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Species Composition, Diversity and Vertical Structure of Homegardens

(Case Study in Ama Sub-township, Ayeyarwady Region)

Yati Soe

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ရတီစိုး၊ ဒေါက်တာစန်းဝင်း၊ ဒေါက်တာမြသန္တာတိုး

စာတမ်းအကျဉ်း

ဥယျာဉ်ခြံသီးနှံသစ်တောရောနှောစိုက်ပျိုးခြင်းတွင်ပါဝင်သော အပင်မျိုးစိတ်၊ မျိုးစုံမျိုးကွဲ၊ ရွက်အုပ်လွှာနှင့် စပ်လျဉ်း၍ လေ့လာဆန်းစစ်မှုတစ်ခုကို အမာမြို့နယ်ခွဲ၊ ဖျာပုံမြို့နယ်အတွင်းရှိ ကျေးရွာသုံးရွာတွင် ပြုလုပ်ခဲ့ပါသည်။ ဒေသခံများအနေဖြင့် မိမိတို့ဥယျာဉ်ခြံ အတွင်းရှိအပင်များကို အသုံးပြုနေကြသည့် အခြေအနေများကိုလည်း ထည့်သွင်းလေ့လာခဲ့ပါသည်။ ဤလေ့လာမှုတွင် အပင်မျိုးစိတ် စုစုပေါင်း ၁၂၉ မျိုးတွေ့ရှိခဲ့ရပြီး မျိုးနွယ်အနေဖြင့် ၆၅ ခု ပါဝင်ကြောင်း လေ့လာခဲ့ရပါသည်။ ၎င်းတို့၏ အလေ့အထအရခွဲခြားမည်ဆိုလျှင် အပင်ကြီး၊ ခြုံပုတ်ပင်၊ အပင်ငယ်၊ ပင်ပျော့၊ နွယ်ပင်နှင့်ဝါးပင် ဟူ၍ ၆ မျိုးတွေ့ရပြီး အပင်ကြီးမျိုးစိတ်များကို အများဆုံး တွေ့ရှိခဲ့ရပါသည်။ အပင်မျိုးစိတ်စုံလင်စွာ တွေ့ရှိရသည့်အနက် အုန်း၊ ကွမ်းသီး၊ အိုးဘုတ်၊ အုံတုံ၊ မဏိသြဂ တို့မှာ အများဆုံးတွေ့ရှိရသော မျိုးစိတ်များဖြစ်ပါသည်။ အပင်မျိုးစုံမျိုးကွဲစုံလင်မှုကို တွက်ချက်ကြည့်ရာတွင် လေ့လာခဲ့သည့်ဥယျာဉ်ခြံများတွင် မျိုးစုံမျိုးကွဲစုံလင်စွာရှိသည့်အပြင် ပါဝင်နေသော အပင်များမှာလည်း ညီညွတ်မျှတစွာ ပြန့်နှံ့ပေါက်ရောက်နေကြကြောင်းတွေ့ရှိခဲ့ရပါသည်။ လေ့လာခဲ့သည့် ဥယျာဉ်ခြံများတွင်တွေ့ရသော ရွက်အုပ်အလွှာမှာ အခြားစာတမ်းအများစုတွင် တွေ့ရှိမှုများနည်းတူ အလွှာ ၅ လွှာရှိကြောင်း လေ့လာခဲ့ရပါသည်။ ဒေသခံပြည်သူများအနေဖြင့် ဥယျာဉ်ခြံအတွင်းရှိ အပင်မျိုးစိတ်များကို ဆောက်လုပ်ရေးလုပ်ငန်းများအတွက် အဓိကသုံးစွဲကြပြီး အစားအစာ၊ လောင်စာ၊ သဘာဝဆေးဖြစ် သုံးစွဲကြကြောင်းကိုလည်း တွေ့ရှိခဲ့ရပါသည်။ ဤစာတမ်းတွင် လေ့လာ တွေ့ရှိချက်များအရ ဥယျာဉ်ခြံသီးနှံသစ်တောရောနှောစိုက်ပျိုးခြင်းသည် ဒေသခံပြည်သူများအတွက် အခြေခံလိုအပ်ချက်ဖြစ်သော သစ်၊ လောင်စာ၊ အစားအစာများကို

ထောက်ပံ့ပေးရုံသာမက အပင်မျိုးစုံမျိုးကွဲများ ထိန်းသိမ်းပေးသည့်အတွက် ဂေဟစနစ် ထိန်းသိမ်းရာတွင် အထောက်အကူပြုနိုင်ပါကြောင်း လေ့လာတွေ့ရှိရပါသည်။

Species Composition, Diversity and Vertical Structure of Homegardens (Case Study in Ama Sub – Township, Ayeyarwady Region)

Yati Soe, Range Officer

Dr. SanWin, Pro- Rector

Dr. Mya Thandar Toe, Lecturer

ABSTRACT

A study was conducted in homegardens of three villages under Ama Sub-township, Pyapon Township to document their species composition, diversity and vertical structure with regard to habits of plants and local uses. As many as 129 species of different plants belonging to 65 families were recorded in the study area. Mimosaceae (8 species), Fabaceae (6 species), Euphorbiaceae (5 species), Arecaceae (5 species), Poaceae (5 species), Anacardiaceae (4 species) and Caesalpiniaceae (4 species) are the predominant families. In case of the habits of plants, trees are the dominant habit (48 species) followed by shrubs (23 species), small trees (22 species), herbaceous (17 species), climbers/creepers (13 species) and bamboo (6 species). *Cocos nucifera* L. (Ohn), *Areca catechu* L. (Kunthi-pin), *Melastoma malabathricum* L. (Ou-boke), *Litsea glutinosa* (Lour.) C.B.Rob. (Ondon), *Carallia brachiate* (Lour.) Merr. (Mani-aw-ga) are the most common plants occurring in all of the study homegardens. Dominant species include *Cocos nucifera* L. (Ohn), *Areca catechu* L. (Kunthi-pin) and *Musa* spp. (Nga-pyaw) with the highest important value index (IVI) value. The study homegardens have high species diversity with Shannon index value ranging from 3.19 to 3.72 and Simpson's index value, from 0.93 to 0.96. The canopy layers of homegardens have five layers as the typical homegardens. The multi-species of homegarden in the study area are mainly used for building materials. Fruits, vegetables, fuelwood, natural manure are other common uses. In addition, the study area is vertically structured with five layers. The homegardens are important for providing ecological benefits for the farmers and the community. In summary, homegardens play a major role in the conservation of plant species through the production of food, fruits, fodder, medicine, cash income and maintenance of the ecosystem and so on.

Keywords; Canopy, Dominant species, Ecosystem Conservation, Habits, Uses

Species Composition, Diversity and Vertical Structure of Homegardens (Case Study in Ama Sub – Township, Ayeyarwady Region)

1 Introduction

Myanmar has an area of 676,557 sq. km in Southeast Asia. Agriculture and forestry industries are the main economic sector of Myanmar. The total area of agricultural land is 19.5 % of the country's area (World Bank, 2014) and forest cover is 42.92 % of the total country's area (FRA, 2015). In accordance with the Myanmar Population and Housing Census (2014), 70% of the total population lives in the rural area. Most of the rural people are mainly depending on agriculture and natural resources for their basic needs such as food, fuelwood, timber, pole, post and so on.

Agroforestry is a landuse system that involves socially and ecologically acceptable integration of trees with agricultural crops and/or animals, simultaneously or sequentially, so as to get increased total productivity of plant and animal in a sustainable manner from a unit of farmland, especially under conditions of low levels of technology inputs and marginal lands (Nair, 1989). Agroforestry is not new to Myanmar, especially to the rural farmers, since multipurpose tree planting around homesteads, on farm boundaries, in religious areas, and on common lands, etc., has been in practice for over centuries (Dah, 2004). Homegardens are ancient and widespread agroforestry practices. They can be defined as the land surrounding a house on which a mixture of annual and perennial plants are grown together with or without animals, and largely managed by the household members for their own use or commercial purposes (Tiwari et al., 2016).

The basic function of homegardens is subsistence production, particularly in rural areas (Kumar and Nair, 2004; Soemarwoto and Conway, 1992). The second important function of homegardens is the generation of cash income, particularly in regions with good market access (Abebe et al., 2006; Christanty et al., 1986; Michon and Mary, 1994; Trinh et al., 2003). In addition to the productive functions, homegardens also have important social, cultural and ecological functions (Abdoellah et al., 2002; Christanty, 1990; Karyono, 1990; Soemarwoto and Conway, 1992).

Homegardens also fulfill ecological functions, especially in those landscapes where large, monotonous, and monofunctional agricultural fields dominate (Christanty, 1990). The multi-layered vegetation structure of homegardens is said to look like natural forests and offer a habitat of wild plants and animals (Albuquerque et al., 2005; Karyono, 1990; Michon and Mary, 1994). Homegardens are the closest mimic of natural forests in their structure and usually have 3-5 vertical canopy layers. Additionally, homegardens also have distinct horizontal structure. From the conservation point of view, homegardens are regarded as the conservation sites of a wide range of plant diversity. Although the homegardens contribute various socio-economic, ecological and environmental benefits, this study focused on the analysis of the species richness, diversity, vertical structure of homegardens.

2 Objectives

The objectives of the study are;

(i) to assess plant species richness in the study homegardens

(ii) to study plant species diversity and

(iii) to document the vertical structure of homegardens in the study area.

3 Materials and Methods

3.1 Selection of the sampled villages

The study villages were selected based on the following criteria. A brief profile of the selected villages is described in Figure **1**.

i. The villages with the presence of homegarden agroforestry practice

ii. The villages where the livelihood of local people are depending on agroforestry practices and

iii. The villages where any research on this topic has not been conducted yet

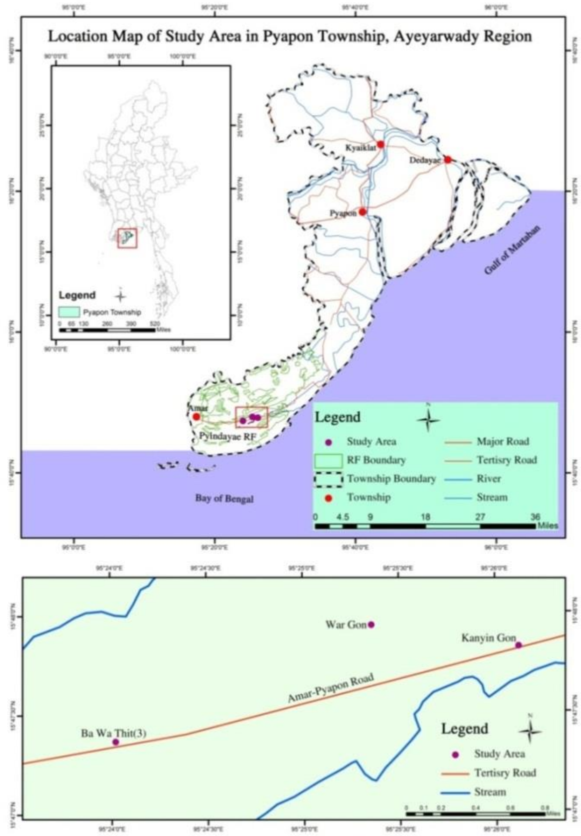


Figure 1. Location Map of the Study Villages

3.2 Plot setting, tree census, sampling

A vegetation survey was carried out to assess the species composition, diversity, and vertical structure of homegardens. Different plant species growing in the homegardens, the vertical layers of homegardens, diameter of the trees species etc., were counted and measured during the vegetation survey. There are various methods of conducting vegetation survey such as DAFOR, Counts, Transects, Quadrants method and so on (Sutherland, 2006). Quadrant method was used in the current study to collect required data because this method can be applied to measure the species composition, density, and frequency over the large area. Different vegetation types required different quadrant sizes. Vegetation with smaller plants, greater plant density or greater plant diversity should require smaller quadrants. According to Sutherland (2006), most often used quadrant sizes are 25-100 m^2 for tall-shrub communities and 400-2,500 m^2 for trees in woods and forests. In setting up the distance between the sampled quadrants, random method was used because the units of population are homogeneous in nature in the current study. Moreover, the study villages are located in almost the same geographic area and hence, the systematic method mainly used to assess the heterogeneous population is not appropriate for my study.

The total sampled area of homegardens in all study villages is 3 ha. Sampled size adequacy was evaluated using the two methods: species-area curve and where a variable can be singled out, seeking a sample size that will yield a standard error less than or equal to 10% of the mean for that variable (McCune et al., 2002). Historically, ecologists have used these two methods to evaluate sample size adequacy. To assess the species composition and plant diversity in the study homegardens, 75 units of (20x20 m) size main sample plots (25 units in each village) were laid (Figure 2). In the main sample plots of (20x20 m) size, all trees with diameter at breast height (DBH ≥5 cm) were measured and counted. After measuring and counting trees within the main plots, these trees were marked using sticky notes to avoid overlapping of trees. The local name of tree species was identified with the help of local people who have the experience on identifying plant species. The local names of the plants were then converted to scientific names using checklist documented by Kress et al. (2003) and ONO (n.d). Within the main sample plots of the study villages, 75 units of (10x10m) size subplots (25 units in each village) were laid in order to count and mark shrubs, herbaceous and climber species. Plant species in the ground layer is too dense and so subplots were divided to count the plants in this layer. To know the species richness in the ground layer, shrubs, herbaceous, and climber/creepers species were counted and identified their local terms. In case of uncertainty of the local name of plant species (e.g some species have two local names), cross checking was made using the checklists of Kress et al. (2003) and ONO (n.d).

To assess vertical canopy structure of homegardens, height measurements of the plants were needed. Height measurement of the plants in homegardens was conducted using a normal stick with 6 m height. It is better to use height measuring stick in conducting height measurement, but only a normal stick was used to measure height in this study.

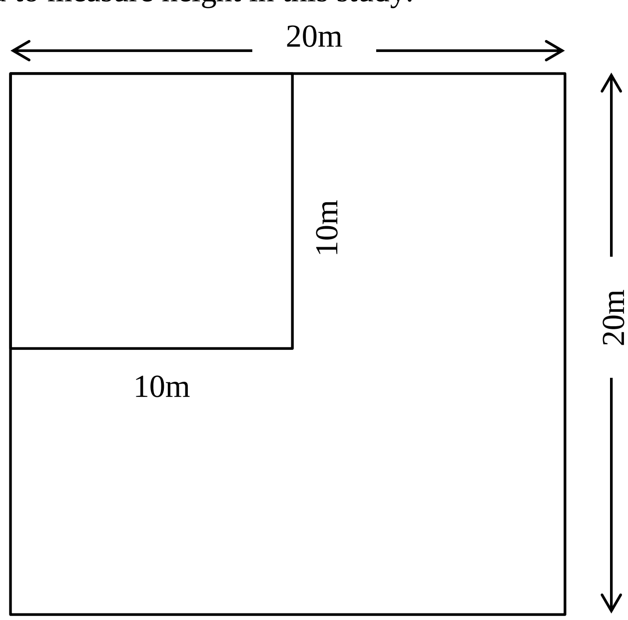


Figure 2. Layout of the sample plot

3.3 Evaluation of the sample size adequacy

Ecologists usually checked sample size adequacy using two methods: species area curve and where a variable can be singled out, seeking a sample size that will produce a standard error less than or equal to 10% of the mean for that variable (McCune et al., 2002). In this study, the sampled size adequacy was also checked using the above two methods.

3.4 Data processing and analysis

Field data were converted to electronic form and all of the vegetation data were analyzed using Microsoft Excel 2010.

3.4.1 Importance value index (IVI)

Importance values are utilized by ecologists to assess the ecological composition of a forest community based on three criteria: how commonly a species occurs across the entire site (frequency), the total number of individuals of that species (density), and the area occupied by that species (dominance) (Burns and Honkala, 1990). This index is also used to determine the overall importance of each species in the community structure. In calculating this index, the percentage values of the relative frequency, relative density, and relative dominance are summed up together and this value is designated as the Importance Value Index or IVI of the species (Curtis, 1959). IVI value is usually between 0 and 100 %.

Importance Value = Relative frequency (RF) + Relative Density (RD) + Relative Dominance (RDo)

(a) **Relative density** is the study of the numerical strength of a species in relation to the total number of individuals of all the species and can be calculated as:

$$\text{Relative density} = \frac{\text{Number of individual of the species}}{\text{Number of individual of all species}} \times 100$$

(b) **Relative frequency** is the degree of dispersion of individual species in an area in relation to the number of all the species occurred.

$$\text{Relative frequency} = \frac{\text{Number of occurrence of the species}}{\text{Number of occurrence of all the species}} \times 100$$

(c) **Relative dominance is** the dominance of a species is determined by the value of the basal cover. Relative dominance is the coverage value of a species with respect to the sum of coverage of the rest of the species in the area.

Relative dominance = $\frac{\text{Total basal area of the species}}{\text{Total basal area of all the species}} \times 100$

3.4.2 Species similarity among the study homegardens

Sorenson's index of similarity was used to compare the vegetative composition (not including the abundance of species) between homegardens of the study villages. All similarity indices are stated in percentages in order to make the comparisons easier to read. Sorensen's index represents the number of common species between two sites (Say Garden A and Garden B). In this case, common species mean the species which can be found in both homegarden A and B. The equation for this measure of similarity is as follows:

$$Ss = \left(\frac{\text{Number of Common Species}}{(Sa+Sb)/2}\right) x100,$$

where Ss is Sorenson's Index, Sa is the number of species in community A and Sb is the number of species in community B.

3.4.3 Shannon Wiener diversity index (SWI)

Diversity indices are used to assess the level of biodiversity in systems. Diversity in any vegetated system is a product of its richness and evenness. Species richness is simply considered as the number of species observed in a sample unit, whether the sample unit is defined as a specific number of individuals or area (McCune et al., 2002). Evenness refers to the balance between the numbers of individual members of species. There are various methods to estimate the diversity of a given vegetated site. The Shannon Wiener diversity index is the most commonly used diversity indicator in plant communities, and it takes a value of zero when there is only one species in a community, and a maximum value when all species are present in equal abundance. The index is easy to use and calculate. The Shannon Wiener diversity index (H′) is high when the relative abundance of the different species in the sample is even and is low when few species are more abundant than the others. It is based on the theory when there is a large number of species with even proportions, the uncertainty that a randomly selected individual belongs to a certain species increases and thus the diversity (Krebs, 1999). The maximum value that the SWI can reach depends on the number of species in the community (maximum H' = ln s).

The formula for calculating the Shannon Wiener diversity index is

$H' = -\Sigma\, p_i \ln p_{i},$

where, H′ is Shannon Wiener index of diversity, p_i is the proportion of the important value of the i^{th} species , p_i is n_i / N (n_i is the importance value index of i^{th} species and N is the importance value index of all the species). The term $p_i \ln p_i$ is calculated and summed for each species in the community. With this index, diversity increases as the species become more evenly distributed in abundance, and more species are added to the community. Shannon index value ranged from 1.5 to 5.0 (Washington, 1984).

3.4.4 Simpson's diversity index

Since evenness and dominance are simply two sides of the same coin, their measures are complementary. Simpson's index is based on the probability of any two individuals drawn at random from an infinitely large community belonging to the same species.

The equation used to calculate Simpson's index was

$$D = \Sigma (p_i)^2,$$

where, D is Simpson index of dominance, p_i is the proportion of important value of the i^{th} species, p_i is n_i / N (n_i is the importance value index of i^{th} species and N is the importance value index of all the species). As the value of D increases, diversity decreases and Simpson's index was therefore usually stated as 1 – D or 1/ D. Simpson's index value is usually between 0 and 1.

3.4.5 Evenness index

An additional measure of diversity, which compares the observed distribution with the maximum possible even distribution of the number of species in the sample (Pielou, 1969) was calculated. Evenness index was used to describe the diversity in terms of evenness i.e. how equally abundant the species were in the homegardens. The measure of Evenness (E) is the ratio of observed diversity to maximum diversity and it is calculated

$$E\ (\%) = \frac{H'}{H\max} \times 100$$ (Magurran, 2013),

where, E is Shannon's Evenness (evenness value, range 0-100%), H' is Shannon Wiener function, H_{max} is maximum possible diversity , s is total number of species and H_{max} is ln (s).

4 Results and Discussion

4.1 Evaluation of the sample size adequacy

Evaluation of the sample size adequacy for three study villages using the species area curve was shown in the Figure 3. The curves are generally flattened out and this means that increasing the sample size will yield only small increases in the number of species.

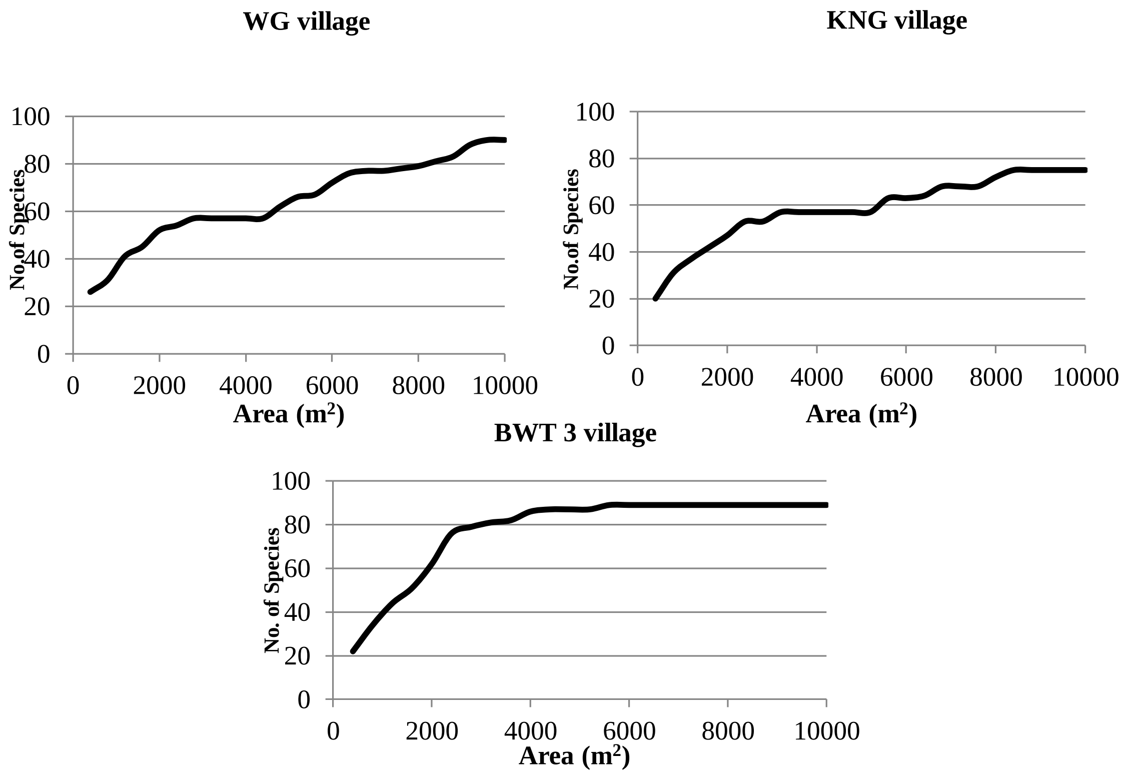


Figure 3. Species area curve of the study villages

The next approach to evaluate the sample size adequacy is that seeking a sample size that will yield a standard error less than or equal to 10% of the mean for that variable. The results are displayed in the Table **1**. All study villages produce sample sizes that yield a standard error less than 10% of the mean and hence, it can be suggested that the sampled size represents the whole population.

Table 1. Sample size adequacy in all study villages

	WG	**KNG**	**BWT3**
Mean	18	16	23
Standard Error	1.06	0.96	0.42

4.2 Brief description of the species composition and diversity of study area

The overall results for species composition and diversity of the study area can be found in the following Table 2. According to the table, the study homegardens have 129 plants species which belongs to 65 families. Average plant density of the study area is 2745 ha^{-1}. They also have high species diversity with average Shannon value of 3.66 and Simpson value of 0.96. Evenness value of the homegardens is high with an average of about 75% and this supports the high diversity of species. Tree species richness and density is highest among the different habit types with 48 recorded species and 843 individuals ha^{-1}. Tree density per hectare is very high and this counting includes all mature and young trees having DBH greater than and less than 5 cm. Trees are the largest share among the different habits of plants and this may be due to market condition and homegardeners' preference of fruit trees as they give continuous production and high income. It was found that the bamboo species richness and density is lowest with 6 species and 37 clumps ha^{-1}.

Table 2. Species composition and diversity of all the study homegardens

	Richness	Average Density/ha	Diversity Indices		
			Shannon	Simpson	Evenness (%)
Family	65				
All Species	129	2,745 (2147-3822)	3.66	0.96	75
Trees	48	843 (755-891)	2.94	0.92	76
Small Trees	22	449 (210-633)	1.65	0.63	54
Shrubs	23	548 (367-880)	2.03	0.80	64
Herbs	17	451 (228-849)	1.76	0.76	62
Climbers/ Creepers	13	417 (123-667)	1.01	0.49	56
Bamboo	6	37 (33-40)	1.4	0.71	78

4.3 Species composition among the study villages

(i) Predominant families

Species richness of the sampled plots was shown in Table 3. In the current study, 129 different plant species which belong to 65 families have been documented.

Table 3. Species richness by family name of the study villages

No.	Family Name	No. of Spp. (Study Villages)	No. of Spp.		
			WG	KNG	BWT3
1	Fabaceae	6	6	4	-
2	Poaceae	5	5	-	-
3	Euphorbiaceae	5	5	5	5
4	Mimosaceae	8	5	4	8
5	Arecaceae	5	4	5	5
6	Anacardiaceae	4	-	4	4
7	Caesalpinaceae	4	-	-	4

Predominant families in the study homegardens were displayed in the above Table 3. The families which have 4 or more number of species are Mimosaceae (8 species), Euphorbiaceae (5 species), Arecaceae (5 species), Fabaceae (6 species), Anacardiaceae (4 species), Caesalpiniaceae (4 species) and so on. Top five dominant families include Mimosaceae, Fabaceae, Poaceae, Euphorbiaceae and Arecaceae. The family Poaceae was found as the dominant family only in WG village while Caesalpinaceae as dominant family only in BWT3 village.

In all study villages, the above seven families composed as top five families. Species such as Don nwe, Taw-pe, Lauk-thay, Wa-bo, Wa-ya, Wa-net, Kanazoe, Ziphyu, Danyin-thi (-pin), Manjan-sha, Malay-sha-padauk, Ohn, Kunthi (-pin), Danon, Thayet, Thiho-thayet, Magyi, Myinga etc., are present under these dominant families. It was found that most of these species are naturally growing in the homegardens while fruit and timber species such as Majan-sha, Ohn, Kunthi (-pin) have cultivated by homegardeners as they are providing the basic needs of local inhabitants. Poaceae family is dominating only in WG village because the village has all recorded bamboo species (6 species) but the KNG and BWT 3 village has only 2 and 4 bamboo species.

(ii) Predominant habits of plants

Species composition in the homegardens can also be described by their habits of plants, namely; trees, shrubs, herbs, climbers/creepers and bamboo. Analysis of the different habits of the plant species (Figure 4) showed that trees are the predominant habit in all study villages which ranged from 44 to 57 species, followed by shrubs, 13 to 18 species; herbs, 8 to 12 species; climbers/ creepers, 7 to 9 species and bamboo, 2 to 6 species respectively.

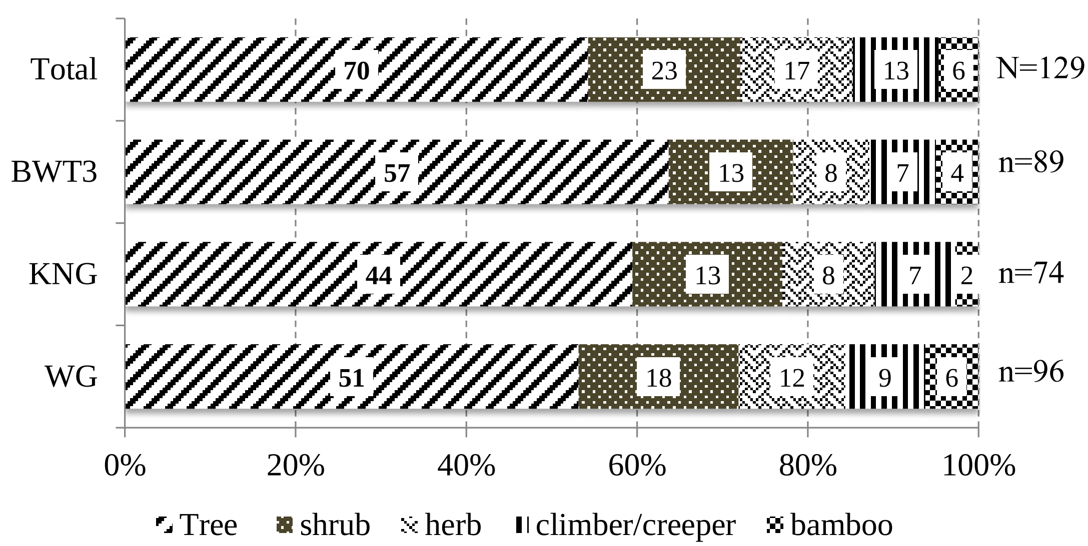


Figure 4. Species richness by different habits of plant

(iii) Comparison of species composition with tropical and semi-tropical homegardens

Comparison of the species richness of current study with that of other tropical and semi-tropical homegardens was shown in the**Error! Reference source not found.**.

Table 4. Comparison of species richness with tropical and semi-tropical homegardens (spp. richness values are descended)

Country	No. of Species	Elevation (m.a.s.l)	Remarks	References
Sri Lanka, South Asia	289	0-300	Delta	Kumari et al., 2009
Mexico	233	1217	Hilly	Blanckaert et al., 2004
Karwar, India	210	6	Delta	Bhat et al., 2014
Kachin, Myanmar	195	146	Plain	Aung, K.M., 2006
Ama Sub-township, Myanmar	129	3	Delta	Current study
Nigeria	84	52	Plain	Udofia et al., 2012
North-Western Ethiopia	69	1500-2300	Hilly	Mekonnen et al., 2014
Sudan, Northern Africa	32	570	Semi-arid	Gebauer,2005

The species composition of the current study is higher than some regions including Nigeria, North-Western Ethiopia, Sudan, Northern Africa but it is lower than Kachin, Myanmar, Karwar India, Mexico and Sri Lanka, South Asia (see Table 4). When comparing the species composition of the same geographic region of three Delta areas, Sri Lanka homegardens have the highest species composition followed by Karwar, India and the current study. Generally, species composition from place to place differs according to various factors including income difference, altitude, personal preferences of homegarden species, soil type, homegarden size and so on (Mekonnen et al., 2014). The study areas of Sri Lanka and Mexico homegardens are located in the suburban area and so, the people in this region prefer to cultivate ornamental plants. Unlike the typical homegardens, the ornamental plants are dominating in the homegardens of Sri Lanka and Karwar, India (Bhat et al., 2014; Kumari et al., 2009). This may be one reason of greater species richness in this region. One more reason of greater species richness may be the dissimilarity of sampled size in the study homegardens. In accordance with many kinds of literature described by various authors, species richness of the tropical region is usually high because of the composition of different plant habit types in this region.

4.4 Frequency and abundance of plant species by villages

Table 5 shows the frequency occurrence of top five species which can be found across the study villages.

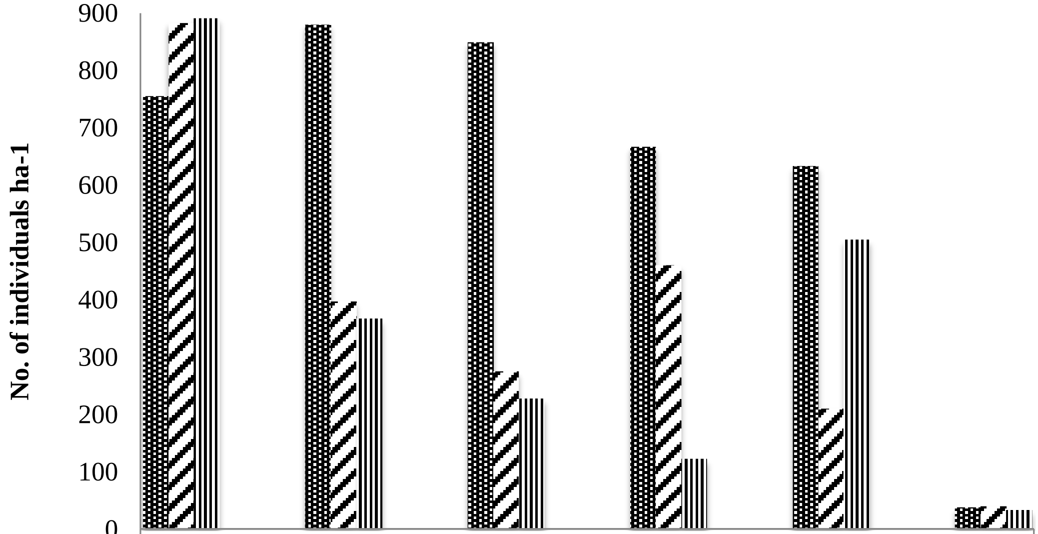
Table 5. Frequency and abundance of plant species in homegardens

No.	Common Name	Scientific Name	Frequency%			Abundance (%)		
			WG	**KNG**	**BWT3**	**WG**	**KNG**	**BWT3**
1	Ohn	*Cocos nucifera* L.	100	100	96	3.69	6.60	9.33
2	Kunthi (pin)	*Areca catechu* L.	96	-	92	15.43	-	7.82
3	Ou-boke	*Melastoma malabathricum* L.	84	-	-	10.81	-	-
4	Naga-mauk	*Leea indica* (Burm.f.) Merr.	60	-	-	1.44	-	-
5	Nasha	*Litsea nitida* (Roxb.) Hook.f.	60	-	-	3.33	-	-
6	Mani-aw-ga	*Carallia brachiata* (Lour.) Merr.	-	-	84	-	-	2.13
7	Ondon	*Litsea glutinosa* (Lour.) C.B.Rob.	-	96	92		7.17	7.48
8	Pyinma	*Lagerstroemia speciosa* (L.) Pers.	-	68	84	-	3.06	3.22
9	Ngayan-padu	*Clerodendrum indicum* (L.)Kuntze	-	72	-	-	4.81	-
10	Nga-pyaw	*Musa* spp.	-	72	-	-	5.37	-

Cocos nucifera (Ohn) has the largest frequency value which ranged from 96 to 100 % in all study villages. Species such as *Areca catechu* (Kunthi-pin), *Litsea glutinosa* (Ondon) and *Lagerstroemia speciosa* (Pyinma) were also found as the frequently appeared species. Almost all homegardeners in the study area have cultivated the fruit trees species of *Cocos nucifera* (Ohn) and *Areca catechu* (Kunthi-pin) in their homegardens because of the provision of highest income and continuous production throughout the whole year. Therefore, these species can be found in almost all the study homegardens. In ecology, abundance is the relative representation of a species in a particular system. It is usually measured as the number of individuals found per sample. The most abundant species in the study homegardens were *Areca catechu* (Kunthi-pin), *Cocos nucifera* (Ohn), *Litsea glutinosa* (Ondon) and *Melastoma malabathricum* (Ou-boke).

4.5 Plant density in homegardens

Plant density of homegardens comprises of the density of each plant habit type; trees, small tree, shrubs, herbs, climbers/creepers and bamboo.



	Trees	Shrubs	Herbs	Climbers/Creepers	Small trees	Bamboo
WG	755	880	849	667	633	38
KNG	883	397	275	460	210	40
BWT3	891	367	228	123	505	33

Figure 5. Plant density in homegardens of the study villages

Tree species composed the highest density in all study villages ranging from 755 to 891 ha^{-1} (this includes all the tree species having DBH greater than and less than 5 cm), followed by shrub density which is between 367 and 880 ha^{-1}, herbs density ranging from 228 to 849 ha^{-1}, climbers/creepers density ranged from 123 to 667 ha^{-1}, small tree density ranging from 210 to 663 ha^{-1} and bamboo density which is between 33 and 40 ha^{-1}. In all study villages, tree and bamboo density is nearly the same while the density of shrubs, herbs, climbers/creepers and small tree density is highly different among the villages. KNG and BWT3 homegardens have the highest tree density and WG village has the highest density of shrubs, herbs, climbers/creepers and small trees. Complete information on plant density in homegardens was shown in Figure 5.

In the study of Das and Das (2005) about Barak Valley, Assam, North East India homegardens, tree density of 831 ha^{-1} was recorded while Abebe (2005) found that the Southern Ethiopia homegardens have the tree density of 475 ha^{-1}. The average tree density of the current study was also high which is about 843 ha^{-1} (see Table 6). Tree density of my study is the counting of individuals of all mature and young trees having DBH greater than and less than 5 cm. The reason of higher tree density may be due to higher number of cultivated trees in the study homegardens. This kind of cultivated trees includes *Cocos nucifera* (Ohn), *Areca catechu* (Kunthi-pin), *Archidendron jiringa* (Danyinthi-pin), *Acacia mangium* (Majan-sha), *Mangifera indica*

(Thayet), *Ceiba pentandra* (Thinbaw-letpan), *Syzygium tetragonum* (Thabye), *Artocarpus heterophyllus* (Peinne) and so on. The next possible reason is that the homegardeners have no systematic planting pattern: usually there are no rows or definite planting spacing and they usually cultivated their plants in the blank space of the homegardens. Hence, the trees in the study homegardens are very dense with these possible reasons.

Table 6. Comparison of plant density with other studies

Country	Density ha^{-1}	References
Ama Sub-township, Myanmar	843	Current Study
Assam, North East India	831	Devi and Das, 2013
Southern Ethiopia	475	Abebe et al., 2013

4.6 The importance of homegarden species

To evaluate the ecological and other benefits of each species documented in the study area, their important values were calculated. Importance value index (IVI) values of top five species were displayed in Table 7 and the values of all recorded species can be found in appendix 3. The species having the maximum IVI value is the dominant species. According to the results, *Cocos nucifera* (Ohn), *Areca catechu* (Kunthi-pin), *Musa* spp. (Nga-pyaw) have the highest IVI values and so these species are dominating in the study homegardens.

Table 7. Importance value index of top five species of the study villages

Species	Scientific Name	WG	KNG	BWT3
Kunthi(-pin)	*Areca catechu* L.	25.34(1st)	-	7.83(2nd)
Ohn	*Cocos nucifera* L.	17.93(2nd)	26.0(1st)	20.26(1st)
Nga-pyaw	*Musa* spp.	5.92(3rd)	8.68(2nd)	-
Wa-bo	*Dendrocalamus brandisii* Wall.ex. Munro	19.41(4th)	-	-
Kanyin-phyu	*Dipterocarpus alatus* Roxb.ex G Don	5.24(5th)	7.10(4th)	-
Pyinma	*Lagerstroemia speciosa* (L.) Pers.	-	7.57(3rd)	4.36(5th)
Peinne	*Artocarpus heterophyllus* Lam.	-	-	6.23(3rd)

Wanet	*Dendrocalamus longispathus* Kurz.	-	6.78(5th)	-
Ondon	*Litsea glutinosa* (Lour.) C.B.Rob.	-	-	5.17(4th)

The fruit tree species are predominating in the homegardens in all study villages. As mentioned above, it can be seen that the major function of homegardens is the production of food and fruits in the study homegardens. The fruit tree species can contribute the highest proportion of homegarden income and these species are the major cash generating species for rural households in the study area. Because the homegardens are composed of different species, they have multiple uses and some species are used for one purpose, some species for more than one purpose while some are used for miscellany. The species, *Cocos nucifera* (Ohn) is used for more than one purpose such as building materials, fuelwood, and fruits. *Areca catechu* (Kunthi-pin) is also used for building materials and fruits while *Musa* spp. (Nga-pyaw) is used for fruits and fodder.

4.7 Sorensen's species similarity among the study villages

The similarity of homegardens species among the study villages was analyzed using Sorensen's species similarity index. In general, species in homegardens of the different regions is very similar to each other as the major function of homegardens is the production of food and fruits.

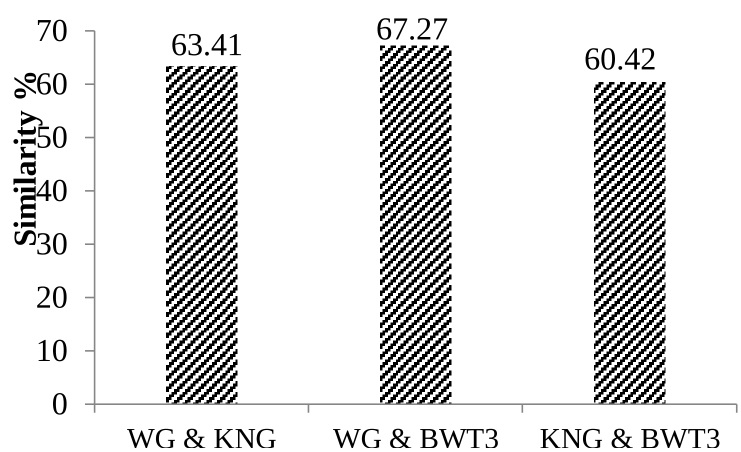


Figure 6. Species similarity between the study villages

In my study, the similarity percentage between the study villages is high which is above 60% and so, it can be seen that the species composition of homegardens is very similar (see Figure 6). In accordance with the local people' response, they choose the species for homegardens which are the most common within the village. The species that are generated year-round production and high market demand are also considered in choosing the species. Top similar trees species between the study villages were listed in the following Table 8.

Table 8. Top similar tree species among the study villages

No.	Common Name	Scientific Name
1	Aukchinsa	*Diospyros ehretioides* Wall.
2	Awzar	*Annona squamosa* L.
3	Kanyin-phyu	*Dipterocarpus alatus* Roxb.ex G Don
4	Ka-si	*Vitex pinnata* L.
5	Kha-aung	*Ficus hispida* L.
6	Kunthi(-pin)	*Areca catechu* L.
7	Kyaung-sha	*Oroxylum indicum* (L.) Kurz
8	Malaka	*Psidium guajava* L.
9	Malay-sha-padauk	*Acacia auriculiformis* A.Cunn.ex Benth.
10	Mani-aw-ga	*Carallia brachiate* (Lour.) Merr.
11	Nga-pyaw	*Musa* spp.
12	Ohn	*Cocos nucifera* L.
13	Ondon	*Litsea glutinosa* (Lour.) C.B.Rob.
14	Peinne	*Artocarpus heterophyllus* Lam.
15	Pyinma	*Lagerstroemia speciosa* (L.) Pers.
16	Shauk(-pin)	*Citrus aurantium* L.
17	Shaw-kanyin	*Sterculia parvifolia* Roxb.ex G.Don
18	Talinekhaung	*Madhuca longifolia* (Koen.) Macbride
19	Thabye	*Syzygium tetragonum* (wight) Wall.
20	Thayet	*Mangifera indica* L.

4.8 Plant species diversity in homegardens

Species diversity of each study villages was assessed and the results were shown in the following Table 9. Shannon, Simpson and evenness indices values were higher in BWT3 village than other two study villages. This may be due to higher woody species richness and evenness index value which leads to the higher species diversity in BWT3 village. This possible explanation was also described in some studies about Sidama homegarden (Abebe, 2005) and North-Western Ethiopia homegardens (Mekonnen et al., 2014).

Table 9. Species diversity in homegardens

Diversity Indices	WG	KNG	BWT3
Shannon Index(H´)	3.19	3.41	3.72
Simpson Index(1-D)	0.93	0.95	0.96
Evenness(E)	66.00	70.00	77.00

Comparison of the species diversity with other studies was presented in the Table 10. Homegardens of the current study has more diverse species than those from North-western Ethiopia which is between 2.31 and 2.43 (Mekonnen et al., 2014), Western Nepal which ranges from 2.19 to 2.45 (Srish et al., 2013) and diversity is within the range of North-east India homegardens which have the value between 2.51 and 4.01 (Tiwari and Tynsong, 2011). The high species richness and evenness in North-east India homegardens lead to the greater species diversity than other regions.

Table 10. Comparison of species diversity with other studies

Country	**Shannon**	**References**
North-east India	2.51 to 4.01	Tiwari and Tynsong, 2011
Ama Sub-township, Myanmar	3.19 to 3.72	Current study
North-western Ethiopia	2.31 to 2.43	Mekonnen et al., 2014
Western Nepal	2.19 to 2.45	Srish et al., 2013

4.9 Vertical stratification of homegardens

Homegardens are characterized by high species diversity and usually 3-5 vertical canopy strata (Fernandes and Nair, 1986). The layered canopy configurations and compatible species admixture are the greatest visible characteristics of all homegardens. Homegardens in the study area have five vertical layers as the typical homegardens. Sketch diagram of the vertical canopy layers of homegardens was shown in the following Figure 7.

Figure 7. Vertical canopy layers of homegardens

According to Fernandes and Nair (1986), the vertical structure of homegardens in the study area can be divided into five layers. In general, all homegardens consist of the herbaceous layer near the ground, a tree layer at upper levels and an intermediate layer in between. Table 11 showed the vertical structure of homegardens from various regions of the world. In this study, vertical canopy structure was divided into five layers; two ground layers, the intermediate layer, and two upper layers.

Table 11. Literature from around the world on the structure of homegardens

Region	Vertical Structure	References
(a) Asia and the Pacific Region		
Indonesia	4 strata	Christanty et al., 1986; Jensen, 1993; Jose and Shanmugaratnam, 1993; Nair, 1979
	3 – 5 strata	Michon, 1983; Soemarwoto, 1987

Pacific	4 strata	Barrau, 1961
Philippines	4 strata	Sommers, 1978
Sri Lanka	3 strata	McConnell and Dharmapala, 1973
	4 strata	Perera and Rajapakse, 1991
(b) America Region		
Grenda	4 strata	Brierley, 1985
Mexico	4 strata	Gliessman et al., 1981
(c) Africa Region		
Nigeria	4 strata	Okafor and Fernandes, 1987; Okigbo, 1989
Tanzania	4 strata	Alriksson and Ohlsson, 1990; Fernandes et al., 1985
Uganda	4 strata	Oduol and Aluma, 1990

Almost all the vertical layers of homegardens have the cash generating fruit trees. The lower layer can usually be partitioned into two, the bottommost being at less than 1.0 m in height, dominated by herbaceous, medicinal and vegetable plants such as *Chromolaena odorata* (Bezat), *Stenochlaena palustris* (Damin nwe), *Spatholobus listeri* (Don nwe), *Xanthosoma lindenii* (Gamone gya), *Amarantus blitoides* (Hinnu-nwe) and the next ground layer of 1 - 5 m height being composed of herbaceous and fruit trees such as *Musa* spp. (Nga-pyaw), *Areca catechu* (Kunthi-pin), *Artocarpus heterophyllus* (Peinne), *Mangifera indica* (Thayet) and so on. The intermediate layer of 5 - 10 m height is covered by *Cocos nucifera* (Ohn), *Musa* spp. (Nga-pyaw), *Areca catechu* (Kunthi-pin), *Acacia mangium* (Manjan-sha), *Acacia auriculiformis* (Malaysha-padauk,) *Melaleuca leucadendra* (Melaluca) and so on. The upper layer can also be divided into two, involving uppermost which is 10-20m and the emergent layer which is greater than 20m height. The uppermost and emergent layer is dominated by fruit trees, bamboo and timber species.

5 Conclusion

Traditional agroforestry practice, homegarden, is supporting the service function. High species richness of homegardens is describing the importance of homegardens in the conservation of plant diversity. The major findings of the species richness, diversity, vertical structure and income contribution of homegardens are given below.

A vegetation survey of homegardens in the study villages of Ama Sub-township has shown that the total number of 129 species belonging to 65 families occurred in them. In all study homegardens, tree accounts for 48 species, shrubs (23 species), small trees (22 species), herbs (17 species), climbers/creepers (13 species) and bamboo (6 species). Trees are found to be predominant among the different habits of plants. Fruit trees such as *Cocos nucifera* (Ohn), *Areca catechu* (Kunthi-pin) and *Musa* spp. (Nga-pyaw) are the dominant plants in all study homegardens, like some other studies around the world. As described in many kinds of literature, the major function of the homegardens in the study area is also food and fruit production. Study homegardens have high species diversity with a Shannon index value range of 3.19 to 3.72 and Simpson's index value range of 0.93 to 0.96. The evenness index value indicated that the species in homegardens have evenness distribution with the value range of between 66 and 77%. The homegardens in the study area also displayed five vertical canopy layers making them typical homegardens.

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