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# Ecosystem Services, Local People Perception and Preferences in Chilimo forest of Ethiopia

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**Abstract**
Site and situation specific assessments of such services are crucial to sustainably conserve and manage forest resources. In this study, using Chilmo forest as a case study site, an attempt has been made to identify the main ecosystem services which are perceived and preferred by local communities. The study triangulated primary data collection methods such as field observations, household surveys, key informant interviews and pebble-distribution methods. In addition, secondary data was used to support and verify the primary data. Combinations of techniques were employed for data analyses. We identified five landscapes and four forest ecosystem services. Out of which, provisioning services are the main source of livelihood and subsistence incomes for local communities. We also found that forests are the sole source of water and fuel wood services in the study area. According to the perception and preferences of local people forest land received the highest scores compared to other landscapes for all services except provisioning services. We conclude that local communities are highly dependent on forests' ecosystem services in the study area. This finding is expected to contribute towards management of the Chilmo forest and to be used as an input for further valuation study.
**Keywords:** Ecosystem service; Valuation; Forest, Ethiopia.
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## 1. Introduction

Ecosystem services are defined as the direct and indirect contributions of ecosystems to human well-being (de Groot et al., 2010). In literature, much attention is given to enhance sustainable management of natural resources and their associated ecosystem services (Daily, 1997). However, land use change has a considerable impact on the worlds' ecosystems (MEA, 2005).Despite forest being known to be significant to the delivery of ecosystem services, they are one of the most threatened ecosystems worldwide (MEA, 2005).

In East Africa, particularly in Ethiopia, loss of ecosystem services caused by the removal of trees is a major problem for the environment and economic development of the country (FAO, 2006; Kindu et al., 2016).Although consistent statistics are not established, a number of scholars estimate deforestation rate at 150,000 to 200,000ha/year (Lemenih and Melaku, 2008). Because of the alarming rate of deforestation, the forest area coverage of Ethiopia dramatically decreased to 4% (Leminih et al., 2015). However, due to large scale reforestation program and massive planting campaigns the forest area coverage has been increased. Currently 98 million peoples are living in Ethiopia from which 80% live in the countryside and highly dependent on forest resources.

Due to high population growth there is high demand for food which ultimately leads to rapid conversion of forest land into agricultural area (Kindu et al., 2013). Land use changes into agricultural area maximize a single output (food) but at the expense of other services such as regulating; cultural and supporting services (Bennett et al., 2009; Loft, 2011; Kindu et al., 2016).

Assessing and being aware of benefit of ecosystem service is essential to understand the importance of ecosystem services for human wellbeing (Costanza et al., 2014).Furthermore, information about ecosystem services is important for decision makers to understand the dependency of local communities on ecosystem services, to incorporate perceptions of stakeholder and to come up with better land use policy (Forster et al., 2015).

Over the last 50 years, the forest management strategy in Ethiopia has negatively affected the forest by hindering local people's access and use right of resources which leads to further devastation of forest resources (Tagesse and Wossen, 2015). Chilmo forest was one of the most exploited forests in the country. Ineffective centralized forest management, frequent political change and associated shift of property rights coupled with land use change led to deforestation in Chilmo forest (Negassa and Wiersum, 2006).

Despite of the tremendous importance of forest ecosystem functions and services, little consideration is given to assess ecosystem services and the benefit that the Chilmo forest ecosystem provides to local communities. Therefore, site-specific information for conservation and management is required (Plummer, 2009, Hein et al., 2006)).

 

## 2. Materials and Methods

### 2.1. Study area

Chilmo forest is one of the few remnants of dry afromontane forest located in Dendi District, western Shewa zone, Oromia regional state, Ethiopia. Chilmo Forest is found 70 km west of Addis Ababa, capital city. The forest is situated between altitudinal range of 2,170-3,054 m above sea level and geographically positioned at 38° 07′ E to 38° 10′ E and 9° 30′ to 9° 50′ N' longitude (Alebachew, 2015).According to Daniel Gamachu, 1977 the rainfall in Chilmo forest and the surrounding area is belongs to type I rainfall regimes which receives rainfall for five months from May- Sep. and reaches peak in July (Shumi, 2009).

The forest area covers 4944 hectares from which 415 hectares is plantation forest (Shumi, 2009).

Currently Chilimo forest is owned by 8 Forest cooperatives and 4 Forest users Group. Over 2858 households live inside the forest (Tagesse and Wossen, 2015). Surprisingly, Chilmo forest is the place where one of the longest rivers (Awash River) originates and also it is the home of over 180 species of birds and 21 species of mammals. Some of the endemic subspecies of mammals include Colobus Monkey, Meneliks bushbuck, Anubis baboon, leopard and Vervet monkey (Woldemariam, 1998). Chilmo forest is rich in diversity of broad leaved tree species mainly Olinia rochetiana, Allophylus abyssinicus, Juniperus procera, cuspidiata, Podocarpus falcatus, Rhus glutinosa, Olea europaea ssp, Scolopia theifolia((Bekele, 2003).

Soromessa and Kelbessa, 2014 also investigate 213 plant species which are categorized into 83 families. Surprisingly, 17 of them are endemic tree species. Maytenus gracilipes species score the maximum density 258.7 stems per hectare followed by Podocarpus falcatus(120 individual per hectare) and Scolopia theifolia (109.3/ha) (Soromessa and Kelbessa, 2014 ). Plantation forest include Hagenia abyssinica, Podocarpus falcatu, Eucalyptus saligna, Eucalyptus camaldulensis, Juniperus procera, Cupressus lusitanica (Kassa et al., 2008).

Chilmo forest provides the services grouped by The economics of ecosystem services and biodiversity (TEEB).It offers provisional services such as timber for construction, farm implement, fire wood, charcoal, wild fruits, tree seed, honey, herbs, medicinal plants; regulating services such as climate regulation, water regulation, erosion regulation, pollination; habitat services such as gene pool protection and Nursery and cultural services.

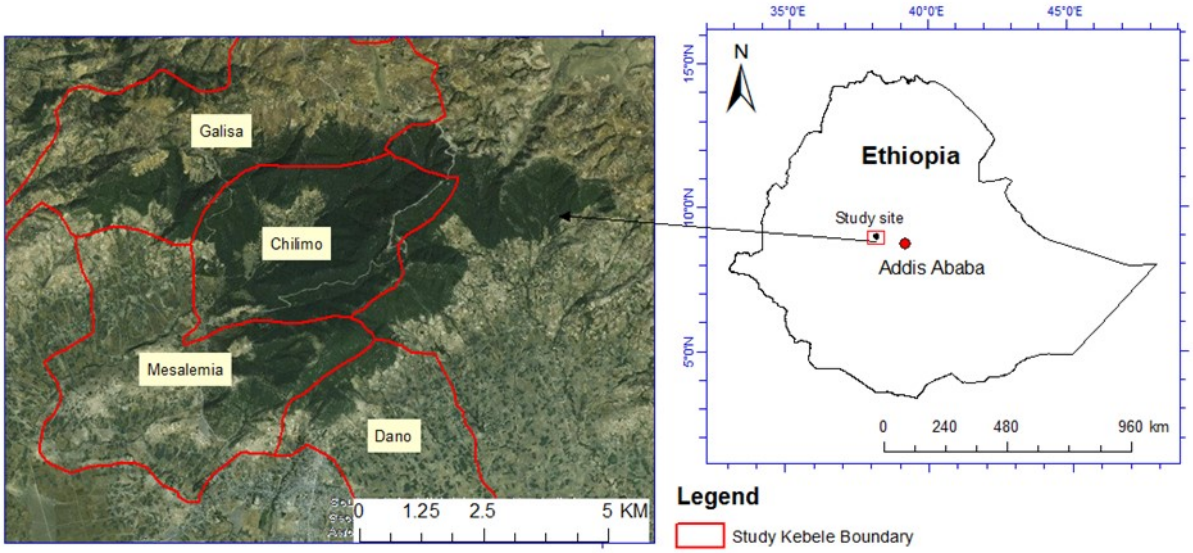


**Figure 1:** Map of the study area (Source: Satellite Imagery from ESRI, Dark green is the Chilmo forest and the rest is other land use types.

### 2.2. Conceptual framework used in this study

A number of frameworks have been developed for analysis of ecosystem services and function (MEA, 2003; MEA, 2005b; Daily, 2000; de Groot et al., 2002; Daily, 1997). In this study, an integrated assessment of ecosystem services was prepared based on the integrated assessment frame work developed by de Groot et al (2002). We adopted their framework as it overcome mismatched scales of analysis and helps to present a conceptual framework for typology for discussing, classifying and valuing ecosystem services and functions. In addition to this framework, we tried to examine the cause and effect of environmental problem on ecosystem services and the relationship between human and environment using DPSIR model (Figure 2). The DPSIR model helps to initiate environment-based development projects and policies as the model easily illustrate the area of intervention (EEA, 2001). The DPSIR framework consists of five components which are influenced each other. It provides detail information about the drivers which are mostly caused by anthropogenic factor which create a pressure on ecosystem, state of the environment, impact on ecosystem and possible and necessary responses

 

(Kristonsen, 2004).

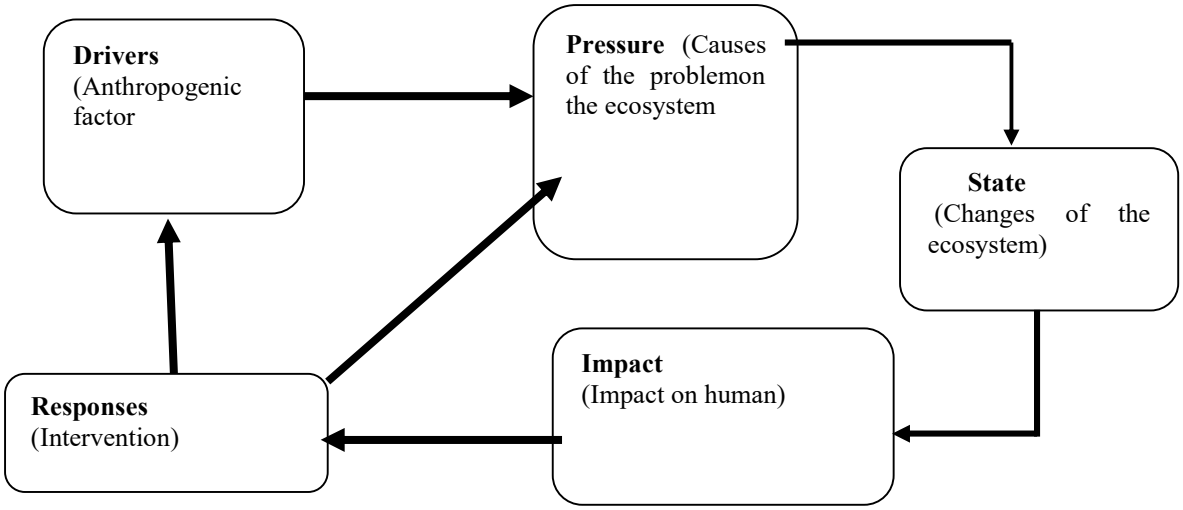


**Figure 2:** A generic DPSIR model (Adapted and modified from: Gregory et al., 2013)

Drivers of changes (in this case deforestation) are classified as direct and indirect drivers based on its immediate impacts. The direct driver of deforestation includes increasing demand of agricultural land, grazing land, settlement place, wood products. The Indirect driver of deforestation is mainly population pressure and poverty. As a result of all these drivers, pressure is exerted on forest ecosystem services that lead to changing the capacity of state to convey vital ecosystem services. The change of state negatively affects the population who are dependent on the ecosystem services. The responses (interventions) are able to influence the driving forces to decrease pressure on the forest.

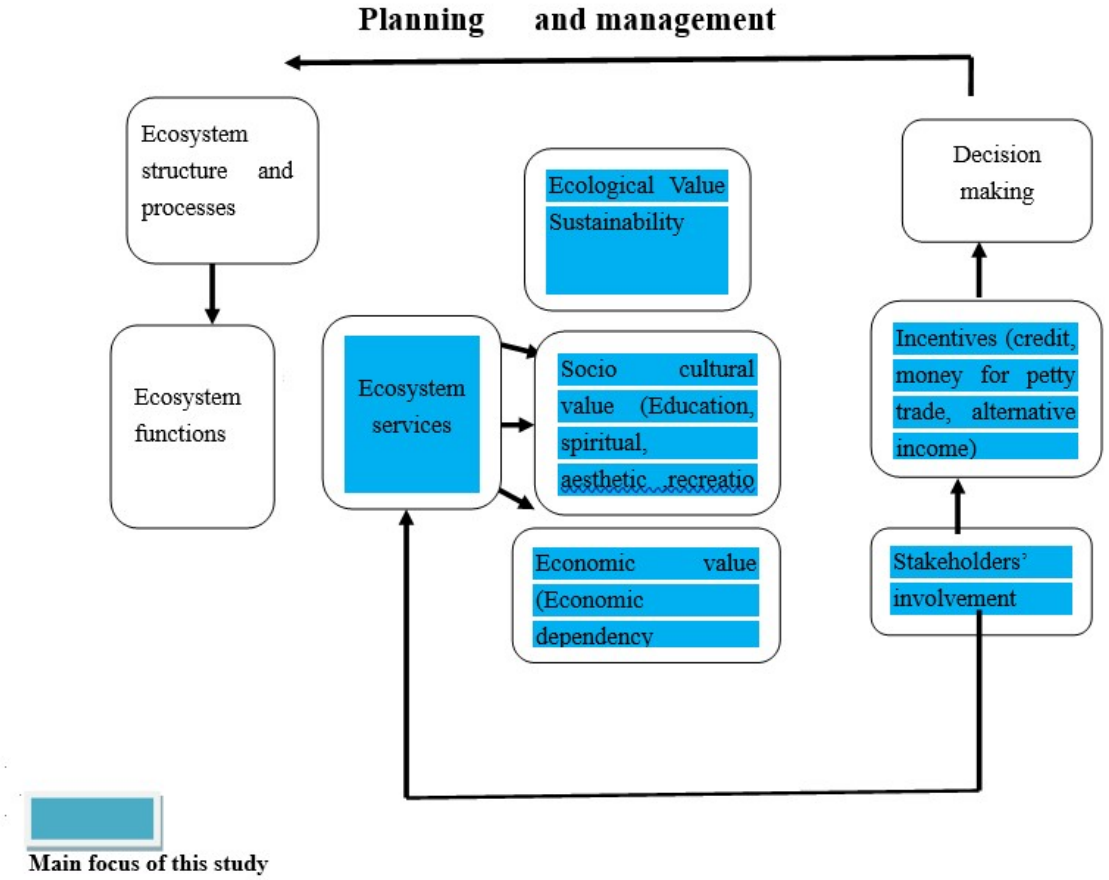


**Figure 3:** Framework for integrated assessment and valuation of ecosystem functions, goods and services in environmental planning management and decision (adapted from de Groot et al. (2002)).

The framework involves detail assessment of ecosystem goods and services which engage the conversation of ecosystem processes and structure into ecosystem functions (Figure 3). Ecosystem function again translated

 

into goods and services. The benefit derived from ecosystem goods and services are valued based on the ecological, socio cultural and economic value. Ecological values are measured in terms of ecological sustainability and socio-cultural values which are measured related to equity and perception of human society toward natural capital and economic values calculated using direct market valuation, indirect market valuation, contingent valuation and group valuation.

### 2.3. Ecosystem services typology used in this study

Ecosystem services in this study include both physical goods and indefinable services provided by Chilmo forest as defined by The Economics of Ecosystem and Biodiversity (TEEB) (van der Ploeg and de Groot, 2010). Ecosystem goods and services provided by Chilmo forest include provisioning, regulating and cultural services that directly affect people and habitat services (Pascual et al, 2010). In this study the classification of ecosystem services was done using the typology of ecosystem functions and services adapted from (Costanza et al., 1997, de Groot, 1992, de Groot et al., 2002) (Table 1).

**Table 1:** Functions, goods and services of natural and semi-natural ecosystems. Adapted from Costanza et al. (1997), De Groot (1992), and De Groot et al. (2002).

| No | Service category | Description | Example |
|---|---|---|---|
| **Regulation function maintenance of essential ecological processes and life support systems** | | | |
| **1** | Gas regulation | Regulation of Atmospheric chemical composition | CO2/O2 balance,O3 for UVB protection, and SOx levels |
| **2** | Climate regulation | Regulation of global temperature, precipitation, and other biologically mediated climatic processes at global or local levels. | Green house gas regulation, DMS production affecting cloud formation |
| **3** | Disturbance regulation | Capacitance, damping and integrity of ecosystem response to environmental variation | Storm protection, Flood control, drought recovery and other aspects of habitat response to environmental variability mainly controlled by vegetation structure. |
| **4** | Water regulation | Regulation of hydrological flow | Provisioning of water for agricultural (such as irrigation) or industrial (such as milling) processes or transportation. |
| **6** | Erosion control and sediment retention | Retention of soil within an ecosystem | Prevention of loss of soil by wind, runoff, storage of silt in lakes and wetlands. |
| **5** | Water supply | Storage and retention of water | Provisioning of water by watersheds, reservoirs and aquifers. |
| **7** | Soil formation | Soil formation process | Weathering of rock and the accumulation of organic material. |
| **8** | Nutrient cycling | Storage, internal cycling, processing and acquisition of nutrients | Nitrogen fixation, N, Pand other elemental or nutrient cycles. |
| **9** | Waste treatment | Recovery of mobile nutrients and removal or breakdown of excess or xenic nutrients and compounds. | Waste treatment, pollution control and detoxification |
| **10** | Pollution | Movement of floral gametes | Provisioning of pollinators for the reproduction of plant populations. |
| **11** | Biological control | Trophic-dynamic regulations of populations | Keystone predator control of prey species, reduction of herbivory by top predators. |
| **Habitat (supporting) functions: Providing habitat (suitable living space) for wild plant and animal species ♦** | | | |
| **12** | Refugium function | Habitat for resident and transient populations. | Nurseries, habitat for migratory species, regional habitat for locally harvested species, or over wintering grounds. |
| **13** | Nursery function | Suitable reproduction-habitat | Maintenance of commercially harvested species Production |

 

| | | | |
|---|---|---|---|
| **Production functions** | **Provision of natural resources** | | |
| **13** | Food production | That portion of gross primary production extractable as food. | Production of fish, game, crops, nuts, fruits by hunting, gathering, subsistence farming or fishing. |
| **14** | Raw materials | That portion of gross primary production extractable as raw materials. | Production of lumber ,fuel or fodder |
| **15** | Genetic resources | Sources of unique biological materials and products | Medicine, products for materials science, genes for resistance to plant pathogens and crop pests, ornamental species (pets and horticultural varieties of plants). |
| | Medicinal resources | Variety in (bio)chemical sub-stances in, and other medicinal uses of, natural biota 17 | Drugs and Pharmaceutical Chemical models and tools Test and essay organism |
| | Ornamental resources | Variety of biota in natural ecosystems with (potential) ornamental use | Resources for fashion, handicraft, jewellery, pets, worship, decoration and souvenirs (e.g. furs, feathers, ivory, orchids, butterflies, Aquarium fish, shells, etc.) |
| **Information functions** | **Providing opportunities for cognitive development** | | |
| **16** | Recreation | Providing opportunities for recreational activities. | Eco-tourism, Sport Fishing, and other outdoor recreational activities. |
| **17** | Cultural | Providing opportunities for non-commercial uses. | Aesthetic, artistic, educational, spiritual, and/or scientific values of ecosystems. |
| | Aesthetic information | Attractive landscape features | Enjoyment of scenery (scenic roads, housing, etc.) |
| | Spiritual and historic information | Variety in natural features with spiritual and historic value Use | information Variety in natural features with spiritual and historic value Use of nature for religious or historic purposes (i.e. heritage value of natural ecosystems and features) |
| | Science and education Carrier Functions providing Habitation | Variety in nature with scientific and educational value | Use of natural systems for school excursions Use of nature for scientific research |

### 2.4. Data source and methodology

The study had employed triangulation of primary data collection methods such as household survey, key informant interview, pebble distribution method, field observation used in system analysis was implemented to retrieve the required data. In addition, secondary data was used to back up the primary data.

#### 2.4.1. Sampling Procedure

In order to analyze if location influences the use of ecosystem services, selection of forest cooperatives was carried out using purposive sampling techniques. Purposive sampling was used to select four forest cooperatives from eight forest cooperatives-based position in the watershed (lower to upper catchment), condition of forest (highly managed to the disturbed forest), accessibility for field work. According to this criteria four forest cooperatives namely Chilmo, Mesalemia , Gallessa and Dano Sengote were selected. Selection of household respondents was carried out using simple random sampling techniques. First we got the sampling frame from each forest cooperatives mainly name of household head, then we selected 25 respondent sample households from each forest cooperatives using lottery system. All the selected respondents were the head of the household. The sample size of the household survey for each cooperative was 13-20% of each total household.A total of 100 household head were participated for the household survey. Semi structured questioner was used to answer the research questions. Before starting household survey we were pre-testing the questioner and we made minor correction. Number of sample household in each forest cooperative was 25.Prior to asking the questions the purpose of the household survey were briefly explained for selected respondents. Primary data from the sample respondent include general information of the respondent such as name, age, sex, , marital status, wealth class,

 

educational status ,number of family members, land holding size and others were included.

Furthermore, pebble distribution method (PDM) was also used to put ecosystem services preferences in order of importance based on perception and knowledge of local people. The participants were selected together with forest union group representatives, experts; forest Enterprise committees and facilitator. The participants for pebble distribution are selected from elders, women, and youth based on the number of years stayed in the area, wealth status and social status. PDM exercised in four forest user group (FUG). The number of participants in each group was eight. The selected participant for PDM reached an agreement before they begun the exercises about the definition of each landscape units. Five landscape units and ten provisioning and three cultural services were explained and used. Each landscape units were written in local terms and drawings for illiterate members for easy understanding and clarification. After arranging the figure of each landscape unit the facilitator demonstrated the steps of the PDM exercises using local language to ensure all the categories are well understood and clear for all participants. In addition, the facilitator explained how they distributed 100 Pebble (in this case Maize seed) to indicate the importance of each landscape units based on the relative importance of each service. One person is responsible to place the pebbles/maize seed on the paper but everyone has to discuss and agree before score is considered final and written down. The scoring for each service was counted and recorded on the data sheet. The participant repeated the exercise for each specific ecosystem services against landscape units.

The services that received high number of maize seeds are the most important services for specific landscape. The better the number of services shows the degree of comparative importance compared to other services specific to each landscape unit. After finishing each game participants were asked for the reason why they gave the highest score for one service related to other services.

### 2.4.2. Data analysis and management

Socioeconomic characteristics of households and summary of their responses about ecosystem services were analyzed using SPSS and Microsoft excel. The analysis was used descriptive statistics mainly frequency, descriptive, bar chart, cross tabulation pie charts and histogram. Data related to perception and preference of ecosystem services were analyzed quantitatively using Microsoft excel. Data collected through key informant interview and field observations was analyzed qualitatively.

## 3. Results

### 3.1. Identification of ecosystem services

Numbers of ecosystem services identified from Chilmo forest are listed below

**Table 2**. Ecosystem services provided by forest

| Services | Services found in Chilmo forest |
|---|---|
| **Provisioning services**<br><br>Food<br>Raw material<br>Medicinal plant<br>Tree seed<br>Water | • Food such as wild fruits , herbs and honey<br>• Use of wood for construction, fencing, charcoal, fuel wood, farm implement, Animal fodder (leaves and grasses), thatching grass<br>• Medicinal plant such as Prunus Africana,Hayginia abssinica<br>• Tree seed Provision of water |
| **Regulation services**<br>Climate regulation<br>Water regulation<br>Erosion regulation<br>Temperature regulation<br>Pollination | • Forest cover reduces evapo-transpiration to maintain the microclimate.<br>• Role of forest watershed to capture and store water.<br>• Forest cover reduce wind and water erosion<br>• Vegetation cover use to moderate local temperature<br>• Forest trees helps for survival of pollinators so as boost agricultural production. |
| **Cultural services**<br>Aesthetic<br>Recreation &ecotourism<br>Education &research | • Trees add beauty to the surroundings<br>• Recreation and Ecotourism opportunities<br>• Research site for number of studies. |
| **Habitat services**<br><br>Home of wild animal<br>Nursery | • Home for wild animals and plant species.<br>• Production place<br>• Number of nurse plant to facilitate growth of others |

 

### 3.1.1. Provisioning services

Chilmo forest provides number of provisioning services namely food (wild fruit), raw material, medicinal plants, tree seed and water.

Wild fruits are one of the provisioning services provided by Chilmo forest and commonly eaten by children. However, wild fruit doesn't have market price. So it is difficult to judge the value of wild fruits in economic terms. The most commonly used wild fruits in the study area are *Dovyalis abyssinica, Carissa spinarum (C. edulis), Morus mesozygia, Rosa abyssinica, Ximenia americana, Cordia africana* and *Ficus*. Overall, 73% and 12% of respondents from four forests cooperative collect wild fruit and herbs respectively. 13% of the respondents are not participated in the collection of wild fruit. Children are involved in collecting of wild fruit. In addition Chilmo forest is ideal place for honey production due to diversity of plant species which is suitable for bee forage .Local people has a long history of keeping bee hives in twigs and branches of forest tree. However, our result reveals that only 11% keep beehives inside the forest. Chilmo forest provides number of raw materials for local communities. In this specific study the raw material includes construction wood, charcoal, fuel wood, farm implement, fodder and forest honey.

Construction wood is used for house construction. From the total surveyed households 42% of the respondents are using construction wood from the forest. Permission for harvesting of construction wood is not the same within four forest cooperatives which is based on the condition of forests, availability of suitable tree, household income ,number of request and management power of the cooperatives. For instance, local people in Chimo a forest cooperative has better access of using construction wood (21%) than Dano sengote cooperatives (3%).

Charcoal making and use is illegal from the forest. However, the local people locally produce and use charcoal for household consumption and it is the main source of energy next to fuel wood. Our result shows that 34 % of surveyed sample household use charcoal as energy source.

Furthermore, Fuel wood is the main source of energy in the study area. Interestingly 100 % of household survey respondents use fire wood for cooking and heating. Collection of fire wood is mostly done by women and girls. In all forest cooperatives collection of fire wood from forest is allowed but it is not possible to cut main trees only dried branches, leaves and twigs. Recently local people started to plant Eucalyptus tree to satisfy the demand of wood. Selling of fuel wood is the main source of subsistence income especially for local women's. From the data 70 % of the respondent's only use fire wood for household consumption, 10% of them collect fire wood only for market whereas 20 % of sample household respondents use the fire wood for consumption and market. Due to the proximity of Mesalmia and Dano forest cooperatives to the nearby town, the percentage of local people taking firewood to the market is high compared to Chilmo and Galessa cooperatives.

Since Agriculture is the main occupation for the surrounding communities, wood from Chimo forest is the main input for making agricultural tools. The survey result shows that 87% of the respondent's harvest wood for making farm implement and 84% of men are participated in the preparation of farm tool. Moreover, forest land are the main source of forage for livestock. Livestock graze inside the forest during dry and rainy season because cut and carry system is not that much common in the study area. According to the result 90% of the household's use forest land as a grazing area for livestock's especially during dry season.

Chilmo forest watershed is the place where the longest river "Awash" originates and it is the source of number of streams and rivers .100% of the local people use water coming from the forest. The data revealed that 75 % of the sample households use water coming from the forest both for household consumption and livestock. According to the surveyed data 25% of the local people from Chilmo forest cooperatives use water for irrigation purpose.

Chilmo forest support public and livestock health through providing diverse medicinal trees which are the choice of the majority of poor people. Local people use different parts of medicinal plant mainly leaves roots, fruits for the treatment of different type of disease. According to household survey 41 % of the household use medicinal plants but only 35% are involved in collection and use of medicinal plants. 6% of the local people use the medicinal plant collected by others mostly by neighbors. However, the use of medicinal plant is different between forest cooperatives depend on condition of forest, tree composition and the proximity of the forest cooperatives to the health center. The surveyed household respondents from Chilmo forest cooperatives have a better trend of using medicinal plants compared to other forest cooperatives. Mostly Men are involved in collection of medicinal plants.

Since Chilmo forest is composed of a variety of tree species, local people collect tree seed from the forest both for tree seedling production and for market. However, only 6% of the surveyed sample households collect tree seed from the forest.

### 3.1.2. Regulating services

Forest is the cornerstone for provision of many of ecosystem services. Among all the services regulating ecosystem services are vital to sustain human beings on earth. Regulating services are essential for regulation of ecosystem processes and life support systems and helps to make ecosystem favorable to human beings by managing climate, temperature water and air quality (de Groot et al.,2002 ;De Groot ,2006).This study focused on regulating services such as Climate regulation, water regulation, temperature regulation , erosion control and

pollination. Since the forest is rich in biodiversity it has a capacity to regulate important services through ecological interaction between communities. According to surveyed household respondents 82% of them agreed about regulating capacity of forest such as climate, water, erosion and temperature regulation.

Since climate regulation is the outcome of number of process, it has powerful relation with other regulating services and provisioning services (Smith et al., 2011).It engage in the management of optimum climate mainly temperature and precipitation . The biogeochemical reaction managing global warming through sinking of GHG mainly CO2. Moreover, biophysical effects are responsible to regulate local and regional climate ( Smith et al., 2011).Thus local climate is the result of multiple interaction of global and regional circulation mainly depend on topography ,vegetation cover ,albedo and availability of different water body( de Groot et al 2002).

This subsection gives an overview about climate regulation specific to the study area. Since Chilmo forest is found in central part of Ethiopia, it is the lung of the capital city, Addis Ababa. Therefore, it is a place where many of ecological process take place. Chilmo forest generates favorable microclimate for human wellbeing and other living things inside and around the forest. Furthermore the richness of biodiversity in the forest ecosystem increases the percentage of carbon sequestration on large extent. To explore more about climate data, there is no metrological center setting around the study area. But based on the perception of local people the temperature around Chilmo forest is very favorable and it received sufficient precipitation throughout the year.

Water regulation is mainly determined by the amount of runoff and river discharges in the watershed (de groot, 1992, de Groot et al, 2002). The vegetation cover reduces runoff and increase infiltration rate there by increases water availability in the forest catchment (Bolund and Hunhammar, 1999). The availability of water in the catchment has a great contribution to sustain rivers and streams found around the forest. But it is determined by richness and biodiversity of different species, organic matter content of the soil and soil biological interaction (Pattanayak, 2004., Swift et al., 2004, Harrison et al., 2014).

Pollination is an important sign of healthy forest ecosystem. Number of pollinators are found in Chilmo forest mainly bees, butterflies, beetles. However, honeybee is the most important pollinators in the study area. With the absence of pollinator many plant species will go extinction and difficult to cultivate food and commercial crops (de Groot et al., 2002). Local people hang beehives inside the forest to harvest honey both for household consumption and market.

### 3.1.3. Habitat Services

Chilmo forest are the home of wild animals, birds and plant species. A Total of 180 bird species are recorded in Chilmo forest among which five are endemic to Ethiopia and others are afro tropical highlands biome species. Some of the biome species are *Bostrychia carunculata*, *Agapornis taranta*, *Tauraco leucotis*, *Lybius undatus*, *Zoothera piaggiae*, *Pseudoalcippe abyssinica*, *Parophasma galinieri*, *Parus leuconotus*, *Oriolus monacha*, *Corvus crassirostris*, *Poeoptera stuhlmanni*, *Onychognathus tenuirostris*, *Cinnyricinclus sharpii*, *Cryptospiza salvadorii* and *Serinus nigriceps*. Chilimo forest supports populations of many other important birds including *Accipiter melanoleucus*, *A. tachiro*, *Buteo buteo*, *B. oreophilus*, *Aquila pomarina*, *A. verreauxii*, the poorly known *Kaupifalco monogrammicus* and the forest specialist *Stephanoaetus coronatus*(important bird and biodiversity areas IBAS).

Chilmo forest serves as a genetic pool especially for many of indigenous trees and also it is a breeding site for resident birds and wild animals. In addition to birds and wild animals Chilmo forest is the genetic pool for large number of Afromontane endemic tree and shrubs. For example, Ethiopia endemic tree species includes *Erythrina brucei and Acanthus sennii*. Other major species in the canopy comprises Juniperus *procera*, *Podocarpus falcatus*, *Prunus africana*, *Olea europaeacuspidata*, *Apodytes dimidiata* and *Ficus* spp.

### 3.1.4. Cultural services

Forest has better cultural value compared to other landscape. Before the expansion of Christianity in the study area many people believed that trees have natural power for making rainfall, ensuring abundant harvests, helps herds to multiply. Local people belief that forest and trees are home of the god and significant respect for scared forests and trees because of its importance in the community spiritual life. However, because of the expansion of religions in the study area spiritual service of forest was not in place. According to household survey 83% of the respondents preferred forests for recreational purpose. Local people in Chilmo forest consider themselves as lucky people since they live in wonderful scenery of natural areas. According to the household survey 93% of the respondents inspire by aesthetic service of Chilmo forest.

Forest ecosystems offer significant opportunities for disciplinary and interdisciplinary research, environmental education and training. Due to the presence of complex ecological interaction, rich biodiversity, its proximity to the nearby cities and the main road a number of research projects were carried out from research organization, universities and NGO's. Moreover, number of students from nearby universities, collages and secondary school visited the forest for educational purpose. According to household survey results 69% of the respondents knew about research and educational value of forest.

 

### 3.2. Ecosystem services perceived and preferred by local community

Perception and preference of ecosystem services are different between local community based on the level of dependence, distance from the forest, type of landscape, market and wealth status. For this study Pebble distribution method (PDM) was used to put ecosystem services preferences in order of importance based on perception and knowledge of local people. Five landscape units and ten provisioning and three cultural services were used for the exercises. The numbers of participants for these exercises were eight. The exercise was carried out in four forest cooperatives namely Chilmo, Mesalimya, Galessa and Dano.

### 3.4. PDM exercise on importance of ecosystem services

To begin, eight PDM exercise participants were selected from elders, women, and youth based on the number of years stayed in the area, wealth and social status. Then five landscape units and ten provisioning and three cultural services were selected and explained. Each landscape units were written in local languages and supported with drawings for illiterate members for easy understanding and clarification. After arranging the figure of each landscape unit the facilitator demonstrated the steps of the PDM exercises and how they distributed 100 Pebble (Maize seed) using local language.All participants reached an agreement before the score was considered final and written down. One person was responsible to place the pebbles/maize seed on the paper. The scoring for each service was counted and recorded on the data sheet. Finally the facilitator checked the total number of pebble after each exercises.

### 3.5. Importance of provisioning services perceived and preferred by local community

According to the result of PDM exercises food received the highest score from farm land in four forest cooperatives compared to other landscape (Figure 4). The food received from homestead got the second highest score followed by forest land since it also provides them wild fruit. In most cases Children's and youngsters collect wild fruits from natural forest for consumption However, wild fruits have no market price since it is not traded in local market.

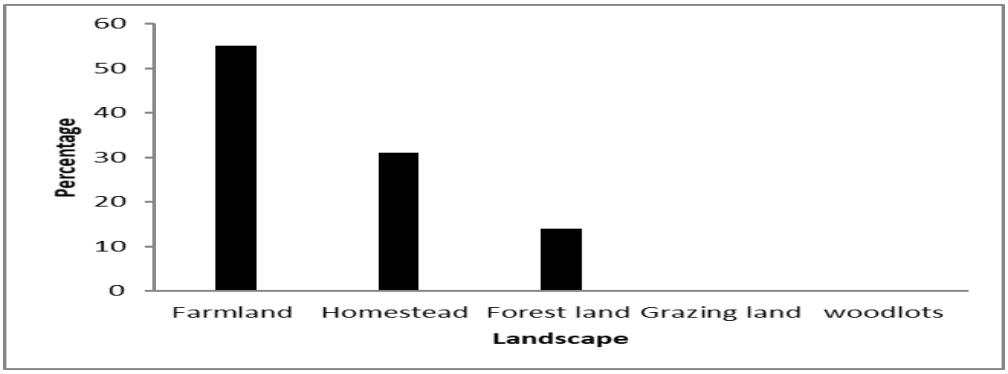


**Figure 4.** Average result of provisioning services (food) based on PDM exercise

Surprisingly based on PDM exercises and household survey the sole source of water for human consumption, livestock and irrigation is the forest. It received 100 % score. According to all PDM exercise the main source of animal fodder is forest land (44%). Animal fodder from grazing land has given the second highest score (34%) followed by farm land (18%) and homestead (5%). The participants preferred to take livestock to forest land not only for forage but also for shade and shelter. On the contrary woodlot doesn't contribute for animal fodder production. This is because the tree species used for woodlot like Eucalyptus is not favorable for grasses.

Forest land received the highest score (75%) for provision of farm implements followed by woodlot (20%) and homestead (5%). Farm land and grazing land has no contribution to the provision of wood for agricultural tool making. Fuel wood is the main source of energy in the study area, all the households use fuel wood as energy source (Figure 5). Fuel wood received the highest score with respect to forest (59). Woodlots got the second highest score (28) followed by homestead (11). Fuel wood from grazing and farm land is insignificant.

 

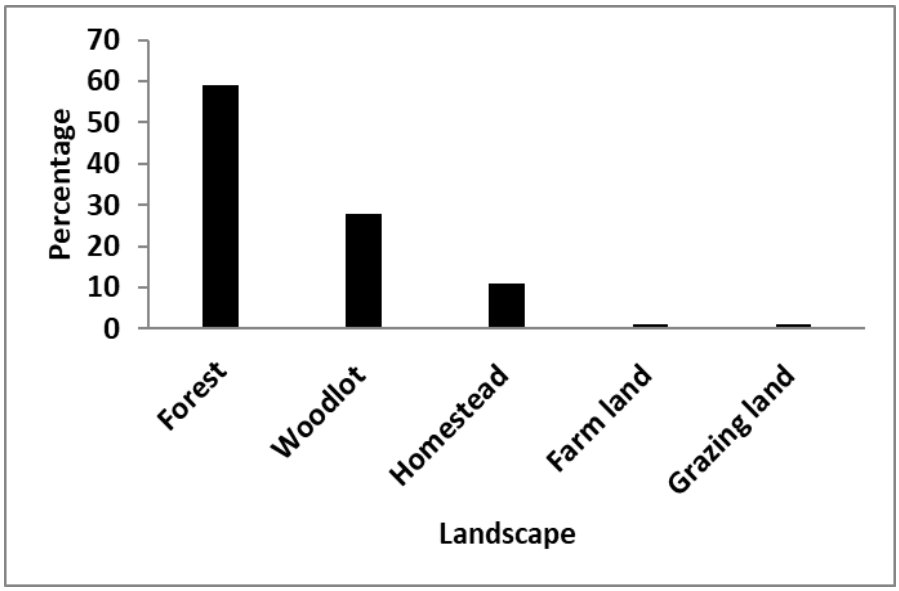


**Figure 5:** PDM exercise result of fuel wood collected from each landscape

Based on the result of PDM participants construction wood from forest landscape received the highest score (60%) followed by woodlands (32%). However, the contribution of homestead and farm land for construction wood is limited. Charcoal is the main source of energy next to fuel wood.But selling of charcoal is not common in the study area. Charcoal received the highest score from forest land (84%) followed by woodlands (14%).

Medicinal plants are the main ecosystem services used by local community to cure both human and livestock disease. We found that medicinal plants from the forest got the highest score (59%) followed by homestead (24%) and woodlots (13%). Chilmo forest provides tree seed for local people. The tree seed collected from the forest are used for seedling production and or for generating income. Our result shows that tree seed received the highest score from forest (68%) followed by woodlot (24%).

Unlike other ecosystem services, honey can be collected from all landscape. However, forest land received the highest score (46%) followed by homestead (21%). Because of low diversity of species in farm land and grazing land, the yield of honey is very low compared to others (Table 3).

**Table 3.** Average PDM score of provisioning services by landscape N=100 pebble

| | Landscape units | | | | |
|---|---|---|---|---|---|
| **Services** | **Homestead (%)** | **Farmland (%)** | **Forest land (%)** | **Woodlot (%)** | **Grazing land (%)** |
| **Food** | 31 | 55 | **14** | 0 | 0 |
| **Water** | 0 | 0 | **100** | 0 | 0 |
| **Charcoal** | 3 | 0 | **84** | 14 | 0 |
| **Farm implement** | 5 | 0 | **75** | 20 | 0 |
| **Tree seed** | 9 | 0 | **68** | 24 | 0 |
| **Construction wood** | 4 | 2 | **60** | 31 | 0 |
| **Fuel wood** | 11 | 1 | **59** | 28 | 1 |
| **Medicine** | 24 | 2 | **59** | 12 | 1 |
| **Honey** | 21 | 7 | **46** | 16 | 11 |
| **Animal fodder** | 5 | 16 | **44** | 0 | 34 |

NB: The red numbers showed the highest scores of the services

### 3.6. Importance of cultural services in relation to Forest cooperatives

Pebble distribution method was used to put three cultural services in order of importance based on local people preferences and knowledge. Cultural services such as Aesthetic, recreation and research/education services were identified and chosen for the PDM exercises (Table 4).

 

**Table 4.** PDM score of cultural services per each cooperative.

| Cooperative | Aesthetic | recreation | Research /education |
|---|---|---|---|
| **Chilmo** | 30% | 30% | 40% |
| **Mesalmia** | 40% | 30% | 30% |
| **Galessa** | 35% | 30% | 35% |
| **Dano** | 45% | 30% | 30% |

Local people enjoy and appreciate the naturalness, beauty and attractiveness of the forest landscape. Most people who are living around the forest consider themselves as a blessed people because of the wonderful scenery of the natural forest. That is why almost 85% of household respondents preferred forests than other areas. In addition according to PDM scoring exercise in all research areas forest provides aesthetic services with almost similar proportion that ranges from 30% to 45%.

The wonderful scenery of the natural forest together with the richness of plant and wildlife species coupled with endemic bird species make Chilmo forest as an ideal place for recreation. PDM exercise participants gave 30% for recreational value for all forest cooperatives. From this result we conclude data collected using different methodology varied based on different perception of people and sample size.

Chilmo forest has been the main research site for research center and universities. Rich diversity and being one of ruminant natural forest in the country attracts the interest of foresters, ecologist, and biologist and so on. Moreover, Chilmo forest plays a significant role for educational purpose. Number of students from nearby school and universities visited the forest. Similarly based on the PDM exercises the participant gave 30-40% for research and educational value for four forest cooperatives.

## 4. Discussion

Data set derived from field observation, household survey, Pebble distribution method and key informant interview were used to provide information regarding to ecosystem services, local people perception and preference in Chilimo forest of Ethiopia, particularly focusing on Chilmo forest. The study was the first in kind because little consideration is given to assess ecosystem service and the benefits that the Chilimo forest ecosystem provided to local communities. Since site specific information for conservation and management is required (Plummer, 2009; Hein et al., 2006). In this study ecosystem services include both physical goods and indefinable services provided by Chilmo forest as defined by The Economics of Ecosystem and Biodiversity (TEEB).

The classification of ecosystem services was done using the typology of ecosystem functions and services adapted from (Costanza et al., 1997; de Groot, 1992; de Groot et al., 2002). Chilmo forest provides a wide variety of provisioning services. First and foremost, the forest ecosystem provides the local communities with food (wild fruit &herbs). Local people mainly children's harvest wild fruits from the forest. The streams and rivers of the Chilmo forest ecosystem provide the local communities with fresh water for household consumption, livestock and irrigation. According to the data the sole source of water for local people is the forest ecosystem. Furthermore, millions of people outside the study area also depend on this forest watershed for water. The forest also has an abundance of natural resources which have been the main source of timber and non timber forest products for the surrounding regions and Oromia regional state as a whole.

Regulating services provided by Chilmo forest ecosystem are enormous. Chilmo forest provides a range of regulating services, one of which is protection from hazard and also regulate water and maintain and protect water drainage of the basins. Furthermore, trees also sequester carbon, decreasing the amount of greenhouse gases in the air. Other regulating services provided by the forest includes: pollination, water regulation, erosion control, and climate regulation. This finding is also supported by current study reported by Adhikari et al.,2018.

Chilmo forest because of its colorful and artistic landscape has been appreciated by local people. Staying in and around the forest is extremely important for local communities. Cultural services are an effective way to convince the local communities to conserve the authentic natural areas. The local communities walk and getting rest (recreational value) and educate their children by transferring their knowledge and showing them the forest and organisms living in it. Similar finding is also supported by previous study reported by Sing et al., 2015. In addition, the habitat services highlight the home of many wild animals, birds and plant species. Moreover, the forest serves as a gene pool for several indigenous tree-species and an important reproduction site for resident birds and other wild animals. Safeguarding of plant and animal habitat in the forest ecosystem is crucial and pre condition to sustain provision of all ecosystem goods and services

Identification of ecosystem services based the perception and preferences on ecosystem services by local people were studied using Pebble distribution methods (PDM). The study identified the main ecosystem services which are perceived and preferred by local communities and brought valuable evidence that showed the importance of ecosystem services for human wellbeing (Costanza et al., 2014). The results showed that forest land received the highest scores compared to other landscapes for all services except food provisioning. Similar to the outcome of the household survey; forest is the only source of water. Other major services obtained from Chilmo forest were

 

charcoal and farm tool. Therefore, information about ecosystem services is important for decision makers to understand the dependency of local communities on ecosystem services, to incorporate perceptions of stakeholder and to come up with better land use policy (Forster et al., 2015).

Even though the study area was expecting to cover 8 forest cooperatives due to lack of time and inaccessibility, four forest cooperatives were selected based on the position in the watershed, condition of forest (managed to the disturbed forest), accessibility for field work and dependence of local people. The selected four forest cooperatives represented well the remaining cooperative. The other challenges encountered the result of this study were limited knowledge of the participants mainly on using pebble distribution methods. Even though PDM exercises were easy to capture participant's opinions and it also creates an opportunity for them to freely discuss and share experiences about the issue at hand (Sheil et al., 2002) the exercise was not appropriate methodology for scoring cultural services. That is why they gave more or less the same scores for identified cultural services. Thus, from this we conclude that using different methodology would help to have more reliable information.

## 5. Conclusions

Forest ecosystem services provide both tangible and intangible benefits for local communities and for the country as a whole. In this study, identification of the main ecosystem services which are perceived and preferred by local communities were undertaken for the first time in Chilmo forest, Ethiopia. Similar to other forest ecosystem, Chilmo forest provides a wide variety of provisioning, regulating, cultural and habitat services for the local communities and the country as a whole.

Perception and preference of local communities toward ecosystem services were analyzed using pebble distribution method. The exercise provides significant information on different type of ecosystem services. Interestingly except food, the main sources of other provisioning services are provided by forest ecosystem. Surprisingly water is the sole source of water in the study area. Therefore, from this we can conclude that forest ecosystem services are the vital source of water, raw material, medicine tree seed and honey.

The findings disclosed that local communities are highly dependent on forests' ecosystem services. The research results will be used for awareness creation and that will have great implication to change the attitude of the stakeholder toward sustainable conservation and management of the forest. Overall the research objectives are achieved and findings will be addressed and have a great toward sustainable use and management of natural resources in the study area and will be uses as an input for further monetary valuation study.

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