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Agrobiodiversity of homegardens in Myanmar

Master's Thesis

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Declaration

I, Su Myat Thwe hereby, declare that I have done this thesis “Agrobiodiversity of homegardens in Myanmar” independently, all texts in this thesis are original, and all the sources have been quoted and acknowledged by means of complete references and according to Citation rules of the FTA.

In April 26th, 2019

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Su Myat Thwe

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Abstract

This survey was conducted in 96 randomly selected homegardens across eight villages of Thegon Township under Pyay district situated in Bago division of Myanmar. The aims of the thesis were to assess species diversity for both cultivated and wild plants, to classify type of local homegardens and finally to document the ethnobotanical knowledge on useful plants and local management practices. Data were collected during August and September 2018, through structured questionnaires, plant inventory and direct observation. The survey was conducted in three main parts, i.e. household survey, vegetation survey and plant artefact interviews. Total number of 246 species from 70 botanical families were identified and the value of Shannon-Wiener index is ranging from 0.1 to 2 with an average value of 1.03. The best represented families with the highest number of species were Fabaceae, Euphorbiaceae, Rutaceae, Zingiberaceae, Apocynaceae and Asteraceae. There were 9 use categories for reported plant species such as food, environmental, medicine, social use, fuel, material, food additive, cosmetic, and effect of poison. The most dominant species were *Tamarindus indica*, *Solanum melongena*, *Mangifera indica*, *Vigna unguiculata* ssp. *Sesquipedalis*, *Leucaena leucocephala*, *Cucumis sativus*, *Albizia lebbek*, *Citrus aurantiifolia*, *Mitragyna rotundifolia and Impatiens balsamina*. We identified 63 species as ecologically important species while other species were mainly used for their food, culture and other purposes. In our study area, type and structure of local homegardens for all households was a combination of subsistence and market gardens with a various level of commercialization. There was a positive correlation between the number of plant species and homegarden size, natural vegetation, species diversity, and number of species commercialized. On the other hand, the homegarden age was correlated negatively with the plant diversity. Finally, our results showed that there were no significant environmental and management effects on species diversity. Most of the respondents managed homegardens both by chemical and biological control methods. While biological management methods were applied for most of the crops, agrochemicals were applied only for commercial crops to control pests, especially insects, and to improve the cash crop yields.

Key words: Agrobiodiversity, homegardens, ethnobotany, useful plants, Myanmar

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List of the abbreviations used in the thesis

ACs	Agrochemicals
FAO	Food and Agricultural Organization of United Nations
FSWG	Food Security Working Group
GDP	Gross Domestic Product
HG	Homegarden
IPGRI	International Plant Genetic Resources Institute
MOALI	Ministry of Agriculture Livestock and Irrigation
MIMU	Myanmar Information Management Unit
MPHC	Myanmar Population and Housing Census
USDA	United States Department of Agriculture
VSAT	Vegetable Sector Acceleration Task Force
WEPs	Wild edible plants

1. Introduction

1.1 Local homegardens under a global change

Homegardens have been described with various English names such as agroforestry homegardens, household or homestead farms, compound farms, backyard gardens, kitchen gardens, village forest gardens, dooryard gardens and house gardens (Kumar & Nair 2004). Homegardens are considered as a sustainable production system in the tropics, which contributes to biodiversity conservation and supports human needs (Das & Das 2005). According to Fernandes & Nair (1986), although homegardens are most prevalent in the tropics, they can be found between 40 º N and 30º S latitudes, with the largest concentration in South- and Southeast Asia, the Pacific islands, East- and West Africa, and Mesoamerica.

Homegardens play an important role in agrobiodiversity conservation and they may also sustain native biodiversity (Blancas et al. 2010), including genetic diversity of species which occurs in forests as wild (Parra et al. 2010). The species-rich agroforestry systems that include numerous cultivated and wild plants (Kumar & Nair 2004) are one of the most interesting and important places for ethnobotanical studies (Fernandes & Nair 1986) and many ethnobotanists have been working and doing research with indigenous peoples in tropical developing countries (Kumar & Nair 2004). In general, the role and structure of homegardens differ from place to place depending on the local environment, socioeconomic, ecological and cultural factors (Ceccolini 2002; Kumar & Nair 2004). When rural and urban homegardens are compared, gardens in rural areas are mainly intended for household subsistence needs, while gardens near urban regions tend to provide income from the products (Miller et al. 2006). Moreover, homegardens contribute to food security because they produce various products across the seasons (Karyono 1990) and fulfil also the ecological and cultural purposes (Abdoellah et al. 2001).

The types of homegardens differ according to socioeconomic factors (Peyre et al. 2006) and they can be different based on the homegarden age, land size and amount of diversity (Kehlenbeck & Maass 2004). Besides, the plant management in each homegarden can varies based on individual household needs (Kimber 1966).

It is known that the structure, diversity and role of homegardens is rapidly changing due to modernization, globalization and growing financial needs (Nair 2006). The native biodiversity is getting lost and the traditional practises are being abandoned. Further research needs to shed light on these dynamic changes and how it influences the diversity and human livelihood.

1.2. Literature review

1.2.1 What is a homegarden and how it functions?

Homegardens are traditional sustainable production systems which have been maintained from generation to generation mainly for the livelihood but also for cultural and ecological purposes. They produce various kinds of food which is a source of nutrition for smallholder farming groups in many tropical and subtropical regions (Whitney et al. 2017). They also serve for satisfying other immediate needs of family members (Bennett-Lartey et al. 2002). In homegardens, there are multi-layered plant canopies which can be beneficial in terms of both the utilization of sunlight and water and soil conservation (Torquebiau 1992). Therefore, they are complex agroecosystems which are important for livelihood, food security, human nutrition and other household needs (Souto & Ticktin 2012). Besides, they preserve much of cultural history of local people and maintain traditional knowledge and management practices (Blanckaert et al. 2004). Homegardens are fundamentally different from large scale agricultural systems with prominent factors such as small-scale, minimum amount of agrochemicals, little mechanization, multi-use and high species diversity of both plants and animals (Hylander & Nemomissa 2008). Also, they are important sites of wild plant domestication and living gene banks conserving traditional crop varieties and rare crop species (*on farm* conservation) (Huber et al. 2010; Eyzaguirre & Linares 2001).

Although households do homegardening mainly for subsistence use, these gardens are gradually more used to increase household's income (Méndez et al. 2001). Currently, homegardens are shifting from a subsistence cropping rather towards cash crops and high-quality products due to the national production strategies, global factors and value chains and increasing financial needs (Montagnini 2006). Traditional homegardens have been menaced by several factors including disappearance of traditional knowledge and and local varieties (Tabuti 2012), health problem of local

household members (UBOS & ICF 2012), pests and diseases problems (Tripathi et al. 2009), and land shortage and soil problems (Nyamukuru et al. 2015).

1.2.2 Structure of homegardens

The structure of homegarden results from the spatial organization of all parts and strata which exist in that homegarden. The spatial features in homegardens are the horizontal and vertical strata which in combination form a full homegarden structure. The vertical strata is the base component which composes only the vegetative layers while the horizontal strata includes all components. These two strata are constantly changing under several factors such as homegarden's age and size, particular season, homegarden type and purpose (Lope-Alzina & Howard 2012). The horizontal structure displays an interesting figure with various uses of different plant species (Blanckaert et al. 2004) and the vertical structure includes one to five strata which is very common in agroforestry systems of tropical countries (Kumar & Nair 2004). This complex structure of horizontal and vertical strata provides various agricultural crops and tree products which are important for household consumption and for selling in the local markets. However, homegardens with more vertical strata produce more goods because of numerous layers with a higher diversity of resources (Montagnini 2006).

The structure of homegardens differs from area to area depending on socioeconomic, ecological and cultural features and physical environmental conditions (Ceccolini 2002; Kumar & Nair 2004; Abdoellah 1990). Besides, one of the main factors affecting the structure is the homegarden size (Abdoellah et al. 2006). From the research point of view, Leiva et al. (2002) reported that the cluster analysis is an analytical method which has been used commonly for classification of homegarden structure.

1.2.3 Types and characteristics of homegardens

There are numerous types of traditional homegardens according to variation in their design, grown species, geographical zones and ethnic groups (Hamilton & Hamilton 2006). The homegarden size, homegarden structure, dominant plants, and socioeconomic factors have been used to classify the types of homegardens (Kehlenbeck & Mass 2004). According to Niñez (1987), a traditional homegaren occur

both in tropical and temperate climates but the tropical homegarden possesses complex vertical strata together with various kind of species and plant life forms while the temperate one is simple as all plants exist within the lower level and mostly annual species are grown.

Homegarden arrangement varies from ornamental homegarden, over kitchen homegarden to a multipurpose agroforestry garden according to the socio-economic conditions and gardener's livelihood strategy (Kehlenbeck & Maass 2004). Three types of homegardens were originally defined by (Terra 1953a & 1953b) such as fenced-in gardens occurring in individual land ownership which are surrounded by individual houses and annual species, vegetable herbs, fruit trees and other kinds of trees. The second types are tree gardens which are designed by a mixture of tree components on communal lands with more wild trees. This type is surrounded by dense cluster of houses and might be connected to a shifting cultivation field. The last third type is formed by clumps of fruit trees and other types of trees which are grown on abandoned shifting cultivation lands.

Moreover, Wiersum (1982) distinguished three types of tree gardening. The first one is homegarden which is developed on private areas around individual houses having fence and many trees species, annual and perennial species, and often also small livestock. The second one is called as mixed garden which is also practiced on private land but outside the villages and perennial species, mostly trees, are dominant with a limited cultivation of annual crops occurring under the canopy of trees. Finally, the third one called forest garden is the same land-use form with mixed gardens where spontaneously growing trees and additional perennial species can be found.

In addition, Niñez (1984) defined four types of gardens according to their characteristics. Firstly, survival garden means that it is the single component farming type where rural people who do not own land grow staple crops together with complementary crops. Secondly, subsistence garden is the multi-component farming method and people grow plants for fruits, vegetables, spices and herbs which are essential for their daily life and sometimes the product surplus is being sold. The third one is market garden which is a multi-component or specialized farming type and people mainly grow market-oriented cash crops which are complementary products for the household. The last one is budget garden which is totally different with the three

previous gardens. People cultivate crops only for economic purposes in this garden and they buy food from market and sometimes they grow food or ornamental plants as a hobby and for household food supplementation.

1.2.4 Ethnobotany and its application for homegarden studies

Ethnobotany is the study of interactions between indigenous peoples and plants with a focus on traditional knowledge, mainly (Turner 1995). This traditional knowledge plays a major role in the relationship between people and their surroundings (Souto & Ticktin 2012). Traditional knowledge highly varies according to the ethnicity (Nakashima et al. 2012). To assess the traditional plant knowledge, quantitative indices in ethnobotany are used commonly (Ahoyo et al. 2017; Whitney et al. 2014). Ethnobotany as a scientific discipline, is a multidisciplinary field including botany, anthropology, economics, and linguistics (Aumeeruddy-Thomas & Shengji 2003).

Nowadays, using plant to cure diseases is still very important and popular, and around 80 % of the world human population is still using plants as a health care option (Bandaranayake 2006). Therefore, ethnobotanists by studying local knowledge can contribute in identifying new drugs for health, nutritious foods or other useful products.

Ethnobotanical surveys could be applied for creating preservation strategies of indigenous plant species and landraces (Pieroni & Giusti 2009). There are many types of ethnobotanical research depending on objectives, and this can vary from documentation of indigenous knowledge to laboratory analysis of biologically active compounds of useful plants species (Khan et al. 2013). Ethnobotanical data is also important for attraction of tourism and its planning and development (Hakim & Nakagoshi 2007). Ethnobotanical study of homegardens is very important due to various reasons but foremost for identifying local agrobiodiversity, documenting associated traditional knowledge and finding a sustainable homegarden management. The present study uses ethnobotanical approach and provides standard information about agrobiodiversity managed and utilized by local indigenous farmers.

1.2.5 Agrobiodiversity in Homegardens

Agrobiodiversity is important part of natural biodiversity and it includes plant genetic resources which are used for both food and agricultural purposes (Negri 2009).

Agrobiodiversity is an interesting homegarden research aspect and it includes a high variety of biological resources such as plants (both wild and domesticated species), animals and microorganisms which are directly or indirectly contributing to people (FAO 1996). This plant diversity is the representative resource of human's selection from generation to generation for their food, medicine, cultural value and others (Nair 2006).

Agrobiodiversity is one of the important resources for both household, researchers and ethnobotanists. Therefore, it supplies raw materials to people and to breeders for production of new varieties which can adapt to changing environment and can fulfil the human needs (IPGRI 1993). Actually, the breeding is important for solving the problem of production of food for more growing population and conservation of natural resources (Cabalda et al. 2011). Furthermore, wild species play an important part in agrobiodiversity and they cross-breed themselves between cultivated plants and wild or weedy species naturally and as a result, gene exchange can still occur in homegardens (Hammer et al. 1999). Farmers maintaining and using wild germplasm has often created better crops by experimenting in their gardens and allowing wild and cultivated biodiversity to interact (Hughes et al. 2007).

Landraces, represented in agrobiodiversity of homegardens, are key resources for preservation of genetic pool in agriculture (Altieri et al. 1987) and they are highly diverse and selected populations according to local management and cultural value. They have ability of particular adaption to their environment and have close relationship to local lands and traditional farming practices (Negri et al. 2009). Besides, they can resist pests and disease problems, changes of enviro-climatic conditions and are more suitable for non-industrial agricultural farming methods (Negri 2005). Maxted et al. (2002) stated that landraces are conserved by in situ management to prevent genetic erosion. However, there is still constraints to preserve landraces from adaption to changing environmental conditions and requirements of the local environments (Negri & Tiranti 2010).

Global agrobiodiversity exits in the complex agroecosystems, especially homegardens and smallholder farmers mainly take care them they are (Galluzzi et al. 2010). Agrodiversity is also strongly related to homegarden age and are used for many purposes. According to Coomes & Ban (2004), there are more species diversity in old

homegarden than new one because gardeners grow new plants. Besides, there is lack of vegetation strata mainly in small homegardens if the plants are more than 5 meters tall (Abdoellah et al. 2001). Therefore, trees species can find with small population in the gardens because they need more space to grow (Pavia et al. 2009).

Species in some traditional homegardens are very important for their cultural and religious purposes and some plants are only preserved for cultural value (Huai et al. 1998). Also, Trinh et al. (2003) stated that every component from gardens possess special cultural meaning and value. However, changing the cultural and socioeconomic value concerns the decreasing of indigenous species because farmers produce more commercial products and traditional knowledge are lost over time around the world (Tesfaye 2005).

Among tropical regions, Southeast Asia countries such as Thailand, Vietnam, Laos, Myanmar, Cambodia, Malaysia, Philippines, Brunei, Indonesia, Timor-Leste and Singapore need conservation of biodiversity, particularly due to the fact that there is higher rate of losses of natural habitat (Sodhi et al. 2004). Thus, almost the whole Southeast Asia is regarded as a biodiversity hotspot due to the loss of endemic species with more than 70 percentages (Myers et al. 2000).

There are a lot of research related with agrobiodiversity in homegardens and can find different levels of species diversity and richness and different uses around the world, especially in tropical regions. For instance, in Indonesia, total number of 127 species was found and farmers used species as vegetable, ornamental, food, fruit, spice, medicinal, and building material, mainly (Abdoellah et al. 2006). Then, another study in Vietnam observed that a total of 208 species which are used for a range of nonmedicinal purposes, especially for food (Hoang et al. 2008). Moreover, Blanckaert et al. (2004) observed at a village in an arid part of Mexico that total number of species is 233 plant species and three main uses such as ornamental, food edible and medicine. In north-eastern Brazil, species diversity is lower than above three studies and total number is 54 species and main purpose of uses are medicine, food, timber, ornamental, shade, forage, poisonous, soap substitutes, and magical (Albuquerque et al. 2005).

1.2.6 Factors influencing diversity in homegardens

Agriculture biodiversity and floristic composition in homegardens often largely varies because of various factors such as cultural background, geographical location, and socioeconomic factors (Eichemberg et al. 2009). Also, other significant influencing factors are gender of homegarden owners (Reyes-García et al. 2010), food preferences (Shrestha et al. 2002), proximity of market (how far to urban markets, accessible to local markets) and finally effect of tourism (Lamont et al. 1999). There is usually positive correlation between agrobiodiversity and size and age of homegarden, soil fertility and availability of workers for maintenance of homegardens (Kehlenbeck & Maass 2006). However, one research showed that small size of homegardens possess more species diversity than larger one because household with small garden grow many crops only for family members, while large household grow same kind of cash crops mostly for sale (Abebe 2013).

Species diversity has also association with household head profile like ethnicity, age, and gender status (Quisumbing et al. 2014). For instance, women are the responsible persons for maintaining species diversity especially of food trees and multipurpose species in Palau (Thaman et al. 2006). In contrast, according to Wiehle et al. (2104), genders of homegarden manager do not affect upon species diversity and richness.

One of the main causes of reducing plant diversity in homegarden is commercialization of farming. Abdoellah et al. (2006) stated that plant diversity has steadily decreased in commercialized homegardens. With a reduction of diversity and homegarden intensification, there are other negative effects such as reducing social equitability, higher level of ecological and financial risks to owners, increased instability and higher external inputs use of fertilizers and pesticides.

Market accessibility is one important socioeconomic factor which cannot be neglected when species diversity is considered. For example, Abebe (2013) revealed that crop species richness decreased when homegardens are located in a proximity to markets, as people become practicing monocropping in their gardens.

1.2.7 Gender and management of homegardens

Plant management in homegardens and household labour division can differ according to local conditions and culture (Kimber 1966). A few studies have dealt with homegarden management, specifically Schroth et al. (2004). Farmer's wife is mostly involved in home gardening and they usually use simple farming tools and technologies to maintain the gardens. For instance, hosepipes and sprinklers are used for watering the plants. In addition, Larios et al. (2013) reported that women are mainly responsible for sowing, planting, maintaining and harvesting the products while men are mainly involved in tree pruning, weed control, application of fertilizer, pest control and harvest of some crops from tall trees.

Although animal and plant waste from farms is often circulated, composted and applied to soil or used for mulching, synthetic fertilizers, pesticides or herbicides are also used (Vogl-Lukasser & Vogl 2004). People use both biological and chemical control methods to manage crops and control pests. Among common biological controls are hand removal of caterpillars or applying lime on tree trunks to prevent ants and *Oidium* sp. Whereas the common chemical control is spraying agrochemicals to prevent infections and pests especially of ornamental plants and cash crops grown in monoculture. For example, when ethnobotanical studies were conducted in Mexico, researchers carefully documented and assessed the traditional management systems of both wild and domesticated species (Bye 1993; Caballero 1994).

Land clearing needs to be considered as an initial work and thinning of some trees is also essential to get sufficient light for plants at lower strata. This heavy work is commonly conducted by men. Various useful wild plants are kept in homegardens for the purposes of construction, fuelwoods, food and others. Then, some fast-growing useful species (eg. *Musa* spp.) are being planted to create favourable conditions of the site (Gajaseni & Gajaseni 1999). Material for fencing such as living shrub fence, bamboos and wood stakes are regularly used in homegardens and these materials are usually obtained by managing wild populations or by planting specific plants (Sunwar et al. 2006).

Farmers are actively involved in on farm conservation and participatory crop evolution. In general, farmer propagate crops by seed and vegetative propagules with artificial selection from vigour of the mother plants (Blancas et al. 2010). Ex situ

conservation is done by gene banks or botanical gardens and plants are collected from their natural habitat and then conserved tin suitable different ways. Nevertheless, only around third of the local genetic resources such as landraces or underutilized species are kept in gene banks (Hammer & Laghetti 2005). Farmers thus play a crucial role in conservation of plant genetic diversity.

1.2.8 Overview of geography, population, and ecology of Myanmar

Republic of the Union of the Myanmar is situated in the South-eastern part of Asia bordered by five different countries namely Bangladesh, India, China, Laos, and Thailand. An estimated area is 261,227 square miles with a population of 51 million (70% living in rural and 30% in urban regions) which consists of 135 distinct ethnic groups (MPHC 2014). The country possesses many resources such as natural gas, gems, oil, petroleum, timber, tin, antimony, zinc, copper, tungsten, lead, coal, marble, and limestone while most parts are covered by forests (deciduous forest (38%), hill evergreen forest (25%), evergreen forest (16%), dry forest (10%), deciduous dipterocarp forest (5%) and tidal, beach, dune and swamp forest (4%)). Climate in Myanmar is tropical monsoon and there are three types of seasons such as cool season from October to February with average temperatures of 20-24˚C, hot season from March to May with average temperatures of 30-35˚C and wet season from June to September with average temperatures of 25-30˚C (FAO 2011).

There are five major topographic and climatic zones namely Shan Plateau, coastal region, central dry zone, mountainous region and finally delta region. Total arable land is 18.2 million ha and 13.3 million ha are used for cultivation at current situation. Among these cultivation lands, 2.1 million ha are under irrigation during mainly monsoon season and 11.2 million ha are rainfed farms. In Myanmar, rice is the main crop and other important crops include pulses, oilseed crops, maize, rubber, sugarcane, cotton, tropical vegetables and fruits (MOALI 2016).

1.2.9 Biodiversity, vegetable cultivation, and homegardens in Myanmar

Myanmar is one of the hotspots of biodiversity and rapidly developing country at the same time (Krupnick & Kress 2003; Myers et al. 2000). According to checklist of trees, shrubs, herbs and climbers, there are 273 plant families, 2,371 genera and over

11,800 species including gymnosperms and angiosperms (Kress e al. 2003). Also, various types of diverse landscapes occurred from the delta and coastal areas in both northern and southern part with continuous geographic variation.

Traditional farming practices and indigenous knowledge have contributed to the conservation of plant genetic diversity for many centuries in Myanmar. The country is recognized for as a global hot spot of genetic diversity of vegetables, which has evolved due to favourable climatic conditions and diversity of the ecological systems. In Myanmar, more than a hundred kinds of vegetables are being grown in different agroecological regions (Swe 2008).

Currently, vegetable gardening generates an important income for smallholder farmers. Approximate number of 750,000 smallholder farmers earn income with a total value of USD 1.2 billion at farm gate prices (VSAT 2016). However, many kinds of vegetables are cultivated in small homegarden plots and some are found growing as weeds in marginal areas within farms or growing wild in both anthropogenic and natural environments. In rural regions, farmers used to collect wild edible plants collected mostly in homegardens and forests, and these plants have been used for household consumption and for getting an additional income by selling surplus products in local markets (Yi 2008). However, despite the high diversity of vegetables and other agrobiodiversity, the most recent FAO national assessment showed that 5.6 million people suffers from undernutrition and 29.2% of children under 5-year-old are stunted (FAO 2018).

1.2.10 Existing research related to homegardens and ethnobotany in Myanmar

Although indigenous people in Myanmar regard natural resources as essential for their culture and welfare (FAO 2010), they do not totally interest to conserve the natural resources. From the research point of view, in Myanmar there is still a lack of information related to homegardens, species diversity and ethnobotanical uses. Only a very few ethnobotanical studies have been conducted and those mostly focused on medicinal plant uses and on financial value. Peters et al. (2007) studied the rattan trade of Northern Myanmar. They found 15 rattan species and half of them being cultivated as commercial. Among those species, seven species are new observations for Myanmar

and two (*Calamus* sp. nov.) are new for science. Inventory of the studied transects showed that the density of commercial rattans in local forests produced per hectare average yield of 40.5 canes being 24-meter long. While all species population actively regenerated, there was less control and management, which could potentially lead to a resource depletion in the future.

An ethnobotanical study was conducted in the village of Ashe Mayan in the Ayeyarwady Delta to assess the subsistence plant resource use in mangrove forest. The cumulative number of plant diversity was 119 species and 28 species were used for medical purposes or as poison, 22 species for crafts, 19 species for food, 14 species for materials of construction, 10 species for tying, 7 species for fuel, 1 species for both roofs and walls and finally, 18 species for other purposes (Ono & Suzuki 2013). In Kachin State of Northern Myanmar, researchers identified 25 species which are used for medicinal purposes in this state. These plants are used by local people since long history to cure bone healing, as a wound healer, back pain, knee pain, joint pain, cold and cough, rheumatoid arthritis, gout, kidney diseases, peptic ulcer, liver cancer, nerve and lung diseases, etc. Mostly, plant parts such as leaves, stems, roots, rhizomes and seed are used and sometimes a whole plant (Aung et al. 2016).

Another pharmaceutical ethnobotany survey was conducted in Hlawgar wildlife park of Yangon with the aim of finding anticancer plant resources. Total 23 families including 32 species were recorded by Myanmar and Thai traditional practitioners. The herbal practitioners referred that 19 species were applied for medical purposes and leaves, flowers, stem, bark, rhizome and roots being used (Thantsin et al. 2016).

As wild edible plants (WEPs) play an important role among local indigenous communities, Shin et al. (2019) studied their use in Southern Shan State of Myanmar. Researchers observed total number of 83 species under 44 families of angiosperms as wild edible plants. 47 species out of 83 species were eaten as vegetables, 31 species as fruits and nuts, 18 species as medicinal foods according to the difference usages. Surprisingly, people with the age from 30 to 39 years had more knowledge how to use the plants than the older people (Shin et al. 2018).

Pritchard et al. (2018) implemented a large-scale survey of homegardens and food security in rural areas among 3,320 households from 129 villages at Chin state, Magway state and Ayeyarwady state. This study showed that households with

homegardens were associated with better food security and dietary diversity outcomes. However, the study emphasized that only 21 percent of the local households had a homegarden.

1.2.11 Problem statement and the study purpose

There are no existing studies and literature specifically related to the topic of agrobiodiversity in homegardens of rural Myanmar. Agricultural surveys have mainly focused on production, while ethnographic studies on ethnicity, religion and class. There is no detailed investigation about local agrobiodiversity, its uses and importance. The current socioeconomic situation in rural areas is that people are now more moving to urban areas and they are becoming less dependent on agriculture for their livelihood. As a result, land owners are decreasing and two challenges on the capacity of homegardens have been intensifying. The first significant challenge for homegardening in Myanmar is the wider processes of agricultural inequality and landlessness, and the second important challenges are the increase of geographical mobility, monetization and marketisation (Pritchard et al. 2018). The assessment of diversity, documentation of knowledge and identification of culturally important and underutilized species is urgently needed to conserve the biocultural heritage and to tap the potential of agrobiodiversity for sustaining the homegardening and scaling its potential and benefits. From the point of using agrochemicals, there is no exact data for fields and homegardens. According to FSWG (2014), all farmers use fertilizers and pesticides excessively and most of them lack knowledge on how to use agrochemicals safely. Therefore, 80% of farmers do not wear suitable protective clothes during application of pesticides. In case of organic fertilizers, most of the farmers use animal manure such as cow dung during the soil preparation and without making compost.

The purpose of this study was to assess the diversity of useful plant species which are important for ecological and cultural purposes in eight villages in Thegon township, Bago division. The diversity assessment was complemented by a documentation of traditional knowledge on local plant uses in order to preserve the knowledge and identify the culturally important species. Then, local homegardens were classified into different management categories, depending on factors influencing the species diversity. Also, management systems with a special reference to a use of

agrochemicals were investigated to see the extent of chemical use and its possible impact on species diversity.

2. Objectives

The thesis aims (1) to assess the diversity of crops and wild useful plant species in homegardens in the study area; (2) to identify ecologically and culturally important species; (3) to classify local home gardens based on the level of diversity and the factors influencing this diversity (this includes the usage of agrochemicals amongst others).

The specific objectives of the thesis are:

(a) to conduct a total species inventory

(b) to document traditional ethnobotanical knowledge on inventoried species

(c) to determine the environmental factors (physical, biotic, managed) influencing the species diversity

3. Methodology

3.1 Study site

In Myanmar, there are seven divisions such as Yangon division, Bago division, Ayeyarwaddy division, Magwe division, Mandalay division, Sagaing division and Thaninthayi division. Among them, the selected Bago division occupies an area of 15214 square miles and is composed of four districts namely Bago, Taungoo, Pyay and Thayawady comprising total number of 28 townships with 1,619 ward/village-tracts. This division possesses the flat land with three north-south mountain ranges which have a relatively low elevation in the northern part and are further lowering to the southern part (MPHC 2014). Moreover, this division is the second largest rice producer after Ayeyarwaddy division and produces other agricultural produces like pulses, sugarcane, groundnut, jute, rubber, Myanmar tobacco, tapioca, banana, dhani (Nipa palm), fruits and many kinds of vegetables. Also, Bago mountain range produces large amounts of high-quality timber (USDA 2005).

Bago division is one of the core regions of central Myanmar within 17° 19' 19" N latitude and 96° 27' 58" E longitude and it is the second largest producer of rice among all states and regions contributing substantially to Myanmar's GDP and economic growth. Since Bago division features both mountains and floodplains, the region has both forests cover dominated by teak production, while the floodplains are important for rice production. Besides agriculture, also mining and industries exists, but are limited to petroleum production and to some natural resources such as salt, ceramics, sugar, paper, plywood, distilleries, and monosodium glutamate.

Among 26 townships, Thegon township under Pyay district in Bago region possesses total cultivation area 96,503 areas. It is located between 18°34' 22.8" (18.623°) north and 95°23' 58.8" (95.3997°) east. The lowest and highest temperature are 25.6°C and 32.6°C. Besides, annual rainfall is around 1843 mm per year. The population in this area possesses 130,957, household number is 35,950 and there are more females than males with 89 males per 100 females according to MPHC (2014). Therefore, mean population per one household is 3.6 persons in this township. The main crops grown in this particular township are: rice, peanut, sesame, sunflower, black gram, green gram, pigeon pea, cotton, sugarcane and maize while the perennial plants

are mango tree, citrus, pumelo, pineapple, sugar apple, cashew tree, tamarind tree and other fruit trees. The rice is mainly exported to Mandalay and Magway divisions. Also, there are valuable natural growing trees and plants such as Burmese teak (*Tectona grandis*) and Pyinkado (*Xylia xylocarpa* Taub) which are important for timber production, Indian snakeroot (*Rauwolfia serpentine*) which is used for medicine, Cogon grass (*Imperata cylindrica*), Nipa palm (*Nypa fruticans*) and Bamboo (*Bambusa* spp.) that are mainly used for construction of houses, shelter for animals and equipment for farming (MFMU 2017). It was chosen as survey area because there is the highest proportion (67.4%) of peoples working in agriculture, forestry and fishing industry. The gender percentage of working at above three industries are 71.6% of males and 61% of females according to MPHC (2014). From the research perspective, there is no study concerning the homegardens in this township. Therefore, a research on species diversity, type, role and function of homegardens is needed in this township and areas of Bago division.

There are 6 wards and the number of village tracts is 50. Among them, three village tracts were chosen namely Lin Lae, Moe Tein Pyin and Za Lae. In these tracts, eight villages which practise homegardening widely were selected: Thegon Yet Kone, Thae Kyaw Kyi, Sin Lu, Za Leit, Oke Shit Kone, Moe Tein Pyin, Bu Pyaw and finally Yone Pin Lan Khwe. Theses studied villages are shown in the **Figure 1.**

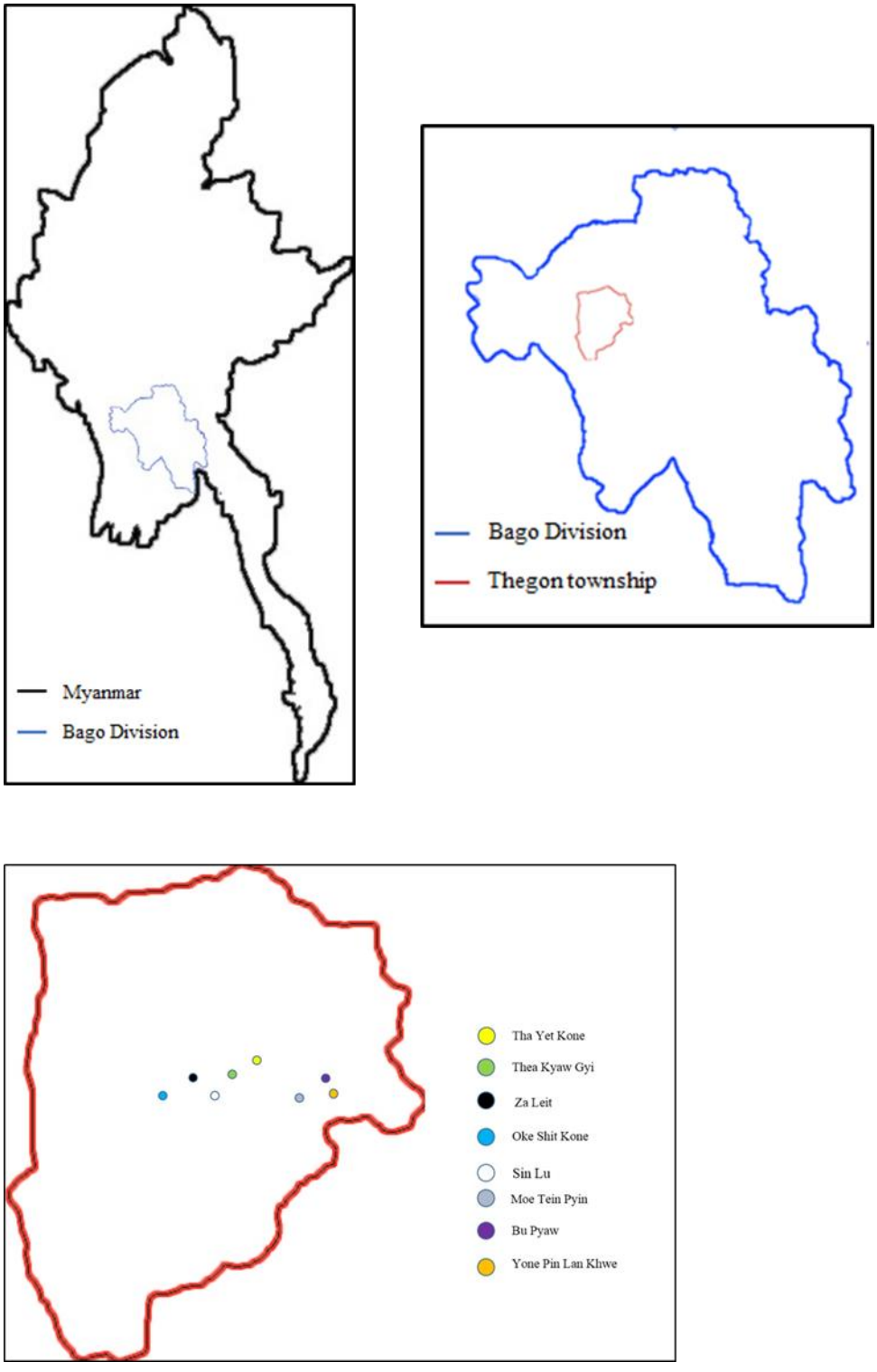

Figure (1) The study area (villages) in the Thegon Township. (*Source: MIMU, 2010*)

3.2 Data collection

The study was conducted during August and September 2018. Number of selected households was determined by using the following formula of Lynh et al. (1974). In total, ninety-six households having homegarden were chosen from three village tracts **(Table 1)**. A random sampling method was used with the assistance of government staffs and village heads of the surveyed villages. Respondents were interviewed by using a structured questionnaire and the interview was held in the native language during both household and vegetative surveys.

Equation for determination of sample size:

$$n = \frac{NZ^2\ P(1-P)}{Nd^2 + Z^2P(1-P)}$$

Where

n=number of samples

N=number of households in the district

Z=the value of the normal variable (1.96) for a confidence level of 0.95

p=the highest possible proportion (0.5), and

d= the sampling error (0.1)

Table (1) Description of village tracts, villages, number of informants and gender.

Village tracts	Villages	Informants	Male	Female
Lin Lae	Tha Yet Kone	11	10	1
	Thae Kyaw Kyi	10	6	4
	Sin Lue	18	9	9
Moe Tain Pyin	Yone Pin Lan Kwe	15	12	3
	Moe Tain Pyin	17	14	3
	Bu Pyaw	6	4	2
Za Leit	Za Leit	5	3	2
	Ohn Chit Kone	14	7	7
Total		96	65	31

Firstly, we met with head of township to permit for data collection and officers who is mainly responsible person for our surveyed villages. Then, we went Interviews were done face to face with the respondents at the home or in homegardens after officers explaining purpose of the research (**Figure 2**). In the first place, basic information was recorded about household including age, gender, education level, number of family members, and ethnicity. Then, characteristics of homegardens (HG) such as age, farm size, homegarden size, soil type, water source, terrain in homegarden, pest damage degrees, weeds conditions and control, land preparation, farm equipment, and storage equipment were specified. Also, vegetation which grown naturally was observed. All individual plants were set from one to five strata such as 1. 0-1 m, 2. 1-2 m, 3. 2-6 m, 4. 6-9 m and 5. >9m according to Kehlenbeck & Maas (2004). After that, informants were asked to list the five key crops, and the crops were categorized into crops for sale and for own consumption.

Secondly, respondents were questioned about the control measurement for their crops, soil fertility, and pests with the use of agrochemicals (ACs) and other methods such as biological control.

Finally, informants were asked by showing and discussing the plant species mentioned on-site for ethnobotanical knowledge and collection of plant samples as

voucher specimens. The ethnobotanical inventory of all useful plants' species was completed with the following information on local names, number of species per homegarden, plant part used, all specific uses, mode of preparation, seed sources, use of agrochemicals, harvest season, place of selling products and price for product (income). Moreover, number of individuals of each species per homegarden were done by counting individuals according to Martin (2004). After that, we took photographs of plants and plant parts, and plant samples were taken during the fieldwork and processed into the voucher specimens by putting samples into newspaper and pressing them by a wooden plant press **(Figure 3)**. For further identification, dried voucher specimens were sent to Plant Biotechnology and Horticultural Department of Yezin Agricultural University to carry out taxonomic identification and to deposit herbarium specimens **(Figure 4)**.

Figure (2) Interviews with respondents at home and garden *(Source: Su Myat Thwe, 2018)*

Figure (3) Collection of plant samples *(Source: Su Myat Thwe, 2018)*

Figure (4) Preparation of herbarium specimens at Plant Biotechnology and Horticultural Department of Yezin Agricultural University *(Source: Su Myat Thwe, 2018)*

3.3 Data analysis

Data were firstly summarized and entered in the MS Office Excel for each home garden. Data were firstly analysed by descriptive statistics and some parts of statistical analyses were performed in IBM SPSS. In particular, correlation analysis was applied to assess the relationship between species diversity (Shannon-Wiener index) and homegarden size, homegarden age, number of species, number of individuals of each species, number of species sold.

Plants were classified according to plant life-form such as annual herb, perennial herb, grasses, trees, shrubs, subshrub, woody perennials, palms, vines, climbers and epiphytic plants (herb refers all herbaceous plants) (Whitney et al. 2017). Then, the biodiversity and ethnobotanical knowledge were analysed quantitatively using relevant and standard indices and indicators. The plant uses were categorized into the standard use categories following the guidelines of Cook (1995).

The following indices were calculated:

3.3.1 Summed dominance ratio (SDR)

The local dominance of species was determined by using the summed dominance ratio (SDR) with the following formula (Chen et al. 2014).

$$SDR\ (\%) = (RI + RF)/2$$

where relative density (RI) (sum of individuals of a crop/sum of all individuals of all crops), relative frequency (RF) (sum of homegardens in which a crop occurred/sum of counts of all crop occurrences in all homegardens surveyed).

3.3.2 Use reports (UR)

UR was used to quantify ethnobotanical information to obtain values for the calculation of analytical indices with the following formula (Tardío & Pardo-de-Santayana 2008):

$$UR_s = \sum_{u=u_1}^{u_{NC}} \sum_{i=i_1}^{i_N} UR_{ui}$$

Firstly, the UR of all the informants (from i_1 to i_N) were summed within each use-category for that species (s) which means the number of informants who state each use-category for the species. Secondly, all the UR of each use-category were summed (from u_1 to u_{NC}). Where NS species is (s_1, s_2,..., s_{NS}), a total number of use-categories NC is (u_1, u_2,..., u_{NC}) and *N* informants is (i_1, i_2,..., i_N).

3.3.3 Cultural Importance index (CI)

The cultural importance index (CI) was calculated to determine the relative importance of different plant species by using the following formula. (Tardío & Pardo-de-Santayana 2008).

$$CI_s = \sum_{u=u_1}^{u_{NC}} \sum_{i=i_1}^{i_N} UR_{ui} / N$$

CI is calculated by dividing UR by the total number of informants.

3.3.4 Shannon-Wiener index

To estimate the level of agrobiodiversity, the Shannon-Wiener index was calculated by the following equation (Magurran 1988):

$$H = \sum_{i=1}^{S} (p_i)(\ln p_i)$$

Where *H* is the Shannon-Wiener index, *S* is the total number of species in the community and *pi* is the proportion of species *i* in the community.

3.3.5 Frequency of Citation (FC)

To determinate the importance and incidence of citation for each specific species, the frequency of citation was used (Albertin & Nair 2004). Calculation is very simple as it is the sum of informants that mention the use of the plant species.

4. Results

4.1 Species diversity

Total number of 246 species from 70 botanical families were identified. Families with the highest number of species were Fabaceae (n=28), Euphorbiaceae (n=15), Rutaceae (n=13), Zingiberaceae (n=11), Apocynaceae and Asteraceae (n=10), Cucurbitaceae, Malvaceae and Poaceae (n=9), Solanaceae (n=7), Lamiaceae and Moraceae (n=6), Arecaceae and Rubiaceae (n=5). The remaining 56 families were represented by less than 5 species. Number of species ranged from 9 to 35 species per homegarden and the average number of species was 22 species per homegarden. Based on summed dominance ratio (SDR), ten most dominant species were *Tamarindus indica*, *Solanum melongena*, *Mangifera indica*, *Vigna unguiculata* ssp. *Sesquipedalis*, *Leucaena leucocephala*, *Cucumis sativus*, *Albizia lebbek*, *Citrus aurantiifolia*, *Mitragyna rotundifolia* and *Impatiens balsamina.*

4.2 Plant uses

Plant uses were categorized into 9 use categories such as food, environmental, medicine, social use, fuel, material, food additive, cosmetic, and effect of poison. The d plant parts and plant life were characterized for all 246 species **(Figure 5,6,7)**. Besides, 170 species were found having only one use, 63 species having two uses, 11 species having three uses, 1 species having 4 uses and 1 species having 5 uses **(Table 2)**.

Table (2) Plant use categories and their number use reports (UR), cultural importance index (CI) and number of plant species

Plant use category	Description	UR	Ci	Plant species
Food	curry, salad, soup, snack, vegetable, dessert, juice, animal food for cattle and pig	995	10.36	96
Environmental	ornamental, fence, shading	260	2.71	63
Medicine	common diseases, skin disease, injury, wound, anti-aging, and others	249	2.59	68
Social use	religious' uses, miscellaneous social uses, smoking, symbol used as a symbol of traditional festival	235	2.45	45
Food additive	spice, ingredient for curry, salad and soup	227	2.36	13
Fuel	fuelwood	186	1.94	23
Material	use for construction, timber, shelter, stake, thatching, household equipment, fibre use for doing pillow	123	1.28	20
Cosmetic	Skin care, shampoo, curing freckle on face	11	0.11	4
Effect of poison	anti pest, anti-snake, mosquito repellent	3	0.03	2

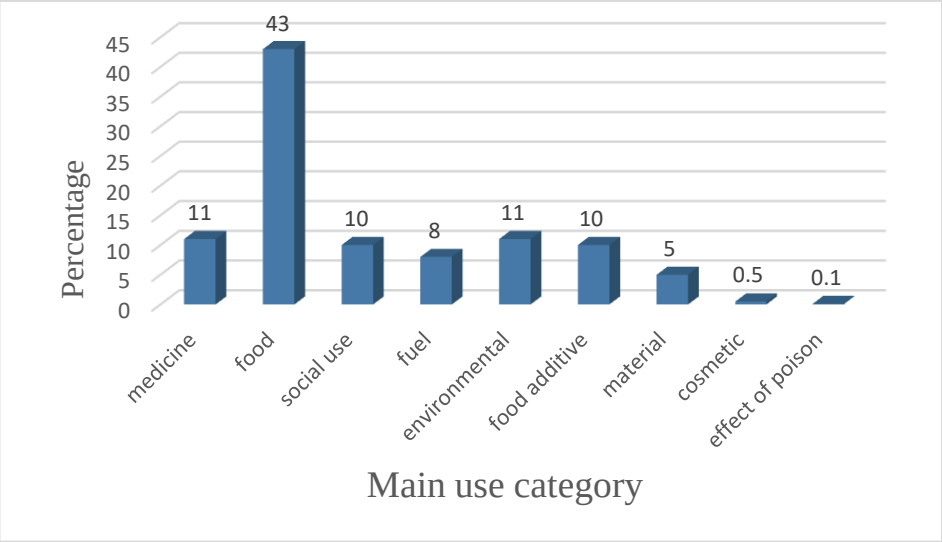

Figure (5) Use Category

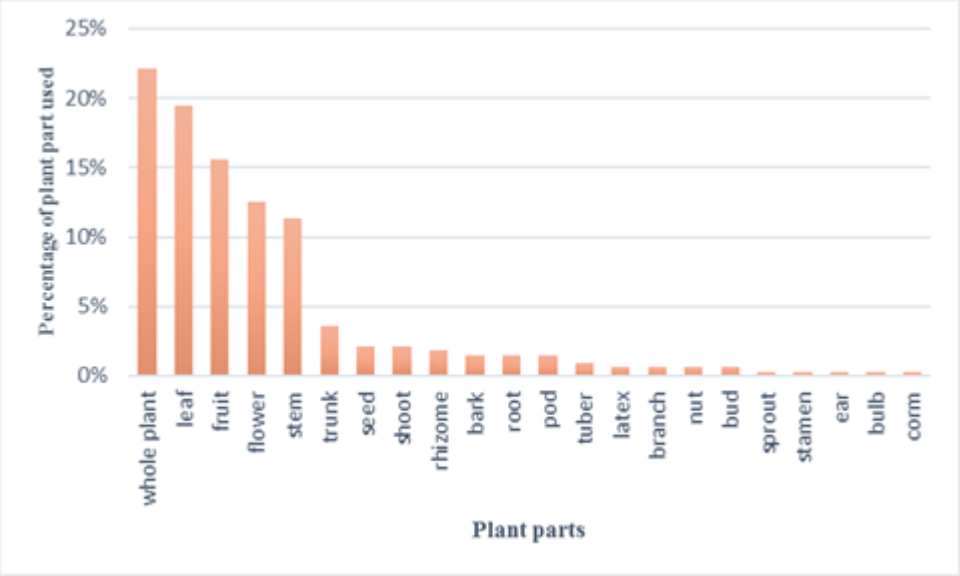

Figure (6) Proportion of plant part used

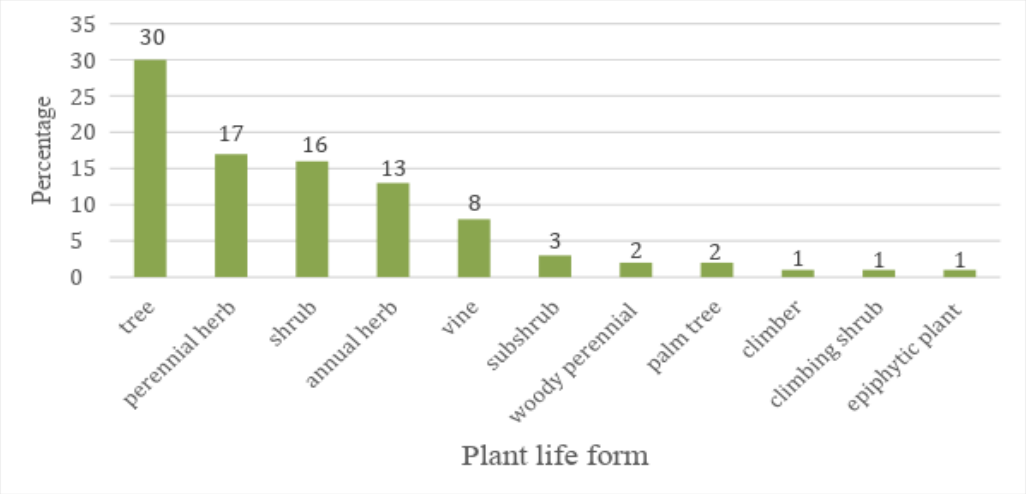

Figure (7) Plant life form

4.2.1 Species used for food

The most cited use category was food which encompasses also the highest number of 96 species **(Table 3)**. The most important species according to use reports and Cultural Importance index were *Tamarindus indica* (145 reports), *Leucaena leucocephala* (84 reports), *Mangifera indica* (66 reports), *Solanum melongena* (60 reports), *Vigna unguiculata* ssp. *sesquipedalis* (55 reports), *Moringa oleifera* (48 reports), *Azadirachta indica* (46 reports), *Cucumis sativus* (45 reports), *Psidium guajava* L. (40 reports), *Carica papaya* (38 reports), *Oroxylum indicum* (36 reports), *Spondias dulcis* (34 reports), *Cocos nucifera* (34 reports), *Musa* spp. (26 reports), *Momordica charantia* (25 reports), *Borassus flabellifer* (23 reports), *Phaseolus lunatus* L. 'Christmas' (22 reports), *Benincasa hispida* (22 reports), *Brassica oleracea* var. *botrytis* (21 reports), *Colocasia esculenta* (21 reports), *Lagenaria siceraria* (21 reports) and *Morinda angustifolia* (20 reports). The remaining species obtained less than 20 use reports.

Among the food crops, 36 species were also commercialized to generate an income. The most widely sold food crops were *Solanum melongena* (58 homegardens), *Vigna unguiculata* ssp. *Sesquipedalis* (56 homegardens), *Cucumis sativus* (46 homegardens), *Momordica charantia* (22 homegardens), *Brassica oleracea* var. *botrytis* (21 homegardens), *Phaseolus lunatus* L. 'Christmas' (18 homegardens), *Capsicum annuum* (17 homegardens), *Abelmoschus esculentus* (16 homegardens), *Allium cepa* (14

homegardens), *Lagenaria siceraria* (11 homegardens), and *Zea mays* (10 homegardens). The other plants were sold by less than 10 respondents.

4.2.2 Medicinal species

The third most important category was medicine and the total number was 68 species **(Table 3)**. Informants used different plant parts for different diseases for both preventive and curative purposes. They are used to treat hypertension, reduce swelling and cure for nausea, eye pain, antitoxic, hepatitis B, injury, constipation, prevention of cancer, anti-aging, kidney disease, dysentery, leukemia, wound, itch, asthma, cholera, anthelmintic medicine, diarrhea, cough, renal lithiasis, sick, pruritus, dizzy, toothache, diabetes, spondylosis, abnormal menses, stomach ache, ascites, gastrointestinal diseases, bleeding from nose, arthritis, bladder stone, hyperglycemia, headache, uterine cancer, diuretic, hypotension, stoke, malaria, paralysis, oliguria, flatulence, vomit, menorrhagia, and poultice. Medicinal species which possesses the highest number of use reports and Cultural Importance index were *Tamarindus indica* (145 reports), *Leucaena leucocephala* (84 reports), *Citrus aurantiifolia* (66 reports), *Moringa oleifera* (48 reports), *Azadirachta indica* (46 reports), *Psidium guajava* L. (40 reports), *Carica papaya* (38 reports), *Cocos nucifera* (34 reports), *Benincasa hispida* (22 reports), *Morinda angustifolia* (20 reports), *Cordyline fruticose* (20 reports), *Curcuma longa* (19 reports), *Citrus limonia* (18 reports), *Hedychium coronarium* J. Koenig (18 reports) and *Aloe vera* Linn. (16 reports). The remaining plants received less than 10 use reports.

4.2.3 Species used for environmental purposes

The second most important use category was environmental use and total number of plants were 63 species **(Table 3)**. I found that respondents used most of tree species as a fence and shading although a few species also for ornamental purposes. Shrub, subshrub and herb were mainly used for the ornamental role. The most culturally important species in this category according to use reports and Cultural Importance index were *Impatiens balsamina* (80 reports), *Azadirachta indica* (46 reports), *Jasminum sambac* (L.) Aiton (32 reports), *Euphorbia neriifolia* (27 reports), *Cosmos bipinnatus* (27 reports), *Cordyline fruticose* (20 reports), *Hedychium coronarium* J. Koenig (18 reports), *Tabernaemontana crassa* (17 reports), *Rosa* spp. (16 reports),

Codiaeum variegatum (14 reports), *Mirabilis jalapa* (10 reports), *Jasminum auriculatum* Vahl (10 reports) and *Gardenia jasminoides* (10 reports) while the other species were not so important as obtaining less than 10 use reports.

4.2.4 Species for social uses

Number of species used for various social uses is 44 species and most of the plants were used for religious purposes such as donation to pagoda and monk, symbol and other traditional social purposes **(Table 3)**. Some species were used for smoking and chewing with added betel nut, lime, tobacco leaf and aniseed. This represents one of the traditions in Myanmar. Furthermore, only one tree was referred as a national flower for traditional Thingyan festival in Myanmar (*Pterocarpus indicus*). Socially used species with the most of use reports and high Cultural Importance index were *Impatiens balsamina* (80 reports), *Cocos nucifera* (34 reports), *Jasminum sambac* (L.) Aiton (32 reports), *Cosmos bipinnatus* (27 reports), *Musa* spp. (26 reports), *Globba winitii* (23 reports), *Cordyline fruticose* (20 reports), *Hedychium coronarium* J. Koenig (18 reports), *Tabernaemontana crassa* (17 reports), *Rosa* spp. (16 reports), *Streblus asper* (16 reports), *Codiaeum variegatum* (14 reports), *Pterocarpus indicus* (12 reports), *Mirabilis jalapa* (10 reports), *Gardenia jasminoides* (10 reports) and *Jasminum auriculatum* Vahl (10 reports).

4.2.5 Species used for fuel

Plants are still used for fuel purposes among the households in the studied villages. Informants used trees as fuelwood for cooking because electricity does not fully reach these areas. Also, fuelwood is used to build a fire during cold season for warming both humans and household animals. This use category included 23 species and most useful species were *Tamarindus indica* (145 reports), *Leucaena leucocephala* (84 reports), *Moringa oleifera* (48 reports), *Albizia lebbek* (47 reports), *Azadirachta indica* (46 reports), *Mitragyna rotundifolia* (43 reports), *Borassus flabellifer* (23 reports) and some other minor ones (Table 3).

4.2.6 Species used as a material

Material use category contained 20 species and they were valuable for constructions and as a household material **(Table 3)**. Trunks were useful for construction of house, hut for household animals, and timber for production of furniture. Other plants were utilized for purposes of thatching the roof, crafting a broom and making a pillow. Among these species, 7 species of higher cultural significance were *Albizia lebbek* (47 reports), *Mitragyna rotundifolia* (43 reports), *Tectona grandis* (24 reports), *Gigantochloa wanet* (22 reports), *Bambusa Chungii* (21 reports), *Streblus asper* (16 reports), and *Pterocarpus indicus* (12 reports).

4.2.7 Species as a food additive

Food additive was one of the essential use categories and 13 species were cited **(Table 3)**. Leaves were mostly used for rice cooking, curry, salad, soup as well as fluid as spice for a pleasant smell. Other plant parts like bulb and fruit pulp was used for taste enhancement. Most important species were *Tamarindus indica* (145 reports), *Citrus aurantiifolia* (66 reports), *Capsicum annuum* (26 reports), *Citrus limonia* (18 reports), *Allium cepa* (17 reports), *Zingiber officinale* (12 reports), *Senegalia pennata* (12 reports), and *Ocimum canum* (10 reports).

4.2.8 Species used in cosmetic and species used for effect of poison

The last two use categories included 4 species used in cosmetic, and 2 species used for effect of poison **(Table 3)**. Bark is used as shampoo with water during washing or bathing. And a yellowish-white cosmetic paste is prepared also from barks (traditional cosmetic for Burmese people). Fleshy fluid and flower stamen are used to care skin and to reach a smooth skin. For effect of poison, two species are very useful, and the leaves and dried rhizome of *Citrus hystrix* and *Curcuma longa* are applied as a prevention of rice weevil by putting it into a rice bag and as mosquito repellent. In case of *Phyllanthus emblica*, fruits are placed around the house and other nearby sites to repel the snakes.

4.3 Natural vegetation (biotic factor)

Among 246 species, sixty species grew naturally in homegardens and their species number per homegarden ranged from 1 to 9 species. However, some wild species occurred only in some gardens apart from 19 common species. Natural vegetation found in 78 homegardens did not occur in the remaining 18 homegardens. According to plant life form, wild species of tree (21), perennial herb (10), annual herb (11), vine (7), shrub (2), woody perennial (2), annual shrub (1), bushy (1), climbing shrub (1), palm tree (1), perennial rhizomatous grass (1), semi-aquatic herb (1), spiny subshrub (1), and subshrub (1) were recorded. These wild plants were used for environmental, food, food additive, fuel, material, medicine and social use purposes (Table 4). It should be noted, that this vegetation is one of the influencing factors on species diversity in the study area.

Table (3) Description of plant life form, plant part use, use categories with the value of user report (UR), cultural importance index (CI), summed dominance ratio (SDR) and frequency of citation (FC) for 246 species documented in the Thegon township, Bago division, Myanmar

No	Local name	English name	Scientific name	Botanical family	Plant life form	Plant part used	Local uses	UR	CI	SDR	FC
1	Man Kyi Pin	Tamarind	*Tamarindus indica*	Fabaceae	tree	fruit, young leaf, stem, whole plant	food additive, food, medicine, fuel, environmental	145	1.51	0.41	78
2	Baw Sakaing	White Leadtree	*Leucaena leucocephala*	Fabaceae	tree	stem, young shoot, young leaf	food, fuel, medicine	84	0.88	0.30	58
3	Dan Pan	Common garden balsam	*Impatiens balsamina*	Balsaminaceae	annual herb	whole plant, flower	environmental, social use	80	0.83	0.21	40
4	Than-ba-ya Thee	Lime	*Citrus aurantiifolia*	Rutaceae	shrub	fruit, leaf	food additive, medicine	66	0.69	0.23	44
5	Tha Yet	Mango	*Mangifera indica*	Anacardiaceae	tree	fruit	food	66	0.69	0.34	66
6	Kha Yan	Eggplant	*Solanum melongena*	Solanaceae	annual herb	fruit	food	60	0.63	0.35	60
7	Pae Taing Htaung	Yard long bean	*Vigna unguiculata*	Fabaceae	vine	pod	food	55	0.58	0.33	55

Table (3) (continued)

			ssp. *sesquipedalis*								
8	Dant Da Lon	Drumstick	*Moringa oleifera*	Moringaceae	tree	fruit, leaf, latex, stem	food, medicine, fuel	48	0.5	0.15	28
9	Koe Ko	Woman's tongue	*Albizia lebbek*	Fabaceae	tree	stem, leaf	fuel, material	47	0.49	0.24	46
10	Ta mar	Neem	*Azadirachta indica*	Meliaceae	tree	leaf, stem, whole plant	food, medicine, fuel, environmental	46	0.48	0.17	32
11	Tha Khwar	Cucumber	*Cucumis sativus*	Cucurbitaceae	vine	fruit	food	45	0.47	0.27	45
12	Bin Ga	Mitragyna	*Mitragyna rotundifolia*	Rubiaceae	tree	trunk, stem	material, fuel	43	0.45	0.23	42
13	Malarkar	Guava	*Psidium guajava* L.	Myrtaceae	tree	fruit, leaf	food, medicine	40	0.42	0.19	36
14	Thin Baw	Papaya	*Carica papaya*	Caricaceae	perennial herb	fruit, young leaf, fruit latex	food, medicine	38	0.4	0.17	32
15	Kyaung Char	Indian trumpet flower	*Oroxylum indicum*	Bignoniaceae	tree	pod	food	36	0.38	0.19	36

Table (3) (continued)

16	Gwe Pin	June plum	*Spondias dulcis*	Anacardiaceae	tree	fruit, young leaf	food	34	0.35	0.18	34
17	Ohn	Coconut palm	*Cocos nucifera*	Arecaceae	palm tree	fruit	food, social use, medicine	34	0.35	0.09	17
18	Sa Pal	Jasmine	*Jasminum sambac* (L.) Aiton	Oleaceae	shrub	whole plant, flower	environmental, social use	32	0.33	0.08	16
19	Shwe Dingar	Garden cosmos	*Cosmos bipinnatus*	Asteraceae	annual herb	whole plant, flower	environmental, social use	27	0.28	0.08	16
20	Ta Saung Kyi	Oleander-leaved euphorbia	*Euphorbia neriifolia*	Euphorbiaceae	shrub	stem	environmental	27	0.28	0.14	27
21	Nga Pyaw Pin	Banana	*Musa* spp.	Musaceae	perennial herb	bud, fruit, stem	food, social use	26	0.27	0.13	25
22	Nga Yoke	Chilli	*Capsicum annuum*	Solanaceae	subshrub	fruit	food additive	26	0.27	0.14	26
23	Gin Khar/ Kyet Hnin Khar Thee	Bitter Gourd	*Momordica charantia*	Cucurbitaceae	vine	fruit	food	25	0.26	0.13	24
24	Kyun Pin	Teak	*Tectona grandis*	Lamiaceae	tree	trunk	material	24	0.25	0.13	24
25	Htan Pin	Asian palmyra palm	*Borassus flabellifer*	Arecaceae	palm tree	stem, fruit, palmyra sprout, root	food, fuel	23	0.24	0.07	14
26	Pa Tain Ma Naing	Dancing Ladies Ginger	*Globba winitii*	Zingiberaceae	annual herb	flower	social use	23	0.24	0.12	23

Table (3) (continued)

27	Kyauk Pha Yone	White gourd	*Benincasa hispida*	Cucurbitaceae	vine	fruit	food, medicine	22	0.23	0.07	13
28	Pae Sate To	Christmas Lima Bean	*Phaseolus lunatus* L 'Christmas'	Fabaceae	vine	seed	food	22	0.23	0.12	22
29	War Nat Warr	Wa-net Bamboo	*Gigantochloa wanet*	Poaceae	woody perennial	stem	material	22	0.23	0.12	22
30	Bu-thi	Bottle gourd	*Lagenaria siceraria*	Cucurbitaceae	vine	shoot	food	21	0.22	0.09	18
31	Htee Yoe War	Barbelletta bamboo	*Bambusa Chungii*	Poaceae	woody perennial	stem	material	21	0.22	0.11	21
32	Pan Gaw Phi Pwint	Cauliflower	*Brassica oleracea* var. botrytis	Brassicaceae	annual herb	flower	food	21	0.22	0.16	21
33	Pain Pin	Taro	*Colocasia esculenta*	Araceae	annual herb	tuber	food	21	0.22	0.10	20
34	Zaw Gyi Taung Hwe	Ti plant	*Cordyline fruticosa*	Asparagaceae	perennial herb	whole plant, leaf	environmental, social use, medicine	20	0.21	0.05	9
35	Awzar	Custard apple	*Annona squamosa*	Annonaceae	shrub	fruit	food	19	0.2	0.1	19
36	Na Nwin	Turmeric	*Curcuma longa*	Zingiberaceae	perennial herb	rhizome	spice, coloring, medicine, repellent	19	0.2	0.03	6
37	Yone Pa Di Thee	Okra	*Abelmoschus esculentus*	Malvaceae	annual herb	pod	food	19	0.2	0.14	19
38	Ywe Yo	Morinda	*Morinda citrifolia*	Rubiaceae	tree	fruit, stem, leaf	medicine, food	20	0.21	0.08	16

Table (3) (continued)

39	Ngwe Pan	White Ginger	*Hedychium coronarium* J. Koenig	Zingiberaceae	perennial herb	tuber, whole plant, flower	medicine, environmental, social use	18	0.12	0.04	7
40	Shauk Thee	Six-month lemon	*Citrus limonia*	Rutaceae	shrub	fruit, young leaf	medicine, food, food additive	18	0.19	0.06	11
41	Kyat thon	Onion	*Allium cepa*	Amaryllidaceae	annual herb	bulb	food additive	17	0.18	0.18	17
42	Sat Kyar Pan	Pinwheel flower	*Tabernaemontana crassa*	Apocynaceae	shrub	whole plant, flower	environmental, social use	17	0.18	0.05	10
43	Hnin Si	Rose	*Rosa* spp.	Rosaceae	woody perennial	whole plant, flower	environmental, social use	16	0.17	0.04	8
44	Ohn Hnae	Siamese rough bush	*Streblus asper*	Moraceae	tree	stem	material, social use	16	0.17	0.08	15
45	Chin Paung	Roselle	*Hibiscus sabdariffa*	Malvaceae	perennial herb	leaf	food	14	0.15	0.09	14
46	Shar Zaung Let Pat	Barbados Aloe	*Aloe vera* Linn.	Asphodelaceae	succulent perennial herb	leaf	medicine, cosmetic	16	0.17	0.05	10
47	Ywet Hla	Garden croton	*Codiaeum variegatum*	Euphorbiaceae	shrub	whole plant, small branches	environmental, social use	14	0.15	0.07	13
48	Pein-ne	Jackfruit	*Artocarpus heterophyllus*	Moraceae	tree	fruit	food	13	0.14	0.07	13

Table (3) (continued)

49	Gin	Ginger	*Zingiber officinale*	Zingiberaceae	perennial herb	rhizome	food additive	12	0.13	0.03	6
50	Padauk	Burmese rosewood	*Pterocarpus indicus*	Fabaceae	tree	flower, trunk	symbol, social use, material	12	0.13	0.03	5
51	Sue poak	Climbing wattle	*Senegalia pennata*	Fabaceae	climbing shrub	leaf	food additive	12	0.13	0.06	12
52	Pyaung Phoo	Maize	*Zea mays*	Poaceae	monecious annual grass	ear	food	11	0.12	0.06	11
53	Lay Nar yi Pan	Four o'clock flower	*Mirabilis jalapa*	Nyctaginaceae	perennial herb	whole plant, flower	environmental, social use	10	0.10	0.03	5
54	Pin Seine	Basil	*Ocimum canum*	Lamiaceae	perennial herb	leaf	food additive	10	0.10	0.05	10
55	Zi Za War	Golden Magic Cape Jasmine	*Gardenia jasminoides*	Rubiaceae	shrub	whole plant, flower	environmental, social use	10	0.10	0.03	5
56	Zun Pan	Mogra	*Jasminum auriculatum* Vahl,	Oleaceae	subshrub	whole plant, flower	environmental, social use	10	0.10	0.03	5
57	Artar Laut	Arrowroot	*Maranta arundinacea*	Marantaceae	perennial herb	rhizome	food	9	0.1	0.05	9
58	Ka Yan Kyut	White eggplant	*Solanum ovigerum*	Solanaceae	perennial herb	fruit	food	9	0.1	0.05	9
59	Kywe Kaw	Pomelo	*Citrus maxima*	Rutaceae	tree	fruit	food	9	0.1	0.05	9
60	Mal Za Le	Kassod tree	*Cassia siamea*	Fabaceae	tree	stem, bud	fuel, medicine	9	0.1	0.03	5

Table (3) (continued)

61	Na Nwin Khar	Turmeric	*Curcuma comosa*	Zingiberaceae	perennial herb	rhizome	medicine	8	0.08	0.04	7
62	San Kwae Pan	Siamese white ixora	*Ixora finlaysoniana*	Rubiaceae	bushy	whole plant, flower	environmental, social use	9	0.1	0.03	5
63	Ywet Hla Kyar	Croton	*Croton* spp.	Euphorbiaceae	shrub	whole plant, small branches	environmental, social use	9	0.1	0.04	7
64	Ar Si Yan Tha Pyay	Eugenia leaf	*Syzygium campanulatum*	Myrtaceae	shrub	whole plant, shoot	environmental, social use	8	0.08	0.02	4
65	Gaw Phi Htoke	Cabbage	*Brassica oleracea* var. capitata	Brassicaceae	annual herb	densely leaved head	food	8	0.08	0.06	8
66	Kiss Me Quick	Crown of thorns	*Euphorbia milii*	Euphorbiaceae	shrub	whole plant, leaf	environmental, medicine	8	0.08	0.02	4
67	Kun Pin	Betel vine	*Piper betle*	Piperaceae	vine	leaf	food	8	0.08	0.04	8
68	Nan Nan	Coriander	*Coriandrum sativum*	Apiaceae	annual herb	whole plant	food additive	8	0.083	0.09	8
69	Pan Tamar	Chinaberry tree	*Melia azedarach*	Meliaceae	tree	stem, whole plant	fuel, environmental	8	0.08	0.03	5
70	Salad	Lettuce	*Lactuca sativa*	Asteraceae	annual herb	leaf	food	8	0.08	0.06	8
71	Thit Kwa	Orchid	*Phalaenopsis* spp.	Orchidaceae	epiphytic plant	whole plant, flower	environmental, social use	8	0.08	0.04	7
72	Bandar	Indian Almond	*Terminalia catappa*	Combretaceae	tree	stem, nut	fuel, food	7	0.07	0.02	4

Table (3) (continued)

73	Kin-mun-chin	Soap Acacia	*Acacia concinna* DC	Fabaceae	climbing shrub	leaf	food	7	0.07	0.04	7
74	Shwe Pha Yone Thee	Pumpkin	*Cucurbita maxima*	Cucurbitaceae	vine	fruit, shoot	food	7	0.07	0.04	7
75	Tha Net Khar Pin	Wood Apple	*Naringi crenulata*	Rutaceae	tree	bark, leaf	cosmetic, medicine	7	0.07	0.03	5
76	Zee Yar Owe Poak	Cumin	*Cuminum cyminum*	Apiaceae	annual herb	leaf	food, medicine	7	0.07	0.03	6
77	Aung Tha Pyay Pan	Java plum	*Syzygium cumini*	Myrtaceae	tree	leaf, fruit	social use, food	6	0.06	0.02	4
78	Ka Yan Chin Thee	Tomato	*Solanum lycopersicum*	Solanaceae	annual herb	fruit	food	6	0.06	0.03	6
79	Kha Wae	Ridged-gourd	*Luffa acutangula*	Cucurbitaceae	annual climbing herb	fruit	food	6	0.06	0.03	6
80	Na Phyu Kyi Pin	Apple of sodom	*Calotropis gigantea*	Apocynaceae	shrub	bark	medicine	6	0.06	0.03	6
81	Ohm Chit	Bael fruit	*Aegle marmelos* Corr	Rutaceae	tree	fruit, leaf	food, medicine	6	0.06	0.02	3
82	Pae Saung Khar Thee	Winged bean	*Psophocarpus tetragonolobus*	Fabaceae	vine	pod	food	6	0.06	0.04	6
83	Pyin Taw Thein	Curry leaf	*Murraya koenigii*	Rutaceae	tree	leaf	food additive	6	0.06	0.03	6
84	Sat Hna Yar Thi Pan	Yellow oleander	*Cascabela thevetia (L.)* Lippold	Apocynaceae	shrub	whole plant, flower	environmental, social use	6	0.06	0.02	3

Table (3) (continued)

85	Shan Nan Nan	Culantro	*Eryngium foetidum*	Apiaceae	perennial herb	leaf	food additive	6	0.06	0.03	6
86	Zee Pin	Jujube	*Ziziphus jujuba*	Rhamnaceae	tree	fruit	food	6	0.06	0.03	6
87	Bauk Thee Pin	Pygmy groundcherry	*Physalis minima*	Solanaceae	perennial herb	fruit, leaf	food, medicine	5	0.05	0.02	4
88	Kadet	Three - Leaved Caper	*Crataeva religiosa* Forst	Capparaceae	tree	stem, leaf	fuel, food	5	0.05	0.03	5
89	Kalar Pin Seine	Holy basil	*Ocimum tenuiflorum*	Lamiaceae	shrub	leaf	medicine	5	0.05	0.03	5
90	Kaung Yan Pan	Rose mallow	*Hibiscus schizopetalus*	Malvaceae	shrub	whole plant, flower	environmental, social use	5	0.05	0.02	4
91	Kyauk Kwe Pin	Chinese Violet	*Asystasia gangetica*	Acanthaceae	perennial herb	leaf, stem	medicine	5	0.05	0.03	5
92	Kyee Kan Pan	Madagascar periwinkle	*Catharanthus roseus*	Apocynaceae	subshrub	whole plant, flower	environmental, social use	5	0.05	0.02	3
93	Kyet-mauk Pan	Cock’s comb	*Celosia argentea*	Amaranthaceae	annual shrub	flower	social use	5	0.05	0.03	5
94	Lan-tama/ Yae Tamar	False ashoka	*Polyalthia longifolia*	Annonaceae	tree	whole plant, stem	environmental, fuel	5	0.05	0.03	5
95	Taw Kyat Hnin Khar	Balsam apple	*Momordica balsamina*	Cucurbitaceae	vine	fruit	food	5	0.05	0.03	5
96	Taw Zee Phyu	Gooseberry	*Phyllanthus emblica*	Phyllanthaceae	tree	fruit	food, medicine, effect of poison	5	0.05	0.01	2

Table (3) (continued)

97	Tayoke Sakar Pan	Frangipani flower	*Plumeria rubra*	Apocynaceae	tree	flower	food	5	0.05	0.03	5
98	Zaw Seine	Green Ti Plant	*Cordyline glauca*	Asparagaceae	shrub	whole plant	social use	5	0.05	0.03	5
99	Ar Yone Pan	Night-flowering jasmine	*Nyctanthes arbortristis*	Oleaceae	shrub	whole plant, flower	environmental, social use	4	0.04	0.01	2
100	Chauk Cho Thee	Sweet orange	*Citrus sinensis*	Rutaceae	shrub	fruit	food	4	0.04	0.02	4
101	Gway Touk Pin	Giant swallowart	*Dregea volubilis*	Apocynaceae	vine	leaf	food	4	0.04	0.02	4
102	Kha Yan Ka Sawe	Indian nightshade	*Solanum indicum*	Solanaceae	shrub	fruit	food	4	0.04	0.02	4
103	Ko Yan Kyi Pin	Lily Poison Bulb	*Crinum asiaticum* Linn	Amaryllidaceae	perennial herb	whole plant, flower	environmental, social use	4	0.04	0.01	2
104	Kun-thee Pin	Betel – nut	*Areca catechu* Linn.	Arecaceae	palm tree	nut	food	4	0.04	0.02	4
105	Kyal Pae	Star Bean	*Plukenetia volubilis*	Euphorbiaceae	vine	seed, pod, shoot	medicine, food	4	0.04	0.02	3
106	Kyo Thee Pin	Ceylon oak	*Schleichera oleosa*	Sapindaceae	tree	fruit	food, medicine	4	0.04	0.01	2
107	Mate Tha Lin	Wild ginger	*Zigiber barbatum*	Zingiberaceae	perennial herb	root	medicine	4	0.04	0.02	4
108	Nar Net	Pineapple	*Ananas comosus*	Bromeliaceae	perennial herb	fruit	food	4	0.04	0.02	4

Table (3) (continued)

109	Nwe Thar Gi Pan	Oleander	*Nerium oleander*	Apocynaceae	shrub	whole plant, flower	environmental, social use	4	0.04	0.01	2
110	Sa Palin	Lemon grass	*Cymbopogon citratus*	Poaceae	perennial herb	stem	food additive, medicine	4	0.04	0.01	2
111	Shwe Ku Than Layet	Tick clover	*Tadehagi triquetrum*	Fabaceae	shrub	leaf	medicne	4	0.04	0.02	4
112	Sin Tone Ma Nwe	Heart-leaved moonseed	*Tinospora cordifolia*	Menispermaceae	climber	stem	medicine	4	0.04	0.02	4
113	Tha Nat Khar Pan	Chinese perfume plant	*Aglaia odorata*	Meliaceae	tree	whole plant, flower	environmental, social use	4	0.04	0.02	3
114	Thit Seint Pin	Bahera	*Terminalia bellirica*	Combretaceae	tree	stem, seed	fuel, food	4	0.04	0.01	2
115	U Ka Lit	Eucalypt	*Eucalyptus globulus*	Myrtaceae	tree	trunk	material	4	0.04	0.02	4
116	Chin Yoke	Garuga plant	*Garuga pinnata*	Burseraceae	tree	trunk, stem	material, medicine	3	0.03	0.01	2
117	Ga Mone Tain Pyar	Black turmeric	*Curcuma caesia*	Zingiberaceae	perennial herb	whole plant, tuber	environmental, medicine	3	0.03	0.01	2
118	Gant Gaw	Cobra's saffron	*Mesua ferrea*	Calophyllaceae	tree	whole plant, flower, stamen	environmental, social use, cosmetic	3	0.03	0.01	1
119	Gone Na Mar	Zig-Zag Plant	*Euphorbia tithymaloides*	Euphorbiaceae	perennial herb	leaf	medicine	3	0.03	0.02	3

Table (3) (continued)

120	Htet Tayar Pan	Marigold	*Tagetes* spp.	Asteraceae	perennial herb	whole plant, flower	environmental, social use	3	0.03	0.01	2
121	Ka Yae	Star Flower	*Minusops elengi*	Sapotaceae	tree	trunk, whole plant, flower	material, environmental, social use	3	0.03	0.01	1
122	Kan Na Phot	Helencha plant	*Enhydra fluctuans*	Asteraceae	semi-aquatic herb	leaf	medicine	3	0.03	0.02	3
123	Kaung Mee Tu Pan	Red hot cat's tail	*Acalypha hispida*	Euphorbiaceae	shrub	whole plant	environmental	3	0.03	0.02	3
124	Kyan	Sugarcane	*Saccharum officinarum*	Poaceae	tall perennial grass	stem	food	3	0.03	0.02	3
125	Kyat Tu Yway Pan	Globba	*Globba sessiliflora*	Zingiberaceae	perennial herb	flower	social use	3	0.03	0.02	3
126	Kyate Hman Ywat	False daisy	*Eclipta prostrata*	Asteraceae	annual herb	flower, leaf, whole plant	medicine	3	0.03	0.02	3
127	Kyet Suu	Phisic Nut	*Jatropha curcas*	Euphorbiaceae	shrub	whole plant	environmental	3	0.03	0.02	3
128	Kyi Pin	Indian Oak	*Barringtonia acutangula*	Lecythidaceae	tree	stem	fuel	3	0.03	0.02	3
129	Lae Pin	Silk cotton tree	*Ceiba pentandra*	Malvaceae	tree	fibre inside fruit	material	3	0.03	0.02	3
130	Lat Pan	Red silk-cotton	*Bombax ceiba*	Malvaceae	tree	stem	fuel	3	0.03	0.02	3

Table (3) (continued)

131	Pha Lan Taung Hmawe	Crepe ginger	*Cheilocostus speciosus*	Costaceae	perennial herb	stem	food	3	0.03	0.02	3
132	Pha Yaung Thit Kwa	Musky-smelling Dendrobium	*Dendrobium moschatum*	Orchidaceae	epiphytic plant	whole plant	environmental	3	0.03	0.02	3
133	Pyin Ma Pin	Queen's crepe-myrtle	*Lagerstroemia speciosa*	Lythraceae	tree	stem, seed	fuel, medicine	3	0.03	0.01	2
134	Sate Phoo	Fingerroot	*Boesenbergia rotunda*	Zingiberaceae	annual herb	rhizome	food	3	0.03	0.02	3
135	Sekku-pan	Great bougainvillea	*Bougainvillea spectabilis*	Nyctaginaceae	shrub	whole plant	environmental	3	0.03	0.02	3
136	Shout Gwe Thee	Kaffir lime	*Citrus hystrix*	Rutaceae	shrub	fruit, leaf	food additive, effect of poison, medicine	3	0.03	0.01	2
137	Tan Myet See Pin	Common wireweed	*Sida acuta*	Malvaceae	subshrub	whole plant	household equipment	3	0.03	0.02	3
138	War Ou / Phyan Pin	Elephant foot yam	*Amorphophallus paeoniifolius*	Araceae	perennial herb	corm	food	3	0.03	0.02	3
139	Yone Pin	Axlewood	*Anogeissus acuminata*	Combretaceae	tree	trunk	material	3	0.03	0.01	3
140	Yuzana Pan	Rosebay	*Murraya paniculata*	Rutaceae	shrub	whole plant, flower	environmental, social use	3	0.03	0.02	2

Table (3) (continued)

141	Zaung Hylar	Star apple	*Averrhoa carambola* Linn.	Oxalidaceae	tree	fruit	food, medicine	3	0.03	0.01	2
142	A Kayit Pin	Indian cork tree	*Millingtonia hortensis*	Bignoniaceae	tree	stem, leaf	fuel, food	2	0.02	0.01	2
143	Daung Ga Mone	Calathea	*Calathea picturata*	Marantaceae	rhizomatous perennial herb	whole plant	environmental	2	0.02	0.01	2
144	Ga Mone Pin	Chinese evergreen	*Aglaonema spp.*	Araceae	perennial herb	whole plant	environmental	2	0.02	0.01	2
145	Hti-ka-yone	Touch-me-not	*Mimosa pudica*	Fabaceae	spiny subshrub	whole plant	medicine	2	0.02	0.01	2
146	Ka Thit	Cockspur Coral tree	*Erythrina crista*	Fabaceae	tree	leaf	food, medicine	2	0.02	0.01	1
147	Kan Zoon Pin	Water spinach	*Ipomoea aquatica*	Convolvulaceae	vine	shoot	food	2	0.02	0.01	2
148	Khar Aung Pin	Hairy fig	*Ficus hispida*	Moraceae	tree	fruit, stem	medicine, fuel	2	0.02	0.01	1
149	Khu Than	Bridal couch tree	*Hymenodictyon orixense*	Rubiaceae	tree	stem	fuel	2	0.02	0.01	2
150	Kwae Lay Yar Thee Pin	Velvet bean	*Mucuna pruriens*	Fabaceae	vine	seed	medicine	2	0.02	0.01	2
151	Kyauk Ket Pan	Wilma Goldcrest Cypress	*Cupressus macrocarpa* 'Wilma Goldcrest	Cupressaceae	woody perennial	whole plant	environmental	2	0.02	0.01	2
152	Kyet Mauk Thee	Rambutan	*Nephelium lappaceum*	Sapindaceae	tree	fruit	food	2	0.02	0.01	2

Table (3) (continued)

153	Mee Gwin Ga Mone	Oyster Plant	*Tradescantia spathacea*	Commelinaceae	perennial herb	leaf	medicine	2	0.02	0.01	2
154	Myin Kwar	Asiatic pennywort	*Hydrocotyle asiatica*	Apiaceae	annual herb	whole plant	food	2	0.02	0.07	2
155	Nagar Mauk	Dragon fruit	*Hylocereus undatus*	Cactaceae	climber	fruit	food	2	0.02	0.01	2
156	Nga Hmwe Pan	Night-blooming jasmine	*Cestrum nocturnum*	Solanaceae	shrub	whole plant, flower	environmental, social use	2	0.02	0.01	1
157	Nga Yant Pa Tu	Tube flower	*Clerodendron siphonanthus* R.Br.	Verbenaceae	annual herb	leaf	food	2	0.02	0.01	2
158	Owe Poak Pin	Indian Rhododendron	*Melastoma malabathricum*	Melastomataceae	shrub	leaf	medicine	2	0.02	0.01	2
159	Pauk Pan Phyu	Vegetable hummingbird	*Sesbania grandiflora*	Fabaceae	tree	flower and young leaf	food	2	0.02	0.01	2
160	Pauk Pin	Flame-of-the-forest	*Butea monosperma*	Fabaceae	tree	trunk, flower	material, medicine	2	0.02	0.01	1
161	Pi Sat Pin	Siam weed	*Chromolaena odorata*	Asteraceae	perennial herb	leaf	medicine	2	0.02	0.01	2
162	Poe Sar Pin	Mulberry	*Morus alba*	Moraceae	tree	leaf	animal food	2	0.02	0.01	2
163	Pone Nyat	Alexandrian laurel	*Calophyllum inophyllum*	Calophyllaceae	tree	trunk	material	2	0.02	0.01	2
164	Pusi Nan	Wild mint	*Mentha arvensis*	Lamiaceae	annual herb	leaf	food	2	0.02	0.01	2

Table (3) (continued)

165	Pwint Tu Ywet Tu	Poinsettia	*Euphorbia pulcherrima*	Euphorbiaceae	shrub	whole plant	environmental	2	0.02	0.01	2
166	Sate Noe	Milk weed	*Euphorbia hirta*	Euphorbiaceae	annual herb	whole plant	medicine	2	0.02	0.01	2
167	Saung Taw Kuu Pan	Snow creeper	*Porana volubilis*	Convolvulaceae	tree	whole plant, flower	environmental, social use	2	0.02	0.01	1
168	Say - gha – gyi	King of Bitters	*Andrographis paniculata* Nees	Acanthaceae	annual herb	leaf	medicine	2	0.02	0.01	2
169	Sein Ga Mone	Lantana	*Lantana camara*	Verbenaceae	subshrub	flower	social use	2	0.02	0.01	2
170	Sein Shal	Golden tickseed	*Coreopsis tinctoria*	Asteraceae	annual herb	whole plant, flower	environmental, social use	2	0.02	0.01	1
171	Sin Hnar Maung Pin	Grey leaf heliotrope plant	*Heliotropium ovalifolium* Forssk.	Boranginaceae	perennial herb	leaf, whole plant	medicine	2	0.02	0.01	2
172	Soon-Mhway-Ywet	Pandan Leave	*Pandanus amaryllifolius*	Pandanaceae	shrub	leaf	food additive	2	0.02	0.01	2
173	Swe Taw Pan	Dwarf white bauhinia	*Bauhinia acuminata*	Fabaceae	shrub	whole plant, leaf	environmental, food	2	0.02	0.01	1
174	Tha Kha Ma Thee	Squash	*Cucumis moschata*	Cucurbitaceae	vine	fruit	food	2	0.02	0.01	2
175	Tha Khout Pwint	Mangrove trumpet tree	*Dilichandrone spathacea*	Bignoniaceae	tree	flower, bark	food, medicine	2	0.02	0.01	1
176	Tha Kyar Ma Kite	Java tea	*Orthosiphon*	Lamiaceae	perennial herb	leaf	medicine	2	0.02	0.01	2

Table (3) (continued)

			aristatus								
177	Tha Net Pin	Fragrant manjack	*Cordia dichotoma*	Boraginaceae	tree	stem	fuel	2	0.02	0.01	2
178	Than Pu Yoe Thee	Lemon	*Citrus limon*	Rutaceae	shrub	fruit	food	2	0.02	0.01	2
179	That Kal	Cogon grass	*Imperata cylindrica*	Poaceae	perennial rhizomatous grass	whole plant	material	2	0.02	0.01	2
180	Thaw Ka Pin	Pride of Burma	*Amherstia nobilis*	Fabaceae	tree	trunk, whole plant	material, environmental	2	0.02	0.01	1
181	Thee Pin	Wood-Apple	*Feronia elephantum*	Rutaceae	tree	fruit	food	2	0.02	0.01	2
182	Thet Yin Kyee	Croton tree	*Croton persimilis*	Euphorbiaceae	tree	leaf	medicine	2	0.02	0.01	2
183	Za Latt Pan	Crape gardenia	*Tabernaemontana divaricata*	Apocynaceae	shrub	whole plant, flower	environmental, social use	2	0.02	0.01	1
184	Ar Thaw Ka Pin	Ashoka tree	*Saraca indica*	Fabaceae	tree	bark	medicine	1	0.01	0.01	1
185	Ball lone pan	Ball lily	*Scadoxus multiflorus*	Amaryllidaceae	perennial bulbous herb	whole plant	environmental	1	0.01	0.01	1
186	Bone Ma Yar Sar	Indian snakeroot	*Rauwolfia serpentina*	Apocynaceae	subshrub	root	medicine	1	0.01	0.01	1
187	Chin-baung-kha	Bastard jute	*Hibiscus cannabinus*	Malvaceae	perennial herb	leaf	food	1	0.01	0.01	1
188	Dae Li Yar Pin	Dahlia	*Dahlia spp.*	Asteraceae	perennial herb	whole plant	environmental	1	0.01	0.01	1

Table (3) (continued)

189	Duyin	Durian	*Durio zibethinus*	Malvaceae	tree	fruit	food	1	0.01	0.01	1
190	Duyin Awzar	Soursop	*Annona muricata*	Annonaceae	tree	fruit	food	1	0.01	0.01	1
191	Eik-tha-ra-muli	Indian birthwort	*Aristolochia indica*	Aristolochiaceae	vine	leaf	medicine	1	0.01	0.01	1
192	Gan Ta Mar Pan	Chrysanthemum	*Chrysanthemum indicum*	Asteraceae	annual herb	flower	social use	1	0.01	0.01	1
193	Ginseng	Asian ginseng	*Panax ginseng*	Araliaceae	perennial herb	leaf	medicine	1	0.01	0.01	1
194	Hmyit	Bamboo shoots	*Bambusa spp.*	Poaceae	woody perennial	shoot	food	1	0.01	0.01	1
195	Hnin Nu New	Amaranthus	*Amaranthus blitum*	Amaranthaceae	annual herb	leaf and young stem	food	1	0.01	0.01	1
196	Hnin Pan	Fairy lily	*Zephyranthes rosea*	Amaryllidaceae	perennial herb	whole plant	environmental	1	0.01	0.01	1
197	Hti Ka Yone	Water mimosa	*Neptunia oleracea*	Fabaceae	aquatic herb	leaf	food	1	0.01	0.01	1
198	Kaung Sae Pin	Indian Acalypha	*Acalypha indica*	Euphorbiaceae	annual herb	root	medicine	1	0.01	0.01	1
199	Khaing Shwe War Pan	Shower-of-gold	*Galphimia gracilis*	Malpighiaceae	shrub	flower	social use	1	0.01	0.01	1
200	Kin Mon Thee	Ivy gourd	*Coccinia grandis*	Cucurbitaceae	vine	fruit	food	1	0.01	0.01	1
201	Lan Shouk Pan	Evergreen spindle	*Euonymus japonicus*	Celastraceae	shrub	whole plant	environmental	1	0.01	0.01	1
202	Lat Nyoe Htoe Pin	Firestick plants	*Euphorbia tirucalli*	Euphorbiaceae	shrub	stem	medicine	1	0.01	0.01	1
203	Lein Maw	Tangor	*Citrus nobilis*	Rutaceae	shrub	fruit	food	1	0.01	0.01	1

Table (3) (continued)

204	Longan	Logan	*Dimocarpus longan*	Sapindaceae	tree	fruit	food	1	0.01	0.01	1
205	Ma Yan Thee	Gandaria	*Bouea burmanica* Griff.	Anacardiaceae	tree	fruit	food	1	0.01	0.01	1
206	Mahar Gar Kyan Sit	Chinese knotweed	*Polygonum chinense*	Polygonaceae	perennial herb	leaf	medicine	1	0.01	0.01	1
207	Mone lar Ywet	Baby Radish leaves	*Raphanus* spp.	Brassicaseae	annual herb	leaf	food	1	0.01	0.01	1
208	Mone lar U Phyu	White Radish	*Raphanus sativus*	Brassicaseae	annual herb	root	food	1	0.01	0.01	1
209	Nagar Set Pin	Snake plant	*Sansevieria trifasciata*	Asparagaceae	perennial herb	whole plant	environmental	1	0.01	0.01	1
210	Nu War	Golden shower	*Cassia fistula* L.	Fabaceae	tree	whole plant	environmental	1	0.01	0.01	1
211	Nwai -pe	Summer bean	*Lablab vulgaris* (L.) Savi	Fabaceae	vine	seed	food	1	0.01	0.01	1
212	Nwe Lein Maw	Passion fruit	*Passiflora edulis*	Passifloraceae	vine	fruit	food	1	0.01	0.01	1
213	Nyaung Pin	Peepul tree	*Ficus religiosa*	Moraceae	tree	whole plant	environmental	1	0.01	0.01	1
214	Pa Tae Gaw	Greater	*Alpinia galanga*	Zingiberaceae	perennial herb	flower	medicine	1	0.01	0.01	1
215	Pane Pan	Tailflower	*Anthurium spp*	Araceae	perennial herb	whole plant	environmental	1	0.01	0.01	1
216	Patar Myar Pan	Faming katy	*Kalanchoe blossfeldiana*	Crassulaceae	perennial herb	whole plant	environmental	1	0.01	0.01	1
217	Pay Pin	Talipot palm	*Corypha umbraculifera*	Arecaceae	tree	fruit	food	1	0.01	0.01	1

Table (3) (continued)

218	Phat Than	Katsagon tree	*Haplophragma adenophyllum*	Bignoniaceae	tree	trunk	material	1	0.01	0.01	1
219	Pi Sat A Phyu	Goatweed	*Ageratum conyzoides*	Asteraceae	annual herb	leaf	medicine	1	0.01	0.01	1
220	Pin Hmae Lein-maw	Mandarin	*Citrus reticulata*	Rutaceae	tree	fruit	food	1	0.01	0.01	1
221	Pwe Kaing Malzali/ Thinbaw Malzali	Ringworm	*Cassia alata* Linn.	Fabaceae	tree	leaf	medicine	1	0.01	0.01	1
222	Sa Kar Lat Pin	Champak	*Magnolia champaca*	Magnoliaceae	tree	whole plant	environmental	1	0.01	0.01	1
223	Sa Par	Rice	*Oryza sativa*	Poaceae	erect annual grass	seed	food	1	0.01	0.01	1
224	Sae Nar Yi Pan	Moss rose	*Portulaca grandiflora*	Portulacaceae	annual herb	whole plant	environmental	1	0.01	0.01	1
225	Sein Pan	Pride of Barbados	*Caesalpinia pulcherrima*	Fabaceae	tree	whole plant	environmental	1	0.01	0.01	1
226	Taung Zi Phyu	Niruri	*Phyllanthus urinaria*	Euphorbiaceae	annual herb	whole plant	medicine	1	0.01	0.01	1
227	Taw Htan (Taung Htan)	Assam Fan Palm	*Livistona jenkinsiana*	Arecaceae	palm tree	leaf	material	1	0.01	0.01	1
228	Taw Lay Hyin	Primrose willow	*Ludwigia hyssopifolia*	Onagraceae	annual herb	whole plant	medicine	1	0.01	0.01	1
229	Tayaw Pin	Hairy indigo	*Grewia hirsuta* Vahl	Malvaceae	tree	bark	cosmetic	1	0.01	0.01	1

Table (3) (continued)

230	Tha Kyar Thee Pin	Sapodilla	*Achras sapota*	Sapotaceae	tree	fruit	food	1	0.01	0.01	1
231	Tha Phan Pin	Cluster fig tree	*Ficus glomerata*	Moraceae	tree	stem	fuel	1	0.01	0.01	1
232	Tha Yat Kinn	Mango ginger	*Curcuma amada*	Zingiberaceae	perennial herb	rhizome	food	1	0.01	0.01	1
233	Than Ma Naing Kyauk Ma Naing	Alyce clover	*Alysicarpus vaginalis*	Fabaceae	perennial herb	leaf	medicine	1	0.01	0.01	1
234	Than Thet Pin	Potka Siris	*Albizia lucidior*	Fabaceae	tree	stem	material	1	0.01	0.01	1
235	Thin Baw Kyat Su	Bellyache bush	*Jatropha gossypiifolia*	Euphorbiaceae	shrub	leaf	medicine	1	0.01	0.01	1
236	Thit Min	Adam's needle	*Yucca gloriosa*	Asparagaceae	shrub	whole plant	environmental	1	0.01	0.01	1
237	Thit Sar Pan (Haw Lan)	Red Gladiolus	*Gladiolus communis*	Iridaceae	annual herb	flower	social use	1	0.01	0.01	1
238	Tight Pan A Pyar	Glory-bower	*Clerodendrum thomsoniae*	Lamiaceae	twining shrub	whole plant	environmental	1	0.01	0.01	1
239	War Min	Buddha Bamboo	*Bambusa tuldoides*	Poaceae	clump-forming bamboo	whole plant	environmental	1	0.01	0.01	1
240	Yae Ta Char Pin	Pacific almond	*Canarium resiniferum*	Burseraceae	tree	trunk	material	1	0.01	0.01	1
241	Yae Tha Kyi Pin	Egyptian rattlepod	*Sesbania sesban*	Fabaceae	tree	leaf	medicine	1	0.01	0.01	1
242	Yangon Sapal	Sarsaparilla	*Jasminum multiflorum*	Apocynaceae	subshrub	flower	social use	1	0.01	0.01	1

Table (3) (continued)

243	Yin Mar	Golden mahogany	*Chukrasia tabularis*	Meliaceae	tree	stem	fuel	1	0.01	0.01	1
244	Yin Tike	Burma Blackwood	*Dalbergia cultrata*	Fabaceae	vine	stem	fuel	1	0.01	0.01	1
245	Ywet Hla Koe Ko	Snow Bush	*Breynia nivosa 'Roseo-Picta"*	Phyllanthaceae	shrub	whole plant	environmental	1	0.01	0.01	1
246	Ywet Kya Pin	Air plant	*Bryophyllum pinnatum*	Crassulaceae	perennial herb	whole plant	environmental	1	0.01	0.01	1

Table (4) Description of sixty species grown naturally in homegardens ordered in descending order of frequency of citation (FC)

No	local name	English Name	Scientific Name	Family	Plant life form	Plant part use	Use category	FC (naturally grown in HG)	FC (cultivated in HG)	FC (total HG)
1	Baw Sakaing	White Leadtree	*Leucaena leucocephala*	Fabaceae	tree	stem, young shoot, young leaf	food, fuel, medicine	34	24	58
2	Koe Ko	Woman's tongue	*Albizia lebbek*	Fabaceae	tree	stem, leaf	fuel, material	23	23	46
3	Dan Pan	Common garden balsam	*Impatiens balsamina*	Balsaminaceae	annual herb	whole plant, flower	environmental, social use	20	20	40
4	Ta mar	Neem	*Azadirachta indica*	Meliaceae	tree	leaf, stem, whole plant	food, medicine, fuel, environmental	14	18	32
5	Dant Da Lon	Drumstick	*Moringa oleifera*	Moringaceae	tree	fruit, leaf, latex, stem	food, medicine, fuel	13	15	28
6	Bin Ga	Mitragyna	*Mitragyna rotundifolia*	Rubiaceae	tree	stem	material, fuel	12	30	42
7	Ta Saung Kyi	Oleander-leaved	*Euphorbia*	Euphorbiaceae	shrub	stem	environmental	9	18	27

Table (4) (continued)

		euphorbia	*neriifolia*							
8	Kyaung Char	Indian trumpet flower	*Oroxylum indicum*	Bignoniaceae	tree	pod	food	8	28	36
9	Man Kyi Pin	Tamarind	*Tamarindus indica*	Fabaceae	tree	fruit, young leaf, stem, plant	food additive, food, medicine, fuel, environmental	8	70	78
10	Ohn Hnae	Siamese rough bush	*Streblus asper*	Moraceae	tree	stem	material, social use	6	9	15
11	Taw Kyat Hnin Khar	Balsam apple	*Momordica balsamina*	Cucurbitaceae	vine	fruit	food	5	0	5
12	Tha Yet	Mango	*Mangifera indica*	Anacardiaceae	tree	fruit	food	5	61	66
13	Kyauk Pha Yone	White gourd	*Benincasa hispida*	Cucurbitaceae	vine	fruit	medicine, food	5	8	13
14	Zee Yar Owe Poak	Cumin	*Cuminum cyminum*	Apiaceae	annual herb	leaf	food, medicine	4	2	6
15	Kha Yan Ka Sawe	Indian nightshade	*Solanum indicum*	Solanaceae	shrub	fruit	food	4	0	4
16	Bauk Thee	Pygmy	*Physalis minima*	Solanaceae	perennial	fruit, leaf	food, medicine	4	0	4

Table (4) (continued)

	Pin	groundcherry			herb					
17	Tan Myet See Pin	Common wireweed	*Sida acuta*	Malvaceae	subshrub	whole plant	material	3	0	3
18	Pha Lan Taung Hmawe	Crepe ginger	*Cheilocostus speciosus*	Costaceae	perennial herb	stem	food	3	0	3
19	Kyate Hman Ywat	False daisy	*Eclipta prostrata*	Asteraceae	annual herb	flower, leaf, whole plant	medicine	3	0	3
20	Kyi Pin	Indian Oak	*Barringtonia acutangula*	Lecythidaceae	tree	stem	fuel	3	0	3
21	Thin Baw	Papaya	*Carica papaya*	Caricaceae	perennial herb	fruit, young leaf, fruit latex	food, medicine	3	29	32
22	Pin Seine	Basil	*Ocimum canum*	Lamiaceae	perennial herb	leaf	food additive	2	8	10
23	Kyauk Kwe Pin	Chinese Violet	*Asystasia gangetica*	Acanthaceae	perennial herb	leaf, stem	medicine	2	3	6
24	That Kal	Cogon grass	*Imperata cylindrica*	Poaceae	perennial rhizomatous grass	whole plant	material	2	0	2
25	Tha Net Pin	Fragrant	*Cordia*	Boraginaceae	tree	stem	fuel	2	0	2

Table (4) (continued)

		manjack	*dichotoma*							
26	Shwe Dingar	Garden cosmos	*Cosmos bipinnatus*	Asteraceae	annual herb	whole plant, flower	environmental, social use	2	14	16
27	Kyat Tu Yway Pan	Globba	*Globba sessiliflora*	Zingiberaceae	perennial herb	flower	social use	2	1	3
28	Sin Hnar Maung Pin	Grey leaf heliotrope plant	*Heliotropium ovalifolium* Forssk.	Boranginaceae	perennial herb	leaf, whole plant	medicine	2	0	2
29	Kan Na Phot	Helencha plant	*Enhydra fluctuans*	Asteraceae	semi-aquatic herb	leaf	medicine	2	1	3
30	Gwe Pin	June plum	*Spondias dulcis*	Anacardiaceae	tree	fruit, young leaf	food	2	32	34
31	Mal Za Le	Kassod tree	*Cassia siamea*	Fabaceae	tree	stem, bud	fuel, medicine	2	3	5
32	Sate Noe	Milk weed	*Euphorbia hirta*	Euphorbiaceae	annual herb	whole plant	medicine	2	0	2
33	Chin Paung	Roselle	*Hibiscus sabdariffa*	Malvaceae	perennial herb	leaf	food	2	12	14
34	Pi Sat Pin	Siam weed	*Chromolaena odorata*	Asteraceae	perennial herb	leaf	medicine	2	0	2
35	San Kwae Pan	Siamese white	*Ixora*	Rubiaceae	bushy	whole plant,	environmental,	2	3	4

Table (4) (continued)

		ixora	*finlaysoniana*			flower	social use			
36	Hti-ka-yone	Touch-me-not	*Mimosa pudica*	Fabaceae	spiny subshrub	whole plant	medicine	2	0	2
37	Nga Yant Pa Tu	Tube flower	*Clerodendron siphonanthus* R.Br.	Verbenaceae	annual herb	leaf	food	2	0	2
38	Htan Pin	Asian palmyra palm	*Borassus flabellifer*	Arecaceae	palm tree	stem, fruit, palmyra sprout, root	food, fuel	1	13	14
39	Yone Pin	Axlewood	*Anogeissus acuminata*	Combretaceae	tree	stem	material	1	2	3
40	Htee Yoe War	Barbelletta bamboo	*Bambusa Chungii*	Poaceae	woody perennial	stem	material	1	20	21
41	Khu Than	Bridal couch tree	*Hymenodictyon orixense*	Rubiaceae	tree	stem	fuel	1	1	2
42	Kyo Thee Pin	Ceylon oak	*Schleichera oleosa*	Sapindaceae	tree	fruit	medicine, food	1	1	2
43	Kyet-mauk Pan	Cock’s comb	*Celosia argentea*	Amaranthaceae	annual shrub	flower	social use	1	4	5
44	Pa Tain Ma	Dancing Ladies	*Globba winitii*	Zingiberaceae	annual herb	flower	social use	1	22	23

Table (4) (continued)

	Naing	Ginger								
45	Gway Touk Pin	Giant swallowart	*Dregea volubilis*	Apocynaceae	vine	leaf	food	1	3	4
46	Pi Sat A Phyu	Goatweed	*Ageratum conyzoides*	Asteraceae	annual herb	leaf	medicine	1	0	1
47	Malarkar	Guava	*Psidium guajava* L.	Myrtaceae	tree	fruit, leaf	food, medicine	1	35	36
48	Kaung Sae Pin	Indian Acalypha	*Acalypha indica*	Euphorbiaceae	annual herb	root	medicine	1	0	1
49	Bandar	Indian Almond	*Terminalia catappa*	Combretaceae	tree	stem, nut	food, fuel	1	3	4
50	Kin Mon Thee	Ivy gourd	*Coccinia grandis*	Cucurbitaceae	vine	fruit	food	1	0	1
51	Ywe Yo	Morinda	*Morinda angustifolia*	Rubiaceae	tree	fruit, stem, leaf	medicine, food	1	15	16
52	Taung Zi Phyu	Niruri	*Phyllanthus urinaria*	Euphorbiaceae	annual herb	whole plant	medicine	1	0	1
53	Taw Lay Hyin	Primrose willow	*Ludwigia hyssopifolia*	Onagraceae	annual herb	whole plant	medicine	1	0	1

Table (4) (continued)

54	Shwe Pha Yone Thee	Pumpkin	*Cucurbita maxima*	Cucurbitaceae	vine	fruit, shoot	food	1	6	7
55	Kin-mun-chin	Soap Acacia	*Acacia concinna* DC	Fabaceae	climbing shrub	leaf	food	1	6	7
56	Tha Kha Ma Thee	Squash	*Cucumis moschata*	Cucurbitaceae	vine	fruit	food	1	1	2
57	Kadet	Three - Leaved Caper	*Crataeva religiosa* Forst	Capparaceae	tree	stem, leaf	fuel, food	1	4	5
58	Pauk Pan Phyu	Vegetable hummingbird	*Sesbania grandiflora*	Fabaceae	tree	flower and young leaf	food	1	1	2
59	War Nat Warr	Wa-net Bamboo	*Gigantochloa wanet*	Poaceae	woody perennial	stem	material	1	21	22
60	Ngwe Pan	White Ginger	*Hedychium coronarium* J. Koenig	Zingiberaceae	perennial herb	tuber, whole plant, flower	environmental, social use, medicine	1	6	7

4.4 Characteristics and type of homegardens

Homegardens were established from 2 to 60 years ago and their size ranged from 405 m^2 to 8,094 m^2. Abdoellah et al. (2006) defined homegardens as commercial when respondents sold more than half of the products for cash and as non-commercial when they consumed more than half of the products. In my studied area, I surveyed 96 homegardens and found that respondents grow crops for both sell and consumption purposes from 7 to 1 sold species per homegarden. They sell more than half of their products, and as a result, I can define that all 96 homegardes are commercial. However, all homegardens were also playing a subsistence role (Niñez 1987), as besides crop commercialization they provide daily supply of food and other household needs. The resulting homegarden type can be therefore characterized as a combination of commercial and subsistence garden at the same time. The number of species which are grown for both purposes was not affected by size of homegarden because some homegardens which grow more species size were relatively small less than 0.7 acre, while other homegardens with 2 to 1 species were larger than 0,7 acre.

4.5 Factors affecting the species diversity

According to SPSS statistical analysis, there was a positive correlation between the number of plant species and homegarden size, natural vegetation, and Shannon-Wiener index. However, there was a negative correlation between the number of species and the age of homegarden. **Figure (8)** showed the relationship between homegarden characteristics and species diversity.

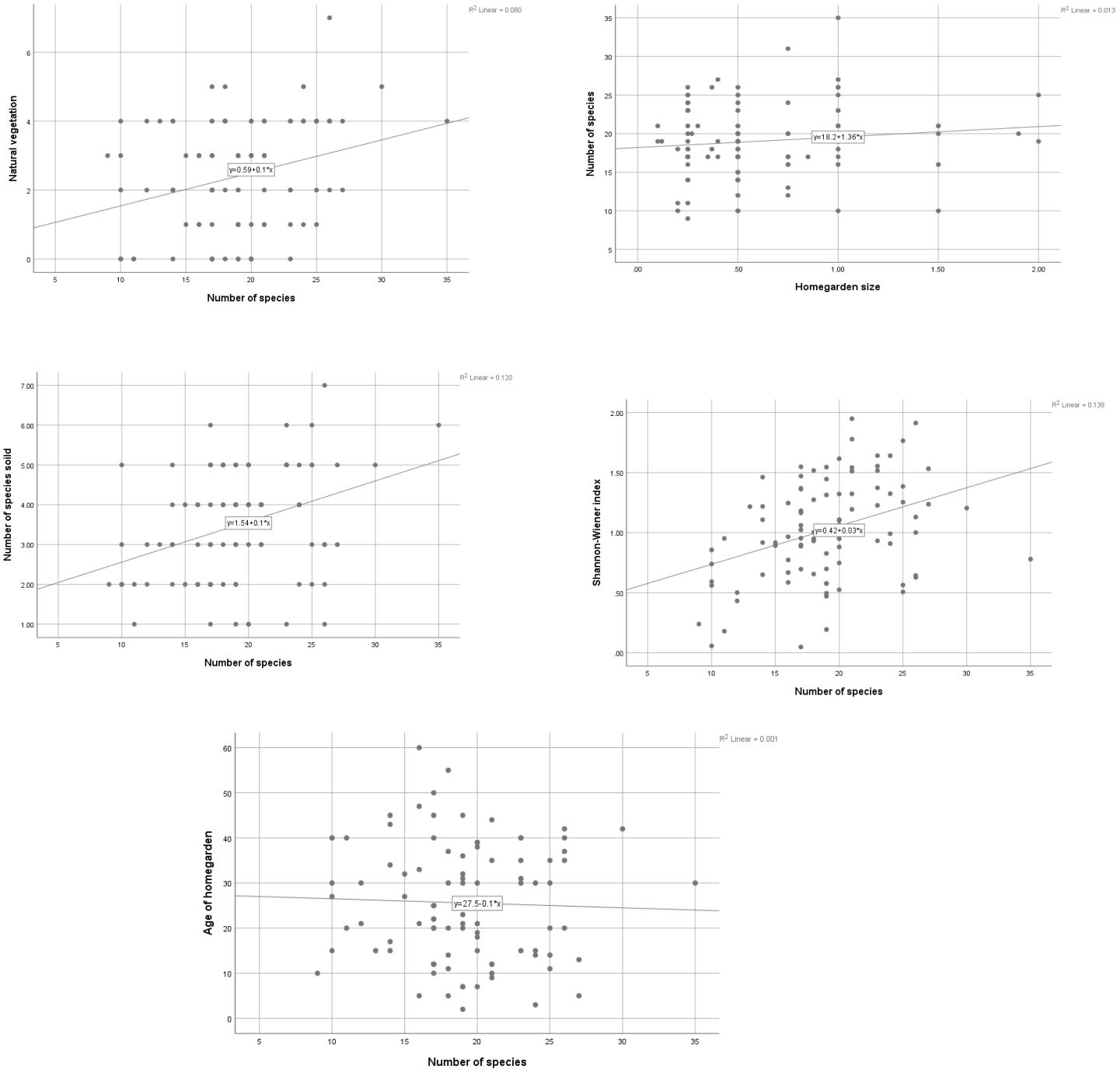

Figure (8) Relationships between homegarden characteristics and species diversity

4.6 Determination of environmental factors

4.6.1 Physical and biotic factors

In the studied villages, there were 6 types of soil such as 1. sandy loam, 2. silt loam, 3. sandy soil, 4. clay soil, 5. loam soil and 6. clay soil. Among them, sandy loam soil was mostly found in 65 homegardens and the second and third one was found in 12 and 10 homegardens, respectively. The remaining soil types were found in 7, 1 and 1 homegardens. The terrain in all homegardens is plain and thus the erosion does not happen commonly. Water management system for growing crops is very simple. During the rainy season, crops are grown as rainfed and during the winter and summer, farmers water the crops by using water from their wells and sometimes through water pipes. Natural vegetation were found as mentioned in the chapter 4.3 and there were a lot of plants grown with proximity to the gardens uch as rice, bitter gourd, yard long bean, cucumber, eggplant, maize, okra, betel vine, lime, coriander, ridged-gourd, bottle gourd, white eggplant, banana, Eugenia leaf, rose, water spinach, lettuce, tomato, winged bean, coconut, cabbage, cauliflower, pumpkin, june plum, chilli and black gram.

Every crop which was grown for sale and consumption was being damaged by pests and diseases with a degree of production damage of ranging mainly from 20 to 50% as well as 100% in some cases. Mostly, insects caused larger damages than fungus or bacteria. Although weeds grew in every homegarden, there was no big damage on crops as the gardeners usually controlled the weeds.

4.6.2 Management factors

Soil preparation was done from 1 to 5 times per year but most commonly 2 times per year. Respondents usually plough the soil with cow and sometimes with machine and they put cow dung, lime, potash fertilizer, compound fertilizer and gypsum during the ploughing. If they perceived that soil is not good for growing crops, they mix the garden soil with a field soil. To improve soil fertility and to increase yield, every homegarden farmer used fertilizer such as urea and compound fertilizer as well as green manure incorporated into soil.

Farm equipment which are commonly used are hoe, sickle, trowel, garden fork, rake, spade, tractor, cart with cow, manual backpack-type sprayer, gardening knife, plough, harrow, digging shovel, watering can, rice thresher machine, three-wheel car

vehicle, manual grass cutter and water pump. To control weeds, gardeners cut the grass with hand tools and machine. Only 26 homegardens use both herbicides and manual control for all crops and the other 70 homegardens only practiced the manual control methods (Figure 9). The herbicide users reported that after they had used herbicides, soil texture became loose and they found dead earthworms.

In case of pest and disease control, respondents controlled them by using chemicals and manual control methods and these agrochemicals were applied only to crops which were targeted for sell (Figure 10). For biological control, they removed pests and infected plant parts by hand, sprayed soap solution and tobacco leaves solution, scattered ash to plant, used local varieties and burnt dried leaves to kill soil-born pests and diseases. If they cannot control it with these local methods, they will apply pesticides especially insecticides and fungicides mostly as a respond and occasionally as a prevention (Figure 11).

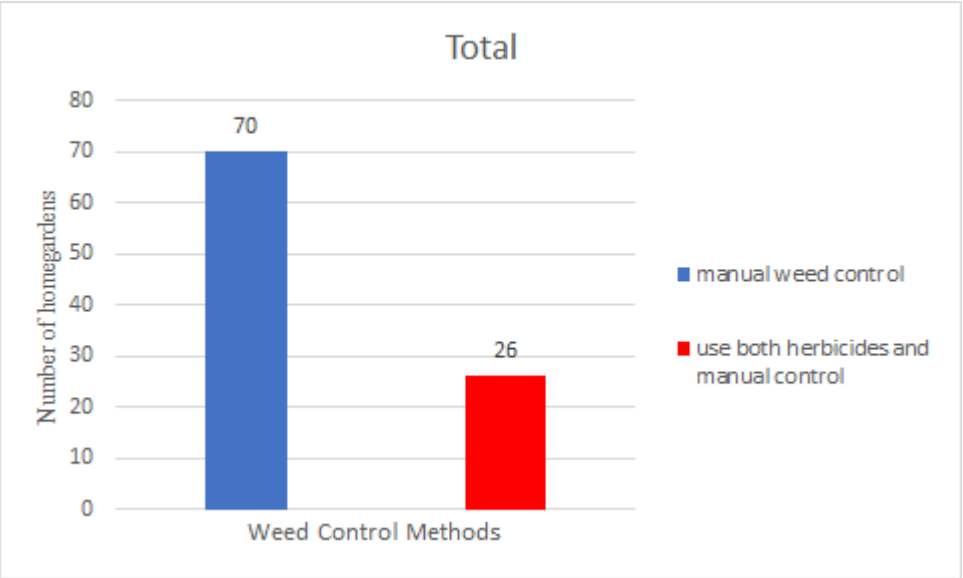

Figure (9) Weed control methods used in surveyed areas

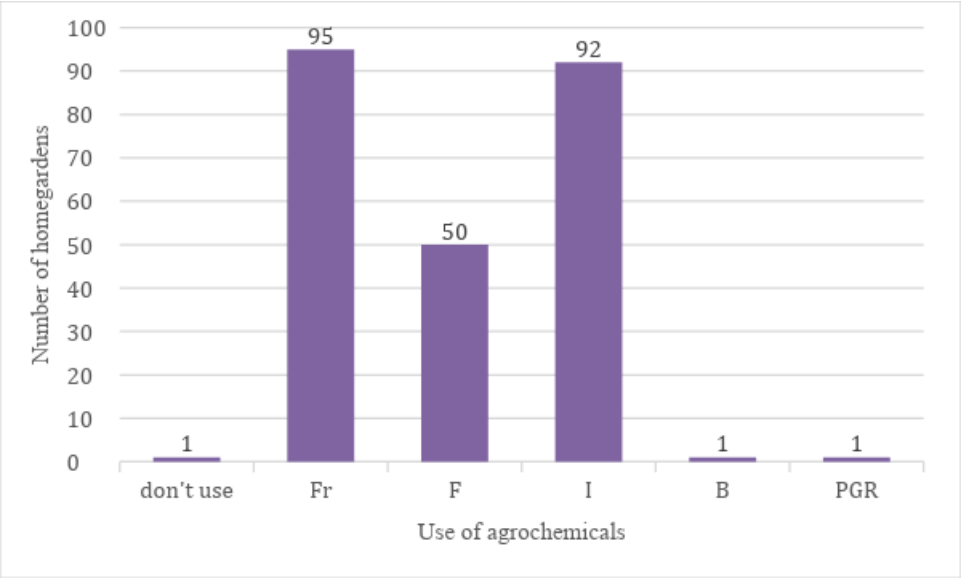

Figure (10) Use of pesticides to control pests and diseases (Fungicides=F, Insecticides=I, Bactericides=B, Plant Growth Regulator=PGR, Fertilizers=Fr)

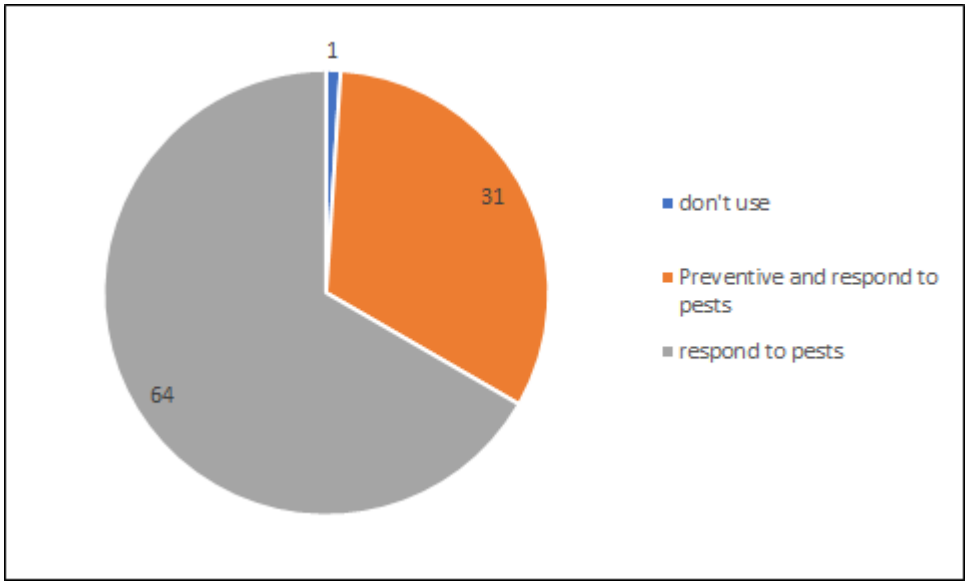

Figure (11) Application of pesticides on crops

5. Discussion

5.1 Characteristics of local homegardens

5.1.1 Size of homegardens

Although there is no standard to classify the common size of homegardens, average size of homegardens worldwide ranges from 1,000 m^2 to 5,000 m^2 according to different geographical and ecological regions (Fernandes & Nair 1986; Kumar et al. 1994). In Vietnam, homegarden size varied from 450 to 12,500 m^2 and average size was 6,475 m^2 (Vlkova et al. 2011). In Thailand, average homegarden size was 1,574 m^2 ranging from 864 m^2 to 2,284 m^2 (Gajaseni & Gajaseni 1999). Kehlenbeck & Mass (2004) found that in Indonesian Sulawesi, the size of homegarden varied from 240 to 2,400 m^2 with average size 1,320 m^2. Besides, average size of homegarden in India was 1,940 m^2 ranging from 535 to 3345 m^2 (Saikia et al. 2012), while in China, the average size reached even 6,678.87 m^2, varying from 1,630 m^2 to 12,385 m^2 (Liu et al. 2019). In our study, average homegarden size is 4,250 m^2 and the size varies from 405 m^2 to 8,094 m^2. Therefore, average homegarden size in Bago division of Myanmar exists within average worldwide size. The Bago homegardens are larger than in certain parts of Thailand, Indonesia and India. In contrast, the average size is smaller than homegardens in the compared areas of Vietnam and China.

5.1.2 Age of homegardens and number of family members

The homegardens in Indonesia were found to be from 1 to 38 years old and belonging from 3 to 11 family members (Kehlenbeck & Mass 2004). In Thailand, age of homegardens was ranging from 2 to 70 years and the number of family members varied from 3 to 5 members according to Lattirasuvan et al. (2010). Vlkova et al. (2011) reported that homegardens in Vietnam were established from 2 to 60 years ago with 1 to 9 family members. In the present study, homegarden age varied from 2 to 60 years old and the number of family members ranged from 1 to 8. Therefore, the age of the local homegardens as well as the number of family members in the study area are generally same with Vietnam's homegardens.

5.2 Structure and types of local homegardens

The horizontal structure is composed of only one vegetative stratum (Lope-Alzina & Howard 2012) while vertical structure includes one to five strata of plant species as agroforestry system in tropical countries (Kumar & Nair 2004). In Thailand, homegardens had vertical structure with four layers of vegetative strata (lower than 1.5, 1.5-10, 10-15, and higher than 15 m) and trees such as leguminous *Albizia lebbeck* were dominant at higher strata (Lattirasuvan et al. 2010). Also, in Vietnam, there was a vertical homegarden structure represented by a high number of trees as 49% of all identified species were trees, mainly fruit species (Vlkova et al. 2011). In my study area, there were five strata such as 0-1 m, 1-2 m, 2-6 m, 6-9 m and >9m. The higher strata with trees were dominant, especially trees used for food and environmental services. The structure of homegardens in Myanmar is similar to countries which have a similar geography.

Abdoellah et al. (2006) using his typology of commercial and non-commercial homegarden types, in Indonesia classified 35 homegardens as commercial and 59 as non-commercial. In my study area, every household grew crops for both consumption and sale purposes and therefore, the studied homegardens in Myanmar could be categorized as combination of commercial market gardens with a subsistence function at the same time.

5.3 Species diversity in homegardens

According to Pritchard et al. (2018), there is a lack of studies and literature specifically corresponding with a topic of home gardens in rural Myanmar and as a result, there is lack of information about species diversity. Our case study shed light on this issue by a complete inventory of 96 homegardens in Bago division. And despite common market orientation of the local homegardens, we found a high agrobiodiversity represented by 246 species from 70 botanical families. The average number of species was 22 species per homegarden varying from 9 to 35 species. Species diversity according to Shannon-Wiener index ranges from 0.1 to 2. The best represented families were Fabaceae, Euphorbiaceae, Rutaceae, Zingiberaceae, Apocynaceae and Asteraceae.

The main uses of the species were food, environmental, medicine, social use, fuel, material, food additive, cosmetic, symbol and effect of poison.

When we compared our result with the species diversity in similar agro-ecological conditions in Vietnam (Vlkova et al 2011), the species richness in Myanmar is higher than in Vietnam. Vlkova et al. (2011) observed a total of sixty-seven species belonging to 35 families among 101 households. These plants were used as food, beverages, spices, stimulants, medicines, fodder, gene sources, tools and materials for construction. Species diversity by Shannon-Wiener index ranged from 0.39 to 1.75. Further, in Thailand, a very high total number of 406 plant species were found in 111 families across 180 households. There were 18 use categories and value of Shannon-Wiener index ranged from 4.56 to 5.06. Kehlenbeck & Mass (2004) found the total number of 149 crop species from small sample size (30 homegardens) in Indonesian Sulawesi with the main use categories of non-staple food, chiefly fruits, vegetables, spices, and medicinal plants. Species diversity according to the value of Shannon-Wiener index was 1.3 to 3.2 in there. Comparing all these study sites, the total species richness in our study area is higher than in Vietnam and Indonesia, but lower than in Thailand. This finding is also supported by the Shannon-Wiener index, with an exception of Indonesia, where despite the total species richness is lower in our area, the Shanon-Wiener index is higher in Indonesia. This is most likely due to the small sample studied in Indonesia.

5.3.1 Wild species in Homegardens

There was a recent ethnobotanical study of wild edible plants use as a medicine across three villages in Southern Shan State, Myanmar (Shin et al. 2018). They found a total of 83 species and the best represented families were Araceae, Fabaceae, and Moraceae. Among them, 47 species were used as wild vegetables, 31 species as fruits and 18 species as medicinal foods. Some species such as *Psidium guajava*, *Phyllanthus emblica*, *Acacia concinna*, *Cheilocostus speciosus*, *Oroxylum indicum* were also found in our study area. Wild plants were present in 78 homegardens and we found 60 wild species used for food, medicine, material, fuel, environmental and social use. Among them, 19 species which were used only for medicine do not occur in all homegardens because respondents think that these species are weeds for them and these plants might

be eliminated. Therefore, all households removed these plants from their gardens apart from 5 households, maximally. In Thailand, they found only 20 wild species from 70 sample sites which were used for food, medicine, fuel and fodder (Cruz-Garcia & Struik 2015). Therefore, wild plant diversity in homegardens of Myanmar is higher than in Thailand.

5.4 Factors affecting species diversity

Our results show that there is a positive relationship between number of species and homegarden size, natural vegetation, and number of species sold. And there is a negative relationship with species diversity and homegarden age as shown by correlation analysis. According to Abebe (2013), proximity to markets mainly affects negatively the crop species richness because farmers grow more cash crops. Also, Abdoellah et al. (2006) stated that species diversity decreased in commercial homegardens due to use of monocultures. In contrast, although farmers in my study areas usually sell their product at farm gate, there is positive correlation between the number of species grown and the number of species sold.

The number of individuals of each plant species have increased with an increasing size of homegardens (Abdellah et al. 2006). Similarly, we found that homegarden size affected positively the number of species. However, there is negative correlation between age of homegarden and number of species in our case and also in Vietnam (Vlkova et al. 2011). There authors also found that there was no significant correlation between these two variables. However, Coomes & Ban (2004) stated that species diversity was higher in older gardens than in the new ones because of incorporating new species in the old gardens.

In our study, we found that there is a significant relationship between number of species and natural vegetation. However, there is no literature to compare this result. Then, Thaman et al. (2006) reported that women are the responsible for maintaining species diversity especially of food trees and extensive multipurpose species. However, there is no correlation between gender and number of species and species diversity. Also, there is no effect of physical and biotic factors to species diversity in the study

villages because soil fertility is relatively good and the terrain in all homegarden is plain. Besides, respondents can receive water sources easily from rain and wells.

5.5 Management practices in homegardens

According to Vlkova et al. (2011), local homegardens in Vietnam used a few external inputs like synthetic fertilizers and other phytosanitary products to improve soil fertility, probably as 34% of homegardens have slope terrain and 77% of homegardens had low soil fertility in Vietnam. Lattirasuvan et al. (2010) also reported that synthetic fertilizer like NPK compound and organic fertilizer like EM solution were used to improve soil fertility in homegardens in Thailand. In our study, all households except one household used fertilizers such as urea and compound fertilizer to stimulate plant growth and to increase the yield. The potash fertilizer, compound fertilizer and gypsum were added into the soil during soil preparation for growing crops.

Kehlenbeck & Mass (2004) claimed that households in Indonesia used a few or no external inputs such as synthetic fertilizer and pesticides while 60% of farmers used soup-suds, removing infected plant parts, dusting with ash, mulch and animal manure to control pests. We found that insecticides were used by 92 households, fungicides by 50 households, bactericides by 1 household, plant growth regulator by 1 household for only crops which are intended to be sold. Biological and cultural practices such as soap solution, removal of pests and infected plant parts, tobacco leaves solution, ash, growing local varieties and burning dried leaves was more commonly applied for crops planned to be consumed within the household. Therefore, when we compare these two facts, households use more pesticides and chemicals in general to control pests of commercial crops which determined to be sold.

6. Conclusion

The study identified and assessed the species diversity and documented the traditional plant knowledge in 8 villages of Bago division in Myanmar. The type of local homegardens and household management was described. A total number of 246 species was recorded with the value of Shannon-Wiener index ranging from 0.1 to 2. The ethnobotanical knowledge of all useful plants was documented by vernacular names and assessed by the number of species per homegarden, plant part used, all specific uses, mode of preparation, seed sources, use of agrochemicals, harvest season, place of selling products and price for product (income).

Among the species, trees were dominant in the study area followed by perennial herbs and shrubs. Multipurpose edible tree *Tamarindus indica* was abundant tree with the highest use value (145 use reports). Considering all species, the most widely used plant part was a whole plant, followed by a leaf. The most culturally important use categories were food, medicine and environmental purposes.

Type and structure of local homegardens for all households was vertical structure with five layers of vegetative strata. According to the functions and characteristics, all homegardens in the study area were commercial homegardens with a persistent subsistence role. There was a positive correlation between number of plant species and homegarden size, natural vegetation, Shannon-Wiener index and number of species commercialized. On the other hand, there was a negative correlation between the number of species and age of homegardens.

When we compared ecologically and culturally important species, there was only 63 out of 246 species of ecological purposes which were used for ornamental purposes, fencing, shading and most of the species were important for the local culture. There were no negative environmental effects on the species diversity. Considering the management system of crops, farmers used both biological and agrochemical methods, when the latter one used especially for the commercial crops.

The study inventoried a high diversity of local crops and associated traditional plant knowledge. Both are still relatively well-preserved in Bago division of Myanmar. However due to the rapid recent changes in the farming systems and particularly in terms of intensification of agrochemical use, the agrobiodiversity is under the increasing

pressure. The present study could be used for raising awareness about the importance and potential of local agrobiodiverity. The culturally important as well as under-utilized species should be further investigated and the pathways for their conservation and scaling should be explored. The collected information could be further used for implementing and planning the governmental and non-governmental programs related to agriculture, nutrition, sustainable development and tourism.

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List of Appendices

Appendix (1) Picture of local homegardens

Appendix (2) Asking about their traditional knowledges all useful plants at gardens

Appendix (3) Preparation and storage of their products

Appendix (4) Sale of their products on farm gate

Appendix (5) Lists of pesticides to control pests in homegardens

No	Pesticides name (a.i)	Types of pesticies	Pests
1	Indoxacarb	I	tobacco cutworm
2	Chlorothalonil, Carbendazim	F	powdery mildew
3	Cartap hydrochloride	I	cabbage moth
4	Mancozeb	F	cercospora leaf spot
5	Acephate Imidacloprid	I	Aphids
6	Diazinon, Thiodicarb	I	boll worm
7	Dimethoate	I	white fly
8	Metalaxyl	F	Damping-off
9	Azoxystrobin	F	Anthracnose
10	Indoxacarb	I	fruit and shoot borer
11	Chlorpyrifos	I	tomato fruitworm
12	Cymoxanil, Dimethomorph	F	downy mildew
13	Abamectin	I	leaf miner
14	Cartap hydrochloride	I	diamondback moth
15	Kausgamycin	B	foot rot
16	Carbaryl, Malathion	I	fruit fly
17	Malathion	I	Red beetle
18	Propiconazole	F	leaf blight
19	Sodium nitrophenol	PGR	for plant frowth

a.i (Active ingredient), I (Insecticides), F (Fungicides), PGR (Plant growth regulator)