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Article · June 2015

DOI: 10.5958/0976-1926.2015.00013.3

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Traditional Knowledge Associated with Tropical Fruit Tree Genetic Resources: Comparison of Upper-Ghat and Coastal Situation of Central Western Ghats, India

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(Received: 14 January 2015; Revised: 8 February 2015; Accepted: 16 February 2015)

The study was taken up in two representative villages each from upper-Ghat and coastal bioclimatic zones of Uttara Kannada district, Karnataka, India with an objective to document the total tropical fruit tree species diversity and the associated traditional knowledge. About 43 tropical fruit tree (TFT) species, were recorded. Seventy four traditional knowledge associated with TFTs were recorded from the study sites. It was noted that traditional knowledge related to culinary uses and processing of TFTs were practised even today. However, traditional knowledge related to medicinal uses showed a decreasing trend, where traditional medicines are being replaced with modern medicines. Cultural Importance (CI) value was calculated for all the 42 TFT genetic resources recorded. Mango showed highest value for CI when considered for each bioclimatic zone as well as when the data was pooled over all the village. Further, other two species that showed relatively higher values of CI were jack fruit and *Garcinia indica*. There was a positive association of the frequency of TFTs and their CI values. Documentation of such invaluable traditional knowledge would establish the rights of local communities over their traditional knowledge and its use. It is suggested that community biodiversity register (CBR) could be effectively adopted to empower local people.

Key Words: Central Western Ghats, Cultural importance value, Traditional knowledge, Tropical fruits

Introduction

Asia is a treasure house of tropical fruit tree (TFT) genetic resources harbouring over 500 species (Ramanatha Rao and Bhag Mal, 2002). In India, central Western Ghats is a rich repository of TFTs housing hundreds of native TFT species such as *Mangifera indica*, *Artocarpus heterophyllus*, *Garcinia indica* etc. Naturally, TFTs form a major part of culture and livelihood of local indigenous people. Being a part of Central Western Ghats, Uttara Kannada district, Karnataka state, has high diversity of TFT species spread in several production systems such as home-gardens, farmlands, etc. Nearly a hundred TFT species form an important source of livelihood, medicine and income of local indigenous people (Bhat *et al.*, 2013). Several wild TFT genetic resources have been partially domesticated and deployed into farming systems. For instance, several varieties of wild aromatic pickle mango (*Mangifera indica*) popularly known as 'Appemidi', an

important commodity of commerce, have been identified by the farmers from the riverine habitats and have been deployed under various agro-forestry systems (Vasudeva and Rajeshwari, 2014). Hence these indigenous people possess knowledge on the use-value of TFTs as food, medicines and other uses (Bhat, 2013). For instance, *Garcinia indica* and *G. gummi-gutta* are used for beverage making from the fruit rind/extracting an edible butter from seeds to be used also for cosmetic/therapeutic benefits which are also mentioned in *Ayurveda* and many other folk systems (Baliga *et al.*, 2011). Many traditional as well as recent medicinal literature have shown the usefulness of Indian gooseberry (*Phyllanthus emblica*) in the treatment of cold, influenza, diabetes, lung problems and also as an immune restorative agent under cancer conditions. *Phyllanthus emblica* is also a rich source of Vitamin C, Iron, Calcium and many other minerals and anti-oxidants (Sampath Kumar *et al.*, 2012).

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Worldwide, the knowledge developed over many generations has supported the local communities to sustainably live and utilize the biodiversity for improved livelihood and health (Kiene, 2006; Maharouf, 2003; Idris, 2003; Delacruz, 2003). In Vietnam, litchi has been used for its medicinal property (Hue, 2003). Documentation of traditional knowledge (TK) on mango and jackfruit in Sri Lanka indicated specific species are used for the treatment of specific ailments (Maharouf, 2003). TK¹ refers to the rational and reliable knowledge, practice and belief of indigenous people developed through generations of intimate contact with the nature by the local people (Mauro and Hardison, 2000). It would include detailed information on species of a locality, use-values of local biodiversity, harvesting and management practices and manipulation of disturbance regimes (Berkes, 1993). This knowledge is unique to a specific community and their culture.

Such knowledge has strong links with TFT genetic resources of India (Ajay and Pratap, 2009). However, TK is constantly under threat due to its mode of transmission and cultural erosion from one generation to another. It is mostly orally transferred, through folklore, songs, practices, rituals *etc.* (Kiene, 2006; Sthapit and Quek, 2006; Huntington, 2000). In addition, rapid agricultural expansion, changing land use pattern and with other social pressures have led to the depletion of TFT genetic resource diversity. Therefore, it is essential that this knowledge is documented and the genetic resources are regularly monitored for their conservation status. There are several international efforts to recognize the importance of protection of TK. World Intellectual Property Organization (WIPO) and UNESCO have adopted a model law on folklore in 1981 and the Convention on Biological Diversity (CBD) highlighted the need to promote and preserve traditional knowledge in 1992. Despite these efforts, universally acceptable solutions for the protection and promotion of TK have yet to emerge.

Documentation is primarily a process by which TK is identified, collected, organized, registered and recorded in order to constantly maintain, manage, use, disseminate and protect against bio-piracy. Bio-piracy

¹ **Traditional knowledge (TK)** is knowledge, know-how, skills and practices that are developed, sustained and passed on from generation to generation within a community, often forming part of its cultural or spiritual identity. www.wipo.int/tp/en/tp/ (accessed on 05/09/2014)

is a situation where indigenous knowledge of nature, originating with indigenous people, is used by others for profit, without permission from and with little or no compensation or recognition to the indigenous people themselves (Pandey, 2014). In the recent past, it is said that many commercial companies had exploited indigenous knowledge, where original knowledge holder was not given due credit. The examples of turmeric, neem and ayahuasca illustrate such issues that arise when patent protection is granted to inventions relating to traditional knowledge which is already in the public domain. In these cases, invalid patents were issued because the patent examiners were not aware of the relevant traditional knowledge. India had many bitter experiences where our traditional knowledge (related to turmeric, neem, basmati rice *etc.*) had been patented by outside parties as their own innovations (www.tkd.res.in). Such instances prompted the international community to take stand on the exploitation of indigenous knowledge access, and Benefit Sharing (ABS) provisions of the CBD. The provisions outline the frame work for the development of legal and ethical bio-prospecting agreements between the 'provider' (host country / community) and 'user' (party outside to the community/country) of TK. National Biodiversity Authority in India is one such national organization involved in the protection of TK and its use which encourages documentation. Under the GEF-UNEP funded project titled "Conservation and sustainable use of cultivated and wild tropical fruit diversity: promoting sustainable livelihood, food security and ecosystem services" TK associated with TFTs were documented adopting multifarious methods. Being implemented in 18 communities of India along with six other 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. With this background, the current study was carried out with an aim of documenting the traditional knowledge associated with TFT and to describe their cultural significance while comparing the two bioclimatic zones of central Western Ghats of India.

Materials and Methods

Two typical villages of upper-Ghat (Salkani and Killara) and two of the coastal zone (Murur and Kallabbe) in the central Western Ghats, Karnataka were selected for the

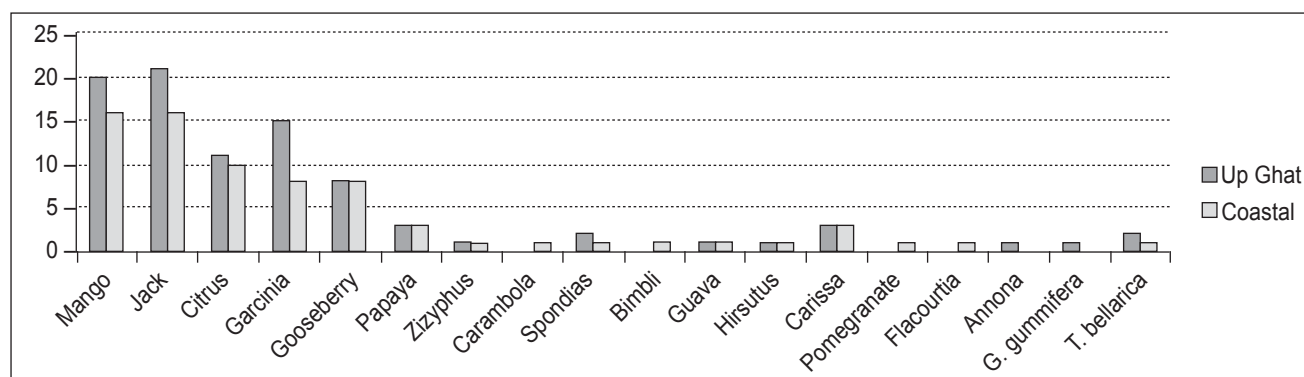


Fig. 1. Comparison of number of TK recorded for different use-values in Upper Ghat and Coastal villages of central Western Ghats

study. These sites are biologically rich but differ with respect to bio-climate and the cultural milieu (Bhat, 2013). The geographical details of the study sites, number of respondents in each village is provided in the Table 1. The coastal zone is situated at an altitude of 20-300 m and receives an average annual rainfall of 3537 mm. The mean maximum temperature ranges from 25-36°C. The upper-Ghat bioclimatic zone is in the crest-line of the Western Ghats hill chain at 400-600 m. The area receives an average annual rainfall of 2830 mm. The mean maximum temperature ranges from 25-32°C.

Villages were surveyed for documenting tropical fruit tree genetic resources and associated TK through personal interview at the household level. The focus was on documenting the TFT diversity in each village, essentially on local varieties. Traditional knowledge in the form of cultivation practices, uses (medicinal, culinary and other uses) and knowledge about species diversity in their village *etc.* were documented. Household was the unit of primary data collection. A pre-tested structured questionnaire was used to collect data on household information, TFT diversity and traditional knowledge associated after taking the Prior Informed Consent (PIC) from the respondents. The criteria for salient difference between varieties/species, as perceived by the farmers, were arrived at through the interviews. This essentially comprises of farmers' descriptors of the local varieties. Farmers' descriptors are those traits used by farmers of

a given location to distinguish varieties of a species. Some of the farmers' descriptors used in distinguishing the varieties were fruit colour, skin texture, taste, aroma and fruiting season. This formed the major knowledge base on traditional classification of TFTs. Interviews of the local communities were recorded through audio-recording devices.

Cultural Importance (CI) Index of each species was computed following Philips and Gentry (1993). This index measures the use-value of a plant by considering the number of informants citing a given use-value.

$$CI = \sum_{i=1}^{i=NU} \frac{URi}{N}$$

Where 'N' is the number of informants, 'NU' is the number of use-values cited and 'UR' is the number of different uses mentioned by each informant *i*.

Results and Discussion

A total of 43 TFT species were recorded from different production systems such as home-gardens, forests, orchards and *bettaland* (a kind of usufruct forest patch provided by the State Forest Department as an incentive to the betel nut farmers in the district of Uttara Kannada) within the study sites (Appendix 1). The villages in the upper-Ghat region recorded 42 TFTs, the coastal villages recorded about 31 TFT species. Each species

Table 1. Geographic features, number of households visited in two bioclimatic zones of central Western Ghats

Village/site	Bioclimatic zone	Latitude	Longitude	Altitude (m above msl)	No. of households interviewed
Salkani	Upper-Ghat	14°39'31"N	74°43'22"E	543 m	40
Killara	Upper-Ghat	14°17'33.1"N	74°53'18.3"E	560 m	40
Kallabbe	Coast	14°23'11.7"N	74°28'46.6"E	25 m	40
Murur	Coast	14°26'54.02"N	74°28'47.3"E	25 m	40

Table 2. Use values of tropical fruit tree genetic resources in four typical villages of Uttara Kannada district

S.No.	Species	Uses*													Total no. of uses
		1	2	3	4	5	6	7	8	9	10	11	12	13	
1	<i>Artocarpus heterophyllus</i>	✓	✓	-	✓	✓	✓	✓	-	✓	✓	-	✓	✓	10
2	<i>Mangifera indica</i>	✓	-	-	✓	✓	✓	✓	-	-	✓	✓	✓	✓	09
3	<i>Phyllanthus emblica</i>	✓	-	-	✓	✓	✓	-	-	✓	-	✓	✓	✓	08
4	<i>Citrus limon</i>	-	-	-	✓	✓	✓	-	-	✓	-	-	✓	✓	06
5	<i>Anacardium occidentale</i>	✓	✓	-	✓	✓	-	-	✓	-	-	-	-	-	05
6	<i>Garcinia indica</i>	-	✓	-	✓	✓	-	-	-	✓	-	-	✓	-	05
7	<i>Psidium guajava</i>	✓	-	-	✓	-	-	-	-	✓	-	-	✓	✓	05
8	<i>Carissa carandus</i>	✓	-	-	✓	✓	✓	-	-	✓	-	-	-	-	05
9	<i>Citrus maxima</i>	✓	-	-	✓	-	✓	-	-	✓	-	-	-	-	04
10	<i>Garcinia gummi-gutta</i>	-	-	✓	✓	✓	-	-	-	✓	-	-	-	-	04
11	<i>Gardenia gummifera</i>	✓	-	-	-	-	-	-	-	✓	-	-	-	-	03
12	<i>Carica papaya</i>	✓	-	-	-	✓	-	-	-	✓	-	-	-	-	03
13	<i>Citrus aurantifolia</i>	-	-	-	✓	✓	-	-	-	✓	-	-	-	-	03
14	<i>Zizyphus rugosa</i>	✓	-	-	-	✓	-	-	-	✓	-	-	-	-	03
15	<i>Averrhoa bilimbi</i>	-	-	-	✓	-	✓	-	-	✓	-	-	-	-	03
16	<i>Syzygium cumini</i>	-	✓	-	-	-	-	-	-	✓	-	-	-	-	02
17	<i>Anona reticulata</i>	✓	-	-	-	-	-	-	-	✓	-	-	-	-	02
18	<i>Flacourtia montana</i>	✓	-	-	-	-	-	-	-	✓	-	-	-	-	02
19	<i>Theobroma cacao</i>	✓	-	-	-	✓	-	-	-	-	-	-	-	-	02
20	<i>Artocarpus altilis</i>	-	-	-	✓	✓	-	-	-	-	-	-	-	-	02
21	<i>Spondias pinnata</i>	✓	-	-	✓	-	-	-	-	-	-	-	-	-	02
22	<i>Tamarindus indica</i>	✓	-	-	✓	-	-	-	-	-	-	-	-	✓	02
23	<i>Semecarpus anacardium</i>	✓	-	-	-	-	-	-	-	✓	-	-	-	-	02
24	<i>Terminalia bellerica</i>	-	-	-	-	✓	-	-	-	✓	-	-	-	-	02
25	<i>Citrus limetta</i>	✓	-	-	-	✓	-	-	-	-	-	-	-	-	02
26	<i>Ficus glomerata</i>	✓	-	-	-	-	-	-	-	✓	-	-	-	-	02
27	<i>Punica granatum</i>	✓	-	-	-	-	-	-	-	✓	-	-	-	-	02
28	<i>Phyllanthus acidus</i>	✓	-	-	-	-	-	-	-	✓	-	-	-	-	02
29	<i>Aporosa lindleyana</i>	✓	-	-	-	-	-	-	-	-	-	-	-	-	01
30	<i>Citrus sinensis</i>	✓	-	-	-	-	-	-	-	-	-	-	-	-	01
31	<i>Achras zapota</i>	✓	-	-	-	-	-	-	-	-	-	-	-	-	01
32	<i>Syzygium jambos</i>	✓	-	-	-	-	-	-	-	-	-	-	-	-	01
33	<i>Ziziphus oenoplea</i>	✓	-	-	-	-	-	-	-	-	-	-	-	-	01
34	<i>Elaeagnus conferta</i>	✓	-	-	-	-	-	-	-	-	-	-	-	-	01
35	<i>Citrus paradisi</i>	-	-	-	-	✓	-	-	-	-	-	-	-	-	01
36	<i>Syzygium malaccense</i>	✓	-	-	-	-	-	-	-	-	-	-	-	-	01
37	<i>Averrhoa carambola</i>	-	-	-	✓	-	-	-	-	-	-	-	-	-	01
38	<i>Buchanania lanzan</i>	✓	-	-	-	-	-	-	-	-	-	-	-	-	01
39	<i>Rourea santaloides</i>	✓	-	-	-	-	-	-	-	-	-	-	-	-	01
40	<i>Syzygium caryophyllatum</i>	✓	-	-	-	-	-	-	-	-	-	-	-	-	01
41	<i>Arocarpus hirsuta</i>	-	-	-	✓	-	-	-	-	-	-	-	-	-	01
42	<i>Artocarpus lakoocha</i>	-	-	-	✓	-	-	-	-	-	-	-	-	-	01

*** Code for uses:**

1. Fresh fruit consumed

2. Seeds consumed

3. Seed butter extracted

4. General culinary use

5. Special dish

6. Pickle making

7. Papad /chips-making

8. Wine making

9. Medicinal purpose

10. Timber

11. Used as mulch

12. Wind break

13. Religious purpose

was categorized into thirteen broad use-values (Table 2). It was found that *Artocarpus heterophyllus* (jackfruit), *Mangifera indica* (mango) and *Phyllanthus emblica* (gooseberry) were used for higher number of uses.

Traditional knowledge was recorded for tropical fruit tree species under four broad use-values viz., related to

culinary use, medicinal use, processing and preservation and related to nursery and maintenance. Seventy four traditional knowledge associated with TFTs were recorded from the study sites (shown as the Appendix 2). It was noted that traditional knowledge related to culinary uses and processing of TFTs were practised even today.

Table 3. Cultural Importance Value index of TFT species (the species that are considered under the TFT project are in bold); the species have been organized according to the overall CI value

S.No.	Species	Cultural index values		
		Pooled over all the Upper-Ghat villages	Pooled over all the Coastal villages	Overall CI
1	<i>Mangifera indica</i>	5.475	4.54	4.64
2	<i>Artocarpus heterophyllus</i>	5.65	2.185	3.90
3	<i>Garcinia indica</i>	3.05	2.28	2.74
4	<i>Anacardium occidentale</i>	2.15	1.93	2.005
5	<i>Citrus limon</i>	1.7	0.65	1.225
6	<i>Averroha bilimbi</i>	0.75	1.01	1.0
7	<i>Citrus sinensis</i>	1.0	1.0	1.0
8	<i>Citrus aurantifolia</i>	0.9	0.1	0.9
9	<i>Carissa carandus</i>	0.8	0.1	0.8
10	<i>Zizyphus rugosa</i>	0.625	1.25	0.75
11	<i>Tamarindus indica</i>	1.0	0.5	0.75
12	<i>Achras zapota</i>	0.81	0.5	0.66
13	<i>Aporosa lindleyana</i>	0.88	0.43	0.64
14	<i>Zizyphus oenoplea</i>	0.7	0.65	0.61
15	<i>Carica papaya</i>	0.975	0.55	0.603
16	<i>Psidium guajava</i>	0.7	0.6	0.53
17	<i>Citrus maxima</i>	0.625	0.5	0.5
18	<i>Syzygium cumini</i>	0.45	0.36	0.48
19	<i>Syzygium caryophyllatum</i>	0.78	0.25	0.48
20	<i>Flacourtia montana</i>	0.78	0.38	0.42
21	<i>Buchanania lanzan</i>	0.41	-	0.41
22	<i>Ficus glomerata</i>	0.38	0.44	0.41
23	<i>Artocarpus hirsuta</i>	0.6	0.32	0.40
24	<i>Phyllanthus emblica</i>	1.35	1.31	0.35
25	<i>Rourea santaloides</i>	0.38	-	0.35
26	<i>Annona reticulata</i>	0.65	0.5	0.35
27	<i>Artocarpus altilis</i>	0.2	0.44	0.34
28	<i>Garcinia gummi-gutta</i>	1.4	0.25	0.33
29	<i>Gardenia gummifera</i>	0.638	-	0.32
30	<i>Artocarpus lakoocha</i>	0.125	0.025	0.31
31	<i>Averroha carambola</i>	-	0.05	0.25
32	<i>Elaeagnus conferta</i>	0.20	-	0.20
33	<i>Garcinia morella</i>	0.375	-	0.19
34	<i>Syzygium malaccense</i>	0.325	-	0.163
35	<i>Spondias pinnata</i>	0.25	1.0	0.14
36	<i>Citrus paradisi</i>	0.12	-	0.12
37	<i>Citrus macroptera</i>	0.1	-	0.1
38	<i>Syzygium jambos</i>	0.125	-	0.07
39	<i>Terminalia bellerica</i>	0.1	0.1	0.05
40	<i>Theobroma cacao</i>	0.15	0.2	0.03
41	<i>Semecarpus anacardium</i>	0.275	0.02	0.03
42	<i>Phyllanthus acidus</i>	0.01	-	0.01

However, traditional knowledge related to medicinal uses showed a decreasing trend, where traditional medicines are being replaced with modern medicines. Home remedies followed for common ailments such as cold, fever, bile reflux and cough were found to be out of practice. However, the knowledge was still held by the community members.

Out of the 43 TFT species recorded from the four villages, about 20 species were used for their culinary use. Out of the 41 species surveyed in the upper-Ghat

villages over 15 were used for culinary use, while the coastal villages with 33 TFT species surveyed about 17 species were used for culinary purposes as mentioned in Table 3. Jackfruit was the most widely used fruit species, with more than 8 dishes prepared. Maximum number of informants (85 per cent) responded about the use of jackfruit for culinary uses. However, upper-Ghat villages recorded more number of dishes/cuisines and more uses (number of households) of TFT genetic resources in culinary use when compared to the coastal villages.

Pickle making was one of the common-most use of the TFTs (N=60) wherein tender mango was used for pickle preparation. People in the upper-Ghat villages showed larger involvement in identifying the better varieties of pickle mango than those from the coastal region.

Out of the 42 species surveyed in two villages of upper-Ghat and coastal zones of Uttara Kannada 16 TFT species were used for medicinal purpose. Lemon juice was prominently used in both bioclimatic zones for medicinal purpose; as many as 14 species were used in the upper-Ghat villages, while 13 species were used in the coastal villages for the same purpose. Use of Indian gooseberry in combination with other plants is a useful medicine for controlling diabetes. Several contemporary literatures support the evidence of use of Indian gooseberry in treating diabetes, inflammatory ailments and asthma etc. (Sampath Kumar *et al.*, 2012; Hussain *et al.*, 2008). The dried fruits are used by the local communities of Uttara Kannada in controlling diabetes and other ailments like breathing problems. Dried jackfruit seeds are used like almond or cashew seeds after frying in oil.

Out of the total 43 species of TFT genetic resources recorded, processing and preservation is done mainly for two species *viz.* 'Appemidi' and *Garcinia* species. Relatively more number of households in the upper-Ghat villages showed participation in processing of both of these fruits. 'Appemidi' (aromatic pickle mango type) has been recently provided with the geographic indication registry by the Government of India (Source: <http://ipindia.nic.in/girindia/images/RegGis.gif>; Gautam *et al.*, 2012).

Cultural Importance (CI) Index is an additive index that takes into account the spread of use (number of informants) for each species and the diversity of uses (number of use) (Manuel *et al.*, 2007). The total number of uses for each species is added to understand the importance of different species found in a particular region. CI was calculated for all the 42 TFT genetic resources recorded from the four typical villages of upper-Ghat and coastal zones. The theoretical highest value of CI is the number of its uses. When the number of uses and the number of users increase, CI value also increases.

Mango showed highest value for CI when considered for each bioclimatic zone as well as when the data

was pooled over all the villages (Table 3). Further, the other two species that show relatively higher values of CI are jackfruit and *Garcinia indica*. Rest of the species showed CI value of less than one. The major TFT genetic resources grown in the home-gardens and farmlands such as *Anacardium occidentale*, *Citrus* species, *Achras zapota*, *Phyllanthus emblica*, *Carissa carandus* and *Averrhoa bilimbi* showed more number of uses for culinary and medicinal values. Preference of a species by farmers seems to be positively associated with the use of that species for household consumption. CI value of a species showed strong correlation with the frequency of occurrence of a species.

The use of *Garcinia indica* is popular among the local communities of Uttara Kannada. Its fruit rind and seeds are used in treating wide range of ailments like fever, cough, bile reflux, obesity, skin problems and for culinary uses. Butter extracted from the seeds is an excellent skin moisturizer used by the local communities. Juice is extracted from the fruit rind are stored in the form of squash for a period of 6-12 months. The juice is served during the hot summers, which is a coolant. Another *Garcinia* species available in the locality *Garcinia gummi-gutta* is also used in extracting butter. *Garcinia* species are preferred for their medicinal uses (Baliga *et al.*, 2011; Jena *et al.*, 2002).

Conclusions

The present study showed that a significant level of TK on the use of TFTs exists in both upper-Ghat and coastal zone of central Western Ghats. The difference in traditional knowledge associated with TFTs is not very prominent between the two bioclimatic zones. However, practice of traditional knowledge was higher in the upper-Ghat villages. Large scale migration of rural youth has been observed in the coastal villages when compared to the upper-Ghat villages is the perceived reason for the same. Rapid documentation of TK needs to be done and such documents should be made available at the local institutions such as village *panchayat*. This could lead to the empowerment of local communities. Creating awareness is important by involving young children so that traditional knowledge evolved over centuries is transferred adequately to the next generation. Documentation of traditional knowledge not only ensures its protection against theft but also ensures financial benefits to the knowledge holder when commercial sectors exploit the knowledge. Community biodiversity register

is an effective tool to officially document the TK and to empower local people (Rijal *et al.*, 2003).

Acknowledgements

This work was partially supported within the framework of the UNEP/GEF Regional Project, “Conservation and Sustainable Use of Cultivated and Wild Tropical Fruit Diversity: Promoting Sustainable Livelihoods, Food Security and Ecosystem Services” implemented by India, Indonesia, Malaysia and Thailand. The project is coordinated by Bioversity International with financing from the Global Environmental Facility (GEF), and implementation support from the United Nations Environment Program (UNEP) and the views expressed here are not necessarily those of UNEP/GEF. We sincerely thank all farming community of Salkani, Kilara, Murur and Kallabbe village who kindly consented and cooperated to provide the information.

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Appendix 1

Tropical fruit tree species recorded in four typical villages belonging upper-Ghat and coastal bioclimatic zones of Uttara Kannada district

S. No.	Scientific Name	Common Name	Family	Native/ Introduced	Villages				Production system
					Salkani	Killara	Murur	Kallabbe	
1.	<i>Anacardium occidentale</i>	Geru	Anacardiaceae	I	✓	✓	✓	✓	Orchard and Bettaland
2.	<i>Mangifera indica</i>	Mavu	Anacardiaceae	N	✓	✓	✓	✓	Home-garden and orchard
3.	<i>Garcinia indica</i>	Murugalu	Clusiaceae	N	✓	✓	✓	✓	Forest/orchard
4.	<i>Artocarpus heterophyllus</i>	Halasu	Moraceae	N	✓	✓	✓	✓	Home-garden
5.	<i>Garcinia gummi-gutta</i>	Uppage	Clusiaceae	N	✓	✓	-	✓	Orchard
6.	<i>Achras zapota</i>	Chikku	Sapotaceae	I	✓	✓	✓	✓	Home-garden
7.	<i>Citrus limon</i>	Nimbu	Rutaceae	N	✓	✓	✓	✓	Home-garden
8.	<i>Carica papaya</i>	Papaya	Caricaceae	I	✓	✓	✓	✓	Home-garden
9.	<i>Phyllanthus emblica</i>	Nelli	Euphorbiaceae	N	✓	✓	✓	✓	Bettaland and Home-garden
10.	<i>Theobroma cacao</i>	Cocoa	Sterculiaceae	I	✓	-	✓	✓	Home-garden
11.	<i>Artocarpus altilis</i>	Beru halasu	Moraceae	N	✓	✓	✓	✓	Home-garden
12.	<i>Citrus aurantifolia</i>	Huli Kanchi	Rutaceae	N	✓	✓	-	✓	Home-garden
13.	<i>Psidium guajava</i>	Perale	Myrtaceae	N	✓	✓	✓	✓	Home-garden
14.	<i>Averrhoa bilimbi</i>	Bimbli	Oxalidaceae	N	-	-	✓	✓	Home-garden
15.	<i>Citrus maxima</i>	Sakkare Kanchi	Rutaceae	N	✓	✓	✓	✓	Home-garden
16.	<i>Anona reticulata</i>	Ramaphala	Anonaceae	N	✓	✓	✓	✓	Home-garden
17.	<i>Citrus paradisi</i>	Panaka Nimbu	Rutaceae	I	✓	-	✓	✓	Home-garden
18.	<i>Syzygium malaccense</i>	Jambe	Myrtaceae	N	✓	✓	-	-	Home-garden
19.	<i>Citrus sinensis</i>	Kittale	Rutaceae	N	✓	✓	-	-	Home-garden
20.	<i>Syzygium jambos</i>	Pannerale	Myrtaceae	N	✓	✓	✓	✓	Home-garden
21.	<i>Averrhoa carambola</i>	Dare Huli/ Karimadala	Oxalidaceae	N	-	-	✓	✓	Home-garden
22.	<i>Spondias pinnata</i>	Amte	Anacardiaceae	N	-	✓	✓	✓	Home-garden
23.	<i>Phyllanthus acidus</i>	Rajanelli	Euphorbiaceae	N	✓	-	-	✓	Home-garden
24.	<i>Tamarindus indica</i>	Hunase	Fabaceae	I	-	✓	✓	✓	Home-garden
25.	<i>Citrus macroptera</i>	Dadli	Rutaceae	N	✓	✓	-	-	
26.	<i>Artocarpus hirsuta</i>	Hebbalasu	Moraceae	N	✓	✓	✓	✓	Forest
27.	<i>Phyllanthus emblica</i>	Nelli	Euphorbiaceae	N	✓	✓	✓	✓	Bettaland
28.	<i>Syzygium cumini</i>	Nerale	Myrtaceae	N	✓	✓	✓	✓	Forest/ Bettaland
29.	<i>Ziziphus rugosa</i>	Mulle Hannu	Rhamnaceae	N	✓	✓	✓	✓	Forest / Bettaland
30.	<i>Aporosa lindleyana</i>	Challe Hannu	Euphorbiaceae	N	✓	✓	✓	✓	Forest/ Bettaland
31.	<i>Buchanania lanzan</i>	Nurukalu	Anacardiaceae	N	✓	✓	-	-	Forest/ Bettaland
32.	<i>Flacourtia montana</i>	Sampige Hannu	Flacourtiaceae	N	✓	✓	✓	✓	Forest
33.	<i>Rourea santaloides</i>	Hulinajjige Hannu	Connaraceae	N	✓	✓	-	-	Forest
34.	<i>Ziziphus oenoplea</i>	Parage Hannu	Rhamnaceae	N	✓	✓	-	-	Forest/ Bettaland
35.	<i>Carissa carandus</i>	Kaulikayi	Apocynaceae	N	✓	-	✓	✓	Forest
36.	<i>Elaeagnus conferta</i>	Halage Hannu	Elaeagnaceae	N	✓	✓	-	-	Forest
37.	<i>Gardenia gummifera</i>	Bikke	Rubiaceae	N	✓	✓	-	-	Forest
38.	<i>Semecarpus anacardium</i>	Guddegeru	Anacardiaceae	N	✓	✓	✓	✓	Forest
39.	<i>Syzygium caryophyllatum</i>	Kuntanerale	Myrtaceae	N	✓	✓	✓	✓	Forest/ Bettaland
40.	<i>Terminalia bellerica</i>	Anale	Combretaceae	N	✓	✓	✓	✓	Forest
41.	<i>Garcinia morella</i>	Arishina Gurage	Clusiaceae	N	-	✓	-	-	Forest
42.	<i>Artocarpus lakoocha</i>	Vate	Moraceae	N	✓	✓	✓	✓	Forest
43.	<i>Ficus glomerata</i>	Attihannu	Moraceae	N	✓	✓	-	-	Home-gardens

Appendix 2

Traditional knowledge associated with tropical fruit trees recorded in the study locations

a. Culinary uses

S.No.	Species/variety	Use	Part used	Brief procedure	Remarks
1.	Jackfruit	<i>Kadabulidli</i>	Fruit rind	Grind the flakes. Add milled rice flour, jaggery, salt and bake in a banana leaf.	Special sweet dish
		Papad	Fruit	Separate the flakes from seeds. Boil in water, grind and apply the paste on a cocoa leaf.	This papad is usually roasted on open flame or else can be cooked in coconut oil.
		<i>Holige</i>	Seeds	Boil the seeds in water, add jaggery. Grind them & make them into tiny balls. Add water and turmeric powder to wheat flour. Stuff grinded seeds into flour balls.	A traditional sweet dish
		<i>Neeragojju</i>	Flakes and seeds	Boil the flakes and seeds in water. Add salt, lemon juice and season with green chili, cumin seeds, asafoetida, mustard & coriander.	It is a type of gravy, usually mixed with rice for taste
		Finger chips	Flakes	Cut the flakes in finger-shape. Fry them. Add salt, red chili powder, cumin powder, asafoetida whilst still hot.	Flakes are expected to be less sweet and crispy
		<i>Genasale</i>	Flakes	Grind the fruit flakes with rice flour, grated coconut, jaggery and salt. Wrap in a banana leaf and bake.	A type of sweet
		<i>Gudna</i>	Seeds	Remove the seed coat and boil. Add salt, jaggery, grated coconut,	
2.	Mango	<i>Gojju</i>	Pulp	Soak the fruit in salt water for some time. Then season it with oil, mustard seeds, green chilli and garlic. Add butter milk after some time.	A type of gravy
		<i>Appehuli</i>	<i>Appe</i> (unripe mango) sap	Add few drops of sap to water. Add salt and jaggery to it. Then season with mustard seeds & green chili.	It improves digestion. It is also taken after major meal
		Pickle	<i>Appe</i> varieties	Mix the appe with salt in layers for 5- days. Dry thoroughly and add the pickle masala. Keep in an air-tight container for few months before it is ready for use.	Pickle from different varieties can be stored from 6 months to 2-3 years. The shelf life depends on the mango variety and procedure
		' <i>Halwa</i> '	Fruit	Juice is extracted from the fruit rind. Boil it after adding sugar. Allow to cool for some time.	It is a type of dessert
3.	White <i>Garcinia indica</i>	Juice	Fruit skin	Soak the skin overnight in water. Season with mustard seeds, cumin seeds, chili and add a pinch of salt.	It has medicinal property. Good for acidity, <i>kapha</i> and bile problems
		Curry	Fruit skin	Soak the fruit in water. Add red chili, clove, black pepper, cinnamon and grind well. Season with cumin and coriander leaves. Add salt.	
		Fish curry	Dried fruit rind	Sun-dry the fruit for few days.	Added as a flavouring agent
	<i>Garcinia indica</i> (Kokum)	Butter	Seeds	Extracted butter is used as cooking oil and for roasting <i>dosa</i> .	<i>Garcinia</i> butter has excellent crack-healing property. It is used as skin moisturizer during winter
4.	<i>Ziziphus rugosa</i> (Bili-Mullehannu)	Juice	Fruit	Separate the fruit from seeds. Add jaggery and grind well.	Acts as a coolant. Keeps the body hydrated
5.	Cashew & Jackfruit	Dry fruits	Seeds	Roast the seeds and eat.	The seeds are roasted and eaten like almond
		Wine	Fruits (cashew)	Juice is extracted and kept in a container below the ground for few days until fermentation process occurs. The juice is processed and wine is obtained.	People followed a crude method for wine preparation
6.	<i>Artocarpus hirsuta</i> (Wild Jack)	Curry	Fruit	This fruit is used as vegetable.	
8.	<i>Spondias pinnata</i> (<i>Amte</i>)	Curry	Fruit	Flavouring agent and adds sour taste to curry.	

b. Medicinal purposes

S. No.	Species	Problem	Part used	Brief procedure	Remarks
1.	Mango	Dysentery	Fruit juice	Mix few drops of mango juice with lemon juice. Make a paste from mango bark using the juice.	Works best for mild form of the problem
	<i>Huli</i> (sour) mango variety	Severe dysentery	Fruit juice	Prepare paste from the bark of ' <i>Huli</i> mango' variety in water	Not in practice these days
	Tender mango (<i>appe</i>)	Intestinal worm problem	Tender endocarp	Eat fresh endocarp of tender mango	Works like a tablet
2.	<i>Syzygium cumini</i> (Jamun)	Bark	Diabetes	Make a paste with water and take regularly.	This treatment keeps a check on sugar level in diabetic patients if good care taken on diet
3.	Gooseberry	Fruits	Diabetes	Roast the fruits in ghee and add fenugreek, jaggery, butter milk and drink regularly.	Gooseberry and fenugreek can be made into powder and stored. This mixture can be used as and when needed
4.	<i>Garcinia indica</i>	Fruit rind	Dysentery	<i>Garcinia</i> butter is mixed with garlic.	For mild dysentery
		Fruit rind	Severe dysentery	<i>Garcinia</i> butter is taken in tea decoction. It can also be taken with rice.	Still used in the villages for dysentery in kids
		Fruit rind (juice)	Bile	Soak the dried fruit rind in water overnight. Drink in the morning before breakfast.	
5.	Papaya	Seeds	Intestine worm	Dry the seeds, powder them. One spoon per one glass of water is recommended.	It is a knowledge held by the local community but not in practice these days
		Fruits	Obesity	Regularly eating papaya fruits is helpful in reducing the weight in overweight persons.	
6.	<i>Citrus limon</i>	Juice	Headache	Put a few drops of lemon juice into hot water and inhale the vapour.	
7.	<i>Annona reticulata</i>	Seeds	Cough Head lice	Add some sugar to lemon juice and drink. Crush the seeds, add coconut oil and apply during night time. Wash the hair in the morning.	Highly effective
8.	<i>Terminalia bellerica</i>	Fruits	Dysentery	Dry the fruits and powder them. Add water and drink.	It is not advisable to pregnant women, which could result in abortion
9.	<i>Gardenia gummifera</i>	Leaf	Indigestion in cattle	Crush the leaves. Add water and feed it to cattle.	

c. Processing and preservation of TFT

S.No.	Species	Part	Use	Brief procedure	Remarks
1.	Mango	Tender mango	Pickle	Separate the waste from the fruits. Soak them in salt water until they shrivel and turn to light brown.	They can be kept for few months
		Sap collection from tender mango	Flavouring agent	Cut the stalk and keep the fruit inverted in a bottle until all the sap is collected.	Stored for a long time (1 year) if kept in air-tight bottle
		Fruits	Ripening	Mango unripe fruits are kept in paddy straw.	It is believed to accelerate ripening process
2.	Jackfruit	Seeds	Eaten like badam, almond	Mix termite soil with the seeds. Keep the seeds in copper vessels.	Shelf life is up to 4-5 months
		Flakes	Edible	Preserved in brine solution	Can be stored up to 7-8 months
3.	<i>Garcinia indica</i>	Seeds	Butter	Separate the seeds from fruit dry them and mix them with ash to get rid of the slime. Fry them until they start giving off oil. Powder and boil in water. Oil floats on the surface. Remove them and it turns to solid at room temperature.	It has excellent medicinal properties and is also used as a natural skin moisturizer, especially during winter
		Seeds	Preservation	Seeds are separated from the fruits. The seeds are mixed with ash. Mixing with ash makes the seeds slime-free and extends the shelf life.	The ash-mixed seeds can be used for sowing as well for other uses like butter extraction
4.	<i>Garcinia indica</i> (White fruit type)	Fruit rind	Squash	Extract juice, add sugar and dry in sun.	It can be stored up to 6 months

d. Pest and disease management

S.No.	Species	Treatment	Brief procedure	Remarks
1.	Mango	Lime water Light burning	Mango fruits are dipped in lime water once to protect from pest and diseases. Arecanut husk is burnt underneath the tree. The smoke is helpful to ward off sucking pests.	It is also supposed to accelerate ripening
2.	Jackfruit	Coating with red soil	Jackfruit seeds are coated with red soil and sun-dried. Then the seeds are stored in mud pots which are stored in muddy pits.	The area should be dry so as to avoid water logging condition. Seeds could be preserved up to 6 months