IMPACT OF PARTICIPATORY FOREST MANAGEMENT ON WOODY SPECIES COMPOSITION THE CASE OF KAKE FOREST OF GUMAY DISTRICT, SOUTH WEST ETHIOPIA

BY

DEREJE TILAHUN

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JIMMA, ETHIOPIA

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Dereje Tilahun

MSc. Thesis

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Major advisor: Kitesa Hundera (PhD, professor)

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March, 2020

Jimma, Ethiopia

DEDICATION

This thesis manuscript is dedicated to my late mother Bekelech Lema

STATEMENT OF THE AUTHOR

By my signature below, I declare and affirm that this thesis is my own work. I have followed all ethical and technical principles of scholarship in the preparation, data collection, data analysis and compilation of the thesis. Any scholar matter that is included in the Thesis has been given recognition through citation.

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BIOGRAPHICAL SKETCH

The author, Dereje Tilahun was born on April 27, 1984 in Goma District, jimma zone, Oromia regional state of Ethiopia. He attended elementary school at Goma -2 komba elementary school and high school at Jimma senior secondary school. And in 1997 E.C He graduated with diploma from Chiro ATVET College. And then after 6 years work service of Gumay Woreda Agricultural Office he graduated in 2009 with BSC degree from JUCAVM in Natural Resource Management. After his graduation, he returned to Gumay Woreda Agricultural office until he joined for MSC degree. In 2017 he joined Jimma University to pursue his graduate studies in forest resource and nature management.

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LIST OF ACRONMYS

BA	Basal Area
CACC	Central Agricultural Census Commission
CDM	Clean Development Mechanism
DBH	Diameter at Breast Height
EFPA	Ethiopian Forest Action Plan
EPA	Environmental Protection Authority
FAO	Food and Agricultural Organization of the United Nations
IVI	Important Value Index
JICA	Japan international cooperation agency
MOA	Ministry Of Agriculture
NGO	Non -Governmental Organization
PFM	Participatory Forest Management
SFCDD	State Forest Conservation and Development Department
SNNP	Southern Nation, Nationalities and People’s Region
UNDP	United Nations Development Program
UNEP	United Nations Environmental Program
UNESCO	United Nations Education, Science and Culture organization
UNFCCC	United Nation Frame Work Convention on Climate Change
USAID	United States Agency for International Development
WBISPP	Woody Biomass Inventory and Strategic Planning Project

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ABSTRACT

Kake forest is one of a very few remnant moist evergreen forests in south western Ethiopia of jimma zone Gumay district. The objective of this research work was to compare the vegetation composition and structure of forest under PFM with outside PFM forest. To investigate the plant structure and species composition of the forest, systematic sampling method was used and the plot quadrats 20m x20 m totally 40 sample plot were used for the study .which of 20 from PFM managed forest and 20 from outside PFM managed forest. The sample quadrats were laid down along transects at a distance of 50m from each other. Results showed that a total of 33 species from PFM managed and 18 from outside PFM managed were recorded. The study on vegetation and population structure showed that the total density of tree species was 626.25/ha from PFM and 425/ha from outside PFM and the respective IVI result for each tree species were also calculated. And the forest had the Shannon- Wiener diversity index of 3.18 and evenness of 0.98 from the PFM managed forest and 2.8 and 0.95 from the outside PFM. But the PFM forest has a better performance than the outside PFM forest this is the result of the limitation of open access and continuous monitoring which is given to the forest by the concerned body to the PFM block. Whereas the open access right brings change in outside PFM block.

Keywords: Kake Forest, PFM and Outside PFM Forest, Species Composition

1. INTRODUCTION

1.1. Background

Globally, 30 percent of the land is covered by forests which account about 3952 million hectares (FAO, 2007). Forests worldwide are known to be critically important habitats for the biodiversity they contain and for the ecological functions they serve (Pearce, 2001).

Africa has 675 million hectares of forest and 350 million hectares of wooded land which together cover 35 per cent of its total land area (FAO, 2010). This includes tropical moist forests primarily in Central and West Africa, tropical dry forest, mostly in East and Southern Africa, including the miombo woodlands in Tanzania and Mozambique, and Mediterranean forests and woodland in North Africa. Especially the most diversified plant species was found in East African Mountains. Tropical Montane Forests are well known among the most hot spot ecosystems on earth. This diversified ecosystem is under severe condition because they are highly suitable for agricultural purposes (Rodrigues *et al.*, 2004).

Ethiopia has a diverse ecosystem, ranging from humid forests and extensive wetlands in the west and south west to the desert of Afar depression in the northeast. The altitudinal range of the country varies from 110 m below sea level at Dalol in Afar to 4620 m.a.s.l. at the highest peak of Rasdejen (IBC, 2008). And the country is the fifth largest floral diversity in tropical Africa (Didita *et al.*, 2010).

Due to its diverse topography that has given rise to the development of wide diversities of flora and fauna rich with endemic elements. Between; 6,000-7,000 species of higher plants are estimated to exist in the country of which about 780-840 (12-13%) plant species are estimated to be endemic (Balcha, *et al*., 2004).

And the country owns a total of 59.7 million ha covered by woody vegetation among which: 3.56 % are high forest (about 4.07 million ha), 49 % woodland (29.24 million ha) and 44.2 % shrubland or bushland (26.4 million ha) and plantations cover estimated to 955,705 ha (WBISPP, 2004). About 95 % of the total high forest of the country is located in three regions namely Oromiya, SNNP and Gambela regional states (Yitebitu and Eyob, 2014).

Oromiya has the highest forest covers (2,547,632 ha) which accounts 63 % of the total forest resource followed by SNNP and Gambela. These states accounts about 19 % (775,393 ha) and 13% (535,393 ha) of the total forest cover of the country respectively (Srinivasan, 2014).

The Ethiopian forests provide a wide variety of wood and non- wood products such as honey, incense, medicinal plants, bamboo, foodstuffs, etc. They are socially and commercially significant to the livelihoods of rural households. Despite its significant importance, deforestation is sever and has a long history in Ethiopia, especially in the central and northern highlands where subsistence farming and settlements has been changing landscapes for millennia (Mulugeta and Habtemariam, 2014). Population increases have resulted in extensive forest clearing for agricultural use, overgrazing, and exploitation of existing forests for fuel wood, fodder, and construction materials (Badege, 2001).

Currently, the remaining natural high forests of the country are mainly found in the southwest, which was remote and inaccessible until recently (WBISPP, 2004; Mulugeta and Habtemariam, 2014). However, the persistence of the remnant forest patches and their indigenous species in many areas are threatened. Nowadays, also the problem of degradation observed in the study area, to minimize the problem some part of the forest area demarcated to be managed through the process of PFM. Participatory forest management (PFM) is an agreed bargain negotiated by government and local communities implemented through fairly divided administration functions, benefits and responsibilities over a particular area of forest land to improve management, ensuring regulated access and use according to a jointly developed forest management plan (Tesfaye *et al.*,2015).

The purpose of PFM can generally be described as solving problems arising from the disagreeing interests and concerns of different social actors within forest resources management, in an effective and equitable way. The literature often applies PFM as an umbrella term to refer to various systems developed in different countries, including community forest management, collaborative forest management, and joint forest management. It encompasses the different forms of arrangement by which government and local communities negotiate and agree to manage and use a particular forest or area of forest, and aims at promoting sustainable management and conservation of forest ecosystems, while improving the livelihoods of people living in, or around, these resources (Tesfaye *et al*., 2015).

In Ethiopia, except individually owned plantations, all forests are under state ownership since mid-1970s. PFM was introduced in the mid-1990s and since then recognized by the government as a mechanism to reverse deforestation and improve management of state-owned natural forest and woodland resources. It, however, remains to be an initiative of NGOs and has not thus far been mainstreamed in government forest management structure. The management regime outside PFM is the status quo where the forest is owned and managed by the state while in reality no protection is provided by the government. Thus, areas outside PFM continue to be poorly protected hence are in reality open access though this varies with location or accessibility and the strength of local government structure to protect forests. The country adopted PFM for three fundamental reasons: 1. legal: in the constitution, the rights of communities to use natural resources is recognized; 2. Practical: the government does not have the resources needed to protect all state-owned forest resources; and 3. Achievement: studies concluded that deforestation and degradation rates are much lower in forests under PFM than in forests outside PFM (Ameha *et al.,* 2014). With the implementation of PFM, the open-access regime that previously characterized resource management in the country has been minimized .Where PFM has taken root to a certain extent (e.g. in the Bale Dodola forests located in Oromiya region), forest degradation has shown substantial decline and tree regeneration has improved (Ameha *et al,* 2014). Although economic returns have been slow to materialize, PFM members are now able to access forest resources legally (Tesfaye *et al*, 2015). Various studies show that without PFM, rates of deforestation may have been much higher (Kassa *et al,* 2009).

1.2. Statement of the Problem

In Ethiopia there is a growing understanding that deforestation and land degradation aggravate poverty, which brings natural resource conservation to the front position of rural development initiatives (Yemiru, 2011). The persistent deforestation and depletion of forest show that the usual top down approaches that were in practice to manage forest in Ethiopia are not guarantee for the conservation of forests. It ignores traditional common property regimes, ignores local resource people's knowledge and disempowered local community in terms of both resource possession and responsible use, (FARM Africa, 2005). Many scholars have argued that conservation efforts which have been tried so far in Ethiopia was conventional and coercive (Tadese and Alemtsehay, 2012). In Ethiopia, decentralized forest resource management was initiated in the mid-1990s with the support of international non-governmental organizations (NGOs) to mitigate natural resource degradation and its effects on the livelihoods of people (Habtamariam *et al.* 2009).

Participatory Forest Management (PFM) is a new pattern of forest management which is adopted and implemented in order to fulfill the interests, respecting of traditional users, and hence such a bottom-up approach may encourage a sense of ownership to the rural people to conserve forest resources and also different studies were conducted in different areas to identify the performance of PFM in improving woody species composition. But, in the study area not conducted any study whether the PFM has some improvement or not and the absence of any previous ecological, botanical studies is also equally vital to call for immediate and timely scientific interventions to uphold the conservation of this natural high forest and to show the composition of woody species of participatory forest management with outside participatory forest management.

1.3. Objective

1.3.1. General Objective

The general objective of this study was:-

To assess the impact of participatory forest management in improving woody species composition under PFM scheme in Gumay district.

1.3.2. Specific Objective

- To compare the woody plant species composition of PFM forest with outside PFM.
- To compare the woody species structure of the forest under PFM with outside PFM
- Compare the diversity, richness and evenness of PFM forest with outside PFM forest

2. LITERATURE REVIEW

2.1 Overview of Ethiopian forests

Ethiopia is endowed different forest biodiversity when compared with different countries of Africa. The reason for this is most part of the country consists of high plateau and mountain ranges (Demel Teketay, 2002).The different physical conditions and variation in altitude have resulted in great diversity of climate, soil and different vegetation cover. Because of this the country has different forest biodiversity (ZerihunWoldu 1999, Demel Teketay, 2002).

Ethiopia is also an important regional center of biological diversity. The diversified topographic features such as ragged mountains, flat toped plateaus, deep gorges, incised river valleys and rolling plains are some of the reasons for Ethiopia have high biodiversities and regional center of biological diversities (Ensermu Kelbessa *etal.*, 1992, Tewolde Birhan, 1988). The flora of Ethiopia is very heterogeneous and has rich endemic species of plants due to the diversity in climate, vegetation and terrain. It is estimated to contain between 6500-7000 species of higher plants of which 12% are endemic (Tewolde, 1991) as cited in Teshome Soromossa *et al*. (2004).

It is believed that substantial portion of the land area in high lands of Ethiopia was covered with forests having wide coverage than at present (Friis, 1986). The presence of a number of isolated forest trees, even on farm lands or patches of forests around church yards and religious burial grounds in this country indicate the occurrence of forests earlier (Tamirat Bekele, 1993).

2.2. Socio-ecological significance of forests

Ecological significance of forests

Forests provide a wide range of ecological significance. There are a number of services that forest provides. The major services that forests provide includes regulation of water regions, modulating climate, maintenance of soil quality, carbon sequestration, maintenance of biodiversity and being the habitat for other species (Daily, 1997).

Socio- economic significance of forests

Human beings are dependent for their substances, health well-being and enjoyment on forest biodiversity. Forest also provides food, recreation, spiritual sustenance, commercially traded products ranging from pharmaceutical to timber and (Murthy et al., 2002 and World Bank 2004).

Forests provide a wide range of products and services. The economic values of forest are the basis of a variety of industries including timber, processed wood and paper, rubber and fruits. They also contain products that are necessary for rural communities including fuel, construction materials and medicines (FAO, 2005).

Forests play pivotal role as source of energy for grazing, and non-timber products. The energy consumption of rural Ethiopia is mainly based on biomass source for which fuel wood being the highest component. The rural Ethiopia households entirely dependent on biomass fuel to meet their energy requirement for cooking, heating and lightening.

2.3. Causes for Ethiopian forest loss

Historical documents indicate that Ethiopia had experienced substantial deforestation, soil degradation and an increase in the area of bare land over the years. The need for fuel wood, farm land, human settlement, shifting cultivation, grazing area, firewood, lack of viable land policy have been indicated as the main cause for forest biodiversity degradation frequently leading to loss of forest cover and biodiversity loss (Kelbessa Ensermu and Teshome Soromessa,2008).

Deforestation, natural disasters such as volcanic eruption, logging, and converging of forests to agricultural lands accounts 40% of Ethiopia forest loss (Tewolde Birhan, 1988).Particularly, the current contributor factors accelerated the declining of woody plant species diversity in Ethiopia are the size and distribution patters of humans and domestic animal populations, the level of resource consumption understanding woody plant species in narrow sense due to low level of awareness, the attention of woody plant species conservation and sustainable use has so far been inadequate (Tesfaye,2007).

In Ethiopia, the excessive exploitation of natural pasture and forests without minimum repair, the extension of cultivation to marginal lands by clearing and burning fragile ecosystem, forest fire, lack of proper forest administration and forest management, lack of compatible forest proclamation and other legislation, lack of constant and sustainable institutional organization has resulted in total deforestation and degradation, loss of fertile cultivable land and soil fertility, exposing the country to drought and famine (UNEP,1995).

The country's high forest and wood lands coverage have been decline in both size and quality. This is due to the increased use of forest lands for farm lands, unwise use and excessive utilization of forest products without considering future generation, ecological and economic consequences (EFAP, 1994). The ever increasing demand for forest products and forest land, together with the alarming rate of population growth has put the remaining patches of forests on the verge of extinction (Tamirat Bekele, 1994).

2.4. Consequences for Ethiopian Forest Loss

Reduction in forest cover has a number of consequences including soil erosion and production capacity for carbon sequestration, loss of biodiversity and instability of ecosystem and reduced availability of various wood and non-wood forest products and services (Alemu Mekonnen and Bluff Stone, 2007).

The depletion of natural vegetation in many parts of the country has also lead to the treat and decline in number and area of distribution of many plant species (Tesfaye Bekele, 2000). Loss of forest biodiversity influences vegetation dynamics and tree density at local and regional level. Environmental problems such as soil degradation, erosion, decreasing biodiversity, loss of potential natural resources, a number of valuable medical plants and associated indigenous knowledge are negative effects resulting from forest biodiversity loss. The general destruction of vegetation results in increased soil erosion, loss of soil fertility, loss of plant and animal genetic resources, climate change, increased run off that leads to flooding reduced infiltration to the water table and decreased water supply to rivers during dry seasons (EFAP, 1994).

2.5. Measures Taken To Prevent Ethiopian Forest Loss

The conversion of natural vegetation and biodiversity loss is currently one of the leading agenda for a number of world conservation organizations, authorities and interest groups (UNDESA, 2004) those stakeholders establish sustainable forest management for biodiversity conservation and sustainable use of resources. Sustainable forest management has been the main focus of the worldwide forestry sectors over many years. It aims to ensure that needs derived from the forest meet present day needs without comprising the ability of future generation. Sustainable forest management also aims at balancing social, economic and environment as objectives. However, only about 5% of the total forest areas in developing countries are managed properly (FAO, 2001), which is very low when compared with developed countries (Girima Amante, 2005)

To minimize the risk, sustainable forest management has been practiced through applying conservation techniques, among techniques, protecting forest areas with restricted access for local communities which have often been introduced in the forest helps to tackle deforestation and its effects (Winberg, 2010).

2.6. The Concept of Participatory Forest Management

The concept of resource co-management in general and forests in particular that incorporates state and citizen participation has been around for decades and has changed in theory, practice, and terminology over the past fifteen years (Farrigan, 2005). There are various definitions given to participatory forest management among different scholars.

(Hobley, 1996). Expressed the term participatory Forest Management (PFM) was used as an umbrella term to include shared forest management, join forest managements, collaborative forest management and community forestry, Community based forest management. According to Weinberg (2010) Participatory Forest Management (PFM) is a mechanism to protect forests and enhance the livelihoods of communities who use and benefit from them in the process. Participatory Forest Management (PFM) is used as a broad term to describe systems in which communities (forest users) and government services work together to define rights of forest use, to develop ways of sharing management responsibilities, and to agree how to divide forest benefits. PFM refers to the legal empowerment of local communities to manage forest resources for, in the first instance, their sustained livelihoods, and in the second instance, conservation values (Zelalem, 2005).

Borrini-Feyerabend (2000) defines PFM as a ‘situation in which two or more social actors negotiate, define and guarantee amongst themselves a fair sharing of the management functions, entitlements and responsibilities for a given territory, area or set of natural resources’. Participatory approaches to natural resource management encompass ideas about the desirability of citizens actively engaging in the institutions, policies and discourses that shape their access to resources. Through participation in collective resource management it is claimed that people can renegotiate norms, challenge inequalities, claim their rights and extend their access (Cleaver, 2007).

The essence of PFM plan are common-property regime and are a body of system of environments, resources, and conservation programs participating local peoples that can be more generally termed as ‘participatory conservation’. Participatory conservation is a way of approaching conservation initiatives, which has emerged along with participatory approaches to development since the 1970’s (Hobley, 1996). From 1890s-1970s conservation was promoted throughout the world using exclusionary means to conserve landscape from human use, like national park model from state led bureaucratic, technocratic or expert driven approach (Berkes, 2004).These model remain common but have lost popularity for numerous reasons, within their boundaries as well as their inflicting negative social impact on local population dependant on the resource (Berkes, 2004). Taking in to consideration about the role of communities in conservation as part of participation, benefit will be gained as conservation incorporate multiple scales of ecological, social, political, and economic concerns (Berkes,2004).

2.7. The Importance of Participatory Forest Management

PFM attempts to secure and improve the livelihoods of local people dependent on forest resources by involving all stakeholders in the process of forest management, understanding their needs and situations, allowing them to influence decisions and receive benefits, and increasing transparency (Hobley,1996). But without clear property rights, as long as resources have value, they will be used in less than ideal ways and almost certainly will be degraded, often to the point where they end up close to worthless. Sometimes this phenomenon is called the "Tragedy of the Commons" (Hardin, 1968) and reflects the idea that potentially very valuable resources can be degraded when it is not clear who gets the products generated from natural resource investments and/or who has the right to control resources. Establishing clear property rights through appropriate institutional arrangements is therefore perhaps the critical prerequisite to enhanced tree planting, stewardship, management, and tree cover in many low income countries (Mekonnen and Randall B., 2008).

As scholars rightly put PFM is process oriented activities and in this activity the main actors are the government and community whether their roles and responsibilities can vary depending on the resource base (Borrini-Feyerabend, 2000). There is no generalized model for a successful PFM approach, but in principle should be based on the existing traditional use, management rules and traditional institutions (Irwin, 2004). Of the different collective decision-making rules, those related to property rights have long been recognized as an important precondition for effective management of the commons. The original argument for increasing community participation in the improving of environment project arise from the need to better target people's need, by including indigenous knowledge, and ensure that benefits are fairly divided and lower management cost (Irwin,2004). The economic reason behind PFM is that the communities will conserve forest resource if benefits of management action outweigh the cost of forest conservation. Therefore the issue is what benefit the communities are gaining out of involving themselves in the process of forest management or tree planting in some case (Zelalem, 2005). PFM is recommended to contribute to improved food security and poverty reduction; it could therefore have the potential to play a part in reaching two of the Sustainable Development Goals; Eradicate Extreme Poverty and Hunger; and Ensure Environmental Sustainability (Weinberg, 2010). Behind the strategy lies an assumption that forest areas that are managed by or together with rural communities are likely to have lower levels of forest disturbance and improved forest condition than areas that are either under exclusive state management or under open access regime (Tom, 2009).

The general viewpoint of managing forest in common is to convince people of the benefit of sustainable utilization and by guaranteeing use rights to engage them in sustainable forest management. For this to be successful people must be convinced that it is indeed possible to maintain the resource over indefinite period of time provided use is regulated. Second, it must be possible to guarantee continued streams of benefit from forest products and services (Yonas, 2007). The forest products under PFM are the most important sources of income contributing to household per capita income and per capital cash income. Governing common pool resources such as forests is difficult because such resources combine the most problematic aspects of resource governance, namely subtract ability and excludability (Ostrom, 1990). These resources are used by multiple individuals while generating finite quantities of resource units, where one person's use subtracts from the quantity of resource units available to others. Moreover, most common-pool resources are sufficiently large that multiple actors can simultaneously use the resource system, and excluding potential beneficiaries is very costly (Ostrom, 1990).

The issue of tenure is also very important. Right of access to and /or ownership of forest resources completely change the perceived and actual values of the resources to the community. Empirically, secured property rights have been linked to more sustainable forestry (Castren, 2005). According to impact assessment made by JICA on Belete-Gera Regional Forest Priority Area (2011) "on average, where there are PFM and people feel a sense of beneficiaries and ownership forest area increases by 1.5 percent in the first two years of study, while forest area where there is no association declines by 3.3 percent. Therefore institutional arrangement like property right regimes is needed so as to conserve the natural resource and it provides incentives for such activities and experiences from Ethiopia show that forests managed and protected by the local communities are more productive, economically, and ecologically. PFM is recognized as a significant route towards securing and sustaining forests. Forest conditions such as seedling and sapling densities improved (Gobeze *et al*, 2009). Following the forest condition improvement, the quality of natural regeneration also increased. Forest is a home for wild life species. PFM has direct impact on reappearance of them. This mean wild life species need stable environment to stay. If the area is protected area, it has its own contribution for their appearance and survival. PFM is a type of management that forest protects, in which ecosystem integrity and biodiversity are maintained and at the same time local communities obtain benefits from forests at the same time (Meshack *et al*, 2006). Additionally PFM has a role in creating conducive environmental condition for life. But conservation of forested ecosystems will be difficult unless people are rewarded for the environmental services of their forests (Smith and Scherr, 2003). Such reward could soon become a reality with agreement being reached, in 2001, on the core elements of the Kyoto Protocol at COP7 (Seventh Session of the Conference of Parties (UNFCCC, 2001). Under the clean development mechanism (CDM) of the Kyoto Protocol, industrialized countries will be able to meet a part of their emission reduction commitments (up to 1% of their 1990 emissions times five) by carrying out specified forestry activities that sequester carbon, in developing countries(UNFCCC, 2001).

2.8. Limitation of Participatory Forest Management

Participatory forest management needs different attentions to achieve the intended objectives. In addition to academic works that demonstrated the potential of PFM, there also existed a concern over the success and sustainability of these co-management initiatives. Especially when applied in wider scales and broader contexts, the performance of this strategy has been found to be varying and requires specific local and regional environmental context (Yonas,2007).One of the prerequisites for successful PFM is local people's active and continued participation (Matta,2005). Though the name PFM is used as a general term to indicate local involvement in forest management, its specific application and types of forests with in which it operates vary widely. According to Yonas (2007), among the many of PFM arrangements in many of African counties, the diversity in group size, group cohesion, and proximity to market is enormous. The typology of PFM differs according to the communities' involvement ranging from simple consultation to contracts, delivery and joint venture. As such it is complex and highly context specific which prevents the possibility of blueprinting the PFM process at operational level (Yonas, 2007). But when developing community based management systems, the appropriate definition of the community is also important. It is vital to assess who are the relevant stakeholders rather than simply identifying all the stakeholders. Communities are not homogeneous and efficient systems require thorough understanding of the internal structures and external linkages of the communities involved (Berkes, 2004). There is no easy correspondence between the community homogeneity and sustainable resource management (Grace, 2007). Another challenge in such undertaking is the reluctance of government bureaucrats to give up power to local communities, in participatory forest management, one need to recognize community based resource management need conducive environment and may become the most efficient land allocation system only under specific circumstance (Berkes, 2004). Setting up this type of forest management system becomes more challenging when participatory forest management is introduced in low value forest area (Castern, 2005). That is if conservation of the forest needs long term investment to obtain worthwhile.

3. MATERIALS AND METHODS

3.1. Description of the Study Area

3.1.1. Location and topography

The study was conducted in kake forest of Gumay District located in Jimma zone of Oromia region, which is found in the southwestern part of Ethiopia, between $7^{o}\,50^{'}$ N-$8^{o}5^{'}$N and 36^{o} $15^{'}$E-36^{o} $40^{'}$E (Fig. 1). It covers an area of 40976 ha and is about 416 KMS far from the national capital, Addis Ababa. Its average altitude approximately ranges between 1400-2200 meters above sea level. Gumay District is characterized by undulating topography with isolated mountains, hills, plateaus, and plains.

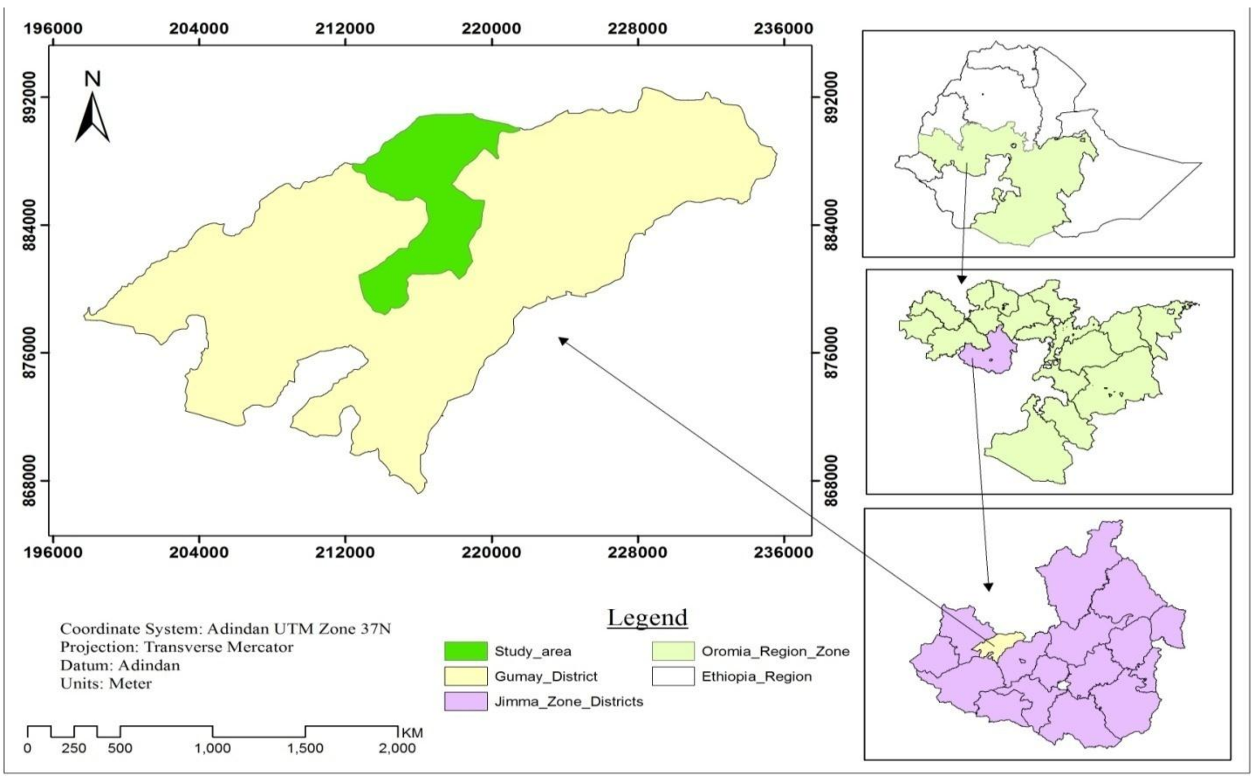


Figure 1: Map of the Study Area

3.1.2. Climate and Vegetation

The climate of the study area is characterized by moderate climate condition; the mean annual temperature of Gumay District varies between 15^{o}c-22.5^{o}c and the rain fall varies between 1500-2000 mm. In terms of vegetation, the study area is endowed. (CACC, 2003)

3.1.3. Soil

Soil types are associated with parent materials and are outcomes of the past geological phenomena. Cambisols, Nitososls, Lithosols, Acrisols, and Vertisols are the dominant soil types in the study area (Woreda Agriculture and Natural Resource Bureau)

3.1.4. Socio-Economic Characteristics

The dominant Socio-economic activity of the study area is agriculture. The mixed farming system is one of the typical smallholders and subsistence rain fed-based agricultural activities. The smallholder farmers cultivate a varieties of crops (maize, and Sorghum), cash crops (coffee and Chat), fruits (banana, orange, mango, and guava), and vegetation. The area is well known by cash crop particularly coffee and its moist evergreen forest. In the area cattle, sheep, goat, poultry are the livestock types kept by the smallholder farmers. Crop production and livestock rearing are equally important activities in the study area (Central Agricultural Census Commission, 2003).

3.2. Methods and Sampling Site Selection

3.2.1. Reconnaissance Survey

Reconnaissance survey of the Forest area was conducted in the first week of February, 2019in order to obtain an impression of the site conditions, to collect information on accessibility and to identify sampling design.

3.2.2. Sampling Design

A systematic sampling design was used to record the data of woody species composition of kake moist evergreen forest, six line transects were laid down starting from the edge to the interior. Sample plots 20m x 20 m, were laid down. The sample plots were laid down along transects at a distance of 50m from each other using measuring tape meter. A total of 40 plots20 from PFM forest and 20 from outside PFM forest were sampled. The data was recorded fromApril-may2019. And the District has 5 kebeles which was demarcated by participatory forest management program. From these 1 kebele was selected randomly and Negochuge kebele from outside participatory forest management was selected purposively.

3.3. Data Collection Method

3.3.1. Vegetation data collection

All woody plant species in the plots were recorded. Each individual of the tree species was counted, their circumference was measured and the height of each tree above 2 m was estimated. The plant specimens collected were brought to the Herbarium of Jima University for identification and using authenticated specimens, consulting experts and referring the published volumes of Flora of Ethiopia and Eritrea (Hedberg and Edwards, 1989 &1995; Edwards *et al.*, 1995, 1997, 2000; Hedberg *et al.*, 2003, 2006; Mesfin Tadesse, 2004;) and Flora of Tropical East Africa (Verdcourt, 1963; Milne-Redhead, 1953).

3.4. Data Analysis

3.4.1. Diversity Indices

Biological diversity can be quantified in different ways. A diversity index is a mathematical measure of species diversity in a community. The two main factors taken into account when measuring diversity are richness and evenness. A diversity index, must be sensitive to both factors, thus must also be sensitive to the different number of species in two or more communities (Mueller-Dombois and Ellenberg, 1974; Frosini, 2006).

Species richness is a measure of the number of different species in a given site and can be expressed in a mathematical index to compare diversity between sites. A richness index may simply coincide with the number of species present in a community, but may also be a function of the number of all the individuals in the community. The species richness of each community is simply the number of species present with at least one individual in a given area(Mueller-Dombois and Ellenberg, 1974; Frosini, 2006). The index is essential in assessing taxonomic and ecological values of a habitat (Mueller-Dombois and Ellenberg, 1974).The second factor, evenness, measures a relative abundance of different species making up the richness of the area (Mueller-Dombois and Ellenberg, 1974).

According to Frosini (2006), an evenness index is a function of the frequencies or proportions pertaining to the species; such an index increases when the proportions tend to be equal or perfect homogeneity and decreases when one species tend to dominate all the others. The interpretation of evenness is strictly dependent on the richness. Species diversity is the product of species richness and evenness. Species diversity index provides information about species endemism, rarity and commonness (Frosini, 2006).Diversity indices also provide more information about community composition than simply Species richness and relative abundance of different species (Kent and Coker, 1992; Frosini, 2006).

The ability to quantify diversity in this way is an important tool for biologists trying to understand community structure. And also measuring diversity has been of historical significance due to the obvious declines in habitat diversity (Frosini, 2006).Among many species, diversity indices the most widely used were Shannon-Wiener diversity index (Mueller-Dombois and Ellenberg, 1974).

3.4.1. 1. Shannon- Wiener index of Diversity

It is the most applicable index of diversity (Grieg-Smith, 1983). The Shannon-Wiener diversity index is one that measure what we will use to draw information from samples in the field. It combines two quantifiable measures; the species richness and species equitability. The Shannon

I. Diversity Index (H') is calculated using the following formula.

$$\mathbf{H' = -\sum_{i=1}^{S} Pi(\ln Pi)}$$

Where S= total number of species; P_{i}= is the proportion of each species (individuals) or the abundance of the i_{th} species expressed as proportion of total cover; and Ln= log base n

High values of Shannon- Wiener diversity index is a representative of more diverse communities (Grieg-Smith, 1983; Kent and Coker, 1992; Frosini, 2006).

II. Shannon's Equitability (E), Evenness were calculated from the ratio of observed diversity to maximum diversity using the equation

E= H'/ H'max, or E = H'/ lns, Equitability assumes a value between 0 and 1 with 1 being complete evenness (Kent and Cooker, 1992). The higher the value of evenness index, the more even the species is in their distribution within the given area.

3.4.2. Analysis of the Vegetation Structure

In this study, the structural analyses of the vegetation were described by using the following components: Frequency, DBH and Height class distribution, Important Value Index (IVI), Basal area, and the Stem density. Tree/shrubs density and basal area values were analyzed on a hectare basis. Tree heights (m) were also classified into classes and the percentage distribution of individuals in each class were computed for each species.

3.4.2.1. Density

$$\text{Density} = \frac{\text{No of individual spps in all sample plot}}{\text{Total number of sample plot studied}}$$

$$\text{Relative density} = \frac{\text{No of individual spps in all sample plot}}{\text{Total number of sample plot studied}} * 100$$

3.4.2.2. Frequency: - is the number of times a particular species is recorded in the sample area. The frequency distribution of tree species was calculated as follow:

$$\%\ \text{frequency of species} = \frac{\text{No. of quadrats in which species A occurs}}{\text{Total No. of quadrants examined}} * 100$$

3.4.2.3. Basal area (BA)

Total basal area is the sum of the stem cross-sectional area at breast height on a per- hectare basis. Generally, it is a measure of dominance where the term "dominance" refers to the degree of coverage of a species as an expression of the space it occupies and were calculated by using DBH; In turn, DBH values were calculated from circumference measurements by using the formula as follows: $\mathbf{d = C/\pi}$

$\mathbf{BA = \pi d^2/4}$, where, π= 3.14; d = DBH (m).

3.4.2.4. Independent t-test

Used to measure the significance of species abundance

3.4.2.5. Importance Value Index (IVI):-

Importance value index combines data for three parameters (relative frequency, relative density and relative abundance). That is why ecologists consider it as the most realistic aspect in vegetation study (Curtis and McIntosh, 1951). It is useful to compare the ecological significance of species (Lamprecht, 1989).

4. RESULT AND DISCUSSION

4.1. Floristic Composition

A total of 33 woody plant species were recorded from the PFM and 18 from the outside PFM.A total of 501 individuals of woody plants were recorded. Among the recorded plants *Vepris dainellii* was the dominant plant species followed by *Olea capensis*, *Ehretia cymosa* and *Croton macrostachus* respectively. *Oxyanthus speciosus* and *Clausenia anisata* was the least dominant in PFM forest (Table1). However from the forest outside PFM a total of 18 different species of woody plants were recorded with a total of 343 individuals of woody plants and among the recorded plants *croton macrostachus* was the dominant species followed by .*Albizia gumifera, Cordia africana and Accacia lahai* respectively. From the recorded data it is possible to understand that the PFM forest has a better species composition. This seems to have been achieved because of the regulated access and the forest development works communities exercised in the forest.

Table 1 Different species of woody plants with their corresponding abundance and average height of forest managed by the process of PFM

No	Name of species	Family name	Habit	Average height (M)	Average height percentage	Abundance
1	*Flacourtia indica*	Flacourtiaceae	T	6	1.6	2
2	*Millettia ferruginea*	Fabaceae	T	14	3.7	9
3	*Syzygium guineense*	Myrtaceae	T	13.8	3.7	15
4	*Oleawelwitschii*	Oleaceae	T	20.8	5.6	15
5	*Brucea antidystrica*	Simarobiaceae	T	10.2	2.7	10
6	*Podocarpus falcatus*	Podocarpaceae	T	38.7	10.3	7
7	*Phyllanthus ovalifolius*	Euphorbiaceae	T	6	1.6	1
8	*Rothmania celliformis*	Rubiaceae	T	9	2.4	2
9	*Olea capensis*	Oleaceae	T	6.4	1.7	82
10	*Vepris dainellii*	Rutaceae	T	6.7	1.8	100
11	*Albizia gumifera*	Fabaceae	T	11.8	3.1	5
12	*Ficus vasta*	Moraceae	T	15.2	4.1	9
13	*Hagenia abyssinica*	Rosaceous	T	16	4.3	1
14	*Vernonia amegdanalis*	Asteraceae	T	7.4	2.0	5
15	*Dracaena steudneri*	Dracaenaceae	S	5	1.3	1
16	*Maytenus arbutiona*	Celasteraceae	S	5	1.3	2
17	*Polyscias fulva*	Araliaceae	T	13.8	3.7	12
18	*Bersema abyssinica*	Melianthaceae	T	7.8	2.1	5
19	*Diosporyus abysssinica*	Ebenaceae	T	16.4	4.4	31
20	*croton macrostachus*	Euphorbiaceae	T	14	3.7	38
21	*Psychotria orophila*	Rubiaceae	S	6.2	1.7	9
22	*Acacia lahai*	Fabaceae	T	8	2.1	4
23	*Pouteria adolfi-friederici*	Sapotaceae	T	19.3	5.2	29
24	*Celtis africana*	Ulmaceae	T	18.5	4.9	9
25	*Oxyanthus speciosus*	Poaceae	T	12	3.2	1
26	*Allophylus abyssinicus*	Sapindaceae	T	8.5	2.3	2
27	*Ficus sycomorus*	Moraceae	T	19	5.1	2
28	*Galineria saxifraga*	Rubiaceae	T	5.7	1.5	26
29	*Pittosporum viridiflorum*	Pittosporaceae	T	7.5	2.0	2
30	*Ehretia cymosa*	Boraginaceous	T	6.8	1.8	50
31	*Clausenia anisata*	Rutaceae	S	6	1.6	1
32	*Cordia africana*	Boraginaceous	T	5.6	1.5	3
33	*Dracaena steudneri*	Dracaenaceae	T	7.6	2.0	11
						501

The life forms of the study forest were trees and shrubs. The tree has the largest proportion of life forms of the species with 30 (90.9 %) species and shrubs with 3 (9.1%) species. T =tree S= shrub

Table2. Different species of woody plants with their corresponding abundance and average height of forest not managed by the participatory forest management

No	Name of species	Family name	Habit	Average height (M)	Average height percentage	Abundance
1	*Acacia lahai*	Fabaceae	T	12	7	26
2	*Albizia gumifera*	Fabaceae	T	13.3	7.7	31
3	*Bridelia micrantha*	Euphorbiaceae	T	4.5	2.6	4
4	*Celtis africana*	Ulmaceae	T	7.1	4.1	25
5	*Cordial Africana*	Boraginaceous	T	9.7	5.6	29
6	*Croton macrostachus*	Euphorbiaceae	T	9.9	5.8	62
7	*Dracaena steudneri*	Dracaenaceae	T	6	3.5	2
8	*Ehretia cymosa*	Boraginaceous	T	6.4	3.7	11
9	*Ficus sycomorus*	Moraceae	T	14.3	8.3	16
10	*Ficus vasta*	Moraceae	T	16.9	9.8	23
11	*Flacourtiaindica*	Flacourtiaceae	T	8	4.6	6
12	*Maesalanceolata*	Myrsainaceae	T	8.6	5	12
13	*Millettiaferruginea*	Fabaceae	T	9.8	5.7	6
14	*Olea capensis*	Oleaceae	T	6.8	3.9	18
15	*Olea welwitschii*	Olaeaceae	T	8.3	4.8	19
16	*Sapimellipticum*	Euphorbiaceae	T	11.2	6.5	17
17	*Syzygiumguineense*	Myrtaceae	T	11.8	6.9	28
18	*Vernonia amegdanalis*	Asteraceae	T	7.5	4.4	8

The life form of the study forest is totally trees. T =tree

Table 3. Independent t- test of species abundance by their management

abundance	N	Mean	Std. Deviation	Std. Error	95% Confidence Interval for Mean		Minimum	Maximum
					Lower Bound	Upper Bound		
Pfm	20	25.00	6.728	1.504	21.85	28.15	11	34
Npfm	20	17.15	3.617	.809	15.46	18.84	12	26
Total	40	21.08	6.650	1.051	18.95	23.20	11	34

P value = 0.001

Comparing the species abundance by their management using an independent t- test the species which is found in PFM is significantly high (P value = 0.001) this is because of the management which is given to the area.

4.2. Analysis of vegetation structure

4.2.1. Density of Trees

The density of tree is expressed as the number of trees per area sampled. It is the crucial parameter for sustainable forest management. The density of tree individuals in PFM Forest was recorded. According to the recorded data the total density was 626.25per hectare and the density of tree individuals of with DBH 0-10cm was 368.75 individuals per hectare, those with 10-20cm was 32.5 individuals per hectare, those with 20-30cm was26.25 individuals per hectare, those with30-40cm was18.75 individuals per hectare, those with 40-50cm was 101.25 individuals per hectare, those with 50-60cm was 33.75 individuals per hectare and > 60cm was 45 individuals per hectare.

The recorded data of PFM forest woody plant species showed that *Veprisdainellii* is the most dominant tree species followed by *Olea capensis*, *Ehretia cymosa* and *Croton macrostachus* respectively. The data analysis from figure 3showed that the majority of woody plant species were distributed in DBH class 0-10cm and the least woody plant species distributed in DBH class 30-40cm.

The ratio described as a/b, is taken as the measure of size class distribution (Grubb *et al.*, 1963).The ratio of density of trees with DBH greater than 10cm to DBH greater than 20cm for PFM forest is 0.28. This indicates that the predominance of small sized individuals.

The ratio of density at DBH class greater than 10cm to density at DBH class greater than 20 cm has been compared with Angada forest (Shambel Alemu, 2011) 1.47 and Gedo forest (Birhanu Kebede et al., 2014) 1.79. The ratio of PFM forest is less than the above mentioned forests. This indicates that there is predominance of small sized individuals in the study forest. Whereas, the data analysis showed that the total density of the recorded forest was 428.75per hectare of forest outside PFM forest with DBH 0-10cm was 35 individuals per hectare, those with 10-20cm was 238.75 individuals per hectare, those with 20-30cm was 91.25 individuals per hectare, those with30-40cm was0 individuals per hectare, those with >40cm was 28.75 individuals per hectare.

And also the recorded data showed that *Croton macrostachus* was the most dominant tree species followed by *Albizia gumifera, Cordia africana* and *Accacia lahai* respectively.

The ratio of density of trees with DBH greater than 10cm to DBH greater than 20cm of the forest is 0.96. This indicates that the predominance of small sized individuals.

The vegetation population structure of the PFM forest exhibited a better structure that show a healthy population distribution across diameter classes compared with the outside PFM forest block. This seems to have been achieved because of the regulated access and the forest development works communities exercised in the forest.

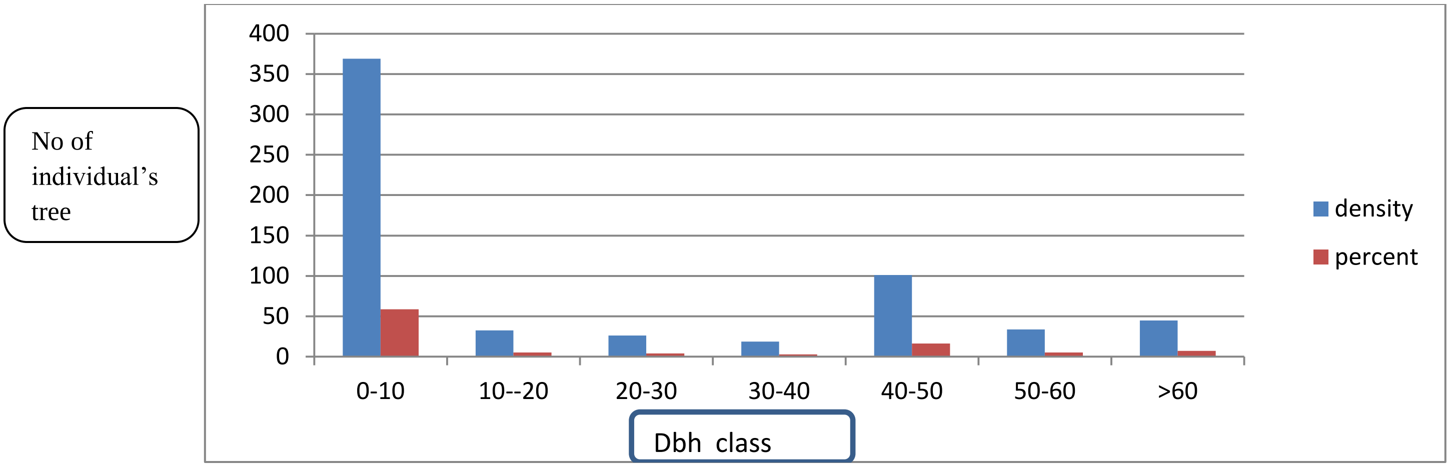


Figure 2. Forest managed through PFM

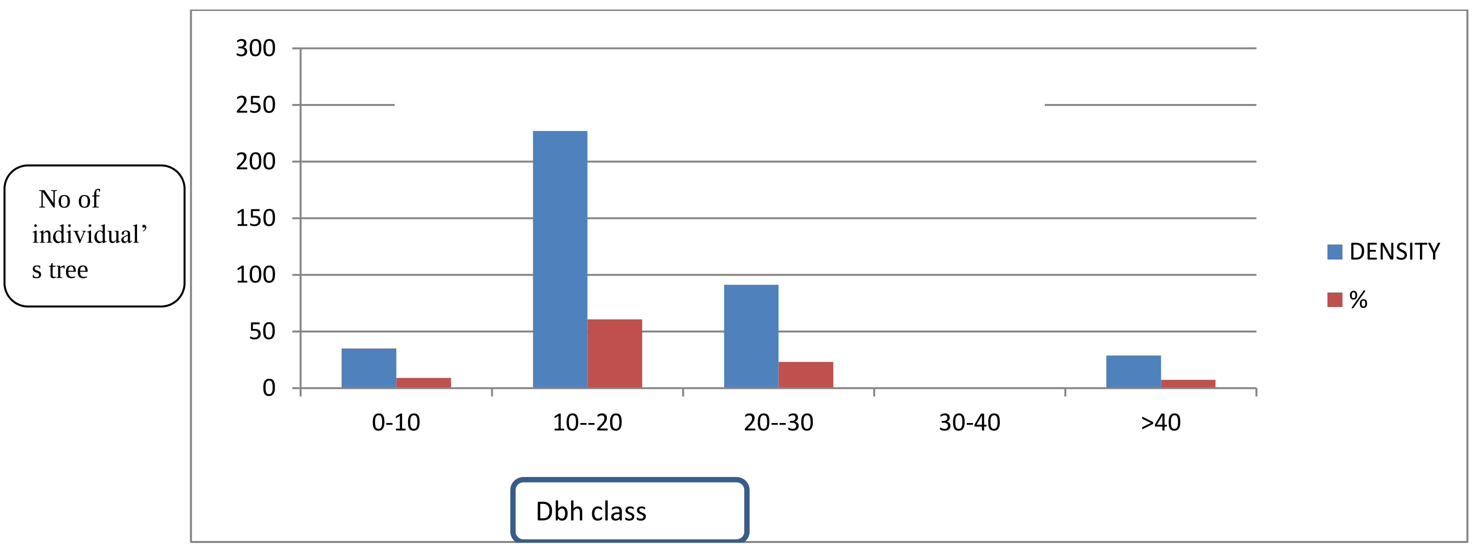


Figure 3. Forest managed through outside PFM

4.2.2. Diameter at Breast Height (DBH)

The distribution of woody plant individuals in different DBH classes was analyzed. The DBH was classified into seven classes 1 (0-10cm), 2 (11-20cm), 3(21-30cm), 4(31-40cm) and 5 (>40cm).

The DBH analysis showed that the majority of woody plant species distributed in the first class (0-10cm) which has a total of 14 species with 311(62.1%) individuals from the total. The least woody plant species distributed in the third and fourth class 20-30 and 30-40 cm respectively. The distribution of woody plant species in DBH class six and seven (76-90 and >90 cm) respectively has a total of 2 species with 7 and 29(1.4 and 5.8%) individuals, the second class has a total of 5 species with 31(6.2%) individuals per hectare, the third, fourth and fifth DBH class has a total of 5, 2 and 5 of woody plant species with 31, 24 and 99 individuals respectively.

The DBH analysis showed that more number of individuals was distributed in the first class and decrease in the DBH class3 and 4 then increase in DBH class 5(Fig. 3). But the DBH analysis of outside PFM forest showed that the majority of woody plant species distributed in the second class (10-20cm) which has a total of 10 species with 190(55.4%) individuals from the total. The least woody plant species distributed in the fourth class 30-40 with 0 individuals.

The distribution of DBH class in PFM forest woody species showed that an inverted J-shape distribution (Fig.4). This is DBH class distribution pattern in which the majority of woody species have the maximum number of individuals in lower DBH classes and there is a gradual decline towards the upper classes. This kind of size class distributions indicates that a good reproduction and recruitment potential in the forest. The same kind of diameter and height class distribution pattern has previously been reported by (Feyera Senbeta, 2006; Abreham Assefa, 2009; Ensermu Kelbessa and Teshome Soromessa 2008).

The DBH and height class distribution with population structure of most tropical tree species and it is an indication of healthy regeneration status of forest (Cesar, 1992).

But it is possible to say that in outside PFM forest areas from the data analysis of the graph as the class of dbh increases the number of tree decreases. This may be the bigger tree species are selectively removed or exploited. (Feyera Senbeta and Demel Teketay, 2003)

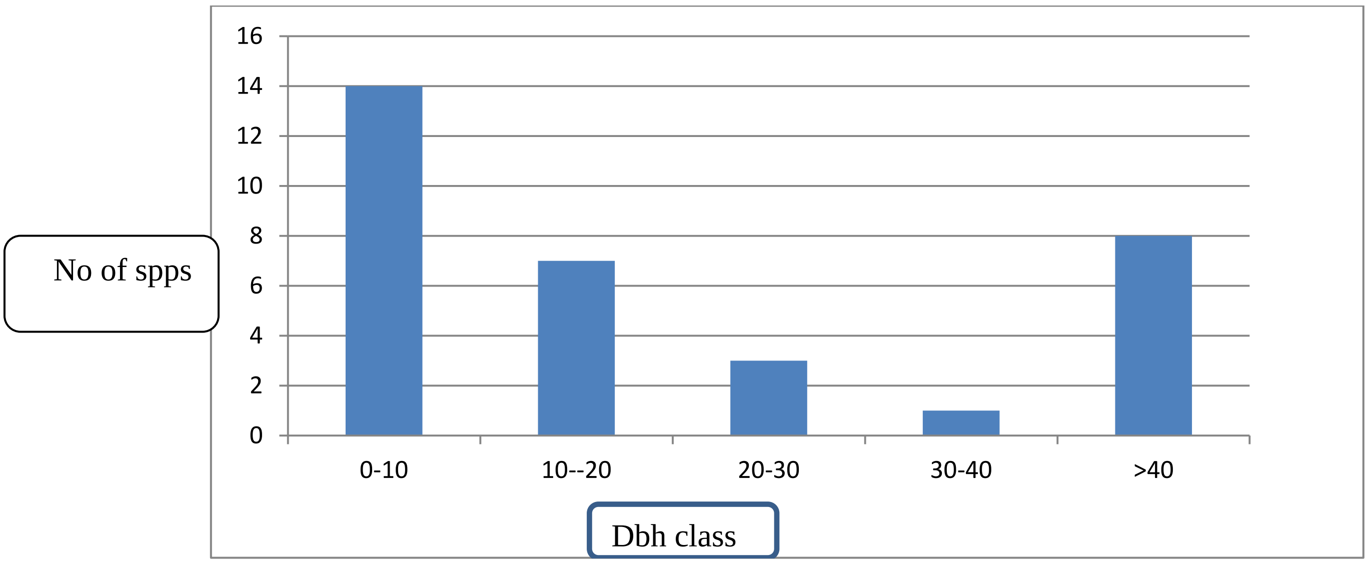


Figure 4. Dbh class of PFM

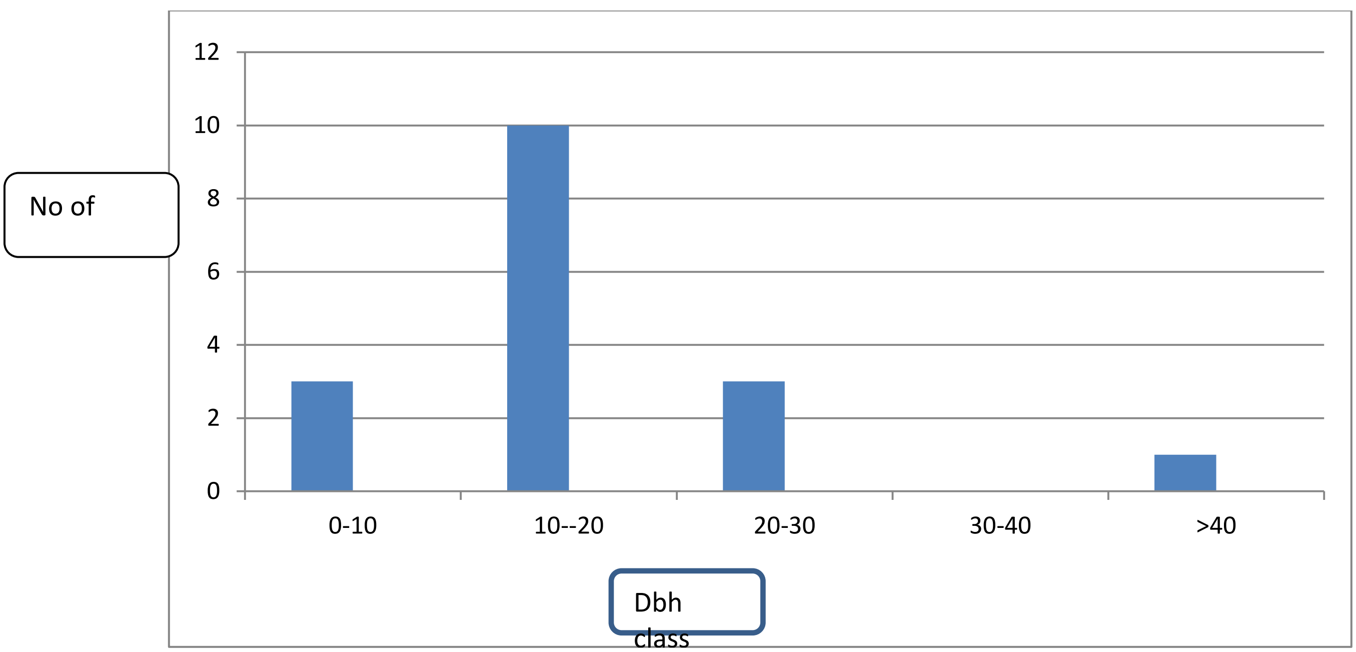


Figure 5. Dbh class of outside PFM

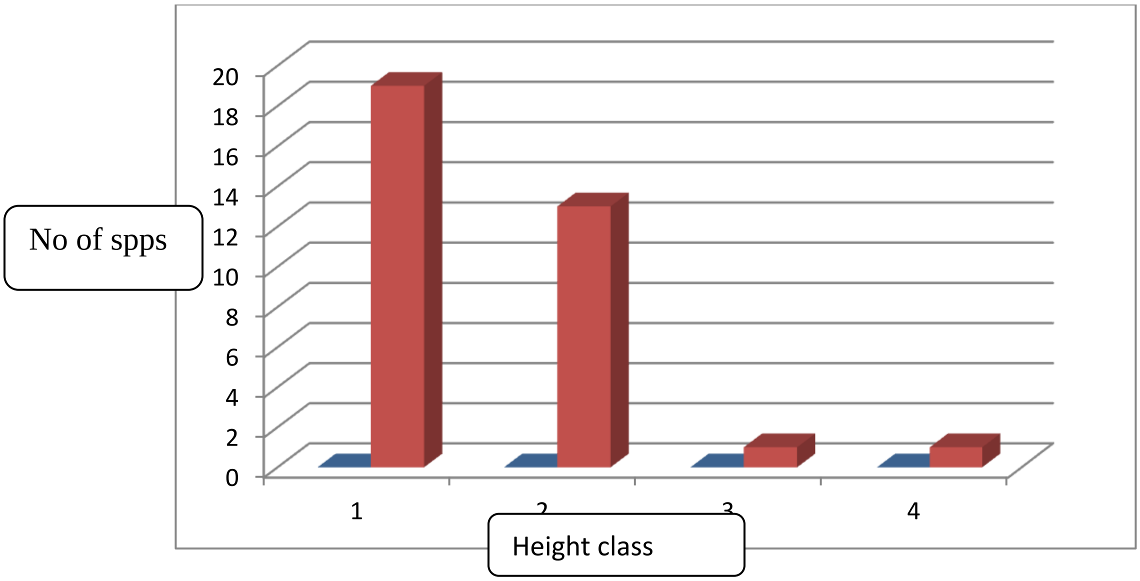
4.2.3. Height of Trees

Height class distribution is the main indicator of the role of a species for the forest structure since each of species represents different layer and determines the vertical variation in the structure of stand Pascal and Pelissier,(1996). However, DBH and height class distribution does not necessarily indicate the pattern of population dynamics and recruitment of a given species.

Individual woody plant species recorded in PFM forest were classified in to four height classes. 1. 0-10m, 2.11-20m, 3.21-30m, 4. 31- 40m.

As the data analysis showed, there is higher number of woody plant species in height class one which has19 species and 305 individuals which has 60.8%,followed by height classes 2(10-20 m) which have 171 individuals which has 34.1 %., third and fourth height classes have 2 species and 15 and 7 individuals with 3 and 1.3% respectively. And there is less number of woody plant species in height class 3 and 4 (20-40m) (figure 7). The tallest species in the study forest *Podocarpus falcatus* with average height 38.5m (10.3%) followed by *Olea welwitschii*, *Pouteria adolfi-friederici* and *Celtis africana* with average height 20.8m (5.6%), 19.3m (5.2%) and 18.5 m (4.9%) respectively.

But where as in outside PFM higher number of woody plant species in height class two which has11 species and followed by height classes 3 (20-30 m) which have 5 species and height class1 and 4 have 1specieseach and the tallest species in the study forest *Ficus vasta* with average height 16.9mfollowed by *Ficus sycomorus* and *Albizia gumifera with 14.3 and 13.3 m respectively.*



1=0-10, 2=10-20, 3=20-30, 4=30-40

Figure 6. Height class of PFM

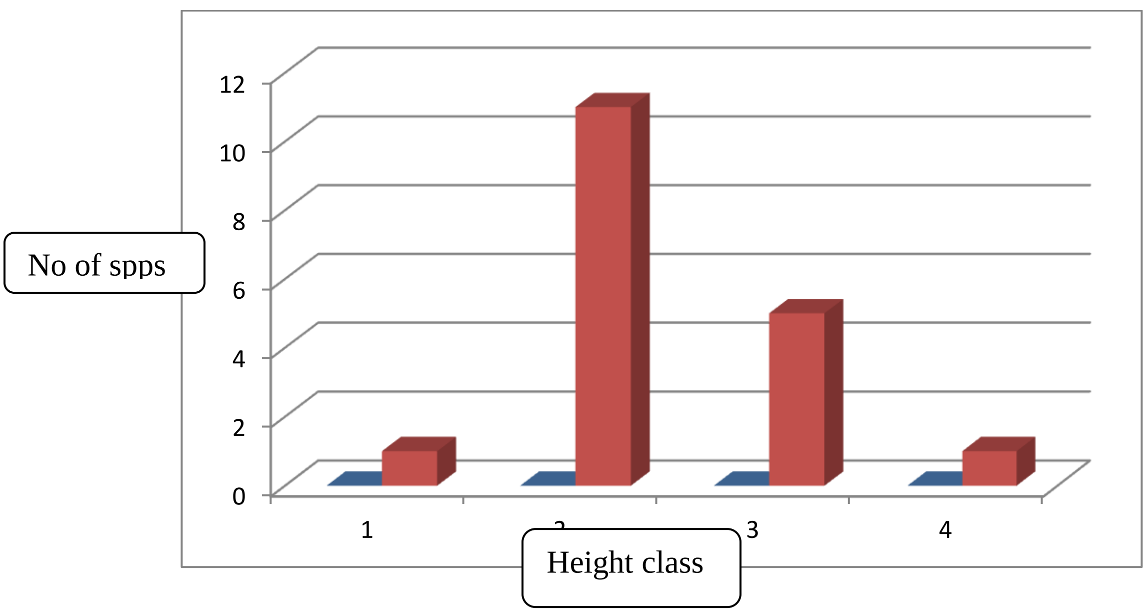


Figure 7. Height class of outside PFM

4.2.4. Basal Area

The basal area of PFM forest was analyzed. The data analysis showed that, the total basal area of all woody plant species in PFM forest was 64.4m2 per hectare (Table 3). As shown from the table *Pouteria adolfi-friederici* has the highest basal area which is 27.5 (42.7%) followed by *croton macrostachus*, *Diosporyus abysssinica*, *Olea welwitschii* and *Podocarpus falcatus* which has basal area of 13.8 %, 11.4 %, 7.4 % and 7.2% respectively.

Basal area provides a better measure of relative importance of the species than simple stem count (Cain and Castro, 1959). Species with the largest contribution in basal area can be considered the most important woody species in the forest. The data analysis showed that the most, important trees species in PFM forest were *Pouteria adolfi-friederici, croton macrostachus*, *Diosporyus abysssinica*, *Olea welwitschii* and *Podocarpus falcatus* (Table 3) PFM forest.

However in outside PFM managed forest as shown in (table 4) *Ficus vasta* has the highest basal area which is 4.99 (31.4 %) followed by *Albizia gumifera*, *Croton macrostachus, Syzygium guineense and Ficus sycomorus* which has basal area of 12.8 %, 9.7%, 9.3 % and 8.9 % respectively and the total basal area of the forest is 15.9 m2 per hectare.

Table 4. Basal area (m2/ha) of woody plant trees species and their percentage contribution in PFM forest

No	Name of species	Family	Basal Area /ha	%
1	*Acacia lahai*	Fabaceae	0.020630781	0.032020
2	*Albizia gumifera*	Fabaceae	0.057226500	0.088820
3	*Allophylus abyssinicus*	Sapindaceae	0.028260000	0.043862
4	*Bersema abyssinica*	Melianthaceae	0.029849625	0.046329
5	*Brucea antidystrica*	Simarobiaceae	0.466329250	0.723777
6	*Celtis africana*	Ulmaceae	0.353250000	0.548269
7	*Clausenia anisata*	Rutaceae	0.007948125	0.012336
8	*Cordia africana*	Boraginaceous	0.735937500	1.142228
9	*croton macrostachus*	Euphorbiaceae	8.916224288	13.838622
10	*Diosporyus abysssinica*	Ebenaceae	7.369271927	11.437641
11	*Dracaena steudneri*	Dracaenaceae	0.065669175	0.101923
12	*Ehretia cymosa*	Boraginaceous	0.404648128	0.628043
13	*Ficus sycomorus*	Moraceae	1.508770000	2.341720
14	*Ficus vasta*	Moraceae	0.044156250	0.068534
15	*Flacourtia indica*	Flacourtiaceae	0.004906250	0.007615
16	*Galineria saxifraga*	Rubiaceae	0.105254159	0.163362
17	*Hagenia abyssinica*	Rosaceous	0.009812500	0.015230
18	*Maytenus arbutiona*	Celasteraceae	0.003974063	0.006168
19	*Maytenus senegalensis*	Celasteraceae	0.007948125	0.012336
20	*Millettia ferruginea*	Fabaceae	0.401920000	0.623809
21	*Olea capensis*	Oleaceae	0.635946928	0.987035
22	*Olea welwitschii*	Oleaceae	4.782121875	7.422198
23	*Oxyanthusspeciosus*	Poaceae	0.028358125	0.044014
24	*Phyllanthus ovalifolius*	Euphorbiaceae	0.004808125	0.007463
25	*Pittosporum viridiflorum*	Pittosporaceae	0.143066250	0.222049
26	*Podocarpus falcatus*	Podocarpaceae	4.669377967	7.247211
27	*Polyscias fulva*	Araliaceae	3.785532975	5.875420
28	*Pouteria adolfi-friederici*	Sapotaceae	27.463404608	42.625182
29	*Psychotria orophila*	Rubiaceae	0.035419396	0.054973
30	*Rothmaniaur celliformis*	Rubiaceae	0.028260000	0.043862
31	*Syzygiumguineense*	Myrtaceae	1.360248000	2.111203
32	*Veprisdainellii*	Rutaceae	0.885578125	1.374481
33	*Vernonia amegdanalis*	Asteraceae	0.066018500	0.102465
	Total		64.4	100

Table 5. Basal area (m2/ha) of woody plant trees species and their percentage contribution in outside PFM forest

No	Species	Family name	Basal area/He	%
1	*Acacia lahai*	Fabaceae	1.493074	9.390402516
2	*Albizia gumifera*	Fabaceae	2.043587	12.85274843
3	*Bridelia micrantha*	Euphorbiaceae	0.063694	0.400591195
4	*Celtis africana*	Ulmaceae	0.420694	2.645874214
5	*Cordial africana*	Boraginaceous	0.873059	5.490937107
6	*Croton macrostachus*	Euphorbiaceae	1.542596	9.701861635
7	*Dracaena steudneri*	Dracaenaceae	0.013978	0.08791195
8	*Ehretia cymosa*	Boraginaceous	0.16342	1.027798742
9	*Ficus sycomorus*	Moraceae	4.996194	31.42260377
10	*Ficus vasta*	Moraceae	1.401399	8.813830189
11	*Flacourtia indica*	Flacourtiaceae	0.095541	0.600886792
12	*Maesalanceolata*	Myrsainaceae	0.343666	2.161421384
13	*Millettia ferruginea*	Fabaceae	0.112128	0.705207547
14	*Olea capensis*	Oleaceae	0.134928	0.848603774
15	*Olea welwitschii*	Olaeaceae	0.343666	2.161421384
16	*Sapim ellipticum*	Euphorbiaceae	0.495504	3.116377358
17	*Syzygium guineense*	Myrtaceae	0.495504	3.116377358
18	*Vernonia amegdanalis*	Asteraceae	0.041207	0.259163522

The basal area of PFM Forest which is 64.4 is compared with the basal area of outside PFM forest 15.9 is high. This is because the studied forest has higher DBH individuals of woody plant species than the other compared forests. The result of basal area was found based on the DBH. Woody plant species which have the highest DBH also have the highest basal area this is due to their management and age.

4.2.5. Frequency

Frequency is the number of plots in which a given species found in an area. It gives an approximate indication for homogeneity and heterogeneity of vegetation. Lamprecht (1989).pointed out that high value in high frequency and lower value in lower frequency classes indicate vegetation homogeneity. Conversely, high percentage of number of species in the lower frequency classes and lower percentage of number of species in the higher frequency classes indicate high degree of floristic heterogeneity (Simson Shibru and Girma Balcha, 2004).

According to table 6, the most frequent species was *Vepris dainellii* with the percentage frequency value 95 % which was followed by *Olea capensis*, *Pouteria adolfi-friederici*, *Diosporyus abysssinica*, *Croton macrostachus* and *Ehretia cymosa* respectively.

Based on the percentage frequency values, the woody plant species of PFM forest were classified into five frequency classes 1,(0-20%), 2.(21-40%), 3.(41-60%), 4.(61-80%), 5.(81-100%) which was expressed in their percentage value. In frequency class 1, 20 species with 60.6% distributed, in frequency classes 2 and 3 12 species six from each with 18.2%, in frequency class 4(61-80) 0 species and in frequency classes 5(81-100) 2 species with 6.1% distributed respectively (Figure 9). And from the data outside PFM the most frequent species was *Croton macrostachus* followed by *Albizia gumifera*, *Cordia africana* and *Syzygium guineense* respectively.

From this study, high frequency values were obtained in lower frequency classes whereas low-frequency values were obtained in higher-frequency classes. From the figure 8 and 9

This might be attributed to its usual occurrence of plant species at wide range of altitude, seed dispersal capacity, germination vigor and resistant to pests and pathogen are some of the factors contributing for the higher frequency of the species. In addition, the high frequency of a species always depends on habitat preferences, adaptation and availability of appropriate conditions for regeneration. But a better distribution was observed from the PFM forest than the outside PFM forest.

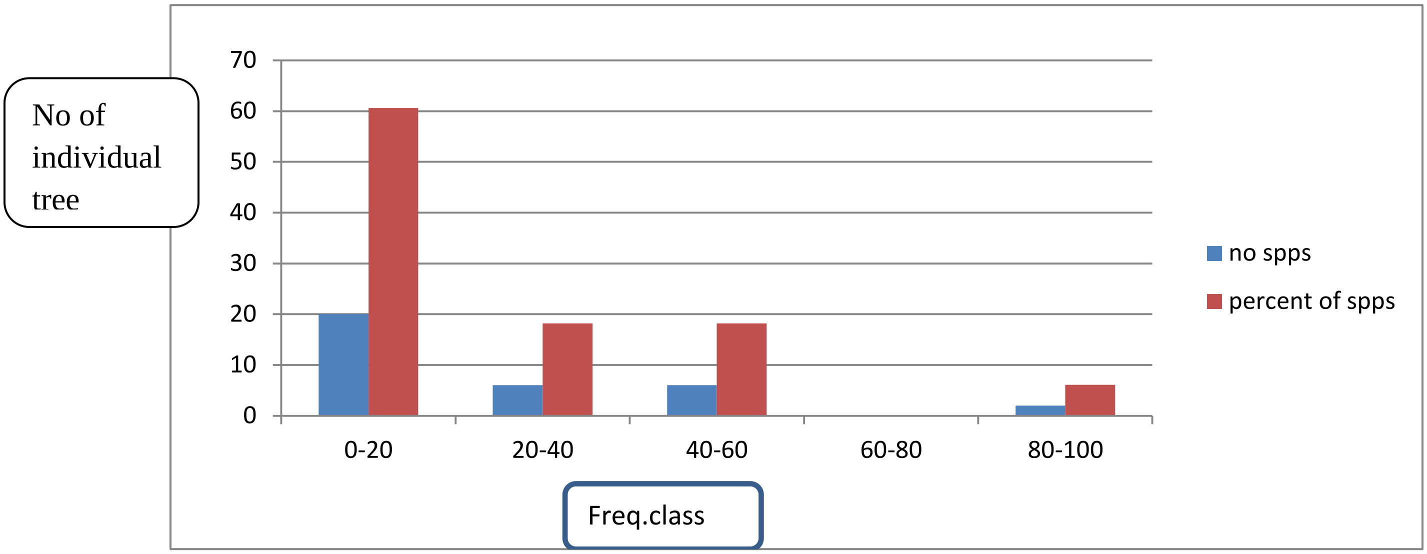


Figure 8. Frequency distribution of woody plant species in PFM Forest

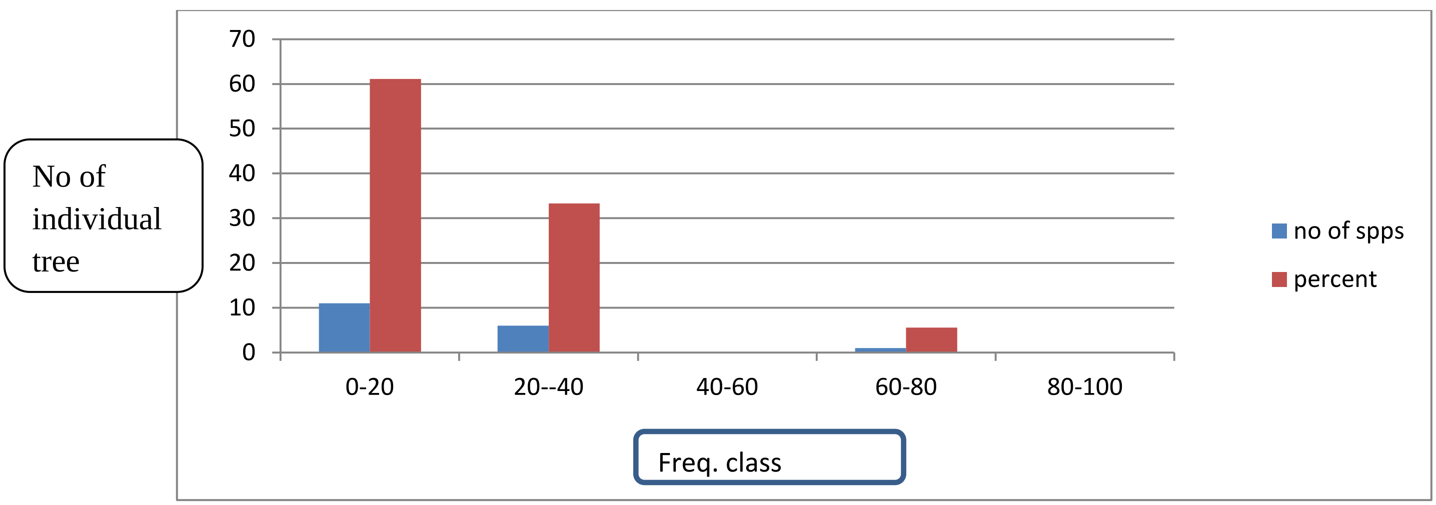


Figure 9. Frequency distribution of woody plant species outside PFM Forest.

4.2.6. Important Value Index (IVI)

Importance value index combines data for three parameters (Relative frequency, Relative density and Relative abundance). That is why ecologists consider it is the most realistic aspect in vegetation study (Curtis and McIntosh, 1951).

It is useful to compare the ecological significance of species (Lamprecht, 1989).The species with greatest importance value are the most dominant of particular vegetation (Simon Shibru and Girma Balcha, 2004).The relative frequency and relative density of PFM and outside PFM illustrated in (Appendix 2).

The IVI of PFM forest was analyzed and the importance value index of the forest is given in table7. As shown in the table *Pouteria adolfi-friederici* was found to have the highest IVI and most important, followed by *Olea capensis*, *croton macrostachus* and *Vepris dainellii* respectively.

However in forest which was outside PFM managed as shown in (table 8) *Croton macrostachus* was found to have the highest IVI and most important, followed by *Ficus vasta*, *Albizia gumifera* and *Syzygium guineense* respectively

Table 6. The Important Value Index of woody plant species in PFM Forest

No	Species	RBA	RF	RD	IVI
1	*Flacourtia indica*	0.0	0.4	0.4	0.8
2	*Millettia ferruginea*	0.6	1.8	1.8	4.2
3	*Syzygiumguineense*	2.1	3.0	3.0	8.1
4	*Olea welwitschii*	7.4	3.0	3.0	13.4
5	*Brucea antidystrica*	0.7	2.0	2.0	4.7
6	*Podocarpus falcatus*	7.2	1.4	1.4	10.0
7	*Phyllanthus ovalifolius*	0.0	0.2	0.2	0.4
8	*Rothmaniaur celliformis*	0.0	0.4	0.4	0.8
9	*Olea capensis*	1.0	16.4	16.4	33.7
10	*Veprisdainellii*	1.4	20.0	20.0	41.3
11	*Albizia gumifera*	0.1	1.0	1.0	2.1
12	*Ficus sycomorus*	2.3	1.8	1.8	5.9
13	*Hagenia abyssinica*	0.0	0.2	0.2	0.4
14	*Vernonia amegdanalis*	0.1	1.0	1.0	2.1
15	*Maytenus senegalensis*	0.0	0.2	0.2	0.4
16	*Maytenus arbutiona*	0.0	0.4	0.4	0.8
17	*Polyscias fulva*	5.9	2.4	2.4	10.7
18	*Bersema abyssinica*	0.0	1.0	1.0	2.0
19	*Diosporyus abysssinica*	11.4	6.2	6.2	23.8
20	*croton macrostachus*	13.8	7.6	7.6	29.0
21	*Psychotria orophila*	0.1	1.8	1.8	3.6
22	*Acacia lahai*	0.0	0.8	0.8	1.6
23	*Pouteria adolfi-friederici*	42.6	5.8	5.8	54.2
24	*Celtis africana*	0.5	1.8	1.8	4.1
25	*Oxyanthusspeciosus*	0.0	0.2	0.2	0.4
26	*Allophylus abyssinicus*	0.0	0.4	0.4	0.8
27	*Ficus vasta*	0.1	0.4	0.4	0.9
28	*Galineria saxifraga*	0.2	5.2	5.2	10.5
29	*Pittosporum viridiflorum*	0.2	0.4	0.4	1.0
30	*Ehretia cymosa*	0.6	10.0	10.0	20.6
31	*Clausenia anisata*	0.0	0.2	0.2	0.4
32	*Cordia africana*	1.1	0.6	0.6	2.3
33	*Dracaena steudneri*	0.1	2.2	2.2	4.5
		100	100	100	**300**

Table 7. The Important Value Index of woody plant species in outside PFM Forest

No	Species	RD	RF	RB	IVI
1	*Maesalanceolata*	3.5	3.5	1.4	8.4
2	*Flacourtia indica*	1.7	1.7	0.6	4.1
3	*Millettia ferruginea*	1.7	1.7	0.7	4.2
4	*Syzygiumguineense*	8.2	8.2	9.0	25.3
5	*Croton macrostachus*	18.1	18.1	9.7	45.9
6	*Olea welwitschii*	5.5	5.5	2.2	13.2
7	*Sapi mellipticum*	5.0	5.0	3.1	13.0
8	*Olea capensis*	5.2	5.2	0.8	11.3
9	*Albizia gumifera*	9.0	9.0	12.9	30.9
10	*Ficus sycomorus*	4.7	4.7	8.8	18.2
11	*Vernonia amegdanalis*	2.3	2.3	0.3	4.9
12	*Celtis africana*	7.3	7.3	2.6	17.2
13	*Ficus vasta*	6.7	6.7	31.5	44.9
14	*Bridelia micrantha*	1.2	1.2	0.4	2.7
15	*Acacia lahai*	7.6	7.6	9.4	24.6
16	*Ehretia cymosa*	3.2	3.2	1.0	7.4
17	*Cordial africana*	8.5	8.5	5.5	22.4
18	*Dracaena steudneri*	0.6	0.6	0.1	1.3
	Total	100	100	100	300

The high IVI value of the species is mainly due to their high dominance and density which may be due to their low demand by the local people for timber and also for their protection from illegal poachers example from the PFM forest *Pouteria adolfi-friederici, Olea capensis, croton macrostachus* and *Vepris dainellii* but from outside PFM forest *Croton macrostachus, Ficus vasta*, *Albizia gumifera* and *Syzygium guineense***.**

Woody Plant Species Diversity and Equitability Analysis

Woody plant species diversity and equitability in the study forest was analyzed by Shannon-Weiner diversity index and equitability (evenness) index. It is the most applicable index of diversity (Greg-Smith, 1983). It accounts both abundance and evenness of the species present. The Shannon-Weiner diversity index varies between 1.5 and 3.5 and rarely exceeds 4.5 (Kent and Cocker, 1992).

The woody plant species and evenness of PFM forest was analyzed. According to the data analysis in table 9, the overall Shannon-Weiner diversity index of the study forest of PFMwas3.18. The study forest has high diversity.

The species evenness value ranges between 0 and 1. When it is 0, the area is dominated by single species and when it is 1, the species are evenly distributed in the area. The data analysis showed that the average evenness value of the study forest of PFM was0.95. This indicates that the species in the study forest are more or less evenly distributed.

However the outside PFM Forest has 2.82 and 0.93 average Shannon Weiner diversity index and average evenness value respectively and compared with the above forest, it has low diversity and low evenness value.

Table 8. Diversity and Evenness of PFM and NPFM forest

	Richness	Diversity	Evenness
PFM	33	3.18	0.95
NPFM	18	2.82	0.93

5. CONCLUSION AND RECOMMENDATION

5.1 Conclusion

Participatory Forest Management has been adopted as an alternative approach since 1970s with the objectives of reducing forest degradation on one hand and improving the forest condition on the other hand.

The woody plant species composition, structure and diversity of PFM Forest were studied. The study showed that a total of 33 species of woody plants were recorded from the PFM forest and 18 species from the outside PFM forest and the total density of PFM forest 626.25 /hek as compared to the outside PFM forest 428.75/ hek PFM forest is in a good condition

The total basal area of woody plant species of PFM forest is 64.4m2 per hectare. *Pouteria adolfi-friederici* has the highest basal area followed by *Croton macrostachus*, *Diosporyus abysssinica* and *Oleawelwitschii* which was the highest basal area when compared to the other woody plant species in the study forest; therefore these are the most important tree species in the forest.

However in outside PFM the total basal area of the forest was 15.9 m2 per hectare. *Ficus vasta* has the highest basal area followed by *Albizia gumifera*, *Croton macrostachus, Syzygium guineense* and *Ficus sycomorus.*

From frequency analysis, *Vepris dainellii* was the most frequent species followed by *Olea Capensis* and *Pouteria adolfi-friederici* on the other hand the least frequent species are *Clausenia anisata* and *Maytenus senegalensis* and from the outside PFM *Croton macrostachus* was the most frequent species followed by *Albizia gumifera* and *Cordia africana.* There is high percentage of number of species in lower frequency classes and low percentage of number of species in higher frequency class. And also more diversity is observed from PFM forest.

Based on the results of this study, it can be said that PFM is good both for the forest and for improving woody species. With regard to the forest it was possible to observe in PFM blocks, compared to forests outside PFM because both forests have the same scenario before the PFM forest demarcated for management.

5.2. Recommendation

Forest provide many advantages such as forest products, home for plants and animals, protect soil erosion, conserve water resources and control ecological climate. But the forest managed through PFM cleared for coffee plantation, fuel wood and timber production. So it needs serious attention for conservation and implements effective management for sustainable use and continues the forest for future generation. Therefore, the following recommendations are forwarded to meet the above objectives:

- It is important to include without PFM forests to be managed under PFM program
- Develop the sense of ownership of the local community through training and continuous monitoring of forest especially for the area of outside PFM area.
- Encourage local community to use alternative energy source for fuel consumption for both areas of forest.
- Continuous forest inventory should be conducted.
- Planning and management of the forest should be assisted by research findings, such as detailed ecological studies in relation to various environmental factors to promote the sustainable use of the forest and its products
- Comprehensive studies should be initiated to document the plant resource utilization pattern.
- Most of the time many studies were not conducted in the area. So detail and further information can possible to produce if research conducted.

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APPENDIX 1

Shannon Diversity Index of PFM

Plot	Richness	Diversity	Evenness
1	11	2.3979	0.909091
2	19	2.94444	0.947368
3	16	2.77259	0.9375
4	16	2.77259	0.9375
5	29	3.3673	0.965517
6	29	3.3673	0.965517
7	23	3.13549	0.956522
8	21	3.04452	0.952381
9	29	3.3673	0.965517
10	28	3.3322	0.964286
11	34	3.52636	0.970588
12	28	3.3322	0.964286
13	33	3.49651	0.969697
14	26	3.2581	0.961538
15	17	2.83321	0.941176
16	29	3.3673	0.965517
17	20	2.99573	0.95
18	33	3.49651	0.969697
19	31	3.43399	0.967742
20	29	3.3673	0.965517

APPENDIX 2

Diversity of Outside PFM

Plot	Richness	Diversity	Evenness
1	12	2.484907	0.916667
2	15	2.70805	0.933333
3	16	2.772588	0.9375
4	15	2.70805	0.933333
5	17	2.833213	0.906988
6	15	2.70805	0.933333
7	17	2.833213	0.906988
8	18	2.890372	0.944444
9	19	2.94444	0.947368
10	26	3.2581	0.961538
11	19	2.94444	0.947368
12	15	2.70805	0.933333
13	16	2.772588	0.9375
14	15	2.70805	0.933333
15	17	2.833213	0.906988
16	18	2.890372	0.944444
17	19	2.94444	0.947368
18	16	2.772588	0.9375
19	26	3.2581	0.961538
20	12	2.484907	0.916667

APPENDIX 3

Relative Frequency and Relative Density of PFM

Scientific Name	Frequency	RF	Density	RD
Flacourtia indica	2	0.399201597	2.5	0.399201597
Millettia ferruginea	9	1.796407186	11.25	1.796407186
Syzygium guineense	15	2.994011976	18.75	2.994011976
Olea welwitschii	15	2.994011976	18.75	2.994011976
Brucea antidystrica	10	1.996007984	12.5	1.996007984
Podocarpus falcatus	7	1.397205589	8.75	1.397205589
Phyllanthus ovalifolius	1	0.199600798	1.25	0.199600798
Rothmania urcelliformis	2	0.399201597	2.5	0.399201597
Olea capensis	82	16.36726547	102.5	16.36726547
Vepris dainellii	100	19.96007984	125	19.96007984
Albizia gumifera	5	0.998003992	6.25	0.998003992
Ficus sycomorus	9	1.796407186	11.25	1.796407186
Hagenia abyssinica	1	0.199600798	1.25	0.199600798
Vernonia amegdanalis	5	0.998003992	6.25	0.998003992
Maytenus senegalensis	1	0.199600798	1.25	0.199600798
Maytenus arbutiona	2	0.399201597	2.5	0.399201597
Polyscias fulva	12	2.395209581	15	2.395209581
Bersema abyssinica	5	0.998003992	6.25	0.998003992
Diosporyus abysssinica	31	6.18762475	38.75	6.18762475
croton macrostachus	38	7.584830339	47.5	7.584830339
Psychotria orophila	9	1.796407186	11.25	1.796407186
Acacia lahai	4	0.798403194	5	0.798403194
Pouteriaadolfi-friederici	29	5.788423154	36.25	5.788423154
Celtis africana	9	1.796407186	11.25	1.796407186
Oxyanthus speciosus	1	0.199600798	1.25	0.199600798
Allophylus abyssinicus	2	0.399201597	2.5	0.399201597
Ficus vasta	2	0.399201597	2.5	0.399201597
Galineria saxifraga	26	5.189620758	32.5	5.189620758
Pittosporum viridiflorum	2	0.399201597	2.5	0.399201597
Ehretia cymosa	50	9.98003992	62.5	9.98003992
Clausenia anisata	1	0.199600798	1.25	0.199600798
Cordia africana	3	0.598802395	3.75	0.598802395
Dracaena steudneri	11	2.195608782	13.75	2.195608782
Total	501	100	626.25	100

Relative Frequency and Relative Density of outside PFM

Scientific Name	Freq.	RF	Density	RD
Maesalanceolata	12	3.498542274	15	3.498542274
Flacourtia indica	6	1.749271137	7.5	1.749271137
Millettia ferruginea	6	1.749271137	7.5	1.749271137
Syzygium guineense	28	8.163265306	35	8.163265306
Croton macrostachus	62	18.07580175	77.5	18.07580175
Olea welwitschii	19	5.539358601	23.75	5.539358601
Sapim ellipticum	17	4.956268222	21.25	4.956268222
Olea capensis	18	5.247813411	22.5	5.247813411
Albizia gumifera	31	9.037900875	38.75	9.037900875
Ficus sycomorus	16	4.664723032	20	4.664723032
Vernonia amegdanalis	8	2.332361516	10	2.332361516
Celtis africana	25	7.288629738	31.25	7.288629738
Ficus vasta	23	6.705539359	28.75	6.705539359
Bridelia micrantha	4	1.166180758	5	1.166180758
Acacia lahai	26	7.580174927	32.5	7.580174927
Ehretia cymosa	11	3.206997085	13.75	3.206997085
Cordial africana	29	8.454810496	36.25	8.454810496
Dracaena steudneri	2	0.583090379	2.5	0.583090379
Total	343	100	428.75	100