Content list available at http://epubs.icar.org.in, www.kiran.nic.in; ISSN: 0970-6429

Indian Journal of Hill Farming

December 2017, Volume 30, Issue 2, Page 313-325

# Traditional Homegardens in Rural Landscapes of Northeast India – A Model for Conserving Plant Species for Sustainability

Sumpam Tangjang[1*] • A. Arunachalam[2]

[1]Department of Botany, Rajiv Gandhi University, Rono Hills, Doimukh-791112, Arunachal Pradesh

[2]Division of Natural Resources Management, Indian Council of Agricultural Research, New Delhi-110012

ARTICLE INFO

*Article history*:
Received 6 December 2016
Revision Received 24 June 2017
Accepted 8 August 2017

*Key words*:
Biodiversity, Homegardens, IKS, Northeast India, Sustainability

ABSTRACT

Call for natural resources management, biodiversity and environmental conservation related subjects are gaining momentum. Conservation scientists, researchers, Non-Governmental Organizations (NGOs) and policy makers are trying to address these issues from local to global levels in all possible ways. In contrast to the present global scenario, the rural folks in the remote tribal inhabited northeast India are, however, silently conserving natural resources and are achieving sustainable agriculture with their rich Indigenous Knowledge Systems (IKS). The study was carried out considering the role of plant species in traditional homegardens for sustainability in Itanagar, Arunachal Pradesh and North Lakhimpur, Assam, two neighbouring Indian states located in the Eastern Himalayas. We recorded 79 plant species belonging to 46 botanical families presenting a multi-tier canopy configuration with intimate mixture that provides a wide ranges of services such as folk medicine, construction material, timber, valuable food sources, cash-income, *etc.* Rice and arecanut were identified as important cultural as well as cash-crops in North Lakhimpur while the farmers' in Itanagar prefers more timber species. The analysis of existing management regime, however, indicates that the local practitioners lack modern scientific knowledge and still follow traditional management systems. The study also reveals that traditional homegardens can be a valuable tool for *in situ* conservation of plant species and maintaining ecosystem functioning.

## 1. Introduction

Northeast India, commonly known as the "Eight Sister States" and each state having distinct cultures and traditions is one of the most ethically and linguistically diverse regions. Thrown across the farthest reaches of India, these remote frontiers, obscured from the greater world by ageless forests and formidable mountain ranges, are a region of rugged beauty, and a collision zone of tribal cultures, climates, landscapes and peoples. About 80% of the rural folks in the region are poor and relies on traditional agriculture such as slash-and-burn and wet-rice cultivation since generations and more recently on traditional homegardens for their day-to-day livelihoods. These indigenous people are, however, bestowed with rich Indigenous Knowledge Systems (IKS), local innovations and creativity. Their traditional land management systems over the generations and its contribution to the rural sustenance, socio-cultural, economic, and ecological as well as personal preferences have been receiving enormous attention from scientists and researchers in the recent past. Homegarden is commonly defined as a land-use system involving deliberate management of multipurpose trees and shrubs in intimate association with annual and perennial agricultural crops and

*Corresponding author: sumpam@gmail.com

invariably livestock within the compounds of individual houses, the whole tree-crop, and animal unit is being intensively managed by family labor (Kumar and Nair 2006). According to Tynsong and Tiwari (2010), homegarden is characterized by different vegetation strata composed of trees, shrubs and herbs in association with annual and perennial agricultural crops and small livestock within the house compounds. Such systems generally reflect the accumulated wisdom over generations of cultural evolution and integrate woody perennials with other life forms which have been practiced mainly by the rural folks for survival and cash income. Numerous and diverse agroforestry systems can be found in the tropics, partly because of their favorable climatic conditions and partly because of the socio-economic factors such as human-population pressure, more availability of labor, smaller land-holding size, complex land tenure, and less proximity to markets (Nair 2007; Nair *et al*. 2008). Most of the plants grown in traditional homegardens of northeast India have multiple uses that plays an important role in household food security, as they are sustainable source of food, fruits, vegetables, folk medicines, cash, and timber and construction materials.

The adoption of traditional homegarden technologies also mitigate biodiversity loss and provide opportunities for improving diversification and range of livelihood options for rural households (Akinnifesi *et al.* 2008). Plants in homegardens are vital sources of folk medicines and play a significant role in the survival of rural tribal communities. According to World Health Organization (2001), herbal medicines serve the health needs of about 80% of the world's population, especially for millions of people in the rural areas of developing countries. This rich medicinal plant knowledge is, however, seriously threatened due to deforestation, environmental degradation and acculturation, currently taking place in the region. Therefore, the traditional homegardens based on the cultivation of a variety of crops and trees have allowed the traditional farmers to maximize harvest security, promote diet diversity under low levels of technology and with limited environmental impact. Most of the homegarden agroforestry species and techniques in the region, however, have not yet been subjected to scientific experiments. A comparative study on homegardens of Assam and Arunachal Pradesh has been attempted in the present study in terms of its role for the rural survival.

## 2. Material and Methods

The study was conducted in Itanagar, and North Lakhimpur (about 60 km from Itanagar). Itanagar (27.1°N 93.62°E at an elevation of 750m asl) is the capital of the Indian state of Arunachal Pradesh, whose name meaning the "Land of Dawn-lit Mountains" and is situated at the foothills of Himalayas. Administratively, it comes under Papum Pare district and is inhabited by myriads of colorful tribes and sub-tribes. The rural areas of the district, however, are inhabited by the "Nyishis", one of the major tribes of Arunachal Pradesh. Lying on the north bank of the Brahmaputra River, North Lakhimpur (27° 13' 60 N and 94° 7' 0 E at an elevation of 100 m asl) is one of the administrative districts of the state of Assam, northeast India. The district is multi-cultural and multi-ethnic in nature. Assamese speaking community such as Chutiya, Ahom, Koch, Bodo along with Mishing tribe dominates the district. Besides, Assamese and Bengali speaking Muslims also have a sizeable population. Tea tribes or Adivasi mainly resides in the western and northern part of the district along the foothills.

The lushness of its landscape, the range of communities and geographical and ecological diversity makes these frontiers quite different from other parts of India. The sites are located in tropical humid environment and usually experiences four distinct seasons, *viz.* autumn (Mid-September – November), winter (December – February), spring (March – April) and rainy or summer (May – August). The study areas receive an average annual rainfall of about 1500 mm with more than 90% of rainfall occurring during monsoon (May – July) registering about 60-80% relative humidity. The occurrence of occasional rainfall during winter season, however, cannot be ruled out *in toto*. The average winter and summer temperature ranges from 10 – 12ºC and 25 – 38ºC respectively. Till date, majority of the rural population are predominantly engaged in agriculture, plantation and forest related activities. Unlike the plains in North Lakhimpur, Itanagar, located in a hilly terrain have limited habitable area and about 80% of its population is living in rural areas whose primary occupation is slash-and-burn cultivation which are extensively practiced in high hills and on gentle slopes in the foothills. Besides farming, animal husbandry, fishing, hunting and collection of non-timber forest products (NTFPs) are additional sources of income. Cattle rearing is common to both Itanagar and North Lakhimpur and are employed in agriculture for ploughing and threshing food grains. Geologically, the parent rock exposed around Itanagar area consists of newer alluvium (newer terrace deposits), represented by valley field deposits, mainly the sediments. In North Lakhimpur, however, the alluvium belonged to Pleistocene and recent times (Kumar 1997).

**Table 1.** Different tree species of traditional homegardens

| Name of the species | Family | Collection No. | Traditional purpose of planting | |
|---|---|---|---|---|
| | | | Study sites | |
| | | | North Lakhimpur | Itanagar |
| *Alstonia scholaris* R.Br. | Apocynaceae | ST12 | Medicinal | N/A |
| *Anthocephalus cadamba* Miq. | Rubiaceae | ST35 | Timber | Timber |
| *Aquilaria agallocha* Roxb. | Thymelaeaceae | ST08 | N/A | Medicinal |
| *Areca catechu* Linn. | Arecaceae | ST03 | Fruits/sell/medicinal | Fruits |
| *Artocarpus heterophyllus* Lam. | Moraceae | ST28 | Fruits/sell | Fruits |
| *Averrhoa carambola* Linn. | Oxalidaceae | ST70 | N/A | Medicinal |
| *Baccaurea sapida* Muell-Arg. | Euphorbiaceae | ST01 | Fruits | N/A |
| *Bauhinia variegata* Linn. | Fabaceae | ST31 | Soil fertility | Cattle feed and soil fertility |
| *Caesalpinia pulcherrima* (Linn.) Sw. | Caesalpiniaceae | ST43 | N/A | Soil fertility |
| *Carica papaya* Linn. | Caricaceae | ST16 | N/A | Fruits/Medicinal |
| *Citrus reticulata* Blanco. | Rutaceae | ST53 | Fruits | Fruits/sell |
| *Citrus sinensis* (Linn.) Osbeck. | Rutaceae | ST67 | Fruits | N/A |
| *Cocos nucifera* Linn. | Arecaceae | ST45 | Consumption and sell | N/A |
| *Dillenia indica* Linn. | Dilleniaceae | ST39 | Fruits/sell/medicinal | N/A |
| *Duabanga sonneratioides* Buch-Ham. | Lythraceae | ST06 | N/A | Timber |
| *Emblica officinalis* Gaertn. | Euphorbiaceae | ST52 | Fruits/sell | N/A |
| *Erythrina indica* Lam. | Fabaceae | ST48 | N/A | Soil restoration |
| *Ficus benghalensis* Linn. | Moraceae | ST19 | N/A | Sacred |
| *Flacourtia cataphracta* Roxb. | Flacourtiaceae | ST30 | Fruits | N/A |
| *Garcinia pedunculata* Roxb. | Clusiaceae | ST09 | Fruits/leaves/Medicinal | NA |
| *Gmelina arborea* Roxb. | Verbenaceae | ST57 | N/A | Timber |
| *Grevillea robusta* A. Cunningham. | Proteaceae | ST05 | N/A | Boundary tree |
| *Heteropanax fragrans* (Roxb.Ex DC) Seem. | Araliaceae | ST14 | Medicinal | N/A |
| *Lagerstroemia flos-reginae* Retz. | Lythraceae | ST60 | N/A | Ornamental |
| *Litchi chinensis* Sonn. | Sapindaceae | ST37 | N/A | Fruits |
| *Livistona jenkinsiana* Griff. | Arecaceae | ST15 | N/A | Roof thatching |
| *Mallotus albus* (Roxb Ex Jack) Mull & Arg. | Euphorbiaceae | ST02 | Present | N/A |
| *Mangifera indica* Linn. | Anacardiaceae | ST46 | Fruits and sell | Fruits |
| *Melia azadirachta* Linn. | Meliaceae | ST13 | Medicinal | Medicinal |
| *Mesua ferrea* Linn. | Clusiaceae | ST69 | N/A | House construction |

| | | | | |
|---|---|---|---|---|
| *Moringa oleifera* Lam. | Moringaceae | ST07 | Fish feed | Medicinal |
| *Morus alba* Linn. | Moraceae | ST32 | Fruits/preparation of gem | N/A |
| *Oroxylum indicum* (Linn.) Vent. | Bignoniaceae | ST18 | Medicinal | N/A |
| *Premna bengalensis* C.B. Clarke. | Verbenaceae | ST54 | Fuelwood | N/A |
| *Psidium guajava* Linn. | Myrtaceae | ST33 | N/A | Fruits/medicinal |
| *Pyrus communis* Linn. | Rosaceae | ST76 | N/A | Fruits |
| *Terminalia myriocarpa* Heureka. & Muell.-Arg. | Combretaceae | ST75 | N/A | Timber |
| *Ziziphus jujuba* Lamk. | Rhamnaceae | ST04 | N/A | Fruits |

**Table 2.** Different shrubs species of traditional homegardens

| **Name of the species** | **Family** | **Collection No.** | **Importance/purpose of plants being cultivated** | |
|---|---|---|---|---|
| | | | **Study sites** | |
| | | | North Lakhimpur | Itanaga |
| *Citrus limon* (Linn.) Burm. | Rutaceae | ST73 | N/A | Fruits/medicinal |
| *Clerodendrum viscosum* Vent. | Verbenace | ST27 | Medicinal | N/A |
| Clerodendrum colebrookianum Walp. | Verbenaceae | ST79 | N/A | Medicinal |
| *Hibiscus-rosa-sinensis* Linn. | Malvaceae | ST11 | Ornamental/Medicinal | Ornamental |
| *Lawsonia inermis* Linn. | Lythraceae | ST49 | Medicinal | N/A |
| *Manihot esculenta* Crantz. | Euphorbiaceae | ST29 | N/A | Tuber for food |
| *Musa* sp. | Musaceae | ST74 | Fruits | Fruits |
| *Ocimum sanctum* Linn. | Lamiaceae | ST17 | Medicinal | Medicinal |
| *Phyllanthus niruri* Linn. | Euphorbiaceae | ST23 | Medicinal | Medicinal |
| *Prunus domestica* Linn. | Rosaceae | ST34 | Fruits | N/A |
| *Saccharum officinarum* Linn. | Poaceae | ST20 | Consumption/medicinal | N/A |
| *Solanum melongena* Linn. | Solanaceae | ST36 | N/A | Vegetable |
| *Tabernaemontana divaricata* (L.) R. Br.ex Roem. & Schult | Apocynaceae | ST26 | N/A | Medicinal |
| *Thuja orientalis* Linn. | Cupressaceae | ST21 | Ornamental | N/A |
| *Zea mays* Linn. | Asteraceae | ST55 | N/A | Food |

The study was based on collection of primary data directly from the field. A total of 80 traditional homegardens (40 from each study site) were randomly selected. Nearly ten field visits of approximately 6-8 days per survey were conducted. Household residents were approached with verbal consent and the objectives of the study was clearly explained. Multistage random sampling method was adopted for data collection. Three complementary approaches were adopted, namely; (a) formal interviews targeting primarily local experienced persons (aged between 40 to 65 years), (b) direct filed observations and (c) interactions usually involving 2–3 members of the selected households through questionnaires. The interview schedule comprised of a general introduction concerning management of traditional homegardens, plant domestication, their uses and finally discussions related to contribution of plant species to the households. Interview sessions usually lasted between 1 to 3 hours including a field-walk to collect plant species. Repeated field visits were made which was very useful as interviewees recalled additional species and confirmed information. The group interviews and discussions were conducted in the mornings and evenings when most of the residents were available. The specimens of all the plants encountered with the help of interviewees were collected and taxonomic identification of the plant species followed Hooker (1894) and Flora of Assam (Kanjilal *et al.,* 1934-1940). The taxonomic identification of the collected plant specimens was also confirmed and compared by consulting the herbaria at Botanical Survey of India (BSI), Itanagar, State Forest Research Institute (SFRI), Itanagar and Rajiv Gandhi University, Itanagar, Arunachal Pradesh, India. All the specimens collected were deposited at the Department of Botany, Rajiv Gandhi University, Itanagar for future references.

## 3. Results and Discussion

Traditional homegarden is one of the vital components of rural landscapes and play a central role in the predominantly bioresource based economy of northeast India. The interest in adoption of homegardens has been focused primarily on their own wisdom and perceptions acquired over generations of experiences, the main criterion being their day-to-day livelihood strategies. It ensures availability of products within the homestead which is particularly important in hilly Itanagar where agricultural fields (shifting agriculture) are generally far off and travel to the fields is difficult and time consuming. All the homegardens studied possessed a multi-layered vegetation structures and the resultant canopy architecture was often comparable to that of a tropical rain forest comprising of big trees, the medium-height trees and shrubs and herbaceous species. The top layer consisted frequently of trees such as *Anthocephalus cadamba, Areca catechu, Artocarpus heterophyllus, etc.* the middle layer of medium-height trees and shrubs species like *Citrus, Averhoa, Musa*, *etc.* while the dominant herbaceous species were *Ageratum conyzoides*, *Drymaria cordata*, *Spilanthes acmella*, *etc.* Jama *et al.* (2006) also reported that most of the east African homegardens are characterized by 3-4 vertical canopy stratification. According to De Clereck and Negreros-Castillo (2000), the structure and number of strata is mainly determined by the management and knowledge of the indigenous farmers. Thus these predominantly artificial ecosystems can be placed between forest and agriculture ecosystems in the forest-agriculture continuum that provide food security to the rural poor and act as safety net in cases of exigency (Tynsong and Tiwari 2010).

Altogether, 79 plant species (38 trees, 15 shrubs and 26 herbaceous species) belonging to 46 botanical families were recorded in the present study. In North Lakhimpur 21 trees, 09 shrubs and 16 herbs while in Itanagar 25 trees, 10 shrubs and 22 herbs were recorded. Twenty-four plant species were common to both the sites. The botanical names with collection number of trees, shrubs and herbs encountered during the study are given in table 1, 2 and 3. Euphorbiaceae with five species was the most dominant family followed by asteraceae and verbenaceae (four), arecaceae, fabaceae, lythraceae, moraceae, poaceae, rubiaceae, rutaceae and solanaceae with three, apocynaceae, dryopteridaceae, clusiaceae, lamiaceae, malvaceae, rosaceae with two while rest of the family was represented by one species each. With the exception of rutaceae with four species of *Citrus* (a fundamental source of vitamin C) and verbenaceae with two species of *Clerodendrum*, the genus to species ratio remained 1:1 throughout the sites.

The enumerated 46 plant families in the present study was higher than the reported value (15 plant families) of homegarden in Southern Andaman (Pandey *et al.,* 2002). The total number of 38 tree species registered in the present study sites was, however, much lower than the 93 tree species reported in Sirsimakki village ecosystem in western Ghats (Shastri *et al.,* 2002). Wezel and Bender (2003) reported a tota of 101 plant species with an average of 18-24 species/homegarden in three village homegardens from Cuba. The species number and diversity were shown to be influenced by altitude of homegardens, age of gardens (Quiroz *et al.,* 2002) or homegarden size (Abdoellah *et al.,* 2001) and other characteristics of the gardener (Leiva *et al.,* 2002; Quiroz *et al.,* 2002) or level of production intensity and market access (Michon and Mary 1994).

**Table 3.** Different herbs species of traditional homegardens

| Name of the species | Family | Collection No. | Importance/purpose of plants being cultivated | |
|---|---|---|---|---|
| | | | Study Sites | |
| | | | North Lakhimpur | Itanagar |
| *Abelmoschus esculentus* (Linn.) Moench. | Malvaceae | ST22 | Vegetable | N/A |
| *Ageratum conyzoides* Linn. | Asteraceae | ST25 | N/A | Weed/medicinal |
| *Alternanthera sessilis* (Linn.) R. Br. | Amaranthaceae | ST47 | Weed | Weed |
| *Ananas comosus* (Linn.) Merr | Bromeliaceae | ST71 | Fruits | Fruits |
| *Andropogon aciculatus* Retz. Ex Roem | Poaceae | ST77 | Weed | Weed |
| *Borreria hispida* (*Linn*.) K. Schum. | Rubiaceae | ST66 | N/A | Weed |
| *Capsicum annuum* Linn. | Solanaceae | ST63 | Vegetable | Vegetable |
| *Centella asiatica* (L.) Urban. | Apiaceae | ST24 | N/A | Weed/Medicinal |
| *Colocasia esculenta* (L.) Schott. | Araceae | ST58 | Food/vegetable | Food/vegetable |
| *Curcuma longa* Linn. | Zingiberaceae | ST10 | Condiment/Medicinal | Condiment/Medicinal |
| *Cynodon dactylon* Pers. | Poaceae | ST68 | N/A | Weed |
| *Cyperus* sp. | Cyperaceae | ST61 | Weed | Weed |
| *Drymaria cordata* Linn. | Caryophyllaceae | ST56 | N/A | Weed/Medicinal |
| *Dryopteris* sp. | Dryopteridaceae | ST41 | Weed | N/A |
| *Glycine max* (Linn.) Merr. | Fabaceae | ST65 | N/A | Vegetable/Chutni |
| *Leucas aspera* Spreng | Lamiaceae | ST64 | N/A | Weed/Medicinal |
| *Lycopersicum esculentum* Linn. | Solanaceae | ST42 | Vegetable/sell | Vegetable |
| *Mikania scandens* (L.) Willd. | Asteraceae | ST59 | N/A | Creeper/medicinal |
| *Oryza sativa* Linn | Poaceae | ST78 | Food/sell | Food |
| *Paederia foetida* Linn. | Rubiaceae | ST62 | Weed | N/A |
| *Polygonum* sp. | Polygonaceae | ST40 | N/A | Weed |
| *Pouzolzia* sp. | Urticaceae | ST50 | Weed | Vegetable |
| *Pteris* sp. | Dryopteridaceae | ST38 | Weed | N/A |
| *Scoparia dulcis* Linn. | Scrophulariaceae | ST44 | Weed | Medicinal |
| *Selaginella* sp. | Selaginellaceae | ST46 | N/A | Weed |

Location and ethnic difference was the main reason in this study. Majority of the plant species recorded, however, were typical plants found in homegardens throughout the tropics *e.g.* banana, arecanut, coconut, jack fruit, guava, papaya, citrus, chilli, *etc.* (Syntong and Tiwari 2010). The plant species in the homegardens fulfil specific objectives of households ranging from edible (*Areca catechu, Musa* spp., *Artocarpus heterophyllus*, *etc*.), folk medicine (*Curcuma longa, Clerodendrum viscosum, Spilanthes acmella*, *etc*.) and horticultural (*Ananas comosus, Citrus* spp., *etc*.) to crafts and construction materials (*Mesua ferrea, Anthocephalus cadamba, etc*.).

### *3.1 Traditional practices of homegardens*

The rural farmers in Itanagar practice agriculture along a traditional line, which is mostly subsistence while in North Lakhimpur the farmers maintain homegardens mostly for cash income. Besides homegardens, they also practice their age-old wet-rice cultivation and fish ponds in their home yards. Trees are planted surrounding the fish pond, and crops inter-planted forming an integrated biological production system. Plants in homegardens play an important role in regulating the microenvironment of the system. The litter of some plant species such as *Leucaena*, *Moringa oleifera*, *etc.* are considered good fish-feed. The gardeners in North Lakhimpur mentioned that homegardens are practiced for their stable yields, varied products, continuous or repeated harvests and low inputs. The interviewees in Itanagar, however, cited that homegardens are the principal source of rural energy and provide countless fuelwood products used in the households. The Nyishi communities in Itanagar rear cows, bullocks, mithun (*Bos frontalis*, a rare and endangered species), chicken and ducks in their homesteads. Rearing of *B. frontalis*, a semi-domesticated animal has occupied a central position in the socio-cultural life of the Nyishi. The cows, an integral part of homegardens in both the sites, not only provide milk but also generates organic manure. Increased productivity from livestock is necessary to meet the increased demand for animal products, to alleviate poverty and to improve the livelihoods of resource-poor farmers (Davendra and Thomas 2002). Rice (*Oryza sativa*), arecanut (*Areca catechu*) and coconut (*Cocos nucifera*) are the most preferred homegarden species in North Lakhimpur because of their socio-cultural and economic importance. The interviewees mentioned that labor input for managing *A. catechu* and *C. nucifera* is less than that for many other crops making them ideal species for homegarden systems. The traditional homegarden provides more or less full-time employment opportunities to both male and female members who have no other source of income resulting in enhancing family income for better livelihood. The Nyishi community on the other hand prefers to cultivate more timber yielding trees such as hollock (*Terminalia myriocarpa*), white teak (*Gmelina arborea*), Nag kesar (*Mesua ferrea*) *etc.* They also cultivate *Livistona jenkinsiana* (locally called 'Toko-patta'), a graceful palm tree. This multipurpose palm tree provides different utility items like the leaves, fibers and fruits and has great potential of income generation and rural employment. The leaves are used for thatching the roofs of traditional rural houses. In fact, it is almost like *B. frontalis* in terms of its importance to the rural poor. Tuberous crops like *Manihot esculenta, Colocasia esculenta* and *Dioscorea* species are most widespread and chief subsidiary food crops among the Nyishi tribe. The differences in plant species selection between the sites may be attributed to the cultural differences between the communities confounded by needs and beliefs. The choice of principal crop species and ensuing overall species diversity and productivity is, however, influenced by site conditions, and are based largely on indigenous knowledge which is part of the cultural patterns of the local community. The practices of traditional homegardens in the region may not be very productive as compared to other parts of the globe as it is suffering from lack of proper designing and management, and therefore much work has to be conducted in this direction for improvement of these traditional systems.

One of the crucial part of any homegarden systems is selection of suitable trees for crops, because only the good combination of trees and crops can offer a productive output. It was interesting to observe that local farmers in both the sites categorize plant species on the basis of light requirement (Table 4). Over all, the number of medium light demanding and shade loving plants were more than the strong and moderate light adaptable plants. They have the concept that if the strong light demanding plants were planted under the shady area it will not give proper growth and production. The wide range of species of different heights and life forms found in traditional homegardens add to their ecological efficiency in terms of use of water, sunlight and nutrients (Blanckaert *et al.,* 2004). Even today, rural communities in northeast India are facing acute poverty levels. This implies that most households suffer from food insecurity, offering enough evidence of the high prevalence of rural poverty. Given the profitability of agroforestry technologies (Ajayi *et al.* 2007) and the impact that they have on households and the environment (Kwesiga *et al.* 2005), efforts are being made to scale up the adoption of homegardens and enhance its acceptability among many more potential farmers who could benefit. The present study reveals that the rural farmers in the study sites have started appreciating this technology and its potential linkage to food security and household welfare

indicators, but they face some challenges such as land constraints and knowledge-intensive nature of the technology. Farmers' acceptability and improved adoption of the technology will be influenced by the extent to which efforts are taken to meet these challenges (Ajayi 2007). The process of adoption of agroforestry technologies is more complicated than those for annual crops and modern agricultural development packages based on chemical inputs (Mercer 2004) because of the multi-components and the multi-years through which testing, modification and "adoption" of agroforestry takes place (Ajayi *et al.,* 2003). Policies conducive to the promotion of agroforestry are lacking in Northeast India especially Arunachal Pradesh. It is therefore important that policies that promote agroforestry are put in place.

### *3.2 Traditional homegardens and medicinal plant diversity*

Of the total 79 plants recorded, 29 species were reportedly used to treat different diseases by the rural people in the study areas. Table 5 gives the ethno-botanical information of plant parts being used and the name of the diseases. All the plants mentioned were available throughout the year in their homesteads. In spite of easy accessibility to the clinics, dispensaries and hospitals these days, rural folk still prefer to use folk medicinal plants to cure the common ailments (like headache, stomach ache, body pain, *etc.*) at a household level. All the plants cited by the informants were cross-verified with traditional plant healers of the study areas. A total of 15 traditional plant healers mostly male (only three female), aged between 40 and 75 years were approached and asked for their consent in talking about various common diseases and their management. Freshly collected morphological parts such as leaf and fruits were mostly used and the method of preparation was mostly by heating, boiling, and maceration and are taken orally. Studies conducted elsewhere also revealed the frequent use of fresh materials to dry ones when they contain volatile oils, the concentration of which could deteriorate on drying (Ignacimuthu *et al.* 2006). According to the local practitioners there were no reports of side effects caused following the use of folk medicines. It was observed that the knowledge on plant use for folk medicines and its transmission was often restricted to oral tradition. Majority of the informants reported that they keep their medicinal plant knowledge secret and that transfer of knowledge has mainly been taking place orally from father/mother to child mainly sons (Muthu and Ignacimuthu 2005; Panghal *et al.* 2010; Deribe *et al.* 2006). However, a study conducted by Jagtap *et al.* (2006) in the rural Amravati district of Maharashtra, India, demonstrated that the traditional knowledge on medicinal plants is transferred to only select teenagers who work as assistants to the recognized Bhumkas in the community. There was high agreement among informants that transfer of knowledge to people outside the family circle, however, take place on substantial payment (Tangjang *et al.,* 2011). It was observed that illiterate elder men have better medicinal plant knowledge compared to literate younger generations and females. These observations correlate well with studies conducted elsewhere (Upadhyay *et al.,* 2007; Panghal *et al.,* 2010). A study conducted by Fassil (2003) in the Northwestern Ethiopia, however, revealed that there are no significant differences in medicinal plant knowledge between men and women. Ninety percent of the informants felt that in the recent years, folk medicine is, no more an attraction to the younger generation as many young people migrate to urban areas for education and job opportunities and also due to acculturation taking place in the region. It is being increasingly felt that this indigenous knowledge not only needs preservation but also documentation.

### *3.3 Functions of Traditional homegardens*

The level of awareness about most of the functional aspects of traditional homegardens is very high among the rural folks in the studied areas. According to Kumar and Nair (2004) and Garrity (2004), the major functions of homegarden technologies particularly in rural areas are subsistence and focus on the role of trees on farms and agricultural landscapes to meet economic production and social and ecological needs; ensure food availability throughout the year through sequencing harvesting of the crops (Arunachalam *et al.* 2002). It was observed that the availability of local fruit trees and nut palms in the sites serves as an important gap-filler when food stocks are low and also as a source of income. The inclusion of indigenous fruit trees (IFTs) on agricultural land in southern Africa was also highlighted by various authors (Kalaba *et al.* 2009). Such production systems have been reported to reduce the risks inherent to monocultures of staple food crops, such as susceptibility to pests and diseases, soil nutrient depletion (Hughes and Haq 2003). The collection of IFTs contributes between 5.5 and 6.5% to the total household income in the rural communities of Southern Africa (Akinnifesi *et al.,* 2008). The moderate domination of fruit species over timber species in North Lakhimpur may be attributed to the gardeners' general perception that fruit species would bring early return as well as its multipurpose nature. Such earnings enable rural dwellers to buy goods and pay for their child's education and other basic services required by the household.

Homegardens are an integrated approach to sustainable land use because of its production and environmental benefits. The concept of homestead agroforestry stems from the expected role of on-farm and off-farm tree production in supporting sustainable land-use and natural-resource management. This concept is based on the premise that land-use systems that are structurally and functionally more complex than either crop or tree monocultures result in greater efficiency of resource (nutrient, light, and water) capture and utilization and greater structural diversity that entails tighter nutrient cycles. While the above- and belowground diversity provides more system stability and resilience at the site-level, the systems provide connectivity with forests and other landscape features at the landscape and watershed levels (Nair *et al.* 2008). These multi-layered, forest-like vegetation cover of homegardens in the present study contributes substantially to the ecological sustainability of the village ecosystems (Kehlenbeck and Maass 2004) by impeding velocity of runoff, checks soil erosion, silting and landslides thus reducing the danger of floods in both the sites. Traditional homegardens can play an important role for carbon sequestration in the future since plant growth is directly proportional to the carbon sequestration capacity of the forest (Kumar 2008; Kumar *et al.* 2008). It is now widely accepted that current global-climate change is the most serious environmental issue affecting human lives on a global scale. The system also provides habitat to wild plants and soil microbial populations and promotes a favorable micro-climate for the household. The leguminous cover crop and the litters derived from the fallen leaves improve soil fertility status by returning the nutrients.

### *3.4 Traditional homegardens and plant species conservation*

Currently, agricultural production the world over is in a state of crisis possibly due to a number of factors such as climate change, soil erosion, soil fertility loss and severe soil moisture stress which is partly due to loss of trees and organic matter (Falco *et al.* 2012) leading to loss of biodiversity. In spite of these, one of the solutions to meet diverse people's requirement with fixed/plot of land is through application of homegarden agroforestry which has more diverse species than monocropping (Mcneely and Schroth 2006; Mekonnen *et al.* 2014). Because of the richness in plant species, homegardens may be regarded as an ideal system for *in-situ* conservation of plant genetic resources. The species composition of homegardens, however, varies according to climatic and edaphic factors of the place and socio-economic conditions of the people. Traditional homegardens in the present study have high plant species where endemic species like *Livistona jenkinsiana* have been maintained and conserved and also harbor plenty of medicinal plant species. Whatsoever, it is now clear that homegardens are storehouse of large species diversity and sustainable resource management and can play an important role in biodiversity conservation. The services provided by homegarden practices to rural livelihoods and conservation of biodiversity have attracted wide attention among agroforestry and conservation scientists (Mcneely and Schroth 2006).

### *3.5 Opportunities and constraints*

There are myriads of opportunities and constraints in adopting traditional homegardens. The most prominent opportunities observed during the study was homegardens play a significant role in rural landscape planning and management. It provides rural poor with food, timber demand, cattle fodder, folk medicines, fuel wood, and control soil erosion and flood. Because of high plant diversity in the homegardens, a wide spectrum of multiple-use plant products can be generated with relatively low labor, cash or other inputs (Tynsong and Tiwari 2010) and provide an additional food supply and cash income for the people (Das and Das 2005). It is reported that in Indonesia and Nicaragua, homegardens contribute 21.1% and 35% of the total income respectively. Studies from south-west Bangladesh (Motiur *et al.* 2006) and north-eastern Bangladesh (Motiur *et al.* 2005) reported that on an average 15.9% and 11.8% respectively of household income is derived from homegardens. The prominent constraints observed, however, were scarcity of arable land, natural calamities like floods and landslides, domestic animal, lack of scientific infrastructure, and so forth. For example, homegardens in Itanagar were largely user oriented, and market access was not fully developed. It was observed that most of the producers sold their produce to neighbors or local traders leading to not getting proper price for their products. If they get their products to the market, they will get proper prices also, which is very much important for the small household owners, therefore creating a scope for income. Besides, analysis of existing management regime indicated that homegardeners do not follow any specific spatial arrangement pattern and there was lack of scientific considerations, specific objectives and goals for raising plants. Till now, there is no specific management plan of homegardens all over the region though it has tremendous contribution to greening the nature. It can be recommended that experimentation with new and diversified tree species can play an important role in enhancing the diversity and distribution of homestead garden.

**Table 4.** List of some plant species categorized by the farmers on the basis of light requirement

| | North Lakhimpur | Itanagar |
|---|---|---|
| Strong light | *Anthocephalus cadamba* | *Anthocephalus cadamba* |
| | *Artocarpus heterophyllus* | *Artocarpus heterophyllus* |
| | *Mangifera indica* | *Gmelina arborea* |
| | *Oroxylum indicum* | *Mangifera indica* |
| | | *Oroxylum indicum* |
| | | *Terminalia myriocarpa* |
| Medium Light | *Areca catechu* | *Aquilaria agallacha* |
| | *Bauhinia variegata* | *Areca catechu* |
| | | *Averrhoa carambola* |
| | | *Bauhinia variegate* |
| | | *Erythrina indica* |
| | | *Ziziphus jujuba* |
| Moderate light | *Alstonia scholaris* | *Ananas comosus* |
| | *Ananas comosus* | *Capsicum annuum* |
| | *Baccaurea sapida* | *Carica papaya* |
| | *Citrus reticulata* | *Citrus reticulata* |
| | *Dillenia indica* | *Duabanga sonneratioides* |
| | *Emblica officinalis* | *Manihot esculenta* |
| | *Flacourtia cataphracta* | *Mesua ferrea* |
| | *Musa* spp. | *Musa* spp. |
| | | *Solanum melongena* |
| | | *Zea mays* |
| Shade lover | *Clerodendrum viscosum* | *Citrus limon* |
| | *Colocasia esculenta* | *Clerodendrum viscosum* |
| | *Curcuma longa* | *Glycine max* |
| | | *Curcuma* |

## Conclusion

Keeping in view the hilly terrain, heavy rainfall, geological conditions, susceptibility to erosion and landslides, traditional homegardens would be most appropriate for adoption, especially in this far-flung Arunachal Pradesh, northeast India. Since the traditional values, culture, faith and indigenous knowledge of various plants being used for different purposes is confined to the traditional societies, recording of this knowledge for future generations is critical otherwise it is in jeopardy in the wake of acculturation, which is taking place in the community at an alarming rate. Information on homegardens was needed because of its potential usefulness in understanding the relative extent of plant diversity and its implications for conservation and management. Homegarden is not a universal remedy but should be included in the set of preference when undertaking issues of population growth, landscape fragmentation, and need to increase tree/green cover and the agricultural goods and services on decreasing land resources.

Induction of leguminous plants species, bamboo, *L. jenkinsiana* palm and medicinal plants would be promising for sustainability of the system in this region. So, if planned appropriately, traditional homegardens have the potential to address a number of land use problems namely, low soil fertility, fodder, fuelwood and timber requirements, and soil and water erosion.

## Acknowledgements

The authors wish to acknowledge all the informants for their active participation and willingness to share their valuable traditional knowledge during the field studies. Financial assistance from the Department of Biotechnology, New Delhi, Government of India, to the first author is highly appreciated.

## References


Abdoellah OS, Takeuchi K, Parikesit, Gunawan B, HY Hadikusumah (2001). Structure and function of homegarden: A revisited Proceedings of Seminar 'Toward Harmonization Between Development and Environmental Conservation in Biological Production', 21-23 February 2001. University of Tokyo, Japan, pp. 167-185.

Ajayi OC, Akinnifesi FK, Gudeta S, S Chakeredza (2007). Adoption of renewable soil fertility replenishment technologies in Southern African Region: Lessons learnt and the way forward. *Natural Resource Forum* 31(4): 306-317.

Ajayi OC, Franzel S, Kuntashula E, F Kwesiga (2003). Adoption of improved fallow soil fertility management practices in Zambia: synthesis and emerging issues. *Agroforestry systems* 59(3): 317-326.

Akinnifesi FK, Sileshi G, Ajayi OC, Chirwa PW, Kwesiga F, R Harawa (2008) Contributions of agroforestry research and development to livelihood of smallholder farmers in Southern Africa: 2. Fruit, medicinal, fuelwood and fodder tree systems. *Agric J* 3(1): 76-88.

Arunachalam A, Khan, ML, K Arunachalam (2002). Balancing traditional jhum cultivation with modern agroforestry in eastern Himalaya – A biodiversity hot spot. *Current Science* 83: 117-118.

Blanckaert I, Swennen RL, Flores, MP, Lopez RR, RL Saade (2004). Floristic composition, plant uses and management practices in homegardens of San Rafael Coxcatlan, Valley of Tehuacan- Cuicatlan, *Mexico. J Arid Environ* 57: 39-62. Doi: 10.1016/S0140-1963(03)00100-9.

Das T, AK Das (2005). Inventorying plant biodiversity in homegardens: A case study in Barak Valley, North East Assam. *Current Science* 89: 155-163.

De Clerk FAJ, P. Negreros-Castillo (2000). Plant species of traditional Mayan homegardens of Mexico as analogs for multistrata agroforests. *Agroforestry Systems* 48: 303-317.

Deribe K, Amberbir A, Getachew B, Y Mussema (2006). A historical overview of traditional medicine practices and policy in Ethiopia. *Ethiopian J Health Dev* 20: 127–134.

Devendra C, D Thomas (2002). Crop-animal interactions in mixed farming systems in Asia. *Agricultural Systems* 7: 27-40.

Fassil H (2003). We do what we know: Local health knowledge and home-based medicinal plant use in Ethiopia. Ph.D. Thesis. Green College, Oxford University.

Falco SD, Yesuf M, Kohlin G, C Ringler (2012). Estimating the impact of climate change on agriculture in low-income countries: Household level evidence from the Nile Basin Ethiopia. *Environmental Resource and Economics* 52: 457 478.

Hooker JD (1894). *Flora of British India*. *Volume 6*. Ashford, Kent, England: L. Reeve and Co. Ltd., NR.Hughes A, Haq N (2003). Promotion of indigenous fruit trees through improved processing and marketing in Asia. *International Forestry Review*. DOI: 10.1505 /IFOR .5.2.176.17415.

Ignacimuthu S, Ayyanar M, K Sivaraman (2006). Ethnobotanical investigations among tribes in Madurai district of Tamil Nadu (India). *J Ethnobiol Ethnomedicine* 2: 25. DOI: 10.1186/1746-4269-2 25.

Jagtap SD, Deokule SS, SV Bhosle (2006). Some unique ethnomedicinal uses of plants used by the Korku tribe of Amravati district of Maharashtra, *India J Ethnopharmacol* 107, 463–469.

Jama B, Elias E, KK Mogotsi (2006). Role of agroforestry in improving food security and natural resource management in dry lands: a regional overview. *J Dry lands* 1: 206-211.

Kalaba FK, Chirwa PW, Prozesky H, C Ham (2009). The role of indigenous fruit trees in rural livelihoods: the case of communities around the Mwekera area, Copperbelt province, Zambia. In: Jaenicke H, Ganry J, HoschleZeledon I, Kahane R (eds.) Underutilized plants for food, Nutrition, Income and Sustainable Development. Proceedings of International Symposium held in Arusha, Tanzania 3-7 March, 2008. Acta Horticulturae 806. International Society for Horticultural Science. Leuven, Belgium 739pp.

Kanjilal UN, Kanjilal PC, Das A, De RN, NL Bor (1934-1940). Flora of Assam. 5 Vols. Shillong: Govt. Press. Karyono 1990. Homegardens in Java: their structure and functions. In: K Landauer, M Brazil (Eds.): Tropical Homegardens. Tokyo, Japan: United Nations University Press, pp. 138-146.

Kehlenbeck K, BL Maass (2004). Crop diversity and classification of homegardens in Central Sulawesi, Indonesia. *Agroforestry Systems* 63: 53-62.

Kumar BM, PKR Nair (2004) The enigma of tropical homegardens. *Agroforestry Systems* 61:135–152.

Kumar BM, PKR Nair (eds) (2006). Tropical homegardens: A time-tested example of sustainable agroforestry. Advances in agroforestry 3. Springer Science, Dordrecht, The Netherlands. 390 p.

Kumar G (1997). Geology of Arunachal Pradesh. Geological Society of India, Bangalore.

Kumar P (2008). Carbon sequestration strategy of Nubra Valley with special reference to agroforestry. DRDO Technology Spectrum, pp. 187–192, 2008.

Kumar P, Gupta S, S Prakash (2008). Carbon pool of orchards in Siachen sector: socio-economic carbon sequestration. In *Advances in Agriculture Environment and Health*, SB Singh, OP Charassia and S. Yadav Eds. pp. 225–233.

Kwesiga F, Franzel S, Mafongoya P, Ajayi OC, Phiri D, Katanga R, Kuntashula E, T Chirwa (2005). Successes in African Agriculture: Case Study of Improved Fallows in Eastern Zambia. Environment and Production Technology Division (EPTD) Discussion Paper 130. Environment and Production Technology Division, International Food Policy Research Institute, Washington DC.

Leiva JM, Azurdia C, Ovando W, López E, H Ayala (2002). Contributions of home gardens to *in situ* conservation in traditional farming systems – Guatemalan component. In: Watson JW and Eyzaguirre PB (eds). Proceedings of the Second International Home Gardens Workshop: contribution of home gardens to *in situ* conservation of plant genetic resources in farming systems, 17-19 July 2001, Witzenhausen, Federal Republic of Germany. International Plant Genetic Resources Institute (IPGRI), Rome, Italy, pp. 56- 72.

Mcneely JA, G Schroth (2006). Agroforestry and biodiversity conservation - traditional practices, present dynamics, and lessons for the future. *Biodiversity Conservation* 15: 549–554.

Mekonnen EL, Asfaw Z, S Zewudie (2014). Plant species diversity of homegarden agroforestry in Jabithenan District, North-Western Ethiopia. *International J Biodivers Conserv* 6: 301-307.

Mercer DE (2004) Adoption of agroforestry innovations in the tropics: A review. *Agroforestry Systems* 61: 311-328.

Michon G, F Mary (1994). Conversion of traditional village gardens and new economic strategies of rural households in the area of Bogor, *Indonesia. Agroforestry Systems* 25: 31–58.

Motiur RM, Tsukamoto J, Furukawa Y, Shibayama Z, I Kawata (2005). Quantitative stand structure of woody components of homestead forests and its implications on silvicultural management: a case study in Sylhet Sadar, Bangladesh *J For Res* 10(4): 285–294.

Motiur RM, Furukawa Y, Kawata I, Rahman MM, M Alam (2006). Role of homestead forests in household economy and factors affecting forest production: a case study in southwest Bangladesh. *J For Res* 11(2): 89–97.

Muthu A, S Ignacimuthu (2005). Traditional knowledge of Kani tribals in Kouthalai of Tirunelveli Hills, Tamil Nadu, India. *J Ethnopharmacol* 102: 246-255.

Nair PKR (2007). The coming of age of agroforestry. *J Sci Food and Agric* 87: 1613–619.

Nair PKR, Gordon AM, Mosquera-Losada M.-R (2008). Agroforestry. p. 101–110. In S.E. Jorgensen and B.D. Faith (ed.) Encyclopedia of ecology. Vol. 1. Elsevier, Oxford, UK.

Pandey CB, Lata K, Venkatesh A, RP Medhi (2002). Home garden: its structure and economic viability in South Andaman, India. *Indian J Agrofor* 4: 17-23.

Panghal M, Arya V, Yadav S, Kumar S, JP Yadav (2010). Indigenous knowledge of medicinal plants used by Saperas community of Khetawas, Jhajjar District, Haryana, India *J Ethnobiol Ethnomedicine* 6: 4. DOI: **10**.1186/1746-4269-6-4.

Quiroz C, Gutiérrez M, Rodríguez D, Pérez D, Ynfante J, Gámez J, Pérez de Fernandez T, Marques A, W Pacheco (2002). Home gardens and *in situ* conservation of agrobiodiversity – Venezuelan component. In: Watson JW and Eyzaguirre PB (eds). Proceedings of the Second International Home Gardens Workshop: contribution of home gardens to *in situ* conservation of plant genetic resources in farming systems, 17-19 July 2001, Witzenhausen, Federal Republic of Germany. International Plant Genetic Resources Institute (IPGRI), Rome, Italy, pp. 73-82.

Shastri CM, Bhat DM, Nagaraja BC, Murali KS, NH Ravindranath (2002). Tree species diversity in a village ecosystem in Uttara Kannada district in Western Ghats, Karnataka. *Current Science* 82: 1080-1084.

Tangjang S, Namsa ND, Aran C, A Litin (2011). An ethnobotanical survey of medicinal plants in the Eastern Himalayan zone of Arunachal Pradesh, India *J Ethnopharmacol* 134: 18–25.

Tynsong H, BK Tiwari (2010). Plant Diversity in the Homegardens and their Significance in the Livelihoods of War Khasi Community of Meghalaya, North-east India *J Biodivers* 1(1): 1-11.

Upadhyaya PB, Roy S, A Kumar (2007). Traditional uses of medicinal plants among the rural communities of Churu district in the Thar Desert, India *J Ethnopharmacol* 113, 387–399.

Wezel A, S Bender (2003). Plant species diversity of homegardens of Cuba and its significance for household food supply. *Agroforestry Systems* 57: 39–49.

World Health Organization (2001). General Guidelines for Methodologies on Research and Evaluation of Traditional Medicine. Geneva, Switzerland; 2001.