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JICA Research Institute
10-5 Ichigaya Honmura-cho
Shinjuku-ku
Tokyo 162-8433 JAPAN
TEL: +81-3-3269-3374
FAX: +81-3-3269-2054

Toward an Accounting of the Values of Ethiopian Forests as Natural Capital

Daiju Narita[*], Mulugeta Lemenih[†], Yukimi Shimoda[‡], and Alemayehu N. Ayana[§]

Abstract

Ethiopia has experienced a long-term problem with deforestation. Despite the broad implications of such deforestation, or more generally of forests, on human life and economic activities, the accounting of a diverse range of forest values in Ethiopia is still in its infancy. This study aims to set a scope for such a comprehensive accounting of forest values in Ethiopia. Along with an overview of both quantitative and qualitative studies on forest values in Ethiopia, we conduct our own tentative estimation of Ethiopian forest values. Unlike the previous attempts at Ethiopian forest accounting, which are built on a direct extension of the SNA (System of National Accounts) framework, our estimation is based on a welfare-economic framework to evaluate changes in the value of forests as natural capital.

Keywords: forest, natural capital, environmental accounting, ecosystem services

[*] Associate Professor, Graduate School of Economics and Business Administration, Hokkaido University, Sapporo, Japan, Kiel Institute for the World Economy, Kiel, Germany, and Visiting Scholar at JICA-RI (E-mail: daiju.narita@econ.hokudai.ac.jp)

[†] Farm Africa, Addis Ababa, Ethiopia

[‡] Research Fellow, JICA Research Institute, Tokyo, Japan

[§] Ethiopian Environment and Forest Research Institute (EEFRI), Addis Ababa, Ethiopia

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1. Introduction

Ethiopia has experienced a long-term problem with deforestation. While the exact scale of past deforestation is still up for debate, there is a general consensus that there has been a great loss of forest cover throughout Ethiopia's long settlement and agricultural history (Gebrehiwot et al. 2014). The problem of forest loss is still ongoing and acute. The Climate-Resilient Green Economy, a recent overarching long term economic development strategy by the Ethiopian government, estimates that 37% of the Ethiopian greenhouse gas emissions in 2010 comes from the forestry sector, mostly attributable to deforestation and forest degradation (Federal Democratic Republic of Ethiopia 2011).

Forests in Ethiopia bring a variety of benefits to people, from providing wood for fuel to providing cultural values. However, many of these benefits from forests do not involve market transactions and therefore are not included in the conventional System of National Accounts (SNA), which is used for calculating Gross Domestic Product (GDP), the standard indicator for evaluating macroeconomic performances. SNA also does not fully take into account the changes in the national forest stock, especially those due to forest degradation. This insufficient inclusion of forest values into the national accounting reflects the fundamental problems with the current SNA recognized by many economists. As a result, there is a growing interest in finding economic indicators that better capture people's well-being than the conventional national accounting (see Stiglitz, Sen, and Fitoussi 2009). A response to such concerns in terms of properly accounting for environmental goods and services is the System of Environmental-Economic Accounting (SEEA) – Central Framework, which is a satellite account of the SNA adopted by the United Nations Statistical Commission (UNSC) during its forty-third session in 2012. Meanwhile, much of the academic literature examines accounting frameworks that do not have a direct link to the SNA but are instead rigorously grounded in the theory of welfare economics (e.g., Perrings and Vincent 2003; Dasgupta 2009). Although both the former and latter sets of accounting frameworks have been developed out of similar concerns, some methodological differences exist between the two because they have different foci and intentions—the former's aim is to properly account for economic activities in a nation, while the latter is concerned with whether the social welfare increases or decreases with changes in the flow of ecosystem services. It is worth noting that the latter often associates its discussions not to GDP but to Net Domestic Product (NDP) (or Net National Product, NNP), an indicator in which capital depreciation is subtracted (unlike GDP) and which is better able to capture an increase or decrease in the national wealth.

This study aims to identify the current state of knowledge and to set a scope for a comprehensive accounting of forest values in Ethiopia, which is inclusive of non-market ecosystem services. In the paper, we first find the state of knowledge relevant to such an accounting and then attempt our own estimation of forest values in Ethiopia, drawing on welfare-economic frameworks discussed in the academic literature (in the second approach described above). The study by Nune, Kassie, and Mungatana (2013).[1] However, this assessment is made as an estimation based on the SNA/SEEA framework, which has some differences from the frameworks based on the theory of welfare economics mentioned above. As a result, they do not explicitly estimate the (temporal change of) value of forest as a stock, as we do. Also, their analysis is particularly disconnected from an emerging literature on the valuation of cultural and non-use ecosystem services of forests in Ethiopia and globally(because many of these services cannot be marketed, even potentially, while the SNA should in principle only reflect goods and services that could be at least potentially transacted at market). Meanwhile, other existing accounting studies on values of ecosystem services in Ethiopia (e.g., Sutcliffe 2009) focus on identifying monetary-equivalent benefits of various forest services individually

[1] The book edited by Hassan and Mungatana (2013) that includes the article by Nune, Kassie, and Mungatana features a number of studies of environmental accounting in African countries using similar approaches to Nune, Kassie, and Mungatana's.

and do not examine well how those values as a whole should factor into a national wealth accounting. In this study, we estimate the value of forests in Ethiopia for a more recent reference year than do Nune, Kassie, and Mungatana (2013) by using additional data drawn mainly from the Forest Sector Review (UNIQUE Forestry and Land Use, 2015: henceforth referred to as FSR). Despite the use of the latest datasets, however, sufficient data for this valuation are still lacking for many of the non-market ecosystem services on Ethiopian forests. Still, we review the literature on evaluation of those services in Ethiopia and explain what future research should investigate.

This paper is organized as follows. We first discuss the theoretical background of comprehensive national accounting of forests. Section 3 summarizes the state of knowledge on the valuation of Ethiopian forests, and Section 4 presents our own estimation of forest accounting for Ethiopia. We discuss our results in Section 5 and conclude in Section 6.

2. Accounting the Ethiopian forests: Theoretical background

Forests are the source of various economic goods such as timber and wood fuel, and the conventional SNA already includes the values of those goods if they or their secondary products are transacted in the market. Still, the information included in the SNA is not sufficient to accurately understand the economic significance of forests for the following three reasons: it misses the economic value of forest goods or services that are not transacted in the market, either because of the domestic or informal nature of their production or because of their property as an externality or a public good (e.g., the hydrological benefits of forests); it does not properly reflect the changes in the forest stock, especially those from forest degradation; or registers some benefits of forests not in the forestry sector but in a different category such as the agricultural sector (e.g., the production of forest coffee). A comprehensive resource accounting based on more than SNA-originated data is therefore needed to accurately assess the value of forests in Ethiopia.

Such a comprehensive resource accounting of Ethiopian forests could be made by estimating the annual value added originating from Ethiopian forests. In this study we conduct our estimation of value added due to the forest by drawing on the literature of accounting of natural capital (e.g., Mäler, Aniyar, and Jansson 2008, 2009; Fenichel et al. 2016). Built on the theory of welfare economics, the framework used here is in some ways similar to the framework of the Inclusive Welfare Index, which is proposed by the United Nation and UNEP (UNU-IHDP and UNEP 2012), and that of the Adjusted Net Saving (also called Genuine Saving or Genuine Investment) utilized by the World Bank (e.g., World Bank 2011) and others.[2]

Drawing on Mäler, Aniyar, and Jansson (2008, 2009) and Fenichel et al. (2016), the indicators of value we consider are derived from the social welfare (national wealth), which is defined as

$$W_t = \sum_{s=t}^{\infty} \frac{U(C_s)}{(1+\delta)^{s-t}} \tag{1}$$

where W_t is the social welfare at year t, $C_s=(c_{1,s}, c_{2,s}, ..., c_{n,s})$ is a vector of consumer goods and services (including ecosystem services) in year s, $U(C_s)$ is the utility function determined by C_s, and δ is the discount rate (to be set at 5%/year in the following analysis, as in UNU-IHDP and UNEP(2012)). Note that the flow of goods and services C_s may or may not represent the optimal consumption path.

[2] See Chapter 7 of UNU-IHDP and UNEP (2012) for a discussion of how the frameworks of SEEA, the Inclusive Welfare Index, and the Adjusted Net Saving conceptually differ from or are similar to each other.

The annual change of the social welfare between year t and year $t+1$ is given by

$$W_{t+1} - W_t = \sum_{i=1}^{n} p_{i,t} \left(K_{i,t+1} - K_{i,t} \right) + \xi_t \qquad (2)$$

Where $p_{i,t}$ and $K_{i,t}$ are the accounting price (shadow price) and capital stock for good or service i at year t(at the beginning of year t for the capital stock).[3] "Capital stock" here could mean both the capital in a conventional sense (man-made capital) and other types of capital including various forms of natural capital. The term ξ_t corresponds to the annual change of social welfare independent of the amounts of capital stocks originating from, for example, technological change independent of capital accumulation.

The accounting price $p_{i,t}$ is given as follows:

$$p_{i,t} = \sum_{s=t}^{\infty} \frac{\frac{\partial U(C_s)}{\partial K_{i,t}}}{(1+\delta)^{s-t}} \qquad (3)$$

Note that p represents the present value of the future changes of consumption due to a marginal change in the stocks today, and that it may be different from the market price. In other words, p is the shadow price of goods or services.[4]

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[3] Here, we are implicitly using the property that the level of pi does not change greatly in the short time interval between t and t+1.

[4] Our estimation is in many ways similar to the calculations based on SEEA proposed by the United Nations (United Nations 2014). Our calculations have particularly strong relevance to SEEA's Experimental Ecosystem Accounting (EEA: European Commission et al. 2013), which explicitly takes into account the degradation of ecosystems. A key difference, however, is that our estimation (like the estimation of the Inclusive Welfare Index) employs the shadow prices of ecosystem services while the SEEA/EEA system places strong emphasis on using the market prices, which in the case of non-market goods are substituted with the hypothetical prices that would become the market prices if the goods were exchanged freely (i.e., effective prices estimated from the replacement cost method). The shadow prices and those hypothetical market prices could differ because the former may include the contribution of the consumer surplus, while the latter does not. We do not take the latter approach of using such hypothetical market prices partly to remain consistent with the Inclusive Wealth Accounting and Adjusted Net Saving literature and also because there is so far no convincing set of empirical estimates of such hypothetical market prices for public goods provided by forests in Ethiopia. Still, the framework

For actual estimations of the accounting price, we use the following formulation, which is in essence the same as that used by Fenichel et al. (2016):

$$p_i(K_i) = \frac{MB_i(K_i) + \dot{p}_i(K_i)}{\delta - \dot{\kappa}}$$

where MB_i is the marginal benefit of the capital stock (i.e., how much an additional increment of stock raises the level of benefit), $\dot{\kappa}_i$ is the growth rate of the capital stock (if time steps are small, $\dot{\kappa}_i \approx \frac{K_{i,t+1} - K_{i,t}}{K_{i,t}}$), and δ is the discount rate.[5]

Here, *p* embodies the marginal service flows (dividends) and capital gains of the evaluated stock, adjusted by time discounting and future stock growth.

The above-formulated quantities could in principle be incorporated into the national accounting (specifically, NDP) in the form of the following value added (see Chapter 8 of UNU-IHDP and UNEP 2012; Dasgupta 2009; and Arrow et al. 2012, for detailed discussions). The value added (*VA*) originating from forests or other tree-covered areas for year *t* is given as follows:

$$VA_{j,t} = U'(C_t)c_{j,t} + \Delta V_{j,t} \tag{4}$$

where

$$\Delta V_{j,t} = p_{j,t}\left(K_{j,t+1} - K_{j,t}\right) \tag{5}$$

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of SEEA/EEA in principle does not rule out the incorporation of non-market ecosystem services, including cultural and non-use services—for example, shadow prices could in principle be adjusted for the SNA purpose by using general-equilibrium or partial equilibrium models. The EEA report notes that establishing accounting approaches for the inclusion of such services deserves further research (European Commission et al. 2013).

[5] An assumption necessary for this formulation is that human behavior on the use of the stock (the “economic program”) is described as a function of the stock size. But this assumption does not have a critical meaning in a practical context of our estimation below.

In the formula, *j* denotes the type of woodland, which this analysis considers natural forest, plantation, woodland, shrub land and trees outside forest (the definitions of those terms are given in Section 4.1). Also, $U'(C_t)c_{j,t}$ is the annual flow of benefits from tree-covered areas of type *j* at time *t*, and $\Delta V_{j,t}$ is the annual change in social welfare due to the annual change in forest stock. In the results below, we show both the benefit flows (the first term of (4)) and the change of stock values (the second term) of forests and other tree-covered areas.

3. Value of Ethiopian forests: State of knowledge and available information

For the purposes of this paper, we formulate the benefits of forests based on the concept of ecosystem services, which are classified into provisioning, regulating, cultural, and supporting services (MEA 2005). Among these, we exclude the supporting services—i.e., the services to support ongoing ecosystem processes (such as maintaining the planetary-scale nitrogen cycles)—from analysis because the benefits of supporting services could in principle be captured as a part of the benefits of other ecosystem services (though those other ecosystem services may or may not be considered forest-related).[6]

Below, we discuss the current understanding of and available information on the value of Ethiopian forests by individual category of ecosystem services. Hard data are available for some of the categories, while inferences from other similar cases (benefit transfer) are necessary for others. There are also types of services on which quantitative estimation is not yet possible in an Ethiopian context.

[6] Supporting services are similarly excluded from valuation in, for example, a global estimate of ecosystem values by De Groot et al. (2012), a study made by the TEEB project.

Provisioning services

Timber, fuelwood and various non-timber forest products (NTFPs) are produced in Ethiopian forests, and the provision of such goods constitutes the provisional services of forests. Some of those goods are formally sold and purchased as market products, and their market values are to be estimated from those records. A significant part of those goods, however, are either domestically used or only informally exchanged in Ethiopia, and their values cannot be drawn directly from market data. It is therefore necessary to make inferences on missing values based on the information of dispersed data sources.

Previous studies similar in scope to ours, such as Nune, Kassie, and Mungatana (2013) and the FSR, conduct estimations of the quantities and values of forest products in Ethiopia, relying on a combination of market data, generalizations of representative values, and expert judgments. In our quantitative estimation in the next section, we primarily use the estimates of production and consumption of wood products in Ethiopia by the FSR, whose estimation methods are as follows: The volumes of consumption (and trade[7]) are estimated from assumed quantities of use per household or per product for individual types of wood products, namely, construction materials (poles and posts), industrial wood for making furniture, utility poles, firewood, and charcoal. According to the FSR, the production of pulp and paper is negligible in Ethiopia. Using those estimates of volumes of wood production, we calculate the values of produced wood by using representative average market prices shown in the FSR. Section 4.1 describes adjustments we made for value estimations using the information from the FSR.

We also draw on the FSR for the value estimation of NTFPs. A discussion of our adjustments of these data is also found in Section 4.1. The following are the major NTFPs that originate from Ethiopian forests, which we consider in the analysis.

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[7] Alem (2015) investigates the Ethiopian trade of forest products in more detail than the FSR. However, there is no substantial difference in the sources of data between the two.

- Forest coffee
- Honey
- Bees wax
- Gums and incense
- Spices
- Bamboo
- Traditional pharmaceutical products
- Fodder
- Wild foods

Among them, forest coffee, honey, bees wax, gums and incense, and spices are products originating from plants or bees in the forest and may be sold and bought in the market. Coffee could grow not only in forests but also in plantations or semi-forest settings, but the natural forest is a no less favorable environment for coffee production than the plantation is, as the maximal production of coffee is obtained from coffee trees under shade, which trees in natural forests provide. Bamboo is used mainly for making light furniture. Traditional pharmaceutical products and wild foods are primarily for domestic consumption and made from plants growing in the forest.

There are no hard estimates of national wild food consumption in Ethiopia, but their importance should not be overlooked. Wild foods provide nutrients for millions of people in the world. The UN Food and Agricultural Organization points out that forests support the entire four pillars of food security—food availability, access to food, stability over time, and food use. The role of wild foods in combating problems of food security is paramount in Ethiopia too.[8] The study conducted in the so-called "green famine belt of Ethiopia" shows that the mean amount of wild foods obtained by households is 156.61 kg per household per annum, which is about 5% of gross food and 9% of net food available from all sources (Guyu and Muluneh 2015). The study concluded that wild foods play an important role in households' resilience to food shortages and

[8] In this study "wild foods" refers to all plant and animal resources that are not domesticated but gathered and hunted from forests and bush-lands for the purpose of human consumption (Guyu and Muluneh 2015).

are likely to continue to do so in the future. The study calls for the adoption of a comprehensive policy that ensures a sustainable supply of wild foods.

Regulating services

A large number of both global and Ethiopia-specific studies have found that the forests offer a variety of regulating services. The carbon sequestration service, which is the absorption and retention of carbon dioxide as a greenhouse gas, is one type of regulating service provided by forests that is relatively easy to define and has been discussed extensively worldwide both by academics and practitioners. Aside from this, Ethiopian forests provide other important regulating services such as their hydrological functions.

Globally, carbon dioxide (CO_2) emissions from forestry and other land use constitute 11% of the total anthropogenic greenhouse gas emissions in 2010 (IPCC 2014, Figure SPM.2). With its relatively long persistence in the atmosphere, emitted CO_2 is globally dispersed, affects the global climate, and has negative consequences on human activities, such as a declining crop yields and intensifying natural disasters from extreme weather. Thus, the unit cost of deforestation in Ethiopia, or the unit benefit of REDD (Reducing Emissions from Deforestation and Forest Degradation) measures in Ethiopia, should in principle be identical with the Social Cost of Carbon (i.e., an estimate of the global economic damages associated with a unit increase in CO_2 emissions in a given year) that is estimated globally (e.g., Interagency Working Group on Social Cost of Carbon 2013).

The value of forest carbon is calculated by multiplying the amount of carbon mass in the forests of Ethiopia and the price of a unit of carbon (tCO2e), which reflects the climate policy. For our estimation of the carbon price level, we use a benchmark value (US$12/tCO2e at a 5% discount rate, adjusted to a 2013 dollar unit)of the Social Cost of Carbon presented by the US government (Interagency Working Group on Social Cost of Carbon 2013, updated in 2015), which is based on three of the best-known global Integrated Assessment Models of climate and the economy (FUND, PAGE and DICE).

There is a widespread recognition by both academics and policymakers that much of the Ethiopian land has been experiencing a serious problem of soil erosion, and that vegetation can mitigate the problem (e.g., Hurni et al. 2015). Previous economic valuation studies of Ethiopia also consider this issue, using various estimation approaches to assess the value of vegetation for soil erosion mitigation. Nune, Kassie, and Mungatana (2013) calculate the value of soil erosion mitigation by forests from estimates of two parameters: the crop productivity loss per unit of soil loss and the soil conservation efficiency of forestland. Meanwhile, Reichhuber and Requate (2012) estimate the value of watershed services by forests including erosion control by referring to figures from a case study in the Mount Kenya Forest Reserve.

Another set of relevant studies use cost-benefit assessments of exclosures to provide estimates of the benefits of exclosures on soil erosion affecting agricultural productivity. Balana et al. (2012) calculate the benefits of vegetation on soil as the increased productivity of plant biomass. Mekuria and Aynekulu (2011) and Mekuria (2013) estimate the value of soil nutrition retention by forests by both investigating physical properties and conducting a socioeconomic survey.

In our estimation, we consider the benefits of soil erosion mitigation not for forests in general but only for exclosures, whose benefits on farming are clearer than those for other types of tree-covered areas, and we estimate monetary-equivalent benefits by parameterizing with a case study by Mekuria et al. (2009).

Soil erosion not only reduces nutrients in farmlands but also causes sedimentation of dams and reservoirs. Keeping natural forests helps reduce the problem of sedimentation, as natural forests are largely able to retain soil on the land (Ahmed and Ismail 2008).This benefit of forests to mitigate sedimentation could be quantified by a replacement cost method.[9] Removal of sediments from dams and reservoirs is widely performed across Ethiopia, involving costs borne by public expenses. In his valuation study of deforestation in south-west Ethiopia (the Baro-Akobo Basin), Sutcliffe (2009) estimates the cost of deforestation from increased sedimentation by assuming it to be equivalent to the increase of removal costs of sediments. In this study, we take a similar approach to estimation to Sufcliffe (for our case, as a benefit of keeping forests, not as a cost of deforestation) by using more recent data from observational studies of Haregeweyn et al. (2012) in Tigray and of Mekonnen et al. (2015) in Amhara. We calculate monetary values by taking an average of their estimates of the Specific Sediment Yield (SSY), and applying the unit removal cost by machinery, 33.35ETB/m^3, as used by Haregeweyn et al. (2012).

The presence of vegetation generally affects the hydrology of river basins and also water quality (Brauman et al. 2007). The nature of forests' effects on hydrology is however influenced by various factors such as topology, rainfall patterns, the size of watersheds, and soil conditions. A review of literature in an Ethiopian context concludes that the effects of forests on river flows are ambiguous, at least at the meso-scale (Gebrehiwot 2015).The effects of forests on water quality (water purification services) are less complex in the sense that they are generally positive, and economic valuation of this aspect has been carried out in various countries (reviewed by Ojea, Martin-Ortega, and Chiabai 2012), though little has been investigated on Ethiopia.

Forests also potentially reduce the flood frequency and damages. A global study by Bradshaw et al. (2007) finds that flood frequency is negatively correlated with the amount of remaining natural forest and positively correlated with the loss of natural forest area. But a later study by Ferreira and Ghimire (2012) concludes that the relationship is not clear when a similar

[9] Replacement cost methods are widely used for the valuation of forests, including for the benefit of sedimentation prevention, but it is noted that the method could overestimate or underestimate the true value of ecosystem services (e.g., Croitoru 2007). In our estimation, we adopt this method not because we regard it as an ideal approach but as a result of data limitations on other valuation methods.

method but a larger dataset are used. As of yet, there is no country-level assessment on the relationship between forest cover and flood frequencies in Ethiopia.

Other important regulating services of forests include pollination, i.e., forests as a habitat for pollinators (an example of such economic analysis is Ricketts et al. 2004); and air quality regulation, with forests serving as sites of pollutant depositions (Myers et al. 2013; Ninan and Inoue 2013). Some studies investigate the economic values of health effects of forests such as an increased malaria incidence due to forest degradation (economic studies are reviewed by Ferraro et al. 2012), but there is no such study for Ethiopia.

Cultural services

Forests provide many cultural services, such as tourism, amenities, spiritual and existence values, cultural heritage, and identity. Although the entirety of those features cannot be fully captured by the utilitarian framework that any economic valuation is based on (see MEA 2003, Chapter 6 for a discussion), a part of those cultural services could be assigned monetary-equivalent values through methods of economic valuation.[10]

The values of forests on tourism are the simplest to be evaluated among all their cultural services. Forests often characterize the landscape and also support the wildlife, and consequently the presence of forests may determine how attractive certain natural areas are to tourists. The number of visitors and the amount of revenues in entry fees to the protected areas (wildlife reserves) in Ethiopia are recorded by the Ethiopian Wildlife Conservation Authority (EWCA); in

[10] While it has yet to propose a clear methodology for it, the SEEA/EEA system does not rule out the adoption of such cultural values in the accounting. In some cases, the cultural values of ecosystems may even be implicitly embodied in the market values. For example, cultural values may be included in the price of a house that has a view of an area (e.g., sea) providing significant amenity values (European Commission et al. 2013, EEA 5.71). However, without adjustments, values estimated by some of the major methods of economic valuation, such as contingent valuation, could not be used for the national accounting, because the price of an ecosystem service evaluated by those methods implicitly includes consumer surplus, rather than being a hypothetical market price if free exchanges take place (discussed by, e.g., Weber 2011).

our estimation below, we count this revenue as the benefit of the forests for tourism.[11] In Ethiopia, all the protected areas could be regarded as natural forests or woodlands. In principle, the economic benefits of protected areas should include secondary benefits such as revenues earned from visitors by hotels and restaurants. But there are no such data available for our analysis, and so they are excluded from estimation.

The cultural services of forests are not limited to tourism but consist of a wide range of features such as religious, spiritual and identity-shaping functions. There are certain cultural meanings of forests found specifically in Ethiopia, such as the tradition in some parts of the country that religious facilities be surrounded by tree-covered areas ("church forests"). In principle, such functions of forests should be considered in a comprehensive accounting of the value of forests. Despite their obvious role in Ethiopian life, however, the literature on the economic valuation of ecosystem services in Ethiopia has largely ignored these functions of forests, and research in anthropology or other disciplines is also patchy on this subject, often focusing on particular practices in particular localities. To offer a comprehensive analysis in this paper, we supplement the information from the existing literature with the findings from our own field study (group and individual interviews), which is conducted in four different locations: Addis Ababa; Jimma; and two villages in the Jimma Zone, in the Oromia National Regional State—one village near the forest area of the Gera district (Village A) and the other in a less-forested area of the Manna district (Village B) (an description of the field study is given in Appendix 1). Despite their apparently importance in people's life, most of the features described below are not easily translated into the framework of economic valuation, nor do we attempt the quantification of those benefits in our analysis. It is rather meant to set a scope for future research.

[11] Data were obtained through written communications with EWCA.

Previous studies have documented that Ethiopian forests carry certain religious values. Through most parts of Ethiopia, patchy woodlands were developed around churches (church forests).[12] In their research on church forests around the Ethiopian Orthodox Tewahido Churches, in the Amhara National Regional State, Wassie, Teketay, and Powell (2005,351) explain that churches "provide valuable, often unique, green space for people to rest their over-stressed minds, and are secure habitats for plants and animals." Church forests and trees are sacred, should not be cut down unless specifically being used for churches, and are "much loved and cared for" (Wassie, Teketay, and Powell 2005, 351-352). Similar forests or trees around churches and mosques are observed in Addis Ababa and Jimma. In an Orthodox church near Village B of our field study, local people had recovered the forest (once it had been destroyed by the dramatic growth of population) and enjoyed resting under trees, and only used them for its particular purposes (an interview with an old man who worked for the church).

Specific beliefs are attached to the forests and trees in Ethiopia. Studies in southwest Ethiopia present some examples. People in a village in the Gomma district have a belief in a spirit in a big tree, *adbar* (Matsumura 2005, 248). The Majangir, a Surmic group living in the southwestern forests, think that a spirit lives in a forest and influences the fate of people (Sato 2005, 266). Me'en, the Surmic-speaking group inhabiting southwestern Ethiopia, use trees and plants for specific rituals and love charms, and for the prevention of snake bites, bullet strikes, and contagious diseases (Abbink 1993). In the Borana Zone, in the Oromia National Regional State, people also used gums and resins from different plants for fragrance in various rituals and festivals (Worku et al. 2011). In our pre-fieldwork in Jimma, an Ethiopian man in his mid-thirties told us that he had as a child observed local residents putting small coins under big trees. A female interviewee of Village B saw a group of women during her childhood cut grass under a

[12] As an attempt to value the church forests, Amare et al. (2016) have conducted a contingent valuation analysis (questionnaire survey) on the willingness to pay for farmers to keep a church forest, although their analysis does not distinguish the cultural benefit and other benefits (e.g., the benefit as a source of fodder) of church forests.

big tree in the forest located between the village and a large local market and put butter on the tree by using the grass. These indicate that people find spiritual aspects in trees and forests and foster beliefs in them.

Similarly, certain trees carry special cultural meanings for particular groups of people in Ethiopia. Such trees are present in Village B and also are reported to have existed in Village A in former times. The tree of *qiltu* (*ficusvasta*) has a special function in Village B. During difficult times (e.g., rain shortages, severe drought, unknown disease, conflicts), both Muslim and Christian community members would gather under the tree, talk about their problems, and pray to their God. Village A used to have a tree with a similar function before Islamic beliefs became prevalent in their area. The function of trees as a meeting place can be seen in other places in Ethiopia. For the Oromo, the Odaa tree (the holy sycamore tree), which is shown in the flag of the Oromia Region, is well known for their Gadaa System, assemblies for socio-political and religious purposes (Hinew 2012). In the case of Wonago district, in the Gedeo Zone in Southern Ethiopia, large trees are selected to serve as meeting places, and these “sacred” trees are neither cut nor used (Negash 2007,166-167).

Our interviewees also witnessed the aesthetic and amenity values of forests or trees. In both urban and rural areas, they often described their perceptions of forests and trees as “refreshing,” “cool,” and “green.” These expressions are partly derived from their interactions with forests and trees through leisure activities (e.g., walking) in forests or parks, where they could enjoy, for instance, seeing green trees, being protected from the strong sunshine, smelling flowers, and listening to birds singing. These reports subtly present the aesthetic value of forests in their lives.

Interactions with forests and trees through everyday lives and cultural practices, part of which has been explained above, contribute to the construction of individual and group identities. The members of Village A remembered an annual celebration of harvesting coffee under a particular big tree in the forest after the rainy season, a tradition they had since lost due to the influence of the Muslim religion. They also knew the history of a very old coffee tree, which had been planted by a far-distant grandfather of a community member in the forest. In Addis Ababa, interviewees told us their stories: fruit trees which had been planted in a house, a picnic in a forest during the Christian-related *Buhe* festival, walking in a forest with friends, and camping in a forest near a lake. These individual memories and family histories form identity though the connection of the past with trees and forests (Sommer 2003). The experiences with accompanying memories foster a feeling of attachment to particular places, or a sense of belonging. In Ethiopia, state-initiated tree planting started at the end of the nineteenth century and continued particularly in urban areas due to steady land tenure (Kassa, Bekele, and Campbell 2011, 466-467). The interviewees in both urban and rural areas experienced planting trees at their schools or organizations. The participation of tree planting creates ties among participants and fosters a sense of where they belong, and consequently "a sense of community identity" (Sommer 2003, 19).

Option values: the values of genetic resources

Some of the ecosystem services provided by Ethiopian forests entail not a benefit for humans at present but a potential benefit in the future, i.e., option values. Forests are home to various plants and microorganisms, which have potentially useful genes for humans in terms of developing new crop varieties and medicines. Those genes and their use may not be well known at present but may bring monetary benefits in the future, and in this sense, conserving forests involves an option value. Ethiopian forests are the place of origin for Arabica coffee (*Coffea arabica*). Hein and Gatzweiler (2006) have estimated the values of the genetic resource of coffee in terms of the possibility for potential varieties of naturally decaffeinated coffee, high yield, or high disease resistance. According to their estimation, the total net benefits of coffee-genetic diversity in Ethiopia amount to 1458million USD, assessed for the year 2004 (at a 5% discount rate), or 883 million USD[13] excluding the benefit of providing varieties of decaffeinated coffee, which Reichhuber and Requate (2012) argue one should. More generally, Ethiopia is located in one of the world's biodiversity hotspots (namely Eastern Afromontane), and thus its forests have the potential to hold useful medicinal substances (bioprospecting). We base our estimation of the bioprospecting value on Costello and Ward (2006), who compute their estimates by examining the approaches in the preceding literature on the topic. We use their mean estimate for Eastern Afromontane, which is 0.06 USD/ha (1.1 ETB/ha).[14]

Forest disservices

The goods and services described above all concern benefits of forests for humans. Forests, however, can also cause harm by, for example, keeping and spreading pests and pathogens. For example, discussing one such disservice in the Ethiopian context, WBSIPP (2004) mentions that trees grown in areas below 1,700m in altitude provide habitats for Tsetse flies, which cause the livestock disease *trypanosomiasis* and the human disease sleeping sickness. In principle, the presence of such harmful effects reduces the value of forests. It is not difficult to conceptually recognize the existence of such disservices, but little research of economic valuation on forest disservices has been done both on Ethiopia and also globally, partly because it is not easy to isolate the effects of such disservices from those of other ecosystem services (mostly in the form of benefits). The issue of forest disservices is discussed in Ninan and Inoue (2013). Here, we conclude that there is no quantifiable information about forest disservices to be utilized for our assessment.

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[13] In a 2013 dollar unit, this is equivalent with 1,104 million USD.
[14] Their estimation assumes a range of discount rate between 1%/year and 10%/year.

4. Estimating the value of forests in Ethiopia

4.1 Data and estimation method

The data on forest coverage and composition are essential for a forest accounting. The availability of such forest statistics, however, is seriously limited in Ethiopia. The last comprehensive dataset on Ethiopian forests at the national level is the Woody Biomass Inventory and Strategic Planning Project published in 2004 (WBISPP 2004). The more recent Global Forest Resources Assessment by FAO (2010) does not document original data on forest coverage and simply use projections of the WBISPP data. Global databases on forest coverage, which are being made easily available (e.g., Hansen et al. 2013), are not yet sufficiently accurate for the purpose of our analysis, and furthermore lack key information such as data on tree compositions.

In the following assessment, we use our estimated values of Ethiopian forest resources for the years 2013 and 2000 (as a reference), the most recent two years for which solid estimates of forest characteristics are available. Since some ecosystem services provided by forests are hard to separate from those provided by other types of tree-covered lands (especially for cultural values of forests),we examine not only the narrowly defined natural forest but also four other types of tree-covered areas :the plantation, the woodland, the shrubland, and the trees outside forests. The definitions of these types we use are consistent with those in the WBISPP.[15] Here we note that the "woodland" includes the lands subject to area exclosure, which is a widespread

[15] WBISPP makes explicit the definitions of "forest," "woodland," and "shrubland." Forest is "a relatively continuous cover of trees, which are evergreen or semi-deciduous, only being leafless for a short period, and then not simultaneously for all species. The canopy should preferably have more than one story." Woodland is "a continuous stand of trees with a crown density of between 20-80%." Shrubland is "a continuous stand of shrubs with a crown density of between 20-100%." "Shrubs" are defined as "a multi-stemmed woody plant in which most of the stems appear at or very close to the ground (i.e., less than 30 cm)." In our assessment, a plantation means a patch of tree-covered land where trees are planted and managed by land owners, as appeared in the governmental statistical records of Ethiopia. By "Trees outside forest," we mean scattered or patches of trees existing on areas that belong to none of the other four categories such as on farmlands, grazing lands or in various forms of agroforestry.

practice in today’s Ethiopia and is to protect degraded areas mainly through social fencing from any form of cultivation, cutting trees and shrubs, or grazing by livestock in order to restore the lands. In many cases, a substantial amount of tree coverage is found in those exclosures (see, e.g., Lemenih and Kassa 2014).

The data used in the paper are sourced from the secondary literature. There are two major items of literature used to extract forest statistics. The first is WBISPP (2004), which is used to obtain the extent of forest area in the year 2000 and the biomass/carbon estimate per unit area in the various forest types of the country. The second data source is the FSR, which is used to obtain the forest area in 2013, current at the time the study was conducted. Both data sources are the most comprehensive national scale documents on the forest sector of Ethiopia. A detailed description of the data used is given in Table 1.

The data obtained for these two years were further analyzed in terms of annual area, volume, and carbon accounting. For the three sets of quantities, the opening stock (referring to the resources at the beginning of the year), increment (stock change during the year) and the closing stock (which is the resource at the end of the year) were calculated. The data provides information on changes in the variables at the beginning and end of the year, hence annual accounting.

Area based accounting

For the area accounting, we calculate the opening area which is the area coverage of the five forest types (natural forests, plantation, woodlands, shrublands, and trees outside forests) at the beginning of the accounting year (2000 and 2013), the area lost and/or gained from deforestation or reforestation/afforestation (AR) during the year, and the area at the end of the year after incorporating the deforestation or AR that took place during the year. The base data are obtained from the WBISPP (2004) and the FSR as shown in Table 2.

The average annual deforestation rate for the period 2000-2013 was obtained by subtracting the forest area estimate of2013 and 2000 and dividing by 13. The closing area at the end of the accounting year was then calculated by subtracting the opening area at the beginning of the year minus the change in area during the year due to deforestation for the natural forests and woodlands. For natural forests, the effects of AR are considered negligible relative to those of deforestation (the effects of afforestation and reforestation are in principle assigned to “Net effects of deforestation and afforestation” and “Rehabilitation and reclassification of area type,” respectively). For plantations, we assumed the annual change (i.e. AR) to be zero since there exists no data on long term systematic afforestation or reforestation in Ethiopia to estimate the average AR rate. However, for the trees outside forest, we assumed that areas deforested from natural forests and woodlands are converted into farmlands with the traditional agroforestry system that is popular throughout Ethiopia. Areas deforested from natural forest and woodlands are therefore included into the trees outside the forest area but with a much reduced stock as estimated in the WBISPP (2004). For the 2013 data, areas regenerated through area exclosure based management are included into the woodlands category as regeneration after estimating the total areas under area exclosure and understanding the rate per year, which happened to be 1%.

Volume-based accounting

For the volume-based accounting, the opening volume was obtained by multiplying the area at the beginning of the year, whose calculation is described above, with the average volume of woody biomass per unit area for each forest type. The closing volume was calculated by subtracting the volume of various products removed from the forests during the year from the opening volume plus incremental yield during the year. The volume of products removed refers to the volume of timber, construction wood, and fuelwood harvested plus the volume of wood lost along with the deforested forest area during the year. See Table 2 for our parameter choices.

Carbon-based accounting

The capacity for carbon retention by forests and woodlands obviously varies depending on prevailing tree species, tree density, and age structure, and the estimation of carbon contents should in principle take into account the heterogeneity of such features across all the forest areas of the country. However, such spatially detailed information of forest characteristics is not available in our case. Given these limitations, we take the following approach to estimation: The annual carbon stock balance or change was calculated by converting the volume-based balance into a carbon equivalent and then carbon dioxide equivalent (CO2e) quantity. That means the volume at the beginning of the year, the volume of timber, construction wood, and fuelwood harvested during the year were all converted to carbon stock equivalent using a Biomass Conversion and Expansion Factor (BCEF) for the various forest types, and using a carbon fraction of 50%, i.e. assuming half of the biomass being carbon based on the IPCC good practice guide (IPCC 2006). The average Root to Shoot (R/S) ratio of 25% was applied to calculate the below ground carbon stock. The range of R/S ratio applied varies from 20 to 30, based on forest types. The carbon stock is converted to CO2e by multiplying the carbon stock with the factor 44/12. See Table 2 for details of our parameter choices.

Value estimation

We conduct estimation of both benefit flows and of changes in stock values. For the latter, the value of stock from future benefit flows is computed based on the framework described in Section 2, combined with the option value and the values associated with land use conversion (i.e., the added value as farmland and the lost value of carbon retention). We estimate the monetary equivalent values of forest goods and services by multiplying the respective tree volume, area, or carbon content by their effective prices, whose information is drawn from the literature, with adjustments of our own. As already noted in Section 3, we draw a great deal of information from the FSR for our value estimation.[16] However, for most goods, the FSR only shows the gross value (i.e., the value inclusive of production costs), and hence some adjustments are necessary to use its information for our purpose, which requires the net value (rent) of wood only. Appendix 2 shows a description of our adjustment approach. Meanwhile, the unit value of farmland is calculated based on the assumptions that 40% of agricultural production is attributed to land input (an assumption taken by Reichhuber and Requate 2012), and that all the deforested land (corresponding to the "Net effects of deforestation and afforestation" category) is converted to farmland. Agricultural production (agricultural GDP) data are from the Ministry of Finance and Economic Development.

Double-counting of values is an extensively discussed issue in forest accounting (e.g., Croitoru 2007). In a sectoral assessment such as ours, double-counting could occur both internally, i.e., across the estimated values in our dataset, and externally, i.e., overlaps of estimation between our assessment and an external reference value such as GDP. For the latter kind of double-counting, what constitutes an overlap is not obvious and depends on what the estimation is in reference to. Given the methodological difference between the SNA/SEEA framework and our estimation (the use of market prices or shadow prices, etc.), our estimated values are not meant to be directly compared with GDP. But still, following Barbier (2013), we treat the estimates as if they are to be added to GDP and separate the values that are already included in a non-forestry aspect of GDP, namely those related to NTFPs and to tourism,[17] and those related to other goods and services. Only the latter is used for stock valuation. Even if they are not meant to be added to GDP, the values of the former category are still meaningful to be

[16] The FSR only presents the total gross production of forest goods for the nation and does not show decompositions of the figures into the categories of tree-covered areas (natural forests, woodland, etc.). Such decomposition is made by our expert judgment.

[17] In his wealth accounting study of Thai mangrove areas, Barbier (2013) excludes regulating services (specifically, flood protection by mangroves) from the accounting by arguing that such benefits are already implicitly included in property values. In Ethiopia, however, land ownership is strictly regulated, and it is not plausible that any regulating services of ecosystem are implicitly taken into account in land transactions. We therefore do not exclude regulating services in stock value assessment.

presented as they show the production values that are not included in the forest-sector GDP but should in principle be included there in the national accounting (as discussed by Nune, Kassie, and Mungatana2013).

As noted in Section 2, the benchmark discount rate used for the estimation of capital value is set to be 5%. The extent of capital gain (the increase rate of the capital price) is in principle an endogenous quantity to be derived as a model solution (Fenichel et al. 2016), but the data limitation does not allow us to compute it endogenously. Alternatively, we consider given levels of 0%/year and 2%/year for the rate, the latter of which is consistent with the finding by Asfaw and Demissie (2012, Table 2) that the price of fuelwood has increase from 7 ETB/GJ to 18 ETB/GJ (from 0.81 to 1.25 USD/GJ) during 2005-2010, evaluated at the current price. As yet another alternative case, we also make an estimate with a 10%/ year discount rate and a 0% increase in capital price.

4.2 Results

In this section, we report our estimates of area, volume, and carbon accounts of Ethiopian forests (in 2013 and 2000), and of annual values of forest services in Ethiopia (in 2013). Although, as we noted earlier, any attempt at a national-level valuation of Ethiopian forests is seriously constrained by significant data limitations within the country, we still present a quantitative estimation as it allows for a comparison with the previous estimates and could be used as a future reference as well.

Physical accounts

Tables 3-5 show the areas of tree-covered lands, and the volumes and carbon contents (in a CO_2 equivalent scale) of woody biomass at a national level by area type. The tables present estimates for the year 2013 and also for the year 2000 as a reference. The data on Tables 3-1 and 3-2 quantitatively support the general picture of recent changes in Ethiopian forests described by

Lemenih and Kassa (2014) and others: deforestation of natural forests has been and still is ongoing in the country, but a great deal of rehabilitation of tree-covered areas is also ongoing in the form of area exclosure. In terms of the areas, the tables show that the woodland and the shrubland are the dominant forms of wood-covered areas in Ethiopia in 2013 (and also in 2000).

In contrast to Table 3, Table 4 indicates that the national-level significance of natural forests is still great if the tree-covered areas are evaluated in volume. The total volume of the woody biomass of Ethiopian natural forests is close to that of woodland in the country (362 million m^3 for natural forests and 404 million m^3 for woodland) in 2013, and the relative share of natural forests to woodland remains nearly the same for 2000 and for 2013 (about 90%). The data reflect the fact that large amounts of trees are harvested from natural forests for timber and woodfuel. Still, the tables also show that the plantation is the most important source of timber and the woodland the most important source of woodfuel.

The estimates of carbon content in Table 5 are consistent with Tables 3 and 4.The carbon content is larger for woodland (1,204 Mt CO2e) than for natural forests (1,079 Mt CO2e) in 2013, and the annual change of carbon content is also larger for woodland (-142 Mt CO2e) than for natural forests (-62 Mt CO2e) for the same year. In fact, the dominance of woodland over natural forests regarding the carbon content is already observable in 2000 (Table 5-2). In an attempt related to ours, the CRGE of the Ethiopian government (Federal Democratic Republic of Ethiopia 2011) estimates that the emissions from forestry amounted to 53 Mt CO2e in 2010. Although not clearly stated, the CRGE’s estimate probably concerns only the natural forests, and in this sense, its number is broadly consistent with our figure.

Annual value added of forest services

Table 6 and 7 show the flow of benefits ($U'(C_t)c_{j,t}$ in Eq.(4) of Section 2) and the change of the value of stock ($\Delta V_{j,t}$ in the same equation) for the year 2013, respectively. The currency unit used is the 2013 Ethiopian Birr (calculated as 18.5 ETB = 1 USD).[18]

Of the flow benefits shown in Table 6, the most important is the benefit of forest coffee production in natural forests (9.1 billion ETB) and the wood fuel production from woodland areas (10.0 billion ETB). While it should be stressed that the estimates are based on very limited information, the benefit flows from goods for mainly home consumption (such as spices) and those from regulating services (such as soil erosion control affecting crop farming and sedimentation) are minor relative to the above items. The total annual amount of flow benefits is 44.9 billion ETB including all goods and services, or 28.5 billion ETB if double-counting with other sectors is excluded.

Meanwhile, reflecting the stock losses through deforestation, the annual change of stock value shown in Table 7 exhibits generally negative values. Substantial losses are associated with losses of future benefit flows (nearly 14.3billion ETB in total, with the order of magnitude remaining constant with different assumptions of the discount rate and the increase rate of capital value). The value associated with carbon dioxide retention is even larger (60.2 billion ETB), suggesting a substantial potential impact of a REDD policy. These negative values are not offset by the positive values from land use conversion to farmland (which produces output). It is also noteworthy that the recent Ethiopian efforts at re-greening are hardly translated into a moderation of stock value loss, as these efforts, while substantially increasing the amount of tree-covered areas, have not yet increased the total tree volume.

[18] Based on the UN Operational Rates of Exchange for the year 2013, http://treasury.un.org/operationalrates/Default.aspx

5. Discussions

Our estimates imply that forests and other woodlands have substantial meaning for the economy and people's lives in Ethiopia. Relative to the Ethiopian nominal GDPof864.7 billion ETB in 2013,[19] the total flow benefits and (negative) change of stock value by our estimation amount to 5% and 6%, respectively. It should be noted, however, that our estimates are not meant to be directly compared to GDP, as we have discussed in earlier sections.

The area and volume accounts of our estimation are roughly consistent with the previous study of Nune, Kassie, and Mungatana (2013), but the flow benefits from the production of timber, wood fuel and other NTFPs by our estimation are substantially higher than their estimate of 9 billion ETB (4 billion ETB + 5 billion ETB: see their Table 17) for the year 2005. This could partly be because of the extremely rapid economic growth of Ethiopia between 2005 and 2013, our reference year.

Our analysis has some similarities to some studies of ecosystem valuation in Ethiopia (Jagger and Pender 2003; Sutcliffe 2009; Reichhuber and Requate 2012; van Zyl 2016), but a direct comparison between ours and these is not possible due to our differing foci in terms of areas and types of ecosystems being considered. However, these studies, ours, and the one conducted by Nune, Kassie, and Mungatana (2013) are built on frameworks that are similar to global studies on the value of ecosystems such as de Groot et al. (2012) and Costanza et al. (2014), although some methodological differences among them do exist at a fundamental level (see also Section 2).

As studies of a related but different approach, research of household surveys on the role of forests on livelihoods has also been made for various locations in Ethiopia (Babulo et al. 2008, 2009; Chilalo and Wiersum 2011; Melaku, Ewnetu, and Teketay 2014; Worku et al. 2014; Tadesse et al. 2014). A global study based on such a framework (Angelsen et al. 2014) exists as

[19] According to the Economics Intelligent Unit (http://country.eiu.com/ethiopia)

well. Since we do not have the data about how many people in Ethiopia live alongside forests or other types of tree-covered areas, we cannot present a comparison of our results with those estimates here. Using data on spatial distributions of population, however, it would be in principle possible to make a comparison between our estimates and those survey-based data.

Apart from its use as a supplementary indicator to GDP, a comprehensive accounting of Ethiopian forest values should also be useful as the basis for REDD policy. Our estimation suggests that considerably large monetary values of carbon retention by a forest could in fact be obtained when the social cost of carbon is used for evaluation. The results also show that the carbon retention benefits of not only natural forests but also of other types of tree-covered land can be substantial.

6. Conclusion

Forests offer a variety of services in Ethiopia, and there is a growing interest in the economic valuation of the diverse benefits of Ethiopian forests on a national scale, to be comparable with standard economic indicators such as GDP. This paper has attempted to identify the current understanding of and to set a scope for a comprehensive national accounting of forest values in Ethiopia, with a quantitative estimation of its own. While some attempts at a valuation of Ethiopian forests, notably that by Nune, Kassie, and Mungatana (2013), already exist, our newer estimation allows us to reflect the recent and growing literature of this field, and also importantly, to assess how the recent efforts toward the regeneration of woodlands in Ethiopia (e.g., Lemenih and Kassa, 2014) affect the total value of tree-covered areas in Ethiopia. Also, unlike the approach taken by Nune, Kassie, and Mungatana to conduct an estimation under an extended SNA framework, we base our estimation on a welfare-economic framework of evaluating how a change of natural stock affects social welfare, as in the World Bank (2011) and UNU-IHDP and UNEP (2012). Treating the change of forest stock as a sort of capital accumulation or depreciation, we find that the recent regeneration of woodlands in Ethiopia does not offset the effects of deforestation when evaluated in monetary terms. In this paper, we have also surveyed the literature on the cultural values the forests have for people in Ethiopia, which is an important aspect in the valuation of Ethiopian forests despite the lack of quantitative estimates.

While our estimation does offer some insights about the value of forests in Ethiopia, our study also highlights the current lack of knowledge and data that needs to be remedied in order to conduct a fuller accounting of forest values in Ethiopia in the future. First, a national forest inventory, which incorporates not only physical data of forest areas and tree volumes but also economic data including the structure of the forestry sector and sector-related taxes, must be taken on a regular basis. A detailed inventory is necessary also for estimating the shadow price of forest goods and services. Second, more research is needed on the physical mechanisms of the regulating services of Ethiopian forests, such hydrological functions, as well as high-resolution datasets of geographical properties such as the flood risks. Third, more research would be needed on the cultural values of forests in Ethiopia—not only quantitative studies of the stated and revealed preference methods but also qualitative studies to identify the significance of forests in Ethiopians' lives. Efforts need to be taken to synthesize the data and insights obtained from those investigations.

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Table 1.Data sources

Data type	Source	Description	Data quality
Forest area in 2000	WBISPP (2004)	This is the first ever comprehensive national scale forest data obtained from original forest inventory. It provided forest area coverage (nationally and for regional states) and standing stock and incremental yield per unit hectare for the various forest types found in the country.	Excellent
Fuelwood supply of 2000	WBISPP (2004)	This data is also obtained from the WBISPP document, which is primary survey data.	Excellent
Timber/industrial wood supply of 2000	Bekele (2011) &FAOSTAT (2000) &)	This data is a compilation of national wood product statistics reported to FAO as part of global data collection. The same data was checked and verified from FAOSTAT for Ethiopia for the year 2000. The data were collected from forest industries and government office.	Medium
Forest area of 2013	FSR (2015)	The FSR(Forest Sector Review) carried out in 2015 is the most compressive assessment of the forest sector of Ethiopia since the Woody Biomass. However, unlike the Woody Biomass Inventory the FSR data was based on projection of the Woody Biomass Data of 2000, integrating several socio-economic changes in the country such as population growth, energy sector changes, economic status change and others. The estimate provided is the most plausible to use for this paper as other national scale primary data are not available.	Medium
Wood product supply and demand for 2013	FSR (2015)	The data on wood product supply and demand for 2013 is also obtained from the FSR (2013) document. The data is compiled from various sources of national statistics such as	Medium

		custom authority of import, Central Statistical authority for industrial wood consumption, forest enterprises for data on local production as well as other sources of data.	
Forest increment	WBISPP (2004)	Incremental yield for the forest and plantation of Ethiopia is obtained from the woody biomass document.	High

Source: Authors

Table 2. Parameter levels for wood growth, volume and carbon content calculations. The levels are set based on WBISPP (2004) and the FSR.

	Natural forest	Plantation	Woodland	Shrubland	Trees outside forest
Standing stock, m^3/ha	132	179	21	15	3.33
Mean Annual Increment (MAI), m^3/ha/year	5.65	12.5	0.8	0.5	0
Biomass Conversion and Expansion Factor (BCEF), t/m^3	1.3	0.7	2.8	2.8	1.3
Carbon fraction	0.5	0.5	0.5	0.5	0.5
Root to Shoot (R/S) ratio	0.25	0.25	0.25	0.25	0.25

Source: Authors

Table 3-1.Area account of the Ethiopian forests in 2013 (ha)

	Natural forest	Plantation	Woodland	Shrubland	Trees outside forest	Total
Opening area	2,900,000	909,500	21,500,000	20,100,000	21,298,529	66,708,029
Net effects of deforestation and afforestation	-64,253	0	-450,500	-369,104	0	-883,858
Rehabilitation and reclassification of area type	0	0	1,642,000	0	514,753	2,156,753
Net change	-64,253	0	1,191,500	-369,104	514,753	1,272,896
Closing area	2,835,747	909,500	22,691,500	19,730,896	21,813,282	67,980,925

Source: Authors

Table 3-2.Area account of the Ethiopian forests in 2000 (ha)

	Natural forest	Plantation	Woodland	Shrubland	Trees outside forest	Total
Opening area	4,072,998	501,522	29,242,950	26,356,068	21,298,529	81,472,067
Net effects of deforestation and afforestation	-90,242	0	-612,742	-483,987	0	-1,186,971
Rehabilitation and reclassification of area type	0	0	0	0	702,984	702,984
Net change	-90,242	0	-612,742	-483,987	702,984	-483,987
Closing area	3,982,756	501,522	28,630,208	25,872,081	22,001,513	80,988,080

Source: Authors

Table 4-1.Volume account of the Ethiopian forests in 2013 (m3) (all in round wood equivalent)

	Natural forest	Plantation	Woodland	Shrubland	Trees outside forest	Total
Opening volume (stock)	382,800,000	162,800,500	451,500,000	301,500,000	70,924,102	1,369,524,602
Increment	16,385,000	11,368,750	17,200,000	10,050,000	0	55,003,750
Timber (roundwood, wood for furniture use, etc.)	-1,827,000	-5,500,000	0	0	0	-7,327,000
Wood fuel (firewood and charcoal)	-26,818,000	-6,793,000	-55,278,000	-21,454,400	-5,363,600	-115,707,000
Net effects of deforestation and afforestation	-8,481,415	0	-9,460,502	-5,536,566	0	-23,478,483
Rehabilitation and reclassification of area type	0	0	16,420		452,626	469,046
Net change	-20,741,415	-924,250	-47,522,082	-16,940,966	-4,910,974	-91,039,688
Closing volume	362,058,585	161,876,250	403,977,918	284,559,034	66,013,127	1,278,484,914

Source: Authors

Table 4-2.Volume account of the Ethiopian forests in 2000 (m3) (all in round wood equivalent)

	Natural forest	Plantation	Woodland	Shrubland	Trees outside forest	Total
Opening volume (stock)	537,635,736	89,772,438	614,101,950	395,341,020	70,924,102	1,707,775,246
Increment	23,012,439	6,269,025	23,394,360	13,178,034	0	65,853,858
Timber (roundwood, wood for furniture use, construction, etc.)	-559,670	-1,684,830	0	0	0	-2,244,500
Wood fuel (firewood and charcoal)	-20,187,610	-5,113,522	-41,611,258	-16,150,088	-4,037,522	-87,100,000
Net effects of deforestation and afforestation	-11,911,996	0	-12,867,580	-7,259,807	0	-32,039,383
Rehabilitation and reclassification of area type	0	0	0	0	625,121	625,121
Net change	-9,646,837	-529,327	-31,084,478	-10,231,861	-3,412,401	-54,904,904
Closing volume	527,988,899	89,243,111	583,017,472	385,109,159	67,511,701	1,652,870,341

Source: Authors

Table 5-1.Physical carbon account of the Ethiopian forests in 2013 (tCO2e)

	Natural forest	Plantation	Woodland	Shrubland	Trees outside forest	Total
Opening stock	1,140,425,000	485,009,823	1,345,093,750	898,218,750	211,294,719	4,080,042,042
Increment	48,813,646	33,869,401	51,241,667	29,940,625	0	163,865,339
Timber (roundwood, wood for furniture use, etc.)	-5,442,938	-16,385,417	0	0	0	-21,828,354
Wood fuel (firewood and charcoal)	-79,895,292	-20,237,479	-164,682,375	-63,916,233	-15,979,058	-344,710,438
Net effects of deforestation and afforestation	-25,267,549	0	-28,184,411	-16,494,354	0	-69,946,315
Rehabilitation and reclassification of area type	0	0	48,918	0	1,348,447	1,397,365
Net change	-61,792,133	-2,753,495	-141,576,202	-50,469,962	-14,630,611	-271,222,403
Closing stock	1,078,632,867	482,256,328	1,203,517,548	847,748,788	196,664,108	3,808,819,639

Source: Authors

Table 5-2.Physical carbon account of the Ethiopian forests in 2000 (tCO2e)

	Natural forest	Plantation	Woodland	Shrubland	Trees outside forest	Total
Opening stock	1,601,706,464	267,447,055	1,829,512,059	1,177,786,789	211,294,719	5,087,747,086
Increment	68,557,890	18,676,470	69,695,698	39,259,560	0	196,189,618
Timber (roundwood, wood for furniture use, etc.)	-1,667,350	-5,019,390	0	0	0	-6,686,740
Wood fuel (firewood and charcoal)	-60,142,255	-15,234,035	-123,966,872	-48,113,804	-12,028,451	-259,485,417
Net effects of deforestation and afforestation	-35,487,820	0	-38,334,667	-21,628,175	0	-95,450,662
Rehabilitation and reclassification of area type	0	0	0	0	1,862,340	1,862,340
Net change	-28,739,535	-1,576,954	-92,605,841	-30,482,419	-10,166,111	-163,570,860
Closing stock	1,572,966,929	265,870,101	1,736,906,218	1,147,304,369	201,128,608	4,924,176,226

Source: Authors

Table 6.Flow benefits of ecosystem services provided by the Ethiopian forests in 2013 (Unit: 2013 billion ETB)

Type		Natural forest	Plantation	Woodland	Shrubland	Trees outside forest	Total
Timber (roundwood, wood for furniture use, etc.)		2.2	4.0	0.0	0.0	0.0	6.2
Wood fuel (firewood and charcoal)		4.8	1.2	10.0	3.9	1.0	20.8
Other NTFPs							
	Forest coffee	9.1	0	0	0	0	9.1
	Honey	1.2	0	0.1	0	0	1.32
	Bees wax	0.1	0	0.01	0	0	0.1
	Gums and incense	0	0	0.1	0	0	0.1
	Spices	0.016	0	0	0	0	0.016
	Bamboo	0.02	0	0.04	0	0	0.06
	Traditional pharmaceutical products	1.1	0	1.6	0	0	2.7
	Fodder	0.7625	0	2.3	0	0	3.1
	Wild foods	N/A	N/A	N/A	N/A	N/A	
Regulating services							
	Soil erosion control (exclosures)	0	0	0.06	0	0	0.06
	Reduction of sedimentation	1.4	0	0	0	0	1.4
Cultural services							
	Tourism	0.01	0	0	0	0	0.01

Flow of benefits, total (i.e., including italicized items)	20.8	5.2	14.1	3.9	1.0	44.9
Sum of entries that could be included in national accounting (i.e., excluding italicized items) -- (i)	8.5	5.2	10.0	3.9	1.0	28.5

Source: Authors

Table 7.Change of the value of the Ethiopian forests in 2013 (Unit: 2013 billion ETB)

Type	Natural forest	Plantation	Woodland	Shrubland	Trees outside forest	Total
Change of the stock value (5% discounting)	-16.5	-1.1	-24.4	-1.9	-3.8	-47.8
Value of future flow benefits (based on (i) of Table 6)						
5% discounting, no capital gain	-4.4	-0.5	-6.8	-2.0	-0.6	-14.3
(5% discounting, 2% increase in *p*)	-5.4	-0.8	-7.8	-2.5	-0.7	-17.2
(10% discounting, no capital gain)	-3.0	-0.3	-5.1	-1.4	-0.4	-10.2
Retention of carbon dioxide	-13.7	-0.6	-31.4	-11.2	-3.2	-60.2
Option values (genetic resources)						
Coffee genes	-0.4	0	0	0	0	-0.4
Bioprospecting	-7E-05	0	0	0	0	-7E-05
Value as agricultural land (conversion from forest)	2.0	0.0	13.8	11.3	0.0	27.1

Source: Authors

Appendix 1: Methods of our supplementary field study about cultural values of forests

The field study was conducted from 20th April to 8th May 2015. The study consists of group discussions and individual semi-structured interviews among target groups, who lived in different circumstances. Each group discussion and individual in-depth interview lasted 1-1.5 hours. The group discussions and individual interviews were conducted in different languages: those in Villages A and B were in Oromo and those in the university and Addis Ababa were in English. The group discussions and interviews were supported by Ethiopian assistants (two in Jimma and two in Addis Ababa) as facilitates and interpreters. In each village in the Jimma Zone, village administrator(s) nominated the participants of the group discussion, among whom we also recruited individual interviewees. The participants from the university were nominated by the head of a department. Interviewees in Addis Ababa were selected with the support of Ethiopian assistants. The lists of target groups and individual interviewees and key questions are shown below.

The list of the target groups

Areas	Forms (languages)	Groups types
Oromia Region		
Forest area (Village A in the Gera district)	Group discussion (Oromo)	2 groups: male and female villagers. Each group consists of 8 persons in a wide age range.
	Individual interviews (Oromo)	2 male and 1 female villagers
Less forest area (Village B in the Mana district)	Group discussion (Oromo)	2 groups: male and female villagers. Each group consists of 8 persons in a wide age range.
	Individual interviews (Oromo)	2 male and 2 female villagers
A university in Jimma	Group discussion (English)	2 groups: male and female students. Each group consists of 8 students.
	Individual interviews (English)	1 male and 1 female students
Addis Ababa		
In the city	Individual interviews (English)	2 male and 2 female residents in different age range.

Source: Authors

The list of the individual interviewees

	Interviewee	Age	Occupation	Religion
1	Village A male (1)	56	Farmer	Muslim
2	Village A male (2)	38	Farmer	Muslim
3	Village A female (1)	45	Farmer	Muslim
4	Village B male (1)	50	Farmer	Muslim
5	Village B male (2)	36	Farmer	Muslim
6	Village B female (1)	40	Farmer	Muslim
7	Village B female (2)	37	Farmer	Muslim
8	University male students	21	Student	Protestant
9	University female student	20	Student	Orthodox
10	Addis Ababa male (1)	56	Researcher	Orthodox
11	Addis Ababa male (2)	40±	Shop owner	Muslim
12	Addis Ababa female (1)	49	Researcher	Protestant
13	Addis Ababa female (2)	32	Teacher	Orthodox

Source: Authors

Key questions

Group discussions

- Common understanding of forests (e.g., locations, characteristics, types of trees)
- Perceptions of forests
- Goods and services that people obtain from forests
- Value of the goods and services (how people attach value to the goods and services obtained from the forest at least in relative measures)
- Occasions to go to forests (why they go, and what they enjoy most from going to forest)
- Memories of forests/trees in schools (e.g., lessons, events), rituals, seasonal festivals, tales etc.

Individual semi-structured interviews

- Memories of forests/trees in his/her work, family life, and childhood
- Perception of forests
- Goods and services that s/he obtains from forests
- Value of the goods and services (how s/he attach value to the goods and services obtained from the forest)
- Frequency of forest visits
- Purpose of forest or forest area visits
- Changes in relation to forests in his/her life (e.g., from youth to adulthood, moving from/to forest areas)

Appendix 2: Adjustments of FSR data for our estimation

Timber and wood fuel

Following Reichhuber and Requate (2012), we assume that the production of $1m^3$of wood necessitates human work labor of 2 man-days. Reichhuber and Requate's estimate is based on an estimated level of the rural wage in 2003 (3 ETB/day), and we assume a 10-fold increase of the wage level between 2003 and 2013 (i.e., 30 ETB/day), in taking into account the changes of agricultural GDP and rural population, whose data area is drawn from the Ministry of Finance and Economic Development and the World Bank. For timber and fuelwood, we subtract this unit cost from the market prices of the goods shown in the FSR. For charcoal, we assume that the net value of wood as input is the same as for fuelwood.

Forest coffee

Following Reichhuber and Requate's (2012) approach of estimating the production cost of semi-forest coffee, we assume that the production of 1 kg of coffee necessitates 16 ETB of labor cost. Here, we make the same adjustment to the rural wage level (a 10-fold increase of labor cost during 2003-2013) as in the above case of timber and wood fuel.

Other NTFPs

The FSR already shows the value added (i.e., values exclusive of production costs) for bamboo, traditional pharmaceutical products, and fodder, and thus we use its estimates for those products without adjustments. For the rest of the products, we take the following approach of adjustments, which is in line with Reichhuber and Requate (2012). For the products that necessitate substantial processing and transport for sale at domestic and foreign markets (honey, bees wax, gum, and incense), we assume a production cost of 40% of sales values, and for the product mainly consumed at home or locally (spices), we assume a production cost of 20% of sales values.

Abstract (in Japanese)

要約

エチオピアは長期にわたって森林消失の問題に直面してきた。そのような森林消失の人間活動への影響、あるいはより一般的な意味で森林と人間活動との関連は多岐にわたるが、人間にとってエチオピアの森林が有するこのような多様な価値に関しての定量的な経済評価は今まであまり行われてこなかった。本研究では、エチオピアの森林の総合的な経済価値評価に関する今後の様々な取組に資することを目指し、既存の定量的及び定性的な関連研究の概観、並びにエチオピアの森林の経済価値に関する独自の試行的定量評価を実施した。評価にあたっては、エチオピアの森林に関する先行研究で用いられたことのある GDP 推計方法（SNA）を直接拡張する手法ではなく、自然資本としての森林の増減を厚生経済学的な考え方に基づき貨幣換算評価する手法を用いている。