Research Paper

Future of Food: Journal on Food, Agriculture and Society
9 (2) January 2021

Dependency and economic benefits of the use of wild food plants among tribal communities in Malai Madeshawara Hills wildlife sanctuary, Southern India

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Data of the article

First received : 26 February 2020 | Last revision received : 22 September 2020
Accepted : 07 November 2020 | Published online : 31 January 2021
DOI : 10.17170/kobra-202011192211

Keywords

Wild food plants, indigenous community, dependency, economic benefits

Wild food plant resources and their indigenous knowledge of use are in danger of being lost in areas where rapid environmental and cultural transformations have led to changes in eating habits and practices. The study assesses the dependency and economic value of wild food plant use among forest-dwelling communities. Community perceptions were used to assess the usage patterns among the two communities. The data was collected through a combination of semi-structured interviews, household questionnaire surveys, and focus group discussions in eight villages. Wild food plants are of vital importance to local communities in terms of food security, dietary diversity, and household economy. Local communities use wild plant species as vegetables, fruits, beverages, in traditional therapeutic practices, and as a symbol of ethnic identity. The taxonomical distribution and diversity of 124 species belonging to 57 families and 91 genera were assessed. The cash value of wild food plants to a household ranged from ₹ 15 to 20 per cent of the annual income. These plants are a reliable safety net for many households and play a vital role in the livelihoods of the local people. The study highlights the dependency and livelihood importance of these plants.

1. Introduction

Wild food plants (WFPs) naturally grow in forests, farmlands, fallow land, roadside, and near bodies of water and streams without human care and are used by local people as sources of food. A large number of people around the world depend on these WFPs, as these not only contribute to food and medicine but also as vital sources of micronutrients. The WFPs are also part of the socio-cultural practices of indigenous communities (Grivetti & Ogle, 2000; Agea *et al.,* 2011; FAO, 2017). Despite the primary reliance of most resource-poor villagers on staple crop plants, the tradition of eating WFPs continues to the present day. In recent years there is a global interest in documenting ethnobotanical information on neglected wild edible food sources.

Over the centuries, people have relied on WFPs resources for their subsistence as they are an efficient and cheap source of several vital micronutrients (Salvi & Katewa, 2016). The dependency on WFPs for food,

nutrients, and therapeutic use exists across the globe (Shumsky *et al.,* 2014; Raghavendra *et al.,* 2017). In tropical Asia and Sub-Saharan Africa, a large number of people are dependent on WFPs as their source of food. The WFPs serve as a "safety net", especially during drought and since these WFPs are quite hardy, that can adapt to local environmental change and bridge the hunger gap (Tebkew *et al.,* 2014; Shumsky *et al.,* 2014; Joshi *et al.,* 2015; Thakur *et al.,* 2017;). Over a thousand WFPs exist in India, and more than 60 % of rural people use these WFPs as their regular food (Rathore, 2009). Despite India being rich in WFPs resources as well as indigenous knowledge of use, their values are not accounted for in any of the economic analyses of natural resources (Bharucha & Pretty, 2010; Raghavendra *et al.,* 2017). These plant resources and their indigenous use are in danger of being lost in areas where environmental and cultural transformations have led to changes in feeding practices (Raghavendra *et al.,* 2017). Further, the degree of WFPs use and its significance is not fully understood (Puri *et al.,* 2015; Sansanelli *et al.,* 2017). The WFPs are also absent from regional and national food balance sheets that guide policies on aid, trade, and the announcement of food crises (Bharucha and Pretty, 2010; Raghavendra *et al.,* 2017).

A forest-dependent community's livelihood is characterized by the relative contribution of each livelihood activity in the form of monetary or non-monetary value. A monetary contribution to household livelihood comes from formal cash income either through local daily wages, government grants, pensions, livestock, and collection of Non-Timber Forest Produce (NTFPs) (Shaanaker *et al.,* 2004; Puri *et al.,* 2015). Many studies have revealed that non-farm activities account for more than 70% of the total livelihood of households in India (Raghavendra *et al.,* 2017). Historically, subsistence farming, collection of WFPs for self-consumption, and other forest resources used in day- to- day needs constitute non-monetary benefits. The contribution of non-monetary benefits to the total household's income is critically important (Laucena *et al.,* 2007; Ojelel & Kakudidi, 2015;). A community's traditional use of WFPs is part of living links with the land and the plants of the region (Bhatia *et al.,* 2018).

For instance, Philips and Gentry (1993) developed a use-value index, and later, Pieroni (2001), developed a cultural food significance index. Gracia et al. (2006) developed a method to value plant species based on their economical and practical characteristics.

The contribution of WFPs to rural household income is significant and plays a vital role in rural livelihoods in developing countries (Joshi *et al.,* 2015). Yet, the economic values of WFPs have not been assessed at the state or national or international level (Shumsky *et al.,* 2014). Many attempts were made to quantify the economic benefits of WFPs (Bharucha & Prety, 2010). Still, few studies have supplemented the economic valuation of WFPs with presumptions of complexity in the quantitative assessment. Most of the data available has been obtained from case studies on individual local communities or community groups, which do not have authenticity in many cases (Singh *et al.,* 2016). Further, most of the plants collected are used for consumption through sharing or bartering (Geng *et al.,* 2016). The economic value of WFPs consumption in forested communities is thus poorly understood (Agea *et al.,* 2011; Gracia *et al.,* 2015).

In the Malai Madeshwara Hills Wildlife Sanctuary (MM Hills), both the Soliga and Beda Gampana communities, locally known as Lingayat, depend on WFPs resources. WFPs have been a part of their food security, providing cultural and social identity, as well as providing economic supplement for many generations (Kothari *et al.,* 2012; Harisha *et al.,* 2015). However, WFPs are ignored in economic and livelihood valuation, and there is a considerable gap in understanding the dependency on WFPs, which plays a vital role in the local people's diet. There is no information available regarding the systematic knowledge collection process and economic valuations that remain absent in the policy framework in the study area.

It is, therefore, important to understand the scope of dependency on WFPs and their economic benefits as dietary alternatives for future foods. However, agricultural yields have failed to satisfy the need for the daily diet as the population is increasing geometrically. To meet this challenge, increasing the use of WFPs in the diet becomes crucial. The importance of the evaluation of the dependency and the economic value of lesser-known WFPs is crucial. It has been realized to a greater extent by the scientific world in recent years. The present study used both qualitative and quantitative information to understand the dependency and economic benefits of WFPs to rural households. The

ISSN-Internet 2197-411x OLCL 862804632
UniKassel & VDW, Germany- January 2021

objectives of the study were: (1) to assess the dependency on WFPs and (2) to assess the economic benefits of WFPs for local communities.

2. Material and methods

2.1. Study site

The study was conducted in MM Hills, located in South India, between latitude 12° 13' and 11° 55' N and 77° 30' and 77° 47'E (Figure 1). It falls in the southern tropical dry zone topography and mountainous north-south trending hill ranges of the Eastern Ghats. The sanctuary covers an area of 906.2 km² and has an undulating terrain and mosaic habitat. The scenic hills and valleys are covered with extensive forests and a chain of continuous mountain peaks with elevation ranging from 600-1380 m.

The climate of MM Hills is quite moderate throughout the year with hot summers and cold winters. The mean annual temperature in the study area is 35.3°C and varies between 24°C in winter to 42°C in summer (Indian Meteorological Data, 2016). It receives rain from the southwest monsoon between May-August and from the northeast monsoon between September-December with a pronounced dry period between January and March. There is considerable variation in rainfall with topography, and the average annual rainfall is 1048mm. However, most of the rain is derived from the northeast monsoon during September-November.

The forest abounds with a large variety of medicinal herbs used by local people in traditional healthcare, cultural, and religious systems. However, the forests are subjected to much anthropogenic activity, including agriculture, pilgrimage, quarrying, minor forest produce, and fuelwood and other development activities (Shaanker *et al.,* 2004). Despite tremendous anthropogenic pressure, the area is rich in biodiversity with 800 species of higher plants (Champion & Seth, 1968). It has different forest types such as dry deciduous (64.34%), scrub woodland (20.50%), and scattered patches of moist deciduous and riparian forest (2.47%) (Champion & Seth, 1968).

There are 16 settlements (villages) scattered within this sanctuary, with another 15 villages spread around its periphery. The local communities depend

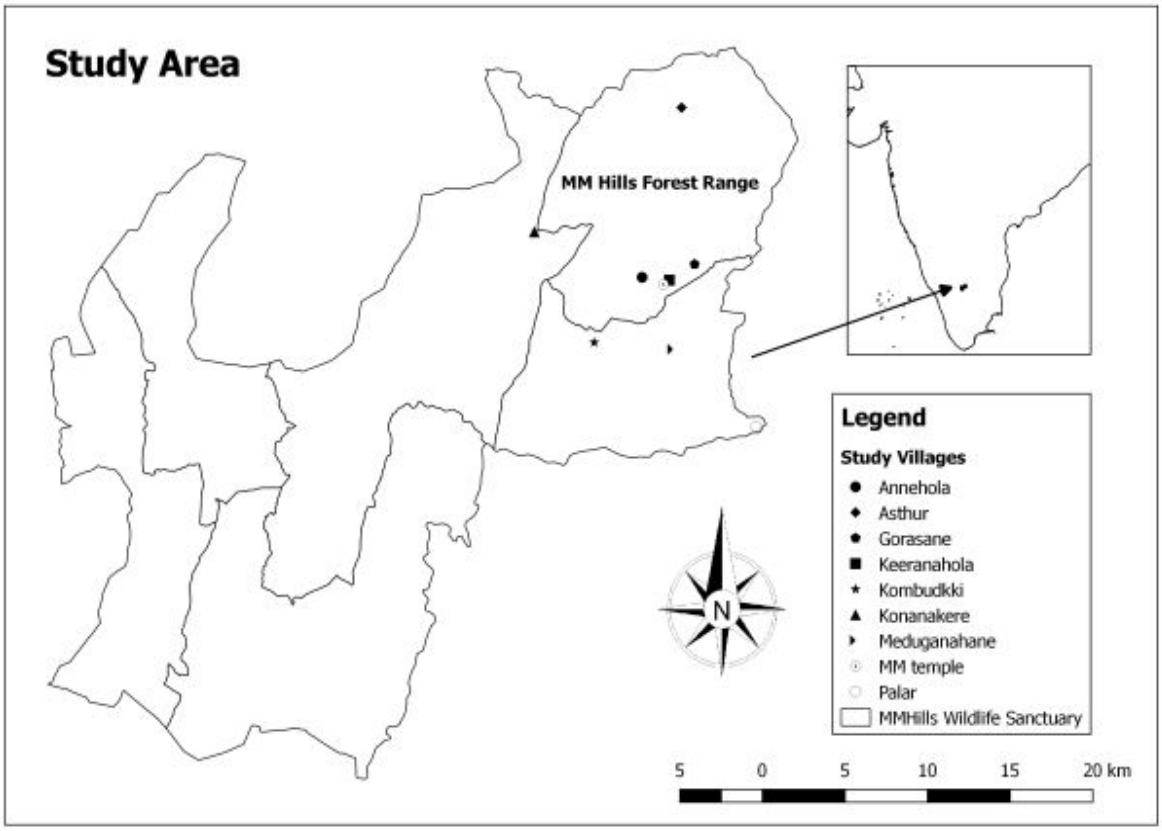

Figure 1. Study area and village locations

on the forest for NTFP and fuelwood collection and for grazing their livestock. They earn their livelihood through agriculture, the sale of NTFP, basket weaving, or through wages working as migratory labourers in stone quarrying or coffee estates and cities (Harisha *et al.,* 2013; Shaanker *et al.,* 2004). About eight villages constitute a homogenous community called Soligas, whereas 23 villages are heterogeneous communities. The Soligas and Beda Gampana are the major communities living in these villages (Table 1).

2.2. Study methods

For the study, eight villages were selected based on the community composition, distance from the town and, location in the forest. Two villages are located at the forest's edge, and the rest are located in the core of the forest. Five villages are located close to town and the main road. Three villages are located in remote forest areas. In four villages both the Soliga and Beda Gampana communities were present, whereas the other four villages only the Soliga community resides. These two indigenous communities have been living in MM Hills for centuries and use common habitat and bioresources. Though they have similar cultural, social, and economic status, they differ in their dietary practices. While the Soligas consume a wide range of both plant and animal-based diet, Beda Gampanas consume an only plant-based diet. All the villages have historically been using WFPs as food, medicine, and as part of their cultural practice. The relevant qualitative and quantitative data was collected from January 2015 to March 2016 through household surveys, key informant interviews, market surveys, and focused group discussions. Prior informed consent (PIC) was taken from the participants for the study with the intent of ensuring welfare, equitable sharing of benefits (monetary and non-monetary), and protection of traditional knowledge. After obtaining the consent from the knowledge holders that the knowledge will be public domain through publication, the data on this study was processed for publication.

Table 1. Socio-economic profile of Soliga and Beda Gampana

Factors	Soliga	Beda Gampana
Family size	4.42 ±2.04	4.60±2.03
Landholding	1.48±1.19	1.67±1.25
Clan system	3 distinct groups (5 clans, 7 clans, and 12 clans)	Only one group (5 clans)
Number of villages (Haadi) where the community is living (distribution)	143 villages in 5 districts	128 villages in 2 districts
Present a diet system	Vegetarian and non-vegetarian	Strictly vegetarian
State reservation category of the community	Scheduled Tribes (ST)	Other Backward Classes (OBC)
Food schemes are available from State Govt.	PDS + special nutritional package (100% free) for every household.	PDS only for Below Poverty Line (BPL) households.
Traditional occupation	Hunter-gatherer now settled in villages and farming	Hunter-gatherer turned priest and farming
Average income/capita/year	₹ 26041.00	₹ 26527.00
Source of income	Migration (69%), Farming (21%), Local labour (3%), NTFPs collection (7%)	Migration (58%), Farming (28%), Local labour (5%), NTFPs collection (9%)
Economic status	>80% of households are below the poverty line	<50% of households are -below the poverty line
Number of WFPs known	112	108
Infant and child mortality rate	Less	More

ISSN-Internet 2197-411x OLCL 862804632
UniKassel & VDW, Germany- January 2021

2.2.1. Exploration with villagers and individual interviews

At the beginning of the study, to collect and document the WFPs, three explorations were conducted in different seasons (summer, rainy, and winter). The rains start in May and continue until December. The winter occurs from November to February and summer from March to May. The transect walk was planned for about 8 kilometres covering major land-use types and WFPs-rich areas, which was decided by the community. The first exploration was conducted in Gorasane village, close to the temple town located in the middle of the forest that represents both communities. Similarly, Palar was selected as another sample village and is located on the edge of the forest, and only the Soliga community lives here. The participants were from both communities, and the average participants for each walk were 15 people, in ages ranging from 30 to 55 years with four women and the rest men.

The walk commonly included farmland, fallow land, forest land, bodies of water, and roadside. While walking in the transect, sample plants were documented and collected for further reference and as herbarium depository. Also, ethnographic information was recorded from the participants on the collected plants while walking through the transect. The collection methods, processing recipe, economic and therapeutic values were also discussed during the walk. At the end of each exploration walk, the plant materials collected were authenticated by knowledgeable older adults.

The preliminary identification and documentation (using scientific and vernacular names) were made by examining fresh plants procured by the villager. The plant material was identified with the help of local flora (Gamble, 1957; Saldhana & Nicholson, 1976). The collected voucher specimens were deposited in the herbarium at the Community-based Conservation Centre (CCC) at MM Hills managed by ATREE. A clear expression of consent was obtained before each interview. Throughout this field study, ethical guidelines, as stated by the International Society of Ethnobiology (ISE, 2013), were adopted.

2.2.2. Household survey

Semi-structured interviews (Newing *et al.,* 2011) were conducted for 184 households from eight villages. Interviews were conducted for 23 households, which was 10% of the total households of the village. The households were selected for the interview by considering the family size (number of people in the house), occupation (farming, daily wage, and others), and literacy level (no schooling, primary school, middle school, high school, and college) to draw reliable information. Women were part of the farming activities in all the families of both communities.

The household survey was conducted from August to November 2015, and the same households were revisited from February to May 2016 to fill the gaps, cross-check, and validate the information on WFP's use and socioeconomic profile. During the interviews, vernacular names and photographs of the wild plants were used along with the questionnaire to avoid confusion. The interviews were focused on the WFPs known, frequency of use, reasons for use, and their economic and dietary values. A list of WFPs known, collected, and used from the farms and forests was prepared separately. The respondents' households were also asked about the crops under cultivation, WFPs collection methods, economic and therapeutic value, and preparation methods (recipe). The household interviews were of 1-3 hours duration, and the households were revisited for reliability.

2.2.3. Focus group discussion

Focus Group Discussions (FGD) were conducted twice a year for 2015 and 2016 in all eight villages. The questions were based on the household interviews and exploration to capture and fill in missing information, and to validate the information during the exploration of the household interviews. FGDs provided an opportunity for the local people to take part in the research and share their experiences. Thirty- two FGDs were conducted in the eight study villages, of which four FGDs were conducted in each village at six-month intervals. The average number of participants in each FGD was ranged from 16 to 28 people. In each of the FGDs, more than 30% of total participants were women, and 40% of the total participants were above 60 years old. Equal numbers of participants were present from both the communities in all the FGDs. All

the participants actively participated and shared their knowledge.

Discussions were held with knowledgeable men and women aged between 18 to 80 years in all the eight villages. During the meetings, shortlisted questions were asked, WFPs photographs were shown to the respondents to assess their perception on the livelihood implications of WFPs, and their responses were recorded in detail regarding the dietary values of the WFPs, medicinal values, and economic benefits. These meetings usually took 3-5 hours and were conducted separately.

2.2.4. Market survey

During the study, a market survey was conducted in major seasons like summer, rainy, and winter to capture the seasonal change in the variety of plants sold and to record information on its market price. Two local vegetable markets, one in Kolathur (average 30 kilometres away from the study villages) and another at Hannur (average 40 kilometres away from the study villages) were visited. Semi-structured interviews were conducted with the vendors, and the prices and varieties of vegetables sold, source of procuring, and income were assessed.

2.2.5. Key informant interviews

Eight key informants (one person from each village) were identified, and interviews were conducted to cross-check the information collected during the household survey, focus group discussions, and market survey. The key informants known to be the most knowledgeable were older adults, who had lived and worked in this area and had been using WFPs for a long time. They were frequently consulted during the study to clarify any doubts or confusion regarding the parts used availability of WFPs in the study area, nutritional importance, therapeutic food values, and economic benefit to the households.

2.2.6. Data analysis

The data collected during the exploration and household surveys were used to assess the number of species collected, the source, the season of collection, parts collected, and frequency of use. Descriptive analysis was used to categorize the WFPs in terms of the plant family, genus, plant part used, life form, use category, and available season. The percentage of species used in the forest and farmlands were calculated. Further, the percentage of different parts used for food was calculated. The Use Index (UI) was calculated for each species using the equation UI=Us/N, where Us is the number of households which uses a particular species and N is the total number of households interviewed in the research area (Laucena *et al.,* 2007; Phillips & Gentry, 1993).

The key informant interview data were used to validate the quantitative and qualitative information collected from the FGD and the market survey. The household data was also used to develop a socioeconomic profile and to calculate the economic value of each species.
Economic values: The frequency of WFPs collection, time spent, and prevailing daily wages were used to estimate the economic value of all the 124 plant species. The following formula is taken from Gracia et al. (2006) with relevant modification:

EVe=Fee*Tee *Pee

Where EVe is the economic value of the WFPs, Fee is the mean number of days collected and brought to any household, Tee is the mean time spent on the collection of WFPs species, and Pee is the price of the WFPs species. The Spearman correlation coefficient analysis was employed to compare WFPI and other income sources (AGRII, MIGRI, MFPI, LANH, and LANU). Further, the Wilcoxon rank test, a non-parametric test, is used to assess income sources and their relation with WFPI.

Relative importance index: Based on use categories and relative frequency of citation, relative importance index (RII) values were calculated for each species by adopting the formula from Santayana (2003a):

RII=Relative frequency of citation (RFC) + Relative number of use categories (RNU)/2

The RII index theoretically varies from 0 (when nobody mentions any use of the plant) to 1 (when the plant is most frequently mentioned as useful in the number of use categories).

Later, the Spearman correlation coefficient was used

ISSN-Internet 2197-411x OLCL 862804632

to compare the various indices since all the variables considered were not distributed normally. Further, the Wilcoxon rank test, a non-parametric test, was used to assess the significance. The quantitative data analysis was carried out using a spreadsheet and R (version 3.3.1) (R Core Development Team, 2013).

4. Results

4.1. Dependency on WFPs resource

The local communities in the MM Hills use 124 plants for food, 68 species for medicine, 32 species for agriculture and household tools, 14 species for cash income, and 26 species for spiritual and cultural activities. Among the 124 WFPs species listed, 103 species (83.7%) are common across forest and land use types. There are 91 (73.9%) and 96 (78.5%) distributed within the forest and farmland, respectively (Table 2).

The leafy vegetables listed by the local communities were used regularly over generations, and frequent citation indicates their vital importance in the household diet. The results revealed that the source of WFPs from diverse habitats ranging from farmland, wetland, fallow land, and from different forest types starting from scrub at a lower elevation, dry deciduous, riparian at middle elevation, and moist deciduous at a higher elevation.

4.1.1. WFPs diversity

The WFPs collected during the study were distributed among 57 families, 91 genus, and 124 species. The data revealed that the Amaranthaceae family had the highest number of WFPs species- 11 (8.9%), followed by Solanaceae - 7 species (5.6%), and Anacardiaceae - 5 (4.05%). The highest number of WFPs species 6 (4.8%) belonged to the *Solanum* genus, followed by *Amaranthus*- 5 species (4.06%), *Ziziphus* - 4(3.2%), and *Grewia*- 4 (3.2%) (Figure 2).

Herbaceous species belonging to the genus Amaranthus, *Digera, Cassia, Cleome*, and *Cocculus* were abundant in the farmland. Tree genus such as *Grewia, Syzygium, Phyllanthus,* and *Diospyros* species were common and more abundant in the forest habitat. Similarly, climber species belonging to the genus *Dioscorea, Asparagus, Decalepis,* and *Ceropegia* were common and more abundant in the forest than in the farmland. WFPs species such as *Amaranthus viridis L., Solanum erianthum Don.,* and *Anredera vesicaria* (Lam.) Gaertn. fil. were rarely found in the wild and instead, cultivated in the backyard.

4.1.2. Seasonal dependency

The WFPs displayed distinct seasonal patterns. About 81 species were available and collected during the rainy season (May to December). The highest number of leafy vegetables and fruits were collected during the rainy season. Most tubers were available in summer

Table 2. Foraging of WFPs in the study area

Forest & Land Use	No. of WFPs Species Available	% of WFPs Species (to total number of WFPs species documented; N=124)
Forest	91	73.9
Scrub	55	44.7
Dry deciduous	68	55.2
Riparian	23	18.6
Moist deciduous	43	34.9
Non-forest	96	78.5
Farmland	78	63.4
Fallow land	36	29.2
Home garden	18	14.6
Wetland	6	4.8

(February to April), and shoots and flowers were collected in winter (November to January) (Figure 3).

Similarly, vegetables collected from herbs were mainly available (42.3%) in June and July, i.e., the rainy

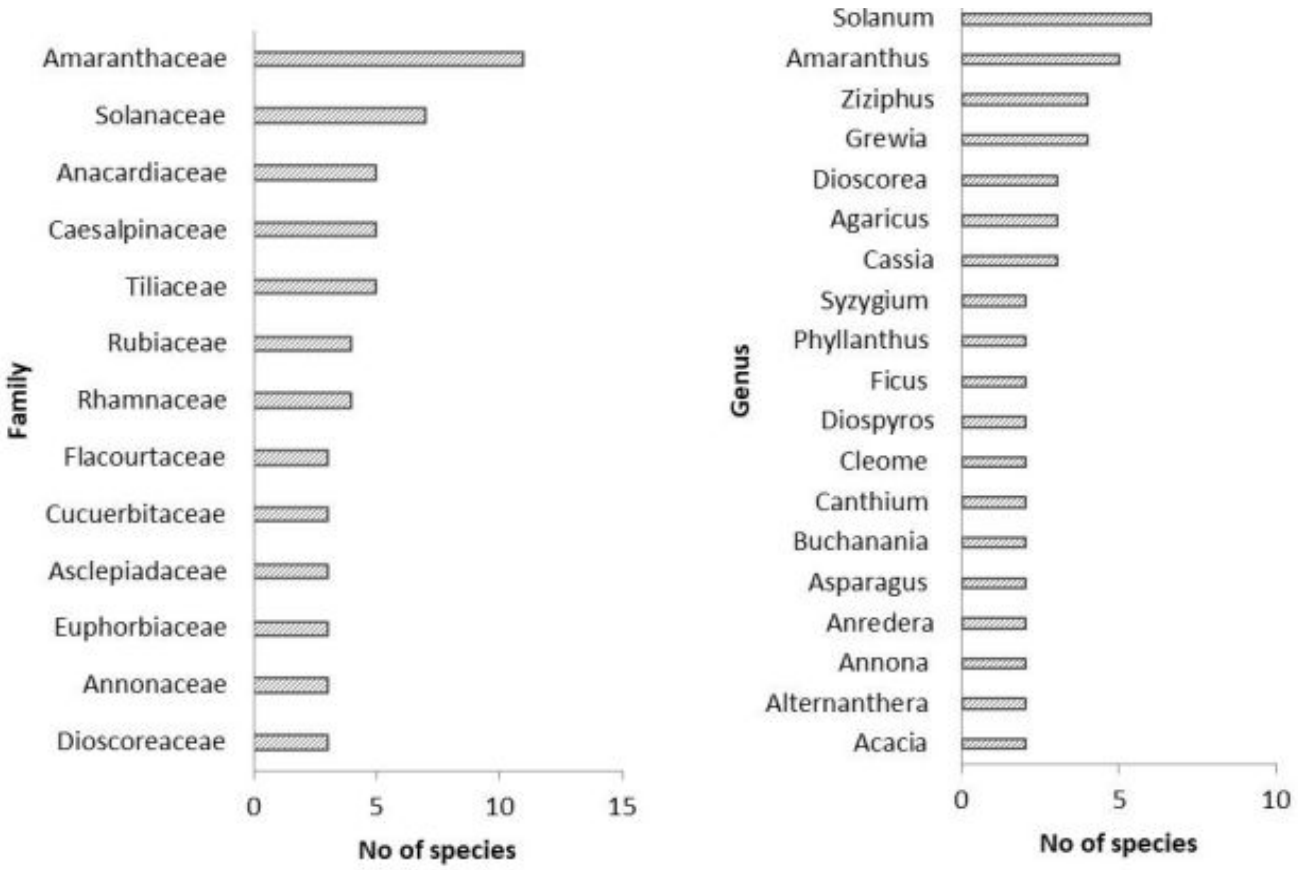

Figure 2. Major botanical families and genus with WFPs species

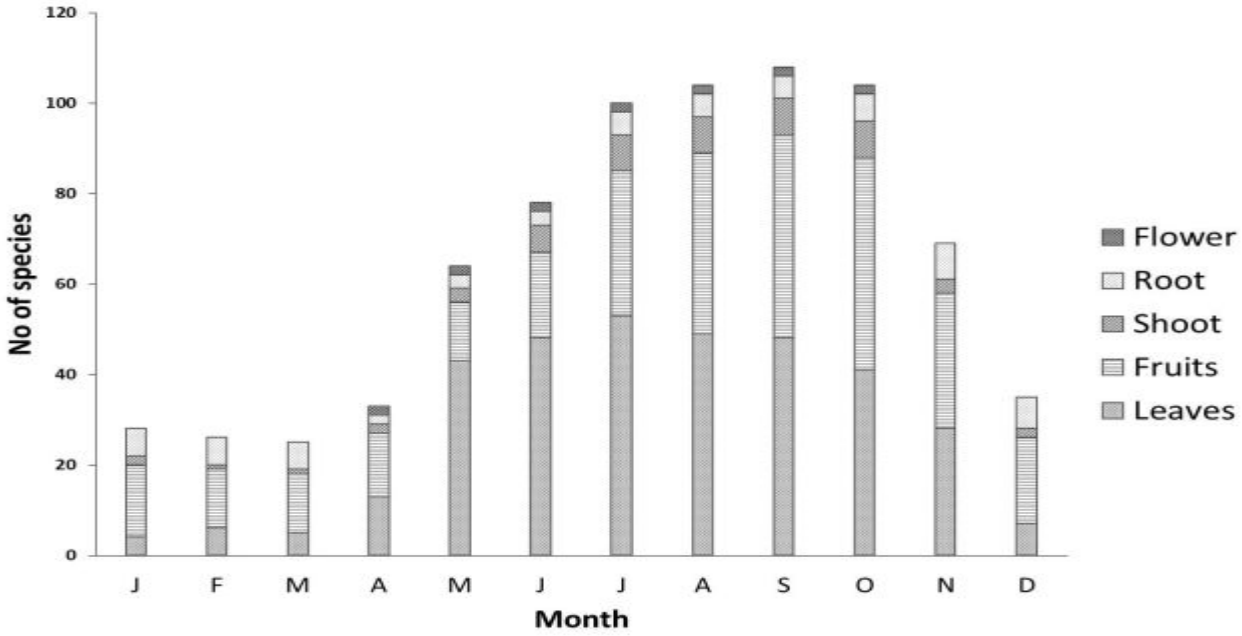

Figure 3. Seasonal forage calendar of WFPs

ISSN-Internet 2197-411x OLCL 862804632

season. Tubers collected from climbers were available highest (36%) in February and March, i.e., in the summer. Fruits and leafy vegetables collected from shrubs (8.4%) were available highest in March, i.e., in the summer. Fruits collected from trees (20.6%) were available throughout the year.

4.1.3. Life form and part used

The life form analysis shows that herbs rank first with 40 species (32.5%), followed by trees at 38 species (30.9%), climbers at 25 species (20.3%), and shrubs at 20 (16.3%) species [Figure 4(a)]. Wild fruits were collected from 53 species (41%), leaf and shoot vegetables from 50 species (39.3%), tubers from 8 species (6.5%), shoots from 5 species (4.1%), flowers from 4 species (3.3%), and whole plant from 3 species (2.4%) [Figure 4(b)]. Herbs are a rich source of leaves and shoots (31 species- 25.2%), while trees are a rich source of wild fruits (31 species- 25.4%), and climbers are the only source of tubers (8 species- 6.5%). Herbaceous species belonging to the genus Amaranthus, Digera, Cassia, Cleome, and Cocculus were the primary source of the leafy shoot. Tree genus such as Grewia, Syzygium, Phyllanthus, and Diospyros species were a common source of wild fruits. Similarly, climber species belonging to the genus Dioscorea, Asparagus, Decalepis, and Ceropegia were the common source of the tuber.

Both the communities have 13 varieties of recipes for preparation for WFPs, and most have therapeutic value. Thirty-nine (31.7%) species are consumed raw, 68 (55.3%) in the form of curry or side dish, and 6 (4.9%) in the form of pickle or herbal drink. Many fruits collected from trees (25 species - 20.3%), climbers (7 species - 5.7%), and shrubs (5 species - 4.1%) are eaten raw. The tubers and fruits collected from climbers (4 species - 3.6%) and trees (6 species - 4.8%) are consumed in the form of pickle, herbal drink, or are eaten raw.

4.1.4. Use index

The Use Index (UI) of WFPs varies from 0.01 to 1.0 (Appendix 1). The UI value indicates the number of households using a particular plant species. For instance, Premna tomentosa Willd. (0.1) and Wrightia tinctoria R. Br. (0.1) are used by only 1% of the sampled households. Whereas, plants such as Celosia argentea L. (1.0), Solanum nigrum L. (1.0), and Jasminum *ritchiei* C.B.Clarke (1.0) are consumed by all the sample households every alternative day until the season is over. The WFPs such as Solanum anguivi Lam. and Celosia argentea L., which have high UI, are abundantly found throughout the year. Moreover, a mixture of 8-10 species [Toddalia asiatica (L.) Lam., Senna auriculate (L.) Roxb., Indigofera tinctoriaL., Cordia dichotoma G. Forst., Diospyros Montana Roxb., Commelina diffusa Burm.f., Boerhavia diffusa L., Euphorbia heyneana Spreng., Amaranthus viridis, and Alternanthera sessilis (L.) DC] are commonly used as vegetables for preparing curry or side dishes.

4.1.5. Frequency of foraging

Both the communities use one or the other WFPs throughout the year. The analysis of the frequency of use shows that 28 species, which are leafy vegetables, are used by 80 to 100% households for more than 20 days in a year. About 26 species, including leafy vegetables, are used by 60 to 80% of households for more than ten days in a year. Around 24 species, comprising of leaves, fruits, and shoots are used by 40 to 60% of the households more than five days in a year (Table 3). More than 90% of the households have their recipe that includes WFPs for dinner. Interestingly, Beda Gampana households (85%) use WFPs more than five times a week, whereas the Soliga households (68%) use WFPs 2 to 3 times a week.

4.2. Economic contribution

4.2.1. Socioeconomic profile of the community

It is important to understand the socioeconomic profile of the communities, which has a direct influence on food practices and dietary diversity. The household survey and FGD data reveal that family size, landholding, annual per capita income, literacy level, and knowledge on WFPs use are quite similar. However, the Beda Gampana community with its strict vegetarian diet do not get the special nutritional package (pulses, millets, eggs, ghee, and cooking oil) although they have a high rate of infant mortality. However, the Soliga community gets a special nutritional package from the government (Table 1). This governmental help provides Soliga households with better food security and high dietary diversity than Beda Gampana.

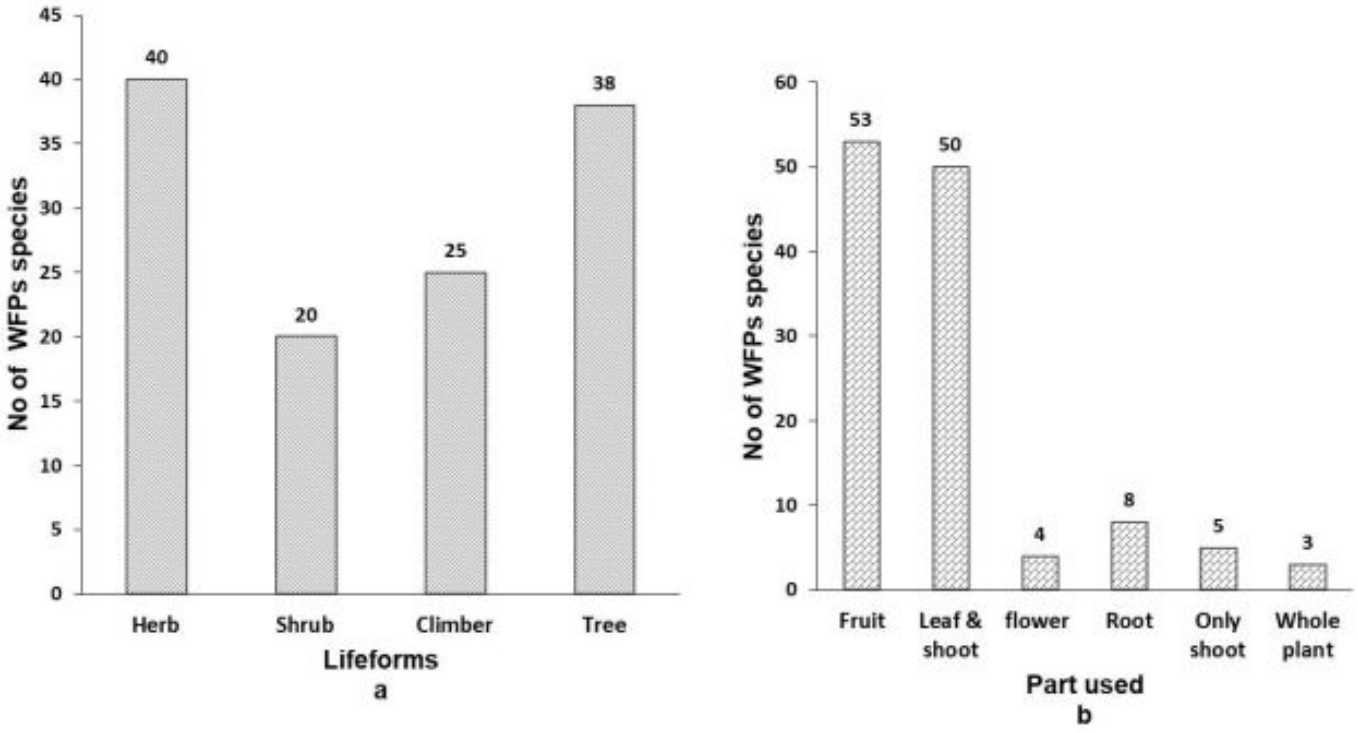

Figure 4. Life form analysis– (a) lifeforms, and (b) part used

Table 3. Foraging frequency and use index value of WFPs

Frequency of Use	No. of Species	Use index (UI=Us/N)	% of Households	Major Species
>20 days /year	28	>0.8	80 to 100	*Jasminum ritchiei, Solanum nigrumL., Celosia argentea, etc.*
10 to 19 days/year	26	0.6 to 0.8	60 to 80	*Cordia dichotoma, Cocculus hirsutus (L.) Diels., Digera muricata, Amaranthus viridis, etc.*
5 to 9 days/year	24	0.4 to 0.6	40 to 60	*Amaranthus polygonoidesL., Alternanthera sessilis, Bacopa monnieri (L.) Pennell, Boerhavia diffusa L.*
2 to 4 days /year	28	0.2 to 0.4	20 to 40	*Coccinia grandis (L.) Voigt, Vachellia farnesiana (L.) Wight & Arn., Solanum torvum Swartz, Euphorbia heyneana, etc.*
One day/year	21	<0.2	0 to 20	*Dioscorea bulbifera L., Grewia hirsute Vahl., Anredera vesicaria, etc.*

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4.2.2. Time allocation for WFPs forage

Both the communities spend 2 to 3 hours per day during summer to forage WFPs, 1 to 2 hours per day in winter, and 0.5 to 1 hour per day in the rainy season. Since both the communities depend on farming for their subsistence, they spend most of their time farming during the rainy season (4 to 5 months). As leafy shoots are available in plenty in the rainy season, many of them forage close to the village. They forage for leafy shoots/fruits in the farmland itself as part of their farming activity every evening, just before leaving for the village. Winter is also a peak crop harvesting season, and a variety of leafy shoots and fruits are available in and around the farmland. Winter is also peak season for NTFPs collection in the forest. Therefore, they visit the forest more frequently and forage WFPs during NTFPs harvest. Thus, they save time from making separate trips to the forest for foraging WFPs. In summer, very few leafy shoots are available in the forest and farmland, but plenty of tubers and fruits are available in the forest. Therefore, they spend more time foraging for tubers and fruits in the forest.

4.2.3. Importance WFPs income

The main source of income was assessed at the household level for both the Soliga and Beda Gampana communities. The income per capita per year showed that daily wages earned through migration to cities or quarries or coffee plantations were the highest (Soliga - ₹ 13666 and Beda Gampana- ₹ 13595) source for both the communities. Interestingly, WFPs' income per capita/year is ₹ 1459.6 for the Soliga and ₹ 1508.5 for the Beda Gampana communities (Table 4). It shows that income through WFPs is as vital as income from agriculture (Appendix 2). It also reveals that both the communities are equally dependent on WFPs for their food, therapeutic and nutritional needs. Statistically, there was no significant difference in per capita income across both communities to the source of household income (Mann-Whitney pairwise comparison, $p>0.05$).

The economic value for the different parts used from WFPs was calculated at the household level for both the communities. The frequency of WFPs collection, time spent, and prevailing daily wages were used to estimate the economic value of all the 124 plant species. The economic value of leaf and shoots (Soliga-₹ 740.1±14.7 and Beda Gampana -₹ 815.2±24) were greater than for fruits (Soliga - ₹ 390.0± 23.6and Beda Gampana-₹ 393.0±33.8). The economic value of tubers (Soliga- ₹ 190.6±21.3 and Beda Gampana-₹ 180.9±20.6) was higher than for flowers, seeds, and bark together (Soliga-₹ 187.1±21.5 and Beda Gampana-₹ 156.7± 21.7)(Figure 5).

4.3. Relationship between WFPs use and other livelihood income sources

The correlation coefficient and Wilcoxon signed-rank tests were carried out between WFPs income and livelihood source variables (Table 5). The daily wages were earned through migration to cities/coffee plantations/quarries showed a significant negative relationship with the overall WFPs income (R^2=-0.410, p=0.007), income within the Soliga community (R^2=-0.419, p=0.004), and income within Beda Gampana community (R^2=-0.400, p=0.05).

Landholding and land-use variables showed a very significant positive relationship with WFPs income

Table 4. Household income profile of Soliga and Beda Gampana

Source of income	Soliga(n=92) Mean & Stdev.	Beda Gampana(n=92) Mean & Stdev.
Migration net income/capita/year	₹ 13666.41 ±123.41	₹ 13595.19 ±233.07
Agri net income/acre/capita/year	₹ 1427.81±216.35	₹ 1954.55 ±242.68
Others(Livestock, NTFPs, fuelwood, and crafting) net income/capita/year	₹ 3428.43 ±147.04	₹ 3367.05 ±125.08
WFPs net income/capita/year	₹ 1459.62 ±123.88	₹ 1508.06 ±114.96

overall (landholding R^2=0.244, p=0.0002; land use R^2=0.242, p=0.0002) and Beda Gampana (landholding R^2=0.205, p=0.0002, land use R^2=0.162, p=0.0002). It indicated that households, which have land and do farming, were dependent more on WFPs source. Also, low cash income families (Less than ₹ 5000.0 per family per year) depend more on WFPs than high cash income families.

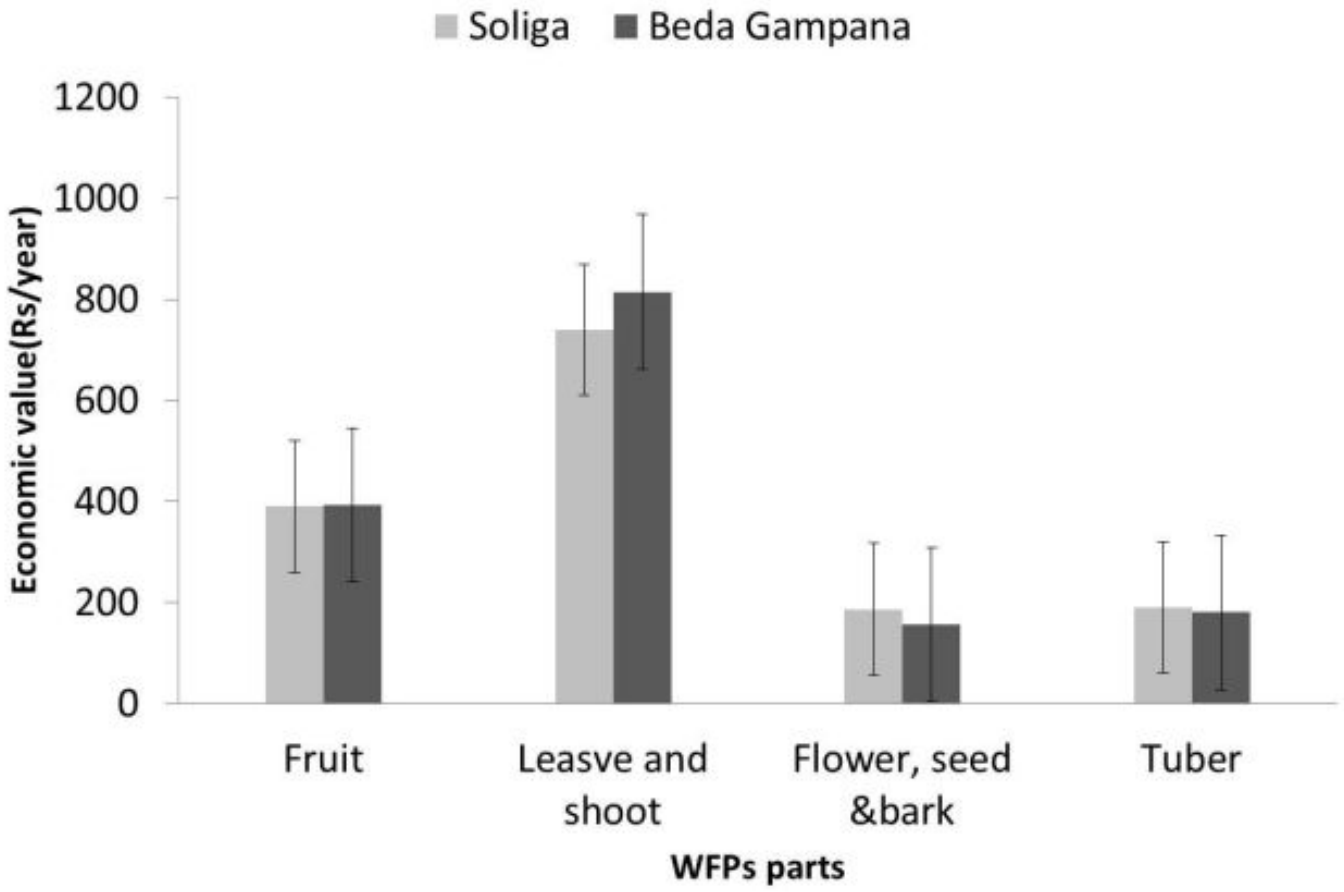

Figure 5. Economic values of different parts used by the communities

Table 5. Wild food plants and income source variables

	Overall		Soliga		Beda Gampana	
Economic Variables	**Correlation with WFPI(R^2)**	***P*-value**	**Correlation with WFPI(R^2)**	***P*-value**	**Correlation with WFPI(R^2)**	***P*-value**
AGRII	0.007	0.02	0.097	0.007	-0.036	0.5
MIGRI	-0.410	0.0007	-0.419	0.004	-0.400	0.05
MFPI	0.293	0.0002	0.172	0.002	0.401	0.0002
LANH	0.244	0.0002	0.282	0.0002	0.205	0.0002
LANU	0.242	0.0002	0.314	0.0002	0.162	0.0002
LIVEI	0.367	0.0005	0.136	0.002	0.416	0.0002
OTHEI	-0.382	0.0005	-0.331	0.005	-0.404	0.0002

WFPI=Wild food plant income; AGRII=Agriculture income; MIGRI=Migration income; MFPI=Minor forest product income; LANH=Land holding size; LANU=Land using size; LIVEI=Livestock income; OTHEI=other income (Business, government or private company employee).

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4.3.1. Relative importance index of WFPs

The relative importance value of all 124 WFPs was estimated based on the use categories and relative frequency of citation (Appendix 3). The descriptive statistical analyses of these relative citations are shown in Table 6, which shows the mean and standard deviation, and minimum and maximum values for each of the use categories. The maximum relative importance index value was scored by the species *Bambusa bambos* (L.) Voss (0.598), whereas the minimum relative importance index value was scored by the species *Grewiasp*. (0.047). The mean relative importance index value was 0.2± 0.1, and 95 WFPs species scored > 0.1 relative importance index value. It shows that most of the WFPs used by both communities have significant relative importance. Most of the species with higher RII values are of multiple popular uses in the study area.

4.3.2. Relationship between economic and relative importance index

The descriptive statistics on economic and relative importance index values were calculated, which classified the WFPs into very low, low, high, and very high-frequency indices values (Table 7). The maximum economic (2137.5) and cultural index value (2086.0) was scored by Jasminum *ritchiei*, while *Bambusa bambos* (0.60) scored high relative importance index value. The mean economic value index was 217.8 ± 275.8, and the relative importance index value was 0.20±0.10. About 65% of the WFPs species have economic index values >150.0. It shows that more than 70 species contribute to the household economy

Table 6: Descriptive statistical values of ten quantitative indices used to assess relative importance index (RII) of 124 WFPs

	HF	MD	AF	CR	WE	SY	FW	OR	TO	OT	RII
Average	101.3	54.8	86.3	3.4	39.0	8.6	8.0	10.9	6.7	9.7	0.2
Standard eviation	32.5	12.2	22.0	2.7	14.4	2.8	1.3	7.8	1.1	1.2	0.1
Minimum	2	0	0	0	0	0	0	0	0	0	0.05
Maximum	184	184	184	184	184	184	75	134	65	75	0.60

HF=Human food, MD=Medicine, AF=Animal food, CR=Craft, WE=Weed, SY=Symbolic, FW=Firewood, OR=Ornamental, TO=Toxic, OT=Other

Table 7. Descriptive Statistical Values, Frequency, and Percentage of Economic and Relative Importance Values of 124 WFPs Species

	EVI		RII	
Average	217.8		0.20	
Standard deviation	25.8		0.10	
Minimum	18.8		0.05	
Maximum	2137.5		0.60	
Range	**Freq.**	**Per cent**	**Freq.**	**Per cent**
Very low(<0.1)	0	0	28	22.8
Low(<1)	0	0	95	77.2
High(<10)	0	0	0	0
Very high(>10)	124	100	0	0

and the diet of the people in the study area.
The regression analysis shows that the relationship between economic value and use index value is very significant (r^2=0.896, p=<0.001). The WFPs species, which scored high economic values, also had high use-values. Similarly, economic values have a highly significant relationship (r^2=0.624, p=<0.05) with a relative importance index. The study also tested the relationship of economic values with the frequency of citation indices for the Soliga and Beda Gampana communities. Within the community, similar relationships were observed (Table 8). This reveals that perception, use, and indigenous knowledge on WFPs are quite similar between the Soliga and Beda Gampana communities.

The people perceived that WFPs species, which have high economic value, also have high relative importance values. For example, *Bambusa* sp., *Vachellia farnesiana*, *Jasminum ritchiei*, *Amaranthus viridis*, *Solanum nigrum*, *Alternanthera sissilis*, and *Celosia argentea* were cited by people in both the economic and relative importance indices. Similarly, WFPs species with high use index values also have high economic values. For example, *Digera muricata, Cocculus hirsutus, Jasminum ritchiei, Amaranthus viridis, Solanum nigrum, Alternanthera sissilis,* and *Celosia argentea* were cited by the people in both the use and economic index values. Correspondingly, WFPs species with high economic values also had a high frequency of citation. For example, *Digera muricata, Cocculus hirsutus, Jasminum ritchiei, Amaranthus viridis, Alternanthera sissilis,* and *Celosia argentea* were frequently cited by the people in the economic index values. Frequently used WFPs species such as *Bambusa* sp., Vachellia farnesiana, Jasminum *ritchiei*, Amaranthus viridis, Solanum nigrum, Alternanthera sissilis, Digera muricata, Cocculus hirsutus, and Celosia argentea have high economic and use index values. It indicates their significant role in the diet, as material, and in medicine (Appendix 4).

5. Discussion

5.1. Dependency on WFPs resource and knowledge of the use

Despite significant socioeconomic changes and globalization, residents belonging to the Soliga and Beda Gampana communities in the MM Hills still depend on many WFPs as well as use these in their daily diet. Both the communities use one or the other WFPs throughout the year every alternate day. The WFPs are a vital source of micronutrients for Beda Gampana communities who have a strictly vegetarian diet. Beda Gampana communities have a more profound knowledge of the collection, preparation, and therapeutic usage of WFPs compared to Soliga communities. More than 124 WFPs species were used as vegetables, fruits, beverages, for food therapy, for economic benefit, and cultural and religious practices. Family structure, economic status, and occupation of the members of the households determine their dependency on the WFPs. Women have more knowledge of WFPs than men, and older people have more knowledge of the number of WFPs known and its usage than younger people (Harisha *et al.,* 2015). The knowledge of use and dependency on WFPs for women and older people is critical for survival, while it is not so for the present younger generation since their food habit and lifestyle is changing rapidly.
The surrounding habitat is the prime source of WFPs

Table 8. Sensitivity analysis: regression of the values between economic value and UI and RII

Index values	Overall		Soliga		Beda Gampana	
	Coefficient	P-value	Coefficient	P-value	Coefficient	P-value
UI (Use Index)	0.896	<0.001	0.847	<0.001	0.903	<0.001
EVI (Economic values index)	0.624	<0.05	0.713	<0.05	0.816	<0.001
RII (Relative importance index)	0.784	<0.001	0.803	<0.001	0.792	<0.001
FC (Frequency of citation)	0.693	<0.001	0.712	<0.001	0.703	<0.001

ISSN-Internet 2197-411x OLCL 862804632
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and frequently cited by local people indicating the importance of the species in the region. Communities depend on WFPs species for their food and medicine; they had in-depth knowledge of the distribution and availability of these WFPs. Many studies have shown that the occurrence of wild leafy vegetables and fruits in the vicinity of the villages offers a unique opportunity for agroforestry species conservation (Sansanelli *et al.,* 2017; Shumsky *et al.,* 2014). Therefore, it is essential to document the use, knowledge, and conservation of WFPs, which offer a wide range of uses in rural households.

The distribution patterns were shared across the arid tropical forest habitat. WFPs species are well-adapted to the climate and geographical conditions. The existence of these taxa in the different regions of the country indicates their wide range of ecological adaptation and their palatability to different ethnic communities (Bharucha& Pretty, 2010; Major 2013). Shrub species belonging to the genus Jasminum, Solanum, and Acacia are common in both farm and forest habitats. These species survive in highly disturbed habitats and have a wide range of distribution across disturbance gradients, geographic, and climatic conditions.

5.2. Seasonal availability, diversity, and dependency

The usage and seasonal availability of WFPs positively correlated. The local communities are aware of the seasonal plant availability and their phenological status (Harisha*et al.,* 2013). Many studies across the world have revealed that plenty of shoots and wild leafy vegetables are available in the rainy season compared to the dry season (Joshi *et al.,* 2015). Similarly, many wild fruits ripen in the winter and are available for consumption (Harisha *et al.,* 2013). It is true that without WFPs, the local people, especially Beda Gampana communities who solely depend on the plant as the primary source of food and practices in MM Hills would have lesser food security and may suffer malnutrition. Both the Soliga and Beda Gampana communities had tremendous knowledge of phenology and the ecological aspect of WFPs. However, Bed Gampana had a deep knowledge of the preparation of food concerning season and their part.

It is well-recorded by many studies that herbs are the prime sources of leafy vegetables in many rural parts of the country (Osewa *et al.,* 2013; Geng *et al.,* 2016). The diversity of use of different parts of WFPs in different seasons of the year has great potential to combat food insecurity and offer nutritional security during drought years (Grivetti & Ogle, 2000; Lulekal *et al.,* 2011). This is especially true in the case of tubers and fruits, which provide essential nutrients to rural households in the summer and drought years (Bhatia *et al.,* 2018). Both the study communities consume more leafy vegetables from herbs, shrubs, and trees, which are available in plenty across the seasons. Sometimes the WFPs is the only source of nutrition and remedy for common health problems in the study area.

WFPs are still crucial in many areas today, and in exceptional cases, maybe the only source of food available (Geng *et al.,* 2016). The Soliga and Beda Gampana communities regularly use 43 WFPs species. In comparison, another 28 WFPs species that are often ignored in regular times become vital when there is a shortage of food grains or drought. The local people repeatedly mentioned this during the interviews.

Seasonality of the agricultural cycle and wild food plant availability is usually linked to rainfall in tropical countries (Bharucha & Pretty, 2010). For example, the human inhabitants of rain forests suffer mild to severe hunger nearly the same time every year, leading to weight loss, which is a matter of serious public health concern (Milow *et al.,* 2011; Raghavendra *et al.,* 2017). Similarly, in tropical dry forest regions, local communities face food shortages from July to October every year (Singh *et al.,* 2016). Seasonality has a critical effect on the nutritional status of young children (between 12 and 24 months) and may expose them to severe malnutrition in the lean period (Madegowda, 2009; Harisha *et al.,* 2015).

5.3. WFPs use and its economic importance

The study revealed that both communities use different parts of the WFPs equally. Previous studies have developed the indices of economic and relative importance index that captures the multiple uses of the plants (Sansanelli *et al.,* 2017; Shumsky *et al.,* 2014). Most of the studies have merged different approaches to allow a more comprehensive valuation of the importance of the WFPs for human well-being (Agea *et al.,* 2011; FAO, 2014; Gracia *et al.,* 2015). These indices measured the use-value of WFPs spe-

cies. For example, WFP species mentioned with higher frequency for a particular use was assigned more use-value than plants mentioned with less frequency. A few studies also focused on estimating the economic value of WFPs for different human societies (Kalita *et al.,* 2014; Geng *et al.,* 2016). The present study indicates that WFPs are mainly used to supplement staple food and to fill-in food gaps. The higher number of plant citations by the communities in the study area indicates a high consumption level and familiarity with these plants. It is a common phenomenon that at times of seasonal food shortages when household stocks were empty and the new crop was still in the field, were typically periods of intensive collection and consumption of WFPs (Kothari *et al.,* 2012; Tsering *et al.,* 2014). Similar findings were recorded by many studies across the globe (Thakur *et al.,* 2017; Joshi *et al.,* 2015). WFPs, therefore, serve as a reliable safety net and provide households with the opportunity to save on the costs of buying food.

The majority of the households consume WFPs daily, indicating the role of WFPs in the diet of the people. The positive relationship between land-based livelihood sources (i.e., crops, NTFPs, and livestock) is an indication of their concurrent relevance to the livelihood (Harish *et al.,* 2015). It has a greater significant relationship with land-based livelihoods and dependency on WFPs for Beda Gampana communities than Soliga. It indicates that WFPs are very important for Beda Gampana communities irrespective of household income and literacy to meet their nutritional needs. Similarly, the monetary value of WFPs to the households is significant compared with NTFPs. The benefits of WFPs resources to forest-dependent communities in the semi-arid tropical region of the country are immense. They can no longer be neglected in national and regional resource accounting. Similar results were recorded in many studies that WFPs use is not only crucial for food and nutritional security, but also to the socio-economy of the local communities (Gracia *et al.,* 2015; Tsering *et al.,* 2014). Studies also describe the relevance and importance of WFPs in rural farming communities (Agea *et al.,* 2011; Tsering *et al.,* 2014; Salvi & Katewa, 2016). The indices provide an understanding of diversity, complexity, and appreciation of these WFPs use systems by the indigenous people in the study area.

The study found a high connection between the economic values and relative importance values of the WFPs. This study also found an association between the income level of the households and their use of the WFPs. The study also demonstrates the high rate of dependency on the use of WFPs. Multiple indices value improves the understanding of the importance of WFPs species. Similarly, observations were recorded in many studies using multiple indices to measure the different aspects of the importance of WFPs for people (Gracia *et al.,* 2015). The advantage of the combination of the three indices offers a more comprehensive valuation of the significance of the plants for local communities than one might obtain from using only a single index (Agea *et al.,* 2011; Raghavendra *et al.,* 2017). Further comprehensive multiple indices would be useful for a better understanding of the issues of conservation and sustainable management of WFPs resources in the study area.

6. Conclusion

The dependency on WFPs resources is inevitable and critical to meet the dietary, therapeutic, socioeconomic, and cultural practices of both the communities. The economic value of WFPs for households is as important as the crops grown for subsistence in both the communities. It revealed that households, which follow the traditional occupation, were still dependent on WFPs for food and other uses than households with non-traditional occupations such as migration, business, and urban labour work. It is a common phenomenon in traditional occupation households that seasonal food shortages faced when the new crop is still in the field are periods of intensive collection and consumption of WFPs. The reliance on WFPs is, therefore, a safety net and vital source of nutrition especially, for the Beda Gampana community who have a strictly vegetarian diet. The WFP's source, availability, and diversity are critically important for Beda Gampana households in MM Hills.

Emphasizing the improvement of nutrition and health through initiatives that protect WFPs diversity and related traditional knowledge systems is critical. Towards this, a systematic review of WFPs resources at the regional and national level with local consultation is necessary. Understanding the role of WFPs in food, nutrition, culture, and economics of the local communities is imperative. The benefits of WFPs resources to the forest-dependent community in the

ISSN-Internet 2197-411x OLCL 862804632
UniKassel & VDW, Germany- January 2021

semi-arid tropical region of the country are vast, and they can no longer be neglected in national and regional resource accounting. Most importantly, to address the challenges posed by recent climate change issues, financial crisis, and their implications on food and nutritional security, the use of WFPs in the diet becomes crucial.

Conflict of Interest

The authors declare that there is no conflict of interest.

Acknowledgement

The authors would like to thank the communities for freely sharing their knowledge. The authors also thank the Salur Mutt, Indian Meteorological Department, Statistical Department, and the Social Welfare Department for generously sharing information. The authors acknowledge the participation of Soliga and Beda Gampana community members and Mr. Madesha, Mr. Narayanan, Ms. Puttamma, and Mr. Thamme Gowda for their help in the collection of data. The permission of the Karnataka Forest Department is gratefully acknowledged.

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ISSN-Internet 2197-411x OLCL 862804632

UniKassel & VDW, Germany-January 2021