Floral diversity of traditional agroforestry homegardens in Konkan coast of Maharashtra, India

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ABSTRACT : The diversity of trees, shrubs, herbs and climbers in traditional agroforestry homegarden system contributes to provision of ecosystem services. Homegarden systems involve deliberate management of multipurpose tree species in intimate association with agricultural crops and invariably livestock. Present study characterizes the floral diversity and composition in the homegardens at proposed Jaitapur Nuclear Power plant site in Konkan coast of Maharashtra (India). For the investigation, 40 homegardens were selected randomly over a 460 km^2 area for floral diversity analysis. Quadrat sampling technique was used for phyto-sociological analysis. In total, 206 plant species belonging to 70 families were recorded. The vegetation consisted of 88 tree, 48 shrub, 44 herb and 26 climber species. The highest number of species were represented by Fabaceae family (13 species), followed by Apocynaceae and Cucurbitaceae (11 species each), Caesalpiniaceae (10 species), Poaceae (9 species) and Euphorbiaceae, Moraceae and Verbenaceae (8 species each). These eight families cover 38% of total richness of the homegarden flora, while 32 families were represented by a single species. The research findings suggest that homegardens of the region are ecologically and ethno-botanically rich. This study provides a basis for developing measures for the conservation and management of natural resources. The homegarden floral biodiversity in study area is prone to drastic decline due to conversion of forest land to plantations and Nuclear Power Plant installation.

Key words: Agroforestry, diversity, dominance, homegardens, IVI and richness.

Received on: 03.12.2019 Accepted on: 04.06.2020

1. INTRODUCTION

Homegardens are traditional agroforestry land-use systems involving deliberate management of multipurpose tree species and shrubs in intimate association with annual and perennial agricultural crops, and invariably livestock within the compounds of individual houses (Das and Das, 2005; Kumar and Nair, 2006; Mohan *et al*., 2007). Worldwide, homegardens have attracted considerable research attention during past three decades (Ceccolini, 2002; Coomes and Ban, 2004). In tropical countries, they provide a diverse and stable supply of socio-economic products and benefits to the families (Christanty, 1990). It is believed that species diversity of tropical homegardens is very high. Das and Das (2005) studied homegarden biodiversity in North-East India and revealed that homegardens exhibit high diversity, comprising of 122 tree and shrub species. Kumar (2001) reported homegardens in Kerala composed of 127 species with more dominance of the fruit trees and concluded that floristic diversity was higher in small homegardens than larger size.

Some researchers agreed that the homegardens are important sites for *in situ* conservation of plant diversity (Saha *et al*., 2009). Kehlenbeck and Maass (2006) argued that the species diversity in homegardens is not static; it varies with time and according to ecological and socio-economic factors and/or characteristics of the homegardens. Besides, it is assumed that being multi-layered vegetation structure, homegardens serve as an important habitat for wild flora and fauna (Kehlenbeck *et al*., 2007). Millat-e-Mustafa *et al*. (1996) studied floristic structure of traditional homestead in Bangladesh and concluded that the species richness and diversity in homegardens vary with the size and region. They reported highest diversity between food and fruit producing species, followed by timber species. Peyre *et al*. (2006) investigated dynamics of traditional homegarden's structure and function in Kerala and argued that traditional homegardens are subject to different conversion processes linked to socio-economic changes.

The Government of India and Maharashtra state government are the planners in relation to national level energy station projects. Accordingly, Jaitapur is one of the four possible sites suggested for 10000MW nuclear power plants by a national level survey in 2005. Jaitapur of Rajapur Tahsil in the Maharashtra state is a typical Konkan village with no polluting industry, mainly because of the remoteness of these areas. People depend mainly on fishing and

agriculture for their livelihoods. They grow plants in traditional homegardens for their livelihoods. The area also has good mangrove vegetation that is also responsible for the rich fishery resources. Mango orchards with internationally famous "Ratnagiri Alphanso" variety is common. It was assumed that homegardens ecosystem will definitely be affected due to nuclear power plant installation and was a need to study diversity and usefulness of homegardens in this area. Therefore, present study was carried out to investigate the structure, composition, distribution, richness and diversity of traditional homegardens present in this area.

2. MATERIALS AND METHODS

Floral vegetation survey was conducted in the South Konkan coast of Maharashtra (16˚ 30' to 16˚ 43' N and 73˚ 19' to 73˚30' E). The vegetation analysis was carried out during 2008-2009. The vegetation sampling was carried out at randomly selected points all over the study area using base map and GPS unit. Stratified random sampling method for florist analysis, which was based on presence and absence of data, was used. Different size quadrats were selected for tree, shrub, herb and climber components. For the investigation, 40 homegardens were selected randomly over a 460 km^2 area for floral diversity analysis. The random points for the study were selected by following Panse and Sukhatme (1985). A quadrat sampling technique was used for vegetation analysis. In each homegarden, 20 m × 10 m size quadrat was laid down to study tree, shrub and climber, and 5 m × 5 m to enumerate herbaceous vegetation within the 20 m × 10 m size quadrat. During survey, owners of the homegardens were consulted regarding local name of plants and their uses. Plant species identification was done from expert botanist at Dr. Balasaheb Sawant Konkan Krishi Vidyapeeth, Dapoli. For this purpose, photographs as well as plant samples were taken to the expert. Also, identification was done using taxonomic literature (Aima, 2009; Ingalhalikar, 2012). The data was analyzed for vegetation characters such as frequency, density and abundance following the methods of Curtis and McIntosh (1950), Whittaker (1972) and Murty *et al*. (2011). The species dominance was quantified by the importance value index (IVI). In calculating the index, the percentage values of relative frequency, relative density and relative dominance were summed up together and this value was designated as IVI of the species (Murty *et* al., 2011). Plant species recorded in study area were compared with the International Union for Conservation of Nature (IUCN) red list of threatened species. The species richness was calculated as the total number of species recorded during study period. The sample based rarefaction curves were computed using Estimate S 8.2.0. The various diversity indices such as Shannon's index (Shannon and Weaver, 1949; Arias-Gonza´lez *et al*., 2011) and Simpson's index of dominance and Simpson's index of diversity (Simpson, 1949; Krebs, 1994) were also computed.

3. RESULTS AND DISCUSSION

Results showed that the homegardens were home of 206 plant species belonging to 70 families. The vegetation consisted of 88 tree, 48 shrub, 44 herb and 26 climber species. The highest number of species belongs to family Fabaceae (13 species), followed by Apocynaceae and Cucurbitaceae (11 species each), Caesalpiniaceae (10 species), Poaceae (9 species) and Euphorbiaceae, Moraceae and Verbenaceae (8 species each). The tree vegetation accounts for 88 species from 36 families (51% of total families), and the highest number of species were belonging to Moraceae (8 species),followed by Caesalpiniaceae (7 species), Rutaceae (6 species) and Anacardiaceae, Combretaceae and Myrtaceae (5 species each). The flora contained 48 shrub species from 21 families. Verbenaceae was the most dominant family representing 6 species of shrubs, followed by Apocynaceae and Euphorbiaceae (5 species each). The herbaceous vegetation was comprising of 44 herb species from 26 families with the highest number of species belonging to Poaceae (5 species), followed by Fabaceae (4 species) and Solanaceae (3 species). The total of 26 climber species, belonging to 11 families, were recorded in the survey. Eleven species were from the Cucurbitaceae family, which contributed 42%. The vegetation is characterized by presence of a high number of understory species (shrubs, herbs and climbers).

An attempt was made to determine uniformity or heterogeneity within the vegetation type. The identified species were segregated into various Raunkiaer's normal frequency classes (Figure1) and found that the species with low frequency values were most numerous. The data on frequency distribution in homegardens vegetation are shown in Figure 2 and 3. Overall frequency of class A was comparatively higher. We compared the obtained frequency diagram with Raunkiaer's normal frequency diagram, the curves do not seem to be J shaped, and it suggests that there was no uniformity.

The data on plant density per hectare indicated that overall density observed was 2286 plants/ha (Table 1). The results showed significant variation in density for tree, shrub, herb and climber elements. The observed tree, shrubs, herbs and climber densities recorded were 131, 107, 1636 and 412 plants/ha, respectively. The tree density estimates were highest for *Cocos nucifera, Mangifera indica, Dendrocalamus strictus, Psidium guajava, Areca catechu* and *Anacardium occidentale*. The prominent dense shrub species was *Jatropha curcas,* followed by *Musa paradisiaca, Hibiscus rosa-sinensis, Gliricidia sepium* and *Justicia adhatoda*. The highest herbaceous floral density was contributed by *Colocasia esculenta,*

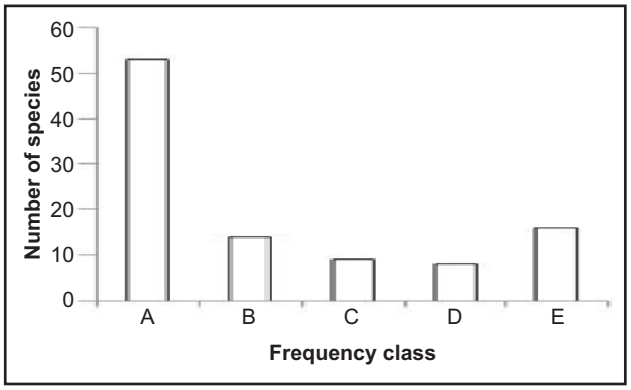

Fig. 1. Raunkiaer's normal frequency diagram.

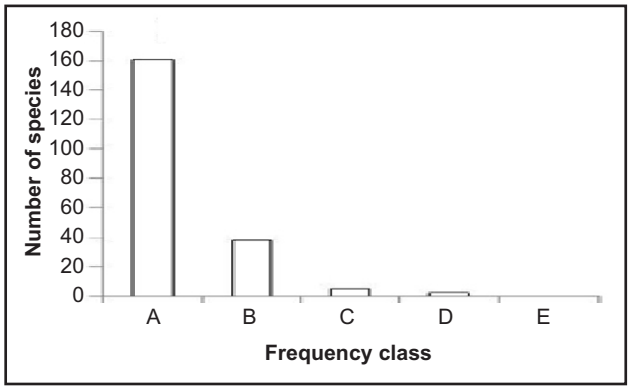

Fig. 2. Frequency diagram of homegarden vegetation.

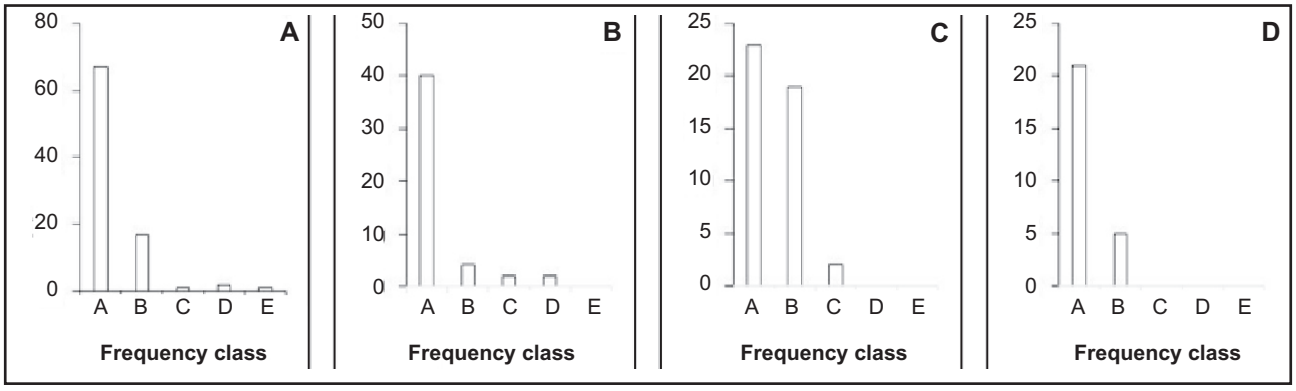

Fig. 3. Frequency diagram showing component-wise number of species in the homegarden. A- Tree species, B- Shrub species, C- Herb species, and D- Climber species.

Table 1. Plant species and their density at surveyed sites.

Sr. No.	Component	Number of Species	Families	Density/ha
1	Tree	88	36	131
2	Shrub	48	21	107
3	Herb	44	26	1636
4	Climber	26	11	412
	Overall	206	88	2286

Table 2. Diversity indices of different components in homegardens.

Components	Shannon Weaver index (H')	Simpson's index (λ)	Simpson's index of diversity (1-λ)	Species evenness (E)
Tree	3.82	0.04	0.96	0.85
Shrub	3.32	0.05	0.95	0.85
Herb	3.48	0.04	0.96	0.92
Climber	3.00	0.06	0.94	0.92
Overall	4.76	0.02	0.98	0.82

Tagetes erecta, Impatiens oppositifolia, Arachis hypogaea and *Ananas comosus.* However, the most dense climber species were *Hemidesmus indicus*, *Trichosanthes cucumerina*, *Piper longum, Piper nigrum* and *Cucumis sativus*.

The species richness was highest (88 species) for tree vegetation, followed by shrub (48 species), herb (44 species) and climber (26 species). The species accumulation curves for tree, shrub, herb and climber species richness were similar (Figure 4). It observed gradual increase in number of species with increase in quadrat number. The findings indicate that the rarefaction curves for different vegetation component are asymptotic, which indicates that sampling was adequate to meet the objectives of the study.

The results on diversity indices and species evenness in the study area are presented in Table 2. The values of Simpson's dominance indices were comparatively low (ranged from 0.04 to 0.06) which suggested high species diversity. However, there was no significant difference in species diversity between four components. Overall Simpson's diversity was high (ranged from 0.94 to 0.96), which suggested high species diversity in tree, shrub and herb components. Comparison of data with the IUCN red List of threatened species (IUCN, 2020) showed that out of 206 plant species recorded in study, *Garcinia indica* was found to be vulnerable (VU) species. *Cajanus cajanifolius, Tabernaemontana heyneana* and *Platycladus orientalis* were found under near threatened plant species. Out of total species found, 69 species were grouped under least concerned (LC) status and 6 species under data deficient (DD). However, 127 species were not evaluated (NE) in IUCN red list of threatened species database (Figure 5).

Top dominant and rare species assemblage in study area was also identified (Table 3). *C. esculenta* was the most dominant species, followed by *C. nucifera, M. indica, M. paradisiaca, T. erecta* and *J. curcas.* The least dominant species were *P. mucronata, C. equisetifolia, T. arjuna, T. paniculata* and *A. altilis.* The floristic analysis indicates high diversity in dominance of tree, shrub, herb and climber species. The most dominant species in the shrub vegetation were *J. curcas, M. paradisiaca, H. rosa-sinensis, G. sepium, J. adhatoda* and *C. cajan.* However, *S. bispinosa, M. paniculata, C. chinense* and *P. mucronata* were rare shrub species. The most dominant herbaceous flora of homegarden constituted the *C. esculenta,* followed by *T. erecta, O. sativa, I. oppositifolia, A. hypogaea* and *A. comosus.* However, the species like *L. nepetifolia, R. serpentina, H. littoralis, C. citratues, M. purpureum* and *V. zizanioides* were least dominant herbaceous plant species. Among climbers, *H. indicus, T. cucumerina, P. longum, P. nigrum, C. sativus* and *S. ovalifolia* constituted highest dominant and the species like *P. edulis, S. amplexicaulis* and *D. alata* were the rare and the least dominated climbers.

The number of individuals (per ha) of understorey species ranged from 1 to 10 and under such circumstances, vegetation was found to be mixed in nature. This conclusion is based on the observations of Richards (2002). The higher density was due to occurrence of numerous herbaceous individuals in understorey. The species accumulation curve reached an asymptote as the chance of discovering new species decreased. After gradual increase in species number, the curve remains flattened with no further addition of new species. Gimaret-Carpentier *et al*. (1998) reported that the species pool in the Western Ghats is not relatively high, so that increasing

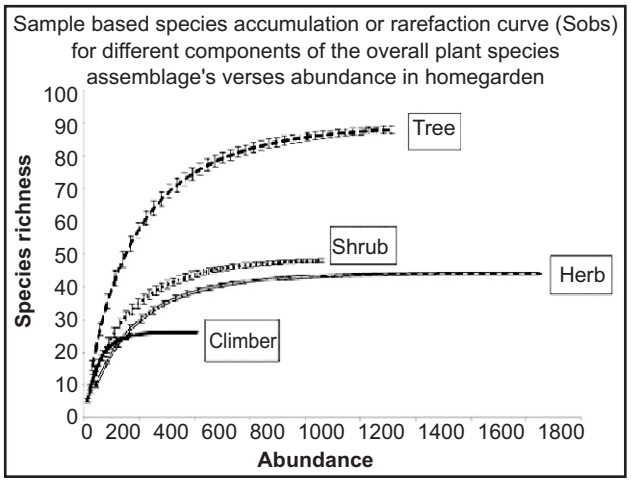

Fig. 4. Rarefaction curve

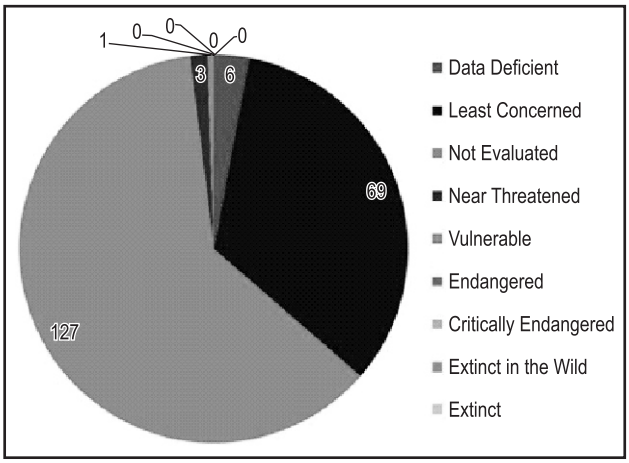

Fig. 5. IUCN red list status of threatened species in the study area.

Table 3. Component-wise list of the species with IVI values in the homegarden.

Tree		Shrub		Herb		Climber	
Name	IVI	Name	IVI	Name	IVI	Name	IVI
Cocos nucifera	22.34	*Jatropha curcas*	23.20	*Colocasia esculenta*	21.36	*Hemidesmus indicus*	30.24
Mangifera indica	15.03	*Musa paradisiaca*	22.21	*Tagetes erecta*	14.94	*Trichosanthes cucumerina*	21.76
Dendrocalamus strictus	13.52	*Hibiscus rosa-sinensis*	17.07	*Oryza sativa*	14.26	*Piper longum*	19.48
Psidium guajava	10.06	*Gliricidia sepium*	16.03	*Impatiens oppositifolia*	11.30	*Piper nigrum*	19.27
Areca catechu	8.89	*Justicia adhatoda*	14.76	*Arachis hypogaea*	11.29	*Cucumis sativus*	18.60
Anacardium occidentale	8.01	*Cajanus cajanifolius*	12.48	*Ananas comosus*	10.20	*Smilax ovalifolia*	16.96
Artocarpus heterophyllus	7.90	*Euphorbia antiquorum*	9.75	*Senecio bombayensis*	7.07	*Momordica charantia*	13.63
Garcinia indica	6.98	*Leea indica*	9.71	*Solanum melongena*	5.82	*Cucumis melo*	11.77
Haldina cordifolia	1.34	*Lantana camara*	2.85	*Leonotis nepetifolia*	2.47	*Dioscorea bulbifera*	8.13
Mitragyna parvifolia	1.34	*Opuntia elatior*	2.16	*Rauvolfia serpentina*	2.42	*Caesalpinia bonduc*	8.13
Casuarina equisetifolia	1.08	*Sesbania bispinosa*	2.16	*Hymenocallis littoralis*	2.21	*Coccinia grandis*	7.14
Terminalia arjuna	1.08	*Microcos paniculata*	1.73	*Cymbopogon citratus*	1.81	*Passiflora edulis*	6.44
Terminalia paniculata	1.08	*Clerodendrum chinense*	1.73	*Maianthemum purpureum*	1.53	*Solena amplexicaulis*	5.81
Artocarpus altilis	1.08	*Premna mucronata*	1.31	*Vetiveria zizanioides*	1.50	*Dioscoria alata*	5.24

the sample size within vegetation does not change the floristic composition but allows a better representation of the rare species. Overall, the most numerous species belonged to lowest frequency class A (0-20%). Similarly, Gleason (1929) found the greatest number of species is those of low frequency, falling in frequency class A (0-20%) and concluded that "Raunkiaer's law of frequency" is merely an expression of the fact that in any association there are more species with few individuals than with many. In our study, the plotted frequency distribution diagram does not resemble with Raunkiaer's normal frequency diagram (J shaped distribution curve) which suggests that the vegetation types in the study area are not structurally uniform. The "law of frequency" was generalized as A>B>C=D<E and discussed in literature (Raunkiaer, 1918 and 1934). The vegetation studies of the Western Ghats by Gimaret-Carpentier *et al*.(1998) suggested that diversity indices are more affected by the addition of rare species with increasing sample size. The similar trend in dominance was observed in several homegarden studies of Western Ghats and Srilanka biodiversity hotspots (Das and Das, 2005). Our study revealed average 39 species (tree, shrub, herb and climbers) per quadrat in homegardens, with more dominance of fruit and multipurpose tree species.

According to Colwell *et al*. (2012), the species richness within a particular habitat is strongly dependent on sample size. It has been suggested that the estimation of species richness and diversity depends on sampling design and choice of species richness or statistical model used to analyze the data (Dorazio *et al*., 2006). The species accumulation curves and several diversity indices have been used for assessing species richness and diversity (Gimaret-Carpentier *et al*., 1998). We did similar floristic diversity investigation of forest ecosystem during same period in study area. It was observed that homegardens or village agroforestry system is structurally similar to tropical forest ecosystem. This could be the reason for high diversity in homegardens. Beside, the climatic conditions and geographical proximity, other factors such as soil fertility, socio-cultural and socio-economic aspect may play a key role in controlling structure, composition and diversity. The homegarden in our study comprised of 206 plant species, this richness value was found in the range of 155 to 328 as recorded by Kumar (2011) at different sites in central Kerala. Based on report of Jose and Shanmugaratnam (1993), it has been concluded that the traditional homegardens are the human made system that stimulates the natural forest in structure and function, and being a multi-layered canopy system are suited maintaining high genetic diversity, which makes the ecosystem highly efficient in harnessing space, soil nutrients, water and energy. Results indicate that presence of threatened species in homegardens may help to conserve rare and threatened species. Installation of nuclear power plant at Jaitapur will affect wild species, therefore, homegardens will play vital role in *in situ* conservation by planting those species in homegardens. Most of the species recorded in homegardens ecosystem are useful in many ways to the owners and local communities. The cultivated plants in homegardens

provide fruits, vegetables, spices, food, shelter, fodder, timber and fuelwood to the locals. Beside, most of the species have ornamental and medicinal properties. However, inventory of floristic diversity in homegardens in Konkan coast of Maharashtra revealed that homegardens are not studied yet. So this study will provide base data for conservation of threatened species.

ACKNOWLEDGEMENTS

This research was made possible through scholarship provided by the Social Justice and Special Assistance Department, Government of Maharashtra (India).

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