekeeping were calculated to be 4.31 ETB per kg of honey. This value includes both transportation (1.39 ETB per kg) and supplementary feed costs (2.92 ETB/kg) (Gebremichael and Gebremedhim, 2014).

Honey hunting, the collection of honey from unmanaged wild hives, is practiced by many people in Ethiopia on an "opportunistic" basis (Solomon, 2007). In 2012-13, the forest-derived value added from honey hunting is estimated to have been 48 million ETB. The total number of wild hives was assumed to be 2.5 million and the average yield per hive was assumed to be 5kg. Since not all wild hives are harvested every year and hives may be located in inaccessible areas, a conservative annual harvesting rate of 10% of all hives was assumed (based on authors' judgement). Honey hunters were assumed to incur no intermediate costs due to the opportunistic and subsistence nature of the practice. Given the significant uncertainty associated with the value added of honey hunting, separate high and low value added estimates were not calculated.

In 2012-13, the forest-derived value added for **transitional honey** production was calculated to be between 18.4 and 20.2 million ETB. These estimates were calculated using production and

[23] A figure of 7.5 million is often cited as an estimate of the total number of managed beehives of all types in Ethiopia (Deffar, 1998; Legesse, 2014; Lehoux and Chakib, 2012; Kinati et al., 2012). The numbers of modern and transitional beehives are quite small (about 150,000 and 50,000 respectively in 2012-13), so the vast majority of managed beehives are of the traditional sort.

[24] This figure is based on honey production data from the CSA, which suggest yields in the range of 6-10 kg/hive/year. It is consistent with values found in the literature, which range from 5-15 kg/hive/year (Deffar, 1998; Legesse, 2014; Miklyaev et al., 2014; Reichhuber and Requate, 2007).

price data from the CSA, adjusted to reflect an assumed share of forest-derived production of 50% for transitional hives (authors' judgement). All transitional hives were assumed to require intermediate inputs, though the amount of such inputs is uncertain. To establish the high and low estimates of value added for transitional hive production, high and low values were estimated for intermediate inputs: the high value included both transport and supplementary feed (4.55 ETB per kg), while the low value included only transport (1.39 ETB per kg) (Abebe, 2009).

In 2012-13, the forest-derived value added from **modern honey** production was calculated to be between 18.7 and 20.9 million ETB. These estimates were calculated using production and price data from the CSA, adjusted to reflect an assumed share of forest-derived production of 20% for modern hives (authors' judgement). All modern hives were assumed to require intermediate inputs, though the amount of such inputs is uncertain. To establish the high and low estimates of value added for modern hive production, high and low values were estimated for intermediate inputs: the high value included transport, supplementary feed and pest control (8.05 ETB per kg), while the low value included only transport and supplementary feed (4.55 ETB per kg) (Abebe, 2009).

National average producer prices for honey from the CSA were used for the period 2003-04 to 2006-07. Between 2007-08 and 2009-10, the average of producer prices from the CSA and FAOSTAT were used. Lastly, producer prices from FAOSTAT were used for 2010-11 to 2012-13. These prices (Table 12) were applied to the four different honey production systems.

Forest-derived honey production contributes to both cash and in-kind income for producers. According to one source (Agriculture Growth Program, no date), about 5% of honey production is consumed directly by the producers' families. Yimer (2016) found this share to be closer to 41%. The average of these figures has been taken here (23%) as the share of forest honey income that is in-kind.

Table 12: Honey prices

Year	ETB per kilogram
2003-04	9.24
2004-05	10.51
2005-06	12.45
2006-07	15.47
2007-08	16.30
2008-09	21.55
2009-10	26.41
2010-11	26.49
2011-12	32.42
2012-13	38.50

2.2.4 Beeswax

Summary of results and comparison with MOFEC estimates

The estimated value added associated with forest-derived beeswax production in Ethiopia is presented in Table 13. In 2012-13, forest-derived beeswax value added is found to have been 191 million ETB (USD30 million; <0.03% GDP).

No information was available to assess the split of beeswax value added between cash and in-kind income. Most beeswax is produced as a by-product of *tej* production[25] and, therefore, is assumed to be mainly sold for cash by *tej* producers to supplement their incomes.

MOFEC does not make an estimate of the value added of beeswax production. This value is included as part of its estimate of honey value added, which is attributed to the livestock agriculture industry.

Table 13: Value added of forest-derived beeswax production

Year	Value added		Share of GDP
	million ETB	million USD	per cent
2005-06	45	21	0.04%
2006-07	58	25	0.04%
2007-08	65	25	0.04%
2008-09	103	30	0.04%
2009-10	100	24	0.03%
2010-11	121	29	0.03%
2011-12	156	32	0.03%
2012-13	191	30	0.03%
2013-14	207	31	0.02%

Valuation method

As with traditional honey production, 70% of beeswax production is assumed to be forest derived. Production data were taken from FAOSTAT (no date). A farm-gate price of 17.6 ETB per kg reported for 2005 by Industrial Project Services (2005a) was used. No data were found relating to the cost of intermediate inputs in beeswax processing. However, Belie (2009) and Yadeta (2014) note that the majority of crude beeswax is produced as a by-product of *tej* production and is minimally processed. Intermediate costs were assumed to be low and a net price (farm-gate price less intermediate costs) of 15 ETB per kg for 2005 was therefore assumed (authors' judgement). After accounting for inflation, this net price was applied to FAO production data to arrive at the time series of value added shown in Table 13.

2.2.5 Medicinal Plants

Summary of results and comparison with MOFEC estimates

The estimated value added associated with forest-derived medicinal plant production in Ethiopia is presented in Table 14. In 2012-13, forest-derived medicinal plant value added is estimated to have been approximately 1.2 billion ETB (USD191 million; 0.16% of GDP). Of this, about 670 million ETB was income to households that collected and used their own medicinal plants. The remaining 530 million ETB represented cash income to households and traditional healers.

MOFEC makes no estimate of medicinal plant value added. Rather, it includes this as part of the value added of the crop agriculture industry. In 2010-11, MOFEC estimated that medicinal plants accounted for a negligibly small share of the total gross output of crop agriculture (just 2.21 million ETB out of a total of 161,070 million ETB). According to Metaferia (2015), MOFEC

[25] *Tej* is a traditional Ethiopian wine (mead) made from honey.

likely underestimates the production of medicinal plants due to unaccounted traditional practices and the use of traditional medicines for livestock. This is an area where improvement of the ESNA is required.

Table 14: Value added of forest-derived medicinal plant production

Year	Value added		Share of GDP
	million ETB	million USD	per cent
2005-06	340	158	0.32%
2006-07	380	164	0.29%
2007-08	450	168	0.26%
2008-09	640	190	0.26%
2009-10	700	167	0.21%
2010-11	750	180	0.19%
2011-12	1,000	204	0.19%
2012-13	1,230	191	0.16%
2013-14	1,330	200	0.15%

Valuation method

In Ethiopia, more than 70% of human and 90% of livestock populations rely on traditional medicine as their primary form of healthcare (Lehoux and Chakib, 2012; Bekele, 2007). Bekele (2007) notes that the demand for medicinal plants in Ethiopia is related to cultural traditions, the trust community members place in traditional medicine and the low costs associated with use. Approximately one thousand medicinal plant species have been identified and it is predicted that another five hundred exist (Awas, personal communication, 2015; Bekele, 2007). Numerous studies (see, for example, d'Avigdor *et al.*, 2014; Lulekal *et al.*, 2008; Megersa *et al.*, 2013) are available describing the various species, uses, management and conservation of medicinal plants. However, research and data regarding the consumption, production and value of medicinal plants is much less prevalent (Awas, personal communication, 2015).

The estimates of medicinal plant valued added presented above reflect only the trade and consumption of the plants and not the value of the healing services offered by the traditional healers who use the plants. Mander *et al.* (2006) calculated the average purchase price of the most common medicinal plants to be 7.5 ETB per kg and the total mass of medicinal plants consumed to be 56,410 tonnes in 2005, of which 87% had an origin in the wild. Awas (personal communication, 2015) places the share of plants originating in the wild somewhat lower at 70%. A figure between these two (80%) was adopted for this study. It is assumed that all medicinal plants are derived from forests or other wooded land.

Assuming that medicinal plant production uses no intermediate inputs, forest-derived value added for 2005 (340 million ETB) was established as the simple product of Mander *et al.*'s price and consumption data multiplied by the wild share of 80% (assuming that all wild plants come from forested areas). This figure was adjusted for inflation to establish the time series in Table 14.

Forest-derived medicinal plant production contributes to both cash and in-kind income for households and traditional healers. producers. The share of in-kind income is estimated to be about 56% of the total based on data from Yimer (2016) on subsistence use of medicinal plants.

2.2.6 Gums and Resins

Summary of results and comparison with MOFEC estimates

The estimated value added associated with gum and resin production in Ethiopia is presented in Table 15. In 2012-13, gum and resin value added is estimated to have been approximately 175 million ETB (USD27 million; 0.02% of GDP). Of this, about 16 million ETB represented in-kind income to collectors that used gums and resins for personal purposes. The remaining 159 million ETB represented cash income to collectors.

MOFEC estimates the value added of gum and resin production in 2012-13 to have been 168 million ETB (Metaferia, 2015), which is very close to the estimate here. MOFEC allocates gum and resin value added to the forestry industry.

Table 15: Value added of forest-derived gum and resin production

Year	Tigray type olibanum	Other gums and resins	Gum Arabic	Total value added		Share of GDP
	million ETB			million ETB	million USD	per cent
2005-06	46	2	3	51	24	0.05%
2006-07	56	2	5	64	28	0.05%
2007-08	71	3	7	81	31	0.05%
2008-09	83	4	7	94	28	0.04%
2009-10	93	4	8	105	25	0.03%
2010-11	112	5	30	146	35	0.04%
2011-12	148	6	26	180	37	0.03%
2012-13	149	6	19	175	27	0.02%
2013-14	183	8	26	216	32	0.02%

Valuation method

The dry forests of Ethiopia contain an abundance of gum and resin producing tree species such as *Acacia*, *Boswellia* and *Commiphora* (Lemenih and Kassa, 2011). According to Kassa *et al.* (2011), the gum and resin sector in Ethiopia is characterized by significant variations in export and production volumes from period to period. Discrepancies between published data sources regarding total production, domestic production and export volumes make characterization of the industry challenging. For this study, consultations with Ethiopian experts, including Wubalem Tadesse, Director General of the Ethiopian Environment and Forest Research Institute and Teklehaimanot Nigatu, Chief Executive Office of the Natural Gum Processing and Marketing Enterprise (NGPME), provided valuable guidance in navigating the uncertainty regarding the industry.

In 2013-14, the domestic consumption of all gums and resins in Ethiopia is estimated to have been 2,500 tonnes (Nigatu, personal communication, 2015). Using this estimate and population data from the World Bank, *per capita* consumption was estimated for 2014 and then applied to population figures for 2003 through 2014 to generate a time series of domestic gum and resin consumption. Domestic production was then estimated as domestic consumption plus exports less imports (Table 16). Export data were available from the International Trade Center (2015)

(ITC) database.[26] All gum Arabic production in Ethiopia is destined for export, so gum Arabic export data were excluded from this calculation.

Table 16: Production of forest-derived gums and resins

Year	Tigray type olibanum	Other Gums and Resins	Gum Arabic	Total Production
	tonnes			
2003-04	8,300	400	400	9,200
2004-05	6,600	300	400	7,400
2005-06	7,800	400	500	8,700
2006-07	8,500	400	600	9,600
2007-08	9,200	500	700	10,400
2008-09	7,400	400	500	8,300
2009-10	7,700	400	500	8,600
2010-11	8,500	400	1,800	10,800
2011-12	8,500	400	1,200	10,100
2012-13	7,000	400	700	8,000
2013-14	7,900	400	900	9,200

Domestic production (other than gum Arabic) consists mainly of Tigray-type olibanum and small amounts of other gums (Borana-type olibanum, Ogaden-type olibanum, opponanax and myrrh) (Nigatu, personal communication, 2015). Nigatu puts the share of Tigray-type olibanum in total gum and resin production at 88% as a minimum.

Separate forest-gate prices were applied to Tigray-type olibanum, gum Arabic and "other gums and resins" (Table 17) (FAO, 2010; Industrial Project Services, 2005b; Kassa *et al.*, 2011). In 2012-13, these prices were estimated to be 25.64 ETB per kg, 26.66 ETB per kg and 19.48 ETB per kg respectively.

Tadesse (personal communication, 2015) notes that professional tappers collect the majority of olibanum; other gums and resins are typically collected by peasant farmers. Therefore, olibanum was assumed to be the only exudate requiring intermediate inputs, which were estimated to cost 4.18 ETB per kg based on data from Tilahun *et al.* (2007). All Tigray-type olibanum collection was assumed to require intermediate inputs and half of Borana- and Ogaden-type olibanum was assumed to do so (author's judgement).

Gum and resin production contributes to both cash and in-kind income for collectors. The share of in-kind income is estimated to be about 9% of the total based on data from Yimer (2016) on subsistence use of gums and resins.

Table 17: Gum and resin prices

Year	Tigray Type Olibanum	Gum Arabic	Other Gums and Resins
	birr		
2003-04	6.03	12.28	4.58
2004-05	6.23	14.13	4.73

[26] The ITC defines Product 1301 as "lac, natural gums, resins, gum/resins and balsams". Though included in the category, there were no exports of lac (a resinous insect secretion) from Ethiopia between 2003 and 2014.

2005-06	7.03	7.31	5.34
2006-07	7.90	8.21	6.00
2007-08	9.25	9.62	7.03
2008-09	13.36	13.89	10.15
2009-10	14.50	15.08	11.03
2010-11	15.67	16.29	11.91
2011-12	20.88	21.70	15.86
2012-13	25.64	26.66	19.48
2013-14	27.72	28.81	21.06

2.2.7 Wild spices

Summary of results and comparison with MOFEC estimates

The estimated value added associated with forest-derived spice production in Ethiopia is presented in Table 18. In 2012-13, forest-derived spice value added is estimated to have been 310 million ETB (USD46 million, 0.04% of GDP). Of this, about 136 million ETB represented in-kind income to households that collected and used their own wild spices. The remaining 174 million ETB represented cash income to collectors.

MOFEC does not make an estimate of the value added of wild spice production due to lack of data (Metaferia, 2015). This is an area where the ESNA requires improvement.

Table 18: Value added of forest-derived spice production

Year	Korerima	Long Pepper	Total Value Added		Share of GDP
	million ETB		million ETB	million USD	per cent
2005-06	75	10	85	40	0.08%
2006-07	84	11	96	41	0.07%
2007-08	99	13	112	42	0.06%
2008-09	143	19	162	48	0.06%
2009-10	155	21	175	42	0.05%
2010-11	167	22	190	45	0.05%
2011-12	223	30	253	51	0.05%
2012-13	274	37	310	46	0.04%
2013-14	296	39	335	50	0.04%

In Ethiopia, the four most important spices are ginger, turmeric, cumin and korerima; respectively, these spices represent 65%, 15%, 8% and 3% of the national spice market (Meaton *et al.*, 2014). Spices of known forest origin are limited to korerima (also referred to as Ethiopian cardamom) and long pepper (*piper capense;* also known as timiz) (Avril, 2008; Gole, personal communication, 2015). Chili pepper has spread to the wild and may be collected in some regions such as Gambella, though the extent to which this occurs is unknown (Avril, 2008; Gole, personal communication, 2015).

Overall, few studies have attempted to estimate the value added of spice production in Ethiopia and even fewer have focused specifically on spices derived from forests. Data on production volumes are limited and prices are known to vary significantly both regionally and seasonally (Avril, 2008; Gole, personal communication, 2015).

According to Yimer (2010), between 2006 and 2010, production of all spices in Ethiopia (wild and cultivated) reached 244,000 tonnes annually. In the absence of other production estimates, this figure is assumed to apply to the entire period from 2003-05 to 2012-13.

Meaton *et al.* (2014) state that korerima represents 3% of the national spice market. No data on the share of long pepper production were found. Assuming that long pepper is less important that korerima, long pepper is assumed to account for 1% of the national spice market. Though the majority of korerima and long pepper are harvested from the forest, they are also cultivated in some areas (Avril, 2008; Gebreazgaabher *et al.* 2014). In the absence of other evidence, 90% of both korerima and long pepper are assumed to be derived from forests (authors' judgement).

In 2007, the farm gate price of long pepper was between 5 and 7 ETB per kg (Avril, 2008). Using the average of these prices (6 ETB per kg) adjusted for inflation, a price time series for 2003-04 to 2012-13 was produced.

In general, the price of korerima is higher than that of other spices (Gole, personal communication, 2015; Jansen, 2002). Using data from the CSA, Avril (2008) put the market price of korerima at just below 20 ETB per kg in 2007. The farm-gate price of korerima was assumed (authors' judgement) to be 75% of the market price, or 15 ETB per kg in 2007. This figure was adjusted for inflation to produce the time series shown in Table 18.

Wild spice production contributes to both cash and in-kind income for collectors. The share of in-kind income is estimated to be about 44% of the total based on data from Yimer (2016) on subsistence use of wild spices.

2.2.8 Thatch

Summary of results and comparison with MOFEC estimates

The estimated value added associated with forest-derived thatch production in Ethiopia is presented in Table 19. In 2012-13, forest-derived thatch value added is estimated to have been 706 million ETB (USD106 million; 0.08% of GDP). Of this, about 621 million ETB represented in-kind income to households that collect and use their own thatch. The remaining 85 million ETB represented cash income to collectors that sell thatch.

MOFEC estimates the value added of thatch production but combines it with the value added of bamboo (see Section 2.1.1) and "other" non-timber forest products, which is attributed to the forestry industry. In total, MOFEC's estimated value added for these products in 2012-13 is 464 million ETB, which is considerably lower than the combined value added of bamboo and thatch estimated here (172 million ETB + 706 million ETB = 878 million ETB). MOFEC's estimate of thatch value added is acknowledged to require improvement (Metaferia, 2015), as it is compiled indirectly using data on the stock of houses in rural and urban areas and assumptions regarding the quantity of thatch used annually. Data on the actual quantities and prices of thatch are not available to MOFEC.

Table 19: Value added of forest-derived thatch

Year	Value added		Share of GDP
	million ETB	million USD	per cent
2010-11	468	95	0.09%
2011-12	518	80	0.07%
2012-13	706	106	0.08%
2013-14	885	121	0.08%

2014-15	978	n/a	n/a

Valuation method

In rural Ethiopia, thatch products are an important construction material. A 2012 study by the CSA in cooperation with the World Bank (Central Statistical Agency and World Bank, 2013) found that 52.2% of rural households continue to use thatch as their roofing material.

Assuming an average rural house size of 5 metres in diameter with a thatch roof 2.5 metres high and 0.3 metres thick, the volume of thatch required for an average house is about 14.2 m^3. Using Yimer's (2016) estimate of 11.7 million rural households dependent on forest resources and the figure of 52.2% quoted above as the share of rural households that are thatched, this implies a total thatch requirement of 87 million m^3. Using a density of pressed hay (similar to thatch) of 0.275 tonnes/m^3 (The Meter, no date) this translates to 23.9 million tonnes of thatch.

Yimer estimates that the annual extraction of thatch by the average rural household in 2014-15 was about 66.2 kg. This amounts to 775,000 tonnes when multiplied by Yimer's estimate of the number of rural households dependent on forest resources (11.7 million). This would imply the complete replacement of the thatched roofs on the current stock of rural Ethiopian homes about once every 30 years. This rate of replacement is consistent with the expected lifetime of thatched roofs in the United Kingdom (Master Thatcher, no date). No data on the expected lifetime of thatched roofs in Ethiopia was found.

Yimer estimates the value added of thatch to be 978 million ETB in 2014-15. The time series in Table 19 has been derived by adjusting Yimer's figure for inflation and data on changes in rural population from the Ethiopian Central Statistical Agency (2013).

Thatch production contributes to both cash and in-kind income for collectors. The share of in-kind income is estimated to be about 88% of the total based on data from Yimer on subsistence use of thatch.

2.2.9 Wild meat

Summary of results and comparison with MOFEC estimates

The estimated value added associated with forest-derived wild meat production in Ethiopia is presented in Table 20. In 2012-13, forest-derived wild meat value added is estimated to have been 461 million ETB (USD69 million; 0.05% of GDP). Of this, about 419 million ETB represented in-kind income to households that captured and consumed their own wild meat. The remaining 42 million ETB represented cash income to collectors.

MOFEC does not make an estimate of the value added of wild meat production due to lack of data (Metaferia, 2015). This is an area where the ESNA requires improvement.

Table 20: Value added of wild meat production

Year	Value added		Share of GDP
	million ETB	million USD	per cent
2010-11	306	62	0.06%
2011-12	339	52	0.05%
2012-13	461	69	0.05%
2013-14	578	79	0.06%
2014-15	639	n/a	n/a

Valuation method

Wild meat is consumed by some rural households in Ethiopia (Obf, 2009; Yimer, 2016), though gathering data on the quantities involved is difficult, as hunting of wild animals other than by licensed trophy hunters is an illegal activity (Yimer, 2016).

Yimer found that an average rural household consumes about 1.09 kg of wild meat per year. This is likely an underestimate, given the reluctance of some households to report consumption of wild meat. Yimer puts a value of 56.3 ETB on this wild meat using prices based on substitute products in local markets, which he equates to a national value added of 639 million ETB.

According to the Central Statistical Agency (2015), the average national retail price for beef was 122.15 ETB/kg in August 2015, while camel meat cost 102.51 ETB/kg. The implicit average price for wild meat from Yimer's survey is, as would be expected for meat captured from the wild, lower than this at 51.2 ETB/kg.

The time series in Table 20 has been derived by adjusting Yimer's 2014-15 figure of 639 million ETB for inflation and data on changes in rural population from the Ethiopian Central Statistical Agency (2013).

Wild meat production contributes to both cash and in-kind income for collectors. The share of in-kind income is estimated to be about 91% of the total based on data from Yimer on subsistence use of wild meat.

2.2.10 Wild edible plants

Summary of results and comparison with MOFEC estimates

The estimated value added associated with forest-derived wild edible plant production in Ethiopia is presented in Table 21. In 2012-13, forest-derived wild plant value added is estimated to have been 257 million ETB (USD39 million; 0.03% of GDP). Of this, about 200 million ETB represented in-kind income to households that collected and consumed their own wild edible plants. The remaining 57 million ETB represented cash income to collectors.

MOFEC does not make an estimate of the value added of wild edible plant production due to lack of data (Metaferia, 2015). This is an area where the ESNA requires improvement.

Table 21: Value added of wild edible plant production

Year	Value added		Share of GDP
	million ETB	million USD	per cent
2010-11	178	36	0.03%
2011-12	193	30	0.03%
2012-13	257	39	0.03%
2013-14	316	43	0.03%
2014-15	349	n/a	n/a

Valuation method

In parts of rural Ethiopia, wild edible plants are an integral component of diets. Wild edible plants are non-cultivated plants with edible portions such as leaves, seeds, fruits, nuts, tubers and roots (Teketay and Eshete, 2004). The consumption of wild edible plants tends to be more prevalent in food insecure areas, where the plants can be a source of emergency, supplementary or seasonal food (Lulekal *et al.*, 2011). Wild edible plants are generally collected and consumed by the same individuals, meaning there are few transactions associated with their use. Research on wild edible plants to date has focused mainly on the geographical distribution, ethnobotanical properties and various uses of the resource base. Information regarding quantities of wild edible plants consumed is limited (Teketay and Eshete, 2004) and difficult to collect (Yimer, 2016). There is some evidence that wild plant consumption is mainly of wild fruits by children while playing or herding cattle (Yimer, 2016).

Yimer (2016) found that an average rural household collects 3.84 kg of wild plants annually for subsistence use and another 1.49 kg for sale in local markets, for a total of 5.33 kg. Yimer puts a value of 23.9 ETB per household on these wild plants using prices based on substitute products in local markets, which he equates to a national value added of 349 million ETB.

According to the Central Statistical Agency (2015), the average national retail prices for fresh vegetables ranged from 3.00 ETB/kg (pumpkin) to 75.03 ETB/kg (garlic) in August 2015. Fresh fruit prices ranged from 6.58 ETB/kg (cactus) to 75.42 ETB/kg (grapes). The implicit average price for wild edible plants from Yimer's (2016) survey is 4.49 ETB/kg, which falls near the bottom of the range of the CSA retail prices, as one would expect for food collected from the wild.

The time series in Table 21 has been derived by adjusting Yimer's 2014-15 figure of 349 million for inflation and data on changes in rural population from the Ethiopian Central Statistical Agency (2013).

Wild edible plant production contributes to both cash and in-kind income for collectors. The share of in-kind income is estimated to be about 78% of the total based on data from Yimer on subsistence use of wild edible plants.

2.2.11 Civet musk

Summary of results and comparison with MOFEC estimates

The estimated value added associated with forest-derived civet musk production in Ethiopia is presented in Table 22. In 2012-13, forest-derived civet musk value added is estimated to have been negligibly small at 405,000 ETB (USD66,000; <0.01% of GDP).

Civet musk production is assumed to contribute only to cash income for collectors, as its use is almost entirely in the perfume industry.

MOFEC does not make an estimate of the value added of civet musk production. This is an area where the ESNA arguably requires improvement, though the value added is so small as to make an essentially negligible contribution to national income.

Table 22: Value added of civet musk production

Year	Value added		Share of GDP
	ETB	USD	per cent
2009-10	229,000	59,000	<0.01
2010-11	248,000	67,000	<0.01
2011-12	330,000	63,000	<0.01
2012-13	405,000	66,000	<0.01
2013-14	438,000	64,000	<0.01

Valuation method

The musk from male civet cats is a valuable input in the global perfume industry. In Ethiopia, civet farms account for the bulk of musk production (Taye, 2009). In some areas of southwest Ethiopia, however, farmers capture civets from forested areas, collect the musk and release the animals back into their natural habitat (Taye, 2009).

To estimate the value added of forest-derived civet musk, an estimate of gross output for the whole industry from Lemenih (2008) was adjusted for inflation to establish a times series. Based on author's judgement, 15% of civet musk is assumed to derive from forest resources. Intermediate inputs are assumed equivalent to 20% of gross output.

2.2.12 Silkworm cocoons

Silkworm production is a nascent industry in Ethiopia. The species of silkworm cultivated in Ethiopia (eri silkworm) feeds on the leaves of the castor oil plant, which are available from Ethiopian forests.

MOFEC estimated the value added of silkworm production in 2010-11 to be very small at 500,000 ETB. None of the research conducted for this study revealed data or methods that could improve upon this estimate.

2.2.13 Dyes and tannins

Historically in Ethiopia, natural dyes originating from plant resources were used for a variety of purposes. Today, relatively few people in the country possess experience with traditional dyeing methods. Limited research has been conducted to identify dye-yielding plants, though it is thought that these plants are numerous (Kechi *et al.*, 2013). No estimate of the value added associated with this production was possible for this study as a result.

3 The economic value of forest regulating services

Summary of results

Table 23 summarizes the estimates of the value added associated with regulating services provided by Ethiopia's forests. In total, these services contributed about 11.7 billion ETB to national income in 2012-13 (USD1.8 billion; 1.35% of GDP).

The most valuable of the services are found to be the pollination of crops (5 billion ETB) and the control of erosion on cropland (6.6 billion ETB). Carbon sequestration is found to be negligibly small at the moment, though it may have significant future potential. Insufficient data were available to estimate the value of water flow control and control of sedimentation in reservoirs.

All of these services, other than carbon sequestration, are already implicitly included in MOFEC's estimate of GDP but they are not attributed to the forestry industry. Rather, they form part of the value added attributed to the crop agriculture and electricity and water industries, the vast majority to the former. Carbon sequestration is currently a gap in the ESNA. While not serious today (since income from carbon sequestration is negligibly small), this gap will require filling if payments for emissions reductions through REDD+ and other mechanisms become important in the future (see Footnote 27 for a possible treatment of this service).

Table 23: Summary of results - Regulating services

Service	Contribution to national income, 2012-13			Currently measured in Ethiopian SNA?				Income type			
				Yes		No		Direct		Indirect	Non-market
	million ETB	million USD	Share	Directly	Implicitly	Data gap	Out of scope	Cash share	In-kind share		
Carbon sequestration	2.8	0	<0.01%			X		100%	0%		
Pollination	5,013	752	0.58%		Crop agriculture					X	
Water flow control	n/a	n/a	n/a		Crop agriculture, electricity and water					X	
Soil erosion control	6,647	996	0.77%		Crop agriculture					X	
Reservoir sedimentation control	n/a	n/a	n/a		Electricity and water					X	
Total, regulating services	**11,663**	**1,751**	**1.35%**								

3.1 Forest carbon sequestration

Summary of results and comparison with MOFEC estimates

The estimated value added associated with forest carbon sequestration in Ethiopia in 2012-13 is 2.8 million ETB (USD430,000; <0.01% of GDP).

All of this value added is in the form of cash income.

MOFEC does not make an estimate of the value added of carbon sequestration. This is an area where the ESNA requires improvement even though the value added is currently so small as to make an negligible contribution to national income.[27]

Carbon sequestration in Ethiopia

Carbon sequestration by Ethiopian forests has the potential to contribute to the Ethiopian well-being in two ways. First, sequestration of carbon in Ethiopian forests (as with all global forests) plays a part in limiting the build-up of CO_2 in the atmosphere, thereby slowing the rate of climate change. To the extent that Ethiopians' well-being is threatened by climate change, the role Ethiopia's forests play in limiting it represents an indirect contribution to this well-being. Any such contribution will be minor however. Ethiopia's forests represent just a small share of global forests and the benefits of their carbon sequestration are enjoyed by all global citizens and not just Ethiopians. In addition, the impacts of climate change on Ethiopian's well-being are uncertain at this point, since the changes are just beginning to manifest themselves. For these

Text Box 1 - Humbo and Soddo CDM Project

The *Humbo and Soddo Community-Based Natural Regeneration Project* is a Clean Development Mechanism (CDM) initiative located in Southern Nations, Nationalities, and People's Region (SNNPR) state. The project, initiated in 2004, involves the rehabilitation of degraded forestland to sequester carbon and provide a variety of other community benefits (greater availability of non-timber forest products, for example). The project was the first carbon sequestration project in Ethiopia and the first forestry CDM project in Africa (Cross and McGhee, 2015).

About 888,000 tonnes of CO_2 is expected to be sequestered at the site over 30 years, generating certified emission reduction credits. The World Bank's BioCarbon Fund has committed to purchasing 165,000 tonnes worth of these credits and will pay close to US$826,000 (USD5 per tonne) to the local communities over a minimum of ten years. Further revenue will be available to the community from the sale of the remaining carbon credits not purchased by the World Bank on the secondary carbon market, as well as from the sale of timber products from designated woodlots in the project area (Serkovic, 2013).

To date, 2,728 ha of degraded forest have been rehabilitated and improved practices have been implemented on a further 700 ha of managed forest (Cross and McGhee, 2015). As of July 2013, the project had generated USD148,659 in income for the local community and an additional USD174,000 was expected (Tefera, 2013).

[27] As noted below, it is possible that the value added of carbon sequestration will be substantial in the future if Ethiopia begins to receive significant international payments for certified greenhouse gas emissions reductions. For this reason, consideration should be given to the proper treatment of these payments in the ESNA even if they are today negligible. Though this question was not considered in detail for this study, a reasonable approach may be to consider such payments as exports of services derived from Ethiopia's forest asset. In this case, the full value of the exports in any given year (that is, the total payments received that year) would add to national income.

reasons, no effort has been made to try to quantify the indirect impact of carbon sequestration on Ethiopian's well-being in this study.

Much more important than the indirect well-being impact of carbon sequestration – at least in the short term – is the potential for Ethiopia to gain foreign income in return for increasing the rate at which carbon is sequestered in its forests or decreasing the rate at which it is emitted due to deforestation. Such results-based payments (RBP) represent a potentially source of forest-derived income for Ethiopia.

At the moment, payments for emissions reductions are negligible in the Ethiopian national context. Only one project is currently operational in the country (see Text Box 1 above) and it had generated just 2.8 million ETB as of 2013, all of which flowed to local communities in SNNPR state (for which the project undoubtedly has significant benefits). Since carbon sequestration is not a significant source of income for Ethiopia today, and given the inherent uncertainty about future income (which is both related to potential availability of finance for results-based payments and the ability of Ethiopia to generate verified results of emission reductions or removals), it is not considered further in this report.

3.2 Forest pollination

Summary of results and comparison with MOFEC estimates

The estimated value added associated with the forest pollination service in Ethiopia is presented in Table 24. In 2012-13, the estimated value added associated with forest-derived pollination services is about 5 billion ETB (USD752 million; 0.58% of GDP).

Forest pollination does not result in direct cash or in-kind income. Rather, the associated income is generated when farmers sell crops (cash income) or consume those crops themselves for subsistence purposes (in-kind income).

As an indirect income source, MOFEC makes no estimate of value added from pollination. However, this income is captured implicitly in MOFEC's measure of the value added of the crop agriculture industry. The value added of pollination estimated here for 2012-13 accounts for about 2.1% of crop agriculture value added in that year.

Table 24: Value added of forest-derived pollination, by crop - 2012-13

Crop	Value added	Share of GDP	
	million ETB	million USD	per cent
Avocado	68	10	0.01%
Citrus	5	1	<0.00%
Coffee	3,156	473	0.36%
Ground nuts	86	13	0.01%
Mango	157	24	0.02%
Rapeseed	122	18	0.01%
Safflower	2	0	<0.01%
Other oil seeds	462	69	0.05%
Seed cotton	209	31	0.02%
Sesame seed	530	79	0.06%
Soy bean	216	32	0.02%
Total	**5,014**	**752**	**0.58%**

The role of forests in pollination

Both managed and wild pollinators[28] are declining in abundance and diversity worldwide, raising fears of a pollination crisis. Managed honey bees have been dying off due to disease and colony collapse. The main threat to wild pollinators is the loss of habitat.

Pollinators play an important role in plant reproduction. While many plants are capable of self-pollination, the majority depend to some extent on animal pollinators. A loss in the diversity and abundance of pollinators can lead to a parallel loss of plant diversity and abundance.

Animal pollination is an important ecosystem service for agricultural production. Pollinators can improve the quality and quantity of many crops – even those that are capable of self-pollination – increasing yields and farmer incomes as a result. A wide variety of agricultural crops would decline in productivity in the absence of animal pollination, including some 70% of the 1,330 crops grown in tropical regions. Of the 57 major crops worldwide, 39 benefit to some degree from animal pollination. Crops that depend on animal pollination include fruits, vegetables, nuts and oil seeds (Aizen *et al.*, 2009).

Many of the crops that rely on animal pollination, including coffee, have relatively high market prices and are important to regional economies. The production of crops reliant on pollinators is also increasing faster than the production of crops that are not reliant on pollination (Aizen *et al.*, 2009). This creates a worrying scenario for future agricultural production should pollinator abundance and diversity continue to decline.

The use of managed honey bee colonies has become common for pollinating monoculture crops. The economic value of managed honey bees is easily estimated, as there are markets where bee colonies can be hired for pollination. However, wild pollinators also play an important role in the pollination of many crops that should not be ignored when estimating the economic value of pollination. Visits by diverse wild pollinators are beneficial to many crops, leading to more uniform quality and greater quantity (Klein, 2009). A recent study by Kleijn *et al.* found that wild bees contributed about the same economic value as managed bees worldwide (Kleijn *et al.*, 2015). For some crops, such as coffee, wild bees are more effective pollinators than managed bees (Klein *et al.*, 2007)

Retaining the services of wild pollinators requires that natural habitat is maintained within agricultural landscapes. Pollinators have a limited foraging range and depend on natural habitat to nest and feed. Declines in wild bees in agricultural landscapes have been linked to loss of natural habitats that provide feeding and nesting ground (Klein *et al.*, 2007).

Valuation method

The economic value of wild pollination is captured in the market value of the crops that rely on it. Unlike managed pollination, however, it is not revealed by the market since no payment is made for wild pollination services. This value represents the contribution to agricultural output of the ecosystem that provides the pollinators' habitat. In the case of forest-based pollinators, it is a forest ecosystem service at work.

[28] Wild pollinators are mainly insects of various types but other animals such as birds and small mammals also act as pollinators in some cases.

A number of studies have attempted to determine the economic value of pollination. These studies generally estimate the value of pollination based on the productivity gains realized by farmers. Pollination increases yields, which in turn increases income. Early studies used the total value of crops dependant on pollinators to estimate economic value (Gallai *et al.*, 2009).

A more nuanced approach is to calculate dependence ratios, found by comparing the yield and quality of crops exposed to pollinators to those separated from pollinators. It is important to consider the degree to which individual crops depend on pollination, as crops are affected to varying degrees. The most complete study of pollinator dependence ratios is that by Klein *et al.* (2007). These authors conducted a meta review of pollination studies around the world and quantified the pollinator dependence of agricultural crops into four categories: little dependence (0-10%), modest dependence (10-40%), great dependence (40-90%) and essential (90-100%).

Estimating the value of wild pollinators requires knowledge of the foraging range of wild pollinators and the ratio of wild to managed pollinator visits for each crop. Ricketts *et al.* (2004) found that pollinator richness and number of visits both decline with distance from nesting areas. For instance, wild bumblebee visits to rapeseed fields declined significantly beyond 750 metres from nests. Visits from wild honeybees to coffee crops declined significantly beyond 1000 metres from forest blocks. For this study, wild bees in Ethiopia are assumed to forage over a range of 1 kilometre.

Ideally, the proportion of visits of wild pollinators to a crop is also taken into account when estimating the value of wild pollinators. Doing so ensures that the value of managed pollinators is not incorrectly assigned to wild pollinators. There are few studies on pollinator visits in Ethiopia that would allow this. In the absence of data on pollinator visits, all pollination within 1 kilometre of Ethiopian forests is assumed to be done by wild pollinators. Managed honey bees are less prevalent in developing countries, including Ethiopia (Kasina *et al.*, 2009). Beekeeping in Ethiopia still relies largely on wild honeybees and a majority of beekeepers still use traditional forest-based methods. Hives made from bark or bamboo are hung in trees, which are then inhabited by wild swarms. Little if any management is given to these swarms throughout the year (Bezabeh, 2003).

Data for Ethiopia

Estimating the value of wild pollinators requires data on crop production, prices, pollinator dependence and area of cropland within 1 kilometre of forests. Eleven crops in Ethiopia that are both dependent on pollination and have good data availability were identified: avocado, citrus, coffee, ground nuts, mango, oil seeds, rapeseed, safflower, seed cotton, sesame and soy bean. Data for these eleven crops are presented in Table 25.

Table 25: Crops reliant upon pollination, 2012-13

Crop	Pollinator dependence (%)	Production (tonnes)	Price (ETB/tonne)	Cropland within 1 kilometre of forest (%)
Avocado	65	25,633	4,370	84
Citrus	5	54,063	2,318	84
Coffee	25	373,980	40,180	84
Ground Nuts	5	124,419	15,000	92
Mango	65	69,751	4,130	84
Oil Seeds (nes)	25	212,416	10,740	81
Rapeseed	25	73,110	8,230	81
Safflower	5	13,279	4,543	81
Seed Cotton	25	104,000	10,740	75

Sesame	25	181,376	14,420	81
Soy Bean	25	63,653	15,770	86

Pollination dependence was determined by taking the mean of each dependence ratio range from Klein *et al.* (2007) (see Annex 3 – Pollination dependence ratios). Production and price data are from FAOSTAT (2015), with the exception of coffee, for which production and price data for coffee are from the International Coffee Organization (no date) and the Central Statistical Agency (2011b). Where price data did not exist (citrus and safflower), prices were estimated using the producer price index as suggested by the FAO. Price data for oil seeds and seed cotton were estimated as an average of other oil crops (rapeseed, safflower, sesame, and soy bean) as suggested by the FAO. Analysis was carried out by UNEP-WCMC to assess the area of cropland within 1 kilometre of forests. Cropland extent was extracted from the 2013 Ethiopia land cover map (Ethiopian Mapping Agency, 2013). The SPAM global spatial dataset of crop production statistics (MAPSPAM, no date) was used to select pixels from the 2013 EMA land cover map to determine the area of each crop (see Figure 4).

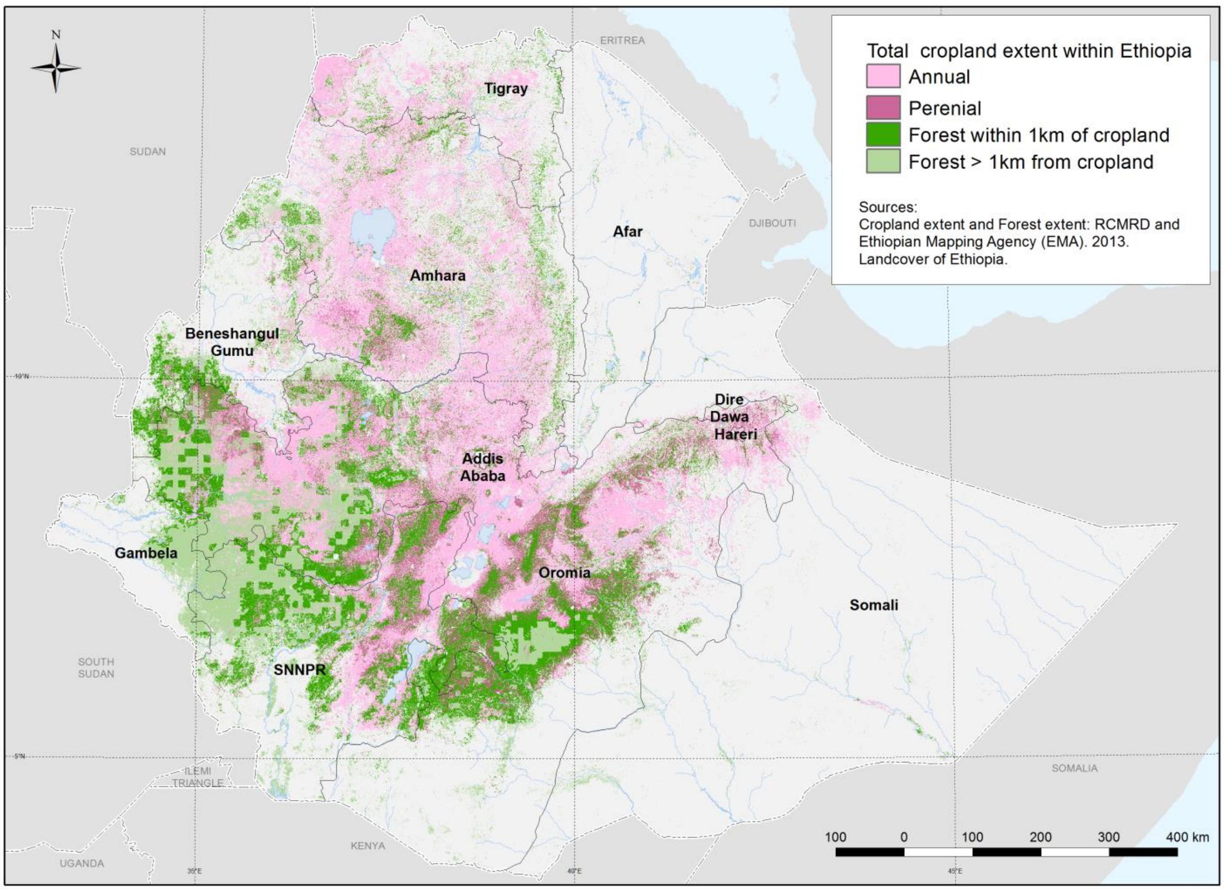


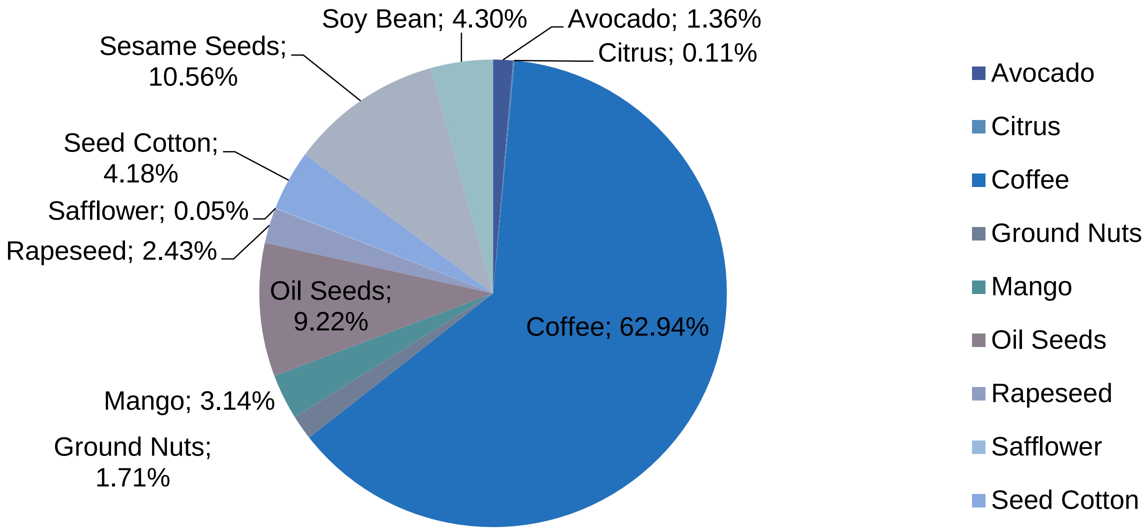
Figure 4: Relationship between cropland and forestland in Ethiopia

Results

The total value of forest-derived pollination services in Ethiopia in 2012-13 is estimated to have been 5,014 million ETB (Table 24 above). The shares of different crops are given in Figure 5. Pollination of coffee by forest-based pollinators was by far the largest contributor to the total value at 3,155 billion ETB, or 63% of the total. This was due to both the relatively high price of coffee and large quantity of production.

Pollination of citrus and safflower contributed the least to the total value of pollination due to low prices, low levels of production and little dependence on pollinators. Despite relatively high prices and production levels, ground nuts also contributed little to the overall value of pollination due to a low dependency ratio. Avocado and mango had the highest dependency ratios (65%). However, they contributed relatively little to the total value of pollination due to relatively low prices and levels of production.

Figure 5: Value added of forest-derived pollination services, share by crop - 2012-13



3.3 Water flow control

No estimate of the value of water flow control was possible for this study due to insufficient data.

Forests and water flow control

Control of the level of lakes, rivers, streams and groundwater is an important forest ecosystem service. Drinking water, sanitation, hydroelectricity production and irrigation all rely on adequate supplies of water.

In the highlands of Ethiopia, where 25 million people with predominately agrarian livelihoods live, 82% of the annual rainfall falls in a period of 3 to 4 months. Reliable water flows to support irrigation in the dry season are, therefore, key to highland agriculture. Farmers can produce crops two or three times a year with sufficient water but only once a year without irrigation (Gebrehiwot, 2015). Water availability during the dry season also limits hydroelectricity production, as hydroelectric dams require certain water levels to maintain output (Guo *et al.*, 2007).

Seasonal distribution of rainfall is often more important than overall rainfall in areas with rainfall that varies significantly over a year, such as Ethiopia (Bruijnzeel, 2004). High rainfall in certain seasons accompanied with agricultural activities on steep slopes can exacerbate soil erosion. This, in turn, can further increase the seasonality of water flows, as soil is important for storing rain water. Water regulation is particularly important in regions with starkly contrasting wet and dry seasons.

Conservation and expansion of forests is seen as a way to regulate water flows. Forests are often thought of as sponges, soaking up water during the wet season and releasing it during the dry season. However, short-term studies performed in tropical regions have found that water yield may actually increase during the dry period after forests have been cleared, the opposite of what is expected by the view of the forest as a sponge. Forest clearing could therefore have a potentially positive economic impact on irrigation and hydroelectricity production, at least in the short term. Over the longer term, it is possible that dry season flows may be reduced as a result of forest clearing, as soil erosion and compaction, overgrazing and the construction of roads and settlements reduce the ability of the soil to store water (Bruijnzeel, 2004). Ultimately, the connection between forest cover and dry season flows is uncertain. There is even greater uncertainty regarding the impact of deforestation on dry season water flows when forest cover change is due to degradation or selective thinning rather than clear cutting (Gebrehiwot, 2015). In a review of the connection between forest cover and water yield in the highlands of Ethiopia, Gebrehiwot (2015) found an inconsistent relationship between land cover and water flows at an intermediate scale.

Given that the role of forest cover in regulating water flows is highly context specific – depending as it does on soil structure, rainfall and slope – it is difficult to generalize about the economic value of water regulation services. Connecting forest cover with water flows can only be accomplished with detailed local studies. For this reason, the economic value of forest water regulation in Ethiopia has not been estimated for this study.

3.4 Soil erosion control on cropland

Summary of results and comparison with MOFEC estimates

The estimated value added associated with forest soil erosion control on cropland in Ethiopia in 2012-13 is 6,647 million ETB (USD997 million; 0.9% of GDP).

Forest soil erosion control does not result in direct cash or in-kind income. Rather, the associated income is generated when farmers sell crops (cash income) or consume those crops themselves for subsistence purposes (in-kind income).

As an indirect income source, MOFEC makes no estimate of value added from soil erosion control. However, this income is captured implicitly in MOFEC's measure of the value added of the crop agriculture industry. The value added of the forest-derived soil erosion control service estimated here for 2012-13 accounts for about 2.7% of crop agriculture value added in that year.

Forests and soil erosion control

Forests perform the important ecosystem service of protection of soil from erosion. Soil erosion reduces the quality of soil, which can result in reduced productivity in both agricultural and forest systems. Soil erosion also increases the level of sediment in water bodies, including reservoirs. Sediment build up can reduce the productivity of hydroelectric dams, irrigation reservoirs and add to the cost of cleaning drinking water. The economic value of soil protection can be estimated by looking at the value derived from protecting the productivity of agricultural land and the benefit gained from avoided sedimentation of reservoirs.

Wind and rain are the primary causes of soil erosion and their impact is increased on hills and mountainsides. Plant cover, including forests, protects soil from erosion by providing a shield against wind and rain. Tree canopies block rain and the litter layer found on forest floors helps to minimize surface erosion. On sloped terrain, the root system of trees helps hold soil in place, reducing the chance of landslides and overall soil loss (Pattanayak, 2004).

Clearing forest for agricultural and pasture land speeds up soil erosion as the land is worked and disturbed. Over time, this reduces agricultural productivity, resulting in lost income. Soil erosion is especially problematic in developing countries where deforestation is widespread and soil-conserving agricultural practices are not always in place. Erosion rates are particularly high in areas where steep land has been converted to agricultural land in order to replace previously degraded land (Pimentel, 2006).

Soil erosion is a major threat to agricultural productivity. Roughly 80% of the world's agricultural land suffers moderate to severe erosion and more than 30% of it has become unusable due to erosion. Small farms in developing countries often face the most severe soil erosion, as they are often located on marginal land with poor soil quality and steep slopes (Pimentel, 2006).

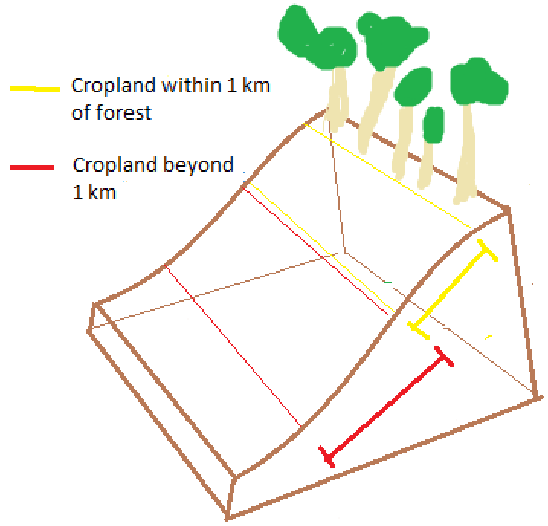
Soil erosion reduces the fertility of the land, which in turn reduces yields and income. Nitrogen, phosphorous, potassium and other vital nutrients are washed away with the soil. Soil that is washed away typically contains three times as much of these nutrients as soil that remains. Nutrient deficient soils typically reduce yields by 15% to 30% (Pimentel, 2006). Farmers can offset some of these nutrient losses, and the resultant productivity losses, by the application of fertilizers. However, the production and application of fertilizer can have environmental costs of its own and fertilizer may not be affordable for poor farmers.

A majority of the cultivated land in Ethiopia is located in the highlands. Soils in this region are diverse, from stony soils in the mountains to deeper, more fertile soils in the hills. The majority of farms in Ethiopia are small scale, subsistence operations that make little use of inorganic fertilizer (World Bank, 2007). These farms are particularly at risk of lost productivity from soil erosion. Protecting existing soil by maintaining existing forest, particularly forest upslope of agricultural land, is one option for maintaining the productivity of these farms.

Valuation method

To estimate the economic value of forest soil erosion control, the web-based policy support tool WaterWorld (Mulligan, 2013) was used by UNEP-WCMC in combination with the EMA land cover dataset (Ethiopian Mapping Agency, 2013) to model soil erosion. Soil erosion was modelled for each watershed basin in Ethiopia in physical terms (tonnes/hectare) for the current (baseline) situation and a scenario in which all forest is removed. The difference in erosion between the two scenarios is taken to be the size of the soil erosion control service currently offered by Ethiopian forests.

Figure 6: Forest erosion control on downslope cropland



Soil erosion on cropland was categorized using 4 different slope classes (FAO, 2006): 0-5%, 5-15%, 15-30% and > 30%. Soil erosion on all cropland was modelled for both the baseline and the deforested scenario.

The modelling distinguished between cropland found within 1 km of forest and cropland further away, as soil erosion control is greatest near to forests (Figure 6). When forests are cleared, erosion increases for all slope classes on cropland within one kilometre to a much greater extent than on more distant cropland. The majority of cropland in Ethiopia is found within one kilometre of forested land.

The value of forest soil erosion control is estimated as the difference in soil erosion on cropland between the deforestation scenario and the baseline scenario (tonnes) multiplied by the cost of crop productivity loss in Ethiopia (ETB/tonne). This cost has been estimated to vary from ETB 0.35/tonne to ETB 0.73/tonne, with an average value of ETB 0.395/tonne (World Food Program Ethiopia, 2005).

Results

Results of the soil erosion modelling are presented in Table 26.

Table 26: Agricultural land erosion data

	Slope Class (%)	Area (ha)	Baseline scenario		Deforested scenario	
			Erosion rate (tonnes/ha)	Soil loss (thousand tonnes)	Erosion rate (tonnes/ha)	Soil loss (thousand tonnes)
Cropland within 1 km of forest	0-5	4,185,290	1.90	7,952	40.0	167,412
	5-15	6,048,500	21.9	132,462	111.6	675,013
	15-30	3,963,900	49.6	196,609	338.1	1,340,194
	>30	2,618,100	185.6	485,919	999.0	2,615,482
Total		**16,815,900**		**822,943**		**4,798,101**
Cropland beyond 1 km	0-5	1,131,430	1.8	2,036	30.6	34,628
	5-15	1,277,800	19.8	25,300	74.4	95,068
	15-30	791,140	52.8	41,772	268.4	212,342
	>30	500,540	144.0	72,078	878.4	439,674
Total		**3,700,900**		**141,187**		**781,706**

The difference in soil loss due to erosion between the baseline and deforested scenarios is 4,615,677 thousand tonnes, of which 3,975,158 (4,798,101 – 822,943) thousand tonnes occurs on cropland within 1 km of forest and 640,519 (781,706 – 141,187) thousand tonnes occurs on more distant cropland. Using the average 2005 value of 0.395 ETB/tonne for the cost of lost crop productivity noted above, the estimate of the soil protection service provided by forests in Ethiopia, inflated to 2012, is 6,647 million ETB (0.9% of GDP). The vast majority of this value is gained from cropland within one kilometre of forests.

4 The economic value of forest cultural and recreational services

Summary of results

Table 27 summarizes the added value associated with the cultural and recreational services provided by Ethiopia's forests. The most valuable of the services was found to be the non-use benefits associated with forests (2.4 billion ETB). The value of foreign tourists visiting Ethiopia's protected areas is estimated to be 850 million ETB. Trophy hunting had a negligible value of 19 million ETB.

Protected-area tourism and trophy hunting are already implicitly included in MOFEC's estimate of GDP but they are not attributed to the forestry industry. Rather, they form part of the value added attributed to the hotel and restaurant, travel and communications, and public administration industries. The value added of these services accounted for about 0.8% of the combined valued added of those industries in 2012-13, all of which flowed in the form of cash income.

Non-use benefits are conceptually out-of-scope in national accounting because they are not the result of economic activity that takes place within the boundaries of the market. As such, they do not form part of MOFEC's estimate of GDP. Moreover, these benefits are not directly comparable with the other values estimated in this study, as the valuation method they rely upon results in the inclusion of consumer surplus[29] in the estimate. For this reason, the value of non-use benefits are reported separately in Table 27 and not included in the total value of cultural and recreational services. Direct comparison of the value of non-use forest benefits with the other values reported in this assessment is discouraged.

[29] Consumer surplus is the amount that consumers are willing to pay for a good or service over and above what the market charges (or would charge) for it. The methods used by economists to illicit individuals' willingness to pay for non-use benefits of forests often result in the inclusion of consumer surplus in the results. Market prices, on the other hand, eliminate consumer surplus because supply and demand meet at the price determined by the willingness to pay of the marginal and not the average consumer.

Table 27: Summary of results - Cultural and recreational services

Service	Contribution to national income, 2012-13			Currently measured in Ethiopian SNA?				Income type			
				Yes		No		Direct			
	million ETB	million USD	Share	Directly	Implicitly	Data gap	Out of scope	Cash Share	In-kind share	Indirect	Non-market
Protected-area tourism	850	127	0.10%		Hotel and restaurant, travel and communications, public administration			100%	0%		
Trophy hunting	19	3	<0.01%		Hotel and restaurant, travel and communications, public administration			100%	0%		
Total, cultural and recreational services*	**869**	**130**	**0.10%**								
Non-use forest benefits	*2,400*	*360*	*n/a*				*X*				*X*

*Non-use benefits are not included in the total value of cultural and recreational services because they are conceptually inconsistent with the other values reported. Non-use benefits were measured using the results of willingness-to-pay surveys that result in the inclusion of consumer surplus in the estimate. Protected-area tourism and trophy hunting were measured on the basis of market prices, which exclude consumer surplus.

4.1 Protected-area tourism

Summary of results and comparison with MOFEC estimates

The estimated value added associated with protected area tourism in Ethiopia is presented in Table 28. In 2012-13, protected area tourism value added is found to have been about 850 million ETB (USD127 million; 0.1% of GDP), all of which flows as cash income.

MOFEC makes no estimate of value added from protected area tourism. However, this income is captured implicitly in MOFEC's measures of the value added of the hotel and restaurant industry (visitor accommodations and meals), the transportation and communication industry (visitor transportation) and the public administration industry (park entry fees). The value added of protected area tourism estimated here for 2012-13 accounts for about 0.8% of the combined valued added of those industries in that year.

Table 28: Estimated value of protected area tourism, 2010-2013

Year	Ethiopian tourist in-country spending	Foreign tourist in-country spending	Foreign tourist airfare spending	Total value added		Share of GDP
	million ETB			million ETB	million USD	per cent
2010-11	16	100	344	460	94	0.1%
2011-12	18	132	434	584	90	0.1%
2012-13	30	229	591	850	127	0.1%
2013-14	42	278	606	926	127	0.1%

Protected areas and tourism in Ethiopia

Ethiopia is increasingly well known as a tourist destination, having been named in March 2016 as the "World's Best Tourism Destination 2015" by the European Council on Tourism and Trade. The country is home to several world heritage sites[30] and is well known as a destination for cultural tourism. It is increasingly recognized as a destination for eco-tourism as well, though its full potential in this regard has not been realized (van Zyl, 2015). According to Ethiopia's first *International Travel Survey*, conducted in 2013 by the Ethiopian Ministry of Culture and Tourism (Federal Ministry of Culture and Tourism, 2013), half of the foreign visitors to Ethiopia come for leisure and holidaying. Of those, about 29.3% say that nature and viewing wildlife – or eco-tourism – is the main goal of their visit.

In total, some 596,341 foreigners visited Ethiopia in 2012 according to the *Tourist Statistics Bulletin 2009-2012* (Federal Ministry of Culture and Tourism, 2013), suggesting that about 87,400 foreigners travelled to Ethiopia in 2012 for the purpose of eco-tourism. For this study, visits to Ethiopia's protected areas (national parks, wildlife sanctuaries and hunting areas) are assumed to represent the majority of eco-tourism activities in the country. It is unlikely that many eco-tourists, especially those from outside Ethiopia, visit sites lying outside of protected areas.

[30] Eight UNESCO world heritage sites are located in Ethiopia.

According to the Ethiopian Wildlife Conservation Authority, Ethiopia is home to 20 national parks, 2 wildlife sanctuaries, 2 wildlife reserves, 17 controlled hunting areas, 7 open hunting areas and 3 community conservation areas (see Annex 5 – Protected Areas of Ethiopia).

The administration of these sites is shared between the federal and regional governments, with some national parks administered by regional governments (for example, Mago National Park is administered by the government of SNNPRS).

Though not all protected areas are found in heavily forested areas of the country (see Figure 7), all offer the opportunity to experience treed landscapes to some extent (Institute of Biodiversity Conservation, 2005). We therefore treat them all as offering forest-based recreation services for the purposes of this report, acknowledging that this may somewhat overstate the forest-derived income of protected area tourism.

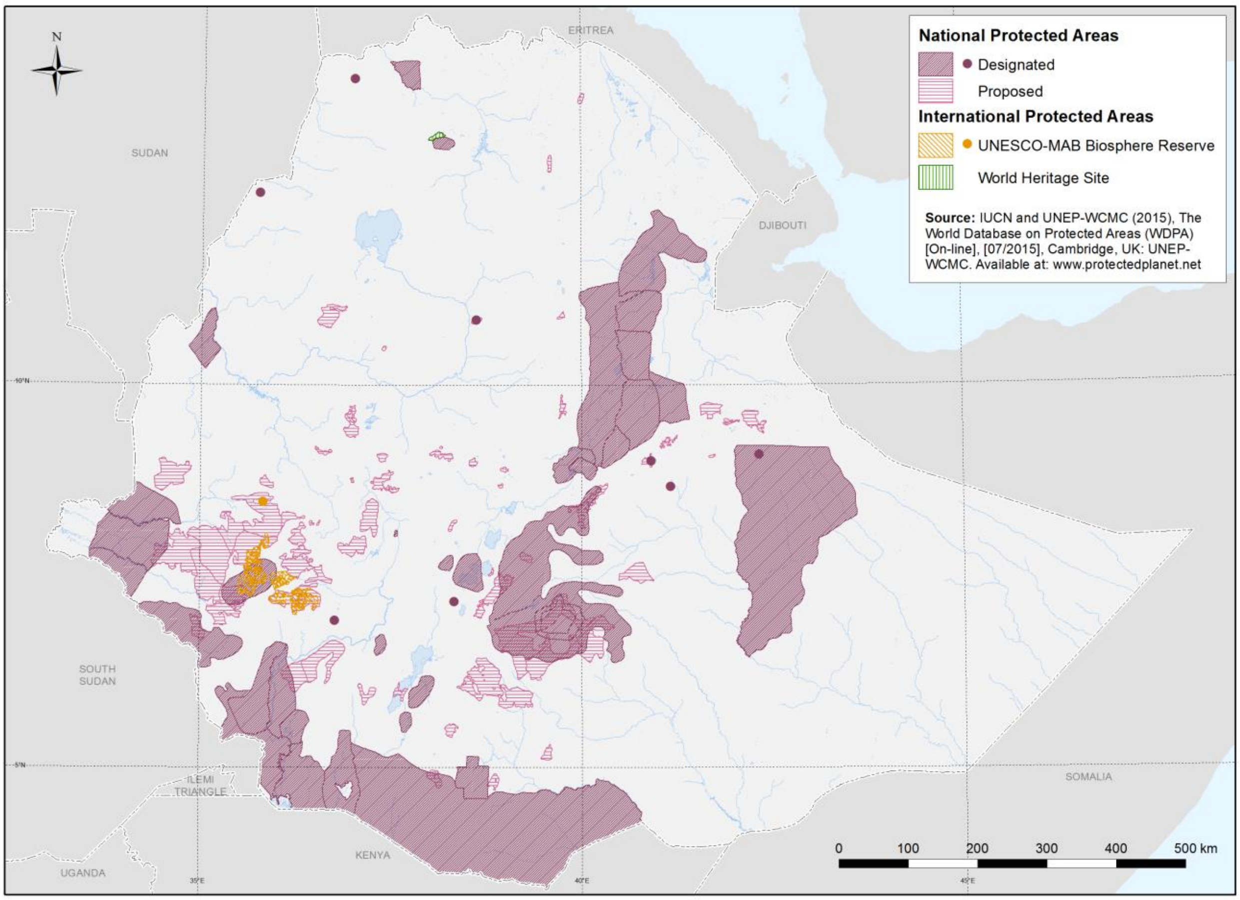


Figure 7: Location of Ethiopia's Protected Areas

Valuation method

Attendance data are available only for a subset of Ethiopia's protected areas. Those areas for which data are available drew 98,637 visitors of all sorts in 2013, the last year for which complete data are available (Mekonnen, A., personal communication). Of these, 51,418 were foreigners and the remainder were either Ethiopian nationals (43,086) or foreign nationals resident in Ethiopia (4,133). Table 29 presents the attendance figures for those protected areas with such data for 2013.

Table 29: Visitors to selected Ethiopian protected areas, 2013

Protected area	Ethiopian citizens	Resident foreign tourists	Foreign tourists	Total
Abijatta-Shalla Lakes National Park	7,637	1,120	7,562	16,319
Awash National Park	4,654	1,148	6,095	11,897
Babile Elephant Sanctuary	119	15	159	293
Bale Mountains National Park	3,122	521	2,278	5,921
Chebera Churchura National Park	50	-	10	60
Gambela National Park	41	3	176	220
Gibe Sheleko National Park	-	7	47	54
Mago National Park	290	-	8,157	8,447
Maze National Park	97	-	7	104
Nechisar National Park	10,427	934	11,385	22,746
Omo National Park	9	-	150	159
Senkelle Wildlife Sanctuary	459	38	670	1,167
Simian Mountains National Park	1,904	347	13,732	15,983
Yangudi-Rassa National Park	-	-	108	108
Total	**28,809**	**4,133**	**50,536**	**83,478**

As noted above, data from Ethiopia's Tourist Statistics Bulletin (Federal Ministry of Culture and Tourism, 2013) suggest that a total of about 87,400 foreigners visited Ethiopia in 2012 for the purpose of eco-tourism, or about 169% of the foreigners who visited the selected protected areas tracked by the EWCA. Assuming that all of 87,400 foreign eco-tourists visited protected areas, the partial protected area visitor data for 2010-2013 provided by the EWCA were adjusted to account for visits to protected areas not covered in the EWCA data (Table 30). Note that the undercount of foreign eco-tourists in the EWCA data is assumed to apply equally to the EWCA estimate of Ethiopian eco-tourists.

Table 30: Estimated total visitors to all Ethiopian protected areas, 2010-2013

Year	Estimated total Ethiopian visitors*	Estimated total foreign visitors
2010	38,400	55,000
2011	40,000	66,800
2012	48,900	87,400
2013	56,200	86,200

*Includes resident foreign nationals

According to the *International Visitors Survey* (Federal Ministry of Culture and Tourism, 2013), the average foreign tourist travelling to Ethiopia for leisure and holidaying of any kind spent USD161 (1074 ETB) per day while visiting the country in 2013. We assume this figure is representative of foreign tourists visiting protected areas. We assume Ethiopian citizens who visited protected areas spent less than this because they faced lower expenses per visit (for example, by bringing their own food rather than eating in restaurants, using their own vehicles rather than purchasing transport and, for those who live close by, using their own accommodations rather than staying in hotels or lodges) and because of the budget constraint imposed by their generally lower level of household income. The figure of 35% of foreign tourist daily spending (376 ETB) assumed by van Zyl (2015) in his study of the value of Ethiopian protected areas is adopted here as the estimate of daily spending by Ethiopian tourists to protected areas. To estimate total in-country tourist spending on protected area visits, each foreign eco-tourist is assumed to spend three days visiting protected areas and each national eco-tourist to spend two days.

In addition to in-country spending, foreign eco-tourists also spend money on travel to Ethiopia in order to visit protected areas. If those travellers come aboard Ethiopian Airlines, the value of their tickets represents an Ethiopian service export and contributes to national GDP. We assume that most tourists traveling to Ethiopia to visit protected areas come from Europe, North America or Asia.[31] Analysis of flight landings at Addis Ababa airport from cities on these continents suggests that the majority of such flights are code-shared flights with Ethiopian Airlines as one of the partner airlines. A few flights are operated solely by Ethiopian Airlines and almost none are operated solely by other airlines. It is difficult to generalize about the sharing of revenue on code-shared flights but since the operating airline bears the majority of the costs it is assumed also to receive the majority of the revenue. Based on airfare data taken from the internet and adjusted for inflation, the average 2013 spending on air travel by these tourists is estimated to be 8,785 ETB per flight, of which 7,028 ETB (80%) flows to Ethiopian Airlines.[32] This cost was deflated by 4% a year to account for the rise in international air travel costs in creating the time series of air travel costs.

Results

Table 28 above shows the estimates of the Ethiopian income generated by eco-tourism from 2010 to 2013, which are the sum of in-country spending on protected area visits by Ethiopian citizens and foreign visitors plus spending on Ethiopian Airlines travel by foreign visitors. In 2012-13, this ecosystem service generated about 850 million ETB (0.1% of GDP).

Tourists who visit a protected area do so for a variety of reasons that might be expressed generically as the “enjoyment of nature”. This enjoyment combines the benefits received from all the ecological attributes of the area: forest landscapes, other landscapes, water bodies and wildlife. Because these attributes combine seamlessly to form the ecosystem the area has been set aside to protect, it is not a simple matter to determine which of the attributes, if any, is the primary reason for a given tourist’s visit. For this reason, no attempt to allocate a portion of expenditures on protected area tourism to the enjoyment of forests has been made. Rather, it is assumed that all of these expenditures represent forest ecosystem benefits. This is justified on the grounds that forests or shrublands are in most, if not all, protected areas the dominant landscape, providing the ecological setting within which the other attributes of the protected area, including wildlife, exist. Though this likely overstates the tourism benefits of forests, particularly for protected areas where trees are less dominant, the overestimation is not likely significant.

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[31] About 28% of foreign visitors to Ethiopia come from other African countries also visit Ethiopia and about 30% of those indicate leisure and holiday as the primary motivation for their visit. No data are available on the share of African leisure tourists who list nature and wildlife as the reason for their visit but most Africans travelling to Ethiopia are assumed do not do so for the purpose of visiting protected areas but to visit cultural or religious sites.

[32] Based on the weighted average of a round-trip economy ticket on Ethiopian Airlines from New York, F**<0.1**rankfurt, Riyadh and Kuala Lumpur, assuming that 28% of tourists arrive from North America, 41% from Europe, 15% from Asia and 13% from the Middle East. This is consistent with data on non-African foreign tourist arrivals for 2012 from the Ethiopian Tourist Statistics Bulletin 2000-2012 (Federal Ministry of Culture and Tourism, 2013).

4.2 Trophy hunting

Summary of results and comparison with MOFEC estimates

The estimated value added associated with trophy hunting in Ethiopia is presented in Table 31. In 2012-13, trophy hunting value added is estimated to have been a negligible 19 million ETB (USD2.9 million; <0.01% of GDP), all of which flows as cash income.

MOFEC makes no estimate of value added from trophy hunting. However, this income is captured implicitly in MOFEC's measures of the value added of the hotel and restaurant industry (visitor accommodations and meals), the transportation and communication industry (visitor transportation) and the public administration industry (trophy fees). The value added of trophy hunting estimated here for 2012-13 accounts for a negligible share of the combined valued added of those industries in that year.

Table 31: Estimated value of trophy hunting, 2008 - 2013

Year	Hunting fees	Safari costs	Airfare costs	Total value added		Share of GDP
	thousand ETB			thousand ETB	thousand USD	per cent
2008-09	1,490	3,700	410	5,600	1,340	<0.01
2009-10	2,190	5,010	470	7,670	1,870	<0.01
2010-11	2,610	5,530	540	8,680	1,760	<0.01
2011-12	4,490	7,150	620	12,260	1,900	<0.01
2012-13	7,960	10,320	700	18,980	2,850	<0.01
2013-14	9,780	11,730	810	22,320	3,060	<0.01

Valuation method and results

Ethiopia has a small industry based on foreign hunting for big game. In 2008, a total of 57 hunters travelled to Ethiopia in search of hunting trophies (Siege, 2010).[33] These hunters were hosted by several outfitting firms specialized in providing trophy hunting services. According to Siege (2010), the foreign income associated with this activity amounted to approximately USD1.53 million in 2008, including trophy fees paid to government and safari costs paid to the outfitters. In addition, spending on airfare by foreign hunters is estimated to add another USD45,000,[34] for a total income of USD1.58 million in 2008. Assuming a 10% annual increase in the number of trophy hunters visiting Ethiopia (authors' judgement) and accounting for inflation, a figure of about 19 million ETB (<0.1% of GDP) is arrived at for the 2012 study base year.

[33] No more recent data on sport hunting could be obtained for this study.
[34] As in the case of eco-tourism, 80% of the value of all air travel to Ethiopia for foreign hunters is assumed to accrue to Ethiopian Airlines.

4.3 Non-use forest benefits

Summary of results and comparison with MOFEC estimates

The estimated economic value[35] of the non-use benefits associated with forests in 2012-13 is 2.4 billion ETB (USD360 million; 0.3% of GDP), all of which flows as in-kind income.

The economic value of non-use forest benefits is conceptually out-of-scope in national accounting and therefore not estimated by MOFEC.

Measuring non-use forest benefits

Non-use benefits of ecosystems are those that do not result from the use, either direct or indirect, of the goods and/or services it provides. Non-use values are derived from the satisfaction individuals derive from the knowledge that ecosystems exist and may be divided into two categories: existence value and option/bequest value. Existence value is that derived from the simply knowledge that an ecosystem exists, even if the beneficiary will never see or use the ecosystem in question. It reflects the belief of many people that ecosystems have inherent value. Option/bequest value is that derived from the knowledge that an ecosystem has been preserved for possible future use, either by the beneficiary (option value) or by an individual in a later generation (bequest value) (Pascual and Muradian, 2010).

Monetary estimates of ecosystem non-use values can be more difficult to derive than use values, as there is no market for the existence of biodiversity. They are generally estimated using so-called “stated preference” valuation methods in which people are surveyed as to their willingness to pay to preserve ecosystems they have no intention of using. The methods used are meant to simulate hypothetical markets (Pascual and Muradian, 2010).

Such surveys are resource intensive and time consuming to administer. For this reason, willingness-to-pay values are often transferred from an ecosystem that has been studied in one region to a similar ecosystem in another region for which non-use values are sought. This is called “benefit transfer”. When transferring values, it is important to account for economic, social, and ecological differences between the target site and the study site. Benefit transfer can be a simple one-to-one transfer of a value between similar locations, or it can make use of value functions that adjust for ecological and socioeconomic differences between locations (Pascual and Muradian, 2010).

Stated preference studies and developing countries

While there has been a rapid increase in the number of studies valuing ecosystems using stated preference methods, the majority of these are undertaken in high- or upper middle-income countries. They are less often carried out in developing countries in part because of their high resource requirements but also because the guidelines for administering such studies were made for application in developed countries.

Literacy and language issues can also increase costs and threaten reliability. For example, differences in languages may result in translation errors and expensive face-to-face surveys are necessary in areas with low literacy. Resource requirements may also be increased by the difficulty of reaching communities in remote locations.

[35] Unlike in the cases of the other values estimated here, the economic value of non-use forest benefits is not referred to as value added, as that term is properly associated only with income derived from market production activities.

Differing types of environmental knowledge among citizens present another constraint for translating stated preference studies to developing country contexts. Knowledge of environmental conditions in developing countries is often personal and developed through direct experience. However, questions in stated preference studies are often designed around a scientific understanding of the environment.

Understanding of and experience participating in markets is another challenge. People in developing countries sometimes rely on subsistence economies and, as a result, may have trouble expressing the importance of environmental conditions in monetary terms.

These and other issues make it difficult to perform stated preference studies in developing countries. When such studies are carried out, they often focus on easier-to-measure use values rather than non-use values (Christie *et al.*, 2012). As a result, many estimates of non-use values in developing countries are transferred from surveys conducted in developed countries or with tourists visiting developing countries.

Benefits transfer comes with its own set of problems. Income levels have been found to impact willingness to pay (Jacobsen and Hanley, 2009), meaning that non-use values should be expected to be lower in developing countries than in developed countries. When transferring non-use values from developed countries, then, it is important to account for differences in income in addition to ecological differences.[36]

Valuation method

For this study, a range of non-use benefits was estimated. The lower estimate is based on a 2008 forest valuation study that administered a contingent valuation[37] survey to 71 households in the Sheka region of Ethiopia (Seyoum, 2007). As it was performed in Ethiopia, this study reflects the forest ecology and socioeconomic realities of Ethiopia. The study found an annual willingness to pay for non-use forest benefits of just 15.19 ETB per hectare in 2005 (55.47 ETB in 2012 prices). The author speculated that the willingness-to-pay value was lowered by the overall low income level in the region. Insecurity of land tenure also had a negative impact on non-use values, as future control of forest land is not guaranteed. As respondents to the survey were unable to differentiate between existence and bequest values, these categories were collapsed into one to avoid double counting.

The upper estimate of non-use benefits derives from a study of global non-use forest values (Chiabai *et al.*, 2010). These authors performed a meta-analysis of a number of contingent valuation studies in order to develop a model describing the relationship between non-use forest values and a variety of ecological or socioeconomic variables. Three variables were found to be significant for non-use values: population, income and forest area. Population and income were both positively correlated with non-use values. As income and population grow, so too do non-use values in general. Forest size had a negative relationship, on the other hand. As forest area shrank, non-use values grew, reflecting the increased value of what remains. Forest type had no significant impact on non-use values; that a forest exists is apparently more important than what type it is.

[36] However, Ready and Navrud (2006) argue that non-use values should not always be adjusted for income when performing benefits transfer. Particularly when considering international policy, common values should be used to avoid the risk of ascribing less value (and potentially less funding) to poorer countries simply because of their lower income. In reality, such countries need more funding, not less, and it is wise to avoid unintended consequences when carrying out ecosystem valuation.

[37] Contingent valuation is a common stated preference method.

The non-use values typically reported in the studies included in the meta-analysis by Chiabai *et al.* (2010) are considerably higher than that reported in Seyoum's (2007) study in Ethiopia. This is explained by the fact that the vast majority of studies considered in the meta-analysis were either done in developed countries or done in developing countries but based on surveys of people from developed countries (tourists).

Results

Transferring the unit non-use value from Seyoum (2007) to all of Ethiopia's forestland (16,223,300 ha) and adjusting for inflation gives a low estimate of the non-use value of forests of about 900,000 ETB in 2012-13.

The meta-analytic study of Chiabai *et al.* (2010) reported an average annual forest non-use value of about USD25 *per capita* in the year 2000 for Africa countries as a whole (240 ETB per hectare in 2012 after conversion from USD and adjustment for inflation). Multiplied by the forest area of Ethiopia, this gives a high estimate of the non-use value of forests of about 3.9 billion ETB in 2012.

The mean of the upper and lower estimates is 2.4 billion ETB.

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Annex 1 – Definition of forest in Ethiopian land cover mapping

The forest land cover area estimates used in this study have been derived from the most recent land cover mapping available from the Ethiopian Mapping Agency (2013). The analysis of the data was carried out by UNEP-WCMC.

Forest land is defined as follows in the EMA dataset:

- A land-use category that includes areas ***at least 3,500m long and/or 0.5 ha in size*** with at least ***10% cover*** (or equivalent stocking) by live trees of at least 2m in height and measuring 5 cm in diameter at breast height (1.3m), including land that formerly had such tree cover and that will be naturally or artificially regenerated.
- Forest land includes transition zones, such as areas between forest and non-forest lands that have at least 10% cover (or equivalent stocking) with live trees and forest areas adjacent to urban and built-up lands.
- Roadside, streamside and shelterbelt strips of trees must have continuous length of at least 3,500 m and minimum area of 0.5 ha to qualify as forest land.
- Unimproved roads and trails, streams and clearings in forest areas are classified as forest if they are less than about 3,500m long or 0.5 ha in size; otherwise they are excluded from forest land and classified as settlements.
- Tree-covered areas on agricultural land, such as fruit orchards, and tree-covered areas in urban settings, such as city parks, are not considered forest land. However, tree-covered areas in urban settings that are restricted or protected areas that meet the forest definition are considered as forest areas.

Forest land is classified into three sub-categories:

- Dense Forest = >80%
- Moderate Forest = 40 – 79%
- Sparse Forest = 20 – 39%

Annex 2 – Inflation and currency conversion rates used

Inflation Rates

Year	Per cent
2005	12.9
2006	12.3
2007	17.2
2008	44.4
2009	8.5
2010	8.1
2011	33.2
2012	22.8
2013	8.1
2014	7.4
Source: Ethiopian Central Statistical Authority	

ETB to USD conversion (market exchange rates)

Year	ETB per USD
2005	8.708
2006	8.741
2007	9.027
2008	9.617
2009	11.484
2010	14.323
2011	16.905
2012	17.73
2013	18.735
Source: XE, no date	

ETB to USD conversion (purchasing power parities)

Year	ETB per USD
2005	2.144
2006	2.321
2007	2.650
2008	3.387
2009	4.173
2010	4.182
2011	4.919
2012	6.453
2013	6.670
Source: World Bank, no date	

Annex 3 – Pollination dependence ratios

Ideally, the dependence ratios found by Klein et al would be supplemented with country specific data. Using the mean of these dependence ratios allows us to calculate the total value of pollination for a particular crop using the equation below:

$$V_{pollination} = P * Y * d * A$$

Where:

$V_{pollination}$ = Economic value of pollination

P = Producer price ($ per tonne)

Y = Yield (tonnes)

d = Dependence ratio

A = percentage of cropland within 1 km of forest

The equation above gives a total value of pollination, including wild and managed honeybees. Ideally, a variation of this equation would be used that takes into account visits by wild versus managed honeybees. With data on pollinator visits, a variation on the equation above could be used:

$$V_{pollination} = P * Y * d * A * p$$

Where all variables are as above and p is the proportion of pollinator visits by a particular bee species, including wild bees.

Annex 4 – Details of soil erosion modelling

Soil erosion modelling was carried out using the WaterWorld model (Mulligan, 2013) using the 30m Ethiopia EMA land cover dataset for 2013. Soil erosion was modelled for a baseline situation and a scenario whereby all forest is removed to assess the impact of forest on soil erosion protection.

The WaterWorld model is a fully distributed, process-based hydrological model that utilizes remotely sensed and globally available datasets but can be supplemented with local data. The model requires 145 input maps representing some 33 variables over a monthly or diurnal cycle. The variables characterize climate, terrain and vegetation. The model comprises modules for rainfall distribution (wind-driven rainfall), cloud cover, water interception by vegetation, solar radiation receipt (corrected for cloud cover), PET and AET based on climate and vegetation cover, subsurface hydrology (infiltration, through-flow, return-flow and groundwater flow) surface flow, snow and ice and wash soil erosion. The model simulates hydrology for four diurnal time-steps representing a mean diurnal cycle for each of 12 monthly time-steps.

The WaterWorld soil erosion module is a full wash erosion, deposition and transportation module. Soil erosion within WaterWorld is modelled for each pixel using the following erosion equation (Thornes, 1990):

$$E=kQ^{m}S^{n}*e^{-0.07*Vc}$$

where:

E = erosion (mm/month)

K = soil erodability

Q = runoff (mm/month)

m = Manning's m value of 1.66)

S = tangent of slope

n = slope constant (2.0), and

Vc = vegetation cover (%).

The model yields values in mm per year.

Annex 5 – Protected Areas of Ethiopia

Several lists of Ethiopian protected areas exist from different sources and it is not clear which is definitive. The Ethiopian Wildlife Conservation Authority (EWCA) provides a list of 52 sites including national parks, wildlife sanctuaries, wildlife reserves, controlled hunting areas, open hunting areas and community conservation areas. The World Database of Protected Areas (WDPA) (Protected Planet, no date) lists 104 sites in Ethiopia including UNESCO biosphere reserves and world heritage sites, national parks, sanctuaries, wildlife reserves, controlled hunting areas and national forest priority areas. A 2009 study conducted for the ECWA by an Austrian consulting firm (Obf, 2009) listed 48 protected areas including national parks, wildlife sanctuaries, wildlife reserves and controlled hunting areas.

There are considerable discrepancies between these lists; for instance:

- the EWCA list of controlled hunting areas bears little resemblance to the WDPA list, though it is quite similar to the OBF list
- the Yabello site is considered a national park by ECWA and a wildlife sanctuary by WDPA and OBF
- EWCA and OBF list a large national park under the name Geraile that does not appear on the WDPA list[38]
- WDPA lists a large wildlife reserve under the name Mille-Sardo that does not to appear on the EWCA list but does on the OBF list
- The OBF list includes a small national park under the name Denkoro Chaka that does not appear on the EWCA list but does on the WDPA list.

There are many other inconsistencies between the three lists that make it difficult to know which is correct and complete. For the purposes of this study, the list provided by the EWCA is assumed to be the most accurate. It is provided in the table below.

Protected area name	Year established	Area (km^2)
National parks		
Abijata-Shalla Lakes	1963	887
Alatish	1997	2666
Awash	1958	756
Bahir Dar Blue Nile River Millennium	2008	4729
Bale Mountains	1962	2200
Borena saynt	2001	4325
Chebera Churchura	1997	1190
Dati Wolel	1998	431
Gambela	1966	5061
Geraile	1998	3558
Gibe Sheleko	2001	248
Kafeta Shiraro	1999	5000

[38] The WDPA list is not itself internally consistent with regard to this park. While there is no park by any name similar to Geraile on the list of Ethiopian protected areas provided by the WDPA, there is in fact a park by the name of Geralle that appears on WDPA's on-line map of Ethiopia's protected areas.

Loka Abaya	2001	500
Mago	1974	1942
Maze	1997	202
Nechisar	1966	514
Omo	1959	3566
Simian Mountains	1959	412
Yabello	1978	2500
Yangudi-rassa	1969	4731
Wildlife sanctuaries		
Abijata-Shalla Lakes	1963	887
Alatish	1997	2666
Awash	1958	756
Wildlife reserves		
Tama	n/a	1,665
Abasheba Demero	1994	210
Adaba-Dodola		
Areba-Gugu	1995	341
Besemena-Odobulu	1993	350
Bilen Hertalie	n/a	1,090
Chifera	1998	510
Dindin	n/a	280
Hanto	1991	190
Haro Abadiko	2000	200
Hurfa Soma	2000	215
Munessa-Kukie	1993	111
Murullie	n/a	690
Shedem Berbere	1988	170
Sororo-Torgam	2000	78
Telalak-Dewe	n/a	457
Urgan Bula	2000	78
Wilshet-Sala	2000	350
Abasheba Demero	1994	210
Adaba-Dodola	2000	736
Open hunting areas		
Alluto	n/a	280
Debre Libanos	n/a	31
Gara Gumbi	n/a	140
Gara Miti	n/a	240
Gelila Dura	n/a	140
Jibat	n/a	100
Sinana	n/a	15
Community conservation areas		
Garameba	2001	25
Guassa	n/a	n/a
Simien Gibe	2001	49
Source: Ethiopian Wildlife Conservation Authority **(Ethiopian Wildlife Conservation Areas, no date)**		