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Plant Diversity and Vegetation Structure in Differently Sized Home Gardens of Mizoram, India

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***Abstract* – Plant species diversity and vertical profile of vegetation in three differently sized homegardens*viz*. small (0.025- 0.05 ha), medium (0.05- 0.75 ha), large (0.75-1.5 ha) of Mizoram were analysed. A total of 198 species (82 trees, 31 shrubs, and 79 herbs, 6 palms) belonging to 69 families and 169 genus were recorded from the homegardens, the average species diversity index values in the homegardens was high. The vertical structure 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 canopywas occupied mainly by annual/ biennial herbaceous vegetables, tubers and climbers. High species diversity serves the subsistence needs of the people for which these gardens have been popular in this part of the country.**

***Keywords* – Garden Size, Homestead Agroforestry, Species Diversity, Vegetation Profile.**

I. INTRODUCTION

Homegardening has been a long tradition in many tropical countries and is considered second oldest land use system next to shifting cultivation[1]. 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, ahomegarden 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[2,3,4]. This system is 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 [5]and their contribution towards biodiversity conservation [6,7].

According to Huxley [8], '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' and 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.

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[9,10,11],intrinsic characteristics of the gardener, like individual preferences, practices, and culture, which determine crop species composition and diversity[12,13]Garden size and age are also major factors influencing crop diversity and species richness[14,15,16].

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 [17,18]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; however, these traditional gardens in the state have received little scientific attention. The present study is designed to analyse the plant composition, diversity and vegetation structure (both vertical and horizontal stratification) inthree differently sized home gardens.

II. MATERIALS AND METHODS

The study was carried out in four villages *viz*. Sairang, Selesih, Tanhril and Maubawk of Aizawl district (92038' to 92042' E longitude and 23042' to 23046' N latitude, 950 m asl), Mizoram. Individual households having homegarden gardens were considered as a unit of analysis and treated as a system. A stratified sample of forty two homegardens located in these were further 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.

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. Each species recorded in the homegarden was classified by family, habit based on morphology of the plant when it was full grown (tree, shrub, herb or climber) and plant use. Frequency – the fraction of homegarden containing the species[19] – was calculated for all recorded species. Abundance – number of individuals per species – was calculated for trees and shrub species. 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 of individual species [20]. For trees and shrubs relative importance value was used to rank species per life form and only relative frequency for herbs and climbers. Shannon-Weiner index as used to determine the species richness, $H' = \Sigma p_i \ln p_i$[21], where *pi* is the proportional abundance of species *i* (i.e., number of species divided by total number in the community). The dominance index [22]of the community was calculated as $C = \Sigma pi^2$, where *C* is the dominance index and pi is same for Shannon's index. Floristic similarity gardens of different altitudes were calculated with Jaccard's similarity index using the formula $Cj=j/(a+b-j)$ where *Cj* is Jaccard's similarity index, *j* is the number of species shared by the two sites, *a* is number of species in site a, and *b* is the number of species in site b [20].

III. Results and Discussion

3.1. Floristic composition of homegardens:

A total of 198 species (82 trees, 31 shrubs, and 79 herbs, 6 palms) belonging to 69 families and 169 genus were recorded from the homegardens during the survey (Table 1). Most of the homegardensharboured high species diversity. An average of 37 (sd ±9)plant species were 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 (Fig.1).

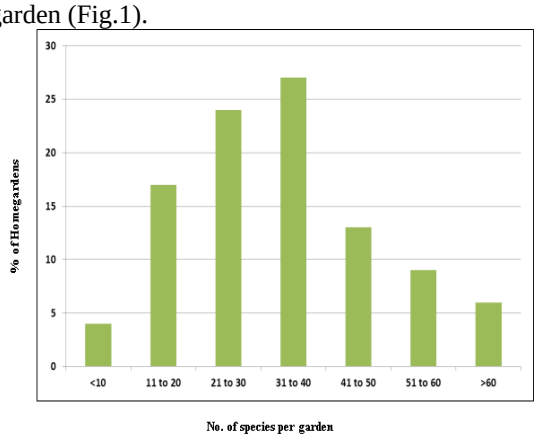

Fig.1. Plant species encountered per homearden in Mizoram

3.2 Plant species diversity and dominance

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 1). Tree species was also recorded highest in small homegarden (66), than medium (54) and large (50) gardens 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).

Table 1: Phytosociological and community indices of different homegardens in Aizawl, 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

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 2).

The present study clearly reveals that the average species diversity index values in the homegardenswas high andwas higher than that of the index value of 1.9-2.7 in the homegardensof Thailand [23](Gajaseni and Gajaseni 1999) and the value of 3.21 in Karnataka [24](Shastriet 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 others [14, 25, 26]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[27].The higher 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. Trees species diversity and richness was also closely related with soil fertility level, particularly the soil organic matter.

Total tree density was higher in the large home garden (249individual 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 *Clerodendrumcolebrookianum*was the most dominant tree species while *Parkiatimoriana*was the most dominant tree species in both medium sized and small sized homegardens. *Acacia pinnata* was invariably the most dominant shrub species in all home gardens.Among the herbs, *Anannascomosus*, *Abelmoschusesculentus*, *Zingiberofficinalis*, *Daucuscarota*, *Cucumissativus*, *Cucurbita maxima* were dominant species in the large home gardens while *Abelmoschusesculentus, Allium cepa, Allium sativum, Musa paradisiaca* and *Zingiberofficinalis* in the medium size home gardens; and species like *Allium sativum*,*Brassica oleracea*var*capitata*,*Anannascomosus*, *Capsicum annum* dominated the small home gardens

Table 2: Similarity indices between different vegetation components across different sized homegardens in Mizoram.

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

There were positive correlations between species diversity and garden size. However, the relationships showed a weak increasing trend (Fig.2). The diversity index of herbs showed higher correlation with increasing size of homegardens.

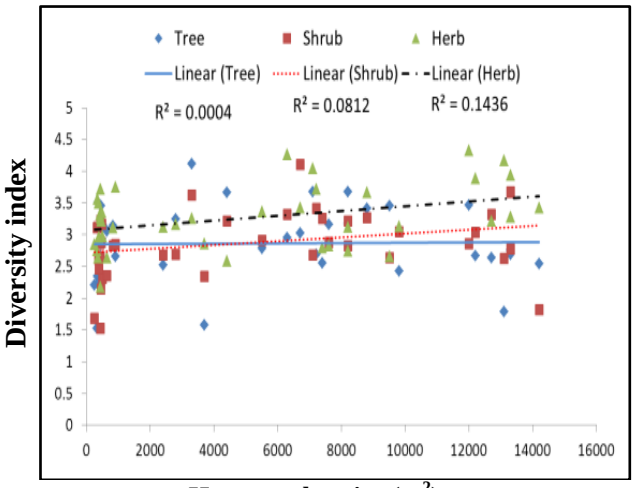

Fig.2. Relationship between diversity index and homegarden size

3.3. Structure of 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 practicalconsiderations as well as traditions. Some clear microzonations were observed in some of medium and large old homegardens. However very little or no zonation was marked in smaller homegarden. 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 areaand 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.

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Fig. 3(a). Vertical profile of large homegarden in Mizoram

(1) *Averrhoacarambola,* (2) *Artocarpusheterophyllus,*
(3) *Parkiatimoriana,* (4) *Quercusserata,*
(5) *Musa paradisiaca* (6) *Carica papaya,*
(7) Mangiferaindica, (8) *Acacia piñata*
(9) Prunusdomestica, (10) *Citrus macroptera,*
(12) *Clerodendroncolebrookianum,* (13) *Trevesiapalmata*

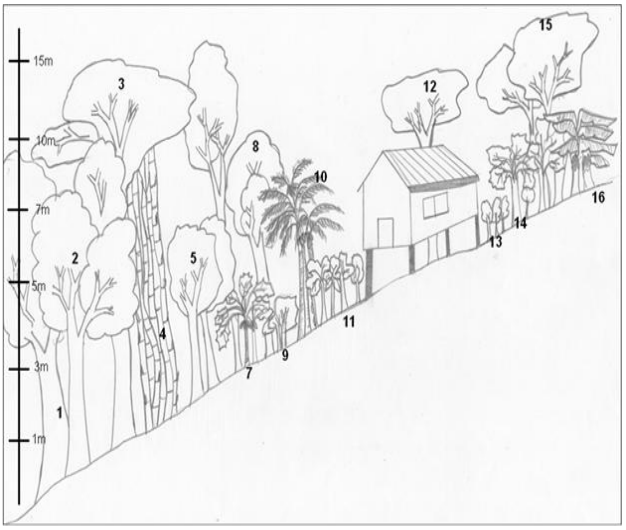

Fig.3(b). Vertical profile of medium homegarden in Mizoram

(1)*Tectonagrandis,* (2) *Averrhoacarambola,*
(3) *Artocarpusheterophyllus,*
(4) *Dendrocalamuslongispatus,* (5) *Citrus macroptera,*
(6) *Parkiatimoriana,* (7) *Carica papaya,*
(8) *Albizziachinensis,* (9), *Acaciapinata,*
(10) *Cocusnucifera,* (11) *Trevesiapalmata,*
(12) *Psidiumguajava,* (13) *Clerodendroncolebrookianum,*
(15) *Mangiferaindica*(16) *Musa paradisiaca*

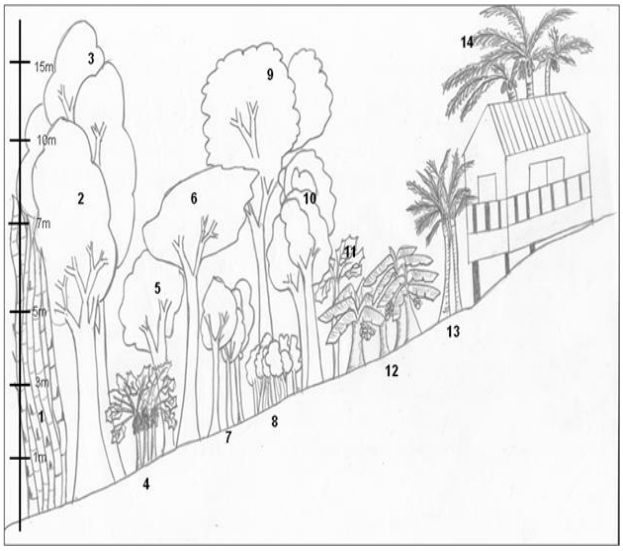

Fig.3(c). Vertical profile of small homegarden in Mizoram.

(1) *Bambusatulda,* (2)*Gmelinaarborea,*
(3) *Tectonagrandis,* (4) *Carica papaya,* (5) *Citrus grandis*
(6) *Artocarpusheterophyllus,* (7) *Psidiumguajava,*
(8) *Citrus reticulata, (9) Parkiatimoriana,*
(10) *Emblicaofficinalis,* (11)*Trevesiapalmata,*
(12) *Musa paradisiaca,* (13) *Areca catechu,*
(14) *Cocusnucifera*

The vertical structure (Figures 3a, b, c) 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, Colocasiaesculenta, Hibiscus* and *Brassica juncea*.In the second stratum (1-5m) *Clerodendrumcolebrookianum*was common in the both small and large gardens while Trevesia palmate was the common species in the middle sized gardens. Other important included*Citrusreticulata,Carica papaya, Musa paradiasiaca*, woody climberslike *Acacia pinnata, Eleagnuslatifolia,*cassavas, coffee and young fruit trees of guava, jackfruit and mango, etc.*Mangiferaindica*was common in the stratum (5-10m) across small and medium gardens and other species included other fruit trees like *Psidiumguajava, Prunus, Pyrus Citrus, Trevesiapalmata*. The uppermost canopy consisted of trees like*Parkiatimoriana* which is grown in highest frequency in most of the gardens and also included species like *Albizziachinensis, Artocarpusheterophyllus, Schimawallichii, Quercusserrata*, etc which extends from 10-15 m.Profile diagram of typical traditional homegarden are depicted in figures3a, b, c for different types of homegardens. 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.There was marked differences in the proportions of crop individuals perstratum between different sized and aged homegardens. In all the homegardens surveyed, crop speciesnumber 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 perstratum(Fig.4). Inall 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, and8–13% 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.

The vertically stratified homegardens are potentially more productive on an area basis since they can capture more resources and exhibit tighter nutrient cycling, than those without a stratified arrangement. For example, in a study of four homegardens in the Petén, Guatemala, Gillespie et al. [28]reported high structural complexity, with full canopy closure in the layers within the canopy. The garden architecture made efficient use of light and space, with intensive management for food and fuel production. The development of homegardens in the area utilized existing trees, leaving the most useful as residuals after thinning, and inserting other desirable trees and shrubs in the understorey and open space. This strategy seemed to maximize light use, according to results of measurements of incident radiation at different canopy levels [28].

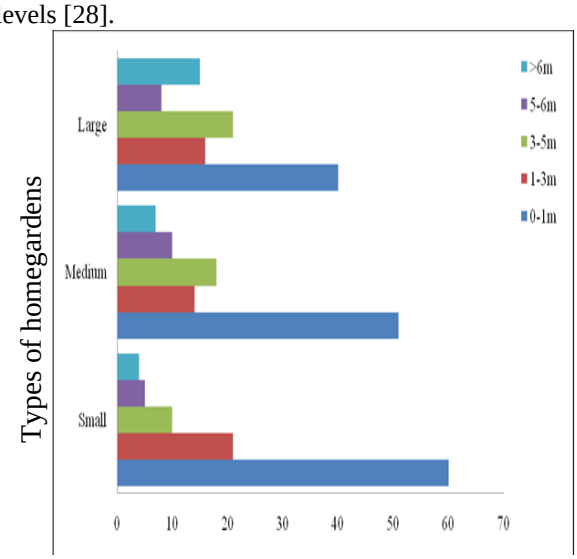

Fig.4. Mean proportion of crop species occurring in different strata inhomegardens

In most Mesoamerican homegardens, each stratum contains plant species that belong to a characteristic life form, much like in a native forest of the same region. In homegardens of the Zona Maya of Quintana Roo, Yucatán Península, Mexico, there were six strata: low herbs, low shrubs, tall shrubs, fruit trees, timber trees, and a stratum with vines [29].These authors studied the species composition of each stratum, and concluded that in these systems the efficient use of space and resources maximized the production of food, timber, medicinal plants, and non-timber products to cover the farmers' needs. They suggested that these systems (or analogs of these in terms of structure and composition) could be managed in a manner that protects the natural resource base of the region.

The varied structure of homegardens is resulted due to variation in the local physical environment, ecological characteristics, and socioeconomic and cultural factors[30, 31, 32]. The complex multi layered vertical and horizontal structure resulted from high diversity of plant species provides efficient utilization of both underground and overground resources [33,34].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. There are reports that this complex structures helps in ameliorating microclimate of homegardens by providing relatively lower air and soil temperature as well as higher humidity suitable for different crop species [23,35]. 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.

The most frequently reported species were *Parkiatimoriana, Psidiumguajava, Mangiferaindica, Trevesiapalata,Artocarpusheterophyllus* among trees, Acacia pinata, Carica papaya, MurrayaKoenigii among shrub and. Cucurbita maxima, Colocasiaesculenta 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. Many others have reported high species diversity in homegardens; for example, Kumar et al. [35] found 127 woody species across the homestead of 14 districts and 3 to 25 species per homestead in Kerela. However, Nair andSreedharan[36]reported 30 arboreal taxa from the selected home gardens of Kerala, 168 species in Santa Rosa in the Peruvian Amazon[37] and 179 species in home gardens of Java [4]. Similarly, Tynsong and Tiwari[38]reported 187 species in homegardens of War Khasi community in Meghalaya.

The farmers practiced no systematic intercropping, rather they practiced random intercropping and similar practice was recorded in Maya homegardens[39, 40, 41, 42].An important characteristic of the Mizohomegardens (Chuktuahhuan) 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.

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. 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 [32].

IV. Conclusion

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. 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.

Acknowledgement

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