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## **CONTRIBUTION OF FOREST ECOSYSTEM SERVICES TO THE LIVELIHOOD OF LOCAL COMMUNITIES: THE CASE OF DESA'A FOREST, EASTERN TIGRAY, NORTHERN ETHIOPIA**

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### **ABSTRACT**

Ecosystem services are ecosystem functions that are useful to human beings. Forests are among the ecological units providing these vital services. However, forests and their ecosystems face a variety of dangers and are being depleted at an alarming rate. Therefore, the main goal of this study was to assess the livelihood dependence of the local community on the main and selected forest ecosystem services and goods provided by the Desa'a Afromontane forests. A structured questionnaire was prepared, and qualitative and quantitative data collection methods were used to collect information on the perceptions and attitudes of local people towards forest ecosystem services and goods in the Desa'a NFPA. The results revealed that the local people of the Desa'a forest are dependent on the ecosystem services and goods generated by the forest. The respondents confirmed that it has been serving as a potential source of fuelwood and other forest products for many years, thus protection and enhancement of the Desa'a forest ecosystem services is important for their livelihood. However, the forest has severely deteriorated. Therefore, the respondents were less certain that it will supply them and their descendants with the products that they will need in ten years' time. Furthermore, a significant number of household respondents said they are willing to restore and conserve the forest. To address the challenges of deforestation and to reduce unsound use of the forest, increasing public understanding of forest ecosystem services and goods is critical. Because socio-economic variables that influence local people's perceptions and attitudes toward forest conservation and restoration can change over time, future research should take the time dimension into account

when studying local communities' observations and attitudes toward forest ecosystem services and goods.

**Key words:** Forest ecosystem services, forest conservation, forest restoration, deforestation, Desa'a forest

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## **ABBREVIATIONS**

CBD	Convention on Biological Diversity
FDRE	Federal Democratic Republic of Ethiopia
FTC	Farmers Training Centre
GI	Group interview
HHs	Households
MAES	Millennium and Assessment of Ecosystem Services
MEA	Millennium Ecosystem Assessment
MEFCC	Ministry of Environment, Forest, and Climate Change
NFPA	National Forest Priority Area
SLM	Sustainable land management
TBFP	Tigray Bureau of Finance and Planning
TBoARD	Tigray Bureau of Agriculture and Rural Development
TEEB	The Economics of Ecosystem and Biodiversity
UN	The United Nations
USD	United States dollars
UNEP	The United Nation Environmental Programme

## **1. INTRODUCTION**

Ecosystem services are the set of ecosystem functions that are useful to human beings. Ecosystem services range from global to microscopic in scale. According to the well-known report, the Millennium Ecosystem Assessment (MEA 2005), humans are completely reliant on the earth's ecosystems. Healthy ecosystems provide steady food, manage epidemics, reduce severe storms, and sustain economically and environmentally useful species. But nowadays, because of ecosystem changes, future risks are increasing.

Forests are examples of ecosystem units; they are vital and self-regulating ecological units. Forests are providing a multitude of services and benefits that contribute to human survival and quality of life. Forests provide natural products, support of life, cultural functions, and regulating functions. In many less developed countries, like Ethiopia, forest resources have functions relating to health, safety, food, energy security, and are a source of wealth for local communities through ecosystem services (Mullan 2014).

Ethiopia possesses more than half of the land mass on the central plateaus covered by Afromontane flora (Bekele, 1994). These plateaus are covered by the dry Afromontane forests which form the major portion of possible natural flora. Based on their growth form structure and cover, Ethiopia has recognized four types of forests. The Desa'a and Hugumbirda forests are two of the rare huge fragments of the plateau dry evergreen forests of the Ethiopian plateau type. Desa'a is among the 58 natural forest remnants in northern Ethiopia that are protected areas by proclamation No. 94/1994 as a National Forest Priority Area (NFPAs) delivering ecological, production, regulating and cultural services to local people (Gidey 2013).

In comparison to a few other smaller areas scattered throughout the region, the Desa'a woodland is one of the largest natural reserves. The forest provides a variety of goods and services. These services include supplying local communities with wood and non-wood products as well as fuel wood and charcoal. However, due to the current population growth, agricultural development, increased need for fuelwood in both rural and urban areas, and other socio-cultural activities, both forest survival in general and biodiversity is deteriorating (Gebreegziabher 1999; Aynekulu et al. 2011).

Forests and their ecosystems face a variety of dangers and are being depleted at an alarming rate despite their importance to human livelihoods and the future of the world's biodiversity. Deforestation is the most serious hazard to the Desa'a forest, especially when combined with unsustainable forestry practices. For generations, the forest has supplied commodities and services to the local community for both sustenance and commercial needs. Farmers in the Desa'a forest have been encroaching on the forest to expand their agricultural holdings, which has led to potential clearance of the forest and has harmed the local community's economic well-being. These farmers appear to pay little attention to the ecological services that would be lost if this was to happen. Many of the environmental benefits are lost not only to them, but also to a much larger group of a people on a local, regional, and worldwide scale (Tesfay 2008; Aynekulu et al. 2011).

The ecosystem provides natural products and services and regulates the climate. These services occur outside the market and, as a result, consumers consider them free. Because of not having a clear market in which to value those services, there is a high motivation to overuse these resources. When long-term resource sustainability is a low priority, as it is when the consequences of overuse are accepted by society, when land tenure is not guaranteed, or when

rural poverty is high, it severely limits the chance of long-term strategic planning for use and management of these resources (UNEP 2012).

In Tigray, including the study area, different ecosystem and biodiversity management, and conservation research takes place. For example, an assessment of human impact, evolutionary patterns and options for sustainable management (Gebreegziabher 1999), structure and species composition of Desa'a, a degraded Afromontane forest (Moonen 2010), land use, land cover change detection and deforestation susceptibility analysis of Desa'a forest (Sebhatleab 2012), management interventions to assist restoration of degraded dry Afromontane forests (Gidey 2013) and the pressures exerted by the local community either to supplement or totally depend upon for their subsistence have been conducted.

However, evidence for the identification of the main ecosystem services together with their contribution to livelihood and the perception of the local community towards resources, and about utilizing and managing them on a sustainable basis, is largely under investigated. There is limited empirical data available about forest ecosystem services and their contributions to the livelihood of local communities. Furthermore, ecosystem services are not often included in land use planning due to lack of appropriate tools and information for decision-makers. This covers information on who benefits from ecosystem services as well as their opinions on the value of ecosystem services. Therefore, this study was conducted in the Desa'a protected forest area in Tigray, Northern Ethiopia with the intention of partially contributing to generating empirical data about the livelihood dependence of the local community directly or indirectly on forest resources, the perceptions of the local community and their willingness to conserve and restore forest ecosystem services.

### **1.1 Goals, objectives and research questions**

The main goal of my study was to assess the livelihood dependence of the local community on selected forest ecosystem services and goods provided by the Desa'a Afromontane forests, which are now under the National Forest Priority Area (NFPA).

The specific objectives were twofold:

- To assess the willingness of forest ecosystem users to conserve and restore that forest.
- To describe the economic, social, and ecological contributions of selected forest ecosystem services to the local community.

In this study, the following research questions were addressed:

1. What is the willingness of the local community to conserve and restore the ecosystem services provided by the Desa'a forest? How can the restoration programmes be improved?
2. What are the Desa'a provisioning forest resources that influence the livelihood of the local community?



## **2. LITRATURE REVIEW**

### **2.1 The concept of ecosystem services**

The Millennium Ecosystem Assessment (MEA) raised public awareness of ecosystems, which is the concept that healthy ecosystems create value flows of benefits to humans (MEA 2005). The MEA, which was started in 2001 by the UN Secretary General and finished in 2005, brought together 1,360 experts to analyse the effect of ecosystem change on human well-being. To highlight the genuine implications for human wellbeing, safety, public relations, and physical wellbeing, a theoretical setting was constructed (Mullan 2014).

The whole world depends fully on the earth's ecosystems for services such as food and water, regulating services like adjusting of climate, supporting services like provisioning of basic services, and social services such as entertainment, education, and other environmental uses. Humans have altered these ecosystems faster and more profoundly in the last 50 years than at any other time in human history, mostly to fulfil rapidly increasing demands for food, fresh water, lumber, fibre, and energy. This global change has resulted in significant net improvements in human well-being and economic prosperity. However, this approach has not benefited all regions or groups of people. Many people have been hurt a a result of this. Furthermore, the entire cost of these gains is only now becoming evident (MEA 2005).

The complex of living creatures and the physical environment with which they interact in a specific location is defined as an ecosystem by the Convention on Biological Diversity (UN 1992). Ecosystem services are the advantages that people receive from the ecosystem (MEA 2005). Furthermore, ecosystem services have been defined as the circumstances and activities that allow the environment to function (Lawton 1998). An ecosystem service is a local network of interacting plants and animals, as well as the area in which they exist, in general. As a result, an ecosystem service is a direct, observable benefit from an ecosystem, such as forest soil erosion avoidance.

Ecosystem process, ecosystem function, and ecosystem services are three interconnected concepts relevant to the provision of ecosystem services. Any physical, chemical, or biological change response that occurs within ecosystems is referred to as an ecological process. Decomposition, production, nutrient cycling, and nutrient and energy fluxes are all examples of ecosystem processes (MEA 2005).

Ecological function, on the other hand, is a subgroup of connections between biophysical structures, biodiversity, and ecosystem processes that support an ecosystem's ability to deliver ecosystem services (TEEB 2012). Finally, ecosystem services are the advantages that humans derive from ecosystems (MEA 2005). As a result, the flow of ecosystem services is viewed as a link between socioeconomic and ecological systems (MAES 2013). It is these characteristics of ecosystem services that are frequently considered when assessing and valuing them. Anthropoc drivers alter ecological processes and functions, which can have a positive or negative impact on service provision.

### **2.2 Forest ecosystem services**

The wood for our homes, the water we drink, and the air we breathe are all examples of forest ecosystem services. The need for ecological services grows in lockstep with the human population. These services are threatened or diminishing in various areas of the globe (MEA 2005).

As the demand for ecosystem services grows, the amount of forest available decreases, as do the ecosystem services it provides, leaving the remaining forests and the services they provide to become even more important. Globally, forests have been destroyed by around 40% in the last three centuries. Individual ecosystem services are also a part of a forest's interconnected web. Reducing one service can have a significant impact on other web strands. If a forest is managed for timber without regard to its other ecosystem services, it may suffer, for example, a reduction in carbon sequestration capability or wildlife protection value. Forest ecosystem services are critical for human survival. Our knowledge of these services is only getting started (MEA 2005).

### **2.3 The economic importance of the forestry sector**

Ethiopia has a wide range of forest resources. An assessment of the contribution of the forests of Ethiopia showed that they produced economic benefits in the form of currency and in-type income equivalent to USD 18.1 billion in 2012/13 (MEFCC [Ministry of Environment, Forest, and Climate Change] 2016). Moreover, the forest sector, through the provision of several ecosystem services, also brings benefits to other sectors, particularly to agriculture. These benefits are estimated to constitute 7.9% of the gross domestic product. In total, the forest sector is estimated to have contributed 14% of the quantified amount of the gross domestic product in 2012/13 (MEFCC 2016). The most vital forestry sector contribution to the livelihood of the local community is divided into three categories: wood fuel, fodder, and non-timber forest products.

Nearly 95% of the nation's energy utilization comes from biomass fuels of which wood fuel is the most crucial, delivering an approximate 68% of the total (FDRE [Federal Democratic Republic of Ethiopia] 2015).

Fodder has high economic significance in Ethiopia. Numerous research projects on multipurpose forage trees have been organized in several areas of Ethiopia (Yadessa et al. 2000). Native multipurpose fodder trees were used to address food shortages during the annual dry spell. Some evidence indicated that native multipurpose fodder trees have valuable societal, commercial, and environmental functions, such as food supply, shelter, customary medicines, bee forage and the preservation of milk, animal nutrition and contributions to domestic income (Tekele et al. 2014; Tadesse & Teketay 2017).

Non-wood forest products include honey, medicinal and spice plants, and fodder. These benefits of environmental services are essential aspects of communities' livelihoods. Edible forest products play a critical role in ensuring food and livelihood security for numerous families and communities all over the globe (Teketay et al. 2010). In Ethiopia, over 300 kinds of wild trees, shrubs and forest plants have been identified as customary food sources (Zemedu & Mesfin 2001).

### **2.4 Importance of local communities' perceptions and attitudes towards forest ecosystem services**

Forest resources are vital for human-beings and humans are dependent on forest ecosystem services. However, forest resources are diminishing the world over because of timber cutting, over grazing and conversion of forest land to agricultural land (Daily 1995). Ethiopian forest resources have been steadily dwindling over time. Both in terms of size and quality, they have shrunk dramatically and consistently (Tesfaye et al. 2012). In Ethiopia, forests were previously administrated by the state with no involvement of local populations. Indigenous knowledge and

respect for natural and cultural heritage are typically abundant in local communities. Local people's involvement in forest conservation might range from simple outreach to complete designation of protection, and administration power to the community (Nelson & Wright 1995). In Ethiopia, most local people's livelihoods depend on the use of the forest and other natural resources. Therefore, knowing the perceptions of the local community is vital for forest restoration, conservation, sustainable utilization, and management of these resources.

## **2.5 Forests, biodiversity, and the driving forces of deforestation**

Humanity is at a crossroads in terms of the environmental consequences of its development choices. Large swathes of the world's forests have been degraded or converted to other purposes. While there are still large areas of productive woods, it is well acknowledged that this resource is finite, and that its intelligent and sustainable use is required (CBD 1996). Forests provide a significant number of commodities and services to humanity. Some of these advantages occur at the local level. Timber, fuelwood, watershed protection, and a variety of non-timber forest products are examples of local/nationally beneficial products and services. Forests, on the other hand, provide global services that extend beyond national borders and have an impact on global welfare. Worldwide temperature regulation and biodiversity provision are two well-known global benefits supplied by trees (MEA 2005).

There are various types of biodiversity, for example genomic diversity, genus diversity, and ecological diversity. A large part of the globe's species is likely to be found in tropical forests (Sandler, 1993). People have reaped significant benefits from tropical biodiversity; for example, tropical plants are the source of one-fourth of all prescription medications sold in the United States of America. This biodiversity also supplies genetic material that can be used in genetic engineering to create pest-resistant crops (Sandler 1993). The main driving reasons behind the current degree of forest loss can be split into two categories: first, proximate causes like logging, habitat alteration, and conversion; second, underlying causes such as social and cultural elements that drive economic activities (Barbier et al. 1995). The size and increase of the human population, culture, ethics, poverty, economic incentives, and institutions are all underlying drivers of forest depletion.

## **2.6 Restoring and managing forest ecosystem services**

Land and forest resource degradation throughout Ethiopia's multiple production systems is thought to be a key impediment to sustainable development, with significant negative effects on the country's economy (Gashaw et al. 2014). Overuse of the country's natural resources is being caused by population increases, periodic famines, widespread poverty, and a lack of complementary economic possibilities (Tesfaye et al. 2014). Conventional resource administration methods, on which local people have relied for centuries, are thus being called into question (Scull et al. 2017). Various restoration operations are necessary to address these issues. Participating local communities in forest ownership, decision-making, and restoration, as well as raising local communities' understanding of forest ecosystem services, how to use them, and how to repair and conserve the services they gain, are among these efforts. Furthermore, adding innovative technologies, such as forest and landscape restoration, may provide efficient, integrated, and sustainable landscape management. Forest landscape restoration is a planned development that restores forest landscapes with the goal of improving environmental reliability and human well-being. Forest landscape characteristics, in general, adhere to guiding concepts such as a focus on landscapes and natural ecosystems, participatory governance, setting-detailed techniques, adaptive management, and restoration of various purposes for various uses (Gitz et al. 2020).

### 3. METHODS

In this chapter, the study area, method selection, the research process, structure of the interviews, data collection, data analysis and ethical considerations will be described.

#### 3.1 Location of the study areas

This research was conducted in different villages located around and within the Desa'a forest, in three districts: Atsbi-wonberta and Enderta in Tigray region, and Berahle in Afar region (Figure 1).

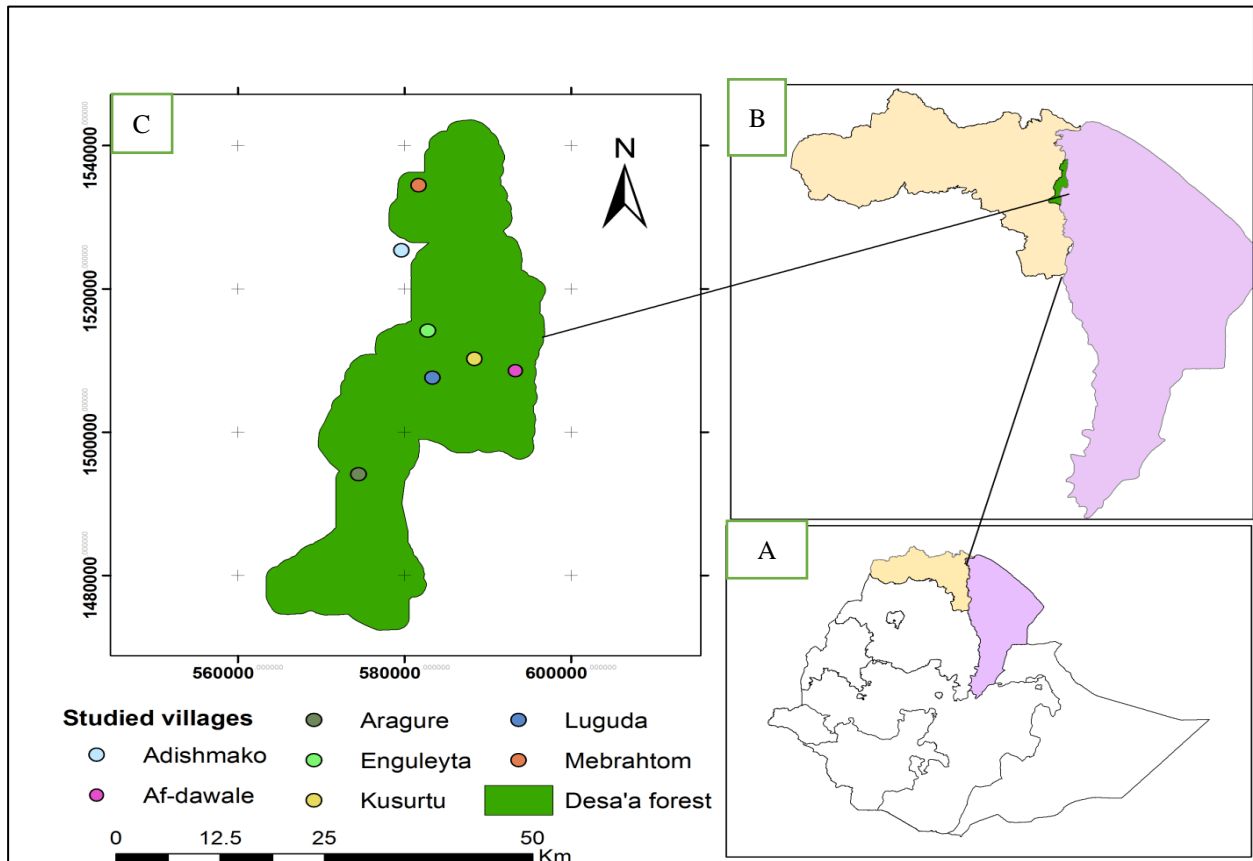


Figure 1. Location of the Desa'a forest: A) Ethiopia with regions, B) Tigray and Afar regions, C) Desa'a forest and the studied kushets. (Source: Gidey 2013).

The Tigray regional state is located between 12°15' and 14°57' N latitude and 36°27' and 39°59' E longitude. It is bordered by Eritrea to the north, Sudan to the west, Amhara regional state to the south and Afar regional state to the east. Tigray region has six administrative zones: the southern zone, the southeast zone, the eastern zone, the central zone, the northwest zone, the western zone, and one special zone, Mekelle city (TBFP [Tigray Bureau of Finance and Planning] 2017). According to the TBFP 2017 projection report, the population of Tigray regional state (rural & urban) was 6.8 million. The total area of Tigray regional state is estimated at 54,570 square km. Highlands, plateaus, and rugged topography are common in most parts of the region, but flat and more suitable for agriculture in the western area of the region. The region is characterized by erratic rain fall. The annual rain fall is 600 mm and the annual mean

temperature is 22°C. The altitude ranges from 76 m.a.s.l. in the eastern part of Tigray up to 3,909 m.a.s.l. in the southern part of Tigray.

### 3.2 Biophysical description of the Desa'a forest

Desa'a forest is one of the leftover patches of the few forest areas in Ethiopia, encompassing about 154,071 hectares. It is situated between 13°20' and 14°10' N latitude and between 39°35' and 39°65' E longitude, along the western ridge of the Great East African valley facing the Afar depression (TBoARD [Tigray Bureau of Agriculture and Rural Development] 2020). It is in two administrative regions, Tigray and Afar. However, the Tigray Region encompasses a large portion of the main part of the forest (Gebreegziabher 1999).

### 3.3 Climate, topography and soil

The Desa'a forest is divided into three agroecological zones: arid lowland, mid-altitude pleasant climate, and high-altitude cold temperatures. The study area's average annual temperature is 18.2°C, with an annual rainfall of 592 mm (Tesfay 2008). The distribution of rainfall in the Desa'a forest is unimodal. The area experiences a long dry season from the beginning of September to the end of June (TBoARD 2020).

The study site is undulating on the plateau to steep slopes along the cliff, frequently dissected by stream incisions with the main drainage system oriented towards the Afar lowlands. The forest is located at an elevation range between 900 m.a.s.l. and 3,100 m.a.s.l. (Gebreegziabher 1999). The plateau of Desa'a forest, about 45% of the area, has a slope greater than 30% (Moonen 2010). The soil types of the Desa'a forest are freely drained and variably textured Combisols, which are common on the flat to steep slopes. Other soils of agricultural importance, such as clay Vertisols, are common on the valley floors and upland plateaus (Agize & Bizuneh 1997).

### 3.4 Vegetation cover

The Desa'a forest used to be dominated by *Juniperus procera* and *Olea europaea* 40 years ago (Friss et al. 1992). Still, the forest vegetation (Fig. 2) is diversified, providing habitat for uncommon tree species such as *Dracaena ombet*, an endangered plant species, and *Erica arborea*, as well as rare bird species such as *Emberiza cineracea* (TBoARD 2020). A major portion of the Desa'a forest has been turned into farmland and grazing areas during this time. Farmland development, fire, free grazing, new settlements, illicit logging, and charcoal production are some of the main causes of forest deterioration (Aynekulu et al. 2011).

The Desa'a forest is a dry Afromontane Forest surrounded by agriculture and grazing savannah grassland with Acacia shrubs (Sebhatleab 2012). It can be asserted that this dry subordinate forest is severely deteriorated (Gebreegziabher 1999). Desa'a woodland has been changed into cultivation and browsing land in major parts. The dispersed plants and remnants on cultivated and grazed fields show that the forest has shrunk in recent years. Fire is also a critical threat to the forest, according to Gebreegziabher 1999, with fires destroying 1000 and 350 hectares of forest land in 1970 and 1998, respectively. Anthropogenic causes are the principal drivers of forest deterioration in the area (Friis et al. 2010 Sebhatleab 2012). Desa'a woodland has also experienced forest disorder due to natural mass tree dieback (Aynekulu et al. 2011).



Figure 2. Dominant vegetation cover in the Desa'a forest. (Photo: Succow Foundation 2020).

### **3.5 Data collection methods**

The research followed a mixed-method sampling technique to select the study area (Taddlie & Yu 2007). In consideration of the research objectives, the study areas of woredas<sup>1</sup> and tabiyas<sup>2</sup> were selected purposively, while the research kushets<sup>3</sup> (i.e. villages) were selected randomly to get a proportional representation of the study area. The household respondents and group interview participants were selected purposively to get in-depth answers. A mixed quantitative and qualitative questionnaire was prepared (Tesfaye et al. 2012) to explore the views and attitudes of local people towards forest ecosystem services and goods.

#### *3.5.1 Sampling technique and site selection*

The study area was selected based on the interest of the Tigray Bureau of Agriculture and Rural Development in developing a management plan for the Desa'a forest, the purpose of the land restoration training programme and the related nature of the study objectives.

In the study, the Woredas were selected purposively because both are relevant to the Desa'a forest. After a discussion with the Woreda Agriculture and Rural Development Office head experts, six Tabiyas were selected purposively as they are immediate stakeholders of the forest. Where a selected Tabiya contained three to four Kushets, those found within the forest were identified. Hence, out of these Tabiyas, seven forest Kushets were selected to get a proportional representation of the study area. The schematic representation of Woredas, Tabiya, and Kushets included in the study area are shown in Figure 3.

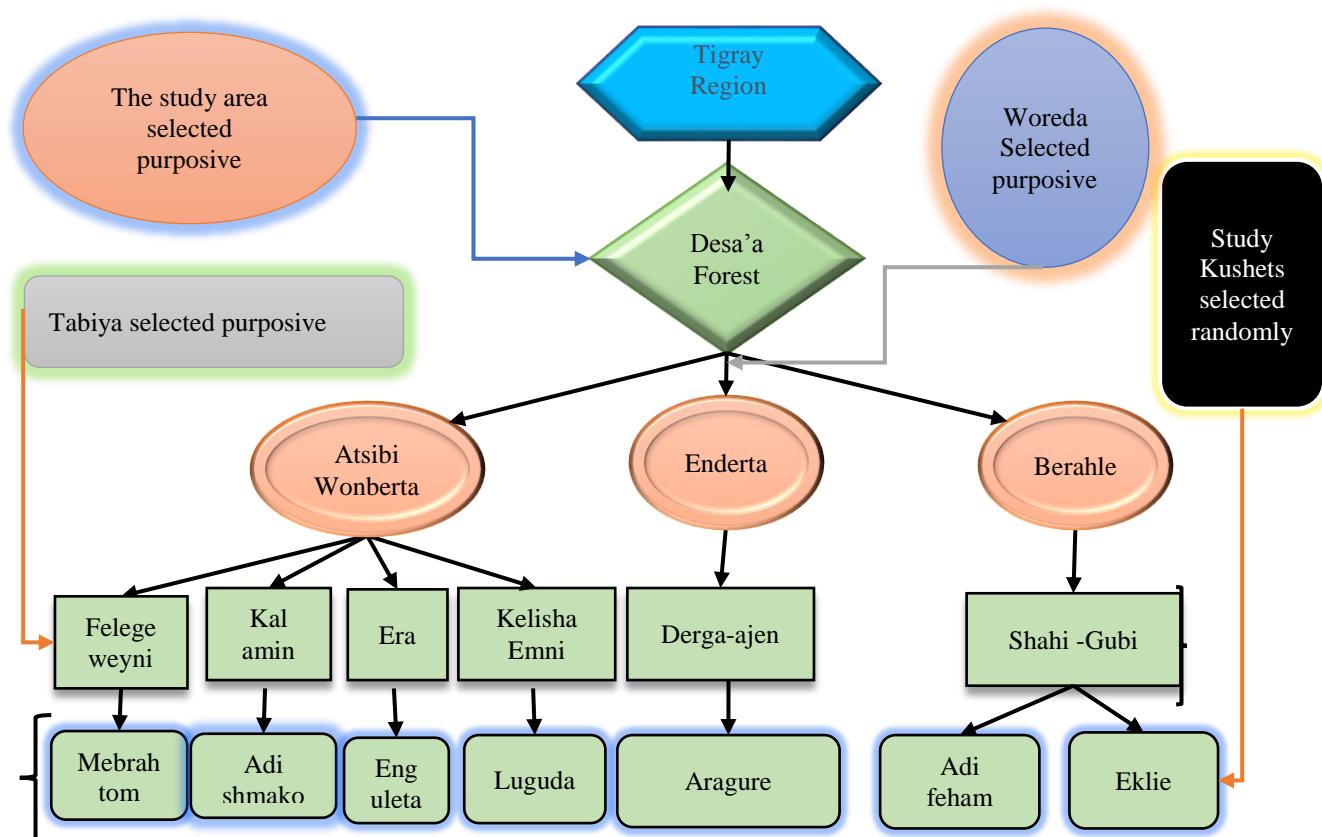


Figure 3. Schematic representations of the study woredas, tabiyas and kushets (i.e. villages).

The study was limited to 20 sample households and 4 group interviews purposively drawn from the selected Kushets. Sample households were proportionally taken from each Kushet. The Woredas, Tabiyas, Kushets and sample sizes drawn from each village are listed in Table 1.

**Table 1.** Distribution of households, focus group representatives and sample households by Woredas, Tabiyas and Kushets.

District	Tabia	Kushet	Households	Sample households	Group discussion
Atsibi-womberta	Felege- Weinni	Mebrahtom	456	4	1
	Kal-Amin	Adishmako	492	4	1
	Kelisha-Emni	Luguda	316	2	
	Era	Enguleyta	320	2	1
Enderta	Dergi-Ajen	Aregure	373	4	1
Berahile	Shahi Gubi	Adi-Faham	132	2	
		Eklie	149	2	
		<b>Total</b>		<b>2238</b>	<b>20</b>

### *3.5.2 Data collection*

A questionnaire was prepared, and the qualitative and quantitative collection of data was done by administering the questionnaire to the selected 20 households and conducting four group interviews. A mixed quantitative and qualitative approach was employed to better understand the local communities' perceptions (Tesfaye et al. 2012; Tadesse & Teketay 2017). The quantitative questions were employed to ascertain household economic characteristics, local community perceptions of forest ecosystem services, and the contribution of forest ecosystem services to livelihood. The qualitative interview questions and the focus group discussion questions were employed to understand the fuelwood contribution of the Desa'a forest, the willingness of the community to restore and conserve the forest, and the deforestation level of the Desa'a forest.

Farmers were classified based on their gender, household leadership, land and livestock ownership, and access to extension services, as they may have had different perceptions and contributions to forest ecosystem services and goods. Due to their significant influence on forest utilization, restoration, and conservation, household leadership, land ownership, and livestock ownership were all considered. Household participants were selected with the help of Tabiya experts and local administration, while group interview participants were selected according to the government structure by Woreda forestry experts and local administration. During the interview and selection of respondents, the use of the government structure was found to be relevant. These forestry experts and local administrators also had the advantage of already being in the study area.

Eight enumerators who were working in the Kushets as natural resource experts were hired as data collectors for the household interviews and four enumerators who were working in the Woreda as forestry experts engaged in the focus group discussion. A short training was given to the enumerators to allow good understanding of the questionnaire. Next, face-to-face interviews with the selected households were undertaken with closed and open-ended questions, and group interviews based on the prepared questionnaire. For better understanding, the questionnaires were translated carefully, without changing the original meaning, into Tigrigna (the local language) and the interviews and discussion took place in Tigrigna. For this study, some farmers were interviewed near the forest and some farmers were interviewed in their homes, while the group interviews were conducted at the farmers' training centre (FTC). Respondents were able to easily relate to what they saw in the forest because the interviews were conducted near or in the forest. For the group interviews, the FTC was better as it is known as the farmers' assembly, or training area.

Four experts worked as research assistants. Three of them were from the Woreda Agriculture and Rural Development Office and one from the Weforest project. Three were from the department of natural resource management, and one was from the department of agricultural extension and communication. They were very knowledgeable and experienced about forestry and community outreach. Before each interview, the enumerators read a letter to respondents which was written by TBoARD, which explained the purpose of the GRÓ Land Restoration Training Programme, the study goals, and the study's ethical precautions. It proved to be a good way to get the conversation started. During the data collection period, tight supervision of the enumerators took place to make timely corrections for mistakes made during the collection.



### *3.5.3 Data analysis*

After the data was collected using the questionnaire, the research assistants transcribed all the field records into Tigrigna, the local language. The researcher studied the transcripts and translated them into English after going over the content. The survey data was coded and entered into Excel. Descriptive methods were then used to analyse the data. The demographic and socio-economic characteristics of the sample households were also analysed using descriptive statistics.

### **3.6 Ethical considerations**

The focus of this study is on humans. As a result, thinking about research ethics is crucial. Voluntary participation, integrity, confidentiality, and anonymity were all important ethical considerations for the participants in this study. This was done to make individuals feel at ease, so they wouldn't feel obligated to join or do anything they didn't want to. Before beginning the interviews, the enumerators informed the interviewees about the purpose of the study, the elements included in the survey, and that they, as participants, had the right to and would always remain anonymous. They also read the support letter from the regional government indicating that the research was permitted. After the participants gave their approval, the interview was recorded using a phone and text. The recordings were only utilized by the researcher during the study, and were deleted once the interview was transcribed. It was critical to understand both the local community's norms and values, as well as the government's rules and regulations.

## **4. RESULTS**

This section presents the results about the local community's perspectives on forest ecosystem services, the communities' willingness to rehabilitate and protect the Desa'a forest, as well as their fuel wood usage and forest degradation.

### **4.1 Household socio-economic characteristics**

In this section, a description of the households' socio-economic characteristics such as age, sex, education, and family size are reported. The age of the household heads ranged from 27 to 90 years old, and the average family size of the households was 5.60, with a minimum of 3 and maximum of 10 people per household. There were 14 (70%) male-headed and 6 (30%) female-headed households. The education levels of household heads ranged from illiterate (zero grades) to tenth grade (10 grades) and of the total of 20 respondents, 7 (35%) were illiterate.

The basic economic resources that could influence household preferences, like land holding and livestock ownership, were assessed (Fig. 4). The largest land holding size was 2 hectares, and the lowest was 0.5 hectares. Eighteen of the households had land, while two households were landless. Another important asset, which is a supplementary source of livelihood and a means of crop production, is livestock ownership. Of the total respondents, 16 households had livestock, while 4 households did not own livestock. The maximum livestock ownership was 5.5 TLU.

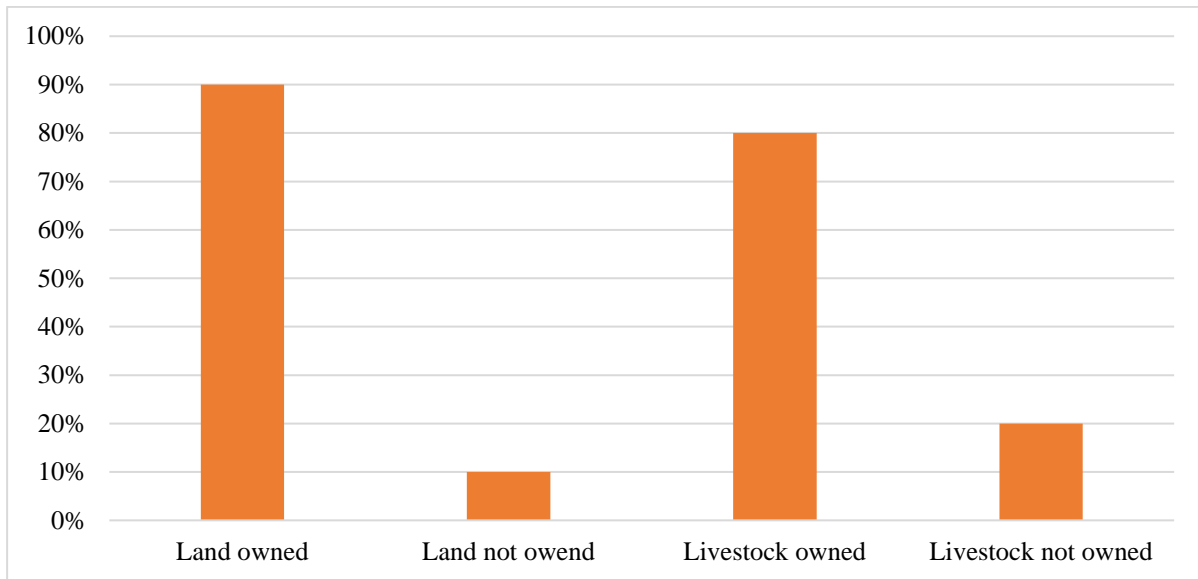


Figure 4. Land and livestock ownership of the study households.

The other critical service characteristics that could influence household preferences was access to extension services. This study showed that 16 (80%) of the households had access to extension services, while 4 (20%) of the households did not have access (Fig. 5). The objective of extension services is to diffuse information, best practice, and innovations regarding forest management, conservation, and restoration. In the study area, development agents are responsible for testing and demonstrating new technologies in forestry and for supplying extension services to farmers. The demand and supply of extension services might be influenced by farmers' perception of these services.

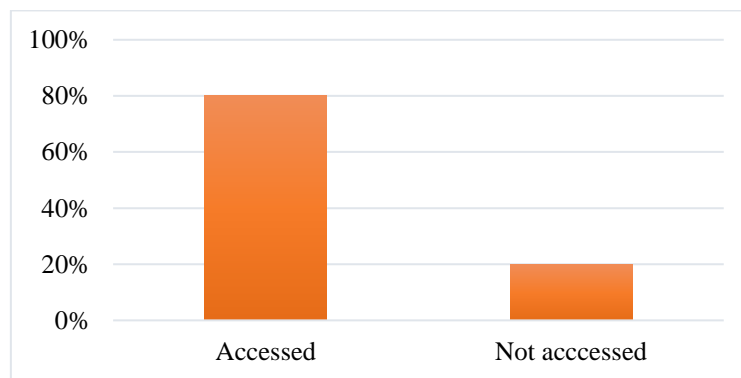


Figure 5. The household respondents' access to natural resource-based extension services in their locality.

#### 4.2 Perceptions on the importance of forest ecosystem services for local livelihoods

From the survey, more than 90% of the respondents said that protection and enhancement of Desa's forest ecosystem services is important for their livelihood (Fig. 6) and that it has served as a potential source of fuel wood and other forest products for many years. Some 80% of the respondents agreed that the Desa's forest is important for generating forest ecosystem services such as the provision of water, forest products and climate regulation.

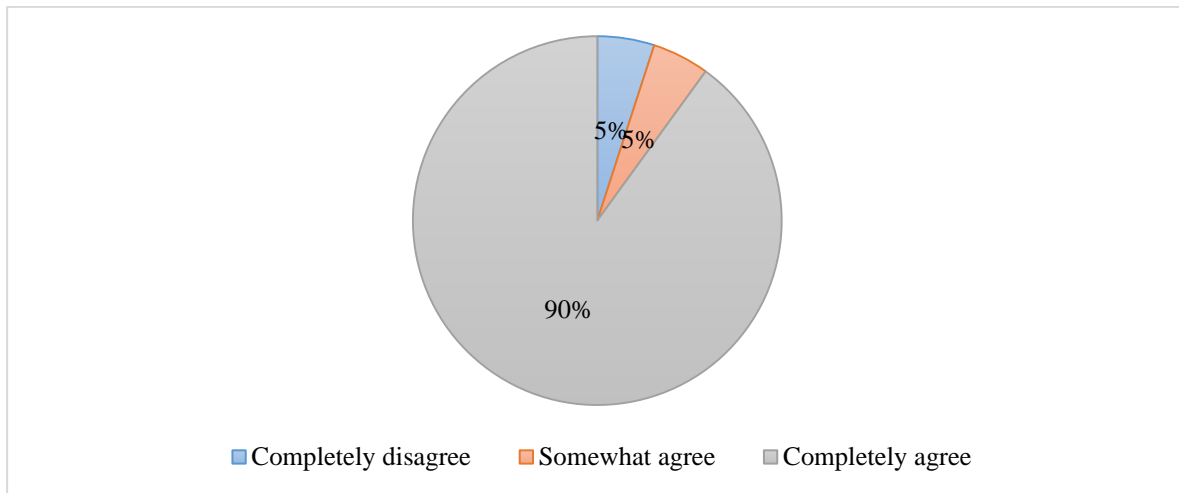


Figure 6. The importance of the forest ecosystem services for protection and enhancement of the local community's livelihood.

However, about 70% of the respondents agreed that the forest has severely deteriorated. Thus, about 65% of the respondents agreed that they are less certain that the forest will be able to supply them and their descendants with the same products in ten years' time. From the survey, 14 (55%) households disagreed with the statement that ecosystem services provided by Desa'a forest to the local community are in good condition (Fig. 7).

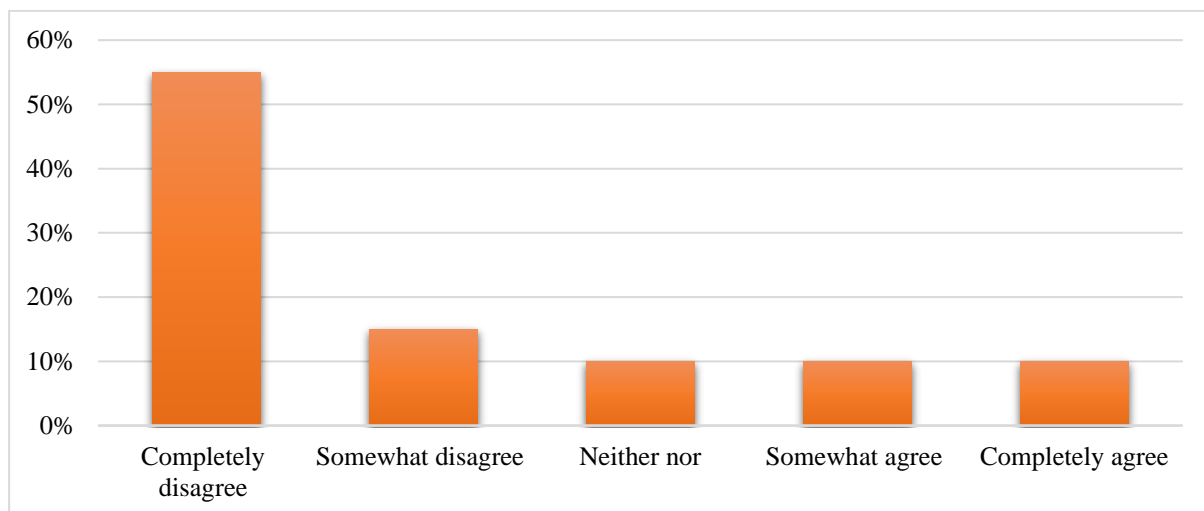


Figure 7. The condition of the Desa'a forest in providing forest ecosystem services and goods to the local communities is good.

Another critical factor concerning sustainable forest management was that about 75% of the respondents were not happy with the current management of the forest (Fig. 8). Similarly, even though in principle fuelwood collection is prohibited, Desa'a forest is still an important source of fuelwood and other forest products for the nearby residents for both subsistence and commercial purposes.

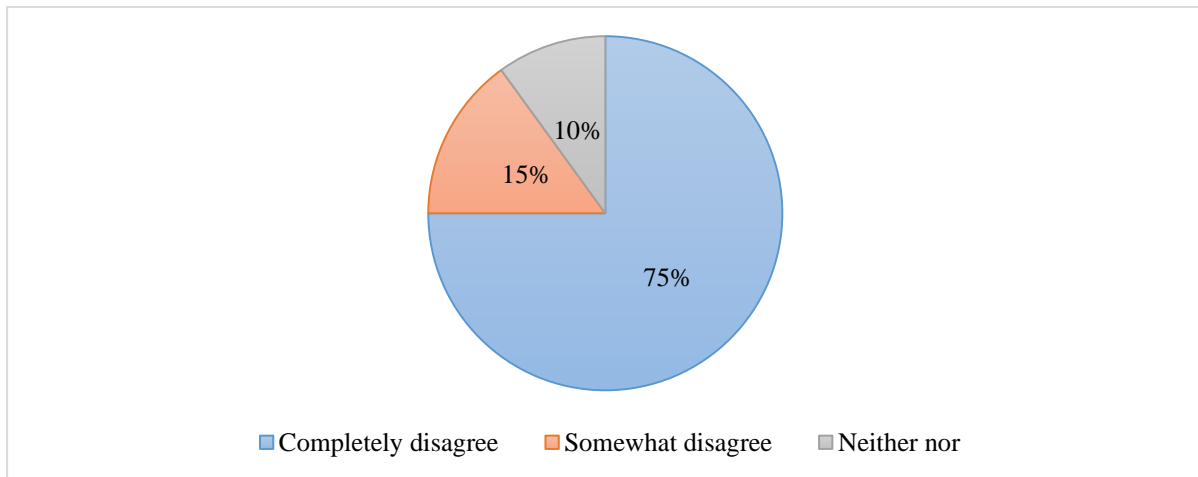


Figure 8. The current management of the forest reflects the interests of local communities and it fully secures the sustainability of the forest resource.

### 4.3 Utilization of forest products and services

The results show that most of the respondents (more than half of the total) confirmed that collection of firewood (90%), leaf litter (85%), water (75%), animal fodder (65%) and apiary farming (60%) were the most frequently utilized services followed by extraction herbs for medicine (45 %), collection of farm implements (40%), collection of building materials (30%) and extraction of food/wild fruits (25%), see Figure 9.

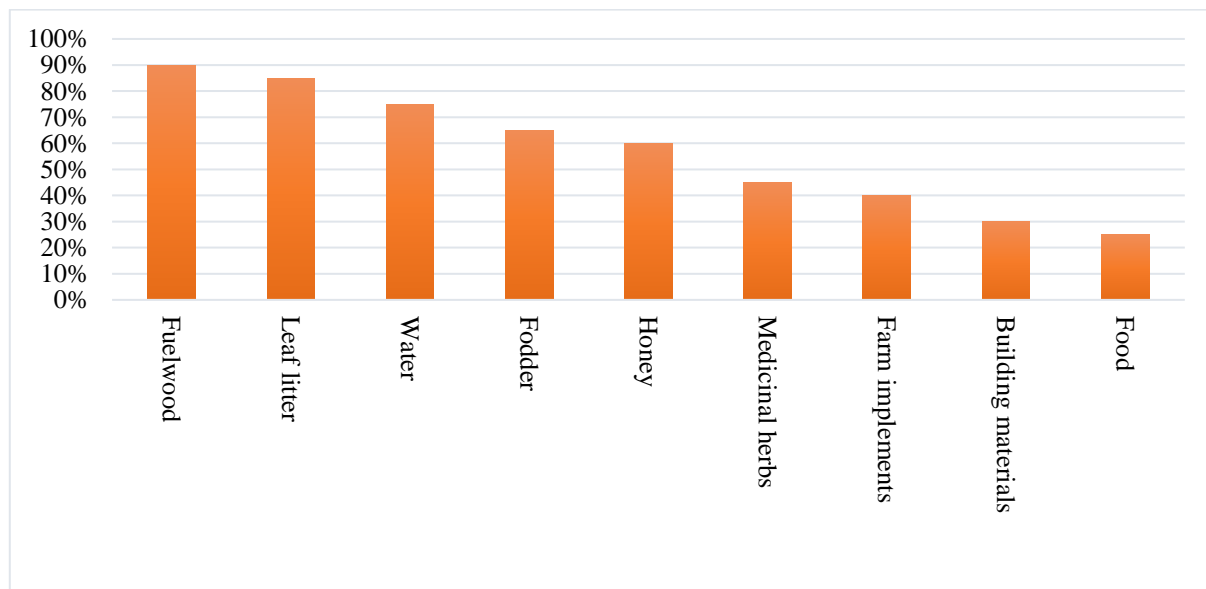


Figure 9. Forest ecosystem services and goods obtained and utilized by the local communities from the Desa'a forest.

According to the respondents, farm implements and building materials were nowadays substituted by their own plantations of eucalyptus species and the collection of herbs for medicine was substituted by modern medical centers around their villages.

#### 4.4 Collection of firewood

In this section, the collection of firewood is reported in Figure 10. The study showed that the collection of firewood is the responsibility of women, girls, and boys. Men were not observed collecting firewood for domestic purposes due to cultural influence, but sometimes men participated in the collection of firewood if there were some events in the house, but this was not common. In all the study villages, it was confirmed that firewood was collected and carried home by women (100%), by women and girls (85%) and by women, girls, and boys (65%).

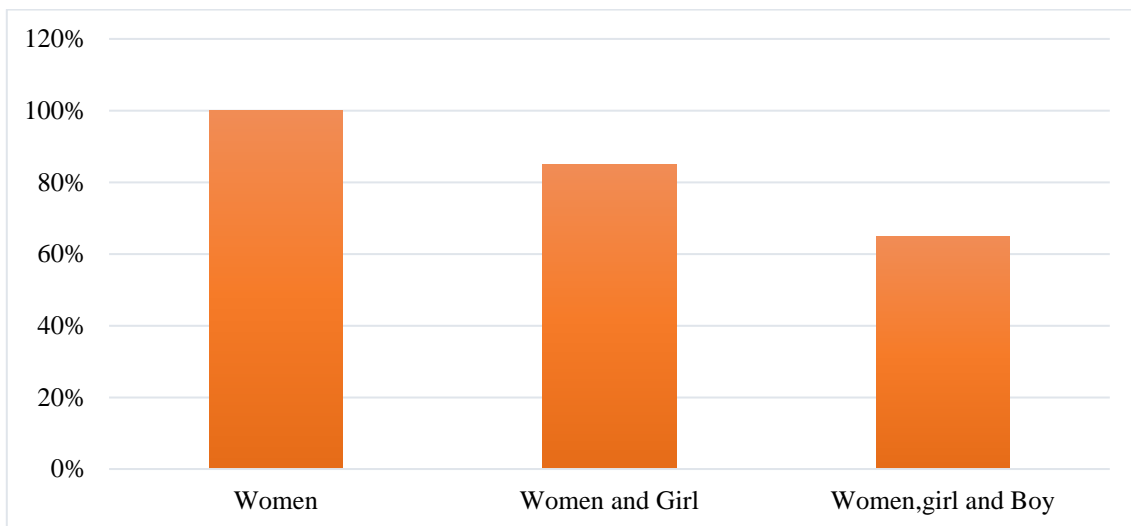


Figure 10. The responsibility for collecting and carrying firewood in the local communities.

Wood is picked off the ground, knocked out of trees with sticks, or cut from trees and shrubs with an axe. Once a sufficient stack of wood has been gathered, it is bound into a bundle using skin or fibre fasteners. In the Desa'a forest, bundles of wood are transported using a different method, which involves carrying the bundles on the back and holding them with the loop of a strap that is looped around the shoulder of the carrier (back loading). Boys carry wood bundles on their heads in every household in the study area (head loading). This study confirmed that the collection and carrying of firewood for home consumption has a negative effect on women. 85% of the households responded that the collection and carrying of firewood takes time from other duties, especially care of children, and cooking. 75% of the households responded that due to deforestation, the source of the wood is far away, the carrying of firewood tires the collectors unreasonably and 65% responded that because of the back loading, they have health problems. The results are illustrated in Figure 11.

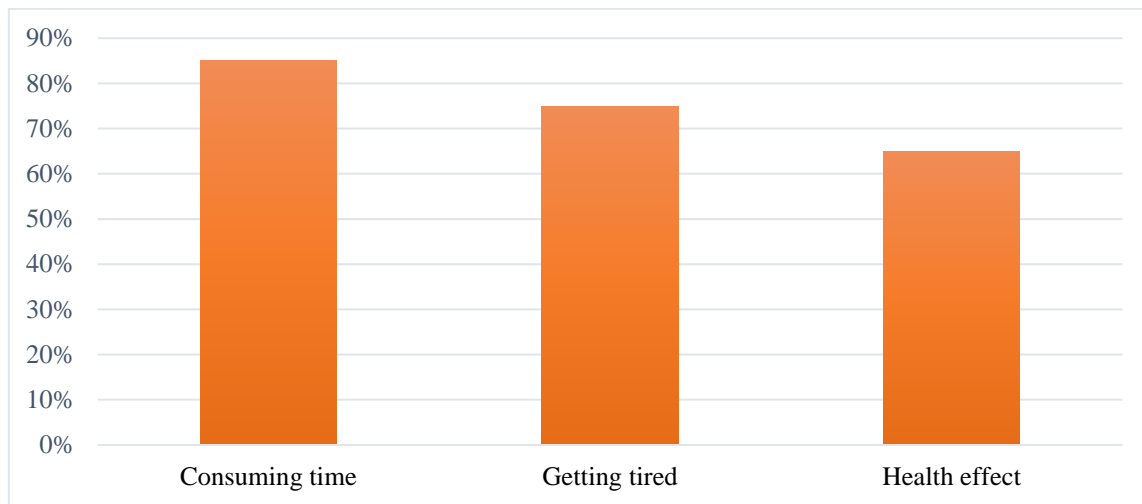


Figure 11. The adverse effect of collection and carrying of firewood on women’s health and livelihood.

The survey also assessed solutions to problems related to firewood collection. The respondents confirmed that introducing improved stoves (85%), introducing solar energy (80%), promoting plantations in the backyard (80%), access to electric power (65%), and introducing biogas technologies (55%) were key solutions to the problem.

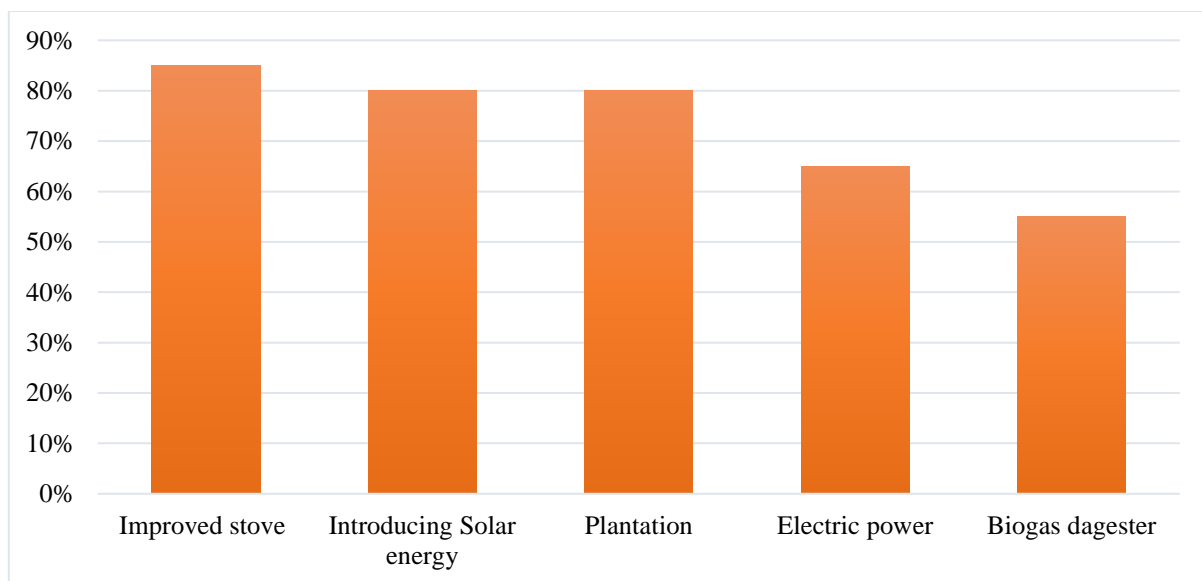


Figure 12. Solutions mentioned by the respondents to solve the adverse effects of collection of firewood on women.

#### 4.5 Deforestation causes and mitigation

In this research, the cause of deforestation in the Desa’a forest and its mitigation measures were assessed. The results showed that 80% of the respondents confirmed that there have been deforestation practices. The most important practices resulting in deforestation were illegal cutting, free grazing, charcoal burning, farming in the forest, forest fires and settlement formation in the forest. Indirect causes were also assessed. The most important indirect practices of deforestation that were reported were lack of knowledge/awareness that illegal

cutting and free grazing are the most important deforestation practices. In contrast, 20% of households from one Kushet described an increase in forest cover. Their reasons were increasing area closures and guarding of the forest in their Kushet.

The study revealed some remedies or mitigation measures for deforestation. Most households reported that awareness creation and increasing knowledge, guarding the forest, planting trees with full management, introducing energy-saving stoves, increasing forest management practices, increasing law enforcement, and controlling grazing are key solutions.

#### 4.6 The willingness of the local community to conserve and restore the Desa'a forest

In this section, the willingness of households to conserve and restore the Desa'a forest, the mechanism for restoration practices, and the time and labor that they want to spend on forest restoration and conservation are reported. Generally, 90% of households were willing to restore and conserve the Desa'a forest. 18 households were willing to participate, while 2 households were not willing to participate in the restoration activities. The willingness of households to conserve and restore the Desa'a forest is shown in Figure 13.

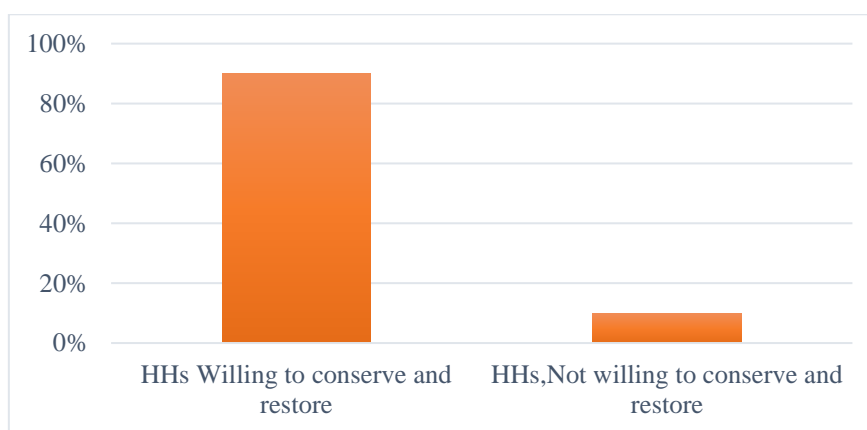


Figure 13. The willingness of households to participate in conserving and restoring the Desa'a forest.

The households preferred different restoration and conservation techniques. 90% of the respondents preferred plantations, 85% soil and water conservation, 85% preferred guarding the forest, 75% mentioned introducing an improved stove to tackle deforestation in the area. 70% of the respondents participated in forest management activities such as watering, weeding, silviculture, and tending activities, and 55% preferred introducing a zero grazing/catch and carry system. This study showed that introducing zero grazing had low acceptance by the interviewees. Some of the restoration and conservation techniques are summarized in Figure 14.

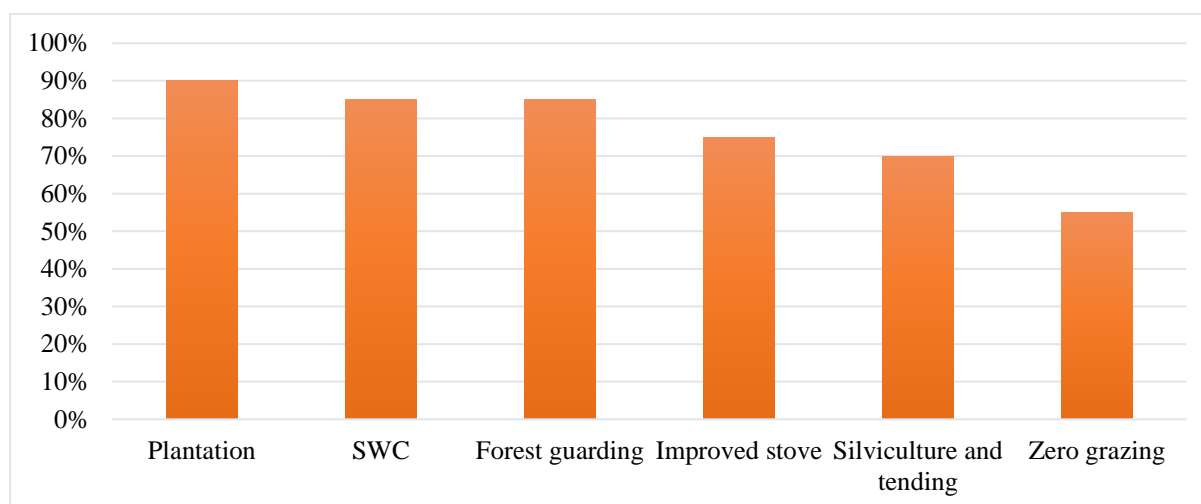


Figure 14. The restoration and conservation techniques selected by household respondents to restore and conserve the Desa'a forest.

#### 4.7 Group interviews

Individuals were chosen from the local administration and representatives, associations, forest guards, and Tabia experts for each Kushet based on the present status of Kushet objectives for the future. Those individuals formed a Kushet or FTC and participated in the group interview. A total of 15 people participated in each group interview.

##### 4.7.1 Forest ecosystem services, use and the contribution of forest products to livelihood improvement

Participants of the GI in each of the four Kushets described the services and products they obtained from the forest. They listed the following services, from highest to lowest: protection against soil erosion and protection of sources of leaf litter (80%), sources of energy like fuelwood and charcoal (75%), improving feed access in the form of harvested fodder (75%) and regulating climate (70%). Services such as grazing of animals inside the forest (55%), shade (40%) and farm tools/construction materials (35%) were also important services obtained from the forest and one Kushet highlighted that it provides income from eco-tourism and recreation.

The GI participants confirmed that the forest ecosystem services and goods support their livelihood. They collect firewood from the forest, which is used 65% for their own home consumption and 45% for the local market. They collect grass from the forest to be used for their animals, and about 25% of them sell the grass. In addition, the respondents confirmed that 40% of them collect honey from the forest and about 80% of them sell it in the local market. The community also reported that the forest has indirect contributions to their livelihoods, such as enhancing water availability, regulating run-off, and increasing soil fertility. The GI confirmed that benefits from the ecosystem service payment have not begun.

##### 4.7.2 Forest/land institutions and arrangements

In terms of forest ownership, it is worth noting that barely half the sample GI were aware of the Desa'a forest boundaries, even though they reside near or within these boundaries. Survey results suggested that ownership of the forest is unclear. The results also indicated that the



government has complete authority over Desa'a forest resources, even though forest management and regulating systems are unclear.

In the case of natural resource rules and regulations in the study area, there are two types of rules to manage the forest and access its natural resources: 1. formal rules developed by the government to protect governmental/state-owned forests, and 2. by-laws (non-formal rules) developed by the community to protect communal natural forests and protected areas. By-laws are in existence to manage forest resources in almost all the sample GI reports, although the few respondents who mentioned the lack of by-laws lived on the edges of the Desa'a forest and near small settlements.

Regarding forest by-law formulation, participants elaborated on the procedure for developing by-laws by both community representatives and the local community. Local administrators from the community, including members of the various community groups, and Tabiya/Kushet experts, drafted and established by-laws. However, some GI respondents expressed ambiguity about the local community's engagement and the formulation of the local by-laws.

#### 4.7.3 Current forest cover, forest maintenance and restoration activities

To better understand trends in forest cover change in Desa'a, the GI was polled to see if they thought it was increasing, decreasing, or staying the same. In all situations, several participants believe that the forest cover is increasing because of the government's and community's diverse forest restoration efforts. The trend of forest cover in their respective Kushets is that it is increasing from year to year, according to 58.3% of GI participants. On the other hand, 41.7% of those polled believed that the forest cover is diminishing for both man-made and natural reasons. The summary is shown in Figure 15.

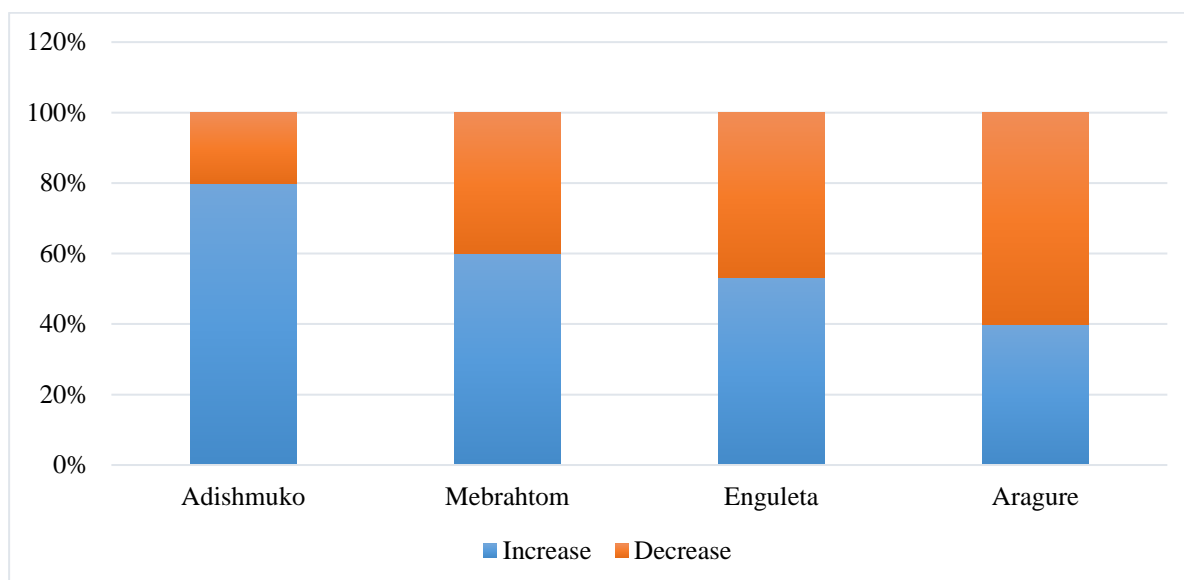


Figure 15. Perception of interviewees from the different communities on the trend of forest cover change.

The GI were questioned about the major reasons for their statements, and the most given reasons were guarding, enrichment plants, and prohibition of livestock and/or free grazing in the forest. The GI participants also claimed that forest cover has declined in recent years due to a variety of factors. Illegal tree cutting, competition for forest products in some of the contentious border

areas between communities of the same ethnic group and with the Afar, are just a few examples. They believed forest cover was decreasing due to weak enforcement mechanisms of forest rules/regulations and by-laws, a lack of community understanding of forest resources, and recurrent drought.

The community participates in forest restoration operations, according to all GI participants. In all the investigated Kushets around the Desa'a forest, all groups of the community ( farmers<sup>4</sup>, youths<sup>5</sup>, and women<sup>6</sup>) participated in forest restoration and management activities, such as tree planting, watering, pruning, soil, and water conservation and guarding. The number of people working on forest restoration activities ranged from a minimum of 600 people in Aragure to 1,300 people in Adishmako.

#### *4.7.4 Conflicts and conflict resolution*

According to the GI's findings, there have been conflicts over forest resources in the last ten years between populations living in various villages sharing a boarder with the Afar region. About 70% of those who took part in the focus group confirmed that there had been disputes in their communities, while 30% of the participants in the focus group discussion said they had witnessed no disputes over forest resources. According to the GI participants, the main reasons for conflicts are competition for scarce forest resources like grass and timber (60%) and a lack of clearly marked boundaries between communities (35%).

Over the last ten years, the frequency of change and the amount of conflict have been assessed. Participants disputed whether during the last decade the trend in conflict had been declining, been constant, or growing from time to time. The GI participants responded that they perceived an increasing trend in conflict in about 25% of the Kushets), that it remained unchanged in 25%, and that the trend was decreasing in 50% of the Kushets. The mechanism of solving conflicts was also investigated. Conflicts were exclusively addressed by the elders in roughly 60% of the Kushets, according to the GI participants, while in another 35% they were controlled by the elders with the help of local administration. In this regard, the dispute resolution processes in most communities (70%) was effective and most disagreements were currently resolved.

#### *4.7.5 Climate change and variability*

Almost all the GI participants agreed that climate change is occurring as evidenced by rising temperatures, irregular rainfall, frequent droughts, new disease and pest outbreaks, and the passage of dry air and strong winds. Droughts have become more common in recent years because of climate change, which has had a direct impact on people's livelihoods in a variety of ways. Droughts in 2001 and 2007 had a severe impact on agriculture and livestock productivity. Climate change was also thought to be the cause of rising temperatures, diminishing moisture, and dry air and strong winds from the Afar region.

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<sup>4</sup> According to the Tigray region's natural resource restoration guideline, a farmer is a man older than 39 years' old who can participate in restoration activities.

<sup>5</sup> A youth is defined as a young man aged from 18 years up to 38 years old.

<sup>6</sup> Women includes all females over than age of 18, whose pregnancy is less than five months old, and whose infants are older than two years.

To identify the major coping strategies during environmental shocks, the GI participants were asked to list them from the highest to the lowest priority. They prioritized the following points:

1. Working as daily labourers in the woreda
2. Waiting for aid from government or non-governmental organizations
3. Selling livestock
4. Working as daily labourers outside the woreda
5. Migration abroad, rock quarry work
6. Consuming wild fruits

## **5. DISCUSSION**

In this section, the results will be discussed in relation to the research questions along with the literature review.

### **5.1 Household socio-economic characteristics**

The socio-economic features of households explored in the following sections will provide insights into the study area. It is critical to collect socio-economic variables from households to understand the relationships or perceptions of individuals of all ages, educational backgrounds, and gender regarding the Desa'a NFPA. Research criteria such as the household head's age, gender, educational level, resource ownership, and access to extension services are thought to influence household choices and reliance on forest ecosystem services and goods.

Older age was shown to have a positive significant influence on households' opinions of forests. This could be described as young people fleeing to other places in search of work to improve their economic position, leaving only older men and women in the kushets (villages). As a result, they must carry the entire responsibility for forest conservation and restoration. Ethiopia, like many poor countries, has a low level of education and a high rate of illiteracy. Farmers' education is thought to improve their ability to access, interpret, and apply natural resource related knowledge as well as their ability to use technologies more effectively. The study also showed that respondents' perceptions of forest ecosystem services and goods were positively influenced by their degree of education. This could be because, as people become more educated, their interest in learning about and participating in forest management, conservation, and restoration grows. These results corroborate previous research (Manjur 2006). Furthermore, respondents who own livestock had a favourable view of forest services and products. This could be because if the forest is restored and protected, they will have access to forage for their livestock through a cut and carry system. The findings also found that those with land ownership had a favourable attitude towards the forest. This could be because if the forest is maintained, it will provide farm implements, reduce soil water erosion, and increase the accumulation of soil organic matter and fundamental soil nutrients.

Households with a large family size and young households, on the other hand, had negative views of the forest. This may be because when families become larger, they desire to expand their agricultural land and want new settlement places. As a result, they are unconcerned with forest conservation and restoration, which limits access to the forest for increasing agricultural lands and new settlements. Furthermore, those who assumed that if forest protection, restoration, and conservation were not established, they would have easy access to the forest. This finding relates to the perception of local people towards forestry (Tadesse & Teketay 2017). Additionally, the gender of the respondents related to both negative and positive

perceptions of the forest. This could be attributed to the fact that male-headed households better understand the indirect values of forest ecosystem services, such as conservation of soil and water loss, soil formation, and regulating the climate, while female-headed households better understand the direct use of forest products, such as fuelwood and herbal medicines. This could affect the long-term strategic plan of the forest positively or negatively. This difference could be due to the difference in perception of the direct and indirect services and goods of the forest.

The extension service's objective is to diffuse information, best practice, and innovations regarding forest management, conservation, and restoration. Development agents are responsible for testing and demonstrating new technologies in forestry and providing extension services to farmers. The study results showed that the demand for and access to extension services are influenced by gender, householders, and resource ownership. The results imply that of the four households that did not have access to the extension service, two were female-headed, and two were landless house heads. This could be due to cultural barriers, and male extension agents have been observed to prioritize male-headed households and farmers who own land and livestock. This might deny female-headed households and landless households' access to information. This interpretation corresponds to the definitions of extension services, which exclude female-headed and landless heads (Semgalawe 1998). Moreover, respondents who participate in income generation and households within the background of education easily adopt technologies and inputs for forest conservation and agricultural production.

## **5.2 Perceptions on ecosystem services and livelihood dependence**

Forests should assist local communities both environmentally and economically. The sustainability of trees is threatened unless they provide tangible benefits to the owner. The duplication of rural development policies, strategies, and methodologies addresses the topic of natural resource conservation, sustainability, and profitability in dry land areas with a high relationship to forests. As a result, the communities surrounded by the Desa'a forest generate a variety of forest services and products from the forest ecosystem. The people who live in and near the Desa'a forest have positive attitudes regarding the forest's contribution to their livelihood. This could be related to the perceived benefits of selling fuelwood, farm implements, construction materials (such as wood and poles), and feed/fodder, and using these items for domestic consumption. The findings relate to the economic contribution of forests (MEFCC 2016; Teketay et al. 2010). The respondents noted that the Desa'a forest also contributed to improving their livelihoods by improving access to water for many reasons (human, livestock, and irrigation). The benefits directly and indirectly contribute to increased income, household consumption, and crop and livestock productivity, which improves the livelihood of the people (Tekele et al. 2014).

The findings of the study also generate relevant and informative knowledge about the indirect uses and services of the forest. For example, both respondents of the household survey and GI noted that forest products and resources also had an indirect contribution to the livelihood of the communities in the surrounding Desa'a forest areas. One of the most important indirect contributions of forest ecosystem services is its positive effect on regulating the microclimate, which moderates temperature and provides pure air to the locality. The GI respondents directly connected with the service protecting them from the Erta Ale volcano, which is located east of the forest and is a source of heat waves in the locality. A member of the community stated that if the Desa'a forest vanishes, the entire ecosystem of the area would be negatively affected. This finding is like the definition of a forest having environmental functions (Lawton 1998). As explained by the GI respondents, trees also serve as a windbreak that absorbs the hot and

dry air blown from the Afar depression and converts it into fresh air. Improving the availability of water, controlling run-off, and reducing soil erosion are among the indirect contributions of forests to livelihoods (Tadesse & Teketay 2017).

Another potential forest ecosystem benefit to communities that has not yet practically started might be found in ecosystem payments, such as carbon trading. There is no ecosystem related payment supplied to the community in the majority of Kushets. However, GI respondents in Kushet Adishmuko argued that there is a form of ecosystem related remuneration because they regard participation in soil and water conservation and plantation activities carried out by programs like SLM, safety net, and Weforest as remuneration. Payments to forest guards are also considered ecological payments. This clearly indicates that, in addition to the direct benefit of the forest, the communities are aware of the indirect uses of the forest.

### **5.3 Deforestation causes and mitigation**

Ethiopia's government, notably in the Tigray region, has concentrated on protecting natural resources in general and forest regions as part of its green economy plan to prevent the negative effects of climate change and to improve the livelihoods of the local community. As a result, considerable attempts to protect natural forests, particularly the Desa'a NFPA and surrounding enclosures, have been made. The study findings revealed different knowledge and attitudes of local communities towards forest degradation in the Desa'a NFPA. The perception of the household respondents was not significantly different, while the GI respondents perceived different attitudes towards the forest cover. Furthermore, two thirds of the GI participants and one fifth of the household respondents, perceived that the forest cover has increased because of various forest restoration measures being taken by the government and community.

Most of the GI respondents from Adishmuko and Mebrahtom Kushets villages assumed that the forest cover had increased in comparison to ten years ago. They explained that the increase in forest cover is primarily due to increased efforts by various concerned bodies to implement forest conservation practices such as controlling free grazing and illegal forest cutting, increasing tree planting, increasing community awareness about forests, a decrease in the frequency of village conflicts, and good law enforcement (local by-laws) as well as good institutional setups (good collaboration between different stakeholders).

Similarly, household respondents from Kushet Adishmuko perceived an increase in forest cover. They described that the increase in forest cover was essentially attributed to forest landscape restoration activities, such as guarding, enrichment plantings, and agricultural expansion. However, other studies reveal that the Desa'a forest's overall forest cover is rapidly dwindling (Aynekulu et al. 2011). However, the respondents perceptions, whether actually correct or not, could be due to observing more guards in and around the forest, as well as planting projects in enclosures and bushlands, leading people to assume that forest cover is increasing. There might be another misunderstanding among the communities: that an increase in enclosure size equals an increase in natural forest cover.

The Desa'a forest is highly degraded and has lost most of its vegetation while being converted to degraded areas. The dense natural forest cover of the rift valley forest (Desa'a forest) has decreased (Gebreegziabher 1999; Aynekulu et al. 2011). The GI participants from Enguleta and Aragure, and most household respondents, argued that the forest cover of the Desa'a forest has decreased. Furthermore, over two thirds of the household respondents confirmed that they are not confident in the services and goods provided by the Desa'a NFPA. Thus, they are less certain that the forest will continue to supply them and their descendants with the products that

they need in the next ten years. This could be because of different anthropogenic, natural, and institutional problems, such as illegal cutting of trees (for home consumption, supply to the local market, poles, and charcoal), expansion of agricultural lands and illegal settlement, weak enforcement mechanisms of forest rules/regulations and by-laws, lack of community awareness of forest resources, frequent drought, and lack of a management plan with clear objectives that is accepted by the community (Aynekulu et al. 2011). Moreover, the boundary of the forest area is not clearly known by most of the community. This may possibly lead to resource vandalism, governance problems, and sources of competition and conflict between households, communities, woredas, and the nearby region of Afar. Another problem that could be a source of forest degradation is low institutional integration among different stakeholders at different levels of government, community, and non-governmental organizations.

Forest degradation in the Desa'a affects the services and goods that are generated by the forest ecosystem and which are essential for the local people's livelihoods. (Sebhatleab 2012). The study findings confirmed that Desa'a forest is the source of fuelwood for the community which is collected and carried by women, girls, and boys. In forests, women are the main collectors and users of forest goods. Deforestation, on the other hand, has had a severe impact on women's personal lives (Tiainen 2019). The community in the study area indeed perceived that the collection and carrying of firewood has an adverse effect on women's and girls' lives. Due to the vanishing of the forest near their homes, they have to walk long distances to collect firewood. As a result, it reduces their time for cooking and childcare. Women are more likely to have to take on the physically demanding task of transporting fuelwood (and other forest products) across long distances and breathe in smoke while cooking. Unplanned pregnancy, infections, and cultural challenges can exacerbate their health problems. In addition, the findings provide useful and explanatory information regarding the effects of climate change problems. As a result, the people were suffering from a shortage of food and water for human consumption, livestock, and irrigation, which were among the problems observed by the community in relation to the loss of forest services and goods from the Desa'a NFPA.

In relation to the research questions, the results revealed that there seem to be different opinions among local people regarding the willingness of the community to conserve and restore the forest in return for getting ecosystem services from the Desa'a NFPA. Forest resources are non-renewable resources if they are not utilized and managed sustainably. The services and goods generated by the Desa'a forest are under high pressure. This is due to different human and natural influences (Friis et al. 2010; Sebhatleab 2012). Various attempts have been made at various levels to keep the forest cover. Among the main activities that have been implemented were area enclosures and natural regeneration, local by-laws, afforestation and reforestation activities, and the implementation of soil and water control mechanisms (cf. Solomon et al. 2018). A significant number of the household respondents and GI participants had a positive response to conserving and restoring the forest. They were willing to conserve and restore the forest by using different forest landscape restoration techniques, such as plantation, soil and water conservation, forest guarding, introducing different energy-saving stoves, solar panels, biogas and other inputs (which can be seen as win-win solutions to reduce deforestation and the adverse effects of firewood collection on women), improving management of the forest, and introducing zero grazing and area enclosures.

In contrast, the study showed that a small number of respondents with large families, young landless respondents and GIs had negative attitudes towards the conservation and restoration of the forest. Local people's negative attitudes towards forest restoration and conservation could be connected to the fact that they may have restricted access to many of the forest's benefits.

When access is completely controlled by the government, local people do not develop a feeling of proprietorship (Tesfaye et al. 2012). Moreover, they perceive that despite the protection and conservation of the forest, they themselves have not benefited economically. Such an attitude may be developed due to absence of correct management and follow up, failure to select suitable tree species for the areas, low survival rate of seedlings due to water shortages, lack of post planting follow up, and poor coordination among relevant stakeholders.

## **6. CONCLUSIONS AND RECOMMENDATIONS**

### **6.1 Conclusions**

Investigating local community perspectives and attitudes about forest ecosystem services and goods is critical for future conservation and restoration of forest resources, as well as for sustainable resource exploitation and management. The mixed method (quantitative and qualitative) approach used in this study discovered that various socio-economic variables significantly influenced positively or negatively the local people's perceptions and attitudes towards the ecosystem services and goods generated by the Desa'a forest, as well as their willingness to conserve and restore the forest.

It is evident that forest ecosystem services and goods play a vital economic role in the life expectancy of the local community. Furthermore, the results suggested that most of the households perceived that they benefited directly and indirectly from the forest ecosystem services and goods generated by Desa'a NFPA. In fact, most of the respondents had positive perceptions and attitudes towards conserving and restoring the Desa'a NFPA to achieve sustainable utilization through different forest landscape restoration techniques, such as plantation of trees, soil water conservation, guarding of the forest, area enclosures, zero grazing and the introduction of energy-saving stoves.

Nevertheless, because of low levels of knowledge or awareness, low access to extension services, poverty, illegal cutting of trees, expansion of agriculture, illegal settlement, overgrazing and uncontrolled grazing, and general mismanagement of the forest, the Desa'a NFPA is under high pressure of deforestation. It is well known that one effect of deforestation is climate change. The farmers around Desa'a forest have long experience and understand how the climate is changing over time. They understand its effect on both farming practices in general and on their livelihoods. In line with the findings of the present study, it is apparent that deforestation affects the livelihood of the local community, especially women. The collection and carrying of fuelwood has an adverse effect on the lives of women.

In summary, the current research investigated relevant techniques for forest land restoration and conservation that might help government officials, experts, local communities, private forest planters and users to meet the opportunities and challenges of forest conservation and management. In addition, it assessed attitudes towards sustainable utilization of forest ecosystem services and goods. Apart from theoretical aims, it is supposed that the findings of the study produced quantitative and qualitative scientific information for policymakers and planners that can guide them toward better and more informed decision-making for ecosystem services and goods utilization, decision-making that is geared towards sustainable management of the forest, thereby addressing the broader goal of poverty reduction in a sustainable manner. As a result, effective forest protection and sustainable usage necessitate a thorough understanding of the perspectives and participation of a variety of stakeholders, including local communities.

## **6.2 Recommendations**

Enhancing local community knowledge and understanding of forest ecosystem services and goods, which is critical to effectively introduce and implement community-based sustainable forest development.

Farmers should be involved in the description of the forest problem, the development of viable solutions, as well as the evaluation of offered solutions and the development and implementation of a Desa's forest management plan. In addition, the management plan should include mechanisms for demarcating the boundaries of the forest area, institutional arrangements, and conflict resolutions.

Farmers should be treated as persons with respected knowledge and awareness about the sustainable use of forest ecosystem services and goods because extension agents are critical in offering insights into how people's needs can be addressed, which includes sustaining healthy environmental conditions.

Since fuelwood gathering and carrying are women's responsibility, forest conservation and restoration programmes should incorporate solutions for collecting and carrying fuelwood to address the problems in relation to the effects of collection of wood on women. Additionally, establishing and encouraging society-based conservation activities that allow communities to profit financially from carbon trading and eco-tourism helps to promote forest conservation and restoration.

Because the socioeconomic variables that influence local people's attitudes towards forest ecosystem services and goods could change over time, future research should take the dimension of time into account when studying community attitudes and perceptions towards forest ecosystem services and goods in the study region.



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## LITERATURE CITED

- Agize K, Bizuneh A (1997) Soil Study of Desa'a Forest. Ministry of Agriculture, Addis Ababa Ethiopia
- Aynekulu E, Denich M, Tsegaye D, Aerts R, Neuwirth B, Boehmer HJ (2011) Dieback affects forest structure in a dry Afromontane Forests in Northern Ethiopia. *Journal of Arid Environment* 75:499-503
- Barbier E, Burgess JC, Folke C (1995) *Paradise lost? The ecological economics of biodiversity*. Earthscan Publications, London, England
- Bekele T (1994) Vegetation ecology of remnant Afromontane forests on the Central Plateau of Shewa, Ethiopia. *Acta Phytogeographic Suecica* 79:1-61
- CBD (Conservation on Biological Diversity) (1996) Reports of the third meeting the conference of the parties to the convention on biological diversity. Buenos Ayres, Argentina.
- Daily GC (1995) Restoring value to the world's degraded lands. *Science* 269:350-354
- FDRE (Federal Democratic Republic of Ethiopia) (2015) Land degradation neutrality national Report to UNCCD. Addis Ababa, Ethiopia.
- Friss I, Demissew S, van Breugel P (2010) Atlas of the potential vegetation of Ethiopia. Royal Danish Academy of Science and Letters, Copenhagen
- Gashaw T, Bantider A, G/Selassie H (2014) Land degradation in Ethiopia causes, impact and rehabilitation techniques. *Earth Science* 4:98-104
- Gebreegiabher Z (1999) An Assessment of human impact, evolutionary pattern and options for sustainable management, UNESCO-MAB (Man and the Biosphere) program. Mekelle, Ethiopia
- Gidey K (2013) Management interventions to assist restoration of degraded dry Afromontane Forest Northern Ethiopia. PhD Dissertation, University of KU Leuven, Belgium
- Gitz V, Place F, Koziell I, Pingault N, Noordwijk M, Alexander M, Minang P (2020) Forest and landscape restoration. Centre for International Forestry Research, Bogor, Indonesia
- Lawton J (1998) Natural services. Pages 75-76. In: Daily (ed) *Societal dependence on natural ecosystems*. Island Press, Washington D.C.
- MAES (Mapping and Assessment of Ecosystems and their Services) (2013) An analytical framework for ecosystem assessment under action 5 of the European Union biodiversity strategy, technical Report. Office of the European Union, Luxembourg.
- Manjur (2006) Farmers' perception and determinations of land management practices in Ofla woreda, Southern Tigray, Ethiopia. Master's thesis, Alamaya University, Ethiopia
- MEA (Millennium Ecosystem Assessment) (2005) *Ecosystems and human well-being synthesis*. Island Press, Washington D.C.

MEFCC (Ministry of Environment, Forest, and Climate Change) (2016) The contribution of forests to national income in Ethiopia and linkage with UN-REDD+ supported Report. Addis Ababa, Ethiopia.

Moonen P (2010) Structure and species composition of Desa'a, a degraded Afromontane Forest in Northern Ethiopia. Master's thesis, University of Ku Leuven, Belgium

Mullan K (2014) The value of forest ecosystem services to developing economics: Centre for Global Development (CGD). (CGD Working Paper 379), Washington DC

Nelson N, Wright S (1995) Power and participatory development, theory, and practice. Intermediate Technology Publications, London

Sandler T (1993) Tropical deforestation, markets and market failures. *Land Economics* 69:225-233

Sebhatleab M (2012) Land use land cover change, detection, and deforestation susceptibility analysis of Desa'a forest. Master's thesis, Bahirdar University, Ethiopia

Semgalawe LM (1998) Household adoption behavior and agriculture sustainability in the Northeastern mountains of Tanzania, the case of soil conservation in the North Pare and West Usambara mountains. Wageningen Agricultural University, Netherlands

Scull P, Cardelus CL, Klepeis P, Woods CL, Frankl A, Nyssen J (2017) The resilience of Ethiopia church forests, interpreting aerial photographs. *Semantic Scholars* 28:1938-2015

Solomon N, Hishe H, Annang T, Papi A, Assante I, Birhane E (2018) Forest cover change, key drivers, and community perceptions in Wujug Mahgo Waren forest of Northern Ethiopia. *Land* 7:32-48

Succow Foundation (2020) Feasibility study for the biosphere reserve Desa'a forest, Tigray Region, Ethiopia  
<https://www.succow-stiftung.de/en/protected-areas-biosphere/ethiopia-dessaa-forest>

Tadesse & Teketay (2017) Perceptions and attitudes of local people towards participatory forest management in Tarmaber district of North Shewa Zone, Ethiopia, the case of Wof-Wasaha forests. *Ecological Processes* 6:17-46

Taddlie, Yu F (2007) Mixed method sampling, a typology with examples. Sage Publications 1:77-100

BoARD (Tigray Bureau of Agriculture and Rural Development) (2020) Geo spatial data base and natural resource interventions in Tigray region, Report. Mekelle, Tigray,  
TBFP (Tigray Bureau of Finance and Plan) (2017) Projection report of population. Mekelle, Tigray

TEEB (The Economics of Ecosystem and Biology) (2012) Ecological and Economic Foundation. In: Kumar (ed). Routledge, Abingdon and New York

Tekele D, Nigatu L, Getachew A (2014) Ecological and socio-economic importance of indigenous multipurpose fodder trees in three districts of Woleyta Zone, Southern Ethiopia. *Biodiversity and Endanger Species* 2:2332-2543

Teketay D, Lemenih M, Bekele T, Yemshaw Y, Feleke S, Tadesse W, Moges Y, Hunde T, Nigussie D (2010) Forest resources and challenges of sustainable forest management and conservation in Ethiopia. Pages 19-64. In: Bongers F, Ten-nigkeit T (eds) *Degraded forest in Eastern Africa, management, and restoration*. The Earth Scan Forest Library, London

Tesfay A (2008) Ethno botanical study of Desa'a forest, uses and management of forest resources by the local people. Master's Thesis, Addis Ababa, Ethiopia

Tesfaye Y, Andres R, Folke B (2012) Attitudes of local people towards collective action for forest management the case of PFM in Dodola area in the Bale mountains, Southern Ethiopia. *Biodiversity Conservation* 21:245-265

Tesfay S, Guyassa E, Joseph A, Brhane E, Wondim GT (2014) Land use and land cover change, woody vegetation diversity in human driven landscape of Gilgel Tekeze catchment, Northern Ethiopia. *International Journal of Forestry Research* 2014:1-10

Tianian S (2009) Women's fuel wood collection and deforestation. Bachelor of thesis, Jonkoping University

UN (United Nations) (1992) *Convention on Biological Diversity*. Riodigenoriyo

UNEP (United Nation Environment Program) (2012) *Environmental accounting of national economic systems, an analysis of West African dryland countries within a global context*. Nairobi, Kenya

Yadessa A, Bekere D, Bekele T (2001) Growth performance of different multipurpose trees and shrub species at Bako, Western Oromia. *Ethiopian Society of Soil Science*, Addis Ababa

Zemedede A, Mesfin T (2001) Prospects for sustainable use and development of wild food plants in Ethiopia. *Economic Botany* 55:47-62

## APPENDICES

### Appendix I Household survey questionnaire

Interview date.....  
 Enumerators Name.....  
 Household code.....  
 Village (Forest Kushet) .....  
 District.....  
 Zone.....  
 Region.....  
 Country.....

Note:

1. Gender: Male (M)=1 Female=0
2. Marital status: Married=1 Single=0

### PART ONE

#### I. Demographic characteristics of the household

##### 1. Demographic characteristics of household

No	Name of the household member	Age (Year)	Education (grades)	Gender (1=M/0=F)	Married=1/Single=0
1					
2					
3					
4					
5					
6					
7					
8					

#### II. Scio-Economic characteristics of the household

2. What is your land holding size .....? In hectare
3. What is your Annual on-farm income? From rain-fed crop..... quintal,  
 From Irrigation..... Birr, from livestock .....Birr
4. What is the number of your Livestock? Oxen.....Cow.....Sheep.....  
 Bull.....Goat.....Donkey.....Mule/Horse.....poultry.....apiary.....  
 Others (specify).....
5. Do you have access to natural resource use and management extension services?  
 Yes=1/No=0
5. Do you have access to natural resource use and management extension services? 1 = Yes 0 = No
6. Does a member of your household participate in non-farm income generating activities? 1 = Yes 0 = No
7. How many members of your family do participate in non-farm income earning activities..... (number)?

**PART TWO- General Information**

**I would like to know how familiar you are with Desa'a forest.**

8. Being a resident around Desa'a forest, have you ever obtained benefits or services from the forest in the last one year?..... Yes = 1 No = 0, If your answer is 'yes# go to Q.9

9. On average, how many times per month do you, or other members of your household, go to the forest to utilize services?.....(number)

10. Do you or your household members obtain the following economic benefits or products from Desa'a forest? (Please choose all numerical codes that apply)

Benefits or Products	Yes = 1	No = 0	Value on own use and sales
Collecting fuelwood (firewood and charcoal)			
Collecting farm implements			
Collecting building materials			
Extracting herbs for medicine			
Extracting food/ wild fruits			
Cut and carry of animal fodder			
Honey (honeybee farming)			
Water			
Leaf litter			
Others			

11. What other forest ecosystem services do you obtain from Desa'a forest?

- 1=Sightseeing 2=Camping 3=Walking 4=Educational reasons/research undertakings
- 5=Spiritual reasons such as holy water If other, specify

**PART THREE- Data on Mapping**

I would like to know where the main and selected forest ecosystem services and the beneficiaries are found in your locality, Desa'a forest.

12. Where do you think are the most common forest ecosystem services located?

- 1=In the middle of the forest 2=Edge of the forest 3=other parts of the forest 4= if others, specify

13. Who does you think are the most benefited beneficiaries from Desa'a forest?

- 1=The core village 2= nearby villages 3= the remote village 4=others

14. Which Forest ecosystem services do you think are deteriorating in the last 10 years?

15. Which Forest ecosystem services do you think are deteriorating in the last 10 years?

16. Have you ever observed any opportunity cost among forest ecosystem services like while you are preserving the forest intact, you probably may loss forest products? If any other trends, how and what are these.

To what extent do you agree, or disagree, with the following statements? (Put the answer of your choice from the given numerical codes in each respective column)

Completely disagree=1, Somewhat disagree=2, Neither agree nor disagree=3, Somewhat agree=4, Completely agree=5

Questions	1	2	3	4	5
17. Forest ecosystem services such as the provision of water, forest products and climate regulation are important					
18. The protection and enhancement of forest ecosystem services is important for the livelihood of your family					
19. Ecosystem services provided by Desa'a forest to the local community are in a good condition.					

20. The overall services provided by Desa'a forest have been damaged a lot in the last 10 years					
21. The forest may not be able to provide your family with the products that need after 10 years.					
22. The current management of the forest reflects the interests of local communities, and it fully secures the sustainability of the forest resource.					
23. Even though in principle fuelwood collection is prohibited in Desa'a forest, but it is an important source of fuelwood and other forest products for the nearby residents for both subsistence and commercial purposes.					
24. As can be understood from the evidence of scholars and relevant literatures studied in the area, Desa'a forest has been severely diminished for the last one decade					

25. Who is collecting firewood in your family? Why? Is there any workload in collecting fuel wood? What do you think to solve the workload?

26. What are the main cause and factors forest degradation in your villages?

27. How would you be willing to contribute to restoring, improving, protecting, and managing the Desa'a forest? By what mechanism? How many days in a year?

## Appendix II Group interviews

Participants from each Kushets (villages) we will have 15 participants. That will be from Tabiya administration 2 one is female, from Kushets (villages) representative 2 one is female, from farmers association 2 farmers, youth association 2 youths, from women association 3 women's, 2 forest guards and 2 development agents.

### I. Background information

Region: .....  
Zone: .....  
District: .....  
Village: .....  
Group: .....  
Number of households in the village: .....  
Number of participants and names: .....  
Date: .....

### II. Forest ecosystems services and use

1. What use/services Desa'a forest provided in the area?
2. Prioritize (rank) forest services based on Q 1?
3. How the services contributing to livelihood of local people?
4. What products do you collect from the forest for Household use?
5. What products do you collect from the forest for sales and who is collecting?
6. Have you ever received any ecosystem payments in your village? If received from whom? How many times? If not, why?

### III. Forest/Land institutions and arrangements

1. Who owns the land? Who has the use right of the forest?
2. Are there any forest or other natural resource rules/regulations/by-laws in your village?
3. Who formulates forest related rule?
4. Who formulates other natural resource rules/regulations/by-laws in your village?
5. How is the involvement of the local people in the decision process of forest related rules/regulations/by-laws in your village?
6. How is the involvement of the local people in the decision-making process of other natural resources rules/regulations/by-laws in your villages?
7. Are there special rules for women, youth, or any vulnerable group?
8. If your answer is yes to Q 7 what does it state about?

### IV. Current Forest cover, forest maintenance and restoration activities

1. Is there any change in forest cover (Increase, Decrease or no change) over the last 10 years' time?
2. If there increase in forest cover why? List the main reasons and root cause?
3. If there is decrease in forest cover why? List the main reasons and cause?
4. Does the village participate in forest restoration? And if so, which groups and how many people, and what are your responsibilities towards the forest conservation, management, and restoration?



**V. Climate change and variability**

1. How are the perceptions of climate change by the community?
2. In the past 10 years have you seen a change in your village? Does the change threaten your livelihood?
3. In your opinion does the change affect the forest in your area? How?