

## Diversity of Tropical Fruits in the Farmlands of Central Western Ghats, India and its Contribution to the Household Income

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Diversity of tropical fruit tree (TFT) species, their occurrence and relationship with cultivated species in home-gardens and their use by humans has rarely been studied systematically in Central Western Ghats. Among all the nine villages sampled in three bioclimatic zones, a total of 10,202 individuals belonging to 55 species were recorded. *Mangifera indica* was the predominantly (n=4,496) found TFT species in the home-gardens and farmlands of Uttara Kannada district. Richness was highest in up-ghat zone (10.92) and substantial lower in coastal zone (5.95) and lowest in eastern plains (4.04). Major factors contributing to low richness is the increasing replacement with exotic commercial crops (cashew) in coastal zone and the low rainfall and varied climatic conditions in eastern zone. Villages of the up-ghat zone, on an average, showed richness index of 10.92 while its value reduced nearly by half when villages of the coastal zone were considered (5.95). The lowest average richness index was found among the villages of the eastern plains (4.04). Overall, nearly one third of all TFT species (36.36 per cent) were non-native to the Western Ghats which was similar in all three zones. However, non-native trees were dominant in coastal zone (54.96%) and less prominent in up-ghat (31.58%) and eastern zone (13.42%). Average family income derived from TFT was Rs 9,595 in coastal zone, Rs 4,207 in up-ghat zone and Rs 10,591 in eastern zone. Contribution of native and non-native TFT species to total household income is low in all three zones, highest contribution was measured in eastern zone (8.18% of the total family income) and coastal zone (7.56%) and even lower in up-ghat zone (2.27%). Correlation analysis showed a positive relationship between diversity and total household income. Regression analysis showed that total family income positively contributes to the level of TFT diversity found on farmlands, this contribution was most significant in coastal and up-ghat zone.

**Key Words:** Central Western Ghats, Household Income, Tropical fruit diversity

### Introduction

Tropical Fruit Tree (TFT) species are intricately associated with the culture of peoples, their livelihoods and food security in South, South-east and East Asia. A rich diversity of over 500 species of TFT, of which about 90% are perennial, found in this region provide for a broad range of livelihood options to local people in the form of food supplements, better nutrition, household income and employment (Bhag Mal *et al.*, 2011). Several TFT species are also used for their medicinal value, as timber and as livestock fodder. It is a well-established fact that biodiversity conservation and the maintenance of associated ecosystem services are vital for human well-being (Beaumont *et al.*, 2011). TFT species provide vital forest products that are important for rural livelihoods and play a crucial role in forest

eco-systems as forage crop for animals. The Asian fruit production system ranges from collecting/gathering of fruit from forest to well-developed home-gardens to intensive commercial plantations. Home-gardens are the most prevalent production system for cultivated fruits in Asia (Anupunt *et al.*, 2002). The diversity of tropical fruits is also higher in India because of the affinity to grow variety of fruits in home-gardens and marginal lands (Ajay and Pratap, 2009).

Being a part of the central Western Ghats of India, Uttara Kannada district in Karnataka has some striking diversity of TFT species (Vasudeva *et al.*, 2011). The district falls under tropical belt of rich forests well suited for diverse wild fruit yielding trees (Varadaranganatha and Madiwalar, 2010; Bhat and Ravindranath, 2011). TFT species are also found commonly in home-gardens and

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planted around home-gardens as well as in farmlands. As various analyses and summary reports have repeatedly indicated (Kumar and Nair, 2004), food plants (food crops and fruit trees) are the most common species in most home-gardens throughout the world. Farming communities and rural settlements of Uttara Kannada district have an age old history of maintaining home-gardens (Bhat and Ravindranath, 2011) and well known for deriving livelihood means from diversified sources. Growing TFT species has been a part of the culture of the farming communities. However, diversity and composition of TFT species and its relationship with family income has rarely been studied systematically in the central Western Ghats. Community management of TFT resources is being addressed under the GEF-UNEP project titled "Conservation and sustainable use of cultivated and wild tropical fruit diversity: promoting sustainable livelihood, food security and ecosystem services". Being implemented in 18 communities of India along with six communities each in Indonesia, Malaysia and Thailand, the immediate objective of the project is to conserve tropical fruit tree genetic resources *in situ* and on farm through strengthening capacity of farmers, user groups, local communities and institutions to sustainably apply good practices and to secure benefits (Sthapit et al., 2013).

### Material and Methods

The study was carried out during 2012-13 to assess the patterns of tropical fruit tree species (TFT) diversity in home-gardens and farmlands as well as to assess the extent of contribution of TFT to the livelihood of local farming community of Uttara Kannada district, Karnataka. The district lies between 14°71' N latitude and 74°78' E longitude. Study area was divided into three bio-climatic zones *viz.*, coastal, up-ghat and eastern plains based on following Pascal (1984).

The coastal zone is characterized by fairly level lands almost at the sea level with an altitude of 20-300 m above Mean Sea Level (MSL). The major soil types in this zone are red clay loam, red lateritic soils and coastal alluvial soil in thin narrow strips; the soils are yellowish brown, brown to grey and acidic in nature. The area receives on an average annual rainfall of 3537mm. The up-ghat bioclimatic zone falls in the crest-line of the Western Ghats and receives an average annual rainfall of around 2800 mm and situated at an altitude of around 650 m. The major soil types in the up-ghat zone are red lateritic, loam, sandy loam to clayey. The mean maximum

temperature ranges from 25-32°C. Evergreen and semi-evergreen formations are fragmented in the crest-line of the Ghats. The eastern plain area lies in the eastern part of the district with an elevation of 550 to 650 m. The major soil types in this zone are clay loams. The area receives on an average annual rainfall of 922 mm. The mean maximum temperature ranges from 26.6-38.6°C.

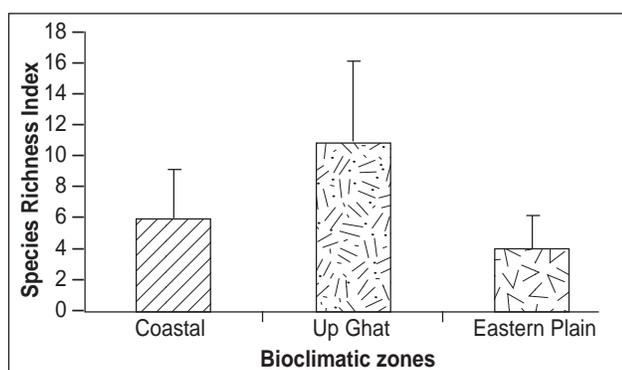
Three typical villages in each of the three distinct bioclimatic zones namely Marugadde, Devgiri and Kotakhanda in coastal; Nilkunda, Chavatti and Bisgod in up-ghat and Kalakardi, Santholli and Koppa in the eastern plain region are included in the study. The background information on altitude, soil types and weather data of the Uttara Kannada district was collected by visiting the district statistical office. Geo co-ordinates of the village were recorded through GPS (Global Positioning System). Table 1 and Fig. 1 show the latitude, longitude, and climatic details of the focal villages selected for the study under different bio-climatic zones of Uttara Kannada district.

In every village 25 households were selected representing all the three sections of farmers on the basis of land-holding (Smallholder farmer = <0.88 hectare land; Medium farmer = 0.88-2 hectares land; Large farmer = >2 hectares land). Hence the data comes from 225 households; 75 households in each of the bioclimatic zone. The identified respondents in each village were interviewed personally using a questionnaire covering several topics. The household survey involved documenting tropical fruit species diversity found on farmlands and assessing their income level among other household characteristics such as family size, education level, ownership of consumer goods and productive assets. The data on the extent of land-use patterns such as home-gardens, orchards and fields were recorded. In home-gardens, the number of tropical fruit tree species, frequency and density, varieties, average age of trees, economic parts of the tree species, consumption pattern *i.e.* for household and sale purpose, area under fruit tree cultivation and size of the field *etc.*, were recorded. The diversity of TFT species was determined using species richness index, Shannon's index, Simpson's index to understand inter- and intra-cluster variability (Magurran and McGill, 2010).

The study evaluated the differences in diversity levels, the occurrence of non-native and native species and income levels between the three classified household groups and three agro-ecological zones using general

**Table 1. Latitude, longitude, and climatic details of the focal villages selected for the study under different bioclimatic zones of Uttara Kannada district**

Villages	Latitude °N	Longitude °E	Average Rainfall (mm)	MSL (m)	Average Farm Size (ha)
<b>COASTAL ZONE</b>					
Kotakhanda	14° 00' 25.47"	74° 35' 35.61"	3625	58	1.5± 1.70
Devgeri	14° 21' 15.82"	74° 24' 33.25"	3540	17	1.3±0.90
Marugadde	14° 44' 12.72"	74° 24' 44.28"	3450	138	1.59±1.07
<b>UP GHAT ZONE</b>					
Nilkunda	14° 26' 59.48"	74° 42' 02.34"	3530	528	1.39±0.25
Chavatti	14° 46' 11.9"	74° 48' 49.80"	2540	515	1.63±1.16
Bisgod	15° 01' 56.30"	74° 38' 55.53"	2420	561	1.37±1.68
<b>EASTERN PLAINS</b>					
Kalakaradi	14° 35' 51.00"	75° 00' 18.57"	900	575	3.83±6.59
Santholli	14° 38' 57.5"	75° 02' 18.15"	925	592	1.90 ±1.86
Koppa	14° 47' 23.15"	75° 02' 14.68"	945	609	1.74±1.33

**Fig. 1. Species richness index of TFT species (pooled over all home-gardens of a zone) across three bio-climatic zones in Uttara Kannada district (error bars indicate standard deviation)**

statistics and assessed the relationship between diversity indicators and welfare indicators using correlations and two stage least squares regression procedure.

## Results and Discussion

### *Patterns of Diversity of TFT across Bioclimatic Zones of the Central Western Ghats*

Among the home-gardens and farmlands of nine villages sampled in three bioclimatic zones of the central Western Ghats, a total of 10,202 individuals belonging to 55 TFT species were recorded (Table 2). Mango was the predominantly (n=4,496) found TFT species. Two introduced species (non-native species) viz. cashew nut, *Anacardium occidentale* (n=1,363) and sapota, *Achras zapota* (n=502), respectively were in second and third positions. Overall, nearly one third of all TFT species found in the study area (29.09%) were non-native to the Western Ghats. Considering the number of individuals,

about 27.76% of them, were non-native. *Garcinia intermedia*, an introduction from the South America, was the rarest TFT species represented by a single individual in a home-garden of up-ghat zone. The top ten species included cashew, sapota, jackfruit, guava, lemon and papaya. *Kokam* (*Garcinia indica*) and *uppage* (*G. gummi-gutta*) were also predominantly found species in the coastal and up-ghat bioclimatic zones but not in the eastern plains. Tamarind (*Tamarindus indicus*) was restricted to the eastern plain zone.

Earlier reports have also shown similar levels of tree diversity in home-gardens. For instance, Kumar and Nair (2004) have reported 69 different species among the home-gardens in Kerala. Mendez *et al.* (2001) have reported 40 fruit trees out of 324 plant species in home-gardens of Nicaragua. Home-gardens of West Java have been shown to possess astounding diversity of species, 56 species of plants in a single home-garden and about 272 species in a hamlet of 41 households (Soemarwoto and Conway, 1991). Styger *et al.* (1999), Pandey *et al.* (2006), Varadaranganatha and Madiwalar (2010), Zaman *et al.* (2010), Bardhan *et al.* (2012) and Saikia *et al.* (2012) also reported that mango species are predominant in home-garden system. Home-garden agroforestry systems in the tropics are structurally complex and hence possess a great diversity of tree species (Nair and Shreedharan, 1986). Such diversified trees on farm lands is generally regarded as a strategy meet the subsistence/cash needs as well as to stabilise yield. Further, different traditional agroforestry systems of the tropics also characteristically possess dominant tree species. For instance, 'enset-coffee agroforestry' home-gardens of Southern Ethiopia, 'shade-coffee based agroforestry' of Kodagu in Southern India.

**Table 2. List of TFT species and their frequency in nine representative villages of Uttara Kannada district belonging to three bio-climatic zones. The species are organized in descending order of their frequency**

S.No.	Botanical name	Family	Exotic/ Native	Coastal			Up-Ghat			Eastern Plain			Total
				Kot	Dev	Mar	Nil	Chv	Bis	Kal	San	Kop	
1	<i>Anacardium occidentale</i> L.	Anacardiaceae	Exotic	436	217	169	117	72	217	34	44	57	1363
2	<i>Achras zapota</i> (L.) P. Royen	Sapotaceae	Exotic	48	15	0	78	62	54	19	44	182	502
3	<i>Psidium guajava</i> L.	Myrtaceae	Exotic	11	8	15	38	36	57	21	79	69	334
4	<i>Carica papaya</i> L.	Caricaceae	Exotic	24	6	18	31	27	48	4	10	8	176
5	<i>Artocarpus incisa</i> L.	Moraceae	Exotic	28	6	11	15	15	26	3	1	4	109
6	<i>Theobroma cacao</i> L.	Malvaceae	Exotic	0	0	0	8	62	7	0	0	0	77
7	<i>Myristica fragrans</i> Houtt.	Myristicaceae	Exotic	31	19	0	0	0	21	0	0	0	71
8	<i>Averrhoa bilimbi</i> L.	Oxalidaceae	Exotic	11	11	6	4	10	21	0	0	0	63
9	<i>Annona squamosa</i> L.	Annonaceae	Exotic	12	9	0	8	10	6	0	6	0	51
10	<i>Annona reticulate</i> L.	Annonaceae	Exotic	0	1	3	12	7	8	3	0	4	38
11	<i>Averrhoa carambola</i> L.	Oxalidaceae	Exotic	1	3	2	3	9	9	0	0	0	27
12	<i>Syzygium samarangense</i> (Blume) Merrill & Perry	Myrtaceae	Exotic	7	0	0	7	3	8	0	0	0	25
13	<i>Syzygium jambos</i> (L.) Alston	Myrtaceae	Exotic	0	2	0	7	9	6	0	0	0	24
14	<i>Ficus carica</i> L.	Moraceae	Exotic	6	0	0	5	8	3	0	0	0	22
15	<i>Citrus sinensis</i> (L.) Osbeck	Rutaceae	Exotic	0	0	0	4	7	0	6	0	4	21
16	<i>Punica granatum</i> L.	Punicaceae	Exotic	0	0	0	4	5	9	0	0	0	18
17	<i>Citrus reticulata</i> Blanco	Rutaceae	Exotic	0	0	0	4	6	0	0	1	0	11
18	<i>Prunus avium</i> (L.) L.	Rosaceae	Exotic	0	0	0	0	0	3	0	0	0	3
19	<i>Garcinia intermedia</i> (Pittier) Hammel	Clusiaceae	Exotic	0	0	0	0	0	1	0	0	0	1
46	<i>Citrus grandis</i> Burm.	Rutaceae	Exotic	5	8	0	0	0	0	0	2	0	15
20	<i>Mangifera indica</i> L.	Anacardiaceae	Native	157	57	166	175	283	290	1135	884	1349	4496
21	<i>Artocarpus integrifolia</i> Lamk.	Moraceae	Native	46	14	22	56	157	105	7	14	36	457
22	<i>Citrus limon</i> Burm.f.	Rutaceae	Native	14	23	18	47	77	52	19	24	22	296
23	<i>Tamarindus indica</i> L.	Fabaceae	Native	4	2	0	3	16	6	88	69	104	292
24	<i>Garcinia indica</i> (Thouras) Choisy.	Clusiaceae	Native	28	23	38	76	14	88	0	0	0	267
25	<i>Garcinia gummi-gutta</i> (L.) N. Robson	Clusiaceae	Native	0	0	2	222	17	3	0	0	0	244
26	<i>Carissa carandas</i> L.	Apocynaceae	Native	60	0	0	32	0	30	0	21	0	143
27	<i>Aporosa lindleyana</i> (Wt.) Baill.	Euphorbiaceae	Native	8	5	2	39	37	35	3	2	2	133
28	<i>Emblica officinalis</i> Geartn.	Phyllanthaceae	Native	0	0	6	11	30	32	4	17	28	128
29	<i>Spondias mangifer</i> (L.f.) Kurz.	Anacardiaceae	Native	11	9	10	11	28	15	2	2	5	93
30	<i>Syzygium cumini</i> (L.) Skeels	Myrtaceae	Native	7	6	7	19	7	14	7	8	5	80
31	<i>Citrus medica</i> L.	Rutaceae	Native	6	0	2	16	35	15	2	0	2	78
32	<i>Artocarpus lakoocha</i> Roxb.	Moraceae	Native	3	0	6	12	8	25	0	0	0	54
33	<i>Phoenix sylvestris</i> (L.) Roxb.	Arecaceae	Native	0	0	0	53	0	0	0	0	0	53
34	<i>Aegle marmelos</i> (L.) Correa	Rutaceae	Native	5	3	2	5	14	20	0	3	0	52
35	<i>Ziziphus rugosa</i> Lamk.	Rhamnaceae	Native	1	5	2	6	13	20	0	3	0	50
36	<i>Phyllanthus acidus</i> (L.) Skeels.	Phyllanthaceae	Native	4	3	2	9	10	4	4	2	7	45
37	<i>Flacourtia montana</i> J. Graham	Flacourtiaceae	Native	12	0	2	6	0	20	0	0	0	40
38	<i>Gardenia gummifera</i> L.	Rubiaceae	Native	0	0	0	16	0	14	0	0	0	30
39	<i>Schleichera oleosa</i> (Lour.) Oken	Sapindaceae	Native	0	0	5	0	0	24	0	0	0	29
40	<i>Buchanania lanzan</i> Spreng	Anacardiaceae	Native	0	0	0	15	0	6	2	0	3	26
41	<i>Ficus glomerata</i> L.	Moraceae	Native	0	1	1	6	7	10	0	0	0	25
42	<i>Elaeagnus conferta</i> Roxb.	Elaeagnaceae	Native	0	0	0	23	0	0	0	0	0	23
43	<i>Grewia tiliaefolia</i> Vahl.	Tiliaceae	Native	0	0	0	0	0	21	0	0	0	21
44	<i>Syzygium operculatum</i> Gamb.	Myrtaceae	Native	0	0	0	4	0	15	0	0	0	19
45	<i>Morus alba</i> L.	Moraceae	Native	6	0	0	0	0	12	0	0	0	18
47	<i>Ziziphus mauritiana</i> Lamk.	Rhamnaceae	Native	0	0	0	0	0	0	4	4	6	14
48	<i>Semecarpus anacardium</i> L.f.	Anacardiaceae	Native	0	0	0	0	0	12	0	0	0	12
49	<i>Grewia microcos</i> L.	Tiliaceae	Native	0	0	0	0	0	6	0	0	0	6
50	<i>Terminalia catappa</i> L.	Combretaceae	Native	6	0	0	0	0	0	0	0	0	6
51	<i>Mammea suriga</i> (Buck.-Ham. ex Roxb.) Kosterm.	Clusiaceae	Native	0	0	0	0	0	5	0	0	0	5
52	<i>Mimusops elengi</i> L.	Sapotaceae	Native	0	0	0	0	0	5	0	0	0	5
53	<i>Citrus</i> sps.	Rutaceae	Native	0	0	0	0	0	4	0	0	0	4
54	<i>Terminalia chebula</i> Retz.	Combretaceae	Native	0	0	1	0	0	0	2	0	1	4
55	<i>Zanthoxylum rhetsa</i> (Roxb.) DC.	Rutaceae	Native	0	0	0	2	0	1	0	0	0	3
Total				998	456	518	1209	1101	1413	1369	1240	1898	10202

Perhaps the highest use-values associated with these species have made them to be a part of these systems.

Higher diversity of TFT species in these systems is generally regarded to contribute to the conservation of native species. However, the present study shows that substantial number of non-native species do occur. Such displacement of indigenous trees by the exotic trees has been shown to occur at intermediate altitudes around Mount Kenya, because of the proportion of indigenous species increased with increasing aridity and temperature. Dominance of exotic species was found at farms of humid, mid- and high lands. Exotic species contributed to the separation of farms in the high lands and upper mid lands, where as indigenous species in the lower mid lands and low lands. As the frequency of most indigenous trees were low, only parts of surveyed farms can contribute to conservation of tree genetic resources, particularly the less intensively managed farms of more arid lands (Kehlenbeck *et al.*, 2011).

The level of diversity and the composition of TFT species showed marked differences across three bioclimatic zones studied. In the coastal zone, 36 TFT species belonging to 18 families were recorded; among these, Moraceae contributed a maximum of six species. A total of 1,972 individuals were sampled in which cashew was the most predominant one (n=822; 41.68 %); mango was the second predominantly found species (n=380; 19.25 %). Interestingly, as much as 30 per cent of the TFT species and little over 50 per cent of the individual trees were non-native in the coastal zone.

In the up-Ghat zone 51 TFT species belonging to 24 families were recorded. Among these, family Rutaceae contributed to a maximum of 7 species (n=309). A total of 3,723 individuals were sampled in the survey and a large number (n=748; 60.27 %) of them were *Mangifera indica*; cashew was the second predominantly found TFT in the up-ghat zone (n=406; 32.71 %). Little over 31 per cent of the TFT species and individual trees were not native in the up-Ghat zone.

In the eastern-plain zone, 26 TFT species belonging to 13 families were recorded. Among these, Rutaceae contributed a maximum of 6 species (n=85). A total of 4,507 individuals were sampled and of which *Mangifera indica* was the predominant TFT (n= 3,368; 74.72 %); *Tamaridus indica* was in the second position (n=261; 5.79 %). Interestingly, as much as 26.92 per cent of the TFT species and little over 13% of the individual trees were non-native to the eastern plain zone.

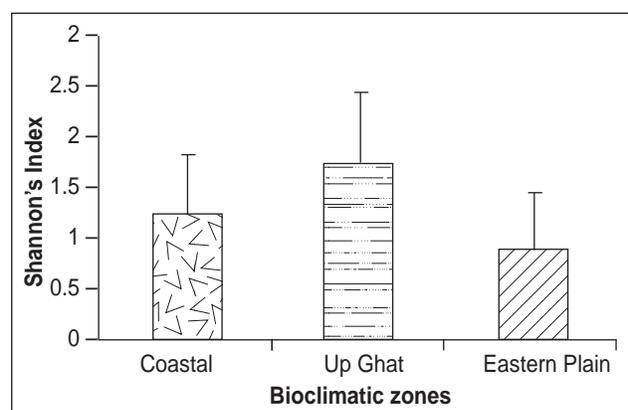
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Species richness index (Fig. 1) and Shannon's index (Fig. 2) computed for TFT species differed across the three bioclimatic zones. Pooled over all households in a zone, average species richness index (10.92) and average Shannon's index (1.73) were the highest for the up-ghat zone. While the richness index in the coast zone was reduced to half (5.95) with an average Shannon's diversity index of (1.25), the lowest average richness index was found in the eastern plains (4.04; Fig. 1) with a lowest average Shannon's diversity index of 0.87 (Fig. 2).

The diversity of TFT species at the village level has been described on several parameters in the Table 3. Even at the village level the zonal patterns were up-held. In every respect of diversity descriptors, the home-gardens and farmlands of up-ghat zone fared better than other zones. Consistently the villages of the eastern plains showed lower values for the diversity. Among the nine villages studied, the home-gardens and farmlands of Bisgod village recorded the highest species richness index (1.27) and Shannon's index (3.07). The species density *i.e.*, mean number of species per unit area of home-garden (8.84) and tree density *i.e.*, mean number of individuals per unit area (26.75) were also found to be the highest in Bisgod.

#### **Average Income from TFT Species Pooled over Three Bio-climatic Zones**

Pooled over all the households of the a bioclimatic zone (n=75), highest average annual income of Rs 10, 591=00 was obtained from TFT species in the eastern plain zone. This, on an average, is about 8.18 % of the total family income (SD  $\pm$  15.07 %). In the coastal zone the average annual income generated per family



**Fig. 2. Shannon's diversity index for TFT species (pooled over all home-gardens of a zone) across three bio-climatic zones in Uttara Kannada district**

**Table 3. Descriptors of TFT species diversity in nine representative villages of Uttara Kannada district belonging to three bio-climatic zones**

S. No.	Village/ Bioclimatic Zone	No. of TFT species	No. of individuals belonging to TFT species	Species Richness Index <sup>1</sup>	Simpson's Index	Shannon's Index	Species density <sup>2</sup>	CV associated with species density	Tree density <sup>3</sup>	CV associated with tree density
1	Kotakhanda / Coastal	29	998	0.92	0.22	2.18	3.62	0.59	22.95	0.71
2	Devigiri/ Coastal	24	456	1.12	0.25	2.10	2.86	1.71	9.51	1.54
3	Marugadde/ Coastal	25	518	1.09	0.22	2.03	1.79	0.75	6.22	0.77
4	Nilkunda / Up-Ghat	40	1209	1.15	0.08	2.94	4.73	1.19	19.12	1.42
5	Chavatti/ Up-Ghat	32	1101	0.96	0.10	2.75	3.92	1.34	14.44	0.88
6	Bisgod/ Up-Ghat	48	1423	1.27	0.08	3.07	8.84	1.19	26.75	0.92
7	Kalakardi / Plains	20	1369	0.54	0.69	0.83	1.13	0.84	8.51	0.89
8	Santholli / Plains	21	1240	0.60	0.51	1.27	1.55	0.84	10.12	1.12
9	Koppa / Plains	20	1898	0.46	0.52	1.20	1.48	1.01	13.62	1.01

\*1= Menhenick's Index

\*2= Mean no. of species per area of home-garden/farmland

\*3= Mean number of individuals per area of home-garden/farmland

by TFT was at Rs 9,595=00 (which is 7.56 % of the total annual family income with a SD of  $\pm 12.65$  %); while the least average income from TFT to was accrued in the up-ghat zone with an average of Rs 4,207=00 (2.27 %  $\pm 2.73$  % of the total family income). Mean per cent income contribution by TFT species across the villages of three bio-climatic zones represented in Fig. 3, also confirms the general trend. In the eastern plains zone popular varieties mango are raised as commercial plantations, hence contributes maximum to the family income. In addition, slightly drier conditions prevailing in the eastern plains are congenial to mango plantations compared to the up-Ghat zone where heavy rainfall may reduce yields. Mango in the up-Ghat zone is more used for preparation of house-hold pickles (aromatic pickle mango) rather than for table purpose (Vasudeva and Rajeshwari, 2014). In contrast, in coastal areas of Uttara Kannada district cashew cultivation is preferred because of its commercial value and established marketing channel (Panda, 2013).

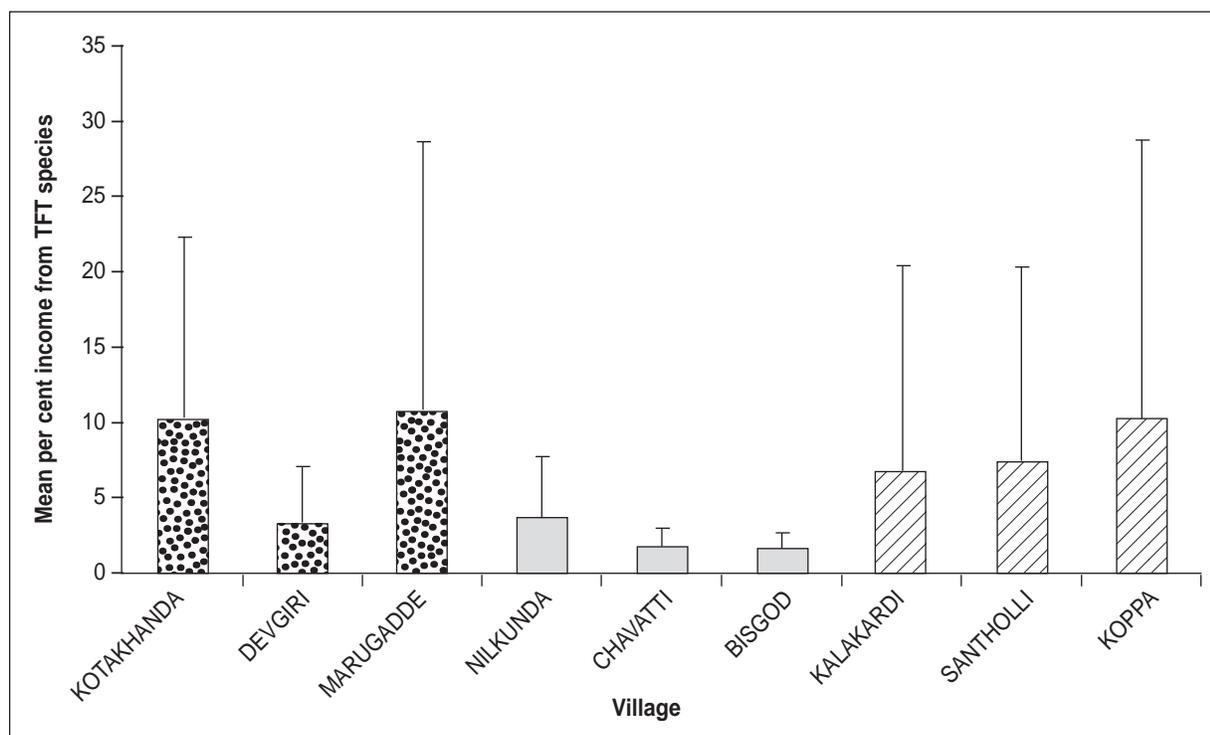
### ***Income as a Driver of TFT Species Diversity***

In the present study, association between total family income and number of TFT species per home-garden (average 1.8 ha landholding) was statistically significant for Coastal zone ( $r=0.234$ ;  $P<0.005$  at 73 df) and for Up-Ghat zone ( $r=0.202$ ;  $P<0.05$  at 73 df). However, the association was poor in the Eastern-plain zone ( $r=0.151$ ; NS) of central Western Ghats. This suggests that the species diversity does increase with the total family

income. However, an exception to this is the eastern plains zone, where the relationship was not significant perhaps because of focus is on a few commercially important varieties/species. Apart from total family income, several motivational factors such as the value attached to the TFT, social factors such as heirloom varieties, are regarded as strong drivers of the diversity of the tropical fruit tree species. The results of the present study do not provide proof for the direction of the relationship or influence of other factors such as land size or household characteristics. Farmers could maintain more diversity simply because of having more space. Other way round, the utilization of diversity could have contributed also to higher incomes. Similar results were reported by Esipisu (2005) where number of varietal richness was positively associated with income of the household. However, the  $R^2$  values were lower.

### **Conclusions**

Clear differences in the composition and diversity of TFT species existed across the bioclimatic zones of the study area. Largest diversity of TFT was found among the up-ghat zone where traditional agroforestry was more prevalent. Introduction of cash crops such as cashew (as in the case of coastal zone) or increased commercialization of a native TFT such as mango (as in the case of eastern-plain) 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). Pooled over all the



**Fig. 3.** Average per cent family income contributed by TFT in nine focal villages across three bio-climatic zones of Uttara Kannada district. The error bars indicate the  $\pm 1$  S.D. The first three villages viz. Kotakhanda, Devgiri and Marugadde belong to coastal bioclimatic zone; Nilkunda, Chavatti and Bisgod belong to up-ghat zone; the eastern plain is represented by Kalakardi, Santholli and Koppa village

households of the a bioclimatic zone, highest average annual income was obtained from TFT species in the eastern plain zone (8.18 % of the total family income). In the coastal zone it was 7.56 % of the total annual family income; while the least average income from TFT to was accrued in the up-Ghat zone (2.27 %). However, regression analysis showed that total family income positively contributes to the level of TFT diversity found on farmlands, this contribution was most significant in Coastal and up-Ghat zone.

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