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Domestication of tropical fruit diversity in homegardens of Uttara Kannada district

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Abstract

Traditional homegardens (HGs) harbor a high level of species diversity and are characterized as sustainable agroecosystem, suitable for on-farm conservation of plant genetic resources. The Western Ghats of India is considered the centre of origin for many tropical fruit trees and serves as a prime habitat for in-situ conservation of long lived, largely out-crossed wild/domesticated Tropical Fruit Tree (TFT) species. This study characterizes diversity homegardens of Uttara Kannada district. Sixty-one species were documented. The homegardens of Uttara Kannada district showed predominant presence of *Cocos nucifera* (n=4373), followed by *Mangifera indica* (n=816), *Artocarpus heterophyllus* (n=913), *Citrus limon* (n=308) and *Anacardium occidentale* (n=374). The Uttara Kannada district documented substantially a higher species richness yet noticed a gradual replacement with exotic cash crops due to homegarden size and topographic environment. This district documented a little more than fifty percent of non-native tropical fruit tree (TFT) species. Thus, importance of homegardens to food security and the autonomy of families in Western Ghats indicate that public policies should be designed to stimulate more diverse production systems in Uttara Kannada district.

Keywords: Agroecosystem, diversity, on-farm conservation, tropical fruit trees, Western Ghats

Introduction

Homegardens harbor a high level of species diversity and are characterized as sustainable ecosystem suitable in *circa-situ* conservation of plant genetic resources (Attah-Krah *et al.* 2004) [3]. Homegardens are space-constrained subsistence farming systems running on traditional low input technologies while maintaining multiple outputs often meeting the livelihood and nutritional security of millions of people in the tropics. They are increasingly recognized as reservoirs of tropical fruit tree species (TFT), intricately associated with culture of people, enhancing family nutritional status and food security by producing a range of fruit, vegetables, spices, medicine, forage and fuel in South, South East and East Asia (Kumar, 2011) [10]. A rich diversity of over 500 species of tropical fruit trees, of which about 90 per cent are perennial, found in Western Ghats of India, providing a broad range of livelihood options to local people in form of food supplements, better nutrition, household income and employment (Bhag Mal *et al.* 2010) [5]. High plant species diversity is the most important structural aspect of homegardens, and it is usually association with interactions of several socio-economic and biophysical factors (Kumar, 2011) [10]. HG are considered as biodiversity hotspots (Kumar and Nair, 2004) [11] recently regarded as critical for their role in conservation of biodiversity in tropical areas and maintaining of ecosystem services (Bardhan *et al.* 2012) [4]. The Asian fruit production system ranges from collecting/gathering of fruit from forest to well-developed homegardens to intensive commercial plantation. Homegardens are the most prevalent production system for cultivated fruits in Asia (Anupunt *et al.* 2003) [2]. The diversity of tropical fruits is also higher in India because of the affinity to grow variety of fruits in homegardens and marginal lands (Ajay and Pratap, 2009) [1].

Being a part of Central Western Ghats of India, Uttara Kannada district in Karnataka reveals some striking diversity of TFT species (Vasudeva *et al.* 2011) [17]. This region falls under tropical belt of rich forests well adapted for growing diverse wild fruit yielding trees (Varadaranganatha and Madiwalar, 2010; Bhat and Ravindranath, 2011) [16, 6]. Tropical fruit tree species are widely available in homegardens and are usually planted in and around homegardens and agriculture lands. Various studies have repeatedly indicated (Kumar and Nair, 2004) [11] food plants (food crops and fruit trees) are the most common species in most homegarden throughout the world. Farming communities and rural settlements of Uttara Kannada district have an age-old history of maintaining homegardens

(Bhat and Ravindranath, 2011) ^[6] and are well known for deriving livelihood means from diversified sources. Characterizing the diversity, composition and ecosystem services they provide, is an important step in recognizing their conservation value (Clarke *et al.* 2014) ^[7]. Growing TFT species has always been a part of the culture of the farming communities. The introduction of exotic species and improved varieties started in the late twentieth century is still on-going. However, reliable data and historical documentation of diversity of species is lacking and remain particularly vague for the region of Western Ghats of India. The present study aims at characterizing the diversity of tropical fruit trees in the agroforestry homegardens of Central Western Ghats and analyzing the factors that influence tree diversity. Results of this study might be used to develop strategies for improving tree genetic resources in domestication programs and enhancing the suitability of agroforestry systems for *circa situm* conservation of these tropical fruit tree species.

Materials and Methods

A total of 198 homegardens were sampled located in 11 taluks of Uttara Kannada district in Central Western Ghats. The homegardens were sampled using a non-probabilistic sampling method (convenience sampling), based on accessibility to homegarden and owner permission. The present research conducted during 2019-21 aimed at documenting the pattern of tropical fruit tree species (TFT) diversity in homegarden in Uttara Kannada district of Karnataka.

The Uttara Kannada district comprises alluvium soil, lateritic soil and clayey soil, receiving an average annual rainfall of 2400 mm rainfall. The location were chosen in Uttara Kannada district to cover a maximum range of agro-environmental factors such as rainfall, temperature and elevation found in this landscape. In each panchayat village, nine owners and/or those responsible for the homegardens were interviewed, assuring representation of three sections of farmers based land holding (small < 2 ha), medium (2 to 5 ha) and large (>5 ha). Thus, floristic data comes from 198 households of bioclimatic zones, documenting tropical fruit species diversity found on farmlands.

The homegardens often display a mosaic of patches or farm units which are distinct from one another because of the dominant crop grown in it. Such patch formations in homegardens have been reported by Mendez *et al.* (2001) ^[13]. Data on total area of farm, each farm unit and land use pattern (such as homegarden, orchards, field), different fruit diversity grown (frequency, density, native, exotic and form of tree) were recorded. For those species that were difficult to identify at field level, plant specimen were collected and submitted for identification. For the purpose of species richness calculation, all tree and shrub species in the farms were considered. But in counting the population (individuals) of each fruit tree species, only trees with a minimum of breast height diameter (DBH) of 5 cm were taken into account. It should be noted that the homegardens stated in this paper are equivalent to a farm system.

Data analysis

Analyses of the data were carried out using quantitative and

qualitative methods. To determine species richness, the total number of species in the farm and farm unit were calculated. The index does not indicate the relative proportion or abundance of a particular species in the farm. Hence, models that incorporate both richness and evenness of relative abundance were required. Shannon index (Shannon and Wiener, 1949) ^[15] and Simpson index were used to understand inter and intra cluster variability (Magurran and McGill, 2010) ^[12]. The variation in species composition, occurrence of native and exotic species and form of species were described using general statistics.

Results and Discussion

Diversity of tropical fruit trees in Central Western Ghats

In total, 10398 individuals belonging to Sixty one tropical fruit tree species were recorded across homegardens of Uttara Kannada district (Table 1). Variable accounts of species diversity have been reported from other parts of India as well. For instance, high diversity of 463 species from high rainfall humid central Kerala is reported (Kumar, 2011) ^[10]. *Cocos nucifera* (n=4373) was predominantly observed tropical fruit tree followed *Mangifera indica* (n=816), *Artocarpus heterophyllus* (n=913), *Citrus limon* (n=308) and *Anacardium occidentale* (n=374) respectively (Table 2). Approximately, 51 per cent of all the tropical fruit species reported were non-native to the Western Ghats, while considering the number of individuals, 49 per cent of reported species were found to be non-native (Fig. 1). *Garcinia intermedia*, an introduced species from South America, was the rarest TFT represented by a single individual in a homegarden. Earlier reports have also shown similar levels of tree diversity in homegardens. For instance, Homegardens of West Java have been shown to possess astounding diversity of 56 species of plants in a single homegarden and about 272 species in a hamlet of 41 households (Soemarwoto and Conway, 1991) ^[14]. Varadaranganatha and Madiwalar (2010) ^[16] and Bardhan *et al.* (2012) ^[4] reported that *Mangifera indica* and *Cocos nucifera* were predominantly observed species in agroforestry homegardens.

Higher diversity of TFT species in these systems is generally regarded to contribute to the conservation of native species (Kehlenbeck *et al.*, 2011) ^[9]. However, the present study shows that substantial number of non-native species do occur. A maximum of seven species were alone observed from family Rutaceae (n=309) followed by Moraceae contributed a maximum of six species diversity

Our results showed that at homegarden in Central Western Ghats, fruit tree diversity resulted from socio-economic factors that had strong influence at the local scale; thus, the owner's decision at local level have stronger influence on the homegardens floristic composition than environmental or socio-economic factors at broader scales. Pooled over all homegardens, Upghat recorded higher mean species richness (11.82; Fig. 2)) and mean Shannon's index (1.83; Fig. 3). While the richness index in the Coast was reduced to half (8.24; Fig. 2)) with mean Shannon's diversity index of 1.34 (Fig. 3), the lowest richness index was observed in homegardens located in Plains region (3.67; Fig. 2)) with a lowest mean Shannon's diversity index of 0.83 (Fig. 3) as a result of greater concentration of few varieties in these regions.

Table 1: Diversity and density of tropical fruit trees in homegardens of Uttara Kannada district

Sl. No.	Scientific Name	Common Name	Family	Habit	Native/ Exotic	Species	Farms	Average	Per cent
1	<i>Cocos nucifera</i>	Coconut	Aracaceae	Tree	Exotic	4373	168	26.03	98.25
2	<i>Mangifera indica</i>	Mango	Anacardiaceae	Tree	Native	816	156	5.23	91.23
3	<i>Artocarpus heterophyllus</i>	Jackfruit	Moraceae	Tree	Native	913	143	6.38	83.63
4	<i>Citrus limon</i>	Lemon	Rutaceae	Tree	Native	308	127	2.43	74.27
5	<i>Anacardium occidentale</i>	Cashew Nut	Anacardiaceae	Tree	Exotic	374	114	3.28	66.67
6	<i>Carica papaya</i>	Papaya	Caricaceae	Tree	Exotic	248	107	2.32	62.57
7	<i>Psidium guajava L.</i>	Guava	Myrtaceae	Tree	Exotic	289	103	2.81	60.23
8	<i>Musa paradisiaca</i>	Banana	Musaceae	Tree	Native	551	100	5.51	58.48
9	<i>Manilkara zapota</i>	Sapota	Sapotaceae	Tree	Exotic	257	95	2.71	55.56
10	<i>Garcinia indica (Thouars) Choisy.</i>	Kokum	Clusiaceae	Tree	Native	320	82	3.9	47.95
11	<i>Myristica fragrans</i>	Nutmeg	Myrticaceae	Tree	Exotic	252	68	3.71	39.77
12	<i>Abelmoschus esculentus (L.) Moenh</i>	Okra	Malvaceae	Shrub	Exotic	62	62	1	36.26
13	<i>Artocarpus lacucha</i>	Monkey Jack	Moraceae	Tree	Native	104	54	1.93	31.58
14	<i>Annona squamosa</i>	Sweet apple	Annonaceae	Tree	Exotic	100	53	1.89	30.99
15	<i>Artocarpus altilis</i>	Bread fruit	Moraceae	Tree	Exotic	88	52	1.69	30.41
16	<i>Averrhoa bilimbi</i>	Bilimbi	Oxalidaceae	Tree	Exotic	89	48	1.85	28.07
17	<i>Annona reticulata</i>	Custard apple	Annonaceae	Tree	Exotic	71	46	1.54	26.9
18	<i>Syzygium cumini</i>	Java plum	Myrtaceae	Tree	Native	105	43	2.44	25.15
19	<i>Artocarpus altilis Fosberg</i>	Bread fruit	Moraceae	Tree	Exotic	60	41	1.46	23.98
20	<i>Spondias pinnata</i>	Amate kaayi	Anacardiaceae	Tree	Native	53	40	1.33	23.39
21	<i>Citrus maxima</i>	Chakkotha	Rutaceae	Tree	Native	54	36	1.5	21.05
22	<i>Syzygium samarangense</i>	Rose apple	Myrtaceae	Tree	Native	50	36	1.39	21.05
23	<i>Artocarpus hirsutus</i>	Hebbalsu	Moraceae	Tree	Native	37	32	1.16	18.71
24	<i>Garcinia gummi-gutta</i>	Camboge	Clusiaceae	Tree	Exotic	68	29	2.34	16.96
25	<i>Carissa carandus</i>	Carandus	Apocynaceae	Tree	Native	64	28	2.29	16.37
26	<i>Annona cherimola</i>	Hanumanphal	Annonaceae	Tree	Exotic	33	26	1.27	15.2
27	<i>Aegle marmelos (L.)Correa</i>	Wood apple	Rurtaceae	Tree	Native	41	23	1.78	13.45
28	<i>Averrhoa carambola</i>	Kamarakshi	Oxalidaceae	Tree	Exotic	46	20	2.3	11.7
29	<i>Phyllanthus embilica L.</i>	Indian gooseberry	Euphorbiaceae	Tree	Native	29	20	1.45	11.7
30	<i>Punica granatum</i>	Pomegranate	Lythraceae	Tree	Native	25	19	1.32	11.11
31	<i>Tamarindus indica</i>	Tamarind	Fabaceae	Tree	Native	29	18	1.61	10.53
32	<i>Justicia adhatoda L.</i>	Malabar nut	Acanthaceae	Shrub	Native	18	18	1	10.53
33	<i>Grewia tiliifolia Vahl</i>	Dhaman	Tiliaceae	Tree	Native	23	16	1.44	9.36
34	<i>Persea americana</i>	Avocado	Lauraceae	Tree	Exotic	27	16	1.69	9.36
35	<i>Ananassa (L.) Merr.</i>	Pineapple	Bromeliaceae	Shrub	Exotic	152	15	10.13	8.77
36	<i>Theobroma cacao</i>	Cocoa	Malvaceae	Tree	Exotic	62	14	4.43	8.19
37	<i>Phyllanthus acidus(l) skeels.</i>	Star gooseberry	Euphorbiaceae	Tree	Native	12	12	1	7.02
38	<i>Gardenia gummifera L.f.</i>	Cumbi-gum	Rubiaceae	Tree	Native	18	10	1.8	5.85
39	<i>Citrus grandis</i>	Pummelo	Rutaceae	Tree	Native	9	9	1	5.26
40	<i>Ficus carica</i>	Common fig	Moraceae	Tree	Native	8	8	1	4.68
41	<i>Ficus glomerata</i>	Cluster fig	Moraceae	Shrub	Exotic	12	8	1.5	4.68
42	<i>Aporosa lindleyana (Wight) Baill.</i>	Aparosa	Phyllanthaceae	Tree	Exotic	14	8	1.75	4.68
43	<i>Citrus medica L.</i>	Citron	Rutaceae	Shrub	Native	8	8	1	4.68
44	<i>Annona muricata L.</i>	Soursop	Annonaceae	Tree	Native	7	6	1.17	3.51
45	<i>Citrus limetta</i>	Sweet Lemon	Rutaceae	Shrub	Exotic	6	6	1	3.51
46	<i>Spondia mangifer</i>	Amate Kaai	Anacardiaceae	Tree	Exotic	7	6	1.17	3.51
47	<i>Elaegnus conferta Roxb.</i>	Eleagnus	Elaeagnaceae	Shrub	Exotic	9	6	1.5	3.51
48	<i>Mammea suriga</i>	Surangi	Clusiaceae	Tree	Exotic	6	6	1	3.51
49	<i>Sapindus trifoliatus</i>	Sapindus	Sapindaceae	Tree	Native	11	5	2.2	2.92
50	<i>Sapindus mukorossi Gaertn.</i>	Indian soapberry	Sapindaceae	Tree	Native	6	5	1.2	2.92
51	<i>Morus alba</i>	Mulberry plant	Moraceae	Tree	Exotic	9	5	1.8	2.92
52	<i>Myristica malabarica</i>	Rampatre	Myristicaceae	Tree	Native	13	5	2.6	2.92
53	<i>Litchi chenensis</i>	Litchi	Sapindaceae	Tree	Exotic	18	4	4.5	2.34
54	<i>Muntingia calabura</i>	Singapore Cherry	Muntingiaceae	Tree	Exotic	4	4	1	2.34
55	<i>Coffea arabica</i>	Coffee	Rubiaceae	Tree	Exotic	11	2	5.5	1.17
56	<i>Cordia obliqua Willd.</i>	Challe	Boraginaceae	Tree	Exotic	3	2	1.5	1.17
57	<i>Elaeocarpus ganitrus</i>	Rudraksh	Elaeocarpaceae	Tree	Native	2	2	1	1.17
58	<i>Arbutus unedo</i>	Strawberry	Ericaceae	Shrub	Exotic	3	1	3	0.58
59	<i>Semecarpus anacardium Linn.</i>	Forest Cashew	Anacardiaceae	Tree	Native	1	1	1	0.58
60	<i>Citrus sinensis (L.) Osbeck</i>	Orange	Rutaceae	Tree	Native	4	1	4	0.58
61	<i>Durio zibethinus</i>	Durian	Malvaceae	Tree	Exotic	6	1	6	0.58

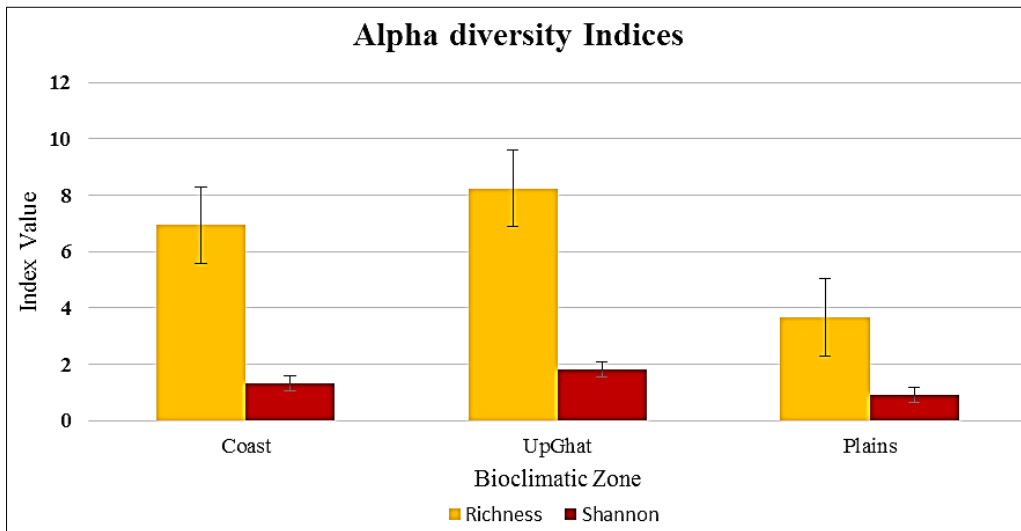


Fig 1: Alpha diversity indices for tropical fruit trees in homegardens of Uttara Kannada district

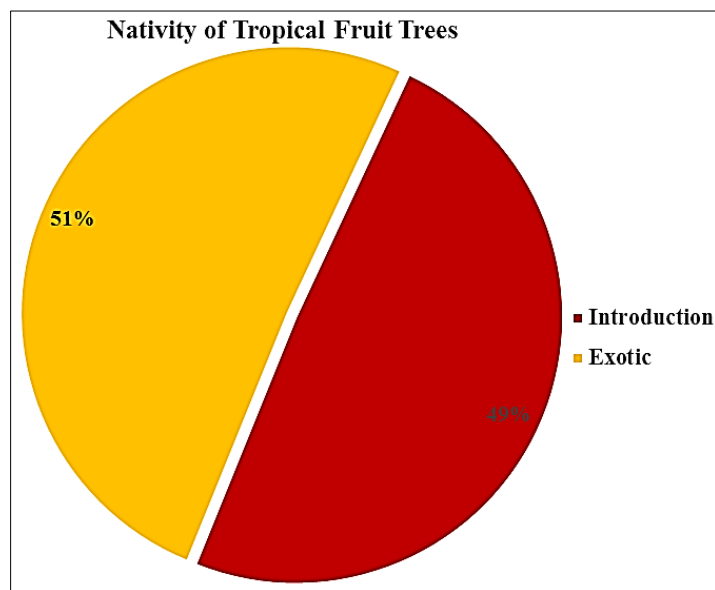


Fig 2: Nativity of tropical fruit trees in homegardens of Uttara Kannada district

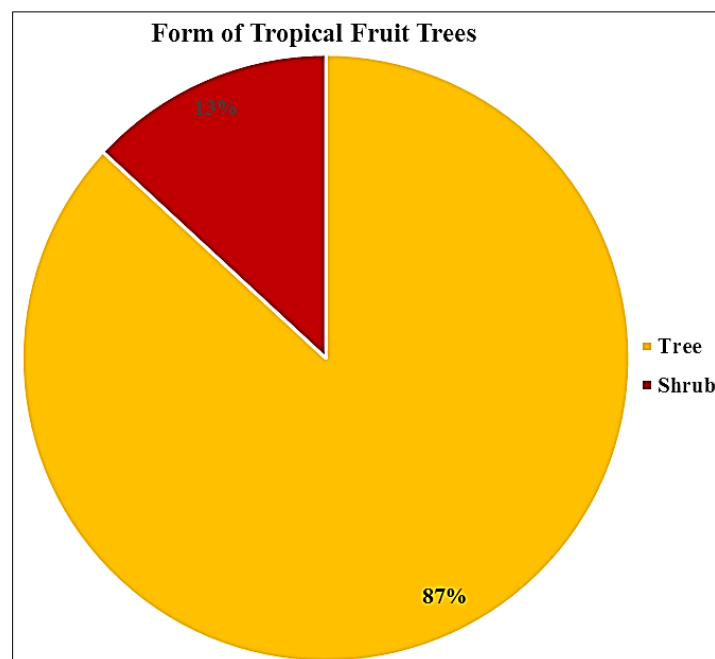


Fig 3: Form of tropical fruit trees in homegardens of Uttara Kannada district

Conclusion

Fruit bearing species significantly contribute to the floristic composition and diversity of homegardens in Central Western Ghats. Thus it was observed that, floristic composition of homegardens in the Central Western Ghats is strongly influenced by landowner's decision at a local level than socio-economic and environmental factors at broader scale. The local factors that influence most are income, homegarden size and topography. Composition and diversity of tropical fruit trees existed across Uttara Kannada district in Central Western Ghats. Higher diversity of tropical fruit tree species was recorded in Up Ghats where traditional agroforestry was more prevalent. Introduction of cash crops such as cashew (as in case of Coast zone) or increased commercialization of a native tropical fruit trees such as Coconut, Mango contributed to the decrease in the diversity. This calls for an urgent revival of interest in use of the traditional varieties of mango and their registration (Gautam *et al.*, 2012)^[8]. Further, influx of monoculture, land fragmentation, market avenue for homegarden products and changing socio-economic & cultural equations have posed immense threats to the future of agroforestry homegarden systems. Thus, importance of homegardens to food security and autonomy of families in Western Ghats indicate that public policies should be designed to stimulate more diverse production system as a strategy to strengthen family agriculture and agrobiodiversity conservation in Central Western Ghats.

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