STUDIES ON STRUCTURAL DIVERSITY AND FUNCTIONAL DYNAMISM OF HOMEGARDENS IN AIZAWL DISTRICT OF MIZORAM

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By:

LEISHANGTHEM JEECEELEE

(Ph.DRegn No. MZU/Ph.D/372 of 02.06.2011)

DEPARTMENT OF FORESTRY
SCHOOL OF EARTH SCIENCES AND NATURAL RESOURCES MANAGEMENT, MIZORAM UNIVERSITY
AIZAWL -796004

Year: 2015

DECLARATION

I, Ms. **Leishangthem Jeeceelee** hereby declare that the subject matter of this thesis entitled "**Studies on the structural diversity and the functional dynamism of home gardens in Aizawl district of Mizoram**" is the record of work done by me, that the content of the thesis did not form basis for the award of any previous degree or to anybody else, and that I have not submitted the thesis in any other University/ Institute for any other degree.

This is being submitted to the Mizoram University for the degree of Doctor of Philosophy in the Department of Forestry.

Date:

Place: (Leishangthem Jeeceelee)

MIZORAM UNIVERSITY

Department of Forestry
School of Earth Sciences and Natural Resources Management,
Aizawl-796004

CERTIFICATE

This is to certify that the thesis entitled **“Studies on the structural diversity and the functional dynamism of home gardens in Aizawl district of Mizoram”**submitted by **Miss Leishangthem Jeeceelee** for the award of degree of Doctor of Philosophy of the Mizoram University,Aizawl, embodies the record of original investigation carried out by her under my supervision. She has been duly registered and the thesis presented is worthy of being considered for the award of the Ph.D Degree. The work has not been submitted for any degree to any other University.

(PROF. U.K. SAHOO)
Department of Forestry
Supervisor

(PROF. U.K. SAHOO)
Head
Department of Forestry
Mizoram University

Date:
Place: Aizawl

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Place: Aizawl

Leishangthem Jeeceelee

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Chapter 1

Introduction

Homegardening has been a long tradition in many tropical countries and is considered second oldest land use system next to shifting cultivation (Nair, 2004). Homegardens are traditional agro-ecosystem, intermediating the highly commercialised agriculture system and primary forest, characterised by its diverse composition and complexity in their structure and multiple function. Generally a homegarden is defined as a land use system having intimate multi-storey combination of diverse mixture of perennial and annual plant species, sometimes in association with domestic animals around the homestead and managed mainly by household members with relatively low labour, cash or other external inputs and mainly meant for subsistence production (Wiersum, 1982; Fernandes and Nair, 1986; Soemarwoto, 1987). This system is also being known and described variously as agroforestry homegardens, household or homestead farm, compound farm, backyard gardens, dooryard gardens, housegardens etc. Some local names such as *Talun-Kebun*, *Pekarangan* of Indonesia, *Shamba*, *Chagga* of East Africa and *Huertos Familiares* of Central America are also being used for homegardens and these names are equally popular in international forum because such gardensare excellent examples of the systems they represent. In Mizoram, the homegardens are locally known as *Chuktuah huan.* Homegardens are believed to have evolved through generations of gradual intensification of cropping in response to increasing pressure and corresponding shortage of arable lands (Kumar and Nair, 2006)

Homegardens have been considered as a sustainable land use system due to its ability to maintain long term production at a desired level and to withstand several disturbances of natural forces (eg. Pest, disease, erosion), demographic pressure and socio-economic development (Soemarwoto and Conway, 1992) and their contribution towards biodiversity conservation (Kehlenbeck and Maass, 2004; Torquebiau, 1992). According to Huxley (1999), 'a sustainable land use system is that which achieves production sufficient to meet the needs of present and future generation while conserving or enhancing the land resources on which that production depends.' The concept of sustainability also includes efficient use of resources, integration of natural bio-geological cycles, restoration after disturbances, reduced risk of environment pollution, maintenance of economic viability of farm operations, enhancement of life quality for farmers and the whole society, and/ or social acceptability (Hartemink, 2003; Huxley 1999; USDA, 2006)

Various attributes of sustainability of homegardens have been described and recognised. For example the system utilised mainly the locally available resources and very little external inputs, adapting to local conditions and maintained through local knowledge and culture, efficient utilization of the resources both horizontally and vertically (Christanty 1990; Soemarwoto and Conway 1992). The multi-layered complex structure combined with high plant diversity in homegardens is believed to contribute substantially to their sustainability concerning ecological aspects by ameliorating microclimate and enabling efficient use of nutrients and other resources (Benjamin et al., 2001; Nair, 2006; Soemarwoto and Conway, 1992; Torquebiau, 1992). Fernandes et al. (1984) and Gajaseni and Gajaseni (1999) particularly emphasized the positive aspects of the relatively lower air and soil temperatures as well as the higher humidity in homegardens with a complex vegetation structure.

There are a combination of various external and intrinsic factors that influence crop diversity of homegardens in space and time. These include agro-ecology (including garden features) and socio-economics (Christanty et al., 1986; Hodel et al., 1999; Hoogerbrugge and Fresco, 993; Soemarwoto, 1987), intrinsic characteristics of the gardener, like individual preferences, practices, and culture, which determine crop species composition and diversity (Abdoellah et al., 2002; Castineiras et al., 2002, Hodel et al. 1999).

Garden size and age are also major factors influencing crop diversity. Many studies indicated that garden size and species richness are positively correlated implying that the larger the garden, the higher the species richness. (Abdoellah et al., 2002; Arifin et al., 1997, 1998; Das and Das, 2005; Sunwar et al 2006; Millat-e-Mustafa et al., 1996; Quiroz et al., 2004). Although farmers decide on the species to be planted and retained in the homegardens based on their utilitarian value of the species nevertheless market proximity and commercialization are also important factors influencing the choice of species. Various socio-economic factors too influence on crop diversity/ species richness (Abdoellah et al., 2002). In remote areas, the household families usually practise traditional subsistence homegardens which provide them diverse products to meet their daily requirements, this encourage the farmers to plant a diverse variety of crops (Abdoellah and Martar, 1986; Millat-e-Mustafa et al., 1996). However, there are also reports of low diversity in very remote and isolated homegardens where the gardeners did not have good contact to other ethnic groups (eg. Wezel and Ohl, 2005). Several studies have shown that market proximity is the predominant factors for shifting subsistence-oriented homegarden production system to market economy system through increase cultivation of cash crops (annual vegetables or ornamentals), thereby homogenising the structure and functions of homegardens (Karyono, 2000; Shrestha et al, 2004).

The varied structure of homegardens is resulted due to variation in the local physical environment, ecological characteristics, and socioeconomic and cultural factors (Christanty et al., 1986; Abdoellah, 1990; Karyono, 1990; Ceccolini, 2002; Kumar and Nair, 2004). The complex multi-layered vertical and horizontal structure resulted from high diversity of plant species provide efficient utilization of both underground and overground resources (Wiersum, 1982; Brownrigg, 1985; Torquebiau, 1992). This complex structure formed by the multi-layered vegetation of diverse species in homegardens contributes substantially to their sustainability concerning both ecological and socio-economic aspects (Torquebiau, 1992; Abdoellah, 1990). There are reports that this complex structure helps in ameliorating microclimate of homegardens by providing relatively lower air and soil temperature as well as higher humidity suitable for different crop species (Fernandes et al., 1984; Gajaseni and Gajaseni, 1999). The combination of annual and perennial species exploits and utilise the available resources (such as water, light, nutrients, etc) complementarily and more efficiently by pumping the nutrients from different layers of soil. However, species complexity in the homegardens is not a natural phenomenon unlike natural system (forests), but a result of deliberate attempts and meticulous selections and management by farmers to provide products they consider important for their subsistence and livelihood.

Homegardens provide multiple functions viz. economic, social and cultural, aesthetic, and ecological (Abdoellah, 1990; Soemarwoto and Conway, 1991; Wezel and Bender, 2003). The important tangible and intangible services provided by homegardens include year round production of food from the multiple uses of homegarden products contributing significantly to meeting the various needs (such as nutrition and income) of the households (Abdoellah and Marten, 1986; Christanty et al., 1986; Abdoellah et al., 1990; Karyono, 1990; Michon and Mary, 1994; Ceccolini, 2002; Blanckaert et al., 2004), a wide spectrum of multiple use products such as firewood, fodder, medicinal and ornamental plants, etc., decrease risks of production failure due to high species diversity, increase resource productivity over time, expansion of the amount and quality of labour applied in the farm, provision of output flexibility and alternative production if unfavorable circumstances develop, potential to serve as repositories of genetic resources and acting as insurance against pest and disease attack (Cromwell et al., 1999). The contributions of homegardens to household economy have also been documented and it depends on the component products and nature of the products utilization. Income derived from homegardens in West Java, for example, ranged from 6.6% to 55.7% of the family's total income (Soemarwoto, 1987). Most of the income is said to be derived from perennials such as fruit and spice trees, cacao, and coffee, but in peri-urban areas or tourist centres as well as in tropical highlands, also vegetables and/or ornamentals are frequently grown as cash crops (Abdoellah et al., 2002; Soemarwoto and Conway, 1992).

Homegardens have been traditionally managed and adapted by gardeners applying different adaptive management and mostly using their indigenous knowledge. Therefore management practices of homegardens may vary from place to place and also from one household to another, resulting to follow different pathways in maintaining their homegardens (Nair, 2001). Further this variation is also influenced by topography, aspects of slope, size of land holdings, resource endowment and individual farer's preference (Rugalema et al, 1994a). The common management practices in traditional homegardens involve pruning, weeding, fertilization, manuring, crop spacing and mulching (Nair and Sreedharan, 1986; Vogl et al., 2003). The threats from disease and pests in the gardens are controlled using homemade remedies such as teas of nettle (*Urtica dioca*), horse tail (*Equisetum*), soft soap or lime in Austria (Vogl et al, 2003)

Use of simple tools like small hoes, rake, spades, forks and watering cans is common in most traditional homegardens throughout the world. However, modern equipment such as rotary cultivators, tillers or flame weeders, sprinkler irrigation system, etc are also reported to be used in large commercialized homegardens (Vogl et al., 2003). Soil fertility of homegardens in different parts of the globe was reported to be maintained mainly through the application of various types of organic matter such a crop residues, tree litter, banana trash, grass mulch, ash, household waste and animal manures (Rugalema et al, 1994a; Vogl et al, 2003). Homegardens are believed to play a special role in addressing the global issues of carbon sequestration. The high species diversity and the multi-layered woody perennial dominated structure of homegardens resembling matured forests (Keem, 2006) are claimed to have higher carbon sequestration potential than other comparable land-use system and promote carbon sequestration (Vandermeer, 1989; Tilman et al., 1997; Huston and Marland, 2003). For example the Javanese and Sumatran homegardens accumulated carbon in the range of 55.8 to 162.7 Mg/ha.

Homegardens are postulated to have the potential to contribute to carbon sequestration through all three mechanisms (Kumar, 2006) *viz.* carbon sequestration, carbon conservation and carbon substitution, which are the ways an agroforestry system can contribute to carbon sequestration (Montagnini and Nair, 2004), while most agroforestry system feature one or two of these mechanisms.

Homegardens are ubiquitous feature of rural landscape of Mizoram. The topography of Mizoram is mostly mountainous and as such poses many challenges in terms of accessibility, steep and fragile landscape, poor transportation and resilient farming system with limited option for change. In Mizoram, homegardening is the most widely practised land use system next to shifting cultivation (Sahoo, 2009; Sahoo et al, 2010) and has been a way of life for several years. It has been playing an important role in supplementing food production, fulfilling diverse needs of the households such as spices and condiments, timber, poles, medicines, fodder, fuelwood, etc. The protective roles of homegardens cannot be ignored in such highly fragile hill ecosystems of the region and is known to protect soil and conserve water through its complex vegetation structure. The homegardens in the state vary greatly in species composition and density with different sizes and ages of the homegardens. However, the species composition is also greatly governed by many factors such as ecology, local food culture, the socio-economic conditions, etc. However these traditional gardens in the state received little scientific attention. In view of the fact that these systems serve to provide numerous ecological, economical and social benefits to the rural poor, these systems need to be researched well. Although each homegarden may be a unique land-use entity in terms of component arrangement, organization and management and thus not only reflects the personal preference of its owner but also provide little scope for a “replicable model’ to be adopted by others. Ecological preservations, economic vitality and social justice could be targeted by judicious land-use management. The developmental intervention of government and non-governmental organization should not only concentrate on introduction of exotic and new cultivars but also to promote and improve the homegarden system, so that these systems could serve as an alternative land use system for Jhum cultivation.

It is an underlying fact that shifting cultivation in the past and in the present day is the foremost reason for loss of valuable tree cover from both urban and rural areas. The failure to plant or replant trees, in general, and changing land management practices that include indiscriminate felling, clearing and burning (as in case of jhum) could be reasons for a poor tree cover. Promotion of homegarden agroforestry would help in increasing tree cover and address indirectly many emerging environmental problems such as climate change and loss of biodiversity. Besides, the state has been increasingly depended on the neighbouring state for numerous food items to satisfy the growing basic needs, necessitating the need for promotion of sustainable land use in the state.

In Mizoram context, while shifting cultivation has been researched well for their socio-ecological bearings in Mizoram (Singh, 1996), very little attention is given to the homegardens (Sahoo, 2009). On the other hand, homegardening is the second most important land use system in Mizoram after shifting cultivation. There is lack of in-depth knowledge and information on species composition in Mizo home gardens. The purpose of the present study was to document species composition and their utilization in the homegarden maintained by Mizos.

The present work was carried out with the following objectives:

a) To study the plant composition, their structure (both vertical and horizontal stratification), and diversity of trees, shrubs and herbs in differently aged- and sized home gardens;

b) To study the ethnic basis of home garden plant use and the role of homegardens in household food security/economic sustainability; and

c) To study and relate the microclimatic and edaphic variables to age and size of the homegardens for their ecological sustainability.

Chapter 2

Review of Literature

A homegarden has been described as an operational farming unit in which a number of compatible crops, trees, shrubs, herbs and livestock are managed to provide diverse products to meet the farmer's basic needs and socio-cultural functions (Christanty, 1990; Campbell et al., 1991; Rugalema et al., 1994a; Shackleton et al., 2008; Silwana ,2000). It is a species rich production system which is considered economically efficient, ecologically sound and biologically sustainable system (Fernangez and Nair, 1986) and well suited for ex-situ conservation of many rare/endangered species. For example Saikia et al (2012) reported that an endangered and red listed species, *Aquilaria malaccensis* was the most dominant tree species in upper Assam. They also contribute greatly to agrobiodiversity conservation (Trinh et al., 2003), including helping to maintain or increase both the phenotypic and genotypic diversities of cultivated plants (Casas et al., 2005; Carmona and Casas, 2005). Some identifying characteristics of homegardens include its proximity to the residence, high diversity of plants, subsistence production supplementing the household production and income (Brownrigg, 1985) and use of low external inputs (Marsh, 1998). The high species diversity is one of the common factors in all the homegardens reported from all over the world and its functional characteristics

(Brierley, 1985) help in ensuring the risk of crop failure and biological stability of crops. Homegardens are thus dynamic systems which have got evolved over centuries due to the adaptive abilities of farmers in response to changing rural and livelihood conditions (Michon and Mary, 1994; Kumar and Nair, 2004).

These indigenous systems are gaining recognition in recent decades as a model for research and design of sustainable agroforestry system due to their efficient nutrient cycling, high biodiversity, soil conservation and carbon stock potential (Jose and Shanmugaratnam, 1993; Torquebiau, 1992). Besides, they are also known for providing a diverse and stable supply of socio-economic products and benefits to the households (Christanty, 1990). The important contribution of homegardens in increasing food production and addressing malnutrition in tropical countries are well documented (Ninez, 1984; Brownrigg, 1985). The organization of the first international conference on tropical homegardens in Java in 1985 (Landauer and Brazil, 1990) exemplifies the importance of homegardens.

Homegardens are reportedly distributed throughout the tropics in Africa, Asia, Central and South America, the Caribbean and the pacific Islands (High and Shackleton, 2000; Nair and Kumar, 2006). Though the records of the extent and distribution of homegardens throughout the world are limited, this system is an age old practice. According to some available information the area occupied by homegardens varied greatly between the countries. They occupied an area of

0.54mha in Bangladesh, 1.05mha in Sri Lanka, 5.13 mha in Indonesia , 1.33mha in Kerala (Kumar, 2006) and over 70% of all the household maintained homegardens in Phillippines (Christanty, 1990).

Different types of homegardens have been reported across the globe which are being classified on the basis of various parameters like size, age, structure, socio-economic value, or dominant species. For example, Kehlenbeck and Maass (2004) described four home garden types distinguished by differences in garden size, and the level of diversity viz. small, moderately old, species- and tree- poor spice garden; medium- sized, old, species-rich fruit tree gardens; large rather young, species- and tree- poor gardens of transmigrant families; Diverse assemblages of rather old, individual gardens with very high crop diversity. The available literature reported that small size, in general, is one of the distinguishing features of most home gardens. For instance, having analyzed ten selected homegarden systems from different ecological and geographical regions, Fernandes and Nair (1986), reported that the average size of the homegarden units is less than 0.5 ha. Other authors reported, to mention a few, from about 0.01 to greater than 0.2 ha in Ethiopia (Zemede, 2001), 0.009 to 0.25 ha in Guatemala (Leiva et al., 2002) and 0.32 ha in Nicaragua (Méndez et al., 2001). Also, 0.16 – 0.59 ha in Ghana (Bennett-Lartey et al., 2002), 0.09 ha in Cuba (Wezel and Bender, 2003), 0.024 - 0.24 ha in Indonesia (Kehlenbeck and Maass, 2004) and 0.30 ha in India (Das and Das, 2005). Although homegarden allocation might be related to various factors, several reports show that it is strongly linked to the size of total landholding. For instance, in Bangladesh, homegarden size was reported to positively correlate with farm size (Ahmed and Rahman, 2004)

The structure and function of homegardens differs from place to place which in turn is influenced by the socio-economic status, personal preferences, culture of the people and ecological conditions of the place (Soemarwoto 1987; Christanty, 1990). Tropical homegardens tend to have complex structure both vertically and horizontally with many species of different life forms. They usually exhibit a complex multi storied, resembling a forest-like structure which provide a more efficient resource utilization and nutrient cycling unit (Fernandes and Nair, 1986). Most homestead systems consist of an herbaceous layer near the ground and a tree layer at higher levels. The crops and trees planted in a homegarden are carefully arranged to provide for specific functions and benefits, which are primarily economic in nature. The horizontal structure of the vegetation generally changes in relation to distance from the house. In contrast, temperate homegardens have simple vertical structures with all the plants unshaded and dominated by annual species. The rural gardens are more complex as they usually have more layers of plant canopy than the urban gardens (Mohan, 2004).

The species composition and crop diversity of homegardens varies according to agro-ecological, climatic, topographic and edaphic factors, socio-economic conditions and personal preference of the farmers. The crop diversity found in the home-gardens probably reflected the specific needs (including food requirements and household dietary priorities and preferences), nutritional complementarities with major food sources, as opposed to economic, ecological and social factors (Kumar and Nair, 2004). The size and age of the gardens and availability of planting area may also contribute to choice of planting or species to be retained. This is indicated by the occurrence of plants of different stages, such as seedlings, saplings and juveniles, mature and old trees (Akinnifesi et al., 2009). Ethnicity of the gardener is also known to contribute to variation in crop diversity of homegardens (Hodel et al., 1999). Different ethnic groups prefer different plant products and, therefore, cultivate according to their preferences in their homegardens (Abdoellah, 1980; Soemarwoto and Conway, 1992; Azurdia and Leiva, 2004; Shrestha et al., 2004; Trinh et al., 2003). Market proximity and extent of commercialization may have same degree of influence on vegetation structure of homegardens. Good market access may drive gardeners from subsistence to semi-commercial or commercial production which may result in cultivation of only a limited number of cash crops, particularly of annual vegetables or ornamentals, leading to both genetic erosion of traditional vegetables and decreasing numbers of perennials species (Peyre et al., 2006; Shrestha et al., 2004). As a consequence, commercial homegardens often lack a complex vegetation structure. However, Lamont et al., 1999 and Trinh et al., 2003 found no influence of these factors on species diversity while a positive influence on these account was observed by Hodel et al., 1999.

Many studies have shown the relation between garden size wit species richness and diversity. As expected, garden size could influence species richness and diversity in the homegardens. A greater species diversity in the large than small gardens (Ahmed and Rahman, 2004; Tesfaye, 2005; Sahoo et al., 2010) reveal farmers having much space to accommodate diverse species. Nevertheless, density decreases as land size increases though the average total number of plants per farm is still higher in the large farms (Ahmed and Rahman, 2004). Islam (1998) and Piniero (2003) suggested that low-income families with their smaller gardens tend to have more diversified crops than the high income families as the former will not have enough money to buy all their necessities so that they depend on their gardens. In addition, diversity and species compositions of gardens were reported to vary by age of homegardens (Wezel and Ohl, 2005) and remoteness (Wezel and Ohl, 2005; Kehlenbeck and Maass, 2004).The correlation between size of home garden and species richness was found to be positive, i.e., the greater the lot size, the greater the species richness (Lamont et al., 1999), although, this relation was not found in the study conducted by Albuquerque et al. (2005) and Eichemberg et al. (2009). However, there was a significant association between species richness and the age of the homegarden i.e. the older the homegarden, the greater the number of plant species found in it (Coomes and Ban, 2004; Eichemberg et al. 2009). Blanckaert et al. (2004) mentioned that the oldest garden shows a rich herbaceous layer almost covering the entire soil, which is characterized by many trees and shrubs filling every gap in the vegetation. However, the youngest garden is characterized by a less dense structure with gaps in the vegetation cover.

Home-gardens are considered as one of the oldest forms of managed land use systems and are frequently regarded as sustainable systems due to their ability to maintain long-term production at a desired level (Christanty, 1990; Soemarwoto and Conway, 1992). A sustainable system is characterised not only by low dependence on external inputs and high adaptation to local conditions, but also by long-term maintenance of productive capacity (Gliessman, 1990a; Torquebiau, 1992).The typical attributes contributing to the sustainability of homegardens are (i) its dependence on locally available and renewable solar and human labor power; (ii) the efficient nutrient cycling, which together with a minimal rate of soil erosion, ensuring long term maintenance of soil fertility; and (iii) a rich genetic resource that minimizes pest and disease problems and enables the system to respond to a wide variety of changing demands (Soemarwoto and Conway, 1992).

Homegardens provide both economic and social benefits through a wide spectrum of multiple use products and services that are essential to the nutritional welfare and security of the household. The primary function of a homegardens is subsistence production, particularly in rural areas (Kumar and Nair, 2004; Soemarwoto and Conway, 1992). The diverse products from both agricultural crops and trees of the homegarden contribute a vital role to the subsistence economy of many areas in the tropics (e.g. Nair, 1993; High and Shackleton, 2000). Homegardens generally serve as a complement to staple crop fields by producing mainly fruits, vegetables, spices, and many non-food products (Albuquerque et al., 2005; Karyono, 1990; Kehlenbeck and Maass, 2004; Kumar and Nair, 2004; Michon and Mary, 1994; Peyre et al., 2006). However, homegardens may also provide large portions of staple food, for example for poor families and in densely populated or heavily degraded areas without sufficient staple crop fields (Soemarwoto and Conway, 1992; Tesfaye Abebe et al., 2006).

The livestock components of homegardens also contribute significantly to nutritional security as well as economics to the households. They have a relatively high nutritional value in terms of protein, minerals, and vitamins (Soemarwoto and Conway, 1992), thus, being important for the nutritional security of the gardeners' families (Nair, 2006) and also offer opportunities for milk and meat-processing ventures, thus increasing employment especially in rural areas. Integration of animals with cropping systems provides means to sustainably intensify agricultural production and contribute to the nutrient cycling in the system. For example, 80% of the N supplies to the soil are made via the manure-compost pathway (Pilbeam et al., 2000). The major function of homegardens in rural areas are subsistence production and solving poverty problems by stimulating small-scale farming activities leading to income generation improving family's financial status (Rogerson, 1996; Soemarwoto and Conway 1992). However, gardeners often do not cultivate certain crops exclusively for sale, but rather sell any marketable surplus of their subsistence crops (Fernandes and Nair, 1986). Thus, the portion of income from a homegarden may vary from 0% (Gebauer, 2005; Méndez et al.,2001) to more than 50% of the household's total cash income (Trinh et al., 2003), depending on market access, among other factors.

Tropical homegardens harbour high plant species diversity, which may act as reservoirs of crop germplasm and serve to conserve rare or threatened species and varieties (Clarke and Thaman, 1993; Smith, 1996). They are also considered as ideal production systems for in situ conservation of genetic resources owing to their large diversity of crop species and cultivated varieties (Watson and Eyzaguirre 2002).

Homegardens are also important from social and cultural perspectives (Abdoellah et al., 2002; Christanty, 1990; Karyono, 2000; Soemarwoto and Conway, 1992). The exchange of homegarden products and planting material is common in many traditional societies. Homegardens also provide shade near living areas while reducing erosion in high rainfall regions (Jose and Shanmugaratnam, 1993).

Homegardens too have high carbon sequestration potential due to their forest-like structure and composition (Kumar, 2006). Trees in these homegardens play a very important role in soil carbon sequestration. The ability of homegardens to sequester carbon in the soil will depend on homegardens characteristics such as land-holding size and age of the system (the length of time during which the land has been under the practice). Since plant species diversity in homegardens is inversely proportional to land-holding size (Kumar et. al, 1994; Mohan et. al, 2007), it is presumed that the small homegardens are likely to sequester more carbon per unit area of land compared to large homegardens.

Homegardens play numerous roles as provision of nutrition, dietary supplements, food security in the times of crisis, shade, fuelwood, cash income, experimentation, aesthetics, medicinal plants and small animal raising (FAO, 1999). Homegarden can enhance food security in several ways, most importantly through direct access to a diversity of nutritionally rich foods, increased purchasing power from savings on food bills and from sale of home garden products and fall back food provision during periods of temporary food scarcity. In many parts of the world, homegarden supplement food supply for people, but in some cases, homegardens can yield basic staples, when they are large enough to plant sufficient quantities of tubers or cereals (Eibl et al., 2000; Wezel and Bender, 2003). In contrast to other types of agroforestry and other production systems, homegardens are very important for supplying the household with food products year round (Budowski, 1990; Eibl et al., 2000). One of the important objectives of the homegarden is to guarantee a minimum supply of different food products at all times of the year, functioning as a buffer in times of low income and food scarcity.

Since homegardens are man-made, they need extensive management. However, the management practice may vary from one household to another, and could be influenced by many factors such as type and fertility of the soil, slope of the garden, size of the holding, size of the household, resource endowment and individual farmer’s preference (Rugalema et al., 1994a). According to Vogl et al. (2003), the management and composition of these homegardens reflects a body of knowledge gained through adaptive management of natural resources by communities, and which is based on the communities’ long-term experience with their local environment. For small and subsistence gardens, the household use simple tools. The management practices in Kerala involved pruning, weeding, fertilization and crop spacing (Nair and Sreedharan, 1986). The cash crops are subjected to more intensive management including use of chemical fertilizers and insecticides, systematic weeding, organic fertilization and row arrangement of trees than the fruit trees and timber species (Nair and Sreedharan, 1986).

In an agroforestry system, the soil is believed to maintain its fertility as a result of adding organic matter, nutrient cycling and protection of soil erosion and atmospheric nitrogen fixation by nitrogen fixing trees (Nair, 1993; Palm, 1995). Soil fertility is maintained in such system through the contribution of decomposed residues from different components like above ground litter and prunings, roots or indirectly as farm yard manure from livestocks, which in turn increase organic matter and biological activity of the soil (Szott et al., 1991) enhancing soil nutrient status. Soil organic matter has many beneficial effects on improving soil physical properties which include increasing water holding capacity, slow release of nutrients, particularly significant in low input farming system (homegarden), enhancement of cation exchange capacity, preserve soil structure, promote higher infiltration capacity (Fritsch, 1993), thereby reducing the risk of soil erosion especially in hilly areas. Soil organic matter is considered as store house of essential plant nutrients and plays an important role in maintaining soil fertility. The roots of the tree component of homegardens also influence the physical properties of soil by penetrating the deeper layer and possibly breaking the compact sub soil and pumping the nutrients from deep layer where the roots of agricultural components cannot reach, subsequently recycle such nutrients to the top soil by adding litter to the soil (Young, 1997). The role of tree roots in reducing nutrient leaching in comparison to sole cropped annuals (Hartemink et al., 1996; Seyfried and Rao, 1991) and formation of a safety net under the root zone of the annual crops have also been reported (Van Noardwijk et al., 1996). Thus agroforestry systems promote closed nutrient cycling by taking up soil nutrients through tree roots and recycling them as a litter, including root residue and helping to synchronize nutrient release with crop requirement by controlling the quality, timing and manner of addition of plant residue (Young, 1991). The dynamics of litter production and decomposition are the processes that replenish the soil nutrient pools, maintain soil life and thus endow sustainability to these agroforests.

In general, the homegardening follows the integrated soil fertility management principle which aims at maximal utilization of available nutrients and consequent minimal reliance on external input to obtain sustainable yield (Dudal and Roy, 1995; Vanlauwe et al., 2002). However, the year-round utilization and continued cultivation over a long period particularly in low-input and subsistence system of homegardens results in substantial losses of nutrient and soil organic carbon from the soils resulted in soil compaction which in turn has profound effect on soil properties; therefore there needs to have regular addition of essential nutrient-based fertilizers to maintain crop production, and farmers add various locally derived soil amendments such as cattle manure, ash, woodland litter, or clay-rich termitaria (Chivaura-Mususa et al., 2000). In the Bukoba, district of North-western Tanzania soil fertility was maintained mainly through the application of various types of organic matter such as crop residues, tree litter, banana trash, grass mulch, household refuse and animal manure (Rugalema et al., 1994a), while in Austria it is maintained by the use of cattle, sheep, horse or chicken manure (Vogl et al., 2003). Some trees and shrubs are reported to accumulate certain nutrients, even in soils which contain very less amount of these nutrients. For example Palms are able to accumulate large amount of Potassium (Folster et al., 1976); Gmelina arborea accumulates Calcium (Sanchez et al, 1985). The intentional management of plant diversity based on the capacity of a species would nevertheless help restore desired ecosystem function and could sustain the yield of the system (Snapp and Silim, 2002).

In multi-strata agroforestry system, multipurpose trees are the main component of the system and litterfall and prunings depend on the tree species, density and management activities such as fertilisation (Rao et al., 1998; Kumar, 2006). However, cases of fertility decline in multistrata agroforestry systems have also been reported especially with soil nitrogen as a limiting factor in such systems (Schroth et al., 2001; Seneviratne et al., 2006). Information on the nutrient availability especially nitrogen from the production and decomposition of litter can provide useful insights into the sustainability of the system (Nair et al., 1999; Seneviratne, 2000). Farmers' knowledge of the litter quality of different species and their planting and management of multiple species with differing rates of litter production and nutrient input plays an important role in the efficient nutrient cycling of the system (Nair et al., 1999; Sinclair and Walker, 1999).

There is a long-held belief and intuition that homegardens provide a large scale intangible benefits, however, convincing evidences to support these conjectures are mostly lacking. In view of the lack of quantitative data on the nature, extent, cultural and ecological significance of homegardens, the implications for planning and management of homegardens become somewhat ambiguous for the policy makers and planners. Systematic studies are therefore essential to determine to what extent the homegardens could generate cash and energy flow, provide dietary supplements, productive, provisioning and ameliorative services. In Mizoram context, the concept of homegardening though is not new, but research based knowledge on homegarden structure and functional understandings are either lacking or very limited.

Chapter 3

Study Area

Introduction

Mizoram state is located in north eastern part (21º58' to 23º35' N latitude and 92º15' to 93º29' E longitude) of India and surrounded by Tripura, Assam and Manipur in north-frontier regions; Bangladesh in west; and Mayanmar in east and south. With a geographical area of 21,087 $km^2$the State is perched on the high hills of the North Eastern part of the country and possibly has the most difficult terrain, over 80% of thetotal geographical area being hilly and with steep hills separated by rivers flowing North toSouth. The undulated topography has varied altitude ranging from 21 to 2157 m above the mean sea level (average 920 m) with an annual rainfall of 2000-3200 mm concentrated during six months.

The State has a Forest cover of 91% and the forestsin Mizoram are classified as tropicial wet evergreen, tropical moist deciduous and sub-tropical pine forests(SFSI Report, 2013).The total population of state is 10.91 lakh and the decadal growth rate during 2001-2011 is 22.78 %, the literacy rate is 91.6 %, and the population density is 51.7 people/ km^2 in 2011 (Anonymous, 2009). In economical classification of workers as per 2001 census majority of Mizoram population (60%), are engaged in agricultural and allied activities for their livelihood.

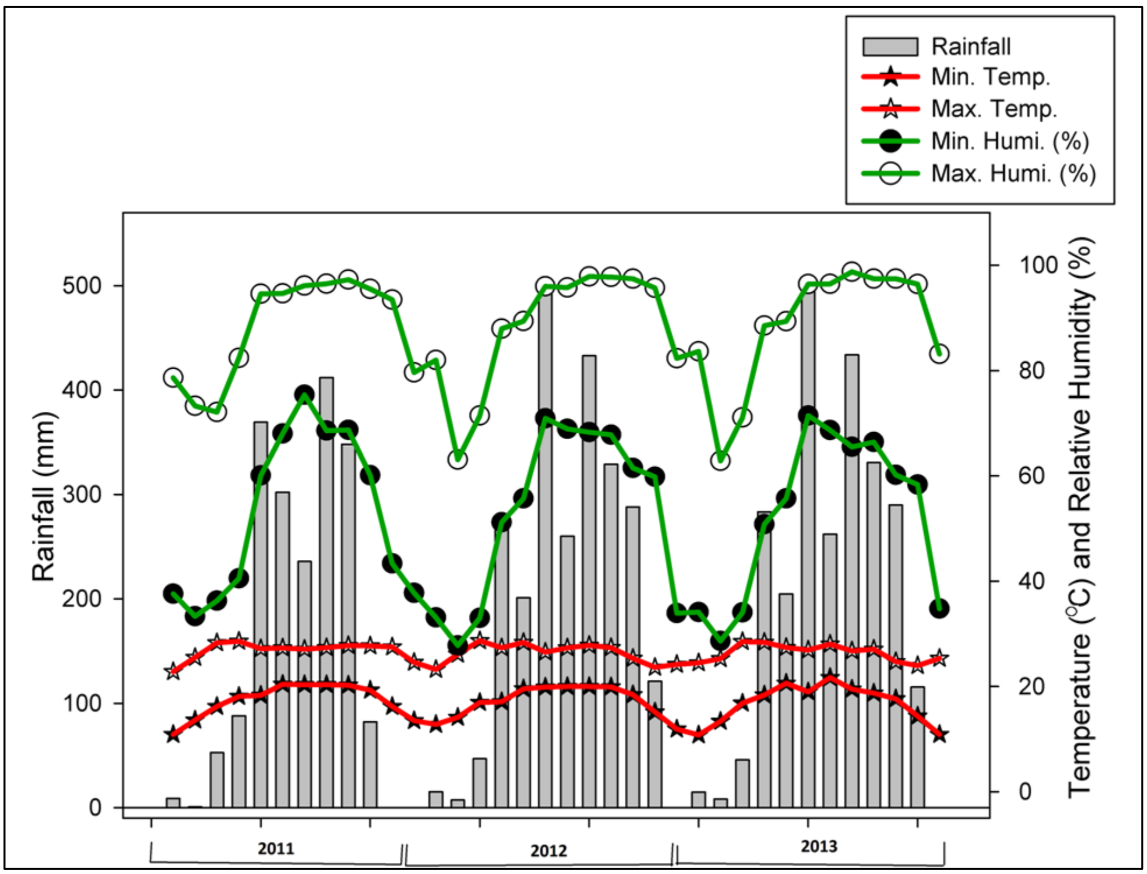
Soil

The soils of Mizoram are dominated by sedimentary formation. These are generally young, immature, mostly developed from parent materials such as farraginous sandstones and shale. The soils in the foot hills are collocium deposit and in plain areas alluvial deposits are predominant. Three soil orders such as ultisols, inceptisols and entisols are found in Mizoram. The soils in the hills are generally acidic in reaction and they are usually dark, highly leached and poor in base, rich in iron and have pH values ranging 4.5 to 5.5 (highly acidic). Soils of the valley flats lands are brown to dark brown, poor in bases, moderately acidic with pH ranging from 5.5 to 6.0. The surface soil textures are loam to clay loam with clay content increasing with depth. Soil moisture regime is classified as Udic as the soil moisture control section is not dry in any part of the state for as long as 90 cumulative days (Colney and Nautiyal, 2013).

Climate

Mizoram experiences a mild and pleasant climate. The upper part of the hills is predictably cold, cool during the summer, while the lower reaches are relatively warm and humid. The average mean winter temperature varies from 7-21 ºC and in the summer, it varies between 20-29 ºCwith 78.08% relative humidity (MIRSAC, 2012). The entire area is under the direct influence of the South-West monsoon. The storms break out during March-April, just before or around the summer. Ample rainfall occurs from May to September with little rain in the dry (cold) season. The average annual rainfall is 2560mm (based on the rainfall data from 2000 to 2010). The average rainfall for Aizawl district is 2080mm.Depending on the variation in temperature and other weather conditions, three seasons (*viz.*, cold or winter season; warm season or spring; rainy season or summer season) are observed in the area as in other parts of the state. The climatogram of the study area is shown in **figure 3.1**.

Figure 3.1: Climatogram showing total monthly rainfall and mean monthly minimum and maximum temperature of Mizoram



Study villages

The present study was conducted in sample villages located in the Aizawl district (92°38` to 92°42` E longitude and 23°42` to 23°46` N latitude, 950 m asl) of Mizoram situated in almost similar physico-climatic terrain. The location of the study villages are shown in figure 3.2. A stratified sample of forty twohomegardens was selected from the four villages *viz*. Sairang, Selesih, Tanhril, Maubawk located in Aizawl district and these homegardens were studied in greater details for their plant composition, structural diversity and functional dynamism over a two years period (2011-12 to 2012-13).

Socio-economic profiles of the studied households

Traditionally, the livelihoods of most of the respondents have been dependent on nearby forests for the biomass they produce and on shifting cultivation in the studied villages. The majority of the population (70%) in the studied areas depends on agriculture (shifting cultivation) and allied activities. Few proportion of population (15%) of the respondents were engaged in government services and followed by wage labour. The size of family ranged from 4-11 numbers and had more or less equal proportion of gender in each household. The highest average member per family (7.2)was found in middle sized homegardens and the lowest (4.4) was found in large sized homegarden households. Average annual family income was highest among respondents of large sized homegarden households (INR

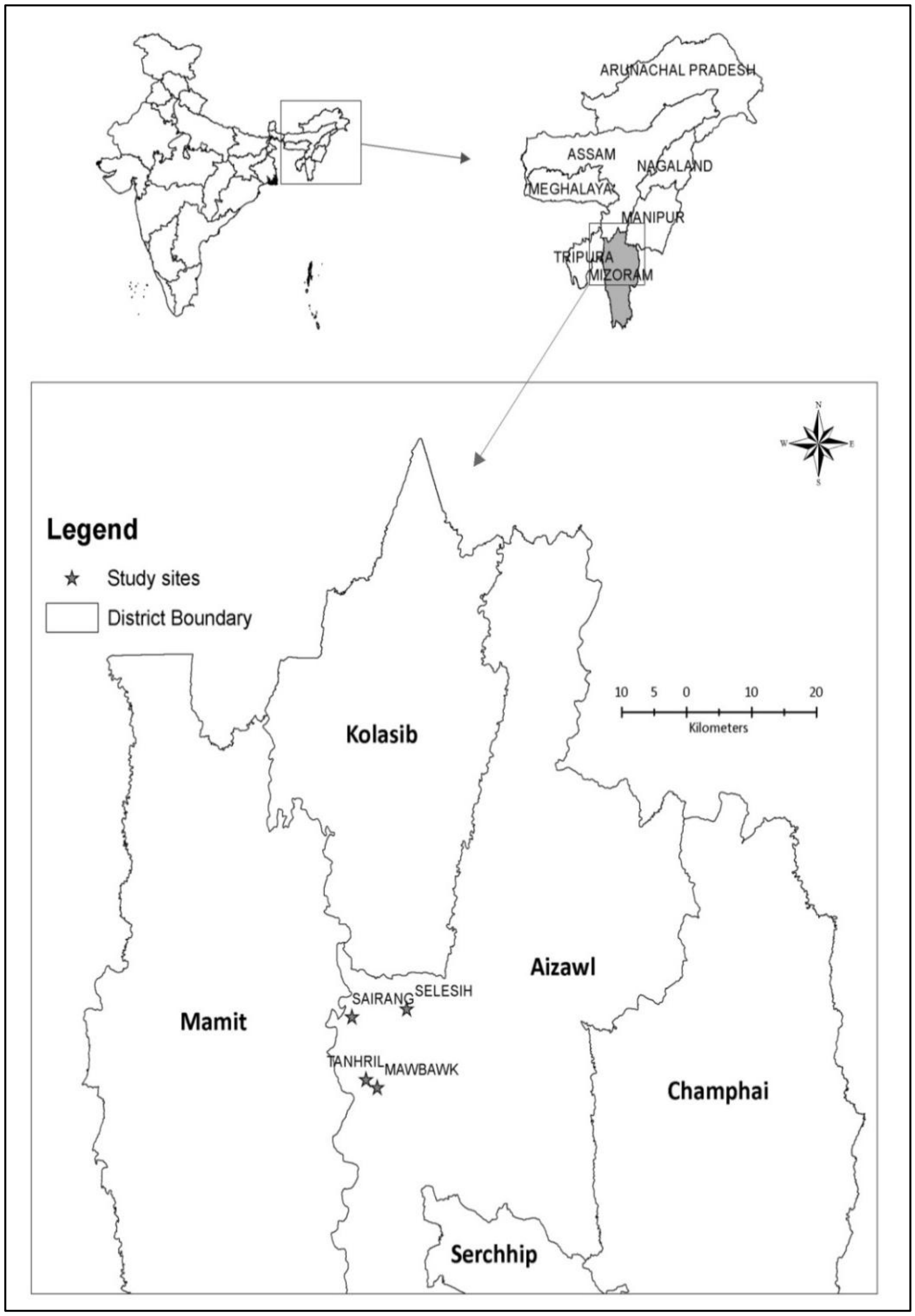
1,21,300) and minimum among small sized homegarden households (INR 48,750). *Jhum* cultivation was the most prevalent land-use practice in the studied areas. They usually cultivated upland rice and annual crops, such as maize, french beans, mustard, cabbage, groundnuts, etc., on their jhum plots and used both for sale and self-consumption.In the studied villages, besides agriculture, livestock rearing also form main source of livelihoods. The most common livestock included pig, poultry, apiculture and cattle. Homegardening was the second most important land use system, next to jhum cultivation in the studied areas. Irrespective of sizes of homegardens, maximum of the household (74%) have homegardens around their houses. All the respondents depend on the homegarden irrespective of whether the garden is for income generation or household consumption.

Table 3.1: Demographic and socio-economic profile of the respondents

Parameters	Large homegardens	Medium homegardens	Small homegardens
Family size	4.4 (3-7)	7.2 (5-11)	5.8 (3-10)
Annual family income (INR)	1,21,300 (73,000 - 2,80,000)	73,400 (10,000 - 1,80,000)	48,750 (10,000 - 90,000)

Values in parentheses are ranges

Figure 3.2: Map showing the location of study sites



Chapter 4

Methodology

4.1. Homegarden sampling

The study was carried out in four villages *viz*. Sairang, Selesih, Tanhril and Maubawk of Aizawl district (92°38` to 92°42` E longitude and 23°42` to 23°46` N latitude, 950 m asl), Mizoram. Individual households having homegarden were considered as a unit of analysis and treated as a system. A stratified sample of forty two homegardens located in these villages was surveyed for studying their structural diversity and functional dynamism. These forty two homegardens were classified into differently sized homegardens viz. small (0.025- 0.05 ha), medium (0.05- 0.75 ha), large (0.75-1.5 ha) of fourteen homegardens in each class. Further, these stratified samples were classified according to their age viz. young (<15 years) - 11 nos, medium (15-30 years) -14 nos and old (>30 years)-17 nos. These homegardens were studied in greater details for their plant composition, structural diversity and functional dynamism over a two years period (2011-12 to 2012-13).

4.2. Phyto-sociological analysis and profile diagram

4.2.1. Data collection

Vegetation enumeration of the homegardens was done in different seasons of the year. All species present in each sampled homegarden were identified and recorded by their botanical name, or by local name and later confirmed from published books. For determining floristic diversity of the homegardens, random quadrats of different sizes were laid. For sampling trees having more than 15 cm diameter and 1.3m height, quadrats of 10m x 10m were laid and the total number of quadrats laid in each home garden was based on the size of the home garden, however a minimum of 10 percent of the total area of the home garden was covered.

Similarly, quadrats measuring 5m x 5m were laid within each 10m x 10m quadrat for studying the shrub species and others wherein herbs and un-established tree species were enumerated through 1m x 1m quadrats. The plant species found in different quadrats within a given homegarden were recorded.

4.2.2. Data analysis

Each species recorded in the homegarden was classified by family, habit, life form and plant utility. Various quantitative parameters such as abundance, frequency and density of trees, shrubs and herbs were determined following the calculation as per Misra (1968).

Importance Value Index

Importantance value index of individual species was derived using the relative values of frequency, abundance and dominance for each species of trees and shrub (Curtis, 1959). Frequency defined as the fraction of homegarden containing the species (Cox, 1990), Abundance which was the number of individuals per species were calculated for all recorded species and the sum of the relative values of frequency, abundance and dominance for each species of trees and shrub was used for deriving the importance value index. These measures have the advantage to level out the bias of single variables such as high absolute abundance.

Diversity indices

Shannon-Wiener index:

It is probably the most common diversity index based on heterogeneity, calculated as follows (Magurran,1988).

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

Where:

H´ = Shannon index of diversity

S = Number of species

pi = Proportional abundance of the *i*th species (i.e., number of species divided by total number in the community).

The measure H´ increases with the number of species and evenness of their abundance. It is sensitive to changes rather in the rare species than in the dominant species of a community (Peet, 1974).

Pielou's evenness index (Pileou, 1969):

The equation is given as follows:

$$E = \frac{H'}{H'_{max}}$$

Where:

H´ = Shannon's index value

H'_{max} = ln S, in which S= total number of species.

Pielou's evenness index ranges from 0 to 1, giving the percentage of H' obtained when all species are evenly distributed. Increasing values indicate more equally abundant species (Ludwig and Reynolds, 1988).

Simpson's index of dominance (Simpson, 1949):

$$C = \sum_{i=1}^{s} pi^2$$

Where:

C = Simpson's Dominance index

s = Number of species

pi = Proportional abundance of the *i*th species

Sorensen's similarity index (Sorensen, 1949):

$$S = \frac{2C}{A + B}$$

Where:

S = Sorensen's similarity coefficient

A = Number of species present in sample A

B = Number of species present in sample B

C = Number of species present in both samples

The vertical stratification was carried out by drawing profile diagrams as per the method outlined in Mueller and Ellenberg (1974).

4.3. Hierarchical cluster analysis

A hierarchical cluster analysis was also applied for classification of the forty two homegardens using tree/shrub species density (i.e. number of individuals per species per unit area) as the main variable. This cluster analysis was performed using SPSS version 20.0 (SPSS Inc.), to detect patterns of similarity and, hence, separate different homegarden types based on their species density. The data for tree/shrub species density were analysed applying squared Euclidean distances as a measure of dissimilarity and the between-group average linkage method (Kehlenbeck and Mass, 2004). Based on this, different homegarden clusters were distinguished and were further assessed with respect to their structural characteristics and functional dynamism. Principal component analysis (PCA) was also performed using SPSS version 20.0 (SPSS Inc.) to deduce the assessment of crop data in the different types of homegardens.

4.4. Microclimatic and edaphic variables

4.4.1. Microclimatic parameters

The microclimate of different home gardens was studied by measuring light intensity, relative humidity, air and soil temperature. All the three parameters were measured randomly at ten places close to the ground surface in each home garden. The light intensity was measured using a digital lux meter. The air temperature and relative humidity were measured using a thermo-hygrometer. Soil temperature was measured using a soil thermometer. These parameters were measured at periodic intervals using standard methods.

4.4.2. Soil sampling and analyses

Five soil samples from two different depths (0-15cm and 15-30cm) were collected randomly from different parts of each selected homegarden for analysis of physical and chemical properties of the soil. All the soils collected were pooled garden-wise and depth-wise and sieved through 2mm mesh screen. The physical characteristics of the soil *viz* bulk density was determined by assessing the dry weight of soil samples with known field volume (6.5cm inner dia core); Water holding capacity (WHC) was determined using Keen's box; Soil texture was determined by Bouyoucos hydrometer method (Anderson and Ingram, 1993). The soil moisture content (SMC), pH, ammonium-N and nitrate-N were determined within 36 hours of sampling following standard procedures given in Anderson and Ingram (1993). Rest of the soil samples were air-dried and analyzed for total kjeldahl nitrogen (TKN) using Kel Plus (Pelican model), while soil organic carbon (SOC) was estimated following the rapid titration method as given in Allen et al (1974) and for obtaining soil organic matter (SOM) value, the SOC values were multiplied by a constant (1.724) for each sample (Allen et al., 1974).

4.5. Economic inputs, outputs and economic sustainability

4.5.1. Data Collection

An interview was conducted through structured and open ended questions on a range of variables relating to socio-economic status like family size and composition, age of respondents, occupation, homegarden size, total family income, income from sale of their products of each household, traditional knowledge and management and utility of trees, crops and livestock within the homegarden. . Information on income from homegarden was also gathered by asking the respondents the amount of homegarden products they had harvested and sold and consumed and the income they incurred from the previous year's sale by recalling method. The total income of the household from various sources including agriculture, off-farm and other sources of income was also calculated in order to compute the contribution of the homegardens towards family gross income. Gross income was calculated by adding the amount of money earned from the products collected from homegardens including those used for self consumption and sale.

The survey also consisted of an inventory of tree, shrub and herb species and a count of all individuals per species. The species were classified according to their life cycle (annual, biennial, perennial) and their use into different categories such as fruits and nuts, staple food, beverages and stimulant species, timber and firewood, medicinal products, religious plants, ornamentals and others. During the survey, information was also collected on management practices for individual species and the main practices that included were weeding, irrigation, application of fertilizers, pruning, etc

4.5.2. Data analysis

Descriptive statistics such as frequencies and percentages for categorical variables and mean standard deviation for continuous variables was employed.

4.6. Home garden plant use

4.6.1. Data collection

The structured open ended questionnaires pertaining to information on different plant use categories were administered to all the sample forty two households and recorded the plant species having ethnobotanical uses and their mode of utilization. The data were collected seasonally so that the seasonal species having ethnobotanical uses were not missed out.

4.6.2. Data analysis

The plant species having medicinal uses found in the homegardens were grouped into family, habit and their mode of utilization. They were also grouped into different plant parts and also according to the ailments for which they are used and treated.

4.7. Statistical analysis

Correlation between species richness and homegarden age, size of the homegarden, and monthly family income was worked out using the Kendall-Tau correlation test (Siegel, 1975). The variations in structural and functional aspects of the homegardens were also correlated with microclimatic and edaphic conditions of the site using ANOVA tests.

Chapter 5

Results and Discussion

5.1. Size and age of homegardens:

In the studied areas, among the forty two homegardens surveyed covering four villages, a wide variation in homegarden size and age was encountered. The size of individual homegardens ranged from 0.033 ha to 1.429 ha with a mean of 0.28 ha area and were suitably grouped into small (0.025-0.05 ha), medium (0.05-0.75 ha) and large (0.75 $\geq$1.5 ha). The mean size was 435 m^2 for small sized homegarden category, 4226 m^2 for medium and 11157 m^2 for large gardens in the studied areas (Table 5.1). Variation in homegarden size is generally attributed to several factors such as topography, socio-economic conditions of the farmers, availability of farm labour, etc. According to Das and Das (2005), the homegarden size by and large is a function of population density. Studies on homegarden systems from different ecological and geographical regions showed that the worldwide average size of homegarden units is around 0.10–0.50 ha (Brownrigg, 1985).

Mizoram being a mountainous and fragile landscape, the homegarden size of the state are expected to be between small and medium size, however, still the observed homegarden sizes fall within the global inventory range of other tropical homegardens. Many small sized homegardens are reported in different places, for example, home garden size ranges from 0.16-0.59 ha in Ghana (Owusu et al., 1994), 0.015-0.5 ha in Vietnam (Trinh et al., 2002), 0.01-0.5 ha in Ethiopia (Asfaw, 2002) and less than 0.5 ha in Kerala, India (KSLUB, 1995). Sunwar (2003) also reported the homegarden size between 434m^2 and 402m^2 for Nepal.

Homegardening is an age old practice and followed world over and most prominent in tropical countries. The age of homegardens, too vary widely and is mostly linked to cultural and biological transformations of the society which practice, and to some extent to the accrued wisdom and insight of the farmers. In the present study, the age of homegarden ranged from 8 years to 65 years with a mean year of 29 years and the homegardens were suitably classified according to their age into young (<15 years), medium (15-30 years) and old (>30 years) (Table 5.1). However, some gardeners were uncertain, in which year they initially planted their homegardens.

Table 5.1: Mean homegarden size and age under different homegarden types

Garden types	Mean size (m^2)	Garden types	Mean (years)
Small	435 ± 13	Young	8.6 ± 1.1
Medium	4226 ± 56	Medium	23.2 ± 1.6
Large	11157 ± 87	Old	46.8 ± 2.63

± Standard error of mean

5.2. Structural Diversity

5.2.1. Floristic composition of homegardens:

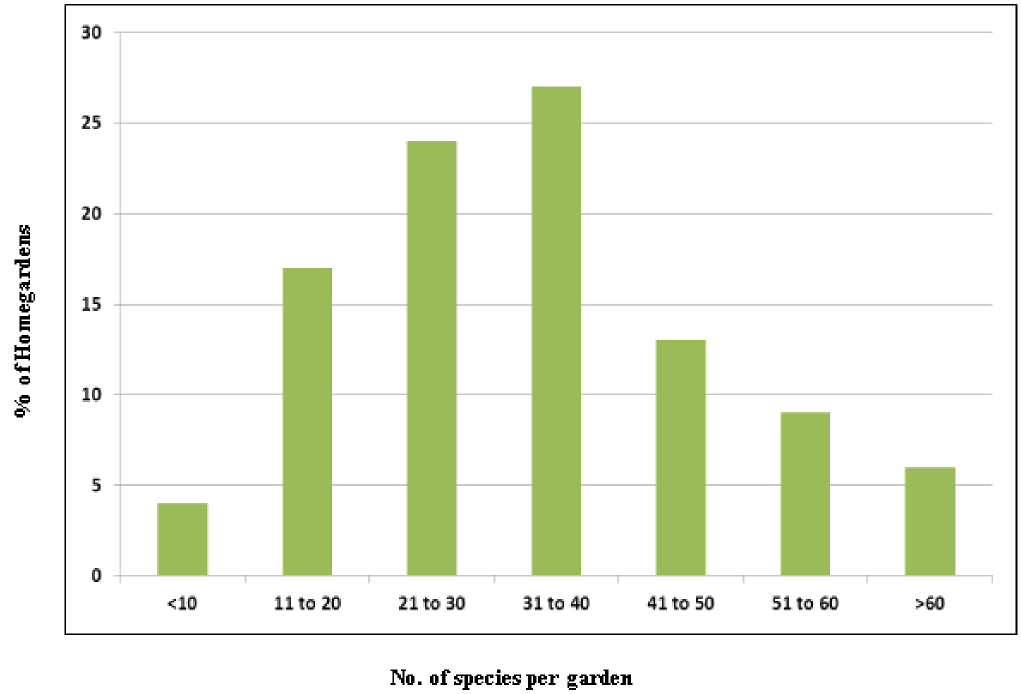
A total of 198 species (82 trees, 31 shrubs, and 79 herbs, 6 palms) belonging to 69 families and 169 genera were recorded from the homegardens during the survey. From a total of 69 families, Papilionaceae had the highest species number (11) in the homegarden flora as it provides a variety of food crops like *Glycine max, Phaseolus vulgaris, Cajanus cajan* etc., followed by Cucurbitaceae (9) Caesalpiniaceae, Euphorbiaceae and Rutaceae (8 each) while Zingiberaceae, Moraceae, Mimosaceae, Solanaceae, shared 5 species each as most of the vegetable crops preferred by the local farmers belong to these plant families.

Thirty families were represented by single species, while 14 families were represented by more than 5 species. Caesalpinaceae, Cucurbitaceae, Euphorbiaceae, Mimosaceae, Moraceae, Musaceae, Papilionaceae, Rutaceae, Solanaceae, Verbenaceae and Zingiberaceae were the most dominant families in the studied home gardens. Most home garden species were perennials (78%) while 16% were annuals and 6% biennials. According to habit, 79 species (40 %) were herbs, 31 (15 %) were shrubs, 82 (41 %) were trees, 6 (4%) were palm. Complete list of the plants, their occurrence and information on their utilization are given in Appendix 1. Species like *Clerodendron colebrookianium, Curcuma longa, Parkia timoriama*, *Brassica juncea*, *Carica papaya, Hibiscus sabdariffa, Eryngium foetida, Colocasia* *esculenta, Trevesia palmata, Artocarpus heterophyllus* and *Cucurbita maxima* were recorded in more than 60% of the homegardens surveyed in the district.

Kumar et al. (1994) found 127 woody species across the homestead of 14 districts and 3 to 25 species per homestead in Kerela. However, Nair and Sreedharan (1986) reported 30 arboreal taxa from the selected home gardens of Kerala. High number of tree and shrub (301 species) have been reported also in Mayan home gardens of Yucatan, Mexico (Rico-Gray and Wienen, 1963), 168 species in Santa Rosa in the Peruvian Amazon (Padoch and de Jong, 1991) and 179 species in home gardens of Java (Soemarwoto 1987). Similarly, Tynsong and Tiwari (2010) reported 187 species in homegardens of War Khasi community in Meghalaya.

Most of the homegardens harboured high species diversity. An average of 37 (SD±9) plant species was recorded per homegarden. About sixty percent of the gardens contain 31-40 plant species while very few gardens have less than 10 species or more than 60 species per garden (Figure 5.1). The average species per homegarden was higher than the number (3 to 25 species per homegarden) reported by Kumar et al (1994) in Kerala.

Figure 5.1: Plant species encountered per homegarden in the surveyed areas



5.2.2. Plant species diversity and dominance in different sized and aged homegardens

Overall plant species was recorded highest in the small sized gardens (157, 79%) distributed in 126 genera and 63 families, followed by medium sized (141, 71%) with 114 genera, 60 families and large sized garden (125, 63%) with 109 genera and 55 families (Table 5.2). Tree species was also recorded highest in small homegarden (66), than medium (54) and large (50) while herbs were recorded highest in medium sized garden. Out of which, 35 tree species (42%) were common to all the home gardens.

Diversity index for trees was maximum in medium sized homegardens (H'=3.780) followed by small (3.325) and large (3.185) homegardens. Least species diversity was recorded for shrubs in small homegardens (3.411) and large garden recorded least herb diversity (3.142). The highest dominace index for tree species was recorded in large homegarden (0.55) followed by medium (0.213) and small (0.17). The maximum value for shrub was recorded in small (0.483) and for herbs it was found in large garden (0.416). Evenness index for tree species varied significantly within the home gardens and it was maximum in the small homegarden (0.622), followed by the medium (0.353) and large home garden (0.314). However, the shrubs evenness index varied slightly with greater values in the medium size home gardens (0.537) followed by large and small home gardens. The maximum value for herb was recorded in small size garden (0.543). The similarity indices determined for tree, shrubs and herbs showed maximum similarity indices between the large sized and medium sized home gardens. Least similarity of plant species were observed among large and small sized home gardens (Table 5.3).

However, the highest number of species was recorded in medium aged homegardens (150, 75.75%) distributed in 136 genera and 65 families, followed by young aged homegarden with 142(71.71%) plant species distributed in 135 genera and 66 families and old aged garden (126, 63.63%) distributed in 118 genera and 64 families. More tree (65 species) and shrub (24 species) were also recorded in medium aged homegarden, while herbs species were highest (68 species) in young aged garden. The Shannon Weaver index shows a higher diversity of trees and shrubs in the medium aged homegarden (H´= 3.862; H'=3.051) as compared to the young and old homegardens. The lesser diveristy index in young and old gardens indicated that only few species were more abundant. The dominance index of tree and shrubs were highest in young gardens followed by old indicating that only a few species dominated the homegardens. The evenness index also showed that in medium aged homegardens most of the species of trees, shrubs and herbs were equally abundant (E = 0.643, E=0.516 and E=0.473 respectively) than young and old aged gardens (Table 5.4). The present study also revealed that 28 trees; 9 shrubs and 32 herbs were common to all differently aged home gardens category. The similarity indices for tree and shrubs were maximum between medium and young aged garden while for herbs it showed between the old and medium aged home gardens. Least similarity of plant species were observed among old and young home gardens (Table 5.5).

The present study clearly reveals that species grown in the traditional home garden systems are confounded by the livelihood requirements and traditional knowledge. Significant difference in species selection for homegarden has also been due to altitudinal/climate regime. The average species diversity index values in the homegardens was high and was higher than that of the index value of 1.9-2.7 in the homegardens of Thailand (Gajaseni and Gajaseni, 1999) and the value of 3.21 in

Karnataka (Shastri et al., 2002). The high species richness index resulted due to higher number of species with significant distribution of individuals of all the species combined with low dominance. However, contrary to the findings by Mendez et al., (2001), Kabir and Webb (2009) and Das and Das (2005) who reported strong relationship between homegarden size and species richness, the average number of species per garden did not differ significantly among the different sized homegardens, but the frequency and density of species increased with decreasing size of homegardens.

The Evenness value in the present study is much higher than the recorded value of 0.282-0.705 in Kerala homegardens (Kumar et al., 1994).The higher eveness index value indicates that the system is more stable and mature and therefore self-sustaining and has the capacity to generate high production output under low input conditions. The high diversity in the homegardens is the result of selection of species by the owners with utility of the specific products as the main criterion. Besides climatic and geographic location, the species diversity also depends on site representativeness; plot dimension, various attributes and the extent of human interaction in the past and present (Wiersum, 2006; Leiva et al 2002). Trees species diversity and richness was also closely related with soil fertility level, particularly the soil organic matter (Huston, 1994; Torquebiau, 1992).

Tree density was found to be higher in the large home garden (249 individual ha^{-1}) and followed by medium size home gardens (216 individual ha^{-1}) and small home garden (195 individual ha^{-1}).

In the large home gardens *Clerodendrum colebrookianum* (IVI 18.537 and density 8.3 individual ha^{-1}), *Parkia timoriana* (IVI 15.106 and density 7.3 individual ha^{-1}), *Mangifera indica* (IVI 15.088 and density 5.9 individual ha^{-1}), *Trevesia palmata* (IVI 14.637 and density 8.6 individual ha^{-1}), *Citrus macroptera* var *anamensis* (IVI 9.326 and density 1.3 individual ha^{-1}), *Emblica officinalis* (IVI 9.297 and density 6.5 individual ha^{-1}) and *Artocarpus heterophyllus* (IVI 8.392 and density 7.1 individual ha-1) were the dominant tree species.

In the medium home gardens species like *Parkia timoriana* (IVI 17.742 and density 6.8 individual ha^{-1}), *Trevesia palmata* (IVI 13.747 and density 7.9 individual ha^{-1}), *Artocarpus heterophyllus* (IVI 12.321and density 6.0 individual ha^{-1}), *Clerodendrum colebrookianum* (IVI 10.355 and density 6.4 individual ha^{-1}); *Callistemon lanceolatus* (IVI 8.453 and density 4.2 individual ha^{-1}), *Albizia odoratissa* (IVI 8.21 and density 3.2 individual ha^{-1}), and *Emblica officinalis* (IVI 7.823 and density 5.7 individual ha^{-1}), were the dominant tree species.

In the small size home gardens species like *Parkia timoriana* (IVI 15.475 and density 7.4 individual ha^{-1}), *Trevesia palmata* (IVI 10.245 and density 7.3 individual ha^{-1}), *Emblica officinalis* (IVI 10.892 and density 6.4 individual ha^{-1}), *Artocarpus* *heterophyllus* (IVI 9.236 and density 5.3 individual ha^{-1}), *Citrus grandis* (IVI 7.342 and density 5.8 individual ha^{-1}), *Clerodendrum colebrookianum* (IVI 6.361 and density 3.5 individual ha^{-1}) *Bauhinia variegate* (IVI 5.733 and density 4.0 individual ha^{-1}) were the dominant tree species.

Shrub species like *Acacia pinnata* (IVI 25.163), *Citrus reticulata* (IVI 19.853), *Carica papaya* (IVI 18.736), *Cajanus cajan* (IVI 18.326), *Solanum nigrum* (IVI 14.853) and *Murraya Koenigii* (IVI 13.931) were dominant in the large home garden and *Acacia pinnata* (IVI 23.742), *Cajanus cajan* (IVI 18.352), *Citrus aurantifolia* (IVI 16.633), *Solanum melongena* (IVI 14.233), *Eleagnus latifolia* (IVI 10.647) were dominant in the medium size home gardens and in the small home garden *Acacia pinnata* (IVI 27.362), *Adhatoda vasica* (IVI 12.134), *Cajanus cajan* (IVI 23.458), *Citrus aurantifolia* (IVI 12.474), *Sida acuta* (IVI 14.733) were the dominant shrubs species. Among the herbs, *Anannas comosus* (IVI 8.833), *Abelmoschus esculentus* (IVI 8.783), *Zingiber officinalis* (IVI 8.722), *Daucus carota* (IVI 7.454), *Cucumis sativus* (IVI 6.826), *Cucurbita maxima* (IVI 6.732) in the large home gardens; *Abelmoschus esculentus* (IVI 9.342), *Allium cepa* (IVI 8.942), *Allium sativum* (IVI 8.381), *Musa paradisiaca* (IVI 8.581) and *Zingiber officinalis* (IVI 7.621) in the medium size home gardens; and species like *Allium sativum* (IVI 8.381), *Brassica oleracea var capitata* (IVI 9.621), *Anannas comosus* (IVI 6.973), *Capsicum annum* (IVI 7.132) dominated the small home gardens (Appendix 2).

Table 5.2: Phyto-sociological and community attributes of differently sized homegardens in Aizawl district of Mizoram

Parameters		Homegarden		
		Small (≤ 0.05 ha)	Medium (>0.05ha, 0.75 ha)	Large (>0.75 ha)
No. of species	Trees	66	54	50
	Shrubs	27	22	19
	Herbs	64	65	56
No. of genera	Trees	52	54	50
	Shrubs	23	15	16
	Herbs	51	45	43
No. of families	Trees	28	22	20
	Shrubs	13	14	15
	Herbs	22	24	20
Diversity index	Trees	3.325	3.780	3.185
	Shrubs	3.411	3.780	3.89
	Herbs	3.624	3.452	3.142
Dominance index	Trees	0.17	0.213	0.55
	Shrubs	0.483	0.421	0.34
	Herbs	0.269	0.314	0.416
Evenness index	Trees	0.622	0.353	0.314
	Shrubs	0.421	0.537	0.528
	Herbs	0.543	0.403	0.207

Table 5.3: Similarity indices between tree, shrub and herb components across differently sized homegardens

Homegarden		Medium	Small
Large	Tree	57.821	48.527
	Shrub	51.936	39.671
	Herb	48.833	42.745
Medium	Tree	-	52.830
	Shrub	-	47.822
	Herb	-	39.813

Table 5.4: Phyto-sociological and community attributes of differently aged homegardens in Aizawl district of Mizoram

Parameters		Homegarden		
		Young (<15 yrs)	Medium (15-30yrs)	Old (>30yrs)
No. of species	Trees	51	65	50
	Shrubs	23	24	21
	Herbs	68	61	55
No. of genera	Trees	48	57	45
	Shrubs	23	21	21
	Herbs	64	58	52
No. of families	Trees	22	28	25
	Shrubs	19	15	16
	Herbs	25	22	23

Diversity index	Trees	3.174	3.862	3.257
	Shrubs	2.839	3.051	2.970
	Herbs	3.516	3.411	3.377
Dominance index	Trees	0.374	0.259	0.331
	Shrubs	0.481	0.362	0.345
	Herbs	0.253	0.271	0.318
Evenness index	Trees	0.371	0.443	0.511
	Shrubs	0.428	0.516	0.349
	Herbs	0.425	0.473	0.461

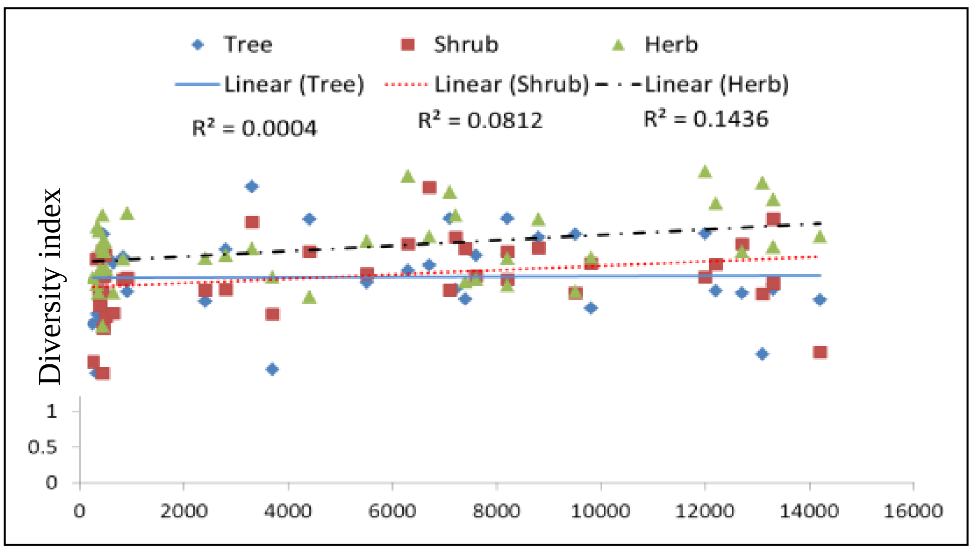
Table 5.5: Similarity indices between tree, shrub and herb components across differently aged homegardens

Homegarden		Medium	Young
Old	Tree	48.76	45.67
	Shrub	52.51	41.54
	Herb	55.73	53.72
Medium	Tree	-	49.78
	Shrub	-	56.28
	Herb	-	43.09

5.2.3. Variation in plant diversity with garden size and garden age

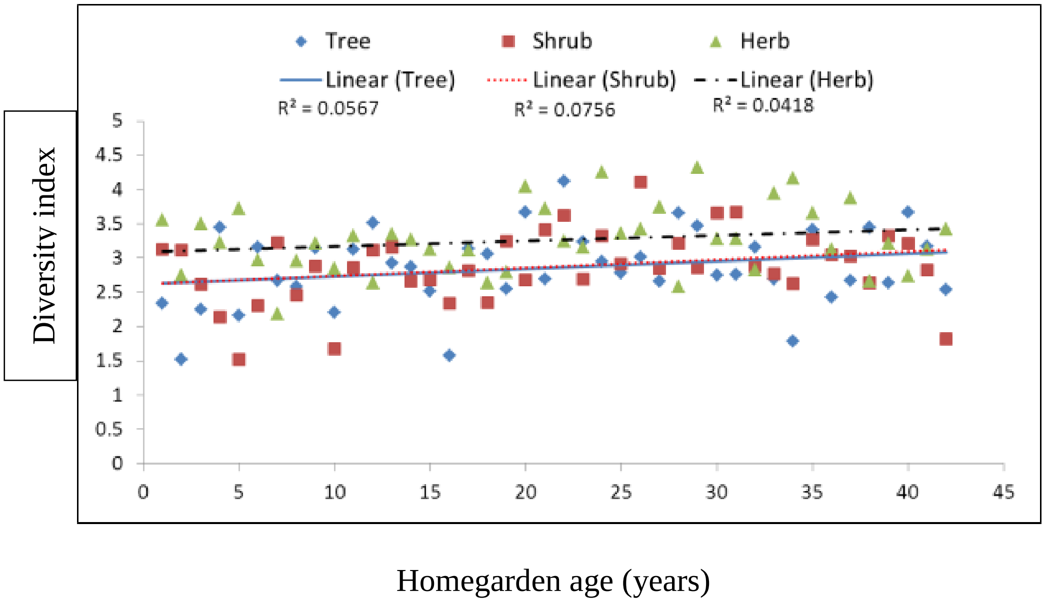
Species diversity was positively correlated with both garden size and garden age (Figure 5.2 and Figure 5.3). However, the relationships showed a weak increasing trend with both homegarden size and age. The diversity index of herbs showed higher correlation with increasing size of homegardens while the shrubs diversity showed higher correlation with increasing age of homegarden.

Figure 5.2: Relationship between diversity index and homegarden size



Homegarden size (m^2)

Figure 5.3: Relationship between diversity index and homegarden age



5.2.4. Structure of homegardens

5.2.4.1. Horizontal structure

There is great diversity in the spatial distribution of crop components grown in homegardens. The horizontal structure of homegardens showed interesting patterns, governed by the uses or functions of the different plant species. The location of the different zones within homegardens was clearly fixed, based on practical considerations as well as traditions. Some clear microzonations were observed in some of medium and large old homegardens. However little zonation could be demarcated in smaller and young homegardens. In most of the surveyed homegardens trees were grown towards the boundary of the garden so as to serve for delineation or fencing of the property. The ornamental plants were grown nearby the houses and front yard to increase the aesthetic value of the surrounding. In most of the homegardens the vegetables and food crops occupied the largest area and are grown close to the house, or sometimes a little farther away from the house, mostly in small groups scattered with a few fruit trees to facilitate management such as weeding or pruning. Fruit trees were often planted along homegarden borders, sometimes also in groups beside or behind the houses. The sizes of micro-zones and their proportions of total homegarden areas differed among different sized homegardens.

5.2.4.2. Vertical Structure of Homegardens:

The vertical structure (Table 5.6) of the vegetation consisted of 3-4 strata in all the homegardens surveyed. The ground layer (0-1m) primarily in the openings of the tree canopy was occupied mainly by annual/ biennial herbaceous vegetables, tubers and climbers, such as *Cucurbita maxima*, *Colocasia esculenta*, *Hibiscus* and *Brassica juncea*. In the second stratum (1-5m) *Clerodendrum colebrookianum* was common in the both small and large gardens while *Trevesia palmata* was the common species in the middle sized gardens. Other important included *Citrus reticulata, Carica papaya, Musa* *paradiasiaca*, woody climbers like *Acacia pinnata, Eleagnus latifolia*, cassavas, coffee and young fruit trees of guava, jackfruit and mango, etc. *Mangifera indica* was common in the stratum (5-10m) across small and medium gardens and other species included other fruit trees like *Psidium guajava, Prunus, Pyrus Citrus, Trevesia palmata*. The uppermost canopy consisted of trees like *Parkia timoriana* which is grown in highest frequency in most of the gardens and also included species like *Albizzia chinensis*, *Artocarpus heterophyllus, Schima wallichii, Quercus serrata*, etc which extends from 10-15 m. Profile diagram of typical traditional homegarden are depicted in figure 5.6-5.8 for different types of homegardens. The mean proportion of crop species occurring in different strata in different homegardens is shown in figure 5.4 and figure 5.5. The small homegardens had the highest proportion (60%) of crop species under the 0 to1 m stratum compared to medium (51%) and large (42%) homegarden and the proportion of crop species under >6m stratum was highest in large homegarden followed by medium and small. Young homegardens had the highest proportion of species under 0 to 1m stratum followed by medium and old homegardens.

There was marked differences in the proportions of crop individuals per stratum between different sized and aged homegardens. In all the homegardens surveyed, crop species number decreased continuously from the lower to the higher strata. However, in the small and young homegardens, most species occurred in the first stratum, only small proportions of crop species were found in the higher strata. Similar differences were revealed when analysing the proportions of crop individuals per stratum. In all the homegardens, the proportions of individuals decreased continuously from lower to higher strata (i.e. 45–60% of individuals occurred in the first, 15–20% in the second, and 8–13% in the third layer). It was also observed that with increasing size and age of homegardens, the proportion of crop species in higher strata also increased which might have resulted from the contribution of tree growth. Gillespie et al. (1993) also reported high structural complexity, with full canopy closure in the layers within the canopy in a study in Petén, Guatemala. Six strata (low herbs, low shrubs, tall shrubs, fruit trees, timber trees, and a stratum with vines) were also observed in homegardens of the Zona Maya of Quintana Roo, Yucatán Península, Mexico (De Clerck and Negreros-Castillo, 2000). The complex and multistratified structure of tropical homegardens provide efficient utilization of resources and tighter nutrient cycling. The garden architecture made efficient use of light and space, with intensive management for food and fuel production.

Table 5.6: Vertical distribution of plant species (trees and shrubs) and their average density in homegardens

Vertical strata	Small HG	Average density per garden	Medium HG	Average density per garden	Large HG	Average density per garden
Emergent Layer (>15m)	*Parkia timoriana,* *Artocarpus heterophyllus*	5.28 3.05	*Tectona grandis,* *Gmelina arborea,* *Parkia timoriana*	2.47 1.65 4.87	*Derris robosta,* *Gmelina arborea* *Parkia timoriana*	1.83 0.53 1.62
Canopy Layer (10-15m)	*Albizzia chinensis,* *Tamarindus indica,* *Quercus serrata*	1.65 1.18 0.82	*Averrhoa carambola,* *A. lakoocha,* *A. Chinensis*	1.57 0.74 2.15	*Cocus nucifera* *Areca catechu* *A. Chinensis*	1.52 2.60 0.53
Understory layer (5-10m)	*Prunus domestica,* *Citrus macroptera,* *Mangiferaindica*	2.63 1.58 4.16	*Citrus grandis* *Mangifera indica* *Litseacubeba*	3.51 2.64 0.73	*Citrus macroptera,* *Schima wallichii,* *Pyrus communis*	1.43 2.24 1.62
Shrub layer (<5m)	*Acacia pinata,* *C. colebrookianum,* *Carica papaya*	4.61 10.32 2.46	*Psidium guajava* *Trevesia palmata* *Emblica officinalis*	2.39 7.31 2.42	*C. colebrookianum* *Citrus reticulata,* *C. papaya*	9.34 7.54 4.43

Figure 5.4: Mean proportion of crop species occurring in different strata in differently sized homegardens

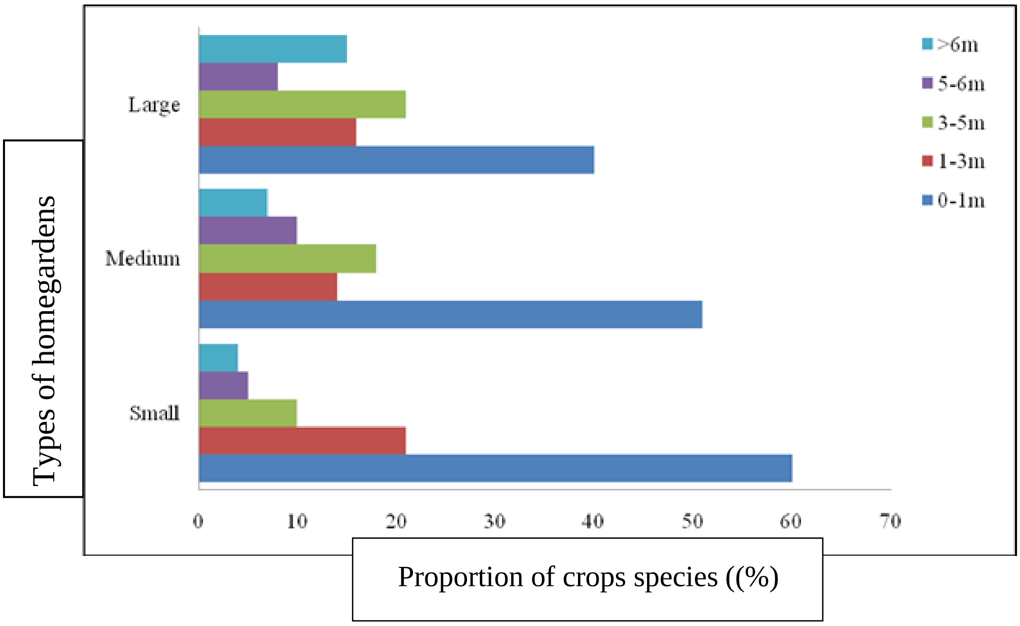


Figure 5.5: Mean proportion of crop species occurring in different strata in differently aged homegardens

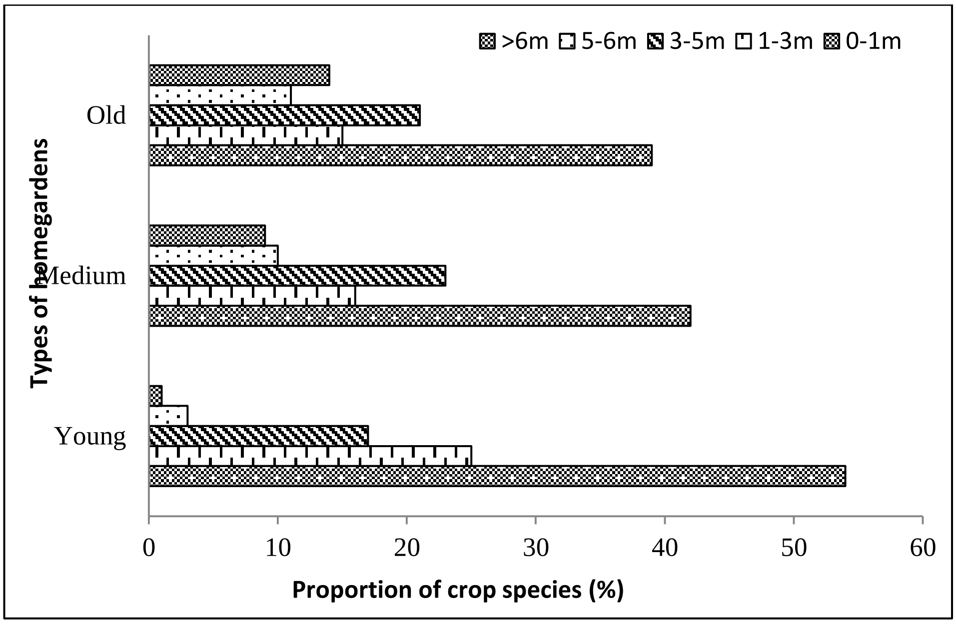
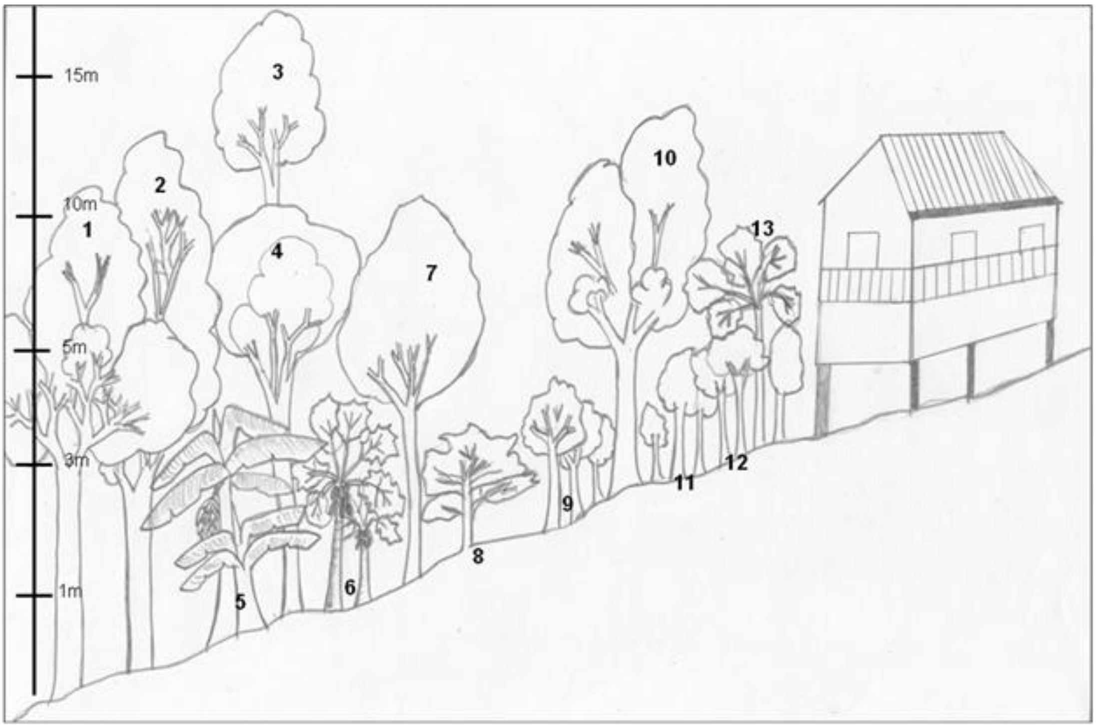


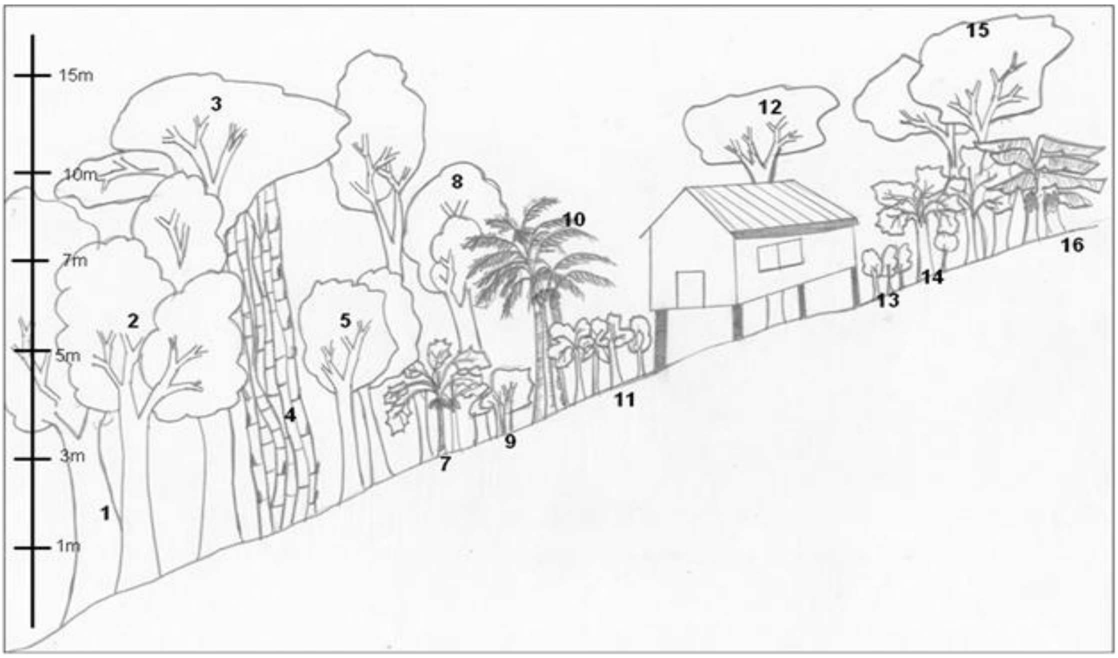
Figure 5.6: Homegarden profile depicting vertical strata in small sized garden.



Legends of the tree numbers corresponds to the species given below:

(1) *Averrhoa carambola*, (2) *Artocarpus heterophyllus*, (3) *Parkia timoriana*, (4) *Quercus serata*, (5) *Musa paradisiaca*, (6) *Carica papaya*, (7) *Mangifera indica*, (8) *Acacia piñata* (9) *Prunus domestica*, (10) *Citrus macroptera*, (12) *Clerodendron colebrookianum*, (13) *Trevesia palmate*

Figure 5.7: Homegarden profile depicting vertical strata in medium sized

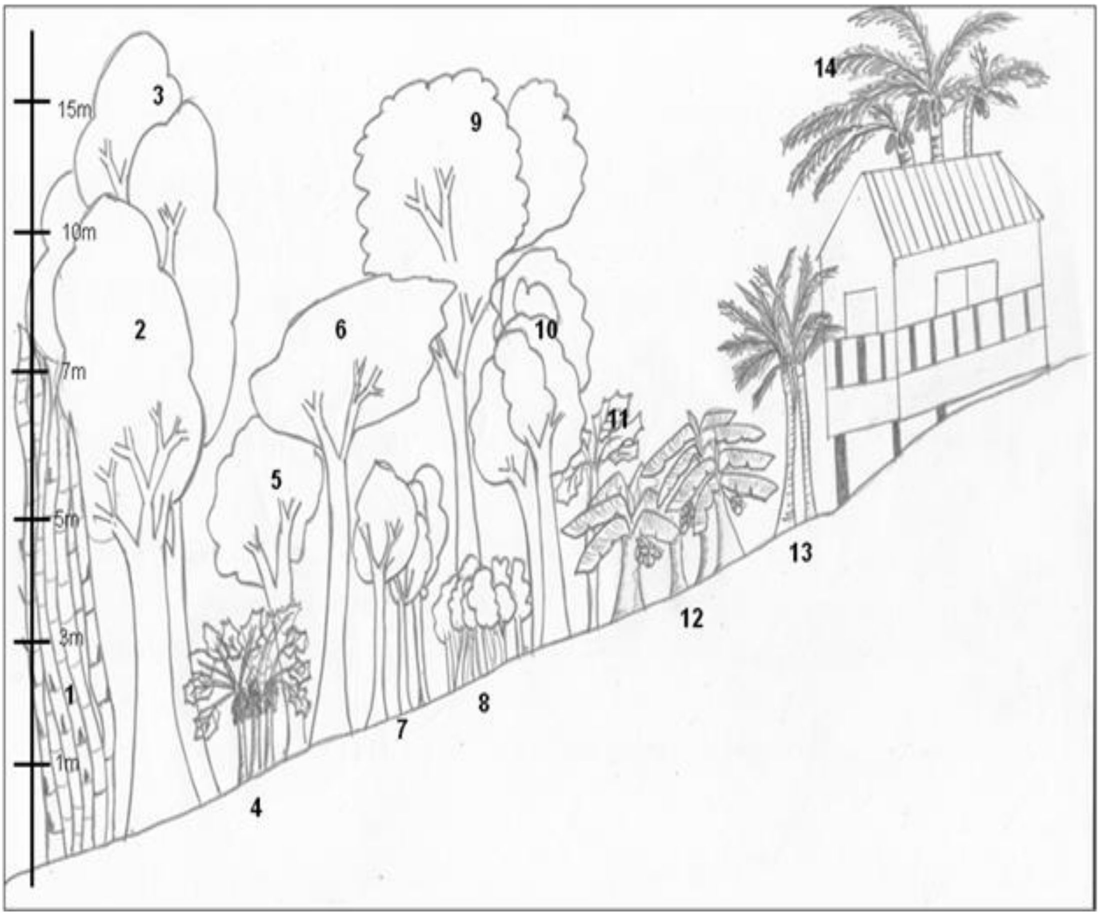


garden.

Legend of the tree numbers corresponds to the species given below:

(1)*Tectona grandis*, (2)*Averrhoa carambola*, (3) *Artocarpus heterophyllus*, (4) *Dendrocalamus longispatus*, (5) *Citrus macroptera*, (6) *Parkia timoriana*, (7) *Carica papaya*, (8) *Albizzia chinensis*, (9) *Acacia pinata*, (10) *Cocus nucifera*, (11) *Trevesia palmata*,(12) *Psidium guajava*, (13) *Clerodendron colebrookianum*, (15) *Mangifera indica* (16) *Musa paradisiaca*

Figure 5.8: Homegarden profile depicting vertical strata in medium sized garden.



Legend of the tree numbers corresponds to the species given below.

(1) *Bambusa tulda*, (2) *Gmelina arborea*, (3)*Tectona grandis*, (4) *Carica papaya*, (5) *Citrus grandis*, (6) *Artocarpus heterophyllus*, (7) *Psidium guajava*, (8) *Citrus reticulate*, (9) *Parkia timoriana*, (10) *Emblica officinalis*, (11) *Trevesia palmata*, (12) *Musa paradisiaca*, (13) *Areca catechu*, (14) *Cocus nucifera*

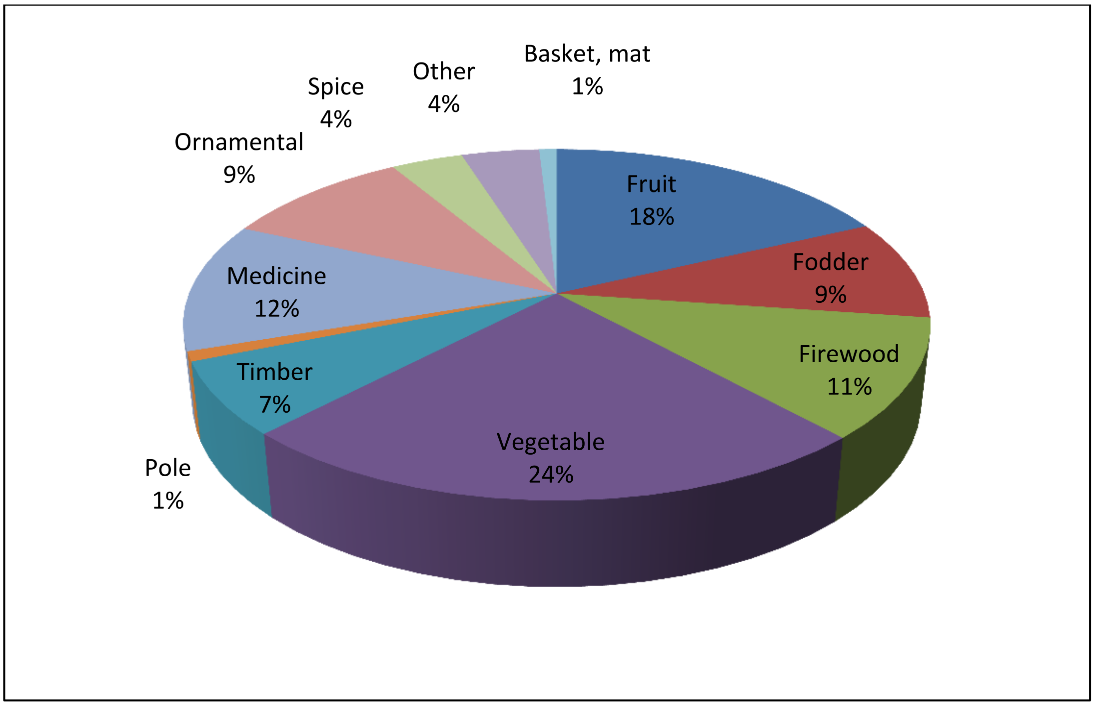
5.3. Functional Dynamism of homegardens

5.3.1. Homegarden plant use

All plant species in the homegardens have been very useful to farmers in some way or the other. Based on the plant use, eleven categories of uses were recorded. Although many of the plants had multiple uses only the major use of the plant, as informed by the farmers were considered for allotting the category. The study shows that vegetables are the major component of the homegarden followed by fruit, medicinal, firewood and ornamental plants. The households cited most species as useful for vegetable (24%) followed by fruit (18%), firewood (12%), medicine (11%), ornamental (9.8%), fodder (9.2%), timber (6.7%) and others (9.3%) (Figure 5.9). The other utility class includes spice, beverage, broom, nut, although important, comprised only of a few species per category. Of the 198 recorded plants 86 have only one indicated use, while 112 had more than one attributed utility in the study area. *Parkia timoriana, Psidium guajava, Clerodendron colebrookianum, Mangifera indica, Prunus domestica, Trevesia palmata, Citrus grandis, Schima wallichii, Artocarpus heterophyllus* etc. are the most important trees which provided multiple uses to the farmers (Appendix 1). Similarly, a good number of shrubs, herbs and climbers are a good source of multiple use and income to the farmers. Out of 82 tree species, 56 species fruit trees were cultivated. The most common fruit trees are

Emblica officinalis, Citrus grandis, Psidium guajava, Tamarindus indica, Prunus domestica etc. Besides the use of the fruits, *Artocarpus heterophyllus, Carallia brachiata* are mainly used for fodder, *Averrhoa carambola, Elaeocarpus floribundus* for construction, *Callistemon lanceolatus, Polyalthia pendula* for ornamental and *Spondias pinnata, Sterculia alata, Sterculia villosa* for making traditional drum. *Aegle marmelos, Garcinia lanceaefolia* are endangered and rare species that are present in the homegarden. *Murraya Koenigii, Elsholtzia communis* are commonly grown for flavour. Most plant products are used mainly for self-consumption or for fodder but their surplus products are also sold in the market. In homegardens of Nicaragua, home consumption was 100% for most fruit trees and herbaceous food species (Méndez et al., 2001). Cash crops like pineapple (*Anannas comosus*), maize (*Zea mays*), areca nut (*Areca catechu*) are income generating source and some common ornamental plants include *Callistemon lanceolatus, Allamanda cathartica, Bougainvillea spectabilis, Caesalpinia pulcherrima, Chrysanthemum indicum, Tagetes.*

Figure 5.9: Plant uses category in the homegardens of Aizawl district, Mizoram, northeast India.



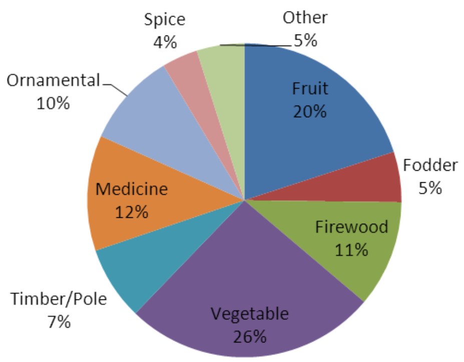
5.3.1.1. Plant use category of differently sized homegardens

In small homegardens, vegetable (26%) occupied the highest percentage of plant use category, followed by fruit (20%), medicine (12%), in medium and large garden, fruit dominates, followed by vegetable, ornamental plants. The variation in use category among the gardens was directly linked to the livelihood conditions of the farmers. Vegetables are the essential food crops for the poor people who mostly own the small gardens, they utilized their homegarden land maximally for primary food production, mostly the staple foods rather than supplementary crops. The results also revealed that with the increase of size, the proportion of ornamental plant use category increased and vegetable decreased (Figure 5.10). This further suggests that supplementary crops are introduced gradually and mostly by affluent people having access to non-farm incomes.

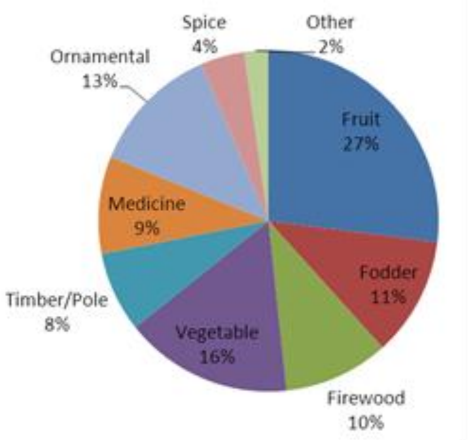
5.3.1.2. Plant use category of differently aged homegardens

Young homegardens had the highest proportion of vegetable (31%), followed by fruits, ornament, and vegetable. With the increase in the age, there was also a trend of decreasing the proportion of vegetable. As discussed earlier, the age of the garden is culturally linked and to some extent to the socio-economic condition of the farmer. The young homegardens support species which are mostly of annuals and biennials. The ratio of the perennials to annuals in these homegardens was somewhat lesser than the medium and old aged homegardens. The intensification of homegarden crops, shifting the ratio of perennial to annuals was clearly visible when one moves from young homegardens to old homegardens.

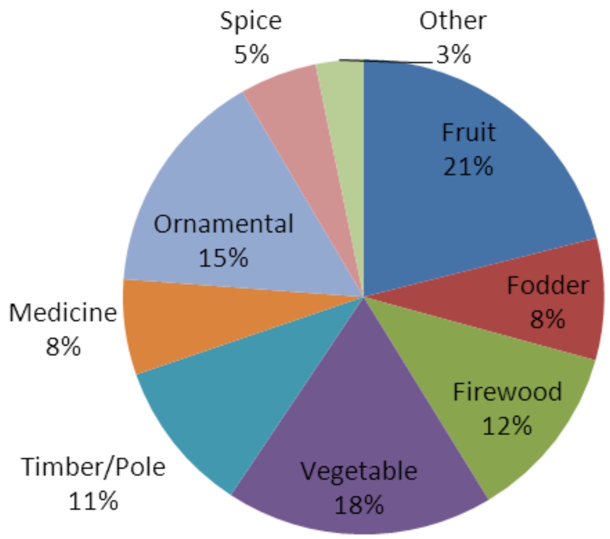
Figure 5.10: Plant uses category in the differently sized homegardens of Aizawl district, Mizoram, northeast India.



Small sized homegarden

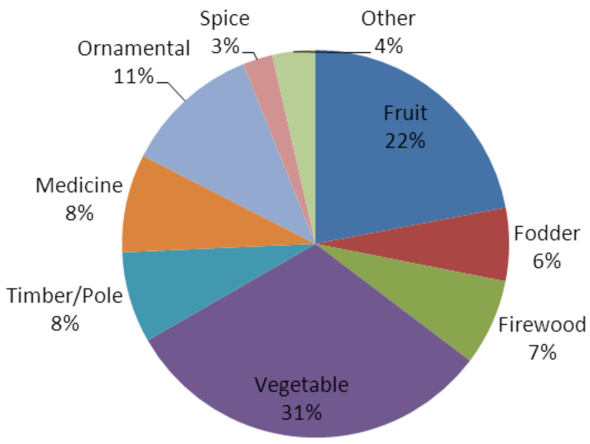


Medium sized homegarden

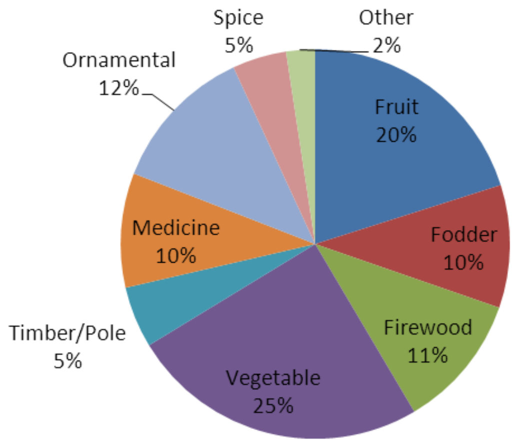


Large sized homegarden

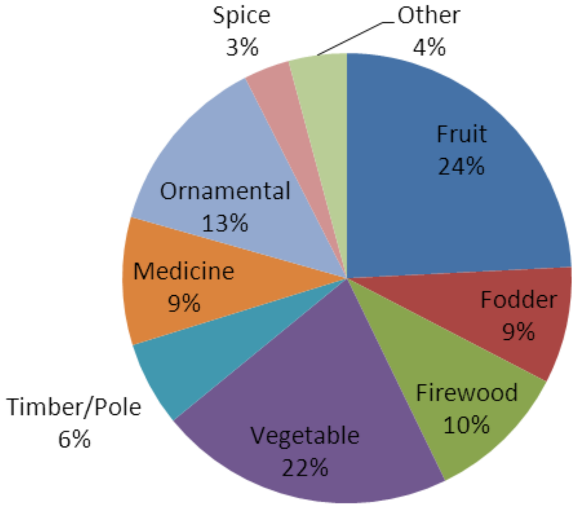
Figure 5.11: Plant use category of differently aged Homegardens of Aizawl district, Mizoram, northeast India.



Young homegarden



Medium aged homegarden



Old Homegarden

5.3.2. Function and role of homegardens:

In all surveyed households, the function of homegardens was influenced by the socio-economic status of household as well as the size and age of homegardens. The primary function of homegardens was subsistence-oriented crop production for supplying the gardeners' families with non-staple food, such as fruits, vegetables, and spices. However, their importance for subsistence decreased with higher income and size of homegarden and some gardens served mainly as sources of cash income or for ornamental purposes (Figure 5.12 and Figure 5.13).

Secondary functions of homegardens were mainly decoration or generation of cash income. The proportions of these functions differed among different size and aged gardens. In most of the small sized and young homegardens, gardeners used their homegarden products mainly for self-consumption, in 80% of small sized garden and about 50% young gardens. In the small sized gardens, about 10% of the gardeners rated their gardens mainly as source for additional cash income. On average, the small sized homegardens were said to contribute about 20% of the total household's cash income (range 8–28%). During the survey, it was found that more than 60% of large homegardens cultivated ornamental plants especially roses and *Anthurium* for export. They were even cultivating off season crops using green house and agro-net house. The trend of commercialization among large homegardens was evident indicating a gradual concentration on a limited number of cash crop species, which in turn would lead to decrease in tree or shrub diversity, thereby homogenizing the structure of homegardens. The ornamental function of homegardens also increased with increasing size and age of gardens. About 20% of both large and old homegarden respondents dedicated most part of the their gardens for cultivating various ornamental plants like *Duranta aspens*, *Chrysanthemum indicum*, *Sansevieria zeylanica*, *Tagetes patula*, *Rosa spp*, *Anthurium*, *etc.*

Figure 5.12: Primary and secondary functions of differently sized homegardens in Aizawl district of Mizoram

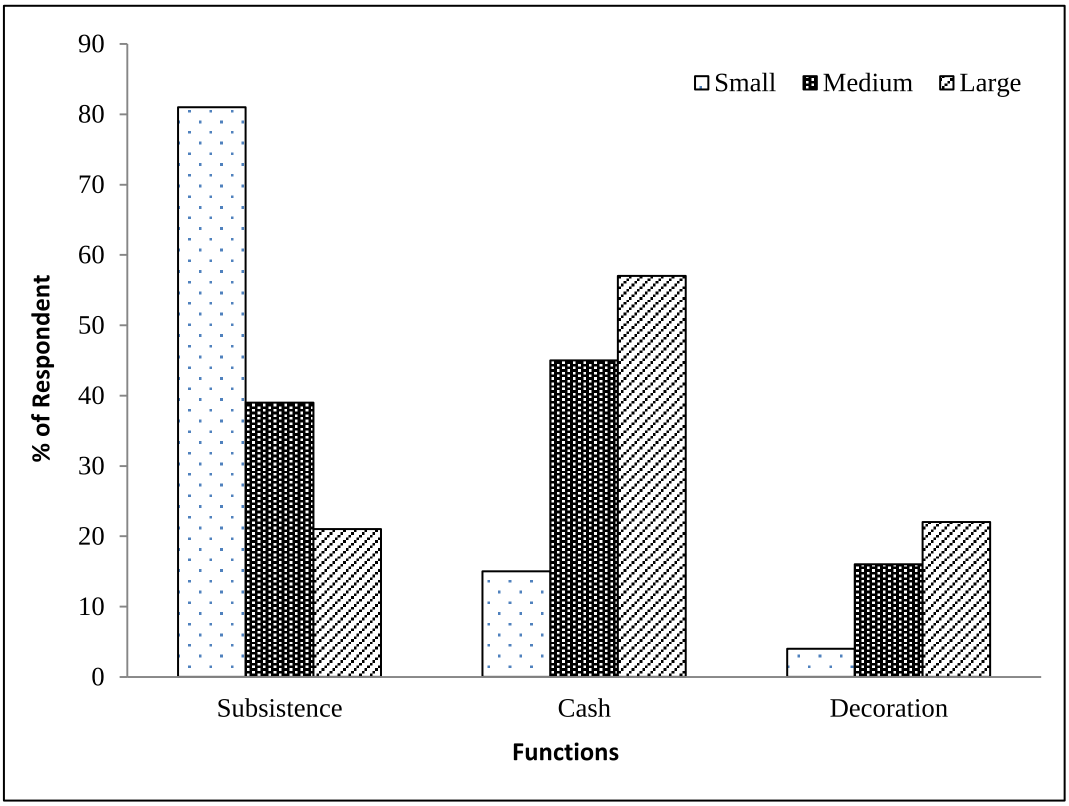
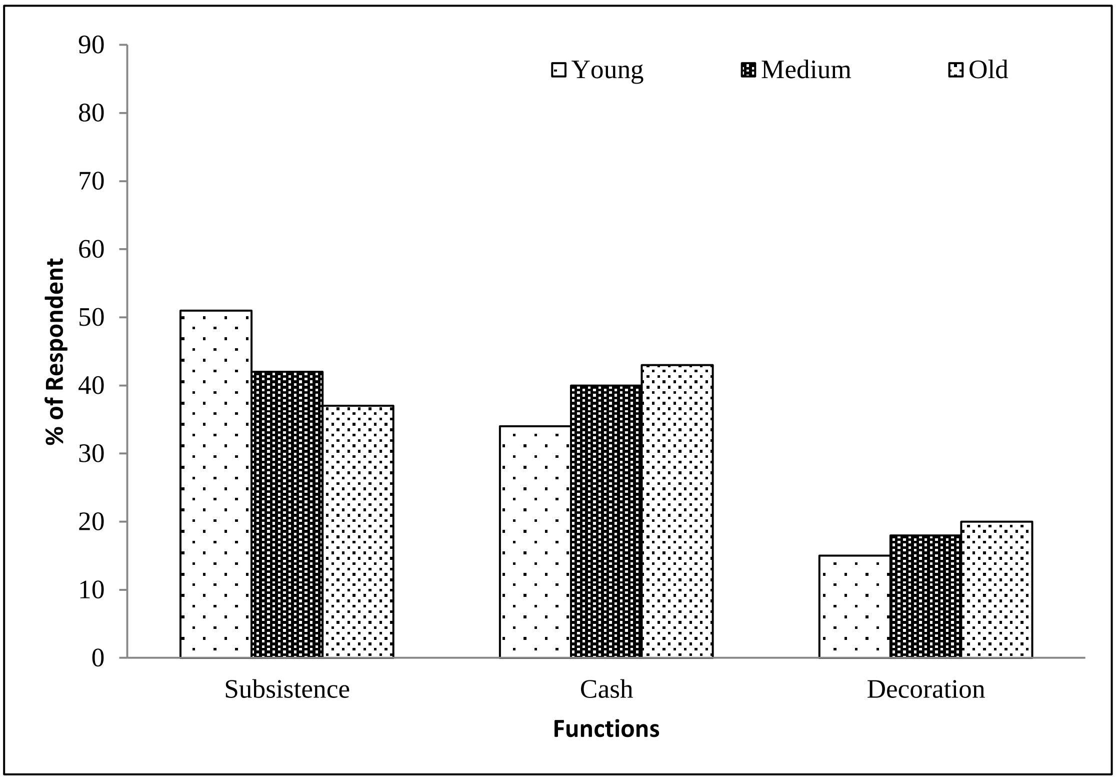


Figure 5.13: Primary and secondary functions of differently aged homegardens in Aizawl district of Mizoram



All the respondents depend on the homegarden irrespective of whether the garden is for income generation or household consumption or medicinal plants. For those gardeners who sell their surplus products for income, the homegarden contributed to as high as 49% of their household income in case of large gardens (Table 5.7) and the lowest was observed in small. In different aged homegadens, the maximum contribution to total household income as observed in middle aged garden followed by old and young.

Table 5.7: Total household income from sale of homegarden products in Aizawl district, Mizoram

Attributes	Garden category	Mean annual proceeds (INR)	Percentage to total household income
Size	Small HG	16,520.00	20.61
	Medium HG	55,640.00	36.93
	Large HG	84,750.00	48.74
Age	Young HG	34,520.00	31.32
	Medium HG	53,430.00	45.67
	Old HG	42,840.00	41.41

Among the garden products whose surplus were sold for income different crops contributed differently across size. Contributions of few prominent crops to the total homegarden income are shown in figures 5.14, 5.15 and 5.16. In the small gardens, *Parkia timoriana* contributed the maximum followed by *Brassica comprestris, Acacia pinnata, Passiflora edulis* and *Zea mays*. In the medium sized gardens, maximum was contributed by Areca catechu followed by *Annanas comosus, Citris reticulata, Passiflora edulis*, etc., and in large garden, highest contribution came from *Anthurium spp*, followed *Areca catechu, Litchi sinensis, Zingiber officinalis*, etc.

Figure 5.14: Proportion of important food crops in small homegarden

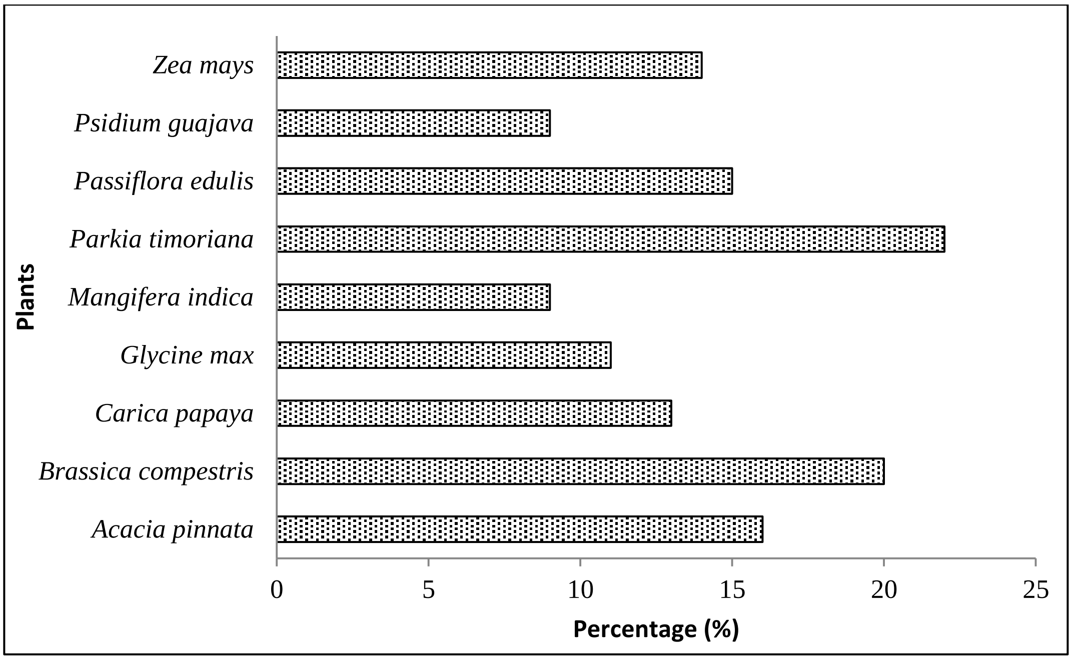


Figure 5.15: Proportion of important food crops in medium sized homegarden

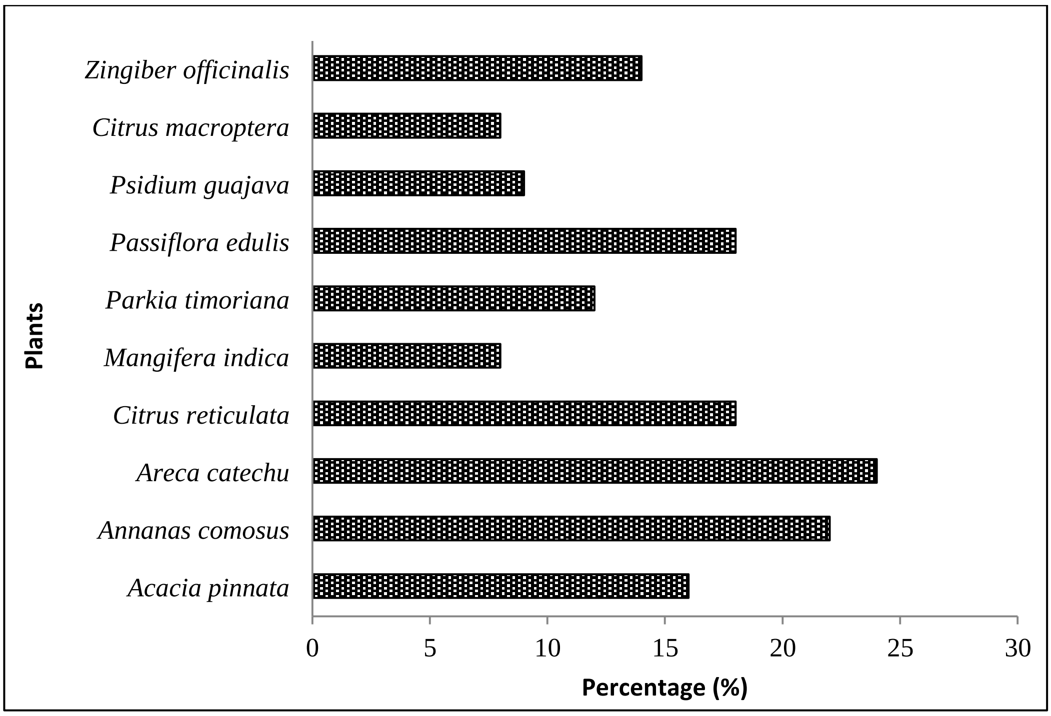
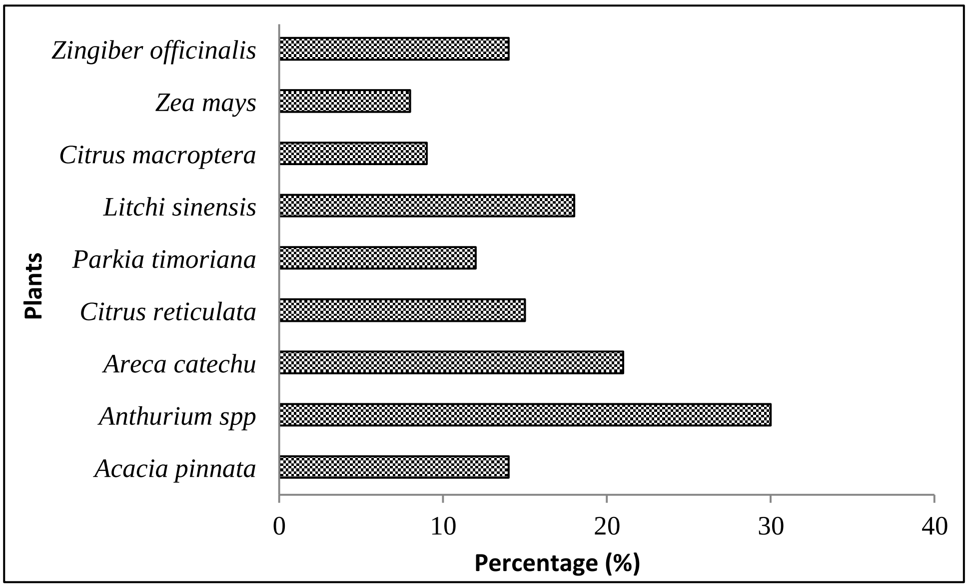


Figure 5.16: Proportion of important food crops in large sized homegarden



5.3.2.1. Sale of homegarden products

All species in the homegarden were used for multiple purposes. Availability of more number of species and individuals contributed to higher production resulting into surplus food products for sale after household consumption. Sale of surplus food was more in case of large homegarden which were with commercial motives and also among the medium size gardens in the case of high altitude gardens. In all 35.8% of the respondents informed that all the products from the homegarden were for household consumption only and the remaining 64.2% sold one or more product from the garden. 35.9% of the respondents informed that more than half of their garden's product went to household consumption and the remaining 40.2% of the respondents informed that half or more of their garden's productions were sold either by self to the market, roadside or through middle men. Majority of the respondents (61.3%) sold their products by themselves while 38.7% sold through middle men directly from their garden. The markets for the destination of the products were usually 1-2 kms (nearest local market) to about 6-10 kms (major market) away while some in some of the cases the gardens were very close to the major roads (highways).

5.3.3. Medicinal plants in homegardens

Most of the plants grown in the homegardens were used as traditional medicines by the respondents. Majority of the households have reported the medicinal values of the plants and their mode of utilization. A list of medicinal plant uses as informed by the respondents are given in table 5.8. Different plant parts like leaves, roots, flower, fruits, barks etc were being used for their different ailments.

Leaf or frond was used in the majority of cases for medicinal preparation (24.61%) followed by root/rhizome / tuber (21.93%), stem/ root bark (15.14%), whole plant (12.83%) fruit (11.72%), seed (8.56%), stem (2.84%), flower (2.37%) (Fig. 5.17). Different ailments were reported to get cured through these plants (Figure 5.18).

Figure 5.17. Utilization of different plant parts of the medicinal plant species

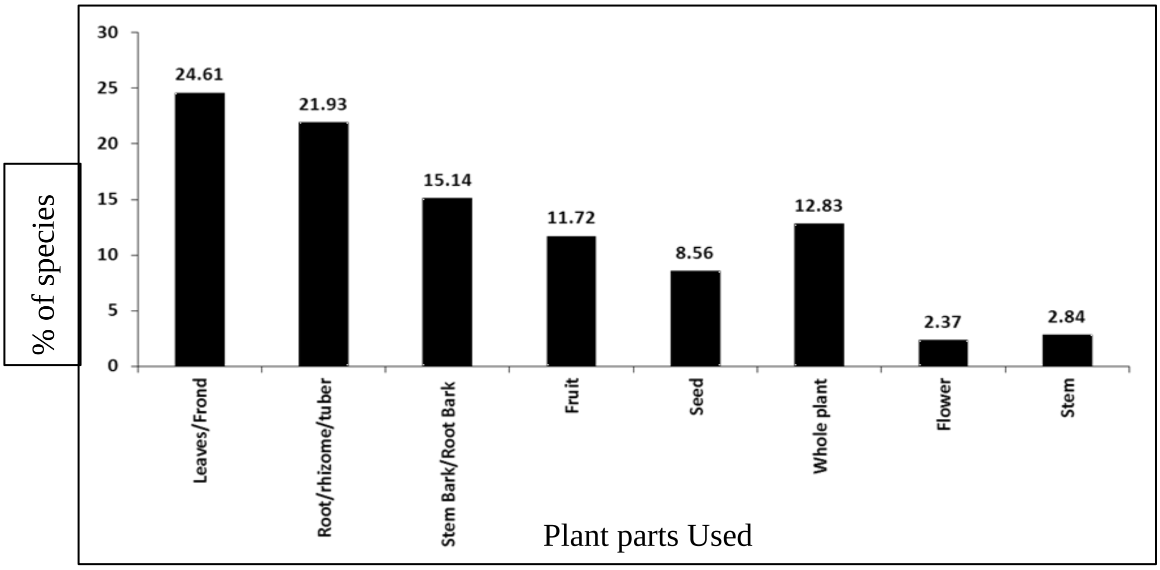


Figure 5.18. Common ailments cured using the plant species grown in homegardens

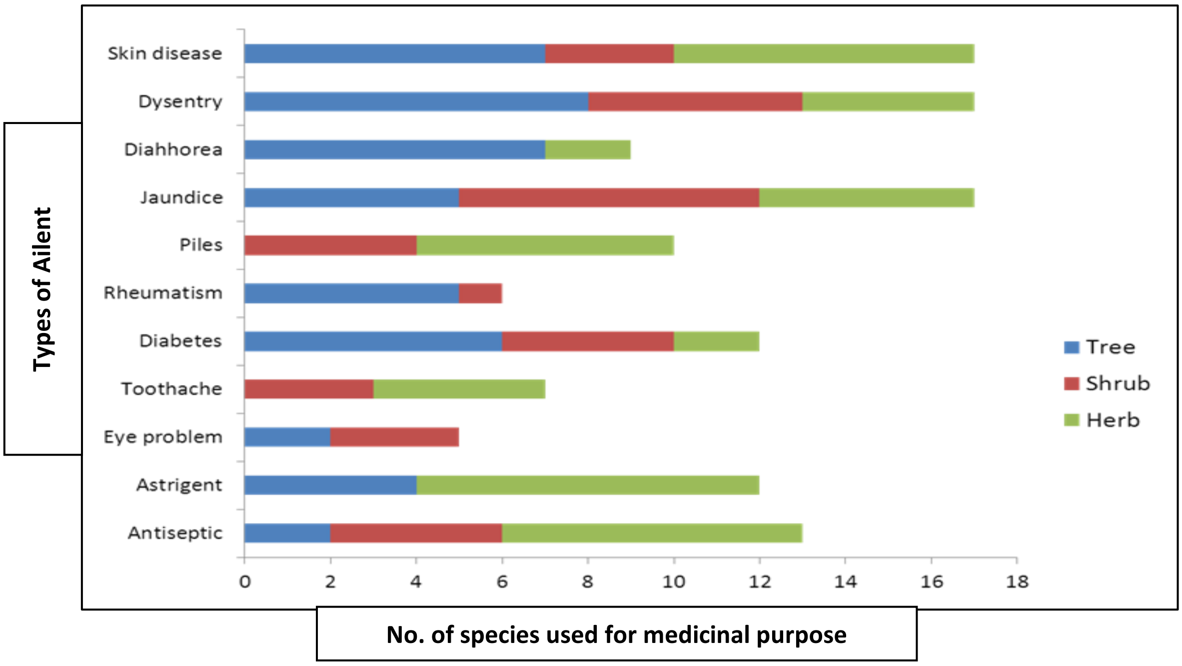


Table 5.8: Traditional uses of the medicinal plants grown in homegardens of Aizawl, Mizoram

Botanical name	**Parts use**	**Mode of Utilization**
Adiantum caudatum	Frond	Crushed frond applied externally on skin diseases
Aegle marmelos	Fruit	Decoction of fruit for curing dysentery
Albizia procera	Leaves	Leaf poultice applied to ulcers
Arenga pinnata	Root	Root decoction applied for bronchitis
Anannas comosus	Leaves, fruit	Juice of crushed leaves/ fruit used for convulsion remedy
Anogeissus acuminate	Bark	The juice of crushed bark used as antiseptic
Averrhoa carambola	Fruit	4-5 slices of fruit taken daily for curing jaundice and bleeding piles
Benincasa hispida	Fruit	Flesh of fruit without seeds mix with sugar and consumed for curing Diarrhoea
Bombax ceiba	Fruit, flower	Fruit and flower used against snake bite
Callicarpa arborea	Bark	Juice of crushed bark taken orally for curing stomach pain, dysentery and vomiting
Cammellia sinnensis	Leaf	Boiled leaf used as astringent, stimulant, diuretic.
Centella asiatica	Leaf	Leaf decoction taken orally for the remedy of asthma and eyes problems
Citrus medica var acidus	Fruit	Fruit juice taken orally for Stomachache
Clerodendron colebrookianum	Leaf	Leaves are boiled and taken for remedy for hypertension
Costus specious	Whole plant	Plant taken raw for remedy of tonsillitis
Cucurbita maxima	Fruit, leaf	Decoction of fruit or leaves taken for the remedy of eye problem and swollen.
Curcuma longa	Rhizome	Rhizome is crushed and the juice is used for antiseptic
Dillenia indica	Fruit	Raw fruit eaten in empty stomach for curing Dysentery
Catharanthus rosea	Leaf	Crushed leaves applied on forehead for remedy from Headache
Dioscorea alata	Tuber	Tuber is used in leprosy, piles and gonal problem.

Raphidophora decursiva	Stem, leaf	Crushed stem and leaf applied on the fractured part of Bone.
Emblica officinalis	Fruit	Raw fruit taken for the remedy of stomach problem
Gmelina arborea	Fruit	Roasted fruit applied externally in itches
Lagerstroemia speciosa	Root, bark	Decoction of root is taken for jaundice and infusion of bark is taken for diarrhea and dysentery.
Ocimum americanum	Whole plant	Whole plant crushed with pineapple leaf and *Acorus* leaf and mix with water and taken orally for Breathing problem
Scoparia dulcis	Leaf, root	Crushed leaf and roots mix with rice water and drink for curing urinary problem
Basella alba var rubra	Leaves	Crushed leaves applied on the burns
Mesua ferrea	Flower, leaf	Flower and leaves used against as snakebite and scorpion sting.
Mimosa pudica	Leaf, root	Leaves and root are used for pile.
Musa paradisiaca	Stem	Stem sap applied for antiseptic
Schima wallichii	Fruit	Decoction of fruit is used for snake bite and insect bite.
Solanum torvum	Seed	The crushed seed is applied to toothache and tooth decay.
Trevesia palmata	Leaf	Juice of crushed leaf taken orally for an effective remedy for colic, stomachache and high blood pressure.
Ziziphus mauritiana	Root	Decoction of root is taken for fever and root powder is applied externally on chronic ulcer.

5.3.4. Management practices followed in different homegardens

Weeding is the most common management practices followed in almost all the homegarden (Table 5.9), followed by watering while sanitary pruning, removing competition, rejuvenation pruning are seldom. Spatial arrangement was common to large and old homegarden. However, there was little evidence of proper spatial arrangement in small and medium homegarden. Ashing and farm yard manuring practices are done in almost half of the homegardens. The management of homegarden is nevertheless linked to the available resources, income, family labour and of course, to some extent, gender issues. The contributions and responsibilities of individuals differ according to the position within a household. The practices like land preparations, soil management, lopping are often carried out by the man while watering, weeding, fertilizing are mostly done by the women though there is no distinct task related gender division in Mizoram. In general, men are typically responsible for field crop and livestock production (cattle) while women for vegetable growing and management of small livestock (usually pigs and chicken).

Table 5.9: Management practices followed in different homegardens of Aizawl district, Mizoram

Management Practices	**Size**			**Age**		
	Small	**Medium**	**Large**	**Young**	**Medium**	**Old**
Weeding	95%	90%	92%	90%	93%	80%
Watering	67%	53%	70%	54%	58%	64%
Lopping	43%	51%	62%	28%	35%	58%
Sanitary pruning	26%	18%	28%	15%	23%	21%
Removing competition	17%	26%	15%	13%	19%	23%
Spatial arrangement	18%	47%	68%	37%	51%	55%
Fertilizing (Ashing/ animal waste)	36%	48%	54%	31%	53%	48%

5.3.5. Hierarchical classification of homegardens

Based on cluster and principal component analysis using tree/ shrub species density, the forty two homegardens were categorized into six homegarden types *viz* type I (n=25), type II (n=3), type III (n=7), type IV (n=4), type V (n=2) and type VI (n=1) (Figure 5.19). This type VI consisted of only one homegarden and was the smallest sized garden (0.025ha) and very few tree and shrubs were grown, therefore in cluster analysis, the garden fell separately.

5.3.5.1. Structural Characteristic of homegarden types

The structural characteristics of these six different homegarden types differed significantly (Table 5.10). The type I homegardens consisted mainly of large and medium sized gardens in the ranged of 0.58 ha-1.36 ha while type II homegardens (n=3) consisted of only medium sized gardens of mean sized 0.28ha and types III, IV, V homegardens consisted of only small sized gardens. In this classification, the age of the homegardens had little significant influence in the clustering. The average number of species in the various homegarden types ranged from 12 to 49 species, however, the highest number of species per garden was recorded in type III followed by type I, IV, V and the least number was recorded in type VI. Similar trend was also observed in tree density of different types of homegardens. Also, the average number of species per homegarden was relatively similar in type IV and V. The diversity index was found highest in type I and followed by type III, IV and V. The highest dominance and evenness index were recorded in type III indicating that in this type of homegarden, production is oriented toward fewer species. Types II, V and VI have lower species diversities (higher Simpson and lower Shannon indices) compared to the other types of homegardens.

5.3.5.2. Functional characteristics

The proportion of species grown in these different homegarden types varied basically according to needs of the households and also functional characteristics of the gardens. A group of eight use category of plant species was recorded based on their major utility products (Figure 5.19), eventhogh most of the species grown in the gardens have multiple usages. The primary function of the homegardens as observed in type III, V, VI was mainly subsistence and production of seasonal vegetables (38%) was the main function of the gardens. Fruits, vegetables, nuts, spices, timber, and ornamental plants, were present in all homegarden types. In all types of homegardens except for type VI, the proportion of all the use categories have almost equal proportions across the garden types. However, the proportion of ornamental plants was highest in type I which consisted of mostly larger sized gardens and the proportion of vegetables increased with decreasing size of the gardens. The relatively less important use categories included medicinal, nut and beverages. The characteristics of the homegardens were also related to the socio-economic conditions and orientation of farmers toward cash income generation or household consumption. Farmers of type V and VI were depended on their homegardens mainly for self-consumption as reflected by the dominance of vegetables and followed by fruit trees.

Table 5.10: Structural Characteristics of six types of homegardens

Parameters	Homegarden types						F-test
	Type I (n=25)	Type II (n=3)	Type III (n=7)	Type IV (n=4)	Type V (n=2)	Type VI (n=1)	
Homegarden size (Ha)	0.67 ±0.01	0.28 ±0.002	0.083 ±0.001	0.031 ±0.001	0.027 ±0.0002	0.025	14.68**
No of species/ garden (Trees, shrubs & herbs)	35.64 ±5.51	22.73 ±6.84	37.49 ±7.31	34.16 ±4.47	34.16 ±4.47	12	7.42**
Basal area (m^2/ha) (Trees & shrubs)	12.75 ±1.46	4.36 ±0.04	7.18 ±0.52	8.11 ±1.06	3.72 ±0.05	1.76	5.51*
Density of trees (ha^{-1})	237.14 ±15.21	164.02 ±12.8	256.38 ±10.84	202.11 ±12.63	176.37 ±13.48	102.12	6.48**
Diversity (*H'*) (Trees & shrubs)	3.351	2.47	3.18	3.06	2.70	1.674	14.85*
Dominance (*C*) (Trees & shrubs)	0.373	0.351	0.426	0.391	0.274	0.314	11.49*
Evenness Index	0.417	0.386	0.469	0.404	0.335	0.376	9.05**

±SE mean, *-P<0.01, **P<0.01

Figure 5.19: Functional characteristics of six different types of homegardens

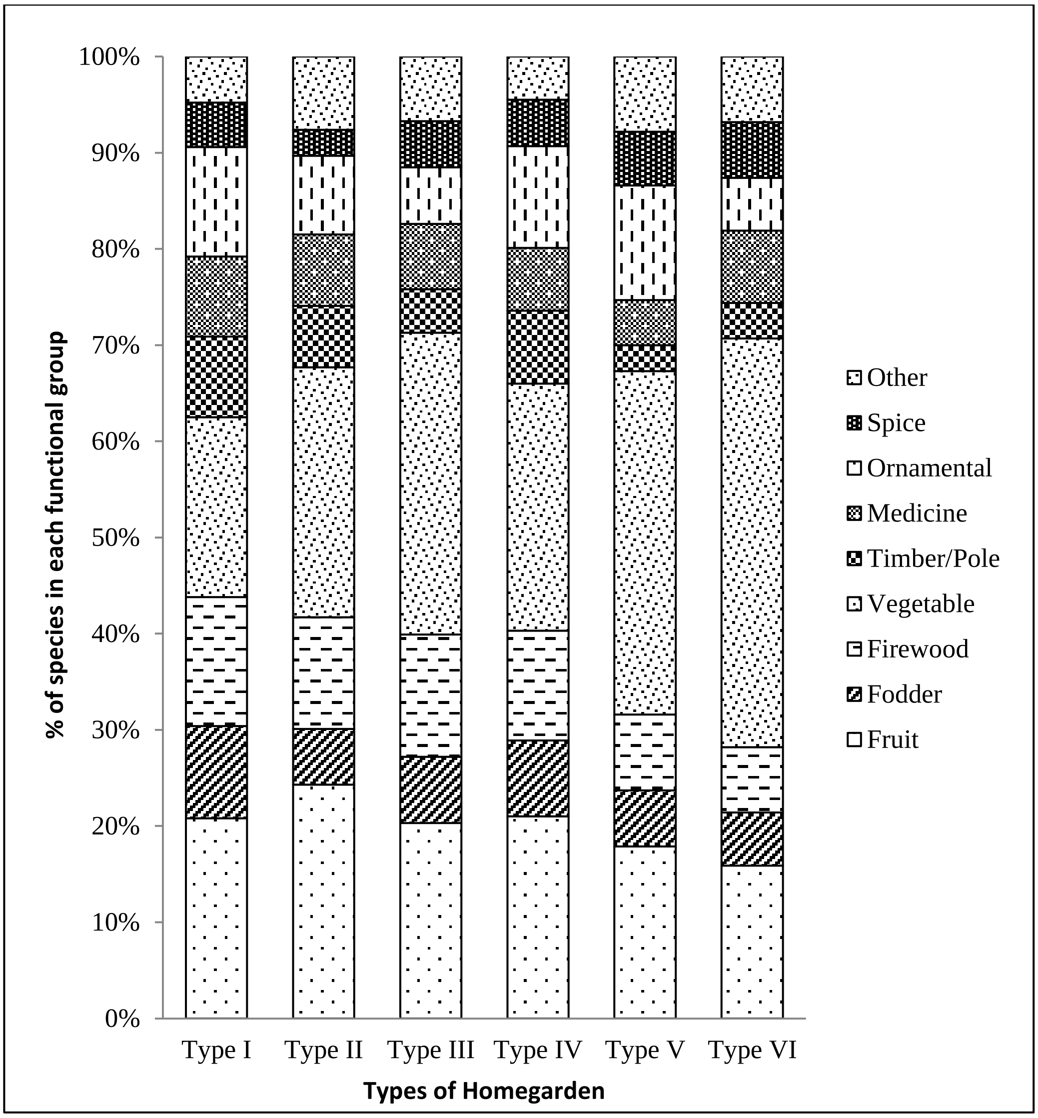


Figure 5.20: Hierarchical classification of forty two homegardens

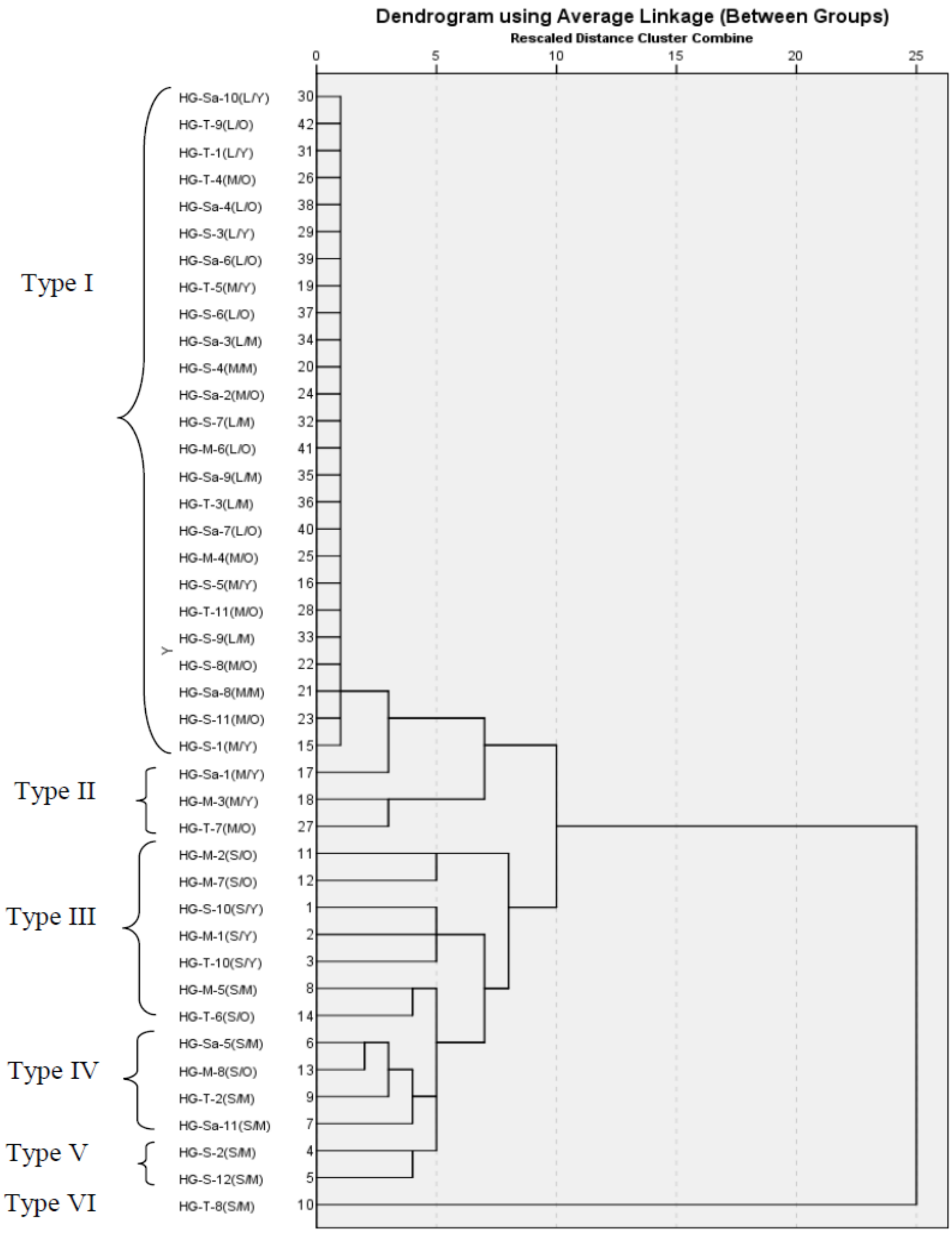
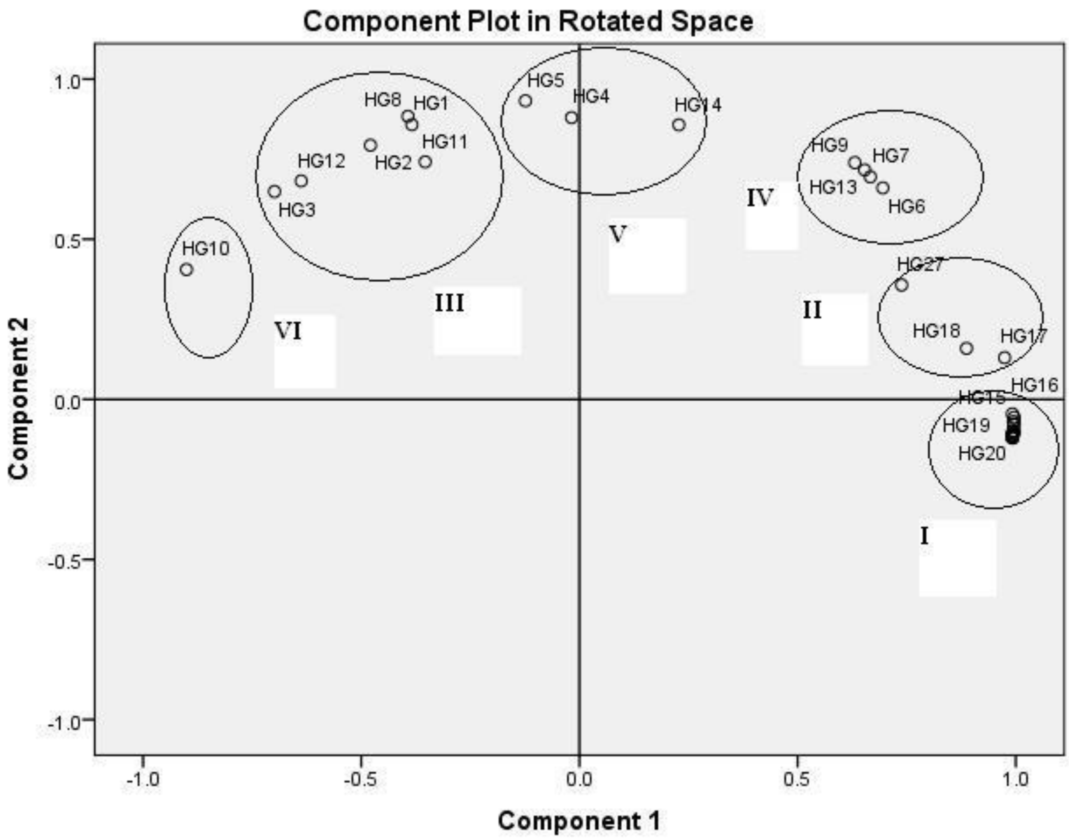


Figure 5.21: Different types of homegardens on the basis of Principal Component Analysis using species density data.



5.4. Micro-climatic and edaphic variables in the homegardens

Microclimate showed little differences within the homegardens. Air and soil temperatures were higher in the medium gardens as compared to the large and small homegarden (Table 5.11) while they are found highest in young gardens (Table 5.12). The light intensity was recorded highest in small and young garden while the highest relative humidity was found in medium sized gardens. Such variation in microclimate within the homegardens depends on a number of external and internal factors, notable among them are duration of sunshine and cloudiness, vegetation, soil properties, topography, tree canopy architecture and phenological stage of the constituent plant species.

Table 5.11. Microclimatic parameters of differently sized homegardens

Parameter	Homegardens		
	Large	Medium	Small
Air temperature (ºC)	28.58 ± 0.83	29.25 ± 0.42	28.88 ± 0.73
Soil temperature (ºC)	26.39 ± 0.47	27.35 ± 0.23	27.43 ± 0.94
Light intensity (Lux)	8864 ± 241	9153 ± 313	9514 ± 292
Relative humidity (%)	71.36 ± 2.11	72.58 ± 3.93	70.44 ± 3.06

Table 5.12. Microclimatic parameters of differently aged homegardens

Parameter	Homegardens		
	Old	Medium	Young
Air temperature (ºC)	29.55 ± 0.49	28.17 ± 0.42	30.75 ± 0.49
Soil temperature (ºC)	27.85 ± 0.38	27.46 ± 0.64	28.81 ± 0.32
Light intensity (Lux)	9056 ± 513	8960 ± 299	9832 ± 412
Relative humidity (%)	72.80 ± 2.18	69.65 ± 2.06	72.50 ± 3.62

All the physical properties of soils of homegardens differed significantly across the sizes as well as with increasing depth. The soil temperature and moisture content differed significantly ($p<0.05$) between the gardens across the size (Table 5.13) and also reduced with increasing depth of soil. The large garden had highest mean values for both the parameters followed by medium and small. While there is no significant variation in soil temperature between the different aged homegardens in upper top layer (Table 5.15). However, a similar trend of decreasing soil temperature with increasing soil depth was observed across different aged homegardens. The bulk densities of medium sized and young aged garden were the least and significantly differed ($p<0.01$) across size and age of homegardens for the upper soil depth (0-15cm). Also the bulk density increased with increasing depth of soil.

Greater soil moisture content and water holding capacity was recorded in the large and old gardens as compared to their respective garden category gardens, this might be due to greater accumulation of organic matter on the floor of large garden, which in turn related to the greater species richness or density in the garden. WHC of soil as influenced by organic matter accumulation is considered one of the important indicators of sustainability.

The relation between species diversity in homegardens and their ecological sustainability have also been discussed by various workers (Soemarwoto, 1987; Torquebiau, 1992; Kumar and Nair, 2004). Water holding capacity is directly related to availability of water for plant uptake which in turn has a direct effect on crop growth particularly in rain- fed areas. In this context, Gupta et al. (1977) have reported increased WHC with greater waste application. WHC in the sites declined with increasing depth registering greater value in the surface (0-15 cm) soil layer in all the homegardens.

Higher values of the major soil physical properties in the top (0-15 cm) layer in the present study sites might also be due to the greater accumulation of litter and other domestic waste on the floor of the traditional home gardens as use of animal wastes such as pig dung and poultry excreta was also a common practice. Soil texture in the sites was relatively consistent throughout the profile, which was typified by sandy loam to loamy sand. However, there was a variation in the sand, silt and clay content across the profile (Table 5.13 and 5.15). These differences among the homegardens are likely due to combination of factors like microclimate, topography and plant species composition as observed by Rhoades (1997), Zinke, (1962) and Pinho et al. (2010) who suggested that the choice of tree species that are planted or otherwise managed in the homegarden may have a significant effect on soil, as even individual trees can alter or improve soils in different ways.

Soil pH was acidic (5.34- 6.21) in all the garden categories with significant variation ($p<0.05$) and decreased with increasing depth of the soil. The decreasing pH with depth might be due to reducing organic matter content and nutrient availability in the deeper layer of soil. The Organic matter accumulated in the soils of homegardens might also have a buffering effect on soil pH due to several processes, which include the increase in CEC and the size of the exchange complex from humification of organic matter additions, the formation of complexes with Aluminum ion, and the release of calcium and magnesium in the soil solution, thus reducing the activity of hydrogen ion (Miyazawa et al., 1993). SOC, TKN, ammonium-N and nitrate-N varied significantly within the homegardens ($P<0.05$). The higher value of SOC was found in middle sized gardens. Total Kjeldhal nitrogen varies appreciably among sites and depth (Table 5.14). The concentration of Kjeldhal nitrogen, ammonium-N, nitrate-N was higher at surface soil (0-15 cm) layer and declined with increasing depth and found highest in large homegardens followed by medium and small gardens. The difference in the available nutrients among homegardens may be related to the variation in SOM which might have resulted in varied level of soil micro fauna which in turn affect the availability of soil nutrients, especially, available N for plant uptake or loss mainly through concurrent processes of mineralization and immobilization (Shi et al., 2006; Pandey and Srivastava, 2009). C/N ratio was higher in small gardens and lowest in large gardens.

Soil Organic matter differed across the study sites significantly which might be due to difference in plant species composition and organic matter in the soil surface. SOM is helpful in ameliorating physical, chemical and biological properties of soil and on creating a favorable medium for biological reactions and life support in the soil environment. The higher value of SOM was reported in medium sized and old aged gardens followed by small, young and large gardens (Table 5.16). The lesser value of SOM for large garden may be due to increasing concentration on a limited number of cash crop species thereby decreasing tree/ shrub diversity resulting in lower organic matter pool in the site. In the medium sized and old aged homegardens trees and shrub diversity, density and basal area are higher which must have resulted in higher litter accumulation on garden floor leading to higher SOM.

TNK and Nitrate- N were significantly correlated with Soil Organic Carbon at p<0.05and p<0.01 respectively. While there was no significant correlation between SOC and Ammonium-N. However, Ammonium –N was significantly correlated with TKN and Nitrate –N (Table 5.17).

Table 5.13. Physical properties of soil across differently sized homegardens of Aizawl district of Mizoram

Parameter	**Homegardens**						**F-value**	
	Large		**Medium**		**Small**			
Depth (cm)	0-15	15-30	0-15	15-30	0-15	15-30	0-15	15-30
Temperature (°C)	30.2 ± 0.6	28.7 ± 0.8	28.6 ± 0.5	27.1 ± 0.4	26.5 ± 0.6	25.3 ± 0.7	12.26*	17.86*
Bulk density (g/cm^3)	1.22 ± 0.02	1.35 ±0.02	1.06 ±0.01	1.12 ±0.02	1.12 ±0.01	1.23 ±0.02	26.86**	14.31*
Moisture content (%)	31.36 ± 0.41	26.33 ±0.18	27.81 ±0.62	24.41 ±0.24	23.71 ±0.29	19.87 ±0.32	15.76*	18.42*
WHC (%)	61.18 ± 5.83	57.63 ±7.11	56.38 ±2.43	51.35 ±2.22	54.61 ±3.32	47.67 ±1.78	21.73**	16.32*
Soil texture								
Sand (%)	60.77 ± 2.76	58.35 ±2.91	56.73 ±4.72	52.38 ±1.74	63.41 ±2.74	56.82 ±1.33	14.37*	24.05**
Silt (%)	27.69 ± 1.23	33.14 ±1.31	25.53 ±2.61	31.65 ±0.61	26.33 ±2.07	26.72 ±0.64	2.74 ns	9.38*
Clay (%)	11.54 ± 1.04	8.51 ±0.64	17.74 ±1.26	15.97 ±1.82	10.26 ±1.03	16.46 ±0.89	3.71*	21.36*
Textural class	Sandy loam	Loamy sand	Sandy loam	Loamy sand	Sandy loam	Sandy loam	*p<0.05	**p<0.01

Table 5.14. Chemical properties of soil across differently sized homegardens in Aizawl district of Mizoram

Homegardens								
Parameters	Large		Medium		Small		F-value	
Depth (cm)	0-15	15-30	0-15	15-30	0-15	15-30	0-15	15-30
pH	5.34 ± 0.08	5.44 ± 0.06	6.08 ± 0.16	5.81 ± 0.24	6.21 ± 0.13	5.43 ± 0.13	10.31*	8.59*
SOC (%)	2.26 ± 0.05	1.96 ± 0.03	2.71 ± 0.08	2.32 ± 0.04	2.54 ±0 .16	2.37 ± 0.04	58.62*	265.8**
SOM (%)	3.89 ± 0.26	3.38 ± 0.07	4.66 ± 0.05	3.99 ± 0.16	4.38 ± 0.14	4.08 ± 0.12	62.86*	79.32*
TKN (%)	0.57 ± 0.08	0.47 ± 0.06	0.51 ± 0.02	0.44 ± 0.03	0.45 ± 0.007	0.42 ± 0.03	37.91*	58.94**
C/N ratio	3.93 ± 0.18	4.0755 ± 0.03	5.29 ± 0.38	5.27 ± 0.04	5.51 ± 0.66	5.63 ± 0.03	12.33*	4.52 ns
NO^{-}_{3}-N (µg g^{-1})	7.44 ± 0.05	6.36 ± 0.41	7.15 ± 0.16	6.83 ± 0.04	6.28 ± 0.18	4.05 ± 0.06	29.53*	63.19*
NH^{+}_{4}-N (µg g^{-1})	6.45 ± 0.02	5.23 ± 0.52	5.72 ± 0.06	4.83 ± 0.39	5.05 ± 0.71	4.61 ± 0.15	15.64*	19.53*

Table 5.15. Physical properties of soil across differently aged homegardens in Aizawl district of Mizoram

Parameters	Homegardens						F-value	
	Old		Medium		Young			
Depth (cm)	0-15	15-30	0-15	15-30	0-15	15-30	0-15	15-30
Temperature (°C)	29.5 ±0.3	27.4 ±0.6	29.2 ±0.5	28.5 ±0.2	29.8 ±0.5	28.2 ±0.9	5.84^{ns}	11.21**
Bulk density (g/cm³)	1.21 ±0.04	1.27 ±0.03	1.17 ±0.02	1.20 ±0.03	1.19 ±0.02	1.25 ±0.02	34.56*	4.32^{ns}
Moisture content (%)	33.41 ±0.51	28.44 ±0.21	31.72 ±0.33	26.82 ±0.16	29.36 ±0.46	24.77 ±0.41	21.22*	32.62*
WHC (%)	58.36 ±4.33	57.81 ±2.41	57.29 ±4.16	55.32 ±1.45	56.39 ±5.25	55.58 ±2.45	5.86^{ns}	11.21*
Soil texture								
Sand (%)	56.62 ±1.46	50.36 ±1.45	58.13 ±3.16	54.88 ±1.29	66.52 ±1.83	65.13 ±1.24	38.77*	68.83*
Silt (%)	30.24 ±2.16	30.11 ±1.21	29.16 ±2.21	30.73 ±1.01	21.36 ±1.11	19.29 ±1.14	6.74 *	30.28**
Clay (%)	13.14 ±1.10	19.53 ±1.04	12.71 ±2.03	14.39 ±1.46	12.12 ±1.02	15.58 ±0.89	6.32ns	18.54*
Textural class	Sandy loam	Loamy sand	Sandy loam	Loamy sand	Sandy loam	Sandy loam	*p<0.05	**p<0.01

Table 5.16. Chemical properties of soil across differently aged homegardens in Aizawl district of Mizoram

Homegardens							F-value	
Parameters	Old		Medium		Young			
Depth	0-15	15-30	0-15	15-30	0-15	15-30	0-15	15-30
pH	6.01 ±0.03	5.89 ±0.02	6.03 ±0.06	5.62 ±0.12	5.92 ±0.12	5.4 3±0.14	14.11*	6.43**
SOC (%)	2.11 ±0.02	1.82 ±0.04	2.26 ±0.05	1.92 ±0.05	1.94 ±0.08	1.43 ±0.05	76.49*	135.08*
SOM (%)	4.58 ±0.16	2.89 ±0.11	4.49 ±0.04	3.14 ±0.18	3.88 ±0.08	2.97 ±0.14	81.13*	43.12*
TKN (%)	0.52 ±0.06	0.48 ±0.06	0.56 ±0.04	0.48 ±0.05	0.51 ±0.04	0.46 ±0.03	16.82*	6.31^{ns}
C/N ratio	4.01 ±0.11	4.09 ±0.08	4.41 ±0.23	4.03 ±0.02	3.93 ±0.36	3.21 ±0.06	23.64*	17.65*
NO^{-}_{3}-N ($\mu g\ g^{-1}$)	8.02 ±0.03	7.21 ±0.52	7.78 ±0.43	6.95 ±0.07	7.01 ±0.16	6.25 ±0.05	32.65*	3.29^{ns}
NH^{+}_{4}-N ($\mu g\ g^{-1}$)	7.32 ±0.03	6.71 ±0.22	6.75 ±0.11	5.93 ±0.29	6.33 ±0.43	5.61 ±0.13	45.28*	85.47*

Table 5.17: Correlation matrix for the relationship between different soil chemical parameters in homegardens

Parameters	pH	SOC	TKN	Nitrate-N
SOC	-0.532**			
TKN	-0.437**	0.762**		
Nitrate-N	-0.481*	0.353*	0.738**	
Ammonium-N	-0.231	0.148	0.436*	0.837**

The most frequently reported species were *Parkia timoriana, Psidium guajava, Mangifera indica, Trevesia palmata, Artocarpus heterophyllus* among trees, *Acacia pinata, Carica papaya, Murraya koenigii* among shrub and *Cucurbita maxima, Colocasia esculenta* and *Brassica juncea, Phaseolus vulgaris, Zea mays* dominated the herbs category. *P. timoriana* provides protein rich green pods and latter two species provide fruits that can be marketed locally. At the family level, Cucurbitaceae, Caesalpiniaceae, Solanaceae, Poaceae, Papillionaceae and Euphorbiaceae demonstrated the highest floristic importance in homegardens. The most conspicuous characteristics of all homegardens irrespective of their size are their layered canopy arrangements and admixture of compatible species.

The farmers practiced no systematic intercropping, rather they practiced random intercropping and similar practice were recorded in Maya homegardens (Barrera, 1980, Rico-Gray et al., 1990, Caballero, 1992, Herrera- Castro, 1992, Herrera-Castro et al., 1993; Montserrat et al., 1993, Ortega et al., 1993). An important characteristic of the Mizo homegardens (Chuktuah huan) is the animal component. The villagers reared cattle, fowls, and pigs mainly for domestic consumption and sometimes for sale. About 90% of the households practiced piggery. The present study clearly reveals that species grown in the traditional home garden systems are confounded by the livelihood requirements and traditional knowledge.

Homegarden plant use

Home gardens are living gene banks and reservoir of plant genetic resources that preserve landraces, obsolete cultivars, rare species and endangered species and species neglected in larger ecosystem (Eyzaguirre and Linares, 2001). Many studies on home garden in other parts of world have revealed (Agelet et al., 2000, Nair, 2001, Vogl-Lukasser et al., 2001, De Clerck and Negreros-Castillo, 2002, Gessler et al., 1998, Hoggerbrugge and Fresco, 1993, Soemarwoto and Conway, 1992, Padoch and De Jong, 1991, Okafor and Fernandes, 1987). Therefore rich species diversity of the home garden system would be important for conservation of plant genetic resources. The composition of such species in a home garden is governed by many factors that make home garden a dynamic system. By combining tree growing and horticultural cultivation, farmers have developed an integrated agricultural and tree production system which makes an optimal use of the soil production capacity, ensures multiple uses of natural resources, and provides multiple and sustained yields of different types of crops for subsistence and additional commercial use. They are therefore often considered as epitome of sustainability (Torquebiau, 1992, Kumar and Nair, 2004).

The practice of homegardening contributes not only in providing numerous direct benefits to the owners and to the users of home garden products but also promotes in-situ biodiversity conservation. The home gardens are dynamic systems and are highly acknowledged for retaining higher diversity that represents microenvironments within larger farming systems; a mimics the natural, multi-layered ecosystem and is agro-ecosystem (Agelet et al., 2000, Nair, 2001). They provide food, vegetables, fruits, fuel wood, small timber, herbs and spices etc for their daily requirement and also a source of income generation. In view of the fact that they also provide numerous ecological, economical and social benefits to the rural poor, the policy makers should promote home gardens in Mizoram to wean away pressures on the ongoing jhum (shifting cultivation). Probably some targeted and well-planned interventions may further be undertaken to strengthen the importance of this production system. It is further envisaged that through a better understanding of the role of farmers and their families as the producers of garden products, it will be possible to improve the management of genetic diversity in home gardens which in turn may result in a better and more sustainable production.

Chapter 6

Summary

Generally, homegardens are considered to be a sustainable agroforestry system harboring high species diversity and with its complex multi-layered structure managed primarily for the production of food and other essential products over the years. They are managed with the primary purpose of subsistence production and income generation while fulfilling various ecological, social and cultural functions. The ecological sustainability and productivity of the homegardens have been attributed to its high species diversity and composition which in turn, are influenced by different agroecological and socio-economic factors. The main objective of the study was to assess the plant species diversity of differently sized and aged homegardens and to document the ethnic basis of home garden plant use and the role of homegardens in household food security. Besides, the study also aimed to relate the microclimatic and edaphic parameters to age and size of the homegardens for their ecological sustainability.

The study was carried out in four villages *viz.* Sairang, Selesih, Tanhril and Maubawk of Aizawl district (92°38` to 92°42` E longitude and 23°42` to 23°46` N latitude, 950 m asl), Mizoram. Forty two homegardens located in these villages were selected using random sampling and surveyed for studying their structural diversity and functional dynamism. These forty two homegardens were classified into differently sized homegardens viz. small (0.025- 0.05 ha), medium (0.05-

0.75 ha), large (0.75-1.5 ha) of fourteen homegardens in each class. Further, these stratified samples were classified according to their age viz. young (<15 years) - 11 nos, medium (15-30 years) -14 nos and old (>30 years)-17 nos. These homegardens were studied in greater details for their plant composition, structural diversity and functional dynamism over a two years period (2011-12 to 2012-13). The plant species were inventoried and determined various quantitative parameters such as abundance, frequency and density of trees, shrubs and herbs. Several diversity indices, dominance and similarity indices were also calculated apart from the frequency, abundance and importance value index of differently sized and aged homegardens. A hierarchical cluster analysis was also applied for classification of the forty two homegardens using tree/shrub species density (i.e. number of individuals per species per unit area) as the main variable. Data on socio-economic activities of the households and also the plant use, management of homegardens and sale of products were also collected. Soil samples were collected randomly from different parts of each selected homegarden for analysis of physical and chemical properties of the soil such as water holding capacity, moisture content, texture, pH value, ammonium-nitrogen, nitrate-nitrogen, total nitrogen and soil organic carbon. The important findings of the present investigation may be summaries as follows:

1) The size of individual homegardens ranged from 0.033 ha to 1.429 ha with a mean of 0.28 ha area and were suitably grouped into small (0.025-0.05 ha), medium (0.05 - 0.75 ha) and large (0.75 - 1.5 ha). The mean size

was 435 m^2 for small sized homegarden category, 4226 m^2 for medium and 11157 m^2 for large gardens in the studied areas.

2) The age of homegarden ranged from 8 years to 65 years with a mean year of 29 years and the homegardens were suitably classified according to their age into young (<15 years), medium (15-30 years) and old (>30 years).

3) A total of 198 species (82 trees, 31 shrubs, and 79 herbs, 6 palms) belonging to 69 families and 169 genera were recorded from the homegardens surveyed. Most home garden species were perennials (78%) while 16% were annuals and 6% biennials. According to habit, 79 species (40 %) were herbs, 31 (15 %) were shrubs, 82 (41 %) were trees, 6 (4%) were palm.

4) Papilionaceae was represented by maximum number of species (11) followed by Cucurbitaceae (9) Caesalpiniaceae, Euphorbiaceae and Rutaceae (8 each) while Zingiberaceae, Moraceae, Mimosaceae, Solanaceae, shared 5 species each. Thirty families were represented by single species, while 14 families were represented by more than 5 species.

5) Species like *Clerodendron colebrookianium, Curcuma longa, Parkia timoriama, Brassica juncea, Carica papaya, Hibiscus sabdariffa, Eryngium foetida, Colocasia esculenta, Trevesia palmata, Artocarpus heterophyllus* and *Cucurbita maxima* were recorded in more than 60% of the homegardens 9surveyed.

6) An average of 37 (SD±9) plant species was recorded per homegarden. About sixty percent of the gardens contain 31-40 plant species while very few gardens have less than 10 species or more than 60 species per garden.

7) Total plant species was recorded highest in the small sized gardens (157, 79%) distributed in 126 genera and 63 families, followed by medium sized (141, 71%) with 114 genera, 60 families and large sized garden (125, 63%) with 109 genera and 55 families. Tree species was also recorded highest in small homegarden (66), than medium (54) and large (50) while herbs were recorded highest in medium sized garden. Out of which, 35 tree species (42%) were common to all the home gardens.

8) The highest number of species was recorded in medium aged homegardens (150, 75.75%) distributed in 136 genera and 65 families, followed by young aged homegarden with 142(71.71%) plant species distributed in 135 genera and 66 families and old aged garden (126, 63.63%) distributed in 118 genera and 64 families. More tree (65 species) and shrub (24 species) were also recorded in medium aged homegarden, while herbs species were highest (68 species) in young aged garden.

9) Shannon-Weiner diversity index of trees for trees was maximum in medium sized homegardens (H’=3.780) followed by small (3.325) and large (3.185) homegardens. Least species diversity was recorded for shrubs in small homegardens (3.411) and large garden recorded least herb diversity (3.142).

10) The highest dominance index for tree species was recorded in large homegarden (0.55) followed by medium (0.213) and small (0.17). The maximum value for shrub was recorded in small (0.483) and for herbs it was found in large garden (0.416).

11) Evenness index for tree species varied significantly within the home gardens and it was maximum in the small homegarden (0.622), followed by the medium (0.353) and large home garden (0.314) ($p<0.01$). The shrubs evenness index varied slightly with greater values in the medium size home gardens (0.537) followed by large and small home gardens. The maximum value for herb was recorded in small size garden (0.543).

12) The Shannon Weaver index showed a higher diversity of trees and shrubs in the medium aged homegarden (H′= 3.862; H'=3.051) as compared to the young and old homegardens.

13) The dominance index of tree and shrubs were highest in young gardens followed by old homegardens. The evenness index also showed that in medium aged homegardens most of the species of trees, shrubs and herbs were equally abundant (E = 0.643, E=0.516 and E=0.473 respectively) than young and old aged gardens

14) Tree density was found to be higher in the large home garden (249 individual ha^{-1}) and followed by medium size home gardens (216 individual ha^{-1}) and small home garden (195 individual ha^{-1}).

15) Large home gardens were dominated by *Clerodendrum colebrookianum* (IVI 18.537 and density 8.3 individual ha-1), *Parkia timoriana* (IVI

15.106 and density 7.3 individual ha-1), and *Mangifera indica* (IVI 15.088 and density 5.9 individual ha-1), The medium home gardens were dominated by species like *Parkia timoriana* (IVI 17.742 and density 6.8 individual ha-1), *Trevesia palmata* (IVI 13.747 and density 7.9 individual ha-1), and *Artocarpus heterophyllus* (IVI 12.321and density 6.0 individual ha-1), and in the small size home gardens species like *Parkia timoriana* (IVI 15.475 and density 7.4 individual ha-1), *Trevesia palmata* (IVI 10.245 and density 7.3 individual ha-1), and *Emblica officinalis* (IVI 10.892 and density 6.4 individual ha-1)

16) Shrub species like *Acacia pinnata* (IVI 25.163), *Citrus reticulata* (IVI 19.853), *Carica papaya* (IVI 18.736) were dominant in the large home garden and *Acacia pinnata* (IVI 23.742), *Cajanus cajan* (IVI 18.352), *Citrus aurantifolia* (IVI 16.633) were dominant in the medium size home gardens and in the small home garden *Acacia pinnata* (IVI 27.362), *Adhatoda vasica* (IVI 12.134) were the dominant shrubs species.

17) The relationships between species diversity and both garden size and garden age showed a weak increasing trend. The diversity index of herbs showed higher correlation with increasing size of homegardens while the shrubs diversity showed higher correlation with increasing age of homegarden.

18) The vertical structure of homegardens composed of 3-4 canopy layers. *Parkia timoriana, Albizzia chinensis* and *Artocarpus heterophyllus* were the principal crops in the emergent layer in large gardens while *Mangifera*

indica was common in the stratum (5-10m) across small and medium gardens and other species included other fruit trees like *Psidium guajava, Prunus, Pyrus Citrus, Trevesia palmata*. In the lowest stratum (1-5m) *Clerodendrum colebrookianum* was common in the both small and large gardens while *Trevesia palmata* was the common species in the middle sized gardens.

19) The small homegardens had the highest proportion (60%) of crop species under the 0 to1 m stratum compared to medium (51%) and large (42%) homegarden and the proportion of crop species under >6m stratum was highest in large homegarden followed by medium and small. Young homegardens had the highest proportion of species under 0 to 1m stratum followed by medium and old homegardens.

20) The study showed that vegetables were the major component of the homegarden followed by fruit, medicinal, firewood and ornamental plants. The households cited most species as useful for vegetable (24%) followed by fruit (18%), firewood (12%), medicine (11%), ornamental (9.8%), fodder (9.2%), timber (6.7%) and others (9.3%). Of the 198 recorded plants 86 have only one indicated use, while 112 had more than one attributed utility in the study area. *Parkia timoriana, Psidium guajava, Clerodendron colebrookianum, Mangifera indica, Prunus domestica, Trevesia palmata, Citrus grandis, Schima wallichii, Artocarpus heterophyllus* etc. were the most important trees which provided multiple uses to the farmers.

21) In small homegardens, vegetable (26%) occupied the highest percentage of plant use category, followed by fruit (20%), medicine (12%), in medium and large garden, fruit dominates, followed by vegetable, ornamental plants. The variation in use category among the gardens was directly linked to the livelihood conditions of the farmers.

22) Young homegardens had the highest proportion of vegetable (31%), followed by fruits, ornament, and vegetable. With the increase in the age, there was also a trend of decreasing the proportion of vegetable.

23) Self-sustenance was the primary function for most of the small sized (80%) and young (50%) homegarden households. On average, the small sized homegardens were said to contribute about 20% of the total household's cash income (range 8–28%) and the highest income contribution was found in large sized gardens (49%). In different aged homegadens, the maximum contribution to total household income as observed in middle aged garden followed by old and young.

24) Most of the plants grown in the homegardens were used as traditional medicines and their different parts used for medicinal preparation were recorded. Leaf or frond was used maximum (24.61%) followed by root/rhizome / tuber (21.93%), stem/ root bark (15.14%), whole plant (12.83%) fruit (11.72%), seed (8.56%), stem (2.84%), flower (2.37%).

25) Based on cluster and principal component analysis using tree/ shrub species density, the forty two homegardens were again categorized into six homegarden types. The type I homegardens consisted mainly of large

and medium sized gardens in the ranged of 0.58 ha-1.36 ha while type II homegardens (n=3) consisted of only medium sized gardens of mean sized 0.28ha and types III, IV, V homegardens consisted of only small sized gardens. The average number of species in the various homegarden types ranged from 12 to 49 species, however, the highest number of species per garden was recorded in type III (37.49±7.31) followed by type I, IV, V and the least number was recorded in type VI (12).

26) The diversity index was found highest in type I (3.351) and followed by type III, IV and V. The highest dominance and evenness index were recorded in type III (0.469) indicating that in this type of homegarden, production is oriented toward fewer species.

27) Microclimate showed little differences within the homegardens. Air and soil temperatures were higher in the medium gardens as compared to the large and small homegarden while they are found highest in young gardens. The light intensity was recorded highest in small (9514±292) and young (9832±412) garden while the highest relative humidity was found in medium sized gardens (72.58±3.93).

28) The physical properties of soils of homegardens differed significantly across the sizes as well as with increasing depth. Significant difference ($p<0.05$) in the soil temperature and moisture content were found across the differently sized and aged homegardens and also across the depth of soil.

29) The concentration of Kjeldhal nitrogen, ammonium-N, nitrate-N was higher at surface soil (0-15 cm) layer and declined with increasing depth and found highest in large homegardens followed by medium and small gardens. The higher value of SOC was found in middle sized gardens. C/N ratio was higher in small gardens and lowest in large gardens. TNK and Nitrate- N were significantly correlated with Soil Organic Carbon at $p<0.05$and $p<0.01$ respectively. While there was no significant correlation between SOC and Ammonium-N.

Conclusion and Recommendations

The practice of homegardening provides numerous direct benefits to the owners as well as to the users of home garden products besides promoting *in-situ* biodiversity conservation. They harbor rich species diversity and their richness is depended upon the socio-economic and ecological factors and preferences of the households. The crop diversity and species composition in homegardens showed spatial differences and was mainly influenced by garden size, garden age, commercialization and mean age of adults in the household. The home gardens are dynamic systems managed primarily by household members, using mainly endogenous or low inputs and producing year-round diverse varieties of food and non-food items like vegetables, fruits, fuel wood, small timber, fodder, herbs and spices etc for their daily requirement and also a source of income generation. These diverse products contribute to food security through diversification of food nutrition, thereby increasing the general wellbeing of the society. However, the productivity of homegardens was not fully utilized neither in subsistence nor in cash-oriented gardens, the reason may be due to lack of proper knowledge on crop husbandry and management of soil quality. Promotion of usage of compost, mulch, and farm yard manure as well as growing of nitrogen-fixing intercrops in the homegardens could help in maintaining soil fertility and sustainability.

In view of the fact that homegardens also provide numerous ecological, economical and social benefits to the rural poor, the extension services for proper management and improvement agroforestry systems (including homegardens) should be provided and also the policy makers should promote home gardens in Mizoram to wean away pressures on the ongoing *jhum* (shifting cultivation). Probably some targeted and well-planned interventions may further be undertaken to strengthen the importance of this production system. It is further envisaged that through a better understanding of the role of farmers and their families as the producers of garden products, it will be possible to improve the management of genetic diversity in homegardens which in turn may result in a better and more sustainable production.

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Appendix 1

Relative frequency (RF) of various plant species & their use in the surveyed homegardens

Botanical name	Local name	RF	Family	Parts used	Uses
Trees					
Aegle marmelos (L.) Correa	Belthei	28.3	Rutaceae	fr, lf	fr, fdd
Albizia odoratissima (L.f.)Benth.	Thingri	40.7	Mimosaceae	wd	fw, con, fur
Albizia procera (Roxb.)	Kangtek	36.9	Mimosaceae	wd	Fw
Anacardium occidentale L.	Sazupumpuithei	25.4	Anacardiaceae	nut	Fd
Anogeissus acuminata (Roxb. ex DC) Wall ex Guill & Pers.	Zairum	39.3	Combretaceae	wd	Fw
Aralia foliolosa Seem.ex C.B. Clarke	Chimchawk	46.6	Araliaceae	tlf	Veg
Artocarpus chama Buch.-Ham.	Tatkawng	44.5	Moraceae	wd, fr	con, fr
Artocarpus heterophyllus L.	Lamkhuang	89.4	Moraceae	fr, lf, wd	veg, fdd, con
Averrhoa carambola L.	Theiherawt	60.8	Oxalidaceae	fr, lf, wd	fr, med, con
Azadirachta indica A.Juss	Nimthing	70.5	Meliaceae	lf, fr	fdd, med
Baccaurea ramiflora Lour.	Pangkai	45.5	Euphorbiaceae	fr	Fr
Bauhinia variegata L.	Vaube	56.9	Caesalpiniaceae	lf, fr, fl	veg, fdd
Bruinsmia polysperma (C.B.Clarke) Steenis	Theirelchhin	33.7	Styraceae	fr, wd	fr, fw, con
Callistemon lanceolatus (Sm.)	Botolbras	68.8	Mrytaceae	orn	Orn
Carallia brachiata (Lour.)Merr.	Theiria	46.8	Rhizophoraceae	wd, fr, lf	fr, con, fdd
Cassia fistula L.	Phungril	43.3	Caesalpiniaceae	fl, wd	veg, fw, med
Cassia tora L.	Kelbe	26.9	Caesalpiniaceae	tlf, wd, pod, lf, fl	veg, fw, fdd

Castanopsis tribuloides A.(DC)	Thingsia	52.5	Fagaceae	wd, nut	fw, pst, fr
Celtis australis L.	Vaibawngchaw	21.3	Ulmaceae	lf, fr, wd	fdd, fr, fw
Cinnamomum tamala (Buch.-Ham.) Nees ex Eberm.	Hnahrimtui	35.1	Lauraceae	lf, wd	con, fw
Citrus grandis (L.) Osbeck.	Sertawk	77.2	Rutaceae	fr	fr, med
Citrus macroptera var *anamensis* Mont.	Hatkora	46.8	Rutaceae	fr	med, flav
Clerodendrum colebrookianum Walp.	Phuinam	90.5	Verbenaceae	lf	veg
Clerodendron serratum (L.)	Leidumsuak	65.3	Verbenaceae	Tlf, fl	Veg
Delonix regia (Hook.) Raf.	April par	46.9	Caesalpiniaceae	wd, orn	fw, orn
Dillenia pentagyna Roxb.	Dengte	62.5	Dilleniaceae	wd, fl bud, fr	fw, veg
Elaeocarpus floribundus Bl.	Thinglung	36.9	Tiliaceae	wd, fr	fw, con, fr
Emblica officinalis Gaertn.	Sunhlu	82.8	Euphorbiaceae	fr	Fr
Erythrina indica (L.) Merr.	Fartuah	42.1	Papilionaceae	orn	orn
Eurya acuminata DC.	Sihneh	46.9	Theaeceae	wd, lf	fw, veg
Ficus elastica Roxb. Ex Hornem.	Thialret	32.8	Moraceae	wd, lf	Fw, fdd
Ficus hirta Vahl.	Sazutheipui	36.8	Moraceae	lf, fr	veg, fr
Ficus hispida L.f.	Theithawt	46.1	Moraceae	wd, lf, fr	fw, veg
Ficus racemosa L.	Theichek	65.2	Moraceae	wd, fr, lf	fw, fr, fdd
Garcinia lancifolia Roxb.	Chengkek	32.4	Guttiferae	fr, lf	fr, veg
Gmelina arborea Roxb.	Thlanvawng	38.9	Verbenaceae	wd, fl, lf	con, veg, fdd
Grevillea robusta A.Cunn. ex R.Br.	Silver oak	41.3	Proteaceae	wd, wt	con, orn
Haldina cordifolia (Roxb.)	Lungkhup	28.3	Rubiaceae	wd, lf	con, fur, fdd
Holarrhena antidysenetrica (L.)Wall. Ex A.DC.	Thlengpa	35.9	Apocynaceae	wd, bk, lf, sd	con, med
Ilex umbellulata (Wall.) Loes.	Thinguihahni	26.8	Aquifoliaceae	wd	Fw

Jacaranda mimosifolia D.Don	Aprilparpawl	31.2	Bignoniaceae	wt	orn
Lagerstroemia speciosa (L.) Pers.	Thlado	58.4	Lythraceae	wd	con, fw
Leucaena leucocephala (Lam.) de Wit	Japan Zawngtah	63.2	Mimosaceae	tlf, lf, pod, wd	veg, fw, pl
Litchi chinensis Hsue.	Vaitheifeimung	42.9	Sapindaceae	fr, wd	fr, fw
Litsea monopetala (Roxb.) Pers.	Nauthak	55.3	Lauraceae	wd, lf	fw, fdd
Malus domestica Borkh.	Apple	46.9	Rosaceae	fr	Fr
Mangifera indica L.	Theihai	82.4	Anacardiaceae	fr	Fr
Mangifera sylvatica Roxb.	Haifavang	64.1	Anacardiaceae	fr	Fr
Melia azedarach L.	Nimsuak	72.4	Meliacaeae	lf, fr, wd	med, fdd, fw
Mesua ferrea L.	Herhse	56.2	Guttiferae	wd	con, fur, fw
Michelia champaca L.	Ngiauhnahhlai	34.8	Magnoliaceae	wd	fur, con
Moringa oleifera Lam.	Thingantam	69.3	Moringaceae	tlf, fl, fr	veg, fdd
Morus alba L.	Thingtheihmu	35.8	Moraceae	tlf, wd	fdd, fw, con
Oroxylum indicum L.	Archangkawm	25.7	Bignoniaceae	tlf, gp	veg, fdd
Parkia timoriana (DC.) Merr.	Zawngtah	92.5	Mimosaceae	pod, lf	veg, med
Persea americana Mill.	Butter thei	67.3	Lauraceae	fr	Fr
Phyllanthus acidus (L.) Skeels	Kawlsunhlu	79.2	Euphorbiaceae	fr	Fr
Pithecellobium montanum Benth.	Ardahsuak	24.8	Mimosaceae	lf	dye
Polyalthia pendula (Sonner.)	Zathu	35.6	Annonaceae	wp	orn
Prunus domestica L.	Theite	29.4	Rosaceae	fr	Fr
Prunus persica (L.) Batsch	Theitehmul	65.3	Rosaceae	fr	Fr
Psidium guajava L.	Kawlthei	81.4	Myrtaceae	fr, lf	fr, med
Pyrus communis L.	Perthei	76.4	Rosaceae	fr, lf	fr, fdd
Rhus semialata Murr.	Khawmhma	69.5	Anacardiaceae	fr, wd	fr, fw
Samanea saman (Jacq.) Merr.	Rain tree	44.8	Mimosaceae	wd, pod	fur, fdd

Saraca asoca (Roxb.) Willd.	Baikang	38.9	Caesalpiniaceae	tlf, wt	veg, orn
Schima wallichii Korth. Choicy	Khiang	78.4	Theaceae	wd	con, fw
Semecarpus anacardium L.f.	Kawhtebel	34.8	Anacardiaceae	wd, rfr	fw,, fr
Spondias pinnata (L.f.) Kurz.	Tawitaw	23.1	Anacardiaceae	wd, fr	fw, dr, fr
Sterculia alata (Roxb.) R.Br.	Vantai	34.1	Sterculiaceae	wd, sd	dr, fw, sd
Syzygium cumini (L.) Skeels	Hmuipui	57.6	Myrtaceae	fr, wd	fr, fw, panel
Tamarindus indica L.	Tengtere	53.2	Caesalpiniaceae	pod, lf, wd	fr, veg, fw
Tectona grandis L.	Tlawr	67.2	Verbenaceae	wd	con, fur, fw
Terminalia bellirica (Gaertn.) Roxb.	Thingvandawt	45.6	Combretaceae	wd, sd	con, sd
Thuja orientalis L.	Fartechi	18.6	Cupressaceae	wp	ornl
Toona ciliata M.Roem	Teipui	33.1	Meliaceae	wd, lf	fur, fdd
Trema orientalis (L.) Bl.	Belphuar	23.4	Ulmaceae	lf	fdd
Trevesia palmata (Roxb. Ex Lindl.)	Kawhtebel	100.0	Araliaceae	st,, fl bud, fr, lf	veg, fdd
Ulmus lanecifolia Roxb. Ex Wall.	Phan	34.1	Ulmaceae	wd, lf	pt, fw, fdd
Vitex penducularis Wall.	Thingkhawilu	28.3	Verbenaceae	wd, lf, bk	pt, fw, med
Zanthoxylum budrunga Wall. Ex DC.	Chingit	45.7	Rutaceae	wd, tlf	pt, veg
Zizyphus jujuba Mill.	Borai	32.9	Rhamnaceae	fr, lf, wd	fr, fdd, fw
Shrubs					
Acacia pennata (L.) Willd.	Khanghu	100.0	Mimosaceae		
Adhatoda vasica Nees.	Kawldai	56.6	Acanthaceae	lf, wp	med, hdg
Allamanda cathartica L.	Hruipangpar	24.9	Apocynaceae	fl	orn
Antidesma acidium Retz.	Thurtean	56.9	Euphorbiaceae	lf, fr	veg, fr
Bougainvillea spectabilis Willd.	Sarawn	37.9	Nyctaginaceae	fl	orn
Caesalpinia pulcherrima (L.) Sw.	Aprilte	44.8	Caesalpiniaceae	fl	orn
Cajanus cajan (L.) MIllsp.	Behling	83.7	Papilionaceae	lf, pod, sd	veg

Camellia sinensis L.	Thingpui	35.7	Theaceae	ff	bvg
Carica papaya L.	Thingfanghma	92.5	Caricaceae	fr	Fr
Cassia alata L.	Arzawldamdawi	25.9	Caesalpiniaceae	lf	med
Citrus aurantifolia Sw.	Serte	56.8	Rutaceae	fr	fr, med
Citrus limon (L.) Burm.f.	Ser	67.1	Rutaceae	fr	fr, med
Citrus reticulata Blanco	Serthlum	78.4	Rutaceae	fr	Fr
Coffea khasiana (Korth.) Hook.f.	Thingsai ngal	36.8	Rubiaceae		
Coffea arabica L.	Coffee thing	41.1	Rubiaceae		
Crotolaria juncea L.	Tumthang	35.5	Papilionaceae	fl, hdg	veg, hdg
Duranta repens L.	Hlingdai	31.4	Verbenaceae	hdg	hdg
Elaeagnus latifolia L.	Sarjukpui	52.7	Eleagnaceae	wd, fr	fw, fr
Euphorbia pulcherrima Willd. Ex Klotzsh	Hnahsen	41.2	Euphorbiaceae	lf, fl	orn
Jatropha curcus L.	Thingthau	33.2	Euphorbiaceae	hdg	fen
Kadsura heteroclita (Roxb.)	Theiarbawm	26.6	Magnoliaceae	fr	Fr
Murraya koenigii (L.)	Arpatil	91.7	Rutaceae	lf	fla
Nerium indicum Mill.	Kananpar	34.0	Apocynaceae	fl	orn
Opuntia stricta (Haw.)	Rulpuilei	31.5	Cactaceae	fr, wp	fr, hdg
Psychotria calocarpa Kurz.	Kawrpelh	45.8	Rubiaceae	lf, bk, stm	lf veg, med
Punica granatum L.	Theibuhfai	53.2	Punicaceae	fr	Fr
Ricinus communis L.	Mutih	62.1	Euphorbiaceae	lf, sd	med
Sida acuta Burm.f.	Khingkhih	28.3	Malvaceae	bl, rt	brm, med
Solanum anguivi Lam.	Samtawkte	36.9	Solanaceae	fr	veg, med
Solanum melongena L.	Bawkbawn	84.3	Solanaceae	fr	veg
Solanum nigrum L.	Anhling	35.4	Solanaceae	lf	veg, med
Herbs					

Abelmoschus esculentus (L.)Moench	Rahnal	84.4	Malvaceae	fr	veg
Acalypha indica L.	Thingtheihmupar	31.2	Euphorbiaceae	fl	orn
Agave americana L.	Saidai	20.1	Agavaceae	wp	orn
Allium cepa L.	Purunsen	93.3	Liliaceae	bul, lf	veg, med
Allium hookerii L.	Mizopurun	79.4	Liliaceae	wp, rt	veg, med
Allium sativum L.	Purunvar	80.3	Liliaceae	bul, lf	con, veg, med
Amomum dealbatum Roxb.	Aidu	78.4	Zingiberaceae	rt, bud	veg
Amorphophallus paeoniifolius (Dennst.)	Telhawng	68.3	Araceae	cor, yl	veg, med
Anannas comosus (L.) Merr.	LaKhuihthei	86.6	Bromeliaceae	fr	Fr
Anoectochilus luteus Lindl.	Hnahmawi	36.6	Orchidaceae	orn	orn
Arachis hypogaea L.	Badam	40.3	Papilionaceae	nut	Fd
Brassica juncea (L.) Czem	Antam	94.6	Cruciferae	lf, sd	veg, med
Bambusa tulda Roxb.	Rawlak	53.8	Poaceae	ys, culm	Veg, basket, mat
Brassica oleracea var *botrytis* L.	Parbawr	78.6	Cruciferae	fl	veg
Brassica oleracea var *capitata* (L.)Alef.	Zikhlum	82.4	Cruciferae	lf, head	veg
Canavalia ensiformis (L.)	Fangra	78.3	Papilionaceae	pod, sd, lf	veg, pulse, fdd
Capsicum annuum L.	Hmarcha	90.4	Solanaceae	fr	con
Capsicum frutescens (L.) Kuntze	Hmarchapui	78.2	Solanaceae	fr	con
Catharanthus roseus (L.) G.Don	Kumtluang	51.7	Apocynaceae	wp	med, orn
Celosia argentea L.	Zoei	43.3	Amaranthaceae	lf, fl	veg
Centella asiatica (L.) Urb.	Lambak	87.1	Umbelliferae	lf, stalk	veg, fdd, med
Chrysanthemum indicum L.	Octoberpar	52.3	Compositae	fl	orn
Colocasia affinis Schott.	Baibing	82.5	Araceae	lf, stalk, fl	veg, fdd
Colocasia esculenta (L.) Schott.	Dawl	93.5	Araceae	cor, stm, lf	veg, fdd

Costus speciosa (J.Konig) Sm.	Sumbul	33.5	Zingiberaceae	rt	med
**Cucumis melo var saccharinus* L.	Hmazil	72.1	Cucurbitaceae	fr	Fr
Cucumis sativus L.	Fanghma	82.1	Cucurbitaceae	fr	Fr
**Cucurbita maxima* Duch	Maien	100.0	Cucurbitaceae	lf, fl, fr	veg
Curcuma longa L.	Aieng	83.6	Zingiberaceae	rh	con, med
Daucus carota L.	Carrot	77.3	Umbelliferae	rt	veg
Dendrocalamus longispathus Kurz.	Rawnal	51.4	Poaceae	ys, culm	veg, buldg, bsk
**Dioscorea alata* L.	Rambachim	66.3	Dioscoreaceae	tub	veg
**Dioscorea glabra* Roxb.	Hrakai	59.4	Dioscoreaceae	tub	veg
Diplazium maximum (D.Don) C.Chr.	Chakawk	82.5	Polypodiaceae	tlf	veg
Elettaria cardamomum (L.) Maton.	Alaichi	47.2	Zingiberaceae	sd	spice, med
Elsholtzia communis (Collett & Hemsl.) Diels	Lengser	86.9	Labiatae	lf, fl	fla
Ensete superbum (Roxb.) Chessman	Saisu	53.8	Musaceae	stm, yf	veg, orn
Entada pursaetha DC	Kawihrui	92.1	Mimosaceae	Tlf	veg
Eryngium foetidum L.	Bahkhawr	90.2	Apiaceae	lf	con
Fagopyrum dibotrys (D.Don.) Hara.	Anbawng	68.3	Polygonaceae	lf	veg, fdd
Glycine max (L.) Merr.	Bekang	83.2	Papilionaceae	sd, wp	veg, med
Hedychium coronarium J.Koenig	Ainawn	74.9	Zingiberaceae	wp	orn
Helianthus annuus L.	Nihawi	35.1	Compositae	sd, wp	sd, orn
Hibiscus rosa-sinensis L.	Banglapar	40.5	Malvaceae	wp	orn
Hibiscus sabdariffa L.	Anthur	73.9	Malvaceae	lf	spice
Hodgsonia macrocarpa Cogn.	Khaum	43.2	Cucurbitaceae	sd	Sd
Homalomena aromatic Shott.	Anchiri	53.2	Araceae	stalk	veg
Houttuynia cordata Thunb.	Uithinthang	86.4	Saurauraceae	wp	veg

Ipomea batatas (L.) Lam.	Kawlbahra	60.4	Convulvulaceae	tub, lf	veg, med
Kaempferia rotunda L.	Tuktinpar	42.3	Zingiberaceae	fl	orn
**Lablab purpureus* (L.)	Bepui	79.4	Papilionaceae	yp, sd	veg
**Lagenaria siceraria* (Mol.) Standl.	Um	43.9	Cucurbitaceae	fr	veg
Latuca indica L.	Khuanglawi	73.2	Compositae	Ylf	veg
**Luffa aegyptiaca* Mill.	Nawhfeawmpawng	33.2	Cucurbitaceae	fr, fibre	veg, luffa
*Lycianthes laevis (*Dunal)	Vanian	50.3	Solanaceae	Lf	veg
Lycopersicon esculentum Mill.	Sapbawkbawn	79.4	Solanaceae	fruit	veg
Melocanna baccifera (Roxb.) Kurz.	Mautak	43.2	Poaceae	culm, st	con, veg
Mirabilis jalapa L.	Artukkhuan	32.9	Nyctaginaceae	Fl	orn
**Momordica charantia* L.	Chhankha	65.4	Cucurbitaceae	yfr, lf	veg
**Momordica mixta* Roxb.	Maitamtawk	84.3	Cucurbitaceae	yfr, lf	veg
Mentha viridis (L.)	Pudina	66.3	Labiatae	Wp	veg, med
Musa paradisiaca L.	Banhla	85.5	Musaceae	vud, fl, stem pith	veg, med
**Passiflora edulis* (L.) Sims	Sapthei	67.8	Passifloraceae	fr, lf	fr, veg, med
Phaseolus vulgaris L.	Bean	90.7	Papilionaceae	Fr, pod	veg
Plantago major (L.)	Kelbaan	46.9	Plantaginaceae	lf	veg, med
**Psophocarpus tetragonolobus* (L.) DC	Chawngbepui	32.8	Papilionaceae	fr	veg
**Pueraria montana* var. *chinensis* (Lour.) Merr.	Zawngtur	45.3	Papilionaceae	tub rt	tub
Saccharum officinarum L.	Fu	76.3	Poaceae	stm	juice, med
Sesamum indicum L.	Chhibung	58.9	Pedaliaceae	sd	oil, sd
Raphanus sativus L.	Buluih	80.7	Cruciferae	rt, lf	veg

Sansevieria zeylanica (L.) Willd.	Rullei	31.7	Agavaceae	orn	orn, med
**Sechium edule* (Jacq.) Sw.	Iskut	73.1	Cucurbitaceae	fr, lf	veg, fdd
Spilanthes acmella (L.) Murr.	Ansate	74.7	Compositae	lf, stm	veg, fdd
Tagetes patula L.	Derhkenbuk	65.3	Compositae	orn	orn
Thysanolaena maxima (Roxb.) Kuntze	Hmunphiah	83.9	Poaceae	fl, panicle	brm
**Vigna unguiculata* (L.) Walp.	Behlawi	83.5	Papilionaceae	ylf, pod, sd	veg
**Vitis vinifera* L.	Grapethei	73.2	Ampelidaceae	fr, lf	fr, med
Zea mays L.	Vai mim	100.0	Poaceae	cob	food
Zingiber officinale Roscoe	Sawthing	93.5	Zingiberaceae	rh, lf	spice, med
Palm					
Areca cathechu L.	Kuhvakung	78.5	Palmae	nut	nut
Arenga pinnata (Wurmb) Merr.	Thangtung	62.5	Palmae	lf, st	veg
Calamus tenius Roxb.	Thilte	37.9	Palmae	fr, st	fr, veg
Caryota urens L.	Tum	44.3	Arecaceae	bud, fibre	veg, fibre
Cocus nucifera L.	Narialthing	53.1	Palmae	fr	Fr
Daemonorops jenkinsiana (Griff.) Mart.	Raichhawk	23.3	Palmae	st, fr, cane	veg, fr, bsk

*climber, Fr-fruit, lf-leaf, wd-wood, tlf-tender leaf, fdd-fodder, veg-vegetable, con-condiment, fur-furniture, med-medicinal, orn-ornamental, fl-flower, fw-fuelwood, wp-whole plant, sd-seed, st-shoot, bk-bark, pt-post, hdg-hedge, bvg-beverage, fen-fencing, fla-flavour, stm-stem, bl-branchlet, rt-root, brm-broom, buldg-building, bsk-basket making, tubrt-tuberous root, tub-tuber, ys-young shoot, rh-rhizome, bul-bulb, cor-corm, ylf-young leaf, yfl-young flower, yfr-young fruit, yp-young pod

Appendix 2(a):

Importance value index (IVI), density (D, trees ha-1) and basal area (BA, m^2 ha^{-1}) of trees (≥30 cm GBH) in the three home gardens in Aizawl district of Mizoram

SL. No	Garden size	Large home garden			Medium home garden			Small homegarden		
	Name of the species	**IVI**	**D**	**BA**	**IVI**	**D**	**BA**	**IVI**	**D**	**BA**
1	*Aegle mermelos* Correa ex Roxb	3.427	3.6	0.391	1.376	1.7	0.276	4.672	2.6	0.732
2	*Albizia odoratissa*	6.132	2.9	0.469	8.21	3.2	0.361	2.452	2.8	0.481
3	*Albizia procera* L.	7.321	4.1	0.533	3.485	2.8	0.219	4.032	4.9	0.605
4	*Anacardium occidentale*	1.532	2.5	1.264	0	0	0	3.854	3.6	0.854
5	*Anogeissus acuminate* (Roxb.) Wall.	0	0	0	7.061	2.2	1.502	2.148	1.4	0.293
6	*Aralia foliosa*	0	0	0	3.266	2.8	0.241	2.771	0.8	0.228
7	*Areca cathechu*	3.478	6.3	0.986	3.579	2.7	0.137	3.054	2.6	0.896
8	*Arengapinnata*	5.623	3.3	0.431	0	0	0	0	0	0
9	*Artocarpous chama* Butch-Ham	2.347	5.2	0.951	0	0	0	3.229	4.4	1.437
10	*Artocarpus heterophyllus* Roxb.	8.392	7.1	1.372	12.321	6	2.584	9.236	5.3	2.869

11	*Averrhoa carombola* L.	0	0	0	7.353	3.6	1.394	4.692	2.1	0.773
12	*Azadirachta indica* A. Juss	2.301	4.1	0.482	3.612	4.1	2.381	3.392	2.6	0.847
13	*Baccaurea ramiflora* Lour	2.644	4.9	0.269	4.277	2.5	1.387	0	0	0
14	*Bauhinia variegata*	5.382	6.2	0.533	3.088	2.6	0.862	5.733	4	0.631
15	*Bruinsmiapolysperma*	0	0	0	1.882	0.7	0.964	2.855	1.6	0.372
16	*Calamus tenius*	2.717	2.7	0.592	0	0	0	3.771	2.2	0.627
17	*Callistemon lanceolatus* DC	2.391	3.1	0.641	8.453	4.2	1.057	4.633	1.7	0.468
18	*Caralliabrachiata*	0	0	0	2.883	3.6	1.112	4.523	3.5	1.325
19	*Caryotaurens*	2.144	4.4	0.655	1.658	0.6	0.718	0	0	0
20	*Cassia fistula* L.	2.305	2.7	0.761	0	0	0	2.804	1.4	0.738
21	*Cassia tora*	4.005	3.3	0.567	4.031	4.2	0.602	1.336	0.8	0.871
22	*Castonopsis tribuloides*	4.231	4.7	0.363	3.722	2.9	1.29	2.871	2.5	0.488
23	*Celtis australis*	2.057	1.8	0.673	0	0	0	0	0	0
24	*Cinnamomun tamala* Nees	1.865	3.1	1.382	2.003	3.6	2.377	4.266	3.7	1.37
25	*Citrus grandis* L	4.327	4.8	0.526	3.932	3.9	1.532	7.342	5.8	1.831
26	*Citrus macroptera* var *anamensis*	9.326	1.3	0.643	3.917	2.9	0.833	2.731	2.1	0.776

27	*Clerodendrum colebrookianum*	18.537	8.3	2.463	10.355	6.4	1.493	6.361	3.5	1.532
28	*Clerodendron serratum*	0	0	0	3.841	3.5	0.871	4.089	3.8	1.474
29	*Cocusnucifera*	2.712	2.4	0.314	0	0	0	3.335	2.6	0.745
30	*Daemonoropsjenkinsianus*	0	0	0	4.22	2.7	0.794	3.157	2.4	0.787
31	*Delonix regia L*	3.99	3.1	0.947	2.965	2.8	1.473	2.771	2.7	0.783
32	*Dillenia pentagyna* Roxb.	1.672	2.6	0.207	3.332	1.7	1.305	3.337	3.8	1.409
33	*Eleocarpus floribundus* Blume	2.445	3.8	1.438	0	0	0	4.204	3.9	1.701
34	*Emblica officinalis*	9.297	*6.5*	1.336	7.823	5.7	1.941	10.892	6.4	2.423
35	*Erythrina indica*	1.775	2.2	1.376	1.438	0.4	0.615	3.537	1.8	0.594
36	*Euryas acuminata*	2.022	0.8	0.543	1.334	0.8	0.582	0	0	0
37	*Ficus elastica*	0	0	0	0	0	0	3.751	2.4	0.695
38	*Ficus hirta*	1.623	2.2	0.951	0	0	0	3.889	2.8	0.323
39	*Ficus hispida*	3.221	*2.7*	0.864	2.664	2.7	1.311	1.471	0.8	0.276
40	*Ficus racemosa*	0	0	0	1.837	2.1	0.438	2.804	1.3	0.642
41	*Garcinia lanceaefolia*	3.255	4.2	0.341	0	0	0	3.338	2.4	0.728
42	*Gmelina arborea*	0	*0*	0	2.418	2.7	1.633	2.481	2.1	0.833

43	*Grevillea robusta*	2.436	*3.6*	0.258	0	0	0	4.345	2.7	0.817
44	*Haldina cordifolia*	0	*0*	0	2.655	3.1	0.599	2.761	1.9	0.476
45	*Holarrhena antidysenterica*	6.921	*4.8*	0.678	4.375	3.7	0.772	3.077	2.6	0.748
46	*Ilex umbellulata*	0	0	0	2.844	2.4	0.375	0	0	0
47	*Jacaranda mimosaefolia*	3.59	3.3	0.216	0	0	0	1.753	0.4	0.173
48	*Lagerstroemia speciosa*	4.453	4.7	0.573	2.743	1.7	0.982	3.844	0.9	0.603
49	*Leucaena leucocephala*	7.451	6.2	1.475	6.788	5.5	1.463	5.791	4	1.576
50	*Litchi chinensis*	4.133	3.1	1.724	2.844	2.4	2.825	0	0	0
51	*Litsea monopetala*	0	0	0	3.221	1.8	0.642	2.904	1.6	0.233
52	*Malus domestica*	5.866	4.8	1.721	0	0	0	3.224	3.1	0.879
53	*Mangifera indica* L.	15.088	5.9	1.508	4.568	3.1	1.814	5.097	2.6	0.721
54	*Mangifera sylvatica* Roxb.	1.223	4.4	0.953	2.443	2.8	0.593	2.225	1.1	0.386
55	*Melia azedaratchta* L.	4.425	6.3	2.801	4.861	4	1.381	4.768	2.9	0.637
56	*Mesua ferrea* L.	4.338	4.1	2.28	2.906	1.7	1.703	0	0	0
57	*Michelia champaca L*	0	0	0	3.227	2.7	0.663	3.337	3.1	1.269
58	*Moringa oleifera*	4.362	2.7	1.573	0	0	1.321	2.741	1.7	0.624

59	*Morus alba*	5.667	*2.9*	1.335	3.604	2.7	0.786	3.609	2.4	0.816
60	*Oroxylon indicum* (L.) Vent	3.063	1.3	1.423	2.79	3.1	0.933	2.044	1.4	0.539
61	*Parkia timoriana*	15.106	7.3	2.653	17.742	6.8	2.857	15.475	7.4	2.782
62	*Persea americana*	3.431	7.6	1.437	2.796	4.3	1.763	4.921	3.1	1.634
63	*Phyllanthus acidus* (L.) Skeels	2.644	3.8	1.543	5.764	3.2	0.675	3.336	2.2	0.863
64	*Pithecolobium montanum*	0	0	0	2.337	3.6	0.363	2.893	1.6	0.655
65	*Polyalthia pendula*	1.343	2.7	0.823	5.004	3.2	0.536	3.337	1.5	0.893
66	*Prunus domestica*	0	0	0	3.951	3.2	0.544	2.847	1.8	0.473
67	*Prunus persica*	1.388	3.6	0.946	3.755	2.8	0.741	3.104	2.3	0.798
68	*Psidium guajava* L.	6.868	4	1.529	2.115	1.7	1.189	3.864	2.1	1.232
69	*Pyrus communis L*	0	0	0	4.975	3.5	0.452	2.731	1.7	0.664
70	*Rhus semialata*	3.921	4.4	0.874	4.711	4.1	0.547	0	0	0
71	*Samania saman*	0	0	0	0	0	0	3.563	2.2	0.838
72	*Saraca asoca*	5.033	2.4	1.763	2.885	1.3	0.236	1.644	0.6	0.086
73	*Schima wallichi* (DC.) Kurth.	4.832	3.1	2.563	3.621	2.8	0.588	3.904	2.1	0.791
74	*Semecarpus anacardium* Roxb.	5.015	2.6	0.949	3.682	2.2	0.506	0	0	0

75	*Spondias pinata* (L). Kurz.	0	0	0	3.534	3.4	0.277	1.907	0.6	0.176
76	*Sterculia villosa* Roxb. ex Smith	3.011	2.2	0.953	0	0	0	2.755	0.9	0.344
77	*Syzigium cumini*	4.942	*3.4*	0.753	4.195	3.6	0.525	4.15	3.4	1.286
78	*Tamarindus indica* L.	5.602	3.6	1.973	3.731	2.9	0.596	2.225	1.3	0.234
79	*Tectona grandis* L.	3.721	1.8	2.012	2.016	0.8	2.864	3.76	2.4	0.595
80	*Terminalia bellerica* (Gaertn.) Roxb	1.226	0.7	0.867	2.449	2.3	0.727	2.441	1.1	0.642
81	*Thuja orientalis*	0	0	0	3.782	2.9	0.066	3.547	1.4	0.262
82	*Toona ciliata*	2.365	3	1.369	3.61	3.3	0.635	4.005	2.6	0.258
83	*Trema orientalis*	0	0	0	2.006	1.7	0.801	0	0	0
84	*Trevesia palmata*	14.637	8.6	2.337	13.747	7.9	1.508	10.245	7.3	1.758
85	*Ulmus lancefolia*	0	0	0	4.375	4.5	0.674	3.872	1.7	0.219
86	*Vitex peduncularis*	3.676	2.7	0.574	3.555	2.4	1.466	4.947	2.6	0.306
87	*Zanthoxylum budrunga*	0	0	0	2.979	1.6	0.657	2.356	1.6	0.138
88	*Zizyphus jujuba*	3.727	2.1	1.673	4.478	2.5	1.732	4.837	2.3	1.09

Appendix 2(b)

Importance value index (IVI) of shrubs in the three home gardens in Aizawl district of Mizoram

Sl. No.	Garden size	Large home garden	Medium home garden	Small homegarden
	Name of the species	**IVI**	**IVI**	**IVI**
1	*Acacia pinnata*	25.163	23.742	27.362
2	*Adhatoda vasica*	8.621	10.732	12.134
3	*Allamanda cathartica*	8.212	8.452	3.782
4	*Antidesma acidium*	2.342	8.324	8.983
5	*Bougainvillea spectabilis*	6.384	8.214	1.234
6	*Caesalpinia pulcherrima*	9.435	5.375	9.674
7	*Cajanus cajan*	18.326	18.352	23.458
8	*Camellia sinensis*	10.783	9.056	6.832
9	*Carica papaya*	18.736	13.589	14.852
10	*Cassia alata*	0	5.904	8.053
11	*Citrus aurantifolia*	11.563	11.956	12.474
12	*Citrus limon*	11.955	11.486	2.736
13	*Citrus reticulata*	19.853	16.633	18.763
14	*Coffea khasiana*	0	6.933	3.442
15	*Coffea arabica*	12.672	4.676	8.922
16	*Crotolaria juncea*	8.469	9.031	0
17	*Duranta repens*	10.045	11.943	7.716
18	*Eleagnus latifolia*	0	10.647	10.936
19	*Euphorbia pulcherrima*	5.786	5.732	5.955
20	*Jatropha curcus*	8.893	7.993	6.421
21	*Kadsuraheteroclita*	6.644	5.832	8.431
22	*Murraya Koenigii*	13.931	9.474	10.233
23	*Nerium indicum*	8.015	0	11.386
24	*Opuntia stricta*	7.036	7.843	8.056
25	*Psychotriacalocarpa*	0	5.884	6.38
26	*Punicagranatum*	13.683	10.234	8.403
27	*Ricinuscommunis*	8.967	8.631	9.632
28	*Sida acuta*	10.337	11.634	14.733
29	*Solanumanguivi*	10.634	12.943	11.534
30	*Solanummelongena*	8.662	14.233	9.56
31	*Solanum nigrum*	14.853	4.522	7.923

Appendix 2(c)

Importance value index (IVI) of herbs in the three home gardens in Aizawl district of Mizoram

	GARDEN SIZE	LARGE HOME GARDEN	MEDIUM HOME GARDEN	SMALL HOMEGARDEN
Sl.No.	**Name of the species**	**IVI**	**IVI**	**IVI**
1	*Abelmoschus esculentus*	8.783	9.342	12.874
2	*Acalypha indica*	3.022	2.82	5.643
3	*Agave americana*	3.832	1.633	2.904
4	*Allium cepa*	5.968	8.942	7.642
5	*Allium hookerii*	4.611	7.055	8.193
6	*Allium sativum*	6.932	8.381	9.621
7	*Amomum dealbatum*	4.815	4.433	3.754
8	*Amorphophallus paeonifolius*	0	6.602	2.843
9	*Anannas comosus*	8.833	6.771	6.973
10	*Anoectochilusluteus*	1.936	2.183	2.156
11	*Arachis hypogaea*	7.53	5.557	6.841
12	*Brassica juncea*	6.883	7.301	4.774
13	*Bambusa tulda*	5.722	3.339	2.955
14	*Brassica oleracea* var *botrytis*	6.099	8.592	5.969
15	*Brassica oleracea* var *capitata*	5.631	6.961	8.754
16	*Canavaliaensiformis*	0	3.339	2.767
17	*Capsicum annum*	5.374	6.904	7.132
18	*Capsicum frutescens*	5.991	4.211	5.085
19	*Catharanthusroseus*	2.933	4.29	4.264
20	*Celosia argentea*	0	2.833	1.963
21	*Centella asiatica*	6.339	5.732	7.435
22	*Chrysanthemum indicum*	4.913	0	2.28
23	*Colocasia affinis*	3.396	6.421	3.906
24	*Colocasia esculenta*	3.772	4.104	4.363
25	*Costus speciosa*	2.088	2.14	3.547

26	*Cucumis melo var saccharinus*(C)	5.443	6.541	4.881
27	*Cucumis sativus*	6.826	0	3.683
28	*Cucurbita maxima* (C)	6.732	7.231	8.473
29	*Curcuma longa*	6.365	5.055	4.072
30	*Daucus carota*	7.454	4.721	4.656
31	*Dendrocalamus longispathus*	2.055	0	1.743
32	*Dioscorea alata*(C)	2.733	3.692	4.134
33	*Dioscorea glabra*(C)	0	5.887	0
34	*Diplazium maxima*	0	2.055	1.323
35	*Elettaria cardamomum*	6.588	4.731	1.487
36	*Elsholtzia communis*	2.432	1.755	0
37	*Ensete superbum*	1.22	2.902	1.979
38	*Entada pursaetha*	2.073	1.866	2.532
39	*Eryngium foetidum*	2.66	2.865	3.883
40	*Fagopyrumdibotrys*	2.084	0	1.403
41	*Glycine max*	4.922	4.766	5.791
42	*Hedychium coronarium*	1.899	0	0
43	*Helianthus annuus*	3.855	3.254	1.725
44	*Hibiscus rosasinensis*	3.843	2.948	4.066
45	*Hibiscus sabdariffa*	3.622	3.398	4.832
46	*Hodgsonia macrocarpa*	0	0	3.487
47	*Homalomena aromatica*	2.331	5.821	1.492
48	*Houttuynia cordata*	4.096	2.886	5.651
49	*Ipomea batatas*	2.881	3.761	5.877
50	*Kaempferia rotunda*	1.963	2.532	1.324
51	*Lablab purpureus*(C)	2.044	5.873	2.823
52	*Lagenariasiceraria*(C)	3.822	1.643	0
53	*Latuca indica*	0	0	3.638
54	*Luffa aegyptiaca*(C)	2.155	1.743	3.417
55	*Lyciantheslaevis*	3.824	1.765	2.066
56	*Lycopersicon esculentum*	3.541	4.852	2.34

57	*Melocanna baccifera*	3.225	1.865	2.713
58	*Mirabilis jalapa*	3.073	1.957	1.711
59	*Momordica charantia*(C)	5.842	4.703	4.823
60	*Momordica mixta*(C)	6.982	4.612	3.794
61	*Mentha viridis*	2.842	6.228	4.544
62	*Musa paradisiaca*	2.733	3.581	2.963
63	*Passifloraedulis*	1.552	3.21	2.108
64	*Phaseolus vulgaris*	5.533	2.231	4.844
65	*Plantago major*	3.821	0	0
66	*Psophocarpustetragonolobus* (C)	0	6.832	3.878
67	*Puerariamontana*var. *chinensis*(C)	4.068	2.651	4.003
68	*Saccharum officinarum*	2.811	3.306	3.701
69	*Sesamum indicum*	4.734	2.487	2.372
70	*Raphanus sativus*	4.078	2.751	2.475
71	*Sansevieria zeylanica*	3.684	2.502	2.088
72	*Sechium edule*(C)	4.166	3.866	3.156
73	*Spilanthes acmella*	0	2.152	1.997
74	*Tagetes spatula*	2.067	3.142	1.769
75	*Thysanolaena maxima*	5.44	2.143	3.232
76	*Vigna anguiculata*(C)	2.955	2.773	3.097
77	*Vitis vinifera*(C)	2.855	0	1.747
78	*Zea mays*	3.951	4.958	5.251
79	*Zingiber officinalis*	8.722	7.621	6.318

QUESTIONNAIRE-BASED INTERVIEW SURVEY

Particulars of the Household

1. Name of the Village-……………………………….
2. Name of the respondent:..……………………….… Sex: ..…… Age: …………
3. Educational qualification-………… Occupation-………. Annual income-………….
4. Number of family members: M: …….. F: ……. Adult: ……… Children: …………
5. Source of income: [ ] Outside employment [ ] Farming outside of homegarden
   [ ] Homegarden [ ] Other business [ ] Family

Particulars of the Homegarden

1. Location:……………………………………………… Altitude: ……………………
2. Area………….. a. small <0.05 ha b. medium 0.05-0.75ha c. large >0.75 ha
3. Age: ……………a. Young (<15 years) b. Medium (15-30 years) c. Old (>30years)

a) Microclimatic and Edaphic Parameters:

i) Light intensity:

ii) Relative Humidity:

iii) Soil Temperature:

b) Phyto-sociological Analysis:

List of cultivated Plants and their uses:

Name of species (local/scientific name)	Habit	Mode of propagation	Time of sowing	Plant Parts used	Uses of crops (self-consumption /sale)

c) Livestocks:

Type of livestocks	No. of Livestock	Hours of attention needed on				Produced		
		Daily	Monthly	Year	Total Quantity	Consumed	Sold	Price/income

d) Economic input/ output

Agriculture: (input & output)

Input

Name of crops	Human labour M/F	Farmyard manure	Seeds/ propagating materials	Hours of attention

Output

Name of crops	Yield	Crop by-product	Self-consumption/ sale

e) Do you use any type of fertilizer? i) chemical ii) animal iii) household wastes iv) compost/other

f) Reasons for fertilizer use: i) soil degradation ii) high requirements of selected plant species iii) commercial production iv) Other

g) How many hours of labor do you put into the garden on a daily basis?

h) Out of the labor input, how much time (in terms of percentage of the total labor input) is spent on the following categories?

i) Planting ii) Weeding iii) Maintenance iv) Harvesting v) Livestock vi) Other

i) List of all economically useful products in the homegarden.

j) Classify these products into three categories: Primary importance, secondary importance, tertiary importance. (Primary: Products that are essential to your livelihood; Secondary: Products that are very important but not absolutely essential; Tertiary: Products that serve a purpose but are not essential).

k) Estimation of the individual productivity of these crops and trees in terms of numbers.

a) Crops used on a daily basis

b) Plants used on a regular (non-daily) basis

c) Plants used infrequently (as according to need, for eg Medicinals)

l) Estimate the percentage of these products that are used for home consumption.

Photo Plate 1: Different fruits in surveyed homegardens

Photo plate 2: Different vegetables in surveyed homegardens






Photo plate 3: Green House cultivation in large commercial homegardens