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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. Combination of techniques were employed for data analyses. Five lanscapes and four forest ecosystem services were identified. Out of which, provisioning services are the main source of livelihood and subsistence incomes for local communities. 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, Forest, Management, Ethiopia, Valuation

1. Introduction

Ecosystem services are defined as the direct and indirect contributions of ecosystems to human well-being [12]. The ecosystem services provided to the local population includes provisioning, regulating, and cultural services that directly affect human well-being, as well as supporting services needed to maintain these three [2]. Forest through crop pollination services also enhances crop production and food security [28] and significant for climate change adaptation and mitigation [18]. Despite forest ecosystem being known to be significant to the delivery of ecosystem services, they are one of the most threatened ecosystems worldwide [22]. Anthropogenic factors create subsequent impact on service provision [25] and reducing the ability of forests to provide goods and services [8]. 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 [16]. Ethiopia's Forest Reference Level study has also estimated a net annual forest loss of approximately 72,000 ha for the period 2000 to 2013 (19). As a result conversion of natural forest to agricultural land diminishes forest cover in alarming rate, In 1978 the forest cover was (69%), in 1991 it was 13%, in 2010 it was 8.5%, and in 2016 it reaches 6.5% [34]. However, due to large scale reforestation program and massive planting campaigns the forest area coverage has been increased to 15.7% [23]. Currently over 100 million peoples are living in Ethiopia from which 80% live in the countryside and highly dependent on forest resources [6]. High population pressure leads to high demand of agricultural land and causes rapid conversion of forest land into agricultural area [15, 24]. Thus Land use changes into agricultural area maximize a single output (food) at the expense of other important ecosystem services [16, 17].

Even though the concept and the importance of ecosystem services is not new in scientific sphere it is unclear about the knowelage and the perception of local communities, who are the main beneficiaries of forest ecosystem services toward each service. Taking into account the prefernance and

perception of local community has been found critical by many of authors as the guiding tool for formulating policy regard to ecosystem conservation and management [4]. Moreover, MEA report, 2005 also emphasized the importance of understanding indigenous knowledge of the local community for addressing the issues of unsustainable management of forest ecosystems.

Despite assessing and being aware of benefit of ecosystem service is essential to understand the importance of ecosystem services for human wellbeing [3] and the significance that preference and perception plays in shaping local livelihoods and sustainable management of forests, little consideration is given to assess ecosystem services and the benefit that the Chilmo forest ecosystem provides to local communities. Morover, site-specific information for conservation and management is a nessesity [14, 27]. Therfore, this study aims to understand the perceived importance of ecosystem services provided by Chilmo forest, in Ethiopia. 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 [7].

2. Materials and Methods

2.1. Study Area Description

The study was carried out in Dendi District, western Shewa zone, Oromia regional state, Ethiopia. Chilmo forest is one of the few remnants of dry afromontane forest found 70 km west of Addis Ababa, capital city. The forest are located 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 [20]. According to Daniel. [5], 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. The forest area covers 4944 hectares from which 415 hectares is plantation forest [30]. Currently Chilimo forest is owned by 8 Forest cooperatives and 4 Forest users Group. Over 2858 households live inside the forest [33]. 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, 21 species of mammals and the forest is also rich in diversity of broad leaved tree species [32].

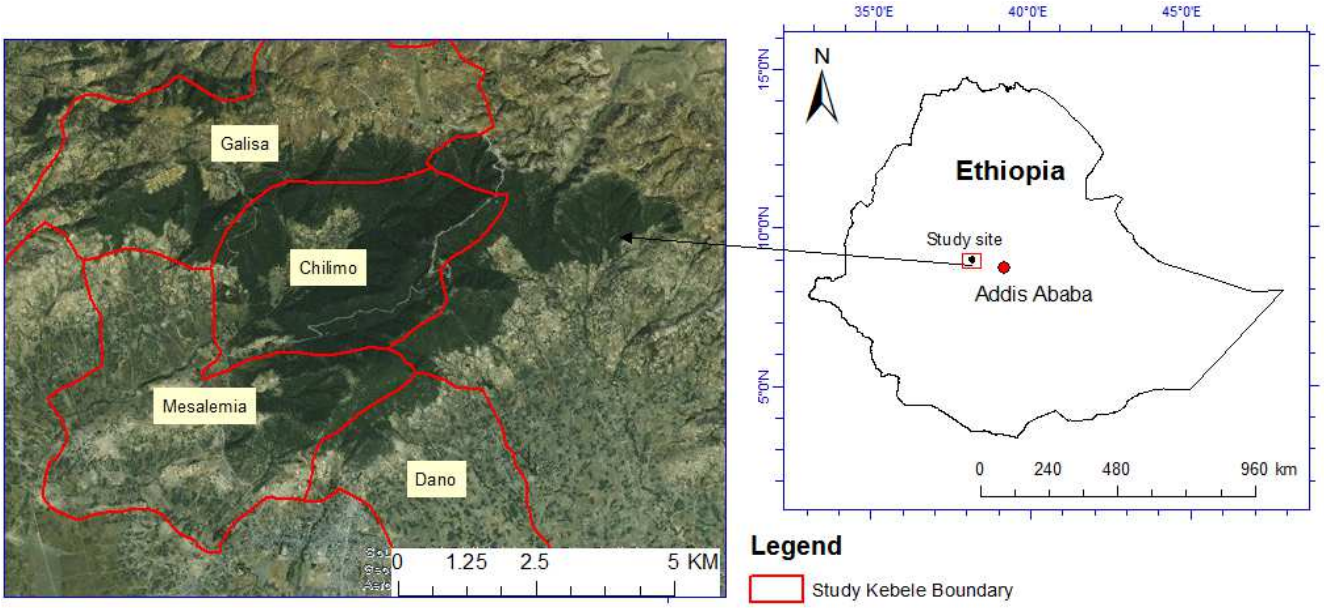

Figure 1. *Map of the study area (Source: Satellite Imagery from ESRI, Dark green is the Chilmo forest and the rest is other land use types.*

2.2. 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) [12]. Ecosystem goods and services provided by Chilmo forest include provisioning, regulating and cultural services that directly affect people and habitat services [26]. In this study the classification of ecosystem services was done using the typology of ecosystem functions and services adapted from [2, 9, 10]. (Table 1).

Table 1. *Functions, goods and services of natural and semi-natural ecosystems.*

No	Service category	Description	Example
Regulation function maintenance of essential ecological processes and life support systems			
1	Gas regulation	Regulation of Atmospheric chemical composition	CO_2/O_2 balance, O_3 for UVB protection, and SOx levels

No	Service category	Description	Example
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.
5	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.
6	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			
14	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.
15	Raw materials	That portion of gross primary production extractable as raw materials.	Production of lumber, fuel or fodder
16	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).
17	Medicinal resources	Variety in (bio)chemical sub-stances in, and other medicinal uses of, natural biota	Drugs and Pharmaceutical Chemical models and tools Test and essay organism
18	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			
19	Recreation	Providing opportunities for recreational activities.	Eco-tourism, Sport Fishing, and other outdoor recreational activities.
20	Cultural	Providing opportunities for non-commercial uses.	Aesthetic, artistic, educational, spiritual, and/or scientific values of ecosystems.
21	Aesthetic information	Attractive landscape features	Enjoyment of scenery (scenic roads, housing, etc.)
22	Spiritual and historic information	Variety in natural features with spiritual and historic value Use	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)
23	Science and education	Variety in nature with scientific and educational value	Use of natural systems for school excursions Use of nature for scientific research
24	Carrier Functions providing		
25	Habitation		

2.3. 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.

2.3.1. Sampling Procedure

The study was conducted on four forest cooperative which are selected purposively based on the position in the watershed (lower to upper catchment), condition of forest (highly managed to the disturbed forest), and accessibility for field work. According to this criteria four forest cooperatives namely Chilmo, Mesalemia, Gallessa and Dano Sengote were selected. Taking sample size of 10% of population, selection of 25 head of the household respondents from each copperative was done through simple random sampling techniques. Household Questionnaire was used to collect the primary data from sample households. The survey was conducted by using both open and closed ended structured

questions. 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. In additin to household survey 4 focus group discussion and 9 key informants interview was conducted. Moreover, key informants interview was carried out with 3 elders, 3 women and 3 experts. 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 for pebble distribution were 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. Five landscape units (homestead, farmland, forestland, woodlot and grazing land) and ten provisioning services were explained and used. 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 ecosystem 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.

2.3.2. Data Analysis and Management

Socioeconomic characteristics of households and summary of their responses about ecosystem services were analyzed using SPSS version 20 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 focus group discussion was analyzed qualitatively.

3. Results

3.1. Basic Profiles of Respondents

This section presents the basic profiles of sampled households with regard to their age, sex, family size, education and no of year stayed in the area. The mean age of the respondents was 47 years. Male-headed households account for about 74% of the respondents. The average family size of the household is 6. While about 46% of the respondents were illiterate, the remaining 45% and 9% attended elementary and secondary schools respectively. Almost all of the sampled households (99.6%) own farmland. Finally our research result depicted that most of the respondents stayed in the area for more than 30 years. Thus the data was collected from person who has firsthand knowledge of the area.

3.2. Identification of Ecosystem Services

Numbers of ecosystem services identified from Chilmo forest are listed below.

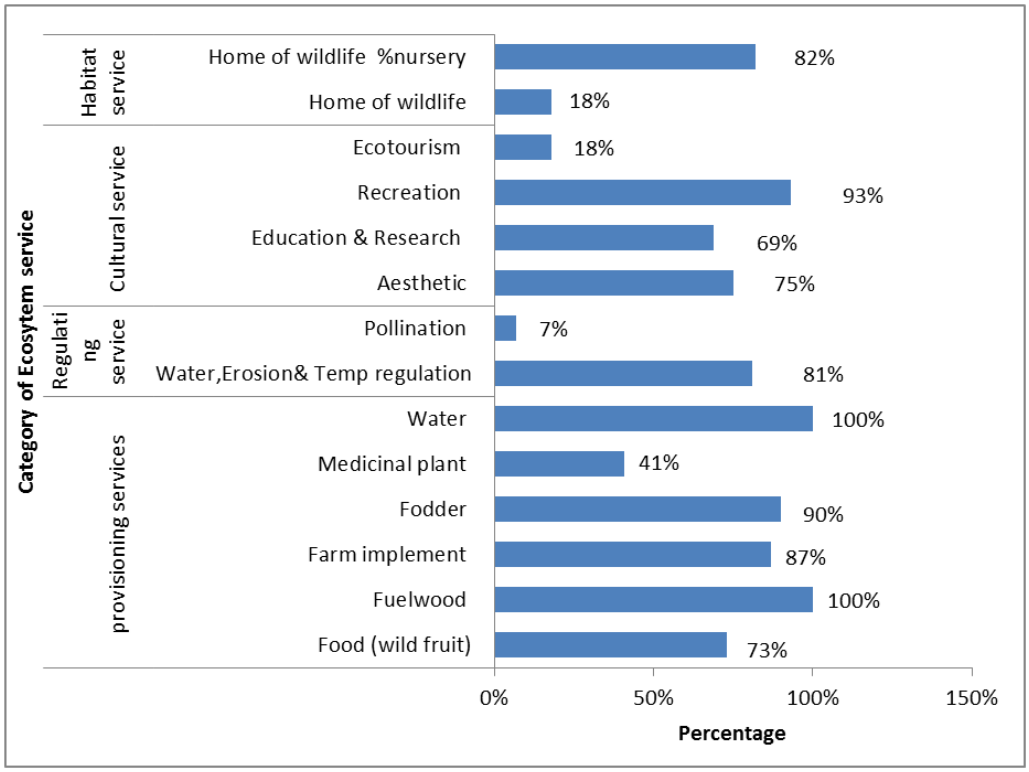

Figure 2. *Identfication rate of each ecosystem services.*

3.2.1. Provisioning Services

Chilmo forest provides number of provisioning services namely food (wild fruit), Raw material (fuel wood, farm implement, fodder), medicinal plants and water. Wild fruits are one of the provisioning services provided by Chilmo forest and commonly eaten by children. 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% of respondents from four forests cooperative collect wild fruit (Figure 2). Chilmo forest provides raw material which includes construction wood, fuel wood, farm implement and fodder. 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 (Figure 2). 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. Selling of fuel wood is the main source of subsistence income especially for local women's.

Since Agriculture is the main occupation for the surrounding communities, the result showed that 87% of the respondent's harvest wood for making farm implement. 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 during dry season 90% of the household's use forest land as a grazing area for their livestock's. on the otherhand Chilmo forest watershed is the place where the longest river "Awash" originates and it is the source of number of strems and rivers. 100% of the local people use water coming from the forest (Figure 2).

Furthermore, 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 almost half of the household respondants use medicinal plants. However, the use of medicinal plant is different between forest cooperatives. It varies based on the condition of forest, tree composition and the proximity of the forest cooperatives to the health center.

3.2.2. 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 [10, 11]. This study focused on regulating services such as Climate regulation, water regulation, temperature regulation, erosion control and pollination. According the result 81% of the respondents knew about regulating capacity of forest ecosystem (Figure 2). This result is in line with the findings of [8].

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. However, based on the perception of local people the temperature around Chilmo forest is very favorable and the study site received sufficient precipitation throughout the year.

Water regulation is mainly determined by the amount of runoff and river discharges in the watershed. The vegetation cover reduces runoff and increase infiltration rate there by increases water availability in the forest catchment [21]. 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 [13].

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 [35]. Despite of agricultural production being the main source of livelihood, crop pollinator service of the forest was not well recognized by surveyed respondents (7%).

3.2.3. 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 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). The forest also serve as a breeding site for resident birds and wild animals. In addition 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. The results of this study revealed that over third quarter of respondents knew habitat services of Chilmo forest both for plant and animal species.

3.2.4. Cultural Services

Most of the participant of the household survey were aware of the cultural value of Chilmo forest, contributed to the maintenance of aesthetic, recreation, ecotourism and constituted a system of knowledge and education (Figure 2). According to household survey 93% of the respondents inspire by recreational value of Chilmo forest.

On the otherhand 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.

3.3. 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 all four forest cooperatives compared to other landscape. The food received from homestead got the second highest score followed by forest land. Surprisingly based on PDM exercises and household survey the sole source of water for human and livestock consumption. According to all PDM exercise the main source of animal fodder is forest land (44%), grazing land has given the second highest score (34%) followed by farm land (18%) and homestead (5%).

Forest land received the highest score (75%) for provision of farm implements followed by woodlot (20%) and homestead (5%). Fuel wood also received the highest score with respect to forest (59). Woodlots got the second highest score (28) followed by homestead (11). 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. The research result revealed 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. The 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 2).

Table 2. *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.

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. 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 (14, 27). 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 [2, 9, 10, 29]. Chilmo forest provides a wide variety of

provisioning services. First and foremost, the forest ecosystem provides the local communities with food (wild fruit &herbs). The streams and rivers of the Chilmo forest ecosystem provide the local communities with fresh water for household consumption and livestock. 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 tempratture regulation. This finding is also supported by [1].

Chilmo forest because of its colorful and artistic landscape has been appreciated by local people. 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 [31]. 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 [3]. 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. Therefore, information about forest 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 [7].

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. 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.

Declarations

Availability of Data and Material

The datasets used and or analyzed during the current study are available from the authors on responsible request.

Competing Interests

I declared that this manuscript is my original work. They have no competing interests in this manuscript.

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