CHAPTER - 9

GENERAL DISCUSSION AND CONCLUSION
Chapter-9

GENERAL DISCUSSION AND CONCLUSIONS

Traditional agroecosystems have not only provided indigenous people with subsistence, such as foods, fruits, medicine, and cash income, but have played an important role in biodiversity conservation, especially for conservation of local crop varieties and species germplasm (Plucknett et. al., 1983; Le et. al., 1999; Levasseur & Olivier, 2000). They have contributed greatly to modern agricultural science as they provide genetic material for breeding programs. It is estimated that 96% of genetic materials in modern agriculture come from traditional agro-ecosystems in developing countries (Primack & Ji, 2000). Traditional agroecosystems all over the world often contain a high diversity of crop varieties. Arora (1997) reported that 320 crop cultivars are cultivated in traditional agriculture systems by indigenous groups in a small mountainous area in India. The indigenous people of Apo Kayan, Kalimantan, grow about 50 varieties of rice (Browning, 1991). In fact, most crop germplasm resources have been conserved effectively by indigenous people through their traditional practices (Plucknett et. al., 1983; Le et. al., 1999; Elias et. al., 2004; Major et. al., 2005). These crop varieties contain abundant genetic diversities of huge value to modern crop breeding. In a sense, traditional agroecosystems can be regarded as a kind of reservoir for storing crop and other economic plant diversity for use in the future (Niñez, 1987; Blanckaert et. al., 2004; Das & Das, 2005).
In the present study, homegarden size ranged between 0.05 ha to 0.72 ha with an average of 0.21 ha which is within the range of the sizes of similar homegardens reported by global inventory of other tropical homegardens by Fernandes and Nair, (1986). Perera et. al. (1991) reported 0.05 to 2.50 ha homegarden size in Kandyan, Sri Lanka. The average size of West Java homegarden was 0.0229 ha (Soemarwoto, 1987) and the size of Santa Rosa homegarden in Amazon varied from 0.0067 to 0.7322 ha (Podoch & Jong, 1991), the size of Bangladesh homegarden ranges from 0.01-1.72 ha (Kabir & Webb, 2008) (Table 9.1).

In the present study, 84 tree species were recorded in the Meitei homegardens belonging to 69 genus and 39 families. Nair & Sreedharan (1986) have reported 30 arboreal taxa from the homegarden of Kerala. Babu et. al. (1992) observed a total of 36 species of woody perennials from the homesteads of southern districts of the Kerala. 127 tree species were recorded from the homegarden of Kerala (Kumar et. al., 1994), while in the homegarden of Karnataka 68 tree species were recorded (Shastri et. al., 2002). Das & Das (2005) documented 87 tree species from the traditional homegardens of Barak valley, which is quite similar with the present study.

The density in the present study was much higher than the values of 238-319 numbers/ha in Kerala homegarden (Kumar et. al., 1994) but lower than the Dargakona village of Barak valley 1535 numbers/ha of (Das & Das, 2005). The range of tree species per homegarden with an average of 9.76 recorded in the present study is lower than the mean of 20 from Dargakona village of Barak valley (Das & Das, 2005), 46 recorded in Kandyan homegarden, Sri Lanka (Perera et. al., 1991) and average of 56
Table 9.1 Summary of homegarden characteristics in tropical countries

<table>
<thead>
<tr>
<th>Country</th>
<th>Local name</th>
<th>Size of homegarden</th>
<th>No. of species</th>
<th>Shannon' index</th>
<th>Dominance index</th>
<th>Reference</th>
</tr>
</thead>
<tbody>
<tr>
<td>Java, Indonesia</td>
<td>Pekarangan</td>
<td>0.01 - 3.0</td>
<td>152</td>
<td>1.38</td>
<td>0.4</td>
<td>Soemarwoto et al., 1976</td>
</tr>
<tr>
<td>N Tanzania</td>
<td>Kibanja, Chagga</td>
<td>0.2 - 1.2</td>
<td>53</td>
<td></td>
<td></td>
<td>Fernandes et al., 1984</td>
</tr>
<tr>
<td>SE Nigeria</td>
<td>Compound farm</td>
<td>0.1 - 3.0</td>
<td>64</td>
<td></td>
<td></td>
<td>Fernandes et al., 1985</td>
</tr>
<tr>
<td>Cuba</td>
<td>Conuco</td>
<td>0.0875</td>
<td>101 (26 trees)</td>
<td>1.79</td>
<td></td>
<td>Wezel and Bender, 2003</td>
</tr>
<tr>
<td>Nepal</td>
<td>Bari</td>
<td>0.035 - 0.0467</td>
<td>123 crop</td>
<td>4.03</td>
<td>0.022</td>
<td>Sunwar, 2003</td>
</tr>
<tr>
<td>Bangladesh</td>
<td>Bari</td>
<td>0.206</td>
<td>142 (76 trees)</td>
<td>3.4</td>
<td>0.066</td>
<td>Alam &amp; Masum, 2005</td>
</tr>
<tr>
<td>Bangladesh</td>
<td>Bari</td>
<td>1.75</td>
<td>419 (106 trees)</td>
<td>3.4</td>
<td>0.066</td>
<td>Kabir &amp; Webb, 2008</td>
</tr>
<tr>
<td>Sri Lanka</td>
<td>Kandy</td>
<td>0.05 - 2.5</td>
<td>61 trees</td>
<td></td>
<td></td>
<td>Perera &amp; Rajapakse, 1991</td>
</tr>
<tr>
<td>Kerala</td>
<td>Compound garden</td>
<td>0.4 - 2.0</td>
<td>127</td>
<td>2.298</td>
<td>0.606</td>
<td>Kumar et al., 1994</td>
</tr>
<tr>
<td>Country</td>
<td>Local name</td>
<td>Size of homegarden</td>
<td>No. of species</td>
<td>Shannon' index</td>
<td>Dominance index</td>
<td>Reference</td>
</tr>
<tr>
<td>----------------------</td>
<td>-----------------------------</td>
<td>--------------------</td>
<td>----------------</td>
<td>----------------</td>
<td>----------------</td>
<td>-------------------------------</td>
</tr>
<tr>
<td>Kerala</td>
<td>Compound garden</td>
<td>0.75-1.0</td>
<td>52 trees</td>
<td>3.25-2.96</td>
<td>0.0527-0.0908</td>
<td>Chandrashekara &amp; Baiju, 2010</td>
</tr>
<tr>
<td>Kerala</td>
<td>Compound garden</td>
<td>1-1.5</td>
<td>101 trees</td>
<td>-</td>
<td>0.251-0.739</td>
<td>Babu et.al, 1992</td>
</tr>
<tr>
<td>South Andaman</td>
<td></td>
<td>0.5</td>
<td>18 trees</td>
<td>1.38</td>
<td>0.4</td>
<td>Pandey et.al, 2006</td>
</tr>
<tr>
<td>Barak valley, Assam</td>
<td></td>
<td>1.28ha</td>
<td>68 trees</td>
<td>-</td>
<td>-</td>
<td>Das &amp; Das, 2005</td>
</tr>
<tr>
<td>Meghalaya</td>
<td></td>
<td>0.02-0.35</td>
<td>197(70 trees)</td>
<td>2.37</td>
<td>-</td>
<td>Tynsong &amp; Tiwari, 2010</td>
</tr>
<tr>
<td>Arunachal Pradesh</td>
<td>(Nirjuli &amp; Doimukh)</td>
<td>0.02-0.04</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>Tangjiang &amp; Arunachalam, 2009</td>
</tr>
<tr>
<td>Kalita</td>
<td></td>
<td>0.04</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>Tangjiang &amp; Arunachalam, 2009</td>
</tr>
<tr>
<td>Apatanis</td>
<td></td>
<td>0.04</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>Tangjiang &amp; Arunachalam, 2009</td>
</tr>
<tr>
<td>Nyishis</td>
<td></td>
<td>0.04</td>
<td>80 plants</td>
<td>-</td>
<td>-</td>
<td>Deb et.al, 2009</td>
</tr>
</tbody>
</table>
species reported in Javanese homegarden (Soemarwoto, 1984). The range of species in the present study was certain to be less as compared to other as the shrubs and herb species were not considered in species inventorsisation. A number of factors such as socio economic status, market, size of homegarden etc. affect the diversity in homegarden (Santhakumar, 1996). Species diversity and composition of homegardens is influenced by ecological, socio-economic and cultural factors (Wiersum, 1982; Michon et. al.,1983; Fernandes & Nair,1986; Soemarwoto, 1987; Arnold & Dewees, 1995).

Traditional homegardens often have complicated vertical structures. The structure and composition of homegardens differ across sites depending on the ecological setting, floristic composition, age and size and socioeconomic functions within different household economies (Wiersum, 1982; Christanty, 1985; Fernandes & Nair, 1986; Soemarwoto & Conway, 1991, Kehlenbeck & Maass, 2004). In the present study four to five vertical canopy layers were demarcated in homegarden. The emergent layer or 5th layer (>15 m), the canopy or 4th layer (10-15 m), the understory or 3rd layer (5-10 m), 2nd layer (1-5 m)and the ground or 1st layer (<1 m). The layerings of vegetation of all the homegardens were different as all the vertical layers were not distinct. In the Kandyan homegarden of Sri lanka four layer were recorded (Perera et. al.,1991) while the homegarden of Andaman and Nicober formed five storied (Pandey et. al.,2006). In the homegarden of Kerala (Kumar et.al., 1994; Nair & Sreedharan, 1986) and west Java (Michon et.al.,1983) maximum species were reported to be found in the ground layer. De Clerck and Negreos-Castillo (2000)
reported five vertical layers for one type of homegarden in Mexico. In the Chao Phraya Basin of Thailand, Gajaseni and Gajaseni (1999) reported on traditional homegardens with four vertical layers.

The Shannon Wiener diversity index and Simpson indices of 90 homegarden were 2.89 and 0.10, which is moderate as compared to other study. Higher diversity index with lower dominance index represent less dominancy of tree species in the homegarden. The tree species diversity of large homegarden is higher (2.93) than medium (2.86) and small homegarden (2.65). Shannon wiener diversity index of Offshore Island of Bangladesh is higher than the present study 3.40 (Alam & Masum, 2005) and in the homegarden of Karnataka 3.21 were recorded (Shastri et.al., 2002). Rico-Gray et.al. (1990) also reported the value of 1.67 and 1.66 for the 2 study sites in Mexico, which is lower than the present study area. In the present study the dominance index of medium homegarden is higher than small and larger homegarden 0.20, 0.18 and 0.16 respectively but in the homegarden of Kerala the dominance index was higher in the small size homegarden (Kumar et.al., 1994) and the values are 0.606, 0.441 and 0.459 respectively in small, medium and large type of homegarden. Jose (1992) estimated an overall Simpson’s diversity value of 0.834 for various components of homegardens (including field crops) across different holding size categories in a village of Thiruvananthapuram district (Kerala). Pandey et.al. (2006) recorded 0.4018 of Simpson index in the study of the Diversity and species structure of homegarden in South Andaman, which is also higher than the present study.
Species richness of 90 homegardens was 8.62 of tree species and species evenness was 0.67, indicating that the tree individuals were distributed evenly.

There is certainly a close relationship between the management and functions of traditional homegardens (Schroth et al., 2004), but actually there have been very few studies specifically on management. Typically, homegardens are associated with abundant knowledge on how to manage plants and their sustainable use. Different zones have been documented by several authors (Brierley, 1985, Abdoellah, 1990; Okigbo, 1990; Padoch & de Jong, 1991). Homegarden zones are easily visualized and their location, size and plant species composition reflect deliberate management strategies. Plants and their local uses which are included in zones, provide additional information on a farmers management priorities and socioeconomic needs (Mendez et al., 2001). The homegarden consists of 11 different zones- Bamboo groves (Wapal), Ocimum sanctum (Tulshibong), Allium odorum (Yennam nakkupi), Cattle shed (Shangol), kept separately for cattle and other domestic animals. The courtyard (Sumang)-space kept in front of the house, is used for threshing, drying of paddy and other homegarden product and also for performing traditional rituals. The out-house (Shangoi) for storing paddy and other house hold products, pond (pokhri), used for fishery and for planting the Neptunia prostrata and Ipomea aquatica, residential zone, scattering zone, boundary zone and worshiping zone (Laishang) are the other zonations found in Meitei homegardens. Among these with the exception of a few others are not systematically arranged. Trees are generally grown in the boundary of the homegarden in the study area. The planting of woody trees in combination with
fruit trees is normally utilized at boundaries of individual landholdings, to act as live fences, as wind breaks and shade trees, and to provide access to fruit. In the Nicaraguan homegarden, 10 management zones were recorded, including the zone of fruit trees and multipurpose trees (Mendez et.al., 2001).

Five species of bamboo were recorded viz. Bambusa balcooa, B.cacharensis, B.nutans B.vulgaris and Bambusa tulda. Among these four species, the Bambusa balcooa is dominating and occurring in 46% of homegarden. It is important to mention that bamboo cultivation by the people in the village has resulted in protection of cattle egret as this form an important habitat for different birds, which needs to be strengthened. Bamboos also form an important commercial source and thus needs to be exploited prudently.

Differences in culture of the farmers also affect the diversity and composition of species, as reported for the Javanese and Sudanese homegardens in Java (Wiersum, 1982; Michon et.al., 1983; Soemarwoto, 1987). These (Ingkhol) gardens are characterised by a unique combination of Areca catechu, Parkia timoriana, Vatica lancofolia, Toona ciliata and other fruiting trees. Moreover, livestock are kept in the gardens and different tree species are grown to serve productive as well as protective functions. Traditional homegardens have been shown to be ecologically sustainable (Torquebiau, 1992; Jose & Shanmugaratnam, 1993; Kehlenbeck & Maass, 2004). Their benefits include maintenance of soil fertility and soil structure and maintaining nutrient cycling (Schroth et.al., 2001). However, along with the loss of traditional life-styles and changes in the socioeconomy, the continuing existence of traditional
agroecosystems has now become questionable. The characteristics and functions of traditional agroecosystems all over the world are under great change (Dash & Mistra, 2001; Trinh et.al., 2003; Soini, 2005; Peyre et.al., 2006). In some parts of the world, many species once commonly cultivated in traditional agroecosystems are becoming lost and, along with this, related knowledge about their management is also being lost (Lamont et.al., 1999; Kumar & Nair, 2004).

**Phenology of trees in homegarden**

Phenology is perhaps the simplest way by which to track changes in the behaviour of species. Various indications of shifts in plant and animal phenology have already been reported for the boreal and temperate zones of the northern hemisphere (Menzel & Estrella, 2001). Phenological analysis of trees provide a potential tool to address critical question related to modeling and monitoring of climate change (Schwartz, 1999). Climate change will affect many aspects of the biology of trees, and its effects on plant phenology would be of immense significance (Corlett & Lafrankie, 1998). In recent years, therefore, the focus of phenological studies has shifted to question of how phenology will be affected by global climate change and what consequences any climate change may have for species distribution and ecosystem function (Singh & Kushwaha, 2005).

Schnelle (1955) discussed the value of phenological observations and concluded that these inexpensive and useful 'plant-instruments' are integral instruments which respond to many meteorological and environmental factors. He concluded that the best method to analyse impacts on plants would be to ask the plants
themselves. In earlier times phenological observations were collected for agriculture and forestry applications, especially regarding the selection of suitable crops and cultivars and in the description of climatological growing conditions. Due to low cost, phenology has also served as a complementary climatological measurement in the environmental sciences (Beaubien, 2001). Karmer (1997) suggests that phenology and climate relationship can also reveal the potential impacts of future climate changes.

The initiation of growth in plants and changes in phenology are governed by various environmental factors and the influence of temperature and moisture has been studied by several workers (Dewald & Steiner 1986; Walter, 1973). Hamann (2004) suggested that climatic factors are not directly responsible for triggering and synchronization of phenological events.

In the present site three leafing patterns were encountered i.e. Periodic growth deciduous (11), Periodic growth evergreen (4) and Continuous growth evergreen (4). Periodic growth leaf exchanging was absent in the present study area. The leaf flush occurs in many tropical species either with the onset of rain after a spell of dry periods, as in Barro Colorado island (Leigh & Windsor, 1982), or early in the dry season as in Costa Rica (Frankie et.al., 1974). In general, such rhythms of leaf flush seem to occur in many tropical forests (Hladik, 1978; Fogden, 1972; Ng, 1974). A proximate cause for the leaf flush soon after the onset of rains is the signaling of the end of unfavourable physiological periods and beginning of a favourable growth period. In the present study site the deciduous tree species initiated their leaf flushing towards the end of winter season and beginning of warm wet rainy season, i.e. it
occurred Feb-March. *Toona ciliata* showed the leaf initiation before rain in the dry periods (Dec-Jan), while other tree species initiated their leaf flushing in February, continued up to July-August with a peak in May just before the onset of monsoon. The observations indicated that most of the species completed leaf development by July and August. *Toona ciliata* is the tree in which leaf flush was seen in the month of December among the deciduous tree species. A few evergreen species eg. *Areca catechu, Cocos nucifera, Mangifera indica, Citrus grandis, Ficus hispida* showed continuous leaf fall and leaf flushing. In all the deciduous tree species leaf flushing periods varied during the period of study. The flushing and leaf production towards the end of dry season and just before the rains has also been reported by several workers (Frankie et.al., 1974; Shukla & Ramakrishnan, 1982; Sundriyal, 1990; Kikim & Yadava, 2001; Singh & Kushwaha, 2005a & b). Leaf flush may be triggered by different control mechanisms e.g. leaf fall, first significant rainfall, or change in photoperiod (Rivera et.al., 2002). The summer flushing enables tree species to activate canopy development before the monsoon rainfall begins, so as to make maximum use of short rainy season for productivity (Singh & Kushwaha, 2005). In the present study *Toona ciliata* was the tree species in which leaf flush started in the end of winter season (Dec), similar to that reported by Kikim and Yadava (2001) in the subtropical forest of Manipur in North eastern India.

The rate of leaf fall during the dry season was strongly correlated with the decline in soil moisture and increasing water stress of the tree (Reich & Borchert, 1982). Reich (1995) suggested that the timing of leaf fall and bud break were
generally determined by tree water stress which in turn was a function of the
interaction between the water status of the environment and the structural and
functional state of the tree. Wide range of leaflessness has been recorded in deciduous
trees in India. The leafless dration of tree species in homegardens of Bontarapur
(Assam) varied from 22 days to 121 days which may be compared with 3 weeks to 7
months leaflessness of the Vindhyan dry deciduous forest (Kushwaha & Singh, 2005),
1-3.5 month leaflessness in Venezuela (Olivares & Medina, 1992) and <1-4 months in
Argentina (Rivera et al., 2002). It seems that in the tropical regions having long dry
season, tree species are adapted in such a way that they can tolerate prolonged water
stress, yet producing and maintaining leaves for longest duration. Leaf fall initiation
was a periodic activity in all species, however the onset of leaf fall initiation was
different among the tree species. The peak leaf fall occurred in the month of
November to December. Among the deciduous tree species, Lagerstroemia speciosa,
Toona ciliata and Spondias pinnata exhibited maximum leaf fall in the month of
November. Whereas Artocarpus chama, Parkia timoriana and Bombax ceiba start
shedding their leaves from early July and continued upto January and remain leafless
for a short duration. Artocarpus chama has the shortest leafless period, and Premna
bengalensis was 121 days, the maximum leafless period. Depending on the leaf
phenology four functional types of deciduousness were calculated, <1 month
deciduous, 1-2 months deciduous and >2 months. Artocarpus chama was the only
tree species which had less than one month, Albizia lebbeck, Cordia grandis, Gmelina
arborea Parkia timoriana, were the tree species which had one to two months
deciduous period. *Bombax ceiba, Erythrina stricta, Lagerstroemia speciosa* and *Premna bengalensis* were the species which had greater than two month deciduous period. The evergreen tree species also shed the leaves in the dry season and peak period was in the month of November - December.

Seasonal duration of leafing, flowering and fruiting mainly determine phenological behaviour in tropical trees. These phenological events are not mutually independent in woody species, and flowering may be partly or wholly dependent on leafing activity (Van Schaik *et al.*, 1993). Nevertheless, tree species with similar leaf phenology often differ in the timing of their flowering and fruiting (Seghieri *et al.*, 1995). The seasonal pattern of flowering in the present homegarden has two peaks; a major peak was recorded in the beginning of March-April and a minor one in October-November. The first peak period of flowering was observed in *Bombax ceiba, Citrus grandis, Erythrina stricta, Lagerstroemia speciosa, Spondias pinnata, Toona ciliata* and the second peak period was observed in few species such as *Areca catechu, Artocarpus heterophyllus, and Parkia timoriana*. *Albizia lebbeck* flowers twice in a year. Among the 19 tree species, 5 are continual and 14 tree species were annuals. In the present study the tree species which are deciduous, flower in pre monsoon dry periods while other evergreen species flowered in later part. In the evergreen species flowering is mostly after leaf flush but the deciduous species exhibited different pattern of flowering a) Flowering before leaf flush and during leafless period eg, *Spondias pinnata, Erythrina stricta, Gmelina arborea* b) Flowering long before leaf flush and during leafless period eg, *Bombax ceiba*. c) Flowering soon after leaf flushes
eg, *Albizia lebbeck*, *Toona ciliata*. d) Flowering later after leaf flushes eg, *Lagerstroemia speciosa*, *Parkia timoriana*. In the present study *Artocarpus chama*, a member of Moraceae, did not produce reproductive parts during 3 years of observation.

In majority of species fruit maturation started from the month of May. The fruiting peak in the study was similar to that in other tropical and ripening of fruits in the latter part of pre-monsoon dry period or close to rainfall (Kikim & Yadava, 2001). Two peak periods of fruiting was observed—one major peak in the month of May-July and a minor one in Oct-Nov. The majority of the species, fruit ripening was close to the rainy season. These could help in fruit dispersal and also to regenerate during the rainy season. In the major peak period the fruit maturation was observed in the tree species *Artocarpus heterophyllus*, *Bombax ceiba*, *Gmelina arborea*, *Mangifera indica* and *Toona ciliata*, and in the minor one the species were *Albizia lebbeck*, *Areca catechu*, *Citrus grandis*, *Parkia timoriana*, and *Spondias pinnata*. *Lagerstroemia speciosa* and *Spondias pinnata* showed a long fruiting period among the tree species of 8 and 9 months respectively. Fruit fall occurred in most of the species during the months of June-July except *Lagerstroemia speciosa*, *Parkia timoriana* in which it occurred during March-April. Fruits of the species like *Musa* species, *Cocos nucifera*, *Carica papaya* were available throughout the year. Fruits of *Averrhoa carambola* and *Psidium guajava* were available twice in a year i.e. during June-July and Nov-Dec. However, the time required for fruit maturation varied considerably with species.
Study of phenology is also becoming increasingly more relevant for sectors like forestry, agriculture, socio-economics and public health. Potential applications of phenological information in the context of global change have been variously discussed (Schwartz, 1999 & Menzel, 2003) Thus, phenology has emerged as an important integrative measure to assess the impact of climate change on ecosystems. Long-term phenological records originating from the plant and animal observation networks provide a useful measure of changes in the species-level biological responses to variations in climate at specific sites (Sparks and Carey, 1995).

In Indian agroforests, existence of several tree functional types, differing in drought-related adaptations and length of deciduousness, poses uncertainty in determination of growing season length. All shifts in phenological phases, especially in the leaf period, have impacts on the climate system itself via feedback mechanisms of surface albedo, carbon-dioxide fluxes and evapotranspiration. Phenological information, which is easily perceived and recorded, can serve as a useful input in environmental education, public awareness, resource management and health programmes (e.g. allergic diseases). Apart from this, phenology may promote both scientific research in school children, and tourism and sports through information such as timing of snowfall and major flowering time. An advantage with phenological observations is that they are extremely suitable to illustrate and communicate climate-change impacts (Kushwaha & Singh, 2005).

Studies on floristic composition and structure in trees are instrumental in the sustainability of trees since they play a major role in the conservation of plant species,
and the management of ecosystems as a whole (Tilman, 1988; Ssegawa & Nkuutu, 2006). Ecosystem services are defined as "the conditions and processes through which natural ecosystems, and the species that make them up, sustain and fulfill human life" (Daily, 1997) ecosystem service tradeoffs arise from management choices made by humans, which can change the type, magnitude, and relative mix of services provided by ecosystems (Rodriguez et al., 2006). As a result, millions of people depending on forests and tree resources for their subsistence have become more vulnerable. The multi-functionality of the agroforestry systems has been realized over the last four decades. Thus, agroforestry system research and development has evolved dramatically with much emphasis on how they function, diversity from local, landscape to regional level, local knowledge systems, economic valuation and environmental services they provide (Beer et al., 2005). Agroforestry was recognized by the Intergovernmental Panel on Climate Change as having potential for sequestering carbon as part of climate change mitigation strategies (Watson et al., 2000).

In the present study the dominant tree species in the three types of the homegardens showed Inverse ‘J’ shaped curve. Basal area distribution also followed the same pattern i.e. decreases with increase in the girth class in three types of homegarden. The number of individuals in the girth class 30-45cm was higher than other girth classes, because the farmer prefer to grow more individuals of Areca catechu for their commercial importance. Areca catechu is grown in most of the homegardens for its commercial importance but it in future it may reduce the species diversity of homegarden. Kumar et al. (1994) also observed the adverse effects of
‘teak boom’ on the species diversity of homegardens in Kerala. The population structure of Artocarpus heterophyllus, Mangifera indica, Syzygium cuminii, Toona ciliata, Psidium guajava and Premna bengalesis showed the ‘L’ shaped structure. The number of individuals in the larger girth classes is comparatively lesser but higher number of individuals in lower girth classes indicates a potential with longer sustainable and indicating focused management by the farmer. The regeneration potential of above mention tree species was good and the farmer also protects them. The number of individuals was less in the higher girth class, which might be due to the harvesting of old aged trees for additional cash benefit income sold or used as timber. Artocarpus heterophyllus, Mangifera indica, Syzygium cuminii because of its value as high quality timber besides being a fruit tree farmer prefer to grow more individual in their homegardens. Kumar et.al. (1994) in their study of woody species diversity in the homegardens of Kerala, India reported slightly skewed distribution having higher frequency in 20-30 cm indicating the healthy population growth in the lower girth class as because of intensive management practice adopted by the farmer such as controlled regeneration, space planting along with harvesting of trees as soon as they attain a certain size of the trees. This indicated that these homegarden are dynamic as well as sustainable land use systems with good regeneration potentials.

Information on diameter increment and growth patterns for individual trees is important tools for tree management. DBH growth rates vary significantly between and within tree species, and also in relation to age, season and microclimatic conditions (Ferri, 1979). Usually, tropical tree species present different behavior under
different conditions, even for the same species or same botanical families. DBH growth is not directly controlled by soil moisture, but by plant hydrological balance in addition to other factors, which in turn, regulated by intensities of water absorption and transpiration (Ferri, 1979).

The value of mean dbh increment for trees >30 cm gbh in present study is 0.23 cm/yr, less than that of 0.27 cm/yr exhibited by trees >30 cm dbh in Mount BellendenKer, Queensland (Herwitz & Young 1994) and the mean annual dbh increment of 0.44 cm/yr for trees 9.5 cm dbh in Mpanga, Uganda (Taylor et.al.,1996). The annual increment in stem diameter in the homegarden of Kerala, India observed by Chandrashekara (2007) was quite high as compared to the present study. The maximum increment was recorded in *Ailanthus triphysa* (3.74 cm/yr) and minimum was of *Xyilia xylocarpa* (1.15 cm/yr) but in the present study the maximum was recorded in *Tectona grandis* (0.47 cm/yr) and minimum was recorded for *Artocarpus chama* (0.10 cm/yr).

Lorenz curves and Gini coefficients are widely used to characterize inequalities in economics and ecology (Beaugrand & Edwards, 2001; Bendel et.al., 1989; Figini, 1998; Harch et.al., 1997; Rousseau et.al., 1999; van Hecke et.al., 1995; Weiner & Solbrig, 1984). The Gini coefficient is a measure of heterogeneity, originally applied by economists to evaluate inequality between persons in wealth and income (Sen, 1973). It has later been applied as a measure of size hierarchies in plant populations (Weiner and Solbrig, 1984). Since total inequality is impossible in a stand with many trees, the theoretical maximum of the Gini coefficient (1) will never be
reached when applied to forest stands. Total inequality is defined as a situation where all individuals except one, in an infinite population, have a value of zero (Weiner & Solbrig, 1984). Gini coefficient can be used as an objective measure to compare tree size diversity in different stands to assess changes in tree size diversity over time at the stand or landscape level (Lundqvist, 1994) to quantify the influence of different silvicultural treatments on tree size diversity. As yet no published information was available on the application of Gini coefficient and Lorenz curve in assessing the size diversity of homegarden/traditional agroforestry trees although few studies were available in forest trees of natural and plantation forests.

It is believed that traditional homegarden practices depend on the type of human community, tradition, needs, beliefs etc. For centuries, human beings have been utilizing plant genetic resource for food, medicine and other cultural purposes. The knowledge of genetic resource used by earlier civilization has descended down to the present day of indigenous and ethnic society, who has inherited that knowledge from their ancestors. This traditional knowledge developed over a period of time, has passed from one generation to another with observation, experimentation trial and error and has become a valuable legacy in this nature, these people have acquired unique knowledge about the sustainable use of wild fauna and flora most of which are not known to the modern society.

The Meitei homegarden traditionally represent complex systems with cultivated tree species. One of the striking features of homegarden of Meitei community is the conservation of Heirloom plants from generation to generation.
Agriculture being the main profession in the rural area of the Barak valley, the Meitei people also dependent on it. The economy of this community is mostly self-sustaining and depends on traditional cultivation practices. Therefore, the socioeconomic development as well as the standard of living of the Meitei here greatly depends on the development of the agricultural sector. The Meitei maintain agrobiodiversity in their homegarden locally called Ingkhol. Such systems are essentially man made and reflect the wisdom of the traditional culture and ecological knowledge that have evolved over the years. Such valuable traditional ecological knowledge systems are based on strong sociocultural and traditional beliefs confounded by the economic status of the people. Various traditional approaches to conservation of nature required a belief system, which includes a number of prescription and proscriptions for restrained resource use (Gadgil & Berkes, 1991). It can be said that people of Meitei community have their traditional system of conserving biodiversity through their ancestor by folklores (Singh & Singh, 1996). Traditional homegardens of Meitei are rich in biological diversity harbouring many species.

Agroforestry has the potential to improve livelihood as it offers multiple alternatives and opportunities to farmers to improve farm production and incomes and also provides productive and protective (biological diversity, healthy ecosystems, protection of soil and water resources, terrestrial carbon storage) forest functions to the ecosystems while protecting the natural environment. It is promoted widely as a sustainability-enhancing practice that combines the best attributes of forestry and agriculture. This practice is now recognized widely as an applied science that is
instrumental in assuring food security, reducing poverty and enhancing ecosystem resilience at the scale of thousands of smallholder farmers in the tropics. Therefore, strengthening linkages between knowledge systems using “Community” participatory management approaches is now seen as critical for sustainable forestry and agroforestry systems (Adhikari et al., 2007; Dhakal et al., 2007; Ramakrishnan, 2007). Traditional agroforestry systems in the mountains are very close to natural ecosystems as they provide ecosystem services similar to the forests such as the biodiversity, provision of food and fibre, water resources and its purification, climate regulation and carbon sequestration, nutrient cycling, primary production, production of oxygen, and soil formation, and recreation and the cultural services for the well being of the people and society. Agroforestry systems of land use and management date back to the early origin of agriculture or settled cultivation. However, modern science has shown how agroforestry systems can be designed for deriving the maximum benefit, on an ecologically sustainable basis. These systems integrate crops and/or livestock with trees and shrubs resulting in multiple benefits including diversified income sources, increased biological production, better water quality, and improved habitat for both humans and wildlife. Trees on farms provide both products and services: they yield food, fuel wood, fodder, timber and medicines, and they replenish organic matter and nutrient levels in soils and help control erosion and conserve water. For example, the Himalayan alder (*Alnus nepalensis*) based agroforestry is particularly useful for supplying nutrients such as nitrogen and phosphorus also to the plantations or croplands located downstream (Singh, 2002). Consequently an agroforestry system
with combination of forestry and agricultural components is an excellent practice where the environmental services are obtained in a sustained manner for both the upland communities and the downstream users. The eastern Himalayan region also comprises diversity of agroforestry system as an important land use practice.

Agroforestry is accepted as one of the sustainable management systems for provisioning functions adopted by the mountain communities in the region. Such systems conserve soil by improving the fertility levels and erosion; provide quality water for local consumption, fodder for livestock, fuel and timber for use as energy and construction materials, and traditional crops for food security. Integration of cash crops in the system gives good economic return that promotes poverty alleviation and contributes to the human well being and good health. One good example of such a traditional agroforestry system is the cultivation of large cardamom as cash crop in the Indian state of Sikkim of the eastern Himalayan region. Such agroforestry systems are unique examples of the ecological sustenance and economic viability for the mountain peoples while providing goods and services to the downstream users (Sharma, et.al., 2007). Traditional ecological knowledge and traditional resource management have played a crucial role historically in resource sustainability and management (Ticktin & Johns, 2002; Miller & Nair, 2005). Along with changes in traditional lifestyles and environments, traditional knowledge on homegardens is fading (Gillespie et.al., 1993). So it is necessary and urgent to conduct studies on traditional management practices in homegardens to document traditional knowledge of
homegarden management, and to explore their scientific meanings (Huai & Hamilton, 2009).

The homegardens are important in providing both economic and ecological benefits, they are also very important for the provision of social and cultural benefits to the individual farmer and to the community. Many plants were cultivated and retained for ornamentation and aesthetics, medicinal uses and in some cases for religious reasons. The farmers also considered food grown in their gardens to be of higher quality, both in terms of taste and shelf life, than produce obtained from the local commercial markets.

The results of this study revealed that in terms of species diversity of trees the ‘Ingkhol’ the traditional Meitei homegardens are richer than several other homegardens in the tropics. Many cultivated fruit trees are managed primarily for their fruits, while the other are managed for multiple use including, timber, fuel, ornamental and ritual reasons. In spite of the intensification of Arecanut in the homegardens of the study village, farmers are managing other trees considering their multiple functions.

It is important to emphasize here that policy makers seldom recognize the importance of homegardens as a powerful landuse model for sustainable production. However, a recent country report by NBPGR (2007) mentions the role of homegardens as important sites for in situ / on farm conservation of land races and wild species valued for human use.

With the increasing emphasis the worldover on carbon sequestration in terrestrial ecosystems, homegardens could be of crucial importance in the carbon-credit
management issues. (Montagnini & Nair, 2004: Kumar, 2011). Future research on homegardens would concentrate on this important issue of carbon management by smallholder farmers.