**Department of Natural Resources Management**

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# Tree species Diversity and Aboveground carbon stocks of Homegarden Agroforestry in Buchach Kebele, Cheha District, Southern Ethiopia.

**A Senior Research Project**

**In Partial Fulfillment of the Requirements for the Bachelor of Science degree in Natural Resource Management (NaRM 3163)**

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## Abbreviations

| | |
|---|---|
| AFs | Agroforestry system |
| AFPs | Agroforestry practice |
| AGB | Above ground biomass |
| C | Carbon |
| $CO_2$ | Carbon dioxide |
| DBH | Diameter at breast height |
| Ha | Hectare |
| IPCC | Intergovernmental panel on climate change |
| KM | Kilometer |
| M.a.s.l | Meter above sea level |
| MPTs | Multi-purpose tree species |
| OM | Organic matter |
| Mg | Mega gram |
| SNNPR | Southern nation nationality and people’s region. |

# Abstract

*Homegarden are traditional agroforestry practices characterized by the complexity of their structure with multiple functions and can be defined as 'land use system involving deliberate management of multipurpose trees and shrubs in intimate association with annual and perennial agricultural crops and invariably livestock within the compounds of individual houses, the whole tree-crop animal unit being intensively managed by family labor. The study was undertaken in tree species diversity and aboveground carbon stocks of Homegarden Agroforestry in Buchach kebele of Cheha district. In order to achieve the objective of the study, both primary and secondary data were generated by employing a descriptive statistic. Simple random sampling was applied to select the sample households to get representative informants whereas purposive sampling was used to select inventory sample of study area. The process of analysis of the study was carried out using descriptive statistic, quantitative indices of species diversity, richness and evenness were measured using diversity index formula by Shannon wiener diversity index and Simpson's diversity index. Allometric equation were used to analysis the carbon sequestration potential of Homegarden agroforestry. the findings of this study indicated that Homegarden agroforestry in the study area have high potential in carbon stock (ranging from 1.0 to 36.87 Mg C ha $^{-1}$) with a mean value of 6.838 Mg C ha$^{-1}$. and main area of ex-situ conservation of tree species like cordia africana. The results show a vast heterogeneity in terms of carbon stock and tree diversity within the less studied homegardens of study area; results that contribute to more knowledge of their expansion potential as well as climate mitigation and adaptation potentials*



**Key words**: - *Agroforestry Practice, Buchach Kebele, AGB, carbon stock, woody species diversity*

# 1.Introduction

## 1.1. Background and Justification

'Biological diversity' or biodiversity is that part of nature which includes the differences in genes among the individuals of a species, the variety and richness of all the plant and animal species at different scales in space, locally, in a region, in the country and the world, and various types of ecosystems within a defined area (Anonymous, 2005). Diversity deals with the degree of nature's variety in the biosphere. This diversity is seen both in natural ecosystems and in agricultural ecosystems. Natural undisturbed tropical forests have much greater species richness than plantations, and the organization of species in an area into distinctive plant and animal communities constitutes ecosystem diversity (Mekuria.G, 2010).

Land use changes of the world have contributed substantially to the rising concentration of $CO_2$ in the earth's atmosphere (IPCC 2007; Nair et al. 2010). Increasing the size of the global terrestrial sink is one strategy for mitigation of $CO_2$ build-up in the atmosphere. Under the Kyoto Protocol's Article 3.3, afforestation and reforestation with agroforestry as a part of it has been recognized as an option for mitigating greenhouse gases (Nair et al., 2009). Agroforestry is a collective name for land use systems where woody perennials (trees, shrubs, palms, bamboos etc.) are deliberately used on the same land management units as agricultural crops and/or animals, in some form of spatial arrangement or temporal sequence (Bishaw and Abdelkadir 2003; Nair et al., 2009; Schoeneberger, 2008). According to (Nair, 2007), Agroforestry is one part of biological diversity which is the practice of growing trees and crops in interacting combinations is recognized worldwide as an integrated approach to sustainable land-use. Agroforestry systems are believed to have a higher potential to sequester carbon because of their perceived ability for greater capture and utilization of growth resources (light, nutrients, and water) than single-species crop or pasture systems. (Nair, *et al*.,2009a). Agroforestry in diverse ecological conditions showed that tree-based agricultural systems, compared to treeless systems, stored more Carbon in deeper soil layers near the tree than away from the tree; higher soil organic carbon content is associated with higher species richness and tree density. (Nair, P, *et al*., 2009b).

The extent of Carbon sequestered in Agroforestry system depends to a great extent on environmental conditions and system management. Trading of the sequestered Carbon is a viable opportunity for economic benefit to agroforestry practitioners, who are mostly resource-poor farmers in developing countries. However, more rigorous research results are required for Agroforestry systems to be used in global agendas of Carbon sequestration (Nelson, K, 2003).

### 1.2 Statement of Problem

Indigenous plant diversity of the country was reduced from time to time and Even, the existing diversity are not being regularly managed, monitored and evaluated to see trends and most of them lack management including component interaction, species fitness to specific ecology, climate and land. Homegarden agroforestry practice as land use considered as germplasm and exi-situ conservation for threatened species of the country. Climate change caused by global warming is a phenomenon partly resulting from abundance of carbon dioxide in the atmosphere. It is the most pressing environmental problem of today. It persists and it cannot be stopped. Rather, it can be mitigating. Emission of carbon from different sources is great challenge and environmental problem of today. Although, the importance and recognition of homegardens for carbon storage has been highlighted earlier (e.g., Kumar 2006; Nair 2012) there is still a lack of quantitative data on homegardens and their carbon content, especially in Cheha Woreda environments in Gurage zone. Homegarden agroforestry practice as land use reduced the atmospheric concentration of carbon dioxide. In addition, there are critical problem in Ethiopia regarding to the adoption Homegarden agroforestry practice and its role for sustainable development, climate change impact control, food security and ecosystem function such as SWC conservation, soil fertility management, micro climate amelioration.

### 1.3 Objectives of the Study

#### 1.3.1 General objective

- To determine the Homegarden Agroforestry tree species diversity and carbon stocks of tree biomass through estimation of standing aboveground biomass.

#### 1.3.2 Specific objectives

- ✓ To determine tree species composition and diversity of Homegarden agroforestry.
- ✓ To assess aboveground biomass of carbon stock in Agroforestry practice tree species.
- ✓ To identify ranking preference of Homegarden Agroforestry species.

### 1.4 Research Questions

- what amount of above ground carbon stock distributed Homegarden AF species?
- What amounts of species richness and composition occurred in the study area?
- Which species is the most preferred in the study area?

### 1.5 Scope of the study

The study is intended to assess and explore tree species diversity and carbon stocks of Homegarden Agroforestry in Buchach Kebele, Cheha District, Gurage Zone, Southern nations, nationality and people region of Ethiopia.

### 1.6 Significance of the study

The study was conducted on the tree species diversity and carbon stocks of Homegarden Agroforestry in Buchach Kebele. Based on this, the study helps to know diversity and composition of different Homegarden species. And for evaluating the role of Homegarden agroforestry in carbon sequestration especially buchach Kebele. And also, it is important to encourage the communities to practices Homegarden agroforestry for carbon sink (sequestration) economic and food security aspect, soil water conservation and ecological function.

# 2. Literature Review

## 2.1 Home garden agroforestry

Homegarden are traditional agroforestry practices characterized by the complexity of their structure with multiple functions and can be defined as 'land use system involving deliberate management of multipurpose trees and shrubs in intimate association with annual and perennial agricultural crops and invariably livestock within the compounds of individual houses, the whole tree-crop animal unit being intensively managed by family labor (Tesfaye Abebe, 2005).

Homegarden agroforestry practices play an important role in the conservation of biodiversity and in sustainable development. They are considered as germplasm banks for many crops and other economic plants. They are also a key site for domestication of wild plants. Traditional home gardens often show complicated structures, diverse floristic compositions, multiple functions, low input (including labor and money), and ecological and socioeconomic sustainability. The characteristics and functions of traditional home gardens are closely related to many factors, such as their geographic location and the cultural backgrounds and socioeconomic conditions of their owners (Megabit. B, 2018).

Homegarden agroforestry contain characteristics including efficient nutrient cycling, high biodiversity, low use of external inputs and soil conservation potential. Homegarden are the closest mimics of natural forests in their structure and usually have 3–4 vertical canopy layers (Zewudie S, 2014). Besides the vertical structure, Homegarden also have distinct horizontal structure which together help in the efficient utilization of water, light and space, and support diverse wildlife species besides meeting various social and basic needs of families. (Lisanework N, 2008).

Homegarden are important in situ conservation sites and in inventorization of such areas can help in the identification and conservation of biodiversity while assessing the sustainability of the system. In order to understand the structure and function of Homegarden, it is necessary to analyses both socio-economic and biophysical aspects of these systems (Abebe. T, 2009).

Homegarden agroforestry is believed to be more diverse due to the combination of crops, trees and livestock and hold a large potential for carbon sequestration, especially for climate change mitigation and adaptation under changing environment. This is because of the multifunctional ecosystem services of Homegarden for storing carbon. (Tilaye.K, 2013).

### 2.2 Species Diversity, Richness and Evenness

The description of plant community involves analysis of species diversity. Diversity and equability of species in a given plant community and helps to explain the underlying reasons for such difference, the two main factors taken in to account when measuring diversity are richness and evenness. 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 (Shannon.C, 2003).

Species richness refers to the total number of species in a community where as evenness is the relative abundance of species within the same or community making up richness of an area. A number of indices of diversity have been devised, each of which seeks to express diversity of sample by a single number. Among many species' diversity indices, probably the most widely used to calculate the diversity and evenness includes Shannon- wiener diversity index, which naturally varies between 1.5 and 3.5 and rarely exceeds 4.5. It is widely used index that combines richness and evenness (Carlo H, 2001).

Species diversity could be viewed from different approaches in terms of alpha, beta and gamma diversity. Alpha diversity refers to diversity of species with in a particular habitat. Beta diversity is a measure of the rate and the extent of change in species a long gradient from one habitat to another. It is between habitat diversity that measures turnover rates. Gamma diversity on the other hand is the diversity of species in comparable habitats a long a geographical gradient and is independent of the two. (Baynes N, 2006).

#### 2.2.1 Abundance, density and Frequency

Abundance is the number of individual's plants per unit area. To measure plant abundance, it requires the counting of individual's plants by a species in a given area which can be used to show spatial distribution and ranges over time (Michael G, 2010). Density refers to the total number of tree species $ha^{-1}$. Frequency is the proportion of plots in which species occurs. It is a measure of occurrence of a given species in a given area which indicates how the species are dispersed and is an ecological meaningful. This means it gives an approximate indication of the homogeneity of the stand under consideration (Volkov.I, 2005).

### 2.3 Aboveground (vegetation) carbon sequestration.

Aboveground Carbon storage is the incorporation of Carbon into plant matter either in the harvested product, or in the parts remaining on site in a living form (Hamburg S, 2007). The amount of biomass, and subsequently Carbon, that is stored depend to a great deal apart from the nature of plant itself on the properties of the soil on which it grows, with higher concentrations of OM, nutrients, and good soil structure, leading to greater biomass production (Graham , 2002). The AGB that is not removed from the site is eventually reincorporated into the soil as plant residues and organic matter. Carbon sequestration depending on a number of factors, including site characteristics, land-use types, species involved, stand age, and management practices (Alegre.O, 2017).

Based on assessments of global terrestrial carbon sinks, two primary beneficial attributes of agroforestry have been identified. The first is direct near-term carbon storage in trees and soils through accumulation of carbon stocks in the form of live tree biomass, wood products, soil organic matter and protection of existing products. The second involves potential to offset greenhouse gas emissions through energy substitution (e.g. Fuel wood from woodlots) and fertilizer substitution (through biological nitrogen fixation and biomass production) (Nair et al. 2009; Albrecht and Kandji 2003) as it responds to climatic change through sequestration of carbon in above-ground plant biomass and the soil. The analysis of Carbon stocks from various parts of the world shows that 1.1–2.2 x $10^{15}$g C could be removed from the atmosphere over the next 50 years if Agroforestry systems are implemented on a global scale (Albrecht and Kandji, 2003). Similarly, studies have confirmed that the agroforestry practices have a potential to sequester greater amount of Carbon replacing carbon emissions caused by deforestation from natural forests (Gupta et al., 2009 and Takimoto et al., 2009). Average carbon storage by agroforestry practices, of which fertilizer trees is an integral part has been estimated as 9, 21, 50, and 63 t Carbon $ha^{-1}$ in semiarid, sub humid, humid, and temperate regions respectively (Montagnini and Nair, 2004; Verchot et al., 2007).

# 3. Material and Methods

## 3.1. Description of the study area

### 3.1.1 Location

The study would be conducted in Buchach Kebele, Cheha woreda, Gurage Zone, SNNP region of Ethiopia. This area is located 171 km Southwest from Addis Ababa and 17 km from Wolkite town. The study in Buchach kebele was focus on tree species diversity and carbon stocks of Homegarden agroforestry. Topographically located N $8^0$ 14’ 6”- $8^0$ 14’ 8” and E $37^0$ 48’ 00”- $37^0$ 50’ 00”. An elevation of above sea level is about 2178 m.a.s.l (Cheha woreda agriculture office 2019).

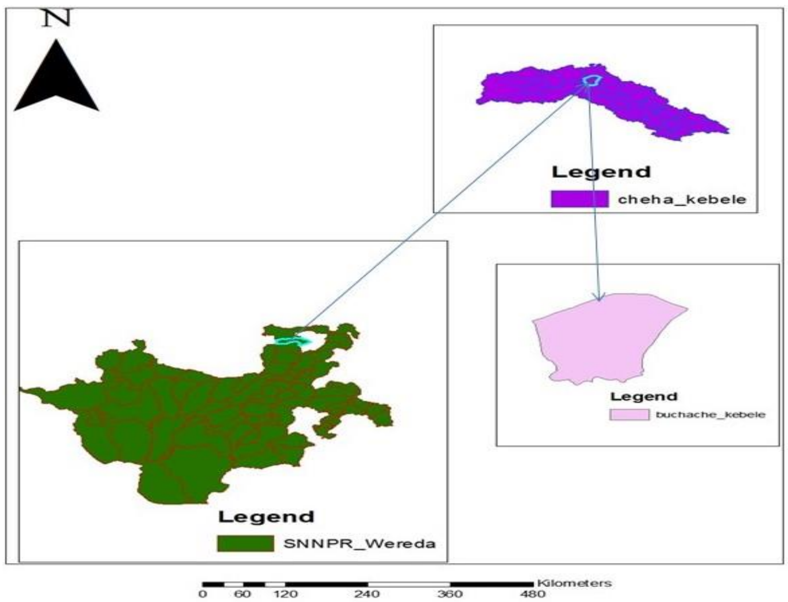


Figure 1:- Map of the study area

### 3.1.2 Population

According to Cheha woreda annual report (unpublished data 2018) show that Buchach kebele has a total population of 3547 of which 1941 and 1606 are males and females respectively. The kebele has 489, (408 male and 88 females headed household) (Cheha woreda Agricultural and Natural Resource Development, 2018).

### 3.1.3 Economic base

Agriculture was the main economic base for the community, which is an agroforestry system-based practice. The components of this agroforestry system are including livestock, fruit trees, vegetables and other cereal crops. The most dominant components are inset, chat and fruit trees.

#### 3.1.4 Land use land cover

The land uses of the study area were both crop cultivation and Livestock rearing. The most important crop in the study area cereal crops includes Inset, chat, tiff, maize and vegetation are mainly grown in the study area. Generally, the socio-economy of the society in the study area has been dominated by agricultural production system. The land was covered by different activity such as grazing land, forest land, crop land and settlement.

## 3.2. Data collection

### 3.2.1 Source of data

The data was collected through both primary and secondary data. The primary data was obtained from interviews, questionnaires, field observation, practical measurement and focus group discussion. I.e. prepare the question for the local people and translate English to Amharic language, prepare open and close ended question distributed to the people and then discussed with the Kebele key stake holders (farmers) and development agent to collect preference of Homegarden Agroforestry species. Whereas secondary data was obtained from different documented materials, published data, unpublished data, and reports, from district Profile.

## 3.3. Methods

### 3.3.1 Site selection

The kebelle administration namely buchach would be selected purposefully based on the extensive presence of Homegarden agroforestry during preliminary-survey and with the district agricultural office and development agent.

### 3.3.2 Homegarden inventory

All perennial trees and woody plants would be identified and recorded by local name and botanical name. For individual tree species height measured using clinometer and DBH measured by using tape.

### 3.3.3. Sampling design and sampling size

Buchach Keble has been 489 household, from those households was collected by using simple random sampling method. The sampling size would be estimated 5%. Among the household 62 sample, farmers were represented by using Cochran formula (1977), to obtain sample size of respondents, which is given by:

$$n = \frac{(z)^2 (p)(q)(N)}{(d)^2 (N-1) + (z)^2 (q)(p)}$$

Where: n – sample size of the respondents

p – Probability of the respondent will be included in the sample (0.05)

q= 1-p = 1-0.05 = 0.95, N – Total number of households = 489

z – Standardized normal variable and value that corresponding to 95% Confidence interval equal to 1.96

d- Allowable error (0.05)

The sample size (n) is 62 based on the above formula

But it was difficult due to limitation of time and other constraints we couldn't collect data from all sampled (respondents). So, we could randomly select 32 respondents. The sample from each village of kebele was selected by simple random sampling method. The inventory data was collected through field observation, counting and measurement by laying quadrants. For this purpose, we used a total of 20 homegarden plots by classifying small, medium and large size (0.25, 0.5 and ≥ 0.75 hectare). each of them by 5×5m quadrant from purposively selected Homegardens.

### 3.4. Materials

Clinometers, meter and string are the materials used to collect vegetation data from sample Homegarden agroforestry sites during the research work.

### 3.5. Data Analysis

The data collected through questionnaires, field observation and interview about preference of Homegarden Agroforestry species would be analyzed by using descriptive statics like percentage and frequency of some qualitative data and quantitative data, then the result was shown by using tables and figures. The quantitative indices of species diversity, richness and evenness were measured using diversity index formula by Shannon and wiener index. The minimum value of

H’ is one (1), which is the value for a community with a single species and increases as species richness and evenness increases. Species richness refers to the number of species per plot/farm while evenness refers to their distribution within and between the different populations (Magurran, 2004). The fruit tree species richness of each farm was determined. The Shannon diversity index (H’) was calculated by using the following formula: The Shannon diversity index (*H*) is an index that is commonly used to characterize species diversity in a community and accounts for both abundance and evenness of the species present. The proportion of species *i* relative to the total number of species ($p_i$) is calculated, and then multiplied by the natural logarithm of this proportion ($\ln p_i$). The resulting product is summed across species, and multiplied by -1: Using Shannon diversity index, H' and evenness (E) was determined using the following formula (Equation 1).

$$H' = -\sum_{i=1}^{s} p_i \ln p_i \ldots\ldots 1$$

Where H’ = Shannon-Wiener Diversity Index, S = number of species

Pi = the proportion of individuals or abundance of the $i^{th}$ species expressed as Proportion of the total abundance,

ln = natural logarithm of pi

Evenness (Shannon equitability) index (E) was calculated to estimate the homogeneous distribution of fruit tree species on Homegarden (Equation 2).

$$E = \frac{H'}{H_{max}} = \frac{H'}{\ln_s} = \frac{\sum_{i=1}^{s} pi \ln pi}{\ln_s} \ldots\ldots 2$$

Where: E = Evenness; H’ = Shannon-Wiener Diversity Index;

Hmax = lnS; S = total number of species in the sample.

The value of EH is between 0 and 1 with 1 being complete evenness. Or the species are evenly distributed, and then H value would be high. So, the H value allows us to know not only the number of species but how the abundance of the species is distributed among all the species in the community

Simpson's diversity index is a measure of diversity which takes into account both species richness and evenness. This diversity index is less sensitive to richness and more sensitive to evenness (Maguran, 2004). The Simpson's diversity was calculated as follows: (Equation 3).

$$D = 1 - \sum_{n=1}^{s} pi^{2} \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots 3$$

Where, D = Simpson's diversity index and Pi = proportions of individuals of the ith specie

S= number of species.

**Density**: refers to the total number of tree species $ha^{-1}$, and calculated by summing up all tree across all sample households (abundance) and translated to hectare base for all the species encountered in the study sample households.

**Frequency**: (Absolute and relative frequency). Absolute frequency is the number of trees in the selected farm where the tree species were recorded, whereas relative frequency is the ratio of the absolute frequency of the species to the sum total of the frequency of all species.

| Type of above-ground biomass | Allometric equation | $R^2$ | Source |
|---|---|---|---|
| Individual trees | $Y = \exp(-2.187 + 0.916 \times \ln(D^2 \times H \times S))$ | 0.99 | Chave et al. 2005 |
| Bananas | $Y = 0.030\ D^{2.13}$ | 0.99 | Hairiah et al. 2010 |
| Palms | $Y = \exp(-2.134 + 2.530\ x\ \ln(D)\}$ | 0.97 | Brown 1997 |

$Y$ = above-ground biomass density (Mg $ha^{-1}$), $D$ = diameter in cm, $H$ = height in m, $S$ = species-specific wood density in g $cm^{-3}$.

Table 1Aboveground biomass carbon stock analysis

But for the present study due to materials and time constraints we have assessed only woody species, above ground biomass and carbon stock in the sampled area in the Buchach kebele.

# 4 Results and Discussion

## Demographic and social characteristics of respondents

According to respondents most of the house holds about (43.8%) is between 41-47 years old, about (21.9%) are between 34-40 years old. The rest (18.8%) and (15.5%) of the respondents are found with age of 48-54 and 55-61 respectively. As a result, almost all of the respondents have awareness about Homegarden agroforestry practice and most of them are practicing and participating in diversification of it because of their age. (Table:2).

According to respondents about 53.1% the respondents are male and the rest 46.9% are female. From this we can conclude more than half of the respondents are male headed households in the study area. As the respondents told females have well in practice of Homegarden agroforestry and diversification of tree species than men because of more adaptation of the environment and household.

According to respondents about 28.1% of the respondents are high family size (8-10), about 37.5% are medium family member (5-7) and the rest 34.4% are small family size (2-4).

According to respondents the economic base of more than 53.1% of respondents are mixed farming system, about 37.5% are crop cultivation and the rest 9.4% are livestock rearing.

As indicated in the table below 37.5% of the respondents have a land size of quarter, about 28.125%, of respondents have a lend size of half, about 25% and 9.375% of respondents have a land size of three-fourth and greater than one Ha respectively (Table: 2).

| Age | Frequency | Percent (%) | Homegarden plot size | frequency | Percent (%) |
|---|---|---|---|---|---|
| 34-40 | 7 | 21.9 | 0.25 | 12 | 37.5 |
| 41-47 | 14 | 43.8 | 0.5 | 9 | 28.125 |
| 48-54 | 6 | 18.8 | 0.75 | 8 | 25 |
| 55-61 | 5 | 15.5 | >1 | 3 | 9.375 |
| Total | 32 | 100 | Total | 32 | 100 |

Table 2- Demographic and social characteristics of respondents.

Source: Field Survey 2019

### 4.1 Woody Species diversity and composition of Homegarden Agroforestry system

The total woody species recorded in buchach kebelle Homegarden agroforests were 21 distributed in 7 families excluding the herbaceous plants, (see Figure 2). Out of the total 21 woody species found in the buchach kebelle, the dominantly observed species were Mangifera indica (17.3%), followed by Percea americana (10.6%), and Coffe arabica (10.04%) were more frequently retained than others. The total number of species recorded (21) was lower than that reported by (Zebene Asfaw *et al*., 2014) 44 woody species from 48 sample in Jabithenan district, north western Ethiopia and he reported most frequent was coffe arabica, Cordia africana, Sesbania sesban, Percea americana, Mangifera indica. This difference was because of species preference, house hold objective and ecology or climate of the area.

When species richness distributed in to Farmers land size (0.25, 0.5 and ≥ 0.75) hectare an average of 235, 159 and 210 species recorded respectively. This shows that highest numbers of woody species were recorded from farmers who have land size of 0.25 hectare while lowest numbers of species were recorded from 0.5-hectare land. The woody species richness for farmers who have 0.25 hectare of land was significantly ($P$ = 0.0202) higher than farmers who have 0.5 and ≥ 0.75 hectare of land size. As a result, farmers who have small area of land size planting high density of plant within specific area.

In addition to this, the pooled Shannon diversity, evenness index and Simpson index of the study site Homegarden agroforestry's was 2.968 with the evenness of 0.97 and Simpson index of 0.8348. Moreover, there was no significant difference in woody species abundance per plot ($P$ = 0.7586). This shows that the study sites have relatively good diversity and evenness. As a result, the tree species in buchach kebelle Homegarden agroforestry are evenly distributed in the study sites.

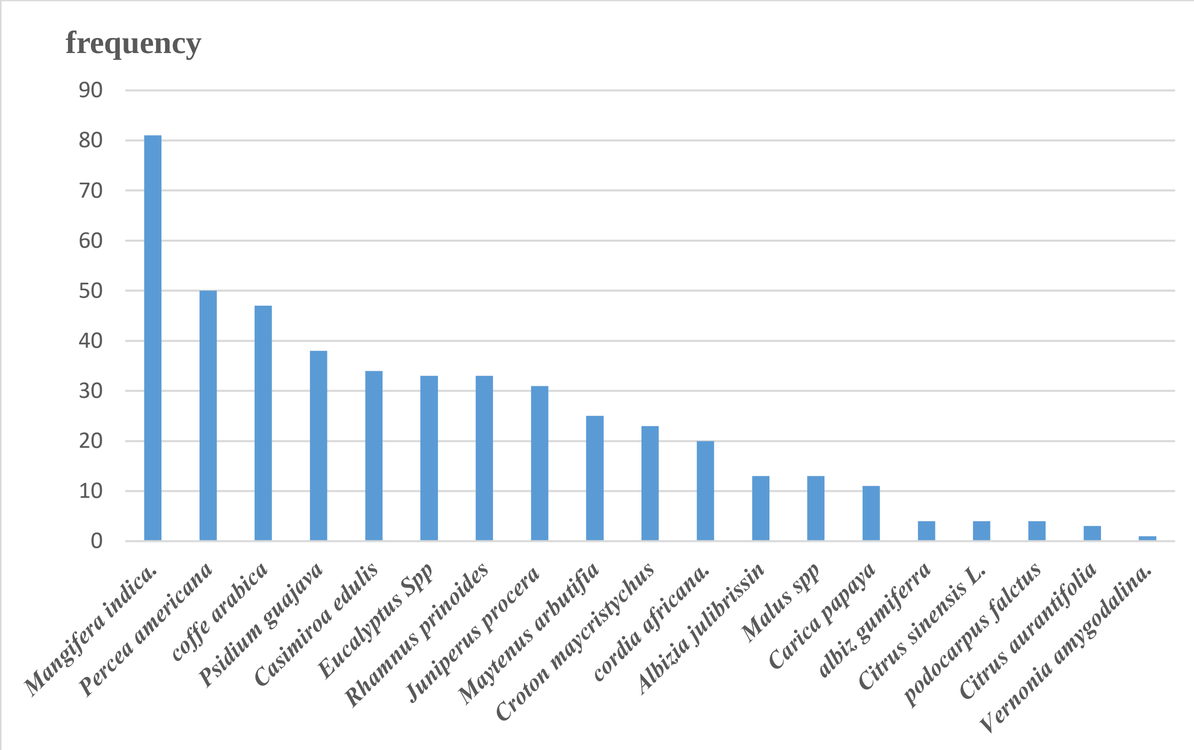


Figure 2 Overall frequent occurance of woody species in Buchach kebele HG AF

Source: Field Survey 2019

**4.2. Carbon stock Distribution and Aboveground Biomass of Homegarden agroforestry**

The DBH of trees from the Buchach Homegarden agroforests was classified into four DBH classes. According to our survey data, in the Buchach kebele the above-ground biomass (AGB) carbon stock for the 20 sampled homegardens ranged from 1.0 to 36.87 Mg C ha $^{-1}$ with a mean value of 6.838 Mg C ha$^{-1}$. Per unit area basis, mean AGB carbon stock was higher in small homegardens (0.25 ha, 7.1 Mg C ha$^{-1}$, n=8) and statistical different ($p< 0.05$) compared to medium (0.5 ha, 3.59 Mg C ha$^{-1}$, n=7) and large (0.75 ha, 2.98 Mg C ha$^{-1}$, n=5) homegardens. By comparing the AGB carbon stock with number of tree species indicate that there is positive trend (not statistically significant) in relationship for small homegardens, a less positive relationship for medium size homegardens and a small negative relationship for large homegardens.

In smaller homegarden size due to land shortage they plant different tree in their homegarden area, in other way larger homegarden holder's plants tree as like parkland or as woodlots area which is far away from homegarden. This is consistent with earlier findings (e.g. Kumar 2011, Pushpakumara *et al*., 2012) small homegarden tree density is some times higher than large size homegardens.

Accordingly, in the present study the three sampled homegarden size have the total AGB of 13.67 t $ha^{-1}$. Then the major parameter used in the model is mainly the DBH, larger diameter class stored a large stock of AGB whereas small amounts of AGB have been stocked by small diameter class.

Accordingly, the survey of data the AGB showed that the highest value (7.81t $ha^{-1}$) was recorded in the DBH range of 75-100 cm where small number of trees representing largest diameter followed by 50-75cm where large number of trees representing this diameter class with AGB of 4.37 t $ha^{-1}$. This is similar with the study of Declerck *et al.*, 2006; the canopy trees with wider diameter classes have a higher AGB as compared to the smaller diameter class. Studies in Cameroon showed that total biomass in cacao agroforests (304 t $ha^{-1}$) (Duguma *et al*., 2001) are much higher than the total biomass of present study (13.67 t $ha^{-1}$) as the present study only considered the standing AGB of woody species agroforests.

Based on the survey carbon stock was derived directly from the aboveground biomass of trees and the total results of three homegarden sampled sites have shown the carbon stock of 7.33 t C $ha^{-1}$. Similarly, the highest AGC stock (3.905 t C $ha^{-1}$) was recorded in the DBH range of 75-100 cm followed by 2.69 t C $ha^{-1}$ in the DBH of 50-75 cm. Therefore, it has been observed that there are strong associations between species richness and aboveground biomass. Accordingly, the AGB estimated for DBH classes showed the decreasing order from 0.25 >0.5 > 0.75 ha homegarden size.

### 4.2.1 Comparative Species' influence to C storage in Buchach HGAF s

According to field survey data, the tree species identified from 20 homegarden agroforests have a DBH range between 4.75 and 90.3 cm. The role of large trees in determining C stocks in AFS of the current study shows its dominant importance on the way to providing environmental services. Consequently, from all tree species encountered in the present-day study, Mangifera indica species contributed 69.23 % of the pooled AGC storage of the agroforestry system.

The six species *Mangifera indica*, *Cordia africana*, *Albizia gumiferra*, *Percea americana Podocarpus falctus* constitute the backbone of the Buchach AFS as they function as both shade trees in addition with socioeconomic and ecological provisions like carbon sequestration. This is in line with the study done by Dossa *et al*. (2008) in South western Togo describes total plant C stock is dominated by the Albizia trees, which contributed 82% of the total AGC. However, from the present study, *Albizia* trees contributed 7.14% of AGC stock only but *Cordia africana* contributed about 69.23% of the standing AGC stock.

| Homegarden size | Scientific name | Local name | DBH | H | Density | AGB kg/ Tree | TC $ha^{-1}$ |
|---|---|---|---|---|---|---|---|
| 0.25 | *Mangifera indica* | Mango | 37 | 13.5 | 31 | 1.09 | 0.545 |
| | *Percea americana* | Avocado | 35 | 12 | 16 | 0.32 | 0.16 |
| | *albiz gumiferra* | Sesa | 68.5 | 27 | 12 | 0.57 | 0.285 |
| | *Psidium guajava* | Zeytona | 18 | 7 | 17 | 0.43 | 0.215 |
| | *Juniperus procera* | Habesha tid | 32 | 17 | 21 | 0.19 | 0.095 |
| | *cordia africana* | Wanza | 78 | 23 | 43 | 1.02 | 0.51 |
| | *croton maycristychus* | Bisana | 74.75 | 25.5 | 27 | 0.58 | 0.29 |
| | *podocarpus falctus* | Zigba | 68.5 | 31 | 13 | 0.48 | 0.24 |
| | *Vernonia amygodalina* | Grawa | 43.75 | 17 | 8 | 0.23 | 0.115 |
| | *Maytenus arbutifia* | kobo | 14.5 | 7 | 8 | 0.09 | 0.045 |
| | *millatia ferrugina* | kewut | 44.75 | 22.5 | 6 | 0.49 | 0.245 |
| | *Eucalyptus globulus* | Bahirzaf | 63 | 36.75 | 14 | 1.54 | 0.77 |
| | **Total** | | | | | **7.1** | **3.55** |
| 0.5 | *Mangifera indica* | Mango | 36 | 14 | 32 | 0.29 | 0.145 |
| | *Percea americana* | Avocado | 27 | 17 | 17 | 0.27 | 0.135 |
| | *albiz gumiferra* | Sesa | 46 | 22 | 11 | 0.76 | 0.38 |
| | *Casimiroa edulis* | Kazmir | 11 | 11 | 5 | 0.19 | 0.095 |
| | *Psidium guajava* | Zeytona | 2 | 5 | 8 | 0.08 | 0.04 |
| | *Juniperus procera* | Habesha tid | 20 | 13 | 18 | 0.05 | 0.025 |
| | *cordia africana* | Wanza | 69 | 24 | 32 | 1.07 | 0.535 |
| | *croton maycristychus* | Bisana | 54 | 23 | 11 | 0.51 | 0.255 |
| | *podocarpus falctus* | Zigba | 52 | 37 | 9 | 0.09 | 0.045 |
| | *Vernonia amygodalina* | Grawa | 29 | 24 | 5 | 0.05 | 0.025 |
| | *Maytenus arbutifia* | Kobo | 9 | 6 | 3 | 0.025 | 0.0125 |
| | *millatia ferrugina* | Kewut | 32 | 20 | 5 | 0.19 | 0.095 |
| | *Eucalyptus globulus* | Bahirzaf | 78 | 43.5 | 11 | 0.021 | 0.0105 |
| | **Total** | | | | | **3.596** | **1.798** |
| 0.75 | *Mangifera indica* | Mango | 34 | 17 | 18 | 0.31 | 0.155 |
| | *Percea americana* | Avocado | 32 | 21 | 11 | 0.45 | 0.225 |
| | *albiz gumiferra* | Sesa | 61 | 18 | 19 | 0.29 | 0.145 |
| | *Casimiroa edulis* | Kazmir | 15 | 8 | 7 | 0.19 | 0.095 |
| | *Psidium guajava* | Zeytona | 26 | 6 | 7 | 0.08 | 0.04 |
| | *Juniperus procera* | Habesha tid | 27 | 15 | 21 | 0.05 | 0.025 |
| | *cordia africana* | Wanza | 71 | 22 | 42 | 0.91 | 0.455 |
| | *croton maycristychus* | Bisana | 73 | 27 | 39 | 0.45 | 0.225 |
| | *podocarpus falctus* | Zigba | 63 | 33 | 21 | 0.05 | 0.025 |
| | *Vernonia amygodalina* | Grawa | 18 | 17 | 5 | 0.07 | 0.035 |

| | | | | | | |
|---|---|---|---|---|---|---|
| *Maytenus arbutifia* | Kobo | 18 | 7 | 8 | 0.03 | 0.015 |
| *millatia ferrugina* | kewut | 38 | 20 | 13 | 0.08 | 0.04 |
| *Eucalyptus globulus* | Bahirzaf | 13 | 7 | 16 | 0.02 | 0.01 |
| **Total** | | | | | **2.98** | **1.49** |

Mean Height (m), DBH (cm), Tree density (No plot-1), AGB (t ha-1) and Carbon stock (t C $ha^{-1}$)

Table 3 :-Total carbon stock analysis of tree species in the study areas.

Source: Field Survey 2019

### 4.3. Dominant woody Species preferences in the study area

In the study area, there is a tradition of retaining woody species during conversion of forest land to agricultural land. About 92% of the respondents have retained different woody species in their homegardens while converting the original forest to settlement areas.

To evaluate farmers' species preferences, respondents were asked to rank the five most important species and then total relative score was calculated. Accordingly, *Enset, Percea americana, Coffea arabica, Mangifera Indica and Eucalyptus, Chata edulis* were the most preferred species for retaining and planting by respondent. As According to respondents, the reasons for retaining different woody species depend on the tangible uses and services that they render to the household. In the study area, the respondents' major reasons for retaining woody species were in the order of their importance as; fuel wood, shade, construction, beehive stand, fence and boundary, agricultural implements, soil fertility, social and cultural value like culture food, source of income such as sustain food security, diversification and Fruit market. This is supported by (Ewuketu.L., et al, 2014) "species abundance in Homegarden is a function of either household preference, objective or best fit to the given ecology and climate". As the respondent told presence of fruit market initiate to practice and seedling of different fruit tree around their home and uncultivated land. Inset is the main consumptive food for the local community.

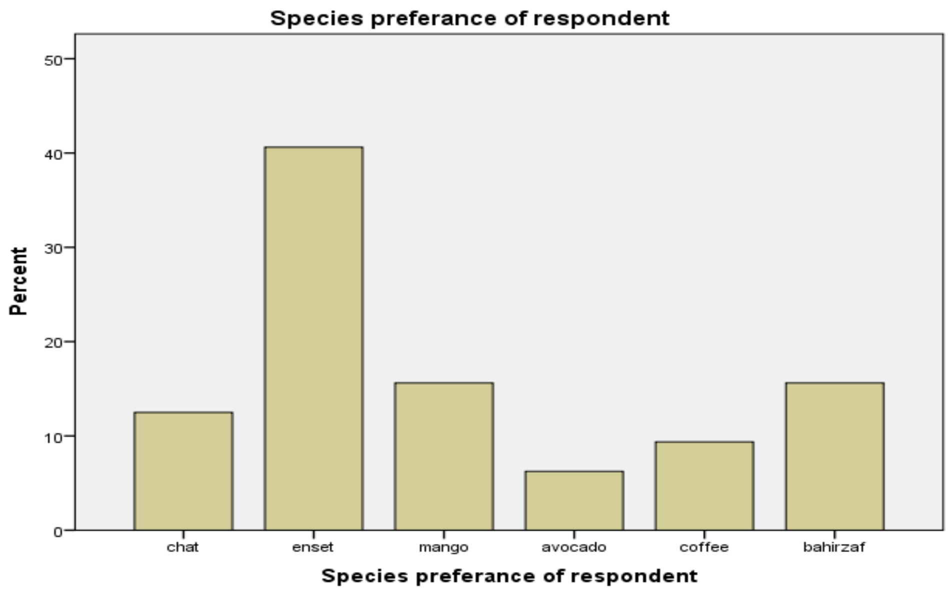


Figure 3:- Species preference of respondents

Source: Field Survey 2019,

The farmers perceived that eucalyptus has a negative effect on food crops, soils, and water. This was attributed to the fact that eucalyptus trees may out compete with food crops for light, nutrients, moisture, and also make tillage practice difficult with their massive root systems and they have allelopathic effects on food crops. But, as shown in the above chart farmers grow eucalyptus trees in high amount (15.6%) on their farmlands for Timber and construction purpose. Thus, farmers mostly planted and grew eucalyptus tree species around home garden and farm boundaries. In contrast, the farmers believed that Enset, Mangifera indica, chata edulis, coffe arabica, Percea americana and Croton macrostachyus have positive effects on food crops, soils, and water. This is because the farmers observed through their life experiences that these species trees can fix nitrogen and thereby increase soil fertility and thereby will make readily available for food crops grown in association with those trees in agroforestry system. In addition, the farmers thought that those tree species can reduce soil erosion caused by rain water and thereby conserve the water in the soil system.

# 5.Conclusion and Future Line of Work

## 5.1Conclusion

In the study area most preferred species retaining and planting by farmers were *Enset, Percea americana, Coffea arabica, Mangifera Indica Eucalyptus, Chata edulis*. This species is the backbone of household economy through provision of edible products such as diversification fruits and contribute for food security, many of them high in value, which can be sold in rural and urban markets such as selling fruits, timber, poles, charcoal and honey. Many trees and shrubs have medicinal value that keeps the farm family healthy and generate additional income. These MPTs that adapt well to the environment and drought tolerant tree species are insurance mechanism against crop failure.

In the study area homegarden agroforestry multipurpose trees play a great role on carbon storage or sequestering vast amount of carbon range from 1.0 to 36.87 Mg C $ha^{-1}$ through accumulation of carbon stocks in the form of live tree biomass, fertilizer substitution (through biological nitrogen fixation and biomass production, reduce land degradation by controlling soil erosion (barrier approach), maintenance of soil organic matter through mulch and biomass transfers, increase plant and ecosystem biodiversity, amelioration of climate variables. Trees can also improve soil fertility by fixing nitrogen from the air and recycling nutrients, thereby helping to increase crop yields. In addition, trees in the study area provide valuable supplemental fodder for animals to enhance livestock production and provide household energy for cooking, heating and lighting.

### 5.2 Future Line of work

In general, based on our study we put and suggest the following recommendations

- In the study area, introduction of exotic species such as Juniperus procera and Eucalyptus increased. So, farmers should be planting and growing different indigenous tree species.
- Moreover, buchach kebelle DAs must focus on awareness creation about these exotic species and increase the distribution of different variety of indigenous seed/seedling.
- Growing and planting of Homegarden agroforestry species require species selection and seedling need based on component interaction. Therefore, farmers in buchach kebelle should be consider component interaction and species muching to the land and other components.
- Because of time constraint and availability of experiment our study were restricted on only woody species diversity and above ground biomass carbon stock by 20 purposively selected samples. therefore, voluntary researcher who need to know the total diversity and total carbon stock potential of buchach kebelle shall be increase the sample size, incorporate all plant species including herbaceous plants, palm trees and below ground carbon stock through soil and root laboratory by destructive method.

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# Appendix

**Wolkite University**

**College of Agriculture and Natural Resource**

**Department of Natural Resource Management**

**Appendix I. Household Questionnaire**

**Dear Respondents**

The main objective of this questionnaire is to collect information about to ranking preference of Homegarden Agroforestry species in buchach kebele for partial fulfillment for the BSc (Bachelor of Science) degree in natural resource management at Wolkite University. The researcher would like to thanks in advance for all your cooperation and participation.

I. Personal Profile

1. Name ________________________
2. Sex ☐ Male ☐ Female

2. Age (Years): ___________

3. Family members in a household: Male ________; Female______: Total ________

4. Level of education: ☐ Illiterate (informal education) ☐ Primary education

☐ Secondary Education ☐ Diploma Holder ☐ Degree holder

☐ Others (specify): ________________________________________

5. Occupation

☐ Crop cultivation ☐ Livestock rearing ☐ Mixed farming others (please specify):________________________________________

**II Farmers preference of Homegarden Agroforestry species.**

1. Do you practice Homegarden agroforestry system in Buchach Kebele? Yes ☐ No ☐
2. If you say YES question No 1 for what purpose you practicing Homegarden agroforestry?

A. increase crop production

B. Food diversification

C. Reduce soil erosion and improve soil fertility

D. Forage production F. Other (Please specify): ______________________________

3. Do you plant and grow tree seedlings in Homegarden agroforestry system? Yes ☐ No ☐
4. If your answer to question No 3 is yes, how much of your land do you allocate for agroforestry system? ☐ Three-fourth ☐ Half ☐ Quarter ☐ All ☐ None ☐ Other (Please specify):_______________________________________________

5. In the existing Homegarden agroforestry system, mention the five-tree species that you most preferred?
   a. ________________________________________________________________________
   b. ________________________________________________________________________
   c. ________________________________________________________________________
   d. ________________________________________________________________________
   e. ________________________________________________________________________

6. Do you agree that planting, growing and managing trees in agroforestry system in Buchach Kebele is environmentally friendly, economically feasible and socially acceptable?
   Strongly agree ☐ Agree ☐ Unsure ☐ Disagree ☐ strongly disagree ☐
7. What do you suggest to be done in the future to promote the practice of the scaling up and the implementation of efficient agroforestry system in the study site? ___________________

Thanks for your time and kind-hearted cooperation!