SACON Technical Report -130

Evaluating the status of NTFP trees and development of a model for sustainable harvest of *Garcinia gummi-gutta* in Aghanashini Lion-tailed Macaque Conservation Reserve, Western Ghats, India

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Rufford Small Grants

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Contents

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Kumara and Santhosh

2014

Chapter I

Introduction, Objectives and Methods

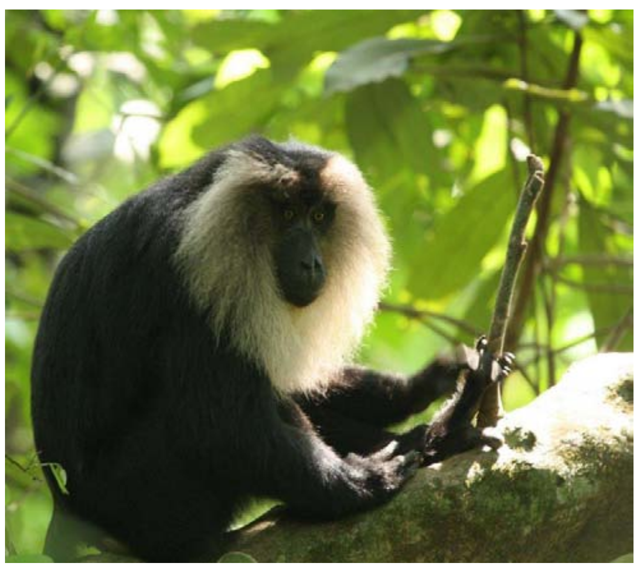
Introduction

The hill ranges of Western Ghats cover less than 6% of India's landmass but harbor more than 30% of the world's plant and vertebrate species (Das et al., 2006), and are thus considered to be one of the global biodiversity hotspot (Myers et al., 2000). About 12% of the mammals species present in the Western Ghats are endemic (Das et al., 2006). The IUCN Red List ranks the lion-tailed macaque (*Macaca silenus*) as "Endangered" (IUCN, 2013), endemic to the narrow ranges of the southern and central Western Ghats. Molur et al. (2003) projected a total lion-tailed macaque population of about 3,500 individuals in 49 sub-populations in eight locations of the Western Ghats. They are locally threatened in most protected areas and reserve forests of the state of Karnataka (Kumara and Sinha, 2009). Karanth (1985) reported about 3,000 individuals in 123 groups in 19 locations in Karnataka from the northernmost Kumta range to southern Brahmagiri Wildlife Sanctuary. Since then, however, there have been declines in numbers of about 69% to 90% in 14 of these forest reserves due to habitat loss, fragmentation and hunting has eliminated them entirely from these five reserves (Kumara and Sinha, 2009).

Karanth (1985) reported few lion-tailed macaque groups in the forests of Sirsi-Honnavara; the study was based largely on secondary information. A short survey by Kumara and Singh (2004a), however, indicated a large population (≥250 individuals) in the same forests among the few large populations of this species in the entire Western Ghats (Kumara and Singh, 2004a). This population presently faces severe threats from encroachment of the forests and valleys for agriculture, developmental activities such as construction of roads, transmission lines, dams, hydroelectric power plants, and hunting (Kumara and Singh, 2004a; Kumara et al., 2008). The problem is that reserve forests are not part of the protected area network. The forests are contiguous, and a conservation strategy is urgently need for the lion–tailed macaques there (Kumara et al., 2008; Kumara and Sinha, 2009). This region also harbors many endemic and endangered species, including plants species such as *Semecarpus kathalekanensis*

(Anacardiceae), *Madhuca bourdillonii* (Sapotaceae), and *Syzygium travancoricum* (Myrtaceae) (Chandran et al., 2008), about 26 amphibians endemic to Western Ghats (Kumara et al*.,* 2008), 17 globally threatened large mammals (Kumara and Singh, 2004b), and also unique '*Myristica* swamps' (Chandran et al., 2008).

As a first step towards conservation, lion-tailed macaques in Sirsi-Honnavara were reassessed to confirm the presence of large population, and developed the boundaries (based on village boundaries) for the management of the area (Kumara et al., 2008; Santhosh et al., 2013). In response to this, the forest department of Government of Karnataka has notified the proposed area, with little modification, as the "Aghanashini Lion-tailed Macaque Conservation Reserve" (ACR) (Kumara, 2011). Few immediate interventions were also suggested, such as to avoid cutting monoculture plantations within the habitat, since they act as a link between most forest stretches and also avoid developmental activities (building roads or laying electricity lines) and prevent further fragmentation of the habitat.



Lion-tailed macaque

The highly undulating terrain where there are evergreen forests is the most important habitat in the landscape for the lion-tailed macaques. The high human density has led local people to expand their agriculture and increase the area of settlements and villages. Forests are shrinking, especially evergreen forest, at a rapid rate (1.9% yearly) leading to the loss of 11.5%

just in the last decade (Kumara et al., 2011). Extension of existing farmlands and further honeycombing of valleys for agriculture, uncontrolled timber extraction, and leaf-litter and green manure collection (Kumara et al., 2008, 2011) are some of the characteristics of the area that are detrimental to the forests.

Second phase of the work suggest an overlap in utilization of resource by both monkeys and man. Out of 13 NTFP collected by people, 9 of them are food of LTM of which *Garcinia gummi-gutta* (Uppage) is the most widely extracted NTFP by all sections of the society. Uppage is the most important food item in the wet season for the LTM as it constitutes 16.41% and contributes 7.14% in its overall diet. These findings were of good interests to the forest managers and they were keen on banning extractions of NTFP from the region. The ban would bring about negative impacts on the economy of people and their livelihood. Thus, an assessment of NTFP species availability in the region, a study to develop a model for sustainable harvest of Uppage and its impact on stand structure, regeneration, and its management for the forest managers were carried out in the ACR to enhance the protection status through proper management.

Study Area

The study site is in central Western Ghats (14°23' N to 14°23'38"N and 74°48'E to 74'38"E), in the district of Uttara Kannada, state of Karnataka, South India (Fig. 1). The legal status of the forest is "Conservation Reserve," with mosaics of revenue lands interspersed around them (Santhosh et al., 2013). The study site falls under the administrative jurisdiction of Kanara Forest Circle, represented by Kyadagi and Siddapur forest ranges in the Sirsi territorial forest Division, and Kumta, Honnavara and Gersoppa forest ranges in the Honnavara territorial forest division. The altitude varies from 300 m to 800 m above sea level. The wet season is from May to October. It rains mostly in July; the total annual rainfall is about 6,000 mm. The study site forms the northern limit of the evergreen forests of plains and low elevations (Pascal, 1988). Forest in the study site was classified as "West coast tropical evergreen forest" with Low-Level type floristics (Champion and Seth, 2005). The vegetation type is *Persea macarantha* –

Diospyros spp. – *Holigarna* spp., which have been replaced by the dominance of *Dipterocarpus indicus* – *Diospyros condolleana* – *Diospyros oocarpa* because of human interference (Pascal, 1988). About 15,000 people dwell in the ACR.The major ethnic community in the area includes *Naika*, *Vokkaliga*, *Gowda*, *Harijana* and *Brahmin.*

Objectives

1. To assess the status of woody trees and regeneration of NTFP trees
2. To explore the availability, harvesting and processing of *Garcinia gummi-gutta*
3. To develop a model for sustainable harvest, processing and marketing strategy for *Garcinia gummi-gutta*

Methods

We selected five sampling locations in and around the ACR, which includes Hosthota, Chiksuli, Kanthota, Kodgi and Devgaar. In each of these locations, sampling was done using circular plots. Within each plot, all the trees with more than 30 cm girth were assessed. A total of 19.2 ha was sampled. Apart from these plots, in each location, 25 plots of the size 20 m X 20 m was laid for the young trees. Within these plots, subplots of 10 m X 10 m were laid in the five such plots to count the saplings of selected species.

To begin with, we interacted with the local people on regular basis and developed a good rapport with them. After reaching the comfortable level, we interviewed them on monthly basis to understand the rate of harvest of selected NTFPs, processing and their marketing strategy. We also organized series of meeting with the local people and forest department officials to form new village forest committees (VFC), to streamline the marketing strategy for the NTFPs. We also interacted with the processing firms and factories to understand their stand on the model that we are developing for the marketing of *Garcinia gummi-gutta*.

The Report

First chapter of the report provide need and background of the study, overall goal of the project and general methodology. Earlier studies have provided the information on use of trees by both local people and lion-tailed macaque for ACR. Floristic diversity, stand structure and regeneration of trees with special references to NTFP trees and important fruit trees for lion-tailed macaque are provided in the chapter-II. Chapter-III summarizes the status of *Garcinia gummi-gutta* in ACR, and provides phenology of the species, harvesting technique and processing of the fruits. Chapter-IV synthesizes the overall findings, contributions, responses for our suggestions by different stakeholders, model for sustainable harvest, people opinion on using driers for *Garcinia gummi-gutta* processing and marketing strategy and road map for future.

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Chapter II

Floristic diversity, stand structure and regeneration of trees with special reference to NTFP species and important fruit trees of lion-tailed macaque

Introduction

Proper understanding of diversity of inhabitant species in given area is pre requisite for the management and protection (Condit et al., 1998). Plant species of an area accounts to one of the primary entity contributing to biodiversity of an area as trees provide resources and habitat for many species (Cannon et al., 1998). Further, plant species inventories have been a determining factor for systematic characterization of forest vegetation (Johnston and Gillman, 1995; Condit, 1996; Pascal and Pelisser, 1996; Ayyappan and Parthasarathy, 1999; Parthasarathy, 1999; Phillips et al., 2003) thus playing an important role in understanding the structure of forests. The structure of climax forests worldwide have changed over the past and are continuously changing presently having been replaced by inferior species due to anthropogenic pressure (Parthasarathy, 1999). Reduction of forests have been from 1%-4% annually (Laurance, 1999) which may have forced many dependent species to extinction.

The forests of Western Ghats have been highly heterogeneous and complex having varied conditions leading to spatial distribution of vegetation (Pascal, 1988). The Uttara Kannada district in Karnataka in the central Western Ghats is the most forested area in south India. These forests are under continuous pressure from the past and recent years due to industrial needs, development and rapid urbanization. There has been a few studies on the distribution and stand structure of trees in the district (Bhat et al., 2001), but there is very little information on ACR. The areas in and around ACR are characterized by natural vegetation which includes evergreen, semi-evergreen and moist deciduous forests (Daniels, 1989). Species composition in ACR was expected to vary across latitudes even within a common forest type (Condit et al., 1996; Fangliang et al., 1997). Further, ACR has experienced high degree of selective logging, large scale submergence of forests in water due to dam constructions, loss of forests due to electrical line erections and colonization of people by encroachments in the last six decades. In addition to this, inhabitant people also have been highly dependent on these forests for subsistence like water, firewood, non-timber forest products (NTFP), green manure and dry leaf litter for agriculture. Kumara and Santhosh (2013) identified the priority food species for LTM and species used by people as NTFP in the area but the status of these plant species across the area needed to be investigated to understand their contribution on overall stand structure of the area. The present chapter discusses on floristic diversity across different regions of ACR, which had a varied degree of anthropogenic interference and access.

Study area

We selected five locations in and around the ACR that include 1.Hosthota, 2.Chiksuli, 3.Kanthota, 4.Kodgi and 5.Devgaar. We have also pointed out one of the location where Roy et al. (2010) studied the floristic diversity and stand structure.

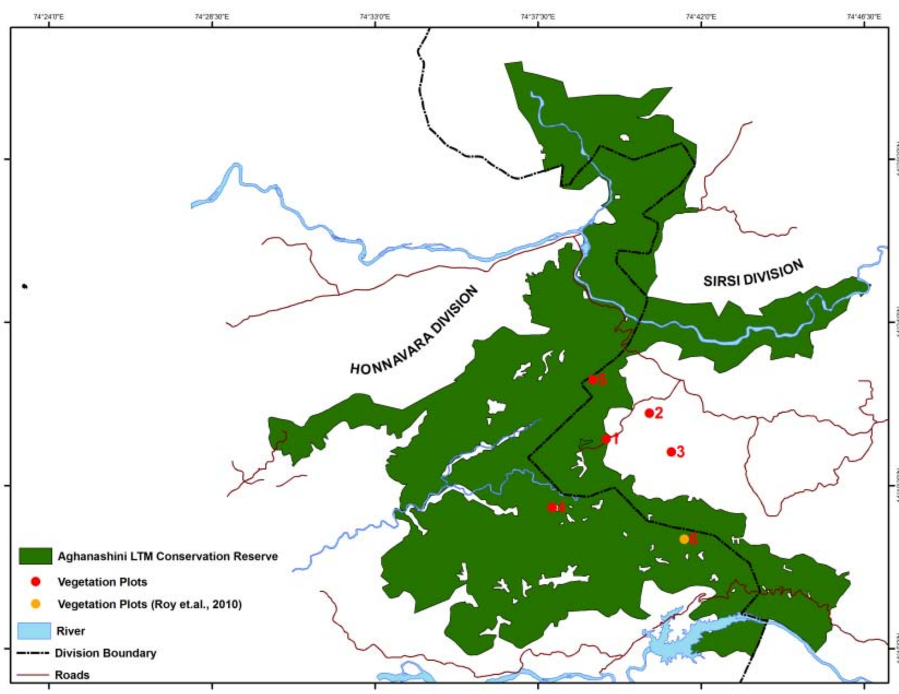


Figure 2.1 Map of Aghanashini Lion-tailed Macaque Conservation Reserve (ACR)

showing the sampling locations for floristic study

Methods

The floristic assessment was made between April 2012 and Dec 2013. Transects were laid in each of these selected locations, which varied in length. On transect line at an interval of 50 m, and 5 m inside from the transect line, circular plots were laid on both the sides of transect. A total of 132, 128, 128, 98, 126 circular plots (10 m radius) were laid in Hosthota (4.14 ha), Chiksuli (4.02 ha), Kanthota (4.02 ha), Kodgi (3.07 ha) and Devgaar (3.95 ha) respectively covering a total area of 19.2 ha (Table 2.1). In every plot, all living trees with GBH (Girth at breast height) greater than 30 cm (12 inch) was noted down as trees, and those with GBH less than 30 cm was considered as young trees (10-30 cm = juvenile trees). For multi-stemmed trees, GBH was separately measured for each stem and was added up. The species identification was done with the help of *'A Field Key to The Trees and Lianas of the Evergreen Forest*'by J.P. Pascal and B.R. Ramesh. The species could not be easily identified was collected and were identified from the taxonomy experts (Srikanth Gunaga and Vigneshwar Hegde, Forestry college, Sirsi). In each of the locations, 25 subplots of 20 m X 20 m were laid and number of individuals of young trees (10-30 cm) was counted with species identity. Further, within these subplots, five 10 m X 10 m plots were laid in each of the locations and saplings of plant species that are of important NTFP species (*viz*. *Garcinia gummi-gutta, Myristica malabarica, Myristica dactyloides, Calamus pseudotenius, Calamus twaitessi, Artocarpus lakoocha*) were counted.

Table 2.1 Sampling efforts for floristic diversity and stand structure

Study locations	Sampling for Trees		Sampling for Juveniles		Sampling for Saplings	
	No. 10 m radius plots	Area (ha)	No. of 400 m^2 plots	Area (ha)	No. of 100 m^2 plots	Area (ha)
Hosthota	132	4.14	25	1.00	5	0.05
Chiksuli	128	4.02	25	1.00	5	0.05
Kanthota	128	4.02	25	1.00	5	0.05
Kodagi	98	3.07	25	1.00	5	0.05
Devgaar	126	3.95	25	1.00	5	0.05
Total	612	19.20	125	5.00	25	0.25

In addition to the data on vegetation, distance of plot from nearest village, number of trails, stump density, presence/absence of firewood and litter collection was collected, which provided the disturbance value for each location. The vegetation data was analysed to obtain the quantitative structure and composition of plant communities using the standard parameters (Table 2.2). The vegetation data was tabulated for frequency, density, abundance, relative frequency, relative density, relative abundance, relative dominance, IVI and composition of plant communities, following Curtis and MC Intosh (1950) and Philips (1959). FIV was calculated by following Mori et al. (1983).

Table 2.2 Calculations of quantitative structure and composition of plant communities

No.	Parameters	Formula
1	**Frequency (%)**	(No. of quadrates in which a species occurred/Total no. of quadrates studied) × 100
2	**Abundance**	Total number of individuals of the species/No. of quadrates in which the species occurred
3	**Density**	Total no. of individuals of a given species/Total no. of quadrates examined
4	**Relative density**	No. of individuals/ No. of individuals of all species
5	**Relative abundance**	(Abundance of species x 100) / Sum of all Abundances
6	**Relative frequency**	Number of quadrates occurring/ Total no. of Quadrates
7	**Basal area**	$(\text{GBH in m})^2 / 4\pi$
8	**Relative Basal area**	(Total basal area of Individuals/ Total basal area of all species) x 100
9	**IVI**	Relative density + Relative dominance +Relative frequency
10	**Family Relative density (%)**	(Number of trees in a family/Total number of trees) x 100
11	**Family Relative Diversity (%)**	(Number of species in a family/total number of species) x 100
12	**Family Relative Dominance (%)**	(Total basal area for all species in a family/Total basal area of all families) x 100
13	**Family Importance Value(FIV)**	Σ of Family relative density, diversity and Dominance
14	**Species occurrence rate**	Species richness / Species density

Results

A total of 6075 number of trees belonging to 102 species were recorded in the 19.20 ha of sampling in five study sites. The details of stand characteristics of woody trees are provided in the Table 2.3. A total of 1503 woody plants of 71 species belonging to 57 genera and 32 families, 1401 woody plants of 73 species belonging to 57 genera and 31 families, 1223 woody plants of 66 species belonging to 53 genera and 30 families, 1121 woody plants of 78 species, belonging to 58 genera and 35 families, and 1367 woody plant of 64 species belonging to 49 genera and 29 families were recorded in 4.14 ha in Hosthata, 4.02 ha in Chiksuli, 4.02 ha in Kanthota, 3.07 ha in Kodgi and 3.95 ha in Devgaar respectively (Table 2.1 and 2.3). Although the species richness (minimum of 62 in Devgaar and maximum of 78 in Kodagi), stand density (minimum of 318.40 in Kanthota and a maximum of 386.50 in Hosthota) and basal area (minimum of 21.50 in Devgaar and a maximum of 45.50 in Kodgi) varied across the sites, only basal area varied significantly across the sites ($\chi^2 = 10.77$, df = 4, $p < 0.05$). The Shannon-Wiener Index values varied from 1.40 in Hosthota to 1.53 in Chiksuli.

Table 2.3 Table showing the details of species richness, generic richness, familial richness, stand density, basal area, Shannon-Wiener index and Simpson index across all the sampled areas of ACR

Stand structure Characteristics	**Hosthota**	**Chiksuli**	**Kanthota**	**Kodgi**	**Devgaar**
Number of Woody species	71	73	66	78	62
Number of Genera	57	54	53	58	47
Number of Families	32	31	30	35	29
Stand Density(Stems/ha)	386.50	349.30	318.40	370.10	344.70
Basal Area(m^2/ha)	26.50	27.10	29.10	45.50	21.50
Shannon-Weiner Index	1.40	1.53	1.46	1.46	1.38
Simpson Index (D)	0.07	0.04	0.05	0.07	0.07

Importance Value Index (IVI)

The importance value index for all the woody plants of each study site are provided in Appendices from 1-5. Figure 2.2 to 2.7 provide the ten most important trees for each study site and their IVI value. The highest IVI was recorded for *Knema attenuata* in Hosthota (28.6) and Devgaar (28.9), where it was in subsequent position at Chiksuli (15.6), Kanthota (17.3) and Kodgi (20.2). *Olea dioca* was recorded as important tree species at Chiksuli (17.9) and Kanthota (27.9), where it second most important tree at Kodgi (23.4). *Diospyros sylvetrica* was the second most important tree at Hosthota (23.9) and Devgaar (20.9), but the species was not recorded in the top ten trees of Chiksuli and Kanthota. *Hopea ponga* was recorded as important tree at

Kodgi (29.8), where it the second most important tree at Hosthota (19.8) and Devgaar (26.2). *Aglaia roxburghiana* is the third most important tree at Chiksuli (14.4) and Kanthota (14.7).

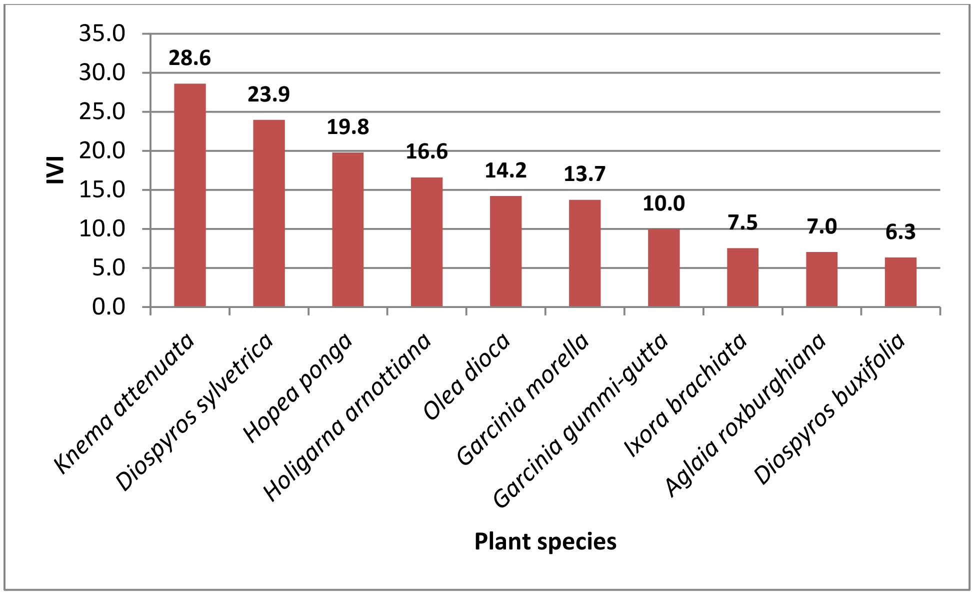


Figure 2.2 Importance Value Index (IVI) for top 10 tree species in Hosthota

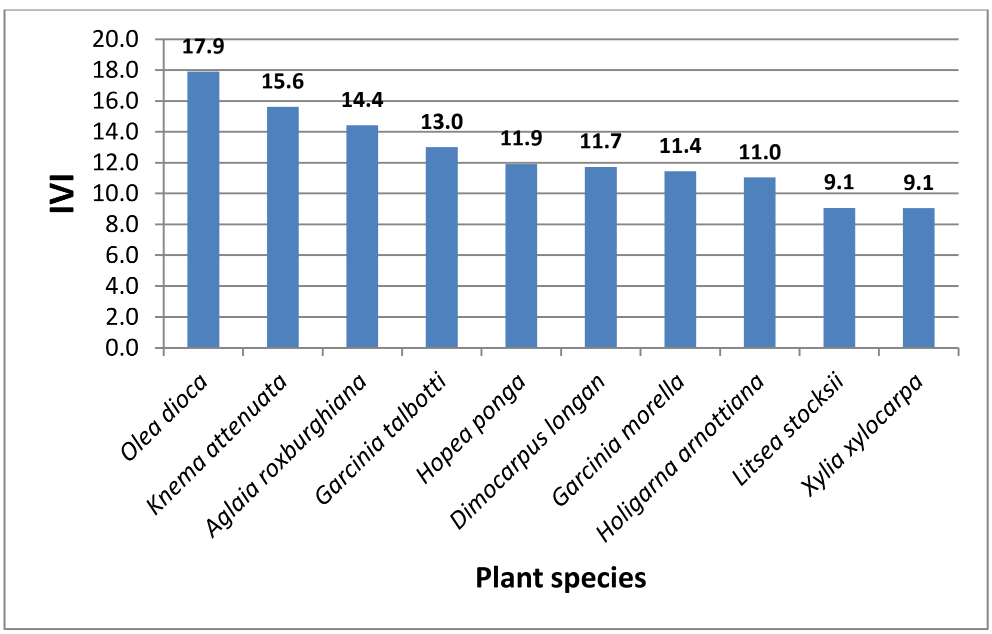


Figure 2.3 Importance Value Index (IVI) for top 10 tree species in Chiksuli

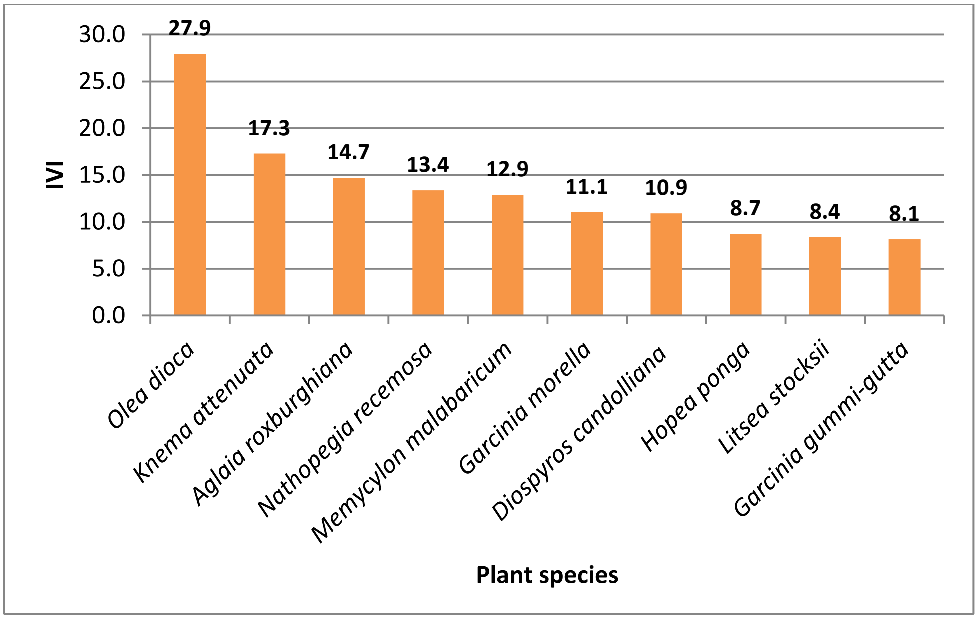


Figure 2.4 Importance Value Index (IVI) for top 10 tree species in Kanthota

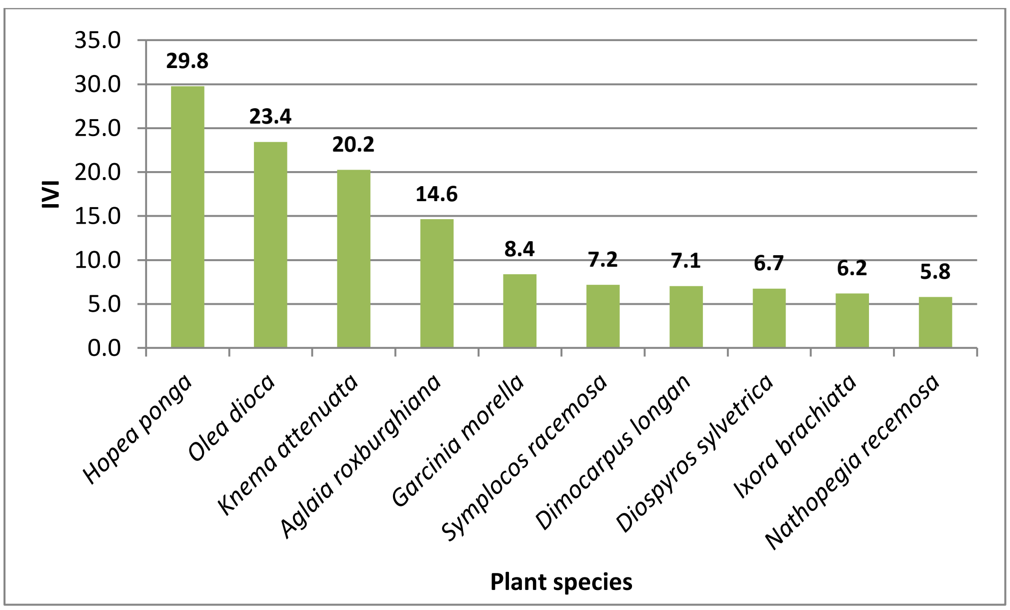


Figure 2.5 Importance Value Index (IVI) for top 10 tree species in Kodgi

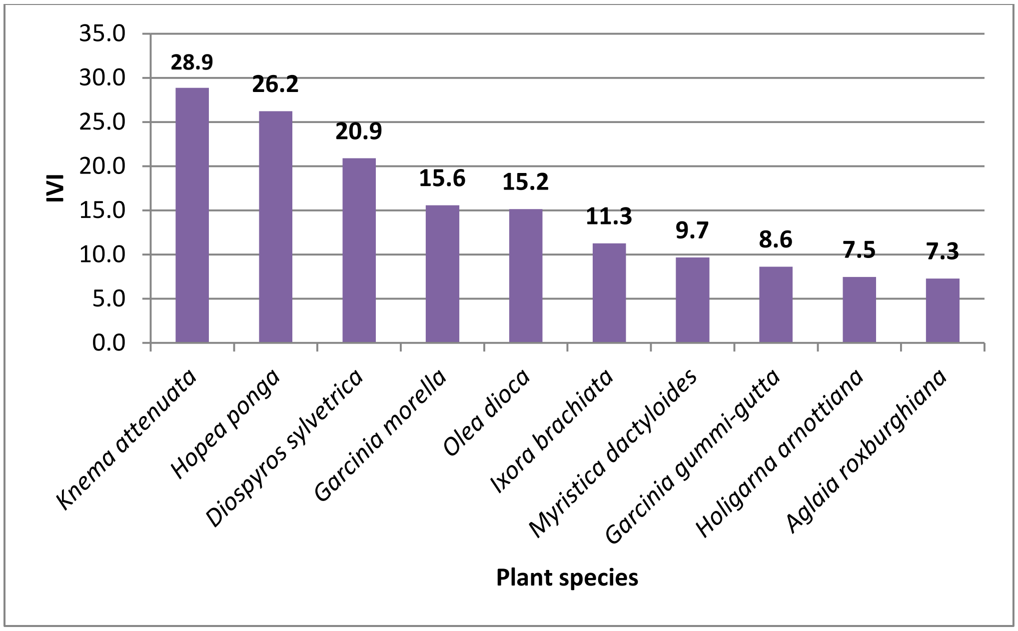


Figure 2.6 Importance Value Index (IVI) for top 10 tree species in Devgaar

Familial composition in different regions of ACR

A total of 102 species belonging to 45 families were recorded in 19.20 ha of sampling in the five study sites. However, the number of families and their representation of species slightly varied across the study sites. Familial importance index for all the study sites area are provided in the Appendices 6-10. The number of families represented in Hosthota, Chiksuli, Kanthota, Kodgi and Devgaar was 32, 31, 30, 35 and 29 respectively.

Hosthota: The family Lauraceae was well represented with eight species followed by Clusiaceae, Ebanaceae and Myrtaceae having five species each, and Anacardiaceae, Euphorbiaceae, Moraceae and Sapotaceae having represented by four species each. At the generic level, the most represented family was Lauraceae (N=7), Euphorbiaceae (N=4) and Sapotaceae (N=4). The family Myristicaceae represented by highest number of individuals (N= 254), which is followed by Ebanaceae (N=236), Dipterocarpaceae (N=158) and Clusiaceae (N=157). The maximum basal area was recorded for family Ebanaceae (17.48) followed by Myrtaceae (11.59) and Anacardiaceae (11.44). Of this, Myristicaceae was the dominated family (16.89%) followed by Ebanaceae (15.70%), Dipterocarpaceae (10.51%) and Clusiaceae (10.44%).

Chiksuli: The family Lauraceae represented by eight species, where Moraceae, Clusiaceae, Myrtaceae represented by five species each. At the generic level, family Lauraceae (N=7) dominated followed by Euphorbiaceae (N=4), Flacortiaceae (N=4) and Anacardiaceae (N=4). The family Clusiaceae was well represented by high number of individuals (N=221), which is followed by Lauraceae (N=143), Oleaceae (N=128) and Myristicaceae (N=118). The maximum basal area was recorded for family Moraceae (18.10) followed by Oleaceae (15.40) and Cluciaceae (13.60). Of this, Clusiaceae was the dominated family (15.90%) followed by Lauraceae (10.30%), Oleaceae (9.20%) and Myristicaceae (8.50%).

Evergreen forests of Aghanashini-Lion tailed macaque Conservation Reserve

Kanthota: The family Lauraceae was represented by eight species. Anacardiaceae, Myristicaceae, Clusiaceae and Ebanaceae were represented by four species each. At the generic level, family Lauraceae dominated with seven species which is followed by Anacardiaceae (N=3), Sapotaceae (N=3), Myristicaceae (N=3), Flacourtiaceae (N=3) and Euphorbiaceae (N=3). The family Oleaceae was well represented with the 187 of individuals which is followed by

Anacardiaceae (N= 143), Myristicaceae (N=126) and Lauraceae (N=113). The maximum basal area was recorded for family Oleaceae (24.60), Lauraceae (19.39) and Celastraceae (14.20). Of this Oleaceae was the dominated family (15.29%) followed by Anacardiaceae (11.69%), Myristicaceae (10.30%) and Lauraceae (9.20%).

Kodgi: The family Lauraceae was represented by seven species, which was followed by Anacardiaceae, Myrtaceae, and Euphorbiaceae with the representation of five species each, Moraceae, Ebanaceae and Cluciaceae were represented by four species each. At the generic level, Lauraceae was dominated with six genera, which is followed by Euphorbiaceae (N=5), Anacardiaceae (N=4) and Sapotaceae (N=3). The family Dipterocarpaceae was well represented with 203 individuals, which was followed by Oleaceae (N= 130) and Myristicaceae (N=128). The maximum basal area was recorded for family Moraceae (50), Oleaceae (15.60) and Euphorbiaceae (14.20). Of this, Dipterocarpaceae was the dominated family (18.14%) followed by Oleaceae (11.62%) and Myristicaceae (11.44%).

Devgaar: The family Clusiaceae and Myrtaceae were represented by five species, each that was followed by Ebanaceae and Anacardiaceae with representation of four species each. At the generic level, family Lauraceae dominated with six genera which is followed by Anacardiaceae (N=3), Sapotaceae (N=3) and Euphorbiaceae (N=3). The family Myristicaceae was well represented with 266 individuals, which is followed by Ebanaceae (N= 204), Dipterocarpaceae (N=202) and Clusiaceae (N=153). The maximum basal area was recorded for family Ebanaceae (13.02), which was followed by Myristicaceae (10.05) and Dipterocarpaceae (9.93). Of this, Myristicaceae was the dominated family (19.7%) followed by Ebanaceae (15.10%), Dipterocarpaceae (14.90%) and Clusiaceae (11.32).

Overall: The family Lauraceae is the most dominant family with 7- 8 species representation in each of the study area, which is followed by Myrtaceae, Clusiaceae and Ebanaceae. Many families were also representated by single species each (18, 15, 15, 18 and 16 families at Hosthota, Chiksuli, Kanthota, Kodgi and Devgaar respectively). The familial importance value was high for Ebanaceae at Hosthota (38.80) and Devgaar (37.00), Clusiaceae at Chiksuli (35.40), Oleaceae at Kanthota (41.00) and Moraceae at Kodgi (42.10).

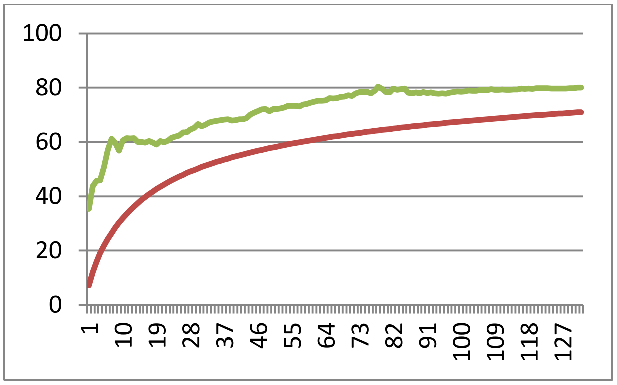
Stand density and basal area of plant species across different study sites

Stand density and basal area of each species across different study sites are provided in Appendix 2.11 and Appendix 2.12 respectively. *Knema attenuata* (34.80 ±22.20) was recorded the highest stand density, which was followed by *Hopea ponga* (33.90±26.40), *Olea dioica* (33.10±10.50)*,* and *Garcinia morella* (18.90±5.00). The highest basal area was shown by *Olea dioica* (14.32±6.78), *Ficus nervosa* (16.57±4.52), *Hopea ponga* (7.20±3.79), *Ficus microcarpa* (10.18±16.13) and *Knema attenuata* (6.05±2.06).

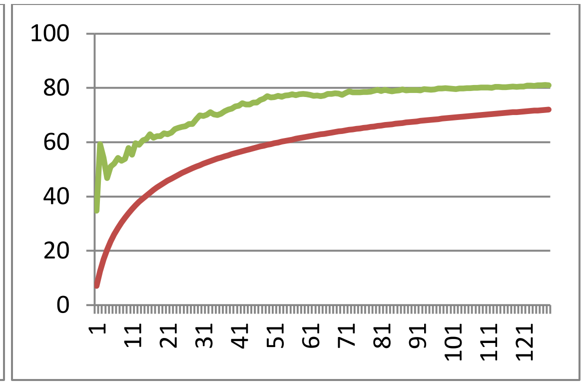
Knema attenuata (57.38), *Hopea ponga* (38.07) and *Olea dioica* (23.37) showed highest stand density in Hosthota while *Olea dioica* (31.84)*, Nathopegia racemosa* (24.88) and *Memycylon malabaricum* (22.89) in Chiksuli, *Olea dioica* (45.27), *Knema attenuata* (24.38) and *Aglaia roxburghiana* (20.15) in Kanthota*, Hopea ponga* (65.8)*, Olea dioica* (42.35) and *Knema attenuata* (38.11) in Kodagi, *Knema attenuata* (51.77)*, Hopea ponga* (51.01) and *Diospyros sylvatica* (34.09) in Devgaar showed high stand density. *Diospyros sylvatica* (12.43), *Syzigium gardneri* (10.69) and *Hopea ponga* (9.09) in Hosthota, *Ficus nervosa* (17.65), *Olea dioica* (15.39) and *Cassine glauca* (5.41) in Chiksuli, *Olea dioica* (24.44), *Persea macarantha* (14.7) and *Cassine glauca* (11.92) in Kanthota, *Ficus microcarpa* (28.79), *Ficus nervosa* (20.46) and *Olea dioica* (15.58) in Kodagi and *Ficus nervosa* (11.61), *Hopea ponga* (9.93) and *Diospyros sylvatica* (9.28) in Devgaar showed the higher basal area.

Species-Area curves

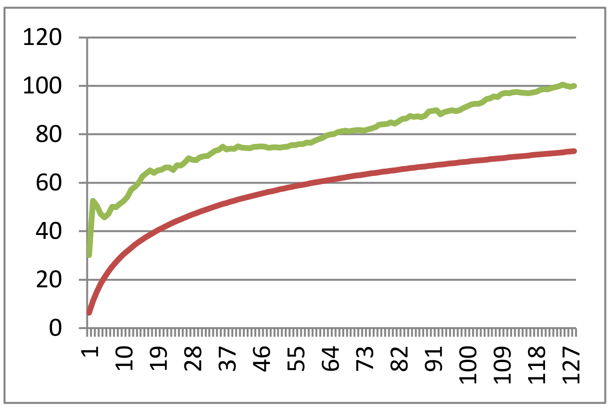
The species-area curves plotted for Hosthota, Chiksuli, Kodgi and Kanthota revealed that species increments happened constantly along the curves until the end of sampling, indicating higher sampling effort required to reach the asymptote (Table 2.4 and Fig.2.7). However, asymptote was achieved only for Devgaar indicating sampling effort to be adequate having negligible difference in estimation value and observed species.



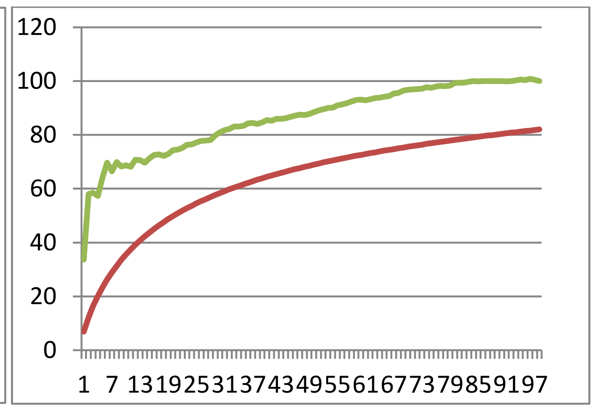
a. Hosthota



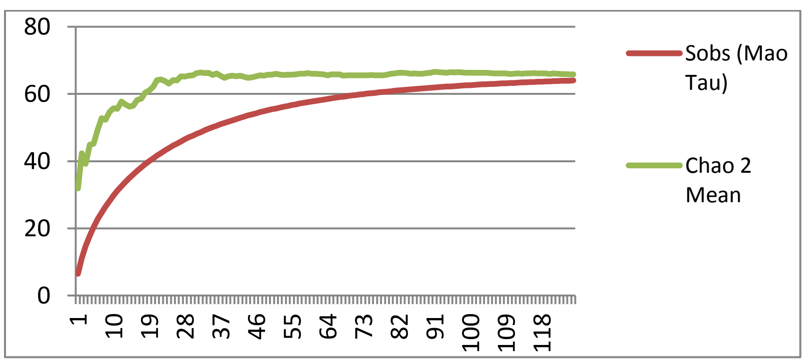
b. Chiksuli



c. Kanthota



d. Kodgi



e. Devgaar

Figure 2.7 Species accumulation curve (observed and expected) for different sampling sites

Table 2.4 Number of expected and observed species in different smapling sites as predicted by Chao2 Mean and SobsMean

	Hosthota	Chiksuli	Kodgi	Kanthota	Devgaar
Observed	71	72	82	73	64
Estimated	80	81	100	100	65.7

Table 2.5 Stand density, species richness, basal area and species occurrence ion different girth classes across different sampling sites

Area	Girth class	Stand density	Species richness	Basal area/ha	Species occurrence rate
Hosthota	**10-30**	1674	60	-	0.03
	30-60	171.78	61	2.71	0.36
	61-90	86.86	51	3.68	0.59
	91-120	52.35	38	4.53	0.73
	121-150	25.57	28	3.54	1.09
	151-180	32.81	18	1.87	0.55
	181-210	7.24	13	2.27	1.80
	>210	9.89	19	7.77	1.92
Chiksuli	**10-30**	3184	63	-	0.01
	30-60	168.69	62	2.62	0.37
	61-90	91.06	52	3.88	0.57
	91-120	44.04	34	3.75	0.77
	121-150	19.41	20	2.78	1.03
	151-180	11.69	23	2.48	1.97
	181-210	5.47	13	1.64	2.37
	>210	8.96	16	10.05	1.79
Kanthota	**10-30**	1030	61	-	0.05
	30-60	153.02	59	2.40	0.39
	61-90	76.13	45	3.30	0.59
	91-120	44.04	41	3.71	0.93
	121-150	19.66	28	2.80	1.42
	151-180	8.96	18	1.85	2.01
	181-210	6.22	13	1.84	2.09
	>210	10.45	15	13.71	1.44
Kodgi	**10-30**	904	53	-	0.05
	30-60	183.61	65	3.14	0.35
	61-90	84.17	49	4.31	0.58
	91-120	42.25	33	4.84	0.78
	121-150	22.75	26	3.66	1.14
	151-180	12.02	16	2.41	1.33
	181-210	9.10	11	2.40	1.21
	>210	16.25	17	17.90	1.05
Devgaar	**10-30**	1362	58	-	0.04
	30-60	179.96	52	2.82	0.29
	61-90	92.26	52	4.01	0.56
	91-120	41.45	34	3.56	0.82
	121-150	15.17	23	2.16	1.52
	151-180	6.57	11	1.39	1.67
	181-210	3.79	11	1.19	2.90
	>210	5.56	12	6.34	2.16

Girth and density class characteristics

As it was expected, the highest stand density and species richness was in the 10-30 cm girth class that gradually tapered down in higher girth classes (Table 2.5). Among the 10-30 cm class, Chiksuli showed highest number of individuals (3184 ha^{-1}) while the minimum was in Kodgi (904 ha^{-1}). Basal area was relatively spread over across different girth classes, however, the basal area in/with 61-120 classes was higher than in any other classes, further, the trees with greater than 210 cm girth class showed much higer basal area than in any other girth classes. Higher values of species occurrence were seen in higher girth classes of all the areas. Majority of the tree species remained in their density class < 20 ha^{-1}, only four to five species of them were in more than 20 ha^{-1} across different sites (Table 2.6).

Table 2.6 Species richness of woody plants in different density classes across different sites

Density Classes	**Species Richness**				
	1	**2**	**3**	**4**	**5**
>101	-	-	-	-	-
100-51	1	-	-	1	2
50-21	5	4	5	3	3
20-3	13	23	17	22	15
<3	53	46	45	51	44
Total	**72**	**73**	**67**	**77**	**64**

Status of NTFP trees across different sampling sites

Highest IVI was exhibited by *Garcinia morella* (12.03±2.74SD) across the sites followed by *Garcinia gummi-gutta* (8.06±1.80), *Myristica dactyloides* (4.35±3.03), *Mangifera indica* (2.77±0.80), *Cinnamomum malabathrum* (2.09±0.39), *Myristica malabarica* (1.97±0.68), *Canerium strictum* (1.22±0.68), *Calophyllum apetalum* (0.95 ± 0.88) and *Artocarpus lakoocha* (0.81±0.74) (Fig. 2.8).

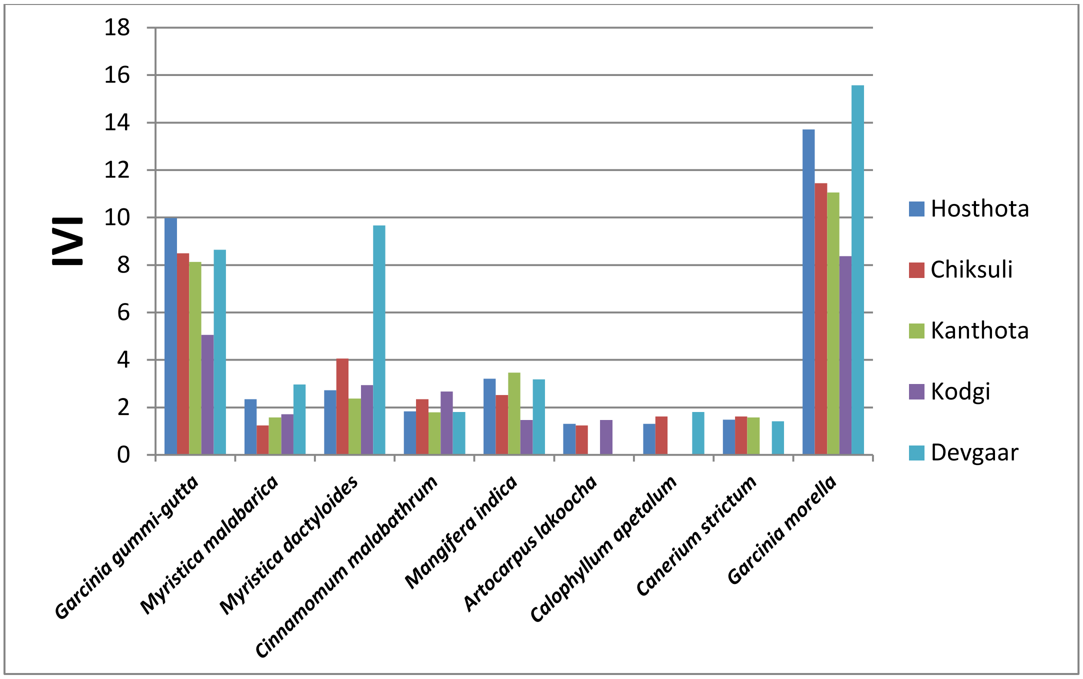


Figure 2.8 IVI of the most important NTFP trees across different sampling sites

The number of seedlings (<10 cm girth) across the sites were dominated by *Garcinia gummi-gutta* (1408±980.88), which was followed by *Calamus pseudotenuis* (376±163.95), *Calamus twaitessi* (76±47.75) and *Myristica dactyloides* (32±33.47) (Figure 2.9). No individuals of *Myristica malabarica* and *Artocarpus lakoocha* were recorded in any of the sites.

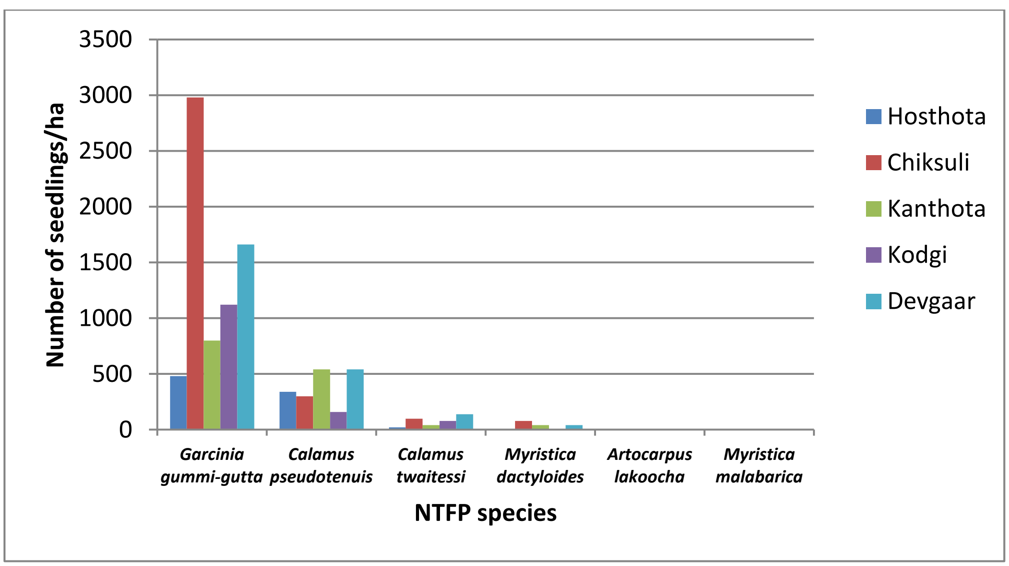


Figure 2.9 Number of seedlings of NTFP tree species (<10 cm) in across the sites

Number of individuals and basal area in different girth classes

Figure 2.10 Number of individuals of NTFP species in different girth classes across the sites

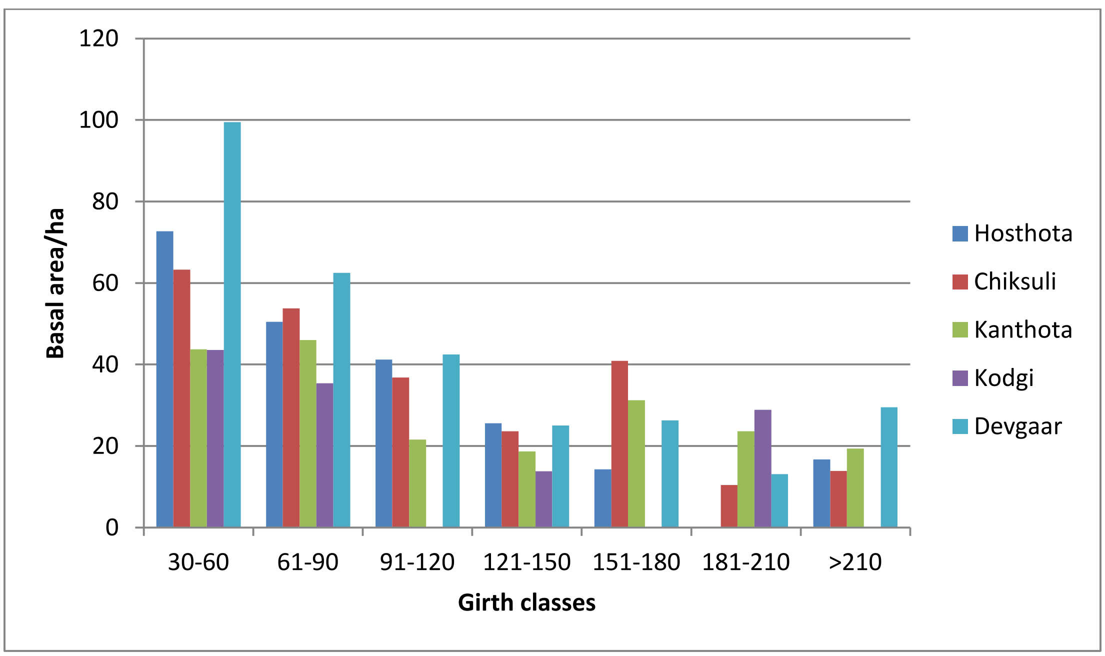


Figure 2.11 Basal areas of NTFP species in different girth classes across the sites

The number of individuals showed gradual decline from lower girth class to higher girth class in all the sites i.e. 208±81.50 individuals in 10-30 cm class, 26.39±9.60 in 31- 60 cm class, 7.68±1.70 in 61-90 cm class, 2.18±1.36 in 91-120 cm class, 0.92±0.22 in 121- 150 cm class, 0.70±0.48 in 151-180 cm class, 0.33±0.25 in 181-210 cm class and 0.20±0.11 in > 210 cm class was recorded (Figure 2.10). Highest basal area (64.50±23.20) was in the 30-60 cm girth class which gradually lowered down i.e. 49.60± 9.90 in 61-90 cm class, 28.40±17.90 in 91-120 cm class, 21.33±5.00 in 121-150 cm class, 22.50±15.80 in 151- 180 cm class, 15.20±11.30 in 181-210 cm class and 15.80±10.60 in >210 cm class (Figure 2.11).

Discussion

The knowledge of stand structure of vegetation of an area contributes largely to the understanding of overall biodiversity parameters as plants provide habitat and food resources to most forest inhabitants (Cannon et al., 1998). Stand structure of forests is highly site specific, and is decided by the biogeography, human interference and climatic conditions (Whitmore, 1998). Thus, the understanding of qualitative and quantitative structural changes across the forest is a critical exercise for management of forests, that too if the forest patch is crucial for the conservation of some important species and having high human dependence for their livelihood. The forests of ACR is one of the important and potential sites for conservation of endangered LTM (Kumara et al., 2004; Santhosh et al., 2013), and many other flora and fauna in the central Western Ghats (Kumara et al., 2008). ACR forms a northern limit of distribution of low and medium elevation dipterocarp forests (Pascal, 1988).

Vegetative parameters in and around ACR show a great degree of variation within the landscape and that their documentation remains very critical for addressing local issues for management. The present study showed species richness of woody plants ranged from 66 to 78 across the sampling sites. The species richness in ACR is much lesser than in the southern Western Ghats (Davidar et al., 2005) e.g. 114 species in in Sengaltheri forests or 116 species in Kalakad-Mundanthurai Tiger Reserve (Parthasarathy, 2001; 1999) and 148 to 153 species in 30 ha of sampling in Vargaliar of Anamalai hills (Ayyappan and Parthasarathy, 1999; 2004), however, it is on par with the species richness reported (37 to 63 species) for north of ACR in

Uttara Kannada (Bhat et al., 2000). The lesser species richness in the central Western Ghats than in the southern Ghats was attributed to changes in the seasonality existing between them in addition to variation in the quantity of rainfall (Davidar et al., 2005). The stand density of trees (>30 cm) ranged between 318 and 386 stems/ha in the ACR, perhaps which is also much lesser than many sites in southern Western Ghats e.g. 851 ha^{-1} in Sengaltheri (Parthasarathy, 2001), 716 ha^{-1} in KMTR (Parthasarathy, 1999), 482 ha^{-1} Courtallam reserve forests (Parthasarathy and Karthikeyan, 1997), 583 ha^{-1} at Kakachi, (Ganesh et al., 1996). However, Ayyappan and Parthasarathy (2004) reported high variation of 273 to 674 stems/ha in Varagaliyar of Anamalai hills. Even within the central Western Ghats, the stem density highly varied from 304 ha^{-1} in Agumbe (Srinivas, 1997) to 635 ha^{-1} in Uppangala (Pascal and Pelisser, 1996), however, 419 ha^{-1} of mean tree density for a closed canopy evergreen forest of Western Ghats was reported (Ghate et al., 1998). The basal area of trees per hectare varied from 21.5 m^2 to 45.5 m^2, which is much lower than in southern Western Ghats e.g. 94.6 m^2 ha^{-1} in KMTR (Parthasarathy, 1999) and 55.34 to 78.32 m^2 ha^{-1} in Sengaltheri (Parthasarathy, 2001). The lesser tree density and basal area in the study sites than in the southern Western Ghats may be due to lesser rainfall and seasonality that vary between them, and however, variation within the landscape may be due to high exploitation of trees over a period.

Size class distribution indicates the stability of trees in the forest community (Pandey, 2006). The higher abundance of plants in lower size classes and gradual tapering across higher size classes in the present study indicates conformity with other regions in the Western Ghats like Sengaltheri (Parthasarathy, 2001). The same was true in relationship between species richness and stand density where highest species richness was in <20-density category across the sites which indicates uniformity in the pattern and existence of disturbance. There were very less individuals across the areas that had a girth >90 cm probably this is due to earlier selective logging (Gadgil and Chandran, 1989).

The species like *Knema attunata, Olea dioica, Hopea ponga* and *Aglaia roxburghiana* showed high importance value in all the areas including southern ACR of the same landscape (Roy et al., 2010). These species were indicated as an important food species for primates in the area (Roy et al., 2010). Further, the species with high IVI in different season also were important food species in that season for LTM (Roy et al., 2010; Kumara and Santhosh, 2013). This indicate that the total species richess is relatively lesser than in the southern Western Ghats, the existing dominant species have become a major food plants of many of these primates in the site, and also they contribute to livelihood (as NTFP and firewood) of local people. Among NTFP tree species, the IVI of *Garcinia gummi-gutta* varied from 5.1 to 10 in the study sites and in the southern part of the same landscape was 7.9 that fell within a range, which indicates the variation in distribution of the species across the ACR. The IVI value of *Caryota urens* in southern ACR was 5.5 (Roy et al., 2010), where in the northern ACR was between 0 and 2. *Myristica malabarica* and *Myristica dactyloides*, which are known to be highly exploited by people for NTFP (Kumara and Santhosh, 2013), showed variation from 1.2-2.9 and 2.4-9.7 respectively indicating high degree of variation across areas. Even in southern part of landscape, the IVI values of 2.6 and 2.7 respectively for both the species (Roy et al., 2010) was well within a range of present study. This indicates the existence of variation in the diversity of NTFP trees within landscape. The species of local interest and food species of LTM need to consider while planning the restoration. The present database indeed helps in deciding the site-specific tree species to achieve this goal.

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Appendix 2.1 Table showing the density and Important Value Index (IVI) for woody plants in Hosthota area.

Name of the species	**Family**	**N**	**No. of plots**	**GBH (m)**	**F**	**A**	**D**	**RF**	**RA**	**RD**	**BA**	**IVI**
Knema attenuata	Myristicaceae	238	93	153.2	70.5	2.6	1.8	9.8	2.9	15.8	8.9	28.6
Diospyros sylvetrica	Ebanaceae	185	87	154.6	65.9	2.1	1.4	9.2	2.4	12.3	12.4	23.9
Hopea ponga	Dipterocarpaceae	158	58	116.2	43.9	2.7	1.2	6.1	3.1	10.5	9.1	19.8
Holigarna arnottiana	Anacardiaceae	111	70	100.8	53.0	1.6	0.8	7.4	1.8	7.4	9.7	16.6
Olea dioica	Oleaceae	97	54	90.9	40.9	1.8	0.7	5.7	2.1	6.5	9.0	14.2
Garcinia morella	Clusiaceae	87	59	39.4	44.7	1.5	0.7	6.2	1.7	5.8	1.5	13.7
Garcinia gummi-gutta	Clusiaceae	59	42	38.5	31.8	1.4	0.4	4.4	1.6	3.9	2.7	10
Ixora brachiata	Rubiaceae	38	36	17.1	27.3	1.1	0.3	3.8	1.2	2.5	0.7	7.5
Aglaia roxburghiana	Meliaceae	39	25	25.3	18.9	1.6	0.3	2.6	1.8	2.6	1.3	7.0
Diospyros buxifolia	Ebanaceae	32	27	36.6	20.5	1.2	0.2	2.9	1.4	2.1	4.4	6.3
Syzigium gardneri	Myrtaceae	28	25	44.0	18.9	1.1	0.2	2.6	1.3	1.9	10.7	5.8
Aparosa lindelana	Euphorbiaceae	26	21	16.4	15.9	1.2	0.2	2.2	1.4	1.7	0.9	5.4
Pterospermum reticulatum	Sterculiaceae	25	14	18.3	10.6	1.8	0.2	1.5	2.0	1.7	1.6	5.2
Vitex altissema	Verbenaceae	20	18	32.0	13.6	1.1	0.2	1.9	1.3	1.3	5.2	4.5
Flacourtia montana	Flacortiaceae	20	18	16.1	13.6	1.1	0.2	1.9	1.3	1.3	0.9	4.5
Nathopegia racemosa	Anacardiaceae	20	15	10.8	11.4	1.3	0.2	1.6	1.5	1.3	0.6	4.4
Litsea stocksii	Lauraceae	19	16	13.3	12.1	1.2	0.1	1.7	1.4	1.3	0.8	4.3
Symplocos racemosa	Symplocaceae	19	14	13.4	10.6	1.4	0.1	1.5	1.6	1.3	0.9	4.3
Artocarpus hirsutus	Moraceae	16	14	13.2	10.6	1.1	0.1	1.5	1.3	1.1	1.3	3.9
Lopopetalum whitianum	Celastraceae	12	8	18.4	6.1	1.5	0.1	0.8	1.7	0.8	3.7	3.4
Memecylon malabaricum	Melastomaceae	12	11	5.4	8.3	1.1	0.1	1.2	1.2	0.8	0.2	3.2
Eleocarpus serratus	Urticaceae	12	11	6.0	8.3	1.1	0.1	1.2	1.2	0.8	0.2	3.2
Cassine glauca	Celastraceae	12	12	17.0	9.1	1.0	0.1	1.3	1.1	0.8	3.4	3.2
Mangefera indica	Anacardiaceae	12	12	8.2	9.1	1.0	0.1	1.3	1.1	0.8	0.5	3.2
Litsea floribonda	Lauraceae	12	11	9.6	8.3	1.1	0.1	1.2	1.2	0.8	0.8	3.2
Persia macarantha	Lauraceae	11	10	18.0	7.6	1.1	0.1	1.1	1.3	0.7	2.9	3.0
Actinodaphne hookeri	Lauraceae	10	8	6.8	6.1	1.3	0.1	0.8	1.4	0.7	0.4	2.9
Belsmedia whitii	Lauraceae	10	9	7.6	6.8	1.1	0.1	1.0	1.3	0.7	0.7	2.9
Diospyros candolliana	Ebanaceae	10	9	6.6	6.8	1.1	0.1	1.0	1.3	0.7	0.4	2.9
Dimocarpus longan	Sapindaceae	10	8	5.8	6.1	1.3	0.1	0.8	1.4	0.7	0.3	2.9
Mimusops elengi	Sapotaceae	10	9	9.1	6.8	1.1	0.1	1.0	1.3	0.7	0.7	2.9
Macarange peltata	Euphorbiaceae	9	7	5.4	5.3	1.3	0.1	0.7	1.5	0.6	0.3	2.8
Xantolis tomentosa	Sapotaceae	4	2	2.1	1.5	2.0	0.0	0.2	2.3	0.3	0.1	2.8
Myristica dactyloides	Myristicaceae	9	8	6.1	6.1	1.1	0.1	0.8	1.3	0.6	0.5	2.7
Holigarna grahmi	Anacardiaceae	8	7	7.4	5.3	1.1	0.1	0.7	1.3	0.5	0.7	2.6
Tabernamontana heyinana	Apocynaceae	8	8	3.3	6.1	1.0	0.1	0.8	1.1	0.5	0.1	2.5
Alsea daphni	Lauraceae	2	1	3.0	0.8	2.0	0.0	0.1	2.3	0.1	0.4	2.5
Chrysophyllum roxburghii	Sapotaceae	6	5	4.7	3.8	1.2	0.0	0.5	1.4	0.4	0.3	2.3

Myristica malabarica	Myristicaceae	7	7	4.4	5.3	1.0	0.1	0.7	1.1	0.5	0.3	2.3
Diospyros angustfolia	Ebanaceae	6	5	2.4	3.8	1.2	0.0	0.5	1.4	0.4	0.1	2.3
Callophylum tomentasum	Clusiaceae	6	5	9.2	3.8	1.2	0.0	0.5	1.4	0.4	1.4	2.3
Lageostromia microcarpa	Lythraceae	5	4	7.3	3.0	1.3	0.0	0.4	1.4	0.3	0.9	2.2
Caryota urens	Aracaceae	3	2	2.6	1.5	1.5	0.0	0.2	1.7	0.2	0.2	2.1
Careya arborea	Aracaceae	3	2	1.5	1.5	1.5	0.0	0.2	1.7	0.2	0.1	2.1
Syzizium hemispermicum	Myrtaceae	3	2	3.7	1.5	1.5	0.0	0.2	1.7	0.2	0.4	2.1
Cinnamomum malabathrum	Lauraceae	4	4	2.1	3.0	1.0	0.0	0.4	1.1	0.3	0.1	1.8
Garcinia talbotti	Clusiaceae	4	4	4.2	3.0	1.0	0.0	0.4	1.1	0.3	0.8	1.8
Maduca longifolia	Sapotaceae	4	4	3.3	3.0	1.0	0.0	0.4	1.1	0.3	0.2	1.8
Carallia brachiata	Rhizophoraceae	3	3	1.3	2.3	1.0	0.0	0.3	1.1	0.2	0.0	1.7
Diospyros montana	Ebanaceae	3	3	2.4	2.3	1.0	0.0	0.3	1.1	0.2	0.2	1.7
Neolitsia zeylanica	Lauraceae	4	5	2.7	3.8	0.8	0.0	0.5	0.9	0.3	0.2	1.7
Canthium dicoccum	Rubiaceae	4	5	2.0	3.8	0.8	0.0	0.5	0.9	0.3	0.1	1.7
Homelium zeylanicum	Flacortiaceae	3	3	1.2	2.3	1.0	0.0	0.3	1.1	0.2	0.0	1.7
Canerium strictum	Burseraceae	2	2	2.0	1.5	1.0	0.0	0.2	1.1	0.1	0.2	1.5
Chukrasia tabularis	Liliaceae	2	2	4.0	1.5	1.0	0.0	0.2	1.1	0.1	0.7	1.5
Artocarpus heterophyllus	Moraceae	2	2	1.7	1.5	1.0	0.0	0.2	1.1	0.1	0.1	1.5
Syzizium laetum	Myrtaceae	2	2	0.9	1.5	1.0	0.0	0.2	1.1	0.1	0.0	1.5
Syzygium cumini	Myrtaceae	2	2	4.1	1.5	1.0	0.0	0.2	1.1	0.1	0.7	1.5
Callicarpa tomentosa	Verbinaceae	2	2	0.8	1.5	1.0	0.0	0.2	1.1	0.1	0.0	1.5
Drypetes confertifolius	Euphorbiaceae	1	1	1.0	0.8	1.0	0.0	0.1	1.1	0.1	0.1	1.3
Callophylum apetalum	Clusiaceae	1	1	0.1	0.8	1.0	0.0	0.1	1.1	0.1	0.0	1.3
Sterculia guttata	Sterculiaceae	1	1	0.8	0.8	1.0	0.0	0.1	1.1	0.1	0.1	1.3
Ficus microcarpa	Moraceae	1	1	4.7	0.8	1.0	0.0	0.1	1.1	0.1	1.8	1.3
Steriospermum personatum	Bignonianaceae	1	1	1.7	0.8	1.0	0.0	0.1	1.1	0.1	0.2	1.3
Euodia lunu-ankenda	Rutaceae	1	1	0.5	0.8	1.0	0.0	0.1	1.1	0.1	0.0	1.3
Syzygium sp.	Myrtaceae	1	1	1.4	0.8	1.0	0.0	0.1	1.1	0.1	0.2	1.3
Albizia lebbeck	Mimosaceae	1	1	1.9	0.8	1.0	0.0	0.1	1.1	0.1	0.2	1.3
Prunus ceylanica	Rosaceae	1	1	1.5	0.8	1.0	0.0	0.1	1.1	0.1	0.2	1.3
Glochidion velutinum	Euphorbiaceae	1	1	0.4	0.8	1.0	0.0	0.1	1.1	0.1	0.0	1.3
Hydnocarpus pentandra	Flacortiaceae	1	1	1.8	0.8	1.0	0.0	0.1	1.1	0.1	0.2	1.3
Artocarpus lakoocha	Moraceae	1	1	0.7	0.8	1.0	0.0	0.1	1.1	0.1	0.0	1.3
Polyanthia fragrens	Anonaceae	1	2	0.9	1.5	0.5	0.0	0.2	0.6	0.1	0.1	0.8

N- Number of Individuals, GBH- Girth at Breast Height, F-Frequency, A-Abundance, D-Density, RF-Relative Frequency, RA-Relative Abundance, RD- Relative Density, BA-Basal Area, IVI-Importance Value Index

Appendix 2.2 Table showing the density and Important Value Index (IVI) for woody plants in Chiksuli area.

Name of the species	Family	N	No. of plots	GBH (m)	F	A	D	RF	RA	RD	BA	IVI
Olea dioica	Oleaceae	128	57	135.7	44.5	2.2	1.0	6.4	2.4	9.1	15.4	17.9
Knema attenuata	Myristicaceae	100	60	76.3	46.9	1.7	0.8	6.7	1.8	7.1	5.4	15.6
Aglaia roxburghiana	Meliaceae	92	54	67.3	42.2	1.7	0.7	6.0	1.8	6.6	5.0	14.4
Garcinia talbotti	Clusiaceae	89	36	72.6	28.1	2.5	0.7	4.0	2.6	6.4	5.6	13.0
Hopea ponga	Dipterocarpaceae	79	34	59.2	26.6	2.3	0.6	3.8	2.5	5.6	4.4	11.9
Dimocarpus longan	Sapindaceae	72	43	43.5	33.6	1.7	0.6	4.8	1.8	5.1	2.6	11.7
Garcinia morella	Clusiaceae	73	37	37.0	28.9	2.0	0.6	4.1	2.1	5.2	1.6	11.4
Holigarna arnottiana	Anacardiaceae	64	44	45.2	34.4	1.5	0.5	4.9	1.5	4.6	3.0	11.0
Litsea stocksii	Lauraceae	52	33	34.4	25.8	1.6	0.4	3.7	1.7	3.7	2.0	9.1
Xylia xylocarpa	Fabaceae	54	18	38.0	14.1	3.0	0.4	2.0	3.2	3.9	2.8	9.1
Diospyros candolliana	Ebanaceae	51	31	37.1	24.2	1.6	0.4	3.5	1.8	3.6	2.6	8.9
Garcinia gummi-gutta	Clusiaceae	45	35	34.7	27.3	1.3	0.4	3.9	1.4	3.2	2.8	8.5
Litsea floribonda	Lauraceae	40	25	31.5	19.5	1.6	0.3	2.8	1.7	2.9	2.7	7.4
Pterospermum reticulatum	Sterculiaceae	37	20	21.2	15.6	1.9	0.3	2.2	2.0	2.6	1.1	6.8
Nathopegia racemosa	Anacardiaceae	27	23	13.6	18.0	1.2	0.2	2.6	1.3	1.9	0.6	5.7
Belsmedia whitii	Lauraceae	24	23	21.3	18.0	1.0	0.2	2.6	1.1	1.7	1.9	5.4
Symplocos racemosa	Symplocaceae	23	15	11.0	11.7	1.5	0.2	1.7	1.6	1.6	0.5	4.9
Ixora brachiata	Rubiaceae	21	17	9.5	13.3	1.2	0.2	1.9	1.3	1.5	0.4	4.7
Mimusops elengi	Sapotaceae	21	17	16.2	13.3	1.2	0.2	1.9	1.3	1.5	1.6	4.7
Myristica dactyloides	Myristicaceae	17	13	11.7	10.2	1.3	0.1	1.5	1.4	1.2	0.8	4.1
Diospyros angustfolia	Ebanaceae	16	16	8.3	12.5	1.0	0.1	1.8	1.1	1.1	0.4	4.0
Holigarna grahmi	Anacardiaceae	16	16	11.4	12.5	1.0	0.1	1.8	1.1	1.1	0.8	4.0
Euodia lunu-ankenda	Rutaceae	15	11	1.3	8.6	1.4	0.1	1.2	1.5	1.1	1.3	3.8
Vitex altissema	Verbenaceae	14	9	19.8	7.0	1.6	0.1	1.0	1.7	1.0	2.8	3.7
Macarange peltata	Euphorbiaceae	14	10	7.7	7.8	1.4	0.1	1.1	1.5	1.0	0.4	3.6
Xantolis tomentosa	Sapotaceae	14	12	10.2	9.4	1.2	0.1	1.3	1.2	1.0	0.7	3.6
Maduca longifolia	Sapotaceae	3	1	2.6	0.8	3.0	0.0	0.1	3.2	0.2	0.2	3.5
Eleocarpus serratus	Urticaceae	13	12	6.5	9.4	1.1	0.1	1.3	1.2	0.9	0.3	3.4
Syzizium hemispermicum	Myrtaceae	12	10	9.0	7.8	1.2	0.1	1.1	1.3	0.9	0.8	3.3
Callicarpa tomentosa	Verbinaceae	12	11	5.1	8.6	1.1	0.1	1.2	1.2	0.9	0.2	3.2
Callophylum tomentasum	Clusiaceae	11	11	21.4	8.6	1.0	0.1	1.2	1.1	0.8	3.6	3.1
Ficus nervosa	Moraceae	9	8	22.9	6.3	1.1	0.1	0.9	1.2	0.6	17.7	2.7
Artocarpus hirsutus	Moraceae	8	7	5.6	5.5	1.1	0.1	0.8	1.2	0.6	0.4	2.6
Flacourtia montana	Flacortiaceae	6	4	3.1	3.1	1.5	0.0	0.4	1.6	0.4	0.1	2.5
Mangefera indica	Anacardiaceae	8	8	3.2	6.3	1.0	0.1	0.9	1.1	0.6	0.1	2.5
Glochidion velutinum	Euphorbiaceae	5	3	4.3	2.3	1.7	0.0	0.3	1.8	0.4	0.4	2.5
Steriospermum personatum	Bignonianaceae	2	1	1.1	0.8	2.0	0.0	0.1	2.1	0.1	0.1	2.4

Memecylon malabaricum	Melastomaceae	7	7	2.7	5.5	1.0	0.1	0.8	1.1	0.5	0.1	2.3
Neolitsia zeylanica	Lauraceae	6	5	3.0	3.9	1.2	0.0	0.6	1.3	0.4	0.1	2.3
Cinnamomum malabathrum	Lauraceae	7	7	3.3	5.5	1.0	0.1	0.8	1.1	0.5	0.1	2.3
Syzizium laetum	Myrtaceae	7	7	2.6	5.5	1.0	0.1	0.8	1.1	0.5	0.1	2.3
Actinodaphne hookeri	Lauraceae	6	6	3.1	4.7	1.0	0.0	0.7	1.1	0.4	0.2	2.2
Tabernamontana heyinana	Apocynaceae	6	6	2.2	4.7	1.0	0.0	0.7	1.1	0.4	0.1	2.2
Casearia beddomi	Flacortiaceae	6	6	3.1	4.7	1.0	0.0	0.7	1.1	0.4	0.2	2.2
Syzigium gardneri	Myrtaceae	6	6	10.8	4.7	1.0	0.0	0.7	1.1	0.4	2.8	2.2
Homelium zeylanicum	Flacortiaceae	5	4	2.8	3.1	1.3	0.0	0.4	1.3	0.4	0.1	2.1
Sterculia guttata	Sterculiaceae	4	3	3.7	2.3	1.3	0.0	0.3	1.4	0.3	0.3	2.0
Cassine glauca	Celastraceae	4	3	11.4	2.3	1.3	0.0	0.3	1.4	0.3	5.4	2.0
Persia macarantha	Lauraceae	5	5	5.2	3.9	1.0	0.0	0.6	1.1	0.4	0.7	2.0
Aparosa lindelana	Euphorbiaceae	4	4	2.2	3.1	1.0	0.0	0.4	1.1	0.3	0.1	1.8
Diospyros buxifolia	Ebanaceae	4	4	6.7	3.1	1.0	0.0	0.4	1.1	0.3	1.2	1.8
Callophylum apetalum	Clusiaceae	3	3	2.1	2.3	1.0	0.0	0.3	1.1	0.2	0.1	1.6
Canerium strictum	Burseraceae	3	3	4.2	2.3	1.0	0.0	0.3	1.1	0.2	0.5	1.6
Alsea daphni	Lauraceae	3	3	3.2	2.3	1.0	0.0	0.3	1.1	0.2	0.3	1.6
Lageostromia microcarpa	Lythraceae	3	3	6.0	2.3	1.0	0.0	0.3	1.1	0.2	1.0	1.6
Nothapodytes nimmoniana	Icaciniceae	3	3	1.1	2.3	1.0	0.0	0.3	1.1	0.2	0.0	1.6
Caryota urens	Aracaceae	2	2	1.8	1.6	1.0	0.0	0.2	1.1	0.1	0.1	1.4
Canthium dicoccum	Rubiaceae	2	2	1.3	1.6	1.0	0.0	0.2	1.1	0.1	0.1	1.4
Diospyros sylvetrica	Ebanaceae	2	2	1.0	1.6	1.0	0.0	0.2	1.1	0.1	0.0	1.4
Syzygium cumini	Myrtaceae	2	2	3.1	1.6	1.0	0.0	0.2	1.1	0.1	0.4	1.4
Terminelia bellarica	Combretaceae	2	2	3.7	1.6	1.0	0.0	0.2	1.1	0.1	0.5	1.4
Ficus microcarpa	Moraceae	1	1	0.6	0.8	1.0	0.0	0.1	1.1	0.1	0.0	1.2
Chrysophyllum roxburghii	Sapotaceae	1	1	1.6	0.8	1.0	0.0	0.1	1.1	0.1	0.2	1.2
Celtis tetandra	Ulmaceae	1	1	0.6	0.8	1.0	0.0	0.1	1.1	0.1	0.0	1.2
Terminalia paniculata	Combretaceae	1	1	1.6	0.8	1.0	0.0	0.1	1.1	0.1	0.2	1.2
Careya arborea	Aracaceae	1	1	0.8	0.8	1.0	0.0	0.1	1.1	0.1	0.0	1.2
Syzygium caryphyllatum	Myrtaceae	1	1	1.2	0.8	1.0	0.0	0.1	1.1	0.1	0.1	1.2
Sapium insigne	Euphorbiaceae	1	1	1.2	0.8	1.0	0.0	0.1	1.1	0.1	0.7	1.2
Alstonia scolaris	Apocynaceae	1	1	0.5	0.8	1.0	0.0	0.1	1.1	0.1	0.0	1.2
Myristica malabarica	Myristicaceae	1	1	0.5	0.8	1.0	0.0	0.1	1.1	0.1	0.0	1.2
Hydnocarpus pentandra	Flacortiaceae	1	1	0.9	0.8	1.0	0.0	0.1	1.1	0.1	0.1	1.2
Artocarpus lakoocha	Moraceae	1	1	0.6	0.8	1.0	0.0	0.1	1.1	0.1	0.0	1.2
Ficus asperima	Moraceae	1	2	0.8	1.6	0.5	0.0	0.2	0.5	0.1	0.1	0.8

N- Number of Individuals, GBH- Girth at Breast Height, F-Frequency, A-Abundance, D-Density, RF-Relative Frequency, RA-Relative Abundance, RD- Relative Density, BA-Basal Area, IVI-Importance Value Index

Appendix 2.3 Table showing the density and Important Value Index (IVI) for woody plants in Kanthota area.

Latin name	Family	N	No. of plots	GBH (m)	F	A	D	RF	RA	RD	BA	IVI
Olea dioica	Oleaceae	182	82	205.2	64.1	2.2	1.4	10.5	2.6	14.9	24.4	27.9
Knema attenuata	Myristicaceae	98	57	66.5	44.5	1.7	0.8	7.3	2.0	8.0	4.1	17.3
Aglaia roxburghiana	Meliaceae	81	48	58.5	37.5	1.7	0.6	6.1	2.0	6.6	5.7	14.7
Nathopegia recemosa	Anacardiaceae	71	45	37.5	35.2	1.6	0.6	5.7	1.8	5.8	1.9	13.4
Memycylon malabaricum	Melastomaceae	72	37	29.2	28.9	1.9	0.6	4.7	2.3	5.9	1.0	12.9
Garcinia morella	Clusiaceae	59	32	30.4	25.0	1.8	0.5	4.1	2.1	4.8	1.4	11.1
Diospyros candolliana	Ebanaceae	56	35	42.4	27.3	1.6	0.4	4.5	1.9	4.6	2.8	10.9
Hopea ponga	Dipterocarpaceae	44	19	30.4	14.8	2.3	0.3	2.4	2.7	3.6	2.0	8.7
Litsea stocksii	Lauraceae	40	26	27.1	20.3	1.5	0.3	3.3	1.8	3.3	1.6	8.4
Garcinia gummi-gutta	Clusiaceae	37	28	34.6	21.9	1.3	0.3	3.6	1.5	3.0	4.8	8.1
Ixora brachiata	Rubiaceae	36	28	22.1	21.9	1.3	0.3	3.6	1.5	2.9	1.0	8.0
Holigarna grahami	Anacardiaceae	35	26	24.1	20.3	1.3	0.3	3.3	1.6	2.9	1.6	7.7
Xantolis tomentosa	Sapotaceae	31	25	22.9	19.5	1.2	0.2	3.2	1.4	2.5	1.7	7.2
Belsmedia whitii	Lauraceae	32	22	24.7	17.2	1.5	0.3	2.8	1.7	2.6	1.8	7.1
Gymnocranthera canarica	Myristicaceae	21	6	21.0	4.7	3.5	0.2	0.8	4.1	1.7	2.7	6.6
Symplocos racemosa	Symplocaceae	29	17	16.2	13.3	1.7	0.2	2.2	2.0	2.4	0.8	6.5
Holigarna arnottiana	Anacardiaceae	26	24	21.7	18.8	1.1	0.2	3.1	1.3	2.1	2.0	6.4
Pterospermum reticulatum	Sterculaceae	25	19	23.3	14.8	1.3	0.2	2.4	1.5	2.0	0.2	6.0
Dimocarpus longan	Sapindaceae	20	12	25.5	9.4	1.7	0.2	1.5	1.9	1.6	2.0	5.1
Eleocarpus serratus	Urticaceae	18	17	12.8	13.3	1.1	0.1	2.2	1.2	1.5	0.8	4.9
Litsea floribonda	Lauraceae	19	14	11.7	10.9	1.4	0.1	1.8	1.6	1.6	0.7	4.9
Glochidion velutinum	Euphorbiaceae	17	10	11.7	7.8	1.7	0.1	1.3	2.0	1.4	0.7	4.6
Cassine glauca	Celastraceae	12	9	32.9	7.0	1.3	0.1	1.1	1.6	1.0	11.9	3.7
Garcinia talbotti	Clusiaceae	9	5	6.2	3.9	1.8	0.1	0.6	2.1	0.7	0.4	3.5
Mangefera indica	Anacardiaceae	11	11	12.8	8.6	1.0	0.1	1.4	1.2	0.9	2.1	3.5
Actinodaphne hookeri	Lauraceae	10	10	6.6	7.8	1.0	0.1	1.3	1.2	0.8	0.4	3.3
Mimusops elangi	Sapotaceae	10	10	5.6	7.8	1.0	0.1	1.3	1.2	0.8	0.3	3.3
Ficus aspirima	Moraceae	6	3	2.1	2.3	2.0	0.0	0.4	2.3	0.5	0.1	3.2
Syzizium laetum	Myrtaceae	9	6	6.5	4.7	1.5	0.1	0.8	1.7	0.7	0.4	3.2
Diospyros montana	Ebanaceae	8	6	6.9	4.7	1.3	0.1	0.8	1.6	0.7	0.6	3.0
Chionanthus malabaricus	Oleaceae	5	3	3.5	2.3	1.7	0.0	0.4	1.9	0.4	0.2	2.7
Aparosa lindleyana	Euphorbiaceae	7	7	6.4	5.5	1.0	0.1	0.9	1.2	0.6	0.6	2.6
Myristica dactyloides	Myristicaceae	5	4	2.5	3.1	1.3	0.0	0.5	1.5	0.4	0.0	2.4
Mastixia arborea	Cornaceae	3	2	2.6	1.6	1.5	0.0	0.3	1.7	0.2	0.2	2.2
Vitex altissema	Verbenaceae	5	5	6.8	3.9	1.0	0.0	0.6	1.2	0.4	0.8	2.2
Persea macarantha	Lauraceae	5	5	18.5	3.9	1.0	0.0	0.6	1.2	0.4	14.7	2.2
Casearia beddomi	Flacortiaceae	5	5	4.6	3.9	1.0	0.0	0.6	1.2	0.4	0.7	2.2
Flacortia sp.	Flacortiaceae	5	5	2.4	3.9	1.0	0.0	0.6	1.2	0.4	0.1	2.2

Diospyros angustfolia	Ebanaceae	5	5	3.6	3.9	1.0	0.0	0.6	1.2	0.4	0.2	2.2
Tabernamontana heyinana	Apocynaceae	4	4	1.9	3.1	1.0	0.0	0.5	1.2	0.3	0.1	2.0
Flacortia montana	Flacortiaceae	4	4	2.0	3.1	1.0	0.0	0.5	1.2	0.3	0.1	2.0
Syzizium cumini	Myrtaceae	4	4	11.5	3.1	1.0	0.0	0.5	1.2	0.3	2.9	2.0
Diospyros buxifolia	Ebanaceae	4	4	6.3	3.1	1.0	0.0	0.5	1.2	0.3	0.8	2.0
Nothopoditis nimmoniana	Icacinaceae	4	4	2.5	3.1	1.0	0.0	0.5	1.2	0.3	0.1	2.0
Neolitsea zeylanica	Lauraceae	3	3	1.3	2.3	1.0	0.0	0.4	1.2	0.2	0.0	1.8
Cinnamomum malabathrum	Lauraceae	3	3	1.9	2.3	1.0	0.0	0.4	1.2	0.2	0.1	1.8
Trichilia connaroides	Meliaceae	3	3	2.9	2.3	1.0	0.0	0.4	1.2	0.2	0.3	1.8
Stereospermum personatum	Bignoniaceae	2	2	1.9	1.6	1.0	0.0	0.3	1.2	0.2	0.1	1.6
Euodia lunu-ankenda	Rutaceae	2	2	1.4	1.6	1.0	0.0	0.3	1.2	0.2	0.1	1.6
Canarium strictum	Burseraceae	2	2	1.8	1.6	1.0	0.0	0.3	1.2	0.2	0.2	1.6
Myristica malabarica	Myristicaceae	2	2	2.5	1.6	1.0	0.0	0.3	1.2	0.2	0.3	1.6
Terminalia bellarica	Combritaceae	2	2	4.0	1.6	1.0	0.0	0.3	1.2	0.2	0.6	1.6
Carallia brachiata	Rhizophoraceae	1	1	1.3	0.8	1.0	0.0	0.1	1.2	0.1	0.1	1.4
Pittosporum floribundam	Pittosporaceae	1	1	0.8	0.8	1.0	0.0	0.1	1.2	0.1	0.1	1.4
Lophopetalum wightianum	Celastraceae	1	1	5.4	0.8	1.0	0.0	0.1	1.2	0.1	2.3	1.4
Sterculia guttata	Sterculiaceae	1	1	0.8	0.8	1.0	0.0	0.1	1.2	0.1	0.1	1.4
Macaranga peltata	Euphorbiaceae	1	1	0.4	0.8	1.0	0.0	0.1	1.2	0.1	0.0	1.4
Homelium ceylanicum	Flacortiaceae	1	1	0.5	0.8	1.0	0.0	0.1	1.2	0.1	0.0	1.4
Artocarpus heterophyllus	Moraceae	1	1	0.4	0.8	1.0	0.0	0.1	1.2	0.1	0.0	1.4
Chrysophyllum roxburghii	Sapotaceae	1	1	1.4	0.8	1.0	0.0	0.1	1.2	0.1	0.2	1.4
Canthium dicoccum	Rubiaceae	1	1	1.8	0.8	1.0	0.0	0.1	1.2	0.1	0.1	1.4
Artocarpus hirsutus	Moraceae	1	1	0.9	0.8	1.0	0.0	0.1	1.2	0.1	0.1	1.4
Celtis tetandra	Ulmaceae	1	1	0.8	0.8	1.0	0.0	0.1	1.2	0.1	0.1	1.4
Alsea daphne	Lauraceae	1	1	1.1	0.8	1.0	0.0	0.1	1.2	0.1	0.1	1.4
Ixora nigricans	Rubiaceae	1	1	0.4	0.8	1.0	0.0	0.1	1.2	0.1	0.0	1.4
Syzizium stocksii	Myrtaceae	1	1	0.4	0.8	1.0	0.0	0.1	1.2	0.1	0.0	1.4
Calophyllum tomentosum	Clusiaceae	1	1	1.3	0.8	1.0	0.0	0.1	1.2	0.1	0.1	1.4

N- Number of Individuals, GBH- Girth at Breast Height, F-Frequency, A-Abundance, D-Density, RF-Relative Frequency, RA-Relative Abundance, RD- Relative Density, BA-Basal Area, IVI-Importance Value Index

Appendix 2.4 Table showing the density and Important Value Index (IVI) for woody plants in Kodgi area.

Latin name	Family	N	No. of plots	GBH (m)	F	A	D	RF	RA	RD	BA	IVI
Hopea ponga	Dipterocarpaceae	202	53	147.1	54.1	3.8	2.1	7.9	3.8	18.0	10.6	29.8
Olea dioica	Oleaceae	130	66	139.0	67.3	2.0	1.3	9.9	2.0	11.6	15.6	23.4
Knema attenuata	Myristicaceae	117	50	73.8	51.0	2.3	1.2	7.5	2.3	10.4	4.4	20.2
Aglaia roxburghiana	Meliaceae	74	42	48.0	42.9	1.8	0.8	6.3	1.8	6.6	3.2	14.6
Garcinia morella	Clusiaceae	39	19	18.3	19.4	2.1	0.4	2.8	2.1	3.5	0.7	8.4
Symplocos racemosa	Symplocaceae	31	18	17.4	18.4	1.7	0.3	2.7	1.7	2.8	0.8	7.2
Dimocarpus longan	Sapindaceae	28	22	41.3	22.4	1.3	0.3	3.3	1.3	2.5	4.6	7.1
Diospyros sylvetrica	Ebanaceae	28	18	19.0	18.4	1.6	0.3	2.7	1.6	2.5	1.3	6.7
Ixora brachiata	Rubiaceae	23	20	10.5	20.4	1.2	0.2	3.0	1.2	2.1	0.4	6.2
Nathopegia recemosa	Anacardiaceae	21	19	9.8	19.4	1.1	0.2	2.8	1.1	1.9	0.5	5.8
Syzizium sp.	Myrtaceae	21	13	16.0	13.3	1.6	0.2	1.9	1.6	1.9	1.2	5.4
Diospyros buxifolia	Ebanaceae	21	13	35.8	13.3	1.6	0.2	1.9	1.6	1.9	6.2	5.4
Holigarna arnottiana	Anacardiaceae	20	14	15.0	14.3	1.4	0.2	2.1	1.4	1.8	1.1	5.3
Diospyros candolliana	Ebanaceae	19	15	15.7	15.3	1.3	0.2	2.2	1.3	1.7	1.6	5.2
Garcinia gummi-gutta	Clusiaceae	17	17	11.5	17.3	1.0	0.2	2.5	1.0	1.5	0.7	5.1
Callicarpa tomentosa	Verbinaceae	8	2	4.0	2.0	4.0	0.1	0.3	4.0	0.7	0.2	5.0
Diospyros angustfolia	Ebanaceae	18	13	12.5	13.3	1.4	0.2	1.9	1.4	1.6	0.9	4.9
Eleocarpus serratus	Urticaceae	17	13	11.2	13.3	1.3	0.2	1.9	1.3	1.5	0.7	4.8
Litsea stocksii	Lauraceae	17	12	11.9	12.2	1.4	0.2	1.8	1.4	1.5	0.8	4.7
Macaranga peltata	Euphorbiaceae	15	6	9.4	6.1	2.5	0.2	0.9	2.5	1.3	0.3	4.7
Saraca asoka	Caesalpinaceae	14	6	10.5	6.1	2.3	0.1	0.9	2.3	1.2	0.8	4.5
Pterospermum reticulatum	Sterculaceae	15	14	22.0	14.3	1.1	0.2	2.1	1.1	1.3	3.5	4.5
Garcinia talbotti	Clusiaceae	15	10	9.6	10.2	1.5	0.2	1.5	1.5	1.3	0.7	4.3
Syzizium stocksii	Myrtaceae	13	12	15.8	12.2	1.1	0.1	1.8	1.1	1.2	2.4	4.0
Vitex altissema	Verbenaceae	12	11	18.4	11.2	1.1	0.1	1.6	1.1	1.1	3.1	3.8
Bishopia javanica	Euphorbiaceae	10	7	30.1	7.1	1.4	0.1	1.0	1.4	0.9	9.1	3.4
Tabernamontana heyinana	Apocynaceae	10	9	4.3	9.2	1.1	0.1	1.3	1.1	0.9	0.1	3.3
Aparosa lindleyana	Euphorbiaceae	9	9	5.4	9.2	1.0	0.1	1.3	1.0	0.8	0.5	3.1
Myristica dactyloides	Myristicaceae	8	6	3.4	6.1	1.3	0.1	0.9	1.3	0.7	0.1	2.9
Cinnamomum malabathrum	Lauraceae	7	7	3.6	7.1	1.0	0.1	1.0	1.0	0.6	0.2	2.7
Syzizium laetum	Myrtaceae	7	6	4.4	6.1	1.2	0.1	0.9	1.2	0.6	0.2	2.7
Litsea floribonda	Lauraceae	7	7	4.4	7.1	1.0	0.1	1.0	1.0	0.6	0.3	2.7
Syzygium caryophyllatum	Myrtaceae	6	4	4.2	4.1	1.5	0.1	0.6	1.5	0.5	0.2	2.6
Glochidion velutinum	Euphorbiaceae	6	4	3.1	4.1	1.5	0.1	0.6	1.5	0.5	0.1	2.6
Buchnania lanzan	Anacardiaceae	6	4	2.7	4.1	1.5	0.1	0.6	1.5	0.5	0.1	2.6
Belsmedia whitii	Lauraceae	6	5	5.1	5.1	1.2	0.1	0.7	1.2	0.5	0.5	2.5
Ficus aspirima	Moraceae	6	6	3.9	6.1	1.0	0.1	0.9	1.0	0.5	0.2	2.4
Syzizium cumini	Myrtaceae	6	6	9.8	6.1	1.0	0.1	0.9	1.0	0.5	2.2	2.4

Lagerstroemia microcarpa	Lythraeceae	6	6	14.8	6.1	1.0	0.1	0.9	1.0	0.5	3.1	2.4
Holigarna grahami	Anacardiaceae	6	6	3.6	6.1	1.0	0.1	0.9	1.0	0.5	0.2	2.4
Persea macarantha	Lauraceae	5	5	9.0	5.1	1.0	0.1	0.7	1.0	0.4	2.0	2.2
Mimusops elangi	Sapotaceae	5	5	1.7	5.1	1.0	0.1	0.7	1.0	0.4	0.0	2.2
Canerium strictum	Aracaceae	4	4	2.4	4.1	1.0	0.0	0.6	1.0	0.4	0.1	2.0
Flacortia montana	Flacortiaceae	4	4	2.8	4.1	1.0	0.0	0.6	1.0	0.4	0.2	2.0
Terminalia tomentosa	Combritaceae	4	4	4.3	4.1	1.0	0.0	0.6	1.0	0.4	0.5	2.0
Ficus nervosa	Moraceae	4	4	24.2	4.1	1.0	0.0	0.6	1.0	0.4	20.5	2.0
Memycylon malabaricum	Melastomaceae	3	3	1.2	3.1	1.0	0.0	0.4	1.0	0.3	0.0	1.7
Neolitsea zeylanica	Lauraceae	3	3	1.5	3.1	1.0	0.0	0.4	1.0	0.3	0.1	1.7
Terminalia paniculata	Combritaceae	3	3	2.9	3.1	1.0	0.0	0.4	1.0	0.3	0.2	1.7
Cassine glauca	Celastraceae	3	3	1.3	3.1	1.0	0.0	0.4	1.0	0.3	0.0	1.7
Careya arborea	Lecythidiaceae	3	3	2.0	3.1	1.0	0.0	0.4	1.0	0.3	0.1	1.7
Polyanthia fragrens	Annonaceae	3	3	2.0	3.1	1.0	0.0	0.4	1.0	0.3	0.1	1.7
Leea indica	Leeaceae	3	3	1.0	3.1	1.0	0.0	0.4	1.0	0.3	0.0	1.7
Myristica malabarica	Myristicaceae	3	3	1.6	3.1	1.0	0.0	0.4	1.0	0.3	0.1	1.7
Pittosporum floribundam	Pittosporaceae	2	2	1.2	2.0	1.0	0.0	0.3	1.0	0.2	0.1	1.5
Lophopetalum wightianum	Celastraceae	2	2	1.2	2.0	1.0	0.0	0.3	1.0	0.2	0.1	1.5
Ficus microcarpa	Moraceae	2	2	26.3	2.0	1.0	0.0	0.3	1.0	0.2	28.8	1.5
Cassine glauca	Celastraceae	2	2	4.1	2.0	1.0	0.0	0.3	1.0	0.2	1.0	1.5
Melia dubia	Meliaceae	2	2	1.0	2.0	1.0	0.0	0.3	1.0	0.2	0.0	1.5
Mangefera indica	Anacardiaceae	2	2	2.4	2.0	1.0	0.0	0.3	1.0	0.2	0.2	1.5
Artocarpus lakoocha	Moraceae	2	2	3.8	2.0	1.0	0.0	0.3	1.0	0.2	0.6	1.5
Carallia brachiata	Rhizophoraceae	1	1	0.9	1.0	1.0	0.0	0.1	1.0	0.1	0.1	1.2
Drypetes confertifolius	Euphorbiaceae	1	1	0.4	1.0	1.0	0.0	0.1	1.0	0.1	0.0	1.2
Mastixia arborea	Cornaceae	1	1	2.0	1.0	1.0	0.0	0.1	1.0	0.1	0.3	1.2
Dipterocarpus indicus	Dipterocarpaceae	1	1	0.5	1.0	1.0	0.0	0.1	1.0	0.1	0.0	1.2
Actinodaphne hookeri	Lauraceae	1	1	1.0	1.0	1.0	0.0	0.1	1.0	0.1	0.0	1.2
Euodia lunu-ankenda	Rutaceae	1	1	2.0	1.0	1.0	0.0	0.1	1.0	0.1	0.3	1.2
Chukrasia tabularis	Liliaceae	1	1	2.8	1.0	1.0	0.0	0.1	1.0	0.1	0.6	1.2
Xantolis tomentosa	Sapotaceae	1	1	0.8	1.0	1.0	0.0	0.1	1.0	0.1	0.0	1.2
Chrysophyllum roxburghii	Sapotaceae	1	1	0.4	1.0	1.0	0.0	0.1	1.0	0.1	0.0	1.2
Eleagnus conferta	Eleagnaceae	1	1	0.9	1.0	1.0	0.0	0.1	1.0	0.1	0.1	1.2
Canthium dicoccum	Rubiaceae	1	1	1.2	1.0	1.0	0.0	0.1	1.0	0.1	0.1	1.2
Canthium angustifolium	Rubiaceae	1	1	0.4	1.0	1.0	0.0	0.1	1.0	0.1	0.0	1.2
Flacortia sp.	Flacortiaceae	1	1	0.3	1.0	1.0	0.0	0.1	1.0	0.1	0.0	1.2
Aglaia sp.	Meliaceae	1	1	0.6	1.0	1.0	0.0	0.1	1.0	0.1	0.0	1.2
Calophyllum tomentosum	Clusiaceae	1	1	0.4	1.0	1.0	0.0	0.1	1.0	0.1	0.0	1.2
Terminalia bellarica	Combritaceae	1	1	1.7	1.0	1.0	0.0	0.1	1.0	0.1	0.2	1.2

N- Number of Individuals, GBH- Girth at Breast Height, F-Frequency, A-Abundance, D-Density, RF-Relative Frequency, RA-Relative Abundance, RD- Relative Density, BA-Basal Area, IVI-Importance Value Index

Appendix 2.5 Table showing the density and Important Value Index (IVI) for woody plants in Devgaar area.

Name	Family	N	No. of plots	GBH (m)	F	A	D	RF	RA	RD	BA	IVI
Knema attenuate	Myristicaceae	205	92	128.9	73.0	2.2	1.6	11.1	2.7	15.0	7.4	28.8
Hopea ponga	Dipterocarpaceae	202	61	140.3	48.4	3.3	1.6	7.3	4.0	14.7	9.9	26.2
Diospyros sylvetrica	Ebanaceae	135	72	108.3	57.1	1.8	1.0	8.7	2.2	9.8	9.2	20.8
Garcinia morella	Clusiaceae	96	52	43.1	41.2	1.8	0.7	6.2	2.2	7.0	1.6	15.5
Olea dioica	Oleaceae	90	54	81.1	42.8	1.6	0.7	6.5	2.0	6.5	7.1	15.1
Ixora brachiata	Rubiaceae	65	35	29.9	27.7	1.8	0.5	4.2	2.2	4.7	1.2	11.2
Myristica dactyloides	Myristicaceae	52	32	33.7	25.4	1.6	0.4	3.8	1.9	3.8	2.3	9.6
Garcinia gummi-gutta	Clusiaceae	44	30	31.4	23.8	1.4	0.3	3.6	1.7	3.2	2.4	8.6
Holigarna arnottiana	Anacardiaceae	35	28	23.8	22.2	1.2	0.2	3.3	1.5	2.5	1.6	7.4
Aglaia roxburghiana	Meliaceae	35	25	20.4	19.8	1.4	0.2	3.0	1.7	2.5	1.0	7.3
Diospyros angustfolia	Ebanaceae	27	19	15.6	15.0	1.4	0.2	2.3	1.7	1.9	0.9	6.0
Diospyros candolliana	Ebanaceae	24	19	16.2	15.0	1.2	0.1	2.3	1.5	1.7	1.0	5.6
Nathopegia recemosa	Anacardiaceae	21	21	9.5	16.6	1.0	0.1	2.5	1.2	1.5	0.4	5.3
Syzizium stocksii	Myrtaceae	22	16	23.5	12.7	1.3	0.1	1.9	1.6	1.6	2.7	5.2
Holigarna graham	Anacardiaceae	21	17	20.1	13.4	1.2	0.1	2.0	1.5	1.5	1.8	5.1
Symplocos racemosa	Symplocaceae	21	15	11.8	11.9	1.4	0.1	1.8	1.7	1.5	0.6	5.0
Homelium ceylanicum	Flacortiaceae	7	2	4.4	1.59	3.5	0.1	0.2	4.2	0.5	0.2	5.0
Diospyros buxifolia	Ebanaceae	18	14	17.3	11.1	1.2	0.1	1.6	1.5	1.3	1.7	4.5
Dimocarpus longan	Sapindaceae	17	12	8.3	9.5	1.4	0.1	1.4	1.7	1.2	0.3	4.4
Mimusops elangi	Sapotaceae	14	13	11.9	10.3	1.0	0.1	1.5	1.3	1.0	0.9	3.9
Litsea stocksii	Lauraceae	13	12	8.1	9.5	1.1	0.1	1.4	1.3	0.9	0.4	3.7
Syzizium sp.	Myrtaceae	5	2	2.7	1.5	2.5	0.04	0.2	3.0	0.3	0.1	3.6
Eleocarpus serratus	Urticaceae	11	10	5.0	7.9	1.1	0.1	1.2	1.3	0.8	0.2	3.3
Aparosa lindleyana	Euphorbiaceae	11	11	6.3	8.7	1.0	0.1	1.3	1.2	0.8	0.3	3.3
Mangefera indica	Anacardiaceae	10	9	6.6	7.1	1.1	0.1	1.1	1.3	0.7	0.4	3.1
Alsea daphne	Lauraceae	7	4	5.1	3.1	1.7	0.1	0.4	2.1	0.5	0.3	3.1
Litsea floribonda	Lauraceae	9	8	7.0	6.3	1.1	0.1	0.9	1.3	0.6	0.4	3.0
Artocarpus hirsutus	Moraceae	9	9	6.4	7.1	1.0	0.1	1.1	1.2	0.6	0.4	2.9
Myristica malabarica	Myristicaceae	9	9	4.2	7.1	1.0	0.1	1.1	1.2	0.6	0.1	2.9
Memycylon malabaricum	Melastomaceae	7	5	2.5	3.9	1.4	0.1	0.6	1.7	0.5	0.1	2.8
Cassine glauca	Celastraceae	8	7	10.6	5.5	1.1	0.1	0.8	1.4	0.5	1.5	2.8
Lophopetalum whitanum	Celastraceae	7	6	10.7	4.7	1.1	0.1	0.7	1.4	0.5	3.6	2.6
Flacortia Montana	Flacortiaceae	6	5	2.7	3.9	1.2	0.05	0.6	1.4	0.4	0.1	2.5

Belsmedia whitii	Lauraceae	6	5	6.2	3.9	1.2	0.05	0.6	1.4	0.4	0.6	2.5
Canthium dicoccum	Rubiaceae	6	6	6.6	4.7	1.0	0.05	0.7	1.2	0.4	0.5	2.3
Terminalia paniculata	Combritaceae	6	6	10.4	4.7	1.0	0.05	0.7	1.2	0.4	1.6	2.3
Syzizium hemispermicum	Myrtaceae	6	6	3.8	4.7	1.0	0.05	0.7	1.2	0.4	0.4	2.3
Calophyllum tomentosum	Clusiaceae	6	6	9.9	4.7	1.0	0.05	0.7	1.2	0.4	1.4	2.3
Vitex altissema	Verbenaceae	5	4	3.8	3.1	1.2	0.04	0.4	1.5	0.3	0.2	2.3
Polyanthia fragrens	Annonaceae	5	4	3.0	3.1	1.2	0.04	0.4	1.5	0.3	0.1	2.3
Caryota urens	Aracaceae	5	5	4.4	3.9	1.0	0.04	0.6	1.2	0.3	0.3	2.1
Flacortia sp.	Flacortiaceae	5	5	2.9	3.9	1.0	0.04	0.6	1.2	0.3	0.1	2.1
Actinodaphne hookeri	Lauraceae	4	4	2.7	3.1	1.0	0.03	0.4	1.2	0.2	0.1	2.0
Macaranga peltata	Euphorbiaceae	4	4	2.1	3.1	1.0	0.03	0.4	1.2	0.2	0.1	2.0
Garcinia talbotti	Clusiaceae	4	4	1.7	3.1	1.0	0.03	0.4	1.2	0.2	0.0	2.0
Pterospermum reticulatum	Sterculaceae	4	4	2.6	3.1	1.0	0.03	0.4	1.2	0.2	0.1	2.0
Lagerstroemia microcarpa	Lythraeceae	4	4	5.7	3.1	1.0	0.03	0.4	1.2	0.2	0.8	2.0
Glochidion velutinum	Euphorbiaceae	4	4	2.2	3.1	1.0	0.03	0.4	1.2	0.2	0.1	2.0
Calophyllum apetalum	Clusiaceae	3	3	1.8	2.3	1.0	0.02	0.3	1.2	0.2	0.1	1.8
Stereospermum personatum	Bignoniaceae	3	3	3.0	2.3	1.0	0.02	0.3	1.2	0.2	0.2	1.8
Cinnamomum malabathrum	Lauraceae	3	3	2.1	2.3	1.0	0.02	0.3	1.2	0.2	0.1	1.8
Syzizium cumini	Myrtaceae	3	3	4.5	2.3	1.0	0.02	0.3	1.2	0.2	0.5	1.8
Ficus nervosa	Moraceae	3	3	17.5	2.3	1.0	0.02	0.3	1.2	0.2	11.1	1.8
Euodia lunankenda	Rutaceae	2	2	1.9	1.5	1.0	0.02	0.2	1.2	0.1	0.1	1.6
Chrysophyllum roxburghii	Sapotaceae	2	2	3.5	1.5	1.0	0.02	0.2	1.2	0.1	0.5	1.6
Trichilia connaroides	Meliaceae	2	2	0.6	1.5	1.0	0.02	0.2	1.2	0.1	0.03	1.6
Syzizium laetum	Myrtaceae	2	2	1.2	1.5	1.0	0.02	0.2	1.2	0.1	0.07	1.6
Carallia brachiata	Rhizophoraceae	1	1	0.7	0.7	1.0	0.01	0.1	1.2	0.1	0.06	1.4
Canarium strictum	Burseraceae	1	1	1.1	0.7	1.0	0.01	0.1	1.2	0.1	0.11	1.4
Xantolis tomentosa	Sapotaceae	1	1	1.0	0.7	1.0	0.01	0.1	1.2	0.1	0.08	1.4
Persea macarantha	Lauraceae	1	1	2.4	0.7	1.0	0.01	0.1	1.2	0.1	0.47	1.4
Tabernamontana heyinana	Apocynaceae	1	1	0.5	0.7	1.0	0.01	0.1	1.2	0.1	0.02	1.4
Ixora nigricans	Rubiaceae	1	1	0.3	0.7	1.0	0.01	0.1	1.2	0.1	0.01	1.4
Callicarpa tomentosa	Verbinaceae	1	1	0.4	0.7	1.0	0.01	0.1	1.2	0.1	0.01	1.4

N- Number of Individuals, GBH- Girth at Breast Height, F-Frequency, A-Abundance, D-Density, RF-Relative Frequency, RA-Relative Abundance, RD- Relative Density, BA-Basal Area, IVI-Importance Value Index

Appendix 2.6 Table showing the contribution of species richness, generic richness, Family relative density, Family relative diversity, Basal Area, Family relative dominance and Family importance Value in Hosthota area

Family	Species Richness	Generic richness	No. of individuals	Family Relative density	Family Relative diversity	Basal area	Family Relative dominance	Family Importance Value
Ebanaceae	5	1	236	15.7	7.0	17.4	16.1	38.8
yristicaceae	3	2	254	16.9	4.2	9.5	8.8	29.9
Anacardiaceae	4	3	151	10.0	5.6	11.4	10.5	26.2
Clusiaceae	5	2	157	10.5	7.04	6.4	5.9	23.4
Lauraceae	8	7	72	4.9	11.2	6.8	5.7	21.8
Myrtaceae	5	1	36	2.4	7.0	11.9	11.0	20.4
Dipterocarpaceae	1	1	158	10.5	1.4	9.0	8.3	20.3
Oleaceae	1	1	97	6.4	1.4	9.0	8.3	16.1
Celastraceae	2	2	24	1.6	2.8	7.0	6.5	10.9
Moraceae	4	2	20	1.3	5.6	3.1	2.8	9.8
Euphorbiaceae	4	4	37	2.4	5.6	1.2	1.1	9.2
Verbenaceae	2	2	22	1.4	2.8	5.1	4.7	9.0
Sapotaceae	4	4	24	1.6	5.6	1.3	1.2	8.4
Flacortiaceae	3	3	24	1.6	4.2	1.1	1.0	6.8
Rubiaceae	2	2	42	2.7	2.8	0.7	0.6	6.2
Meliaceae	1	1	39	2.5	1.4	1.3	1.2	5.2
Sterculiaceae	1	2	26	1.7	1.4	1.6	1.4	4.6
Symplocaceae	1	1	19	1.2	1.4	0.8	0.8	3.4
Aracaceae	2	2	6	0.4	2.8	0.2	0.2	3.4
Lythraceae	1	1	5	0.3	1.4	0.9	0.8	2.5
Urticaceae	1	1	12	0.8	1.4	0.2	0.2	2.4
Melastomaceae	1	1	12	0.8	1.4	0.2	0.1	2.3
Sapindaceae	1	1	10	0.6	1.4	0.2	0.2	2.3
Liliaceae	1	1	2	0.1	1.4	0.6	0.6	2.1
Apocynaceae	1	1	8	0.5	1.4	0.1	0.1	2.0
Burseraceae	1	2	2	0.1	1.4	0.1	0.1	1.7
Bignonianaceae	1	1	1	0.1	1.4	0.2	0.1	1.6
Mimosaceae	1	1	1	0.1	1.4	0.2	0.1	1.6
Rosaceae	1	1	1	0.1	1.4	0.1	0.1	1.6
Rhizophoraceae	1	1	3	0.2	1.4	0.04	0.04	1.6
Anonaceae	1	1	1	0.1	1.4	0.06	0.1	1.5
Rutaceae	1	1	1	0.1	1.4	0.01	0.01	1.4

Appendix 2.7 Table showing the contribution of species richness, generic richness, Family relative density, Family relative diversity, Basal Area, Family relative dominance and Family importance Value in Chiksuli.

Family	Species Richness	Generic richness	No. of individuals	Family Relative density	Family Relative diversity	Basal area	Family Relative dominance	Family Importance Value
Clusiaceae	5	2	221	15.9	6.8	13.6	12.6	35.4
Lauraceae	8	7	143	10.3	10.9	7.9	7.3	28.6
Moraceae	5	2	20	1.4	6.8	18.1	16.7	25.0
Oleaceae	1	1	128	9.2	1.3	15.3	14.1	24.8
Myristicaceae	3	2	118	8.5	4.1	6.1	5.7	18.3
Anacardiaceae	4	3	115	8.3	5.4	4.4	4.0	17.8
Ebanaceae	4	1	73	5.2	5.4	4.1	3.8	14.6
Myrtaceae	5	1	28	2.0	6.8	4.1	3.8	12.7
Meliaceae	1	1	92	6.6	1.3	4.9	4.5	12.6
Dipterocarpaceae	1	1	79	5.7	1.3	4.4	4.0	11.1
Sapotaceae	4	1	21	1.5	5.4	2.7	2.5	9.5
Sapindaceae	1	1	72	5.2	1.3	2.6	2.4	8.9
Euphorbiaceae	4	4	24	1.7	5.4	1.5	1.4	8.6
Fabaceae	1	1	54	3.9	1.3	2.7	2.5	7.8
Verbenaceae	2	2	26	1.8	2.7	2.9	2.7	7.3
Flacortiaceae	4	4	18	1.3	5.4	0.4	0.4	7.2
Sterculiaceae	2	2	41	2.9	2.7	1.4	1.3	7.0
Celastraceae	1	1	4	0.2	1.3	5.4	4.9	6.6
Rubiaceae	2	2	23	1.6	2.7	0.4	0.3	4.7
Combretaceae	2	2	3	0.2	2.7	0.7	0.6	3.6
Rutaceae	1	1	15	1.0	1.3	1.2	1.1	3.6
Symplocaceae	1	1	23	1.6	1.3	0.4	0.4	3.4
Apocynaceae	2	2	7	0.5	2.7	0.1	0.1	3.3
Aracaceae	2	2	3	0.2	2.7	0.1	0.1	3.1
Urticaceae	1	1	13	0.9	1.3	0.2	0.2	2.5
Lythraceae	1	1	3	0.2	1.3	0.9	0.9	2.4
Burseraceae	1	1	3	0.2	1.3	0.5	0.4	2.0
Melastomaceae	1	1	7	0.5	1.3	0.1	0.07	1.9
Icaciniceae	1	1	3	0.2	1.3	0.03	0.03	1.6
Bignonianaceae	1	1	2	0.1	1.3	0.05	0.05	1.5
Ulmaceae	1	1	1	0.1	1.3	0.03	0.03	1.4

Appendix 2.8 Table showing the contribution of species richness,generic richness, Family relative density, Family relative diversity, Basal Area, Family relative dominance and Family importance Value in Kanthota area

Family	Species Richness	Generic richness	No. of individuals	Family Relative density	Family Relative diversity	Basal area	Family Relative dominance	Family Importance Value
Oleaceae	2	2	187	15.2	3.0	24.6	22.7	41.0
Lauraceae	8	7	113	9.2	12.1	19.3	17.8	39.2
Anacardiaceae	4	3	143	11.6	6.0	7.6	7.0	24.8
Myristicaceae	4	3	126	10.0	6.0	7.0	6.5	22.9
Clusiaceae	4	2	107	8.7	6.0	6.7	6.2	21.0
Celastraceae	2	2	13	1.0	3.0	14.2	13.1	17.2
Ebanaceae	4	1	73	5.9	6.0	4.4	4.1	16.1
Meliaceae	2	2	84	6.8	3.0	5.9	5.4	15.3
Sapotaceae	3	3	42	3.4	4.5	2.1	1.9	9.9
Myrtaceae	3	1	15	1.2	4.5	3.3	3.0	8.8
Rubiaceae	3	2	37	3.0	4.5	1.1	1.1	8.6
Melastomaceae	1	1	72	5.8	1.5	0.9	0.9	8.3
Flacortiaceae	4	3	15	1.2	6.0	0.9	0.8	8.1
Euphorbiaceae	3	3	25	2.0	4.5	1.3	1.2	7.8
Dipterocarpaceae	1	1	44	3.6	1.5	2.0	1.8	6.9
Sterculaceae	2	2	26	2.1	3.0	0.2	0.2	5.4
Moraceae	3	2	8	0.6	4.5	0.1	0.1	5.3
Sapindaceae	1	1	20	1.6	1.5	2.0	1.8	5.0
Symplocaceae	1	1	29	2.3	1.5	0.7	0.7	4.6
Urticaceae	1	1	18	1.4	1.5	0.8	0.7	3.7
Verbenaceae	1	1	5	0.4	1.5	0.8	0.7	2.6
Combritaceae	1	1	2	0.1	1.5	0.6	0.5	2.2
Icacinaceae	1	1	4	0.3	1.5	0.1	0.1	1.9
Cornaceae	1	1	3	0.2	1.5	0.2	0.1	1.9
Apocynaceae	1	1	4	0.3	1.5	0.1	0.1	1.9
Burseraceae	1	1	2	0.1	1.5	0.1	0.1	1.8
Bignoniaceae	1	1	2	0.1	1.5	0.1	0.1	1.8
Rutaceae	1	1	2	0.1	1.5	0.1	0.1	1.7
Rhizophoraceae	1	1	1	0.1	1.5	0.1	0.1	1.7
Ulmaceae	1	1	1	0.1	1.5	0.1	0.05	1.6

Appendix 2.9 Table showing the contribution of species richness,generic richness, Family relative density, Family relative diversity, Basal Area, Family relative dominance and Family importance Value in Kodgi area

Family	Species Richness	Generic richness	No. of individuals	Family Relative density	Family Relative diversity	Basal area	Family Relative dominance	Family Importance Value
Moraceae	4	2	14	1.2	5.1	50.0	35.7	42.1
Dipterocarpaceae	2	2	203	18.1	2.6	10.6	7.5	28.3
Oleaceae	1	1	130	11.6	1.3	15.5	11.1	24.0
Ebanaceae	4	1	86	7.6	5.1	10.0	7.1	20.0
Myristicaceae	3	2	128	11.4	3.9	4.6	3.2	18.6
Euphorbiaceae	5	5	41	3.6	6.4	10.0	7.1	17.3
Lauraceae	7	6	46	4.1	9.0	3.8	2.7	15.9
Myrtaceae	5	1	53	4.7	6.4	6.2	4.4	15.7
Clusiaceae	4	2	72	6.4	5.1	2.1	1.5	13.1
Meliaceae	3	2	77	6.8	3.9	3.2	2.2	13.0
Anacardiaceae	5	4	55	4.9	6.4	2.0	1.4	12.8
Sapindaceae	1	1	28	2.5	1.3	4.5	3.2	7.0
Verbenaceae	2	2	20	1.7	2.6	3.3	2.3	6.7
Rubiaceae	3	2	25	2.2	3.9	0.5	0.3	6.5
Celastraceae	3	2	7	0.6	3.9	1.1	0.8	5.3
Combritaceae	3	1	7	0.6	3.9	0.8	0.6	5.1
Sterculaceae	1	1	15	1.3	1.3	3.4	2.4	5.1
Symplocaceae	1	1	31	2.7	1.3	0.8	0.5	4.6
Sapotaceae	3	3	7	0.6	3.9	0.1	0.1	4.5
Lythraeceae	1	1	1	0.1	1.3	3.0	2.1	3.5
Rutaceae	2	2	6	0.5	2.6	0.4	0.3	3.4
Urticaceae	1	1	17	1.5	1.3	0.7	0.5	3.3
Flacortiaceae	2	1	5	0.4	2.6	0.1	0.1	3.1
Caesalpinaceae	1	1	14	1.2	1.3	0.8	0.5	3.1
Apocynaceae	1	1	10	0.8	1.3	0.1	0.1	2.2
Liliaceae	1	1	1	0.1	1.3	0.6	0.4	1.8
Aracaceae	1	1	4	0.3	1.3	0.1	0.1	1.7
Annonaceae	1	1	3	0.2	1.3	0.1	0.1	1.6
Lecythidiaceae	1	1	3	0.2	1.3	0.1	0.1	1.6
Cornaceae	1	1	1	0.1	1.3	0.3	0.2	1.6
Melastomaceae	1	1	3	0.2	1.3	0.03	0.02	1.5
Leeaceae	1	1	3	0.2	1.3	0.02	0.01	1.5
Pittosporaceae	1	1	2	0.1	1.3	0.1	0.04	1.5
Eleagnaceae	1	1	1	0.1	1.3	0.1	0.04	1.4
Rhizophoraceae	1	1	1	0.1	1.3	0.1	0.04	1.4

Appendix 2.10 Table showing the contribution of species richness,generic richness, Family relative density, Family relative diversity, Basal Area, Family relative dominance and Family importance Value in Devgaar area

Family	Species Richness	Generic richness	No. of individuals	Family Relative density	Family Relative diversity	Basal area	Family Relative dominance	Family Importance Value
Ebanaceae	4	1	204	15.0	6.4	13.0	15.4	37.0
Myristicaceae	3	2	266	19.6	4.8	10.0	11.9	36.4
Dipterocarpaceae	1	1	202	14.9	1.6	9.9	11.7	28.3
Clusiaceae	5	2	153	11.3	8.0	5.6	6.7	26.0
Anacardiaceae	4	3	87	6.4	6.4	4.3	5.1	18.0
Lauraceae	7	6	43	3.1	11.2	2.7	3.2	17.7
Oleaceae	1	1	90	6.6	1.6	7.1	8.5	16.8
Moraceae	1	1	3	0.2	1.6	11.6	13.7	15.6
Myrtaceae	5	1	38	2.8	8.0	3.8	4.6	15.4
Rubiaceae	3	2	72	5.3	4.8	1.8	2.1	12.3
Celastraceae	2	2	15	1.1	3.2	5.	6.2	10.5
Sapotaceae	3	3	17	1.2	4.8	1.5	1.8	7.9
Meliaceae	2	2	37	2.7	3.2	1.0	1.2	7.2
Euphorbiaceae	3	3	19	1.4	4.8	0.5	0.6	6.8
Flacortiaceae	3	2	18	1.3	4.8	0.5	0.6	6.7
Combretaceae	1	1	6	0.4	1.6	1.6	1.9	3.9
Verbanaceae	2	2	6	0.4	3.2	0.2	0.3	3.9
Symplocaceae	1	1	21	1.5	1.6	0.6	0.7	3.9
Sapindaceae	1	1	17	1.2	1.6	0.3	0.4	3.3
Lythraeceae	1	1	4	0.3	1.6	0.8	0.9	2.8
Urticaceae	1	1	11	0.8	1.6	0.2	0.2	2.6
Melastomaceae	1	1	7	0.5	1.6	0.1	0.1	2.2
Annonaceae	1	1	5	0.3	1.6	0.1	0.2	2.1
Bignoniaceae	1	1	3	0.2	1.6	0.2	0.3	2.1
Sterculaceae	1	1	4	0.3	1.6	0.1	0.2	2.1
Aracaceae	1	1	1	0.1	1.6	0.3	0.3	2.0
Burseraceae	1	1	1	0.1	1.6	0.1	0.1	1.8
Rhizophoraceae	1	1	1	0.1	1.6	0.1	0.1	1.7
Apocynaceae	1	1	1	0.1	1.6	0.02	0.03	1.7

Appendix 2.11 Stand density of plant species across different study sites

	Density (Trees/ha)					
Name of the species	**Hosthota**	**Chiksuli**	**Kanthota**	**Kodgi**	**Devgaar**	**Mean ±SD**
Knema attenuata	57.35	2.24	24.38	38.11	51.77	34.8±22.2
Hopea ponga	38.07	3.48	10.95	65.80	51.01	33.9 ±26.4
Olea dioica	23.37	31.84	45.27	42.35	22.73	33.1 ±10.5
Garcinia morella	20.96	22.14	14.68	12.70	24.24	18.9 ±5.0
Diospyros sylvetrica	44.58	1.99	0.0	9.12	34.09	18.0 ±20.2
Aglaia roxburghiana	9.40	1.49	20.15	24.10	8.84	12.8 ± 9.2
Nathopegia racemosa	4.82	24.88	17.66	6.84	5.30	11.9 ± 9.0
Holigarna arnottiana	26.75	0.75	6.47	6.51	8.84	9.9±9.9
Memecylon malabaricum	2.89	22.89	17.91	0.98	1.77	9.3 ±10.3
Ixora brachiata	9.16	3.98	8.96	7.49	16.41	9.2 ± 4.5
Garcinia gummi-gutta	14.22	0.25	9.20	5.54	11.11	8.1± 5.4
Litsea stocksii	4.58	9.20	9.95	5.54	3.28	6.5 ± 2.9
Vitex altissema	4.82	17.91	1.24	3.91	1.26	5.8 ± 6.9
Symplocos racemosa	4.58	1.74	7.21	10.10	5.30	5.8 ± 3.1
Diospyros candolliana	2.41	0.0	13.93	0.0	6.06	4.5 ± 5.8
Caryota urens	0.72	19.65	0.0	0.0	1.26	4.3 ± 8.6
Aparosa lindelana	6.27	6.72	1.74	2.93	2.78	4.1 ± 2.3
Eleocarpus serratus	2.89	11.19	0.0	5.54	0.0	3.9 ± 4.7
Myristica dactyloides	2.17	0.25	1.24	2.61	13.13	3.9 ± 5.2
Callophylum apetalum	0.24	18.16	0.0	0.00	0.76	3.8 ± 8.0
Pterospermum reticulatum	6.02	0.75	6.22	4.89	1.01	3.8 ± 2.7
Holigarna grahmi	1.93	0.25	8.71	1.95	5.30	3.6 ± 3.4
Ficus microcarpa	0.24	15.92	0.0	0.65	0.0	3.4 ± 7.0
Actinodaphne hookeri	2.41	9.95	2.49	0.33	1.01	3.2 ± 3.9
Neolitsia zeylanica	0.96	12.94	0.75	0.98	0.0	3.1 ± 5.5
Belsmedia whitii	2.41	1.49	7.96	1.95	1.52	3.1 ± 2.8
Macarange peltata	2.17	5.97	0.25	4.89	1.01	2.9 ± 2.5
Steriospermum personatum	0.24	12.69	0.50	0.0	0.76	2.8 ± 5.5
Diospyros buxifolia	7.71	0.75	1.00	0.0	4.55	2.8 ± 3.3
Sterculia guttata	0.24	13.43	0.25	0.0	0.0	2.8 ± 6.0
Cassine glauca	2.89	3.73	2.99	1.62	2.02	2.7 ± 0.8
Xantolis tomentosa	0.96	3.98	7.71	0.33	0.25	2.6 ± 3.2
Litsea floribonda	2.89	0.25	4.73	2.28	2.27	2.5 ± 1.6
Dimocarpus longan	2.41	0.0	4.98	0.0	4.29	2.3 ± 2.3
Flacourtia montana	4.82	2.99	1.00	1.30	1.52	2.3 ± 1.6
Cinnamomum malabathrum	0.96	5.72	0.75	2.28	0.76	2.1 ± 2.1
Mimusops elengi	2.41	0.25	2.49	1.63	3.54	2.1± 1.2
Chionanthus malabaricus	0.0	1.00	0.0	9.12	0.0	2.0 ± 4.0
Syzizium stocksii	0.0	0.0	0.25	4.23	5.56	2.0 ± 2.7
Garcinia talbotti	0.0	1.49	2.24	4.89	1.01	1.9 ±1.8
Mangefera indica	2.89	0.75	2.74	0.65	2.53	1.9 ±1.1
Diospyros angustfolia	1.45	0.0	1.24	0.0	6.82	1.9 ±2.8
Persea macarantha	2.65	3.48	1.24	1.63	0.25	1.9 ±1.3
Artocarpus hirsutus	3.86	2.74	0.25	0.0	2.27	1.8 ±1.7
Syzygium sp.	0.24	0.0	0.0	6.84	1.26	1.7 ±2.9
Glochidion velutinum	0.24	0.50	4.23	1.95	1.01	1.6 ±1.6
Canerium strictum	0.48	5.22	0.50	1.30	0.25	1.6 ±2.1
Ficus asperima	0.0	4.23	1.49	1.95	0.0	1.5 ±1.7
Eleocarpus serratus	0.0	0.0	4.48	0.0	2.78	1.5 ±2.1
Syzigium gardneri	6.75	0.50	0.0	0.0	0.0	1.5 ±3.0
Diospyros buxifolia	0.0	0.0	0.0	6.84	0.0	1.4 ±3.1
Euodia lunu-ankenda	0.24	5.22	0.50	0.33	0.51	1.4 ±2.2
Diospyros angustfolia	0.0	0.25	0.0	5.86	0.0	1.2 ±2.6
Chrysophyllum roxburghii	1.45	3.48	0.25	0.33	0.51	1.2 ±1.4
Myristica malabarica	1.69	0.50	0.50	0.98	2.27	1.2 ±0.8
Canthium dicoccum	0.96	2.99	0.25	0.0	1.52	1.1 ±1.2
Lopopetalum whitianum	2.89	0.0	0.25	0.65	1.77	1.1 ±1.2
Syzygium cumini	0.48	1.24	1.00	1.95	0.76	1.1 ±0.6

Gymnocranthera canarica	0.0	0.0	5.22	0.0	0.0	1.0 ±2.3
Tabernamontana heyinana	1.93	0.0	0.0	3.26	0.0	1.0 ±1.5
Syzizium laetum	0.48	1.49	2.24	0.0	0.51	0.9 ±0.9
Lageostromia microcarpa	1.20	0.50	0.0	1.95	1.01	0.9± 0.7
Saraca asoka	0.0	0.0	0.0	4.56	0.0	0.9 ±2.0
Tabernamontana heyinana	0.0	3.23	1.00	0.0	0.25	0.9 ± 1.4
Alsea daphni	0.48	1.49	0.25	0.0	1.77	0.8±0.8
Callophylum tomentasum	1.45	0.25	0.25	0.33	1.52	0.8± 0.7
Callicarpa tomentosa	0.48	0.25	0.0	2.61	0.25	0.7 ±1.1
Bishopia javanica	0.0	0.0	0.0	3.26	0.0	0.7 ±1.5
Casearia beddomi	0.0	1.74	1.24	0.0	0.0	0.6 ±0.8
Syzizium hemispermicum	0.72	0.75	0.0	0.0	1.52	0.6 ±0.6
Careya arborea	0.72	1.24	0.0	0.98	0.0	0.6 ±0.6
Flacortia sp.	0.0	0.0	1.24	0.33	1.26	0.6 ±0.6
Terminalia paniculata	0.0	1.74	0.0	0.98	0.0	0.5 ±0.8
Diospyros montana	0.72	0.0	1.99	0.0	0.0	0.5 ±0.9
Syzizium laetum	0.0	0.0	0.0	2.28	0.0	0.5 ±1.0
Celtis tetandra	0.0	1.99	0.25	0.0	0.0	0.4 ±0.9
Homelium ceylanicum	0.0	0.0	0.25	0.0	1.77	0.4 ±0.8
Buchnania lanzan	0.0	0.0	0.0	1.95	0.0	0.4 ±0.9
Syzygium caryophyllatum	0.0	0.0	0.0	1.95	0.0	0.4 ±0.9
Homelium zeylanicum	0.72	1.00	0.0	0.0	0.0	0.3 ±0.5
Carallia brachiata	0.72	0.0	0.25	0.33	0.25	0.3 ±0.3
Terminalia paniculata	0.0	0.0	0.0	0.0	1.52	0.3 ±0.7
Polyanthia fragrens	0.24	0.0	0.0	0.0	1.26	0.3 ±0.5
Xylia xylocarpa	0.0	1.49	0.0	0.0	0.0	0.3 ±0.7
Maduca longifolia	0.96	0.50	0.0	0.0	0.0	0.3 ±0.4
Ficus nervosa	0.0	0.0	0.0	1.30	0.0	0.3 ±0.6
Terminalia tomentosa	0.0	0.0	0.0	1.30	0.0	0.3 ±0.6
Chionanthus malabaricus	0.0	0.0	1.24	0.0	0.0	0.2 ±0.6
Nothapodytes nimmoniana	0.0	0.25	1.00	0.0	0.0	0.3 ±0.4
Artocarpus lakoocha	0.24	0.25	0.0	0.65	0.0	0.2 ±0.3
Terminalia bellarica	0.0	0.25	0.50	0.33	0.0	0.2 ±0.2
Sapium insigne	0.0	1.00	0.0	0.0	0.0	0.2 ±0.4
Syzygium caryphyllatum	0.0	1.00	0.0	0.0	0.0	0.2 ±0.4
Leea indica	0.0	0.0	0.0	0.98	0.0	0.2 ±0.4
Polyanthia fragrens	0.0	0.0	0.0	0.98	0.0	0.2 ±0.4
Garcinia talbotti	0.96	0.0	0.0	0.0	0.0	0.2 ±0.4
Pittosporum floribundam	0.0	0.0	0.25	0.65	0.0	0.2 ±0.3
Chukrasia tabularis	0.48	0.0	0.0	0.33	0.0	0.2 ±0.2
Ficus nervosa	0.0	0.0	0.0	0.0	0.76	0.2 ±0.3
Alstonia scolaris	0.0	0.75	0.0	0.0	0.0	0.2 ±0.3
Mastixia arborea	0.0	0.0	0.75	0.0	0.0	0.2 ±0.3
Trichilia connaroides	0.0	0.0	0.75	0.0	0.0	0.2 ±0.3
Artocarpus heterophyllus	0.48	0.0	0.25	0.0	0.0	0.1 ±0.2
Melia dubia	0.0	0.0	0.0	0.65	0.0	0.1 ±0.3
Drypetes confertifolius	0.24	0.0	0.0	0.33	0.0	0.1 ±0.2
Trichilia connaroides	0.0	0.0	0.0	0.0	0.51	0.1 ±0.2
Ixora nigricans	0.0	0.0	0.25	0.0	0.25	0.1 ±0.1
Ficus nervosa	0.0	0.50	0.0	0.0	0.0	0.1 ±0.2
Hydnocarpus pentandra	0.24	0.25	0.0	0.0	0.0	0.1 ±0.1
Aglaia sp.	0.0	0.0	0.0	0.33	0.0	0.1 ±0.1
Canthium angustifolium	0.0	0.0	0.0	0.33	0.0	0.1 ±0.1
Canthium dicoccum	0.0	0.0	0.0	0.33	0.0	0.1 ±0.1
Dipterocarpus indicus	0.0	0.0	0.0	0.33	0.0	0.1 ±0.1
Eleagnus conferta	0.0	0.0	0.0	0.33	0.0	0.1 ±0.1
Mastixia arborea	0.0	0.0	0.0	0.33	0.0	0.1 ±0.1
Albizia lebbeck	0.24	0.0	0.0	0.0	0.0	0.0
Prunus ceylanica	0.24	0.0	0.0	0.0	0.0	0.0

Appendix 2.12 Basal area of plant species across different study sites

Name of the species	Basal Area					
	Hosthota	Chiksuli	Kanthota	Kodgi	Devgaar	Mean ±SD
Olea dioica	9.02	15.39	24.44	15.58	7.19	14.32 ±6.78
Ficus nervosa	0.0	17.65	0.0	20.46	11.61	16.57 ±4.52
Hopea ponga	9.09	4.40	2.00	10.59	9.93	7.20±3.79
Ficus microcarpa	1.75	0.02	0.0	28.79	0.0	10.18±16.13
Knema attenuata	8.87	5.38	4.10	4.42	7.49	6.05±2.06
Cassine glauca	3.43	5.41	11.92	1.06	1.57	4.67±4.4
Diospyros sylvetrica	12.43	0.03	0.0	1.30	9.28	5.76±6.04
Persia macarantha	2.92	0.71	14.70	2.03	0.47	4.16±5.9
Holigarna arnottiana	9.74	2.99	2.00	1.10	1.61	3.48±3.6
Aglaia roxburghiana	1.33	4.97	5.69	3.15	1.09	3.24±2.08
Diospyros buxifolia	4.38	1.20	0.84	6.23	1.78	2.88±2.33
Syzigium gardneri	10.69	2.75	0.0	0.0	0.0	2.68±4.63
Garcinia gummi-gutta	2.70	2.80	4.76	0.68	2.42	2.67±1.45
Vitex altissema	5.17	2.80	0.81	3.15	0.24	2.43±1.97
Dimocarpus longan	0.29	2.60	2.01	4.57	0.38	1.97±1.77
Lopopetalum whitianum	3.66	0.0	2.29	0.07	3.67	1.93±1.83
Bishopia javanica	0.0	0.0	0.0	9.07	0.0	2.26±4.54
Diospyros candolliana	0.43	2.57	2.82	1.59	1.05	1.69±1.01
Garcinia talbotti	0.84	5.57	0.42	0.75	0.06	1.52±2.28
Syzigium cumini	0.68	0.43	2.88	2.23	0.59	1.36±1.12
Garcinia morella	1.49	1.61	1.36	0.72	1.63	1.36±0.37
Callophylum tomentasum	1.41	3.56	0.13	0.01	1.45	1.31±1.43
Pterospermum reticulatum	1.57	1.10	0.23	3.46	0.17	1.30±1.34
Lageostromia microcarpa	0.92	0.98	0.0	3.07	0.83	1.45±1.08
Litsea stocksii	0.83	2.01	1.62	0.81	0.46	1.14±0.64
Belsmedia whitii	0.70	1.86	1.81	0.50	0.65	1.10±0.67
Holigarna grahmi	0.65	0.76	1.65	0.21	1.88	1.03±0.71
Syzizium stocksii	0.0	0.0	0.01	2.40	2.71	1.02±1.40
Litsea floribonda	0.80	2.66	0.66	0.27	0.45	0.96±0.97
Nathopegia racemosa	0.55	0.58	1.94	0.46	0.40	0.78±0.65
Myristica dactyloides	0.46	0.80	0.02	0.12	2.37	0.75±0.95
Ixora brachiata	0.65	0.36	1.02	0.42	1.22	0.73±0.38
Mimusops elengi	0.74	1.61	0.28	0.04	0.98	0.73±0.62
Symplocos racemosa	0.89	0.48	0.79	0.83	0.66	0.73±0.16
Mangefera indica	0.50	0.10	2.10	0.18	0.44	0.66±0.82
Xylia xylocarpa	0.0	2.75	0.0	0.0	0.0	0.55±1.23
Gymnocranthera canarica	0.0	0.0	2.71	0.0	0.0	0.67±1.36
Xantolis tomentosa	0.05	0.74	1.68	0.05	0.08	0.52±0.71

Diospyros angustfolia	0.08	0.39	0.21	0.89	0.91	0.49±0.38
Aparosa lindelana	0.90	0.10	0.59	0.54	0.33	0.49±0.3
Eleocarpus serratus	0.22	0.27	0.81	0.73	0.22	0.45±0.29
Artocarpus hirsutus	1.26	0.40	0.06	0.0	0.43	0.54±0.51
Terminalia paniculata	0.0	0.20	0.0	0.19	1.63	0.67±0.83
Euodia lunu-ankenda	0.01	1.26	0.09	0.32	0.16	0.36±0.51
Syzizium hemispermicum	0.40	0.79	0.0	0.0	0.40	0.39±0.32
Syzygium sp.	0.16	0.0	0.0	1.18	0.13	0.36±0.55
Flacourtia montana	0.90	0.14	0.09	0.19	0.12	0.28±0.34
Terminelia bellarica	0.0	0.54	0.64	0.23	0.0	0.47±0.21
Memecylon malabaricum	0.20	0.08	0.99	0.04	0.08	0.27±0.4
Glochidion velutinum	0.01	0.35	0.72	0.13	0.10	0.26±0.28
Chukrasia tabularis	0.65	0.0	0.0	0.62	0.0	0.31±0.37
Chrysophyllum roxburghii	0.34	0.19	0.16	0.01	0.51	0.24±0.19
Actinodaphne hookeri	0.40	0.15	0.38	0.04	0.16	0.22±0.16
Canerium strictum	0.17	0.51	0.16	0.14	0.11	0.21±0.16
Alsea daphni	0.37	0.31	0.05	0.0	0.35	0.27±0.15
Macarange peltata	0.26	0.38	0.01	0.33	0.10	0.21±0.16
Canthium dicoccum	0.07	0.06	0.14	0.11	0.57	0.19±0.21
Casearia beddomi	0.0	0.15	0.71	0.0	0.0	0.21±0.34
Syzizium laetum	0.02	0.07	0.43	0.24	0.07	0.16±0.17
Saraca asoka	0.0	0.0	0.0	0.83	0.0	0.20±0.42
Myristica malabarica	0.26	0.01	0.25	0.07	0.19	0.15±0.11
Diospyros montana	0.16	0.0	0.60	0.0	0.0	0.19±0.28
Sapium insigne	0.0	0.72	0.0	0.0	0.0	0.24±0.42
Cinnamomum malabathrum	0.09	0.13	0.11	0.17	0.17	0.13±0.04
Steriospermum personatum	0.21	0.05	0.14	0.0	0.25	0.13±0.11
Caryota urens	0.18	0.12	0.0	0.0	0.31	0.12±0.13
Artocarpus lakoocha	0.03	0.02	0.0	0.56	0.0	0.12±0.25
Mastixia arborea	0.0	0.0	0.21	0.30	0.0	0.10±0.14
Homelium zeylanicum	0.03	0.14	0.02	0.0	0.27	0.11±0.12
Terminalia tomentosa	0.0	0.0	0.0	0.45	0.0	0.09±0.2
Sterculia guttata	0.05	0.34	0.05	0.0	0.0	0.11±0.16
Neolitsia zeylanica	0.17	0.13	0.05	0.06	0.0	0.08±0.07
Maduca longifolia	0.21	0.19	0.0	0.0	0.0	0.08±0.11
Tabernamontana heyinana	0.10	0.06	0.07	0.14	0.02	0.08±0.04
Ficus asperima	0.0	0.05	0.09	0.24	0.0	0.13±0.1
Callicarpa tomentosa	0.02	0.18	0.0	0.16	0.01	0.07±0.09
Polyanthia fragrens	0.06	0.0	0.0	0.12	0.17	0.09±0.07
Syzygium caryphyllatum	0.0	0.11	0.0	0.23	0.0	0.09±0.11
Trichilia connaroides	0.0	0.0	0.27	0.0	0.03	0.08±0.13

Carallia brachiata	0.04	0.0	0.13	0.06	0.06	0.06±0.05
Hydnocarpus pentandra	0.21	0.05	0.0	0.0	0.0	0.05±0.09
Flacortia sp.	0.0	0.0	0.10	0.01	0.15	0.05±0.07
Callophylum apetalum	0.00	0.14	0.0	0.0	0.10	0.06±0.07
Careya arborea	0.08	0.04	0.0	0.12	0.0	0.05±0.05
Albizia lebbeck	0.21	0.0	0.0	0.0	0.0	0.04±0.09
Prunus ceylanica	0.19	0.0	0.0	0.0	0.0	0.04±0.08
Chionanthus malabaricus	0.0	0.0	0.16	0.0	0.0	0.03±0.07
Nothapodytes nimmoniana	0.0	0.03	0.13	0.0	0.0	0.03±0.06
Pittosporum floribundam	0.0	0.0	0.05	0.07	0.0	0.02±0.03
Artocarpus heterophyllus	0.10	0.0	0.01	0.0	0.0	0.03±0.05
Buchnania lanzan	0.0	0.0	0.0	0.10	0.0	0.03±0.05
Drypetes confertifolius	0.08	0.0	0.0	0.01	0.0	0.02±0.03
Eleagnus conferta	0.0	0.0	0.0	0.06	0.0	0.01±0.03
Celtis tetandra	0.0	0.0	0.06	0.0	0.0	0.02±0.03
Melia dubia	0.0	0.0	0.0	0.04	0.0	0.01±0.02
Celtis tetandra	0.0	0.03	0.0	0.0	0.0	0.01±0.02
Leea indica	0.0	0.0	0.0	0.03	0.0	0.01±0.01
Aglaia sp.	0.0	0.0	0.0	0.02	0.0	0.00
Ixora nigricans	0.0	0.0	0.01	0.0	0.01	0.01±0.01
Dipterocarpus indicus	0.0	0.0	0.0	0.02	0.0	0.00
Canthium angustifolium	0.0	0.0	0.0	0.02	0.0	0.00
Alstonia scolaris	0.0	0.01	0.0	0.0	0.0	0.00

Chapter III

Status, productivity and harvesting of *Garcinia gummi-gutta*

Introduction

The genus Garcinia belongs to the family Cluciaceae whose distribution is in Asia, Australia, tropical and southern Africa (Ashish and Parthasarathy, 2010). In the low elevation evergreen forests of Western Ghats, the genus Garcinia is represented by eight species namely, *Garcinia gummi-gutta* (L.) Robson, *G. imbertii* Bourd, *G. indica* (T.) Choisy, *G. morella* (G.) Desr., *G. pictorius* (Roxb.) D'Arcy, *G. rubro-echinata* Kosterm., *G. talbotii* Raiz and Sant., *G. travancorica* Bedd., *G. wightii* T.Andr. (Pascal and Ramesh, 1987). Among all the species, *G. gummi-gutta* and *G. indica* are highly valued for its fruits, and seeds of *G. morella* are sparely collected for oil extraction as NTFP (Kumara and Santhosh, 2013).

Garcinia gummi-gutta is a large under-storey evergreen and lower shola tree, which is endemic to forests of Western Ghats and Sri Lanka (Ramesh and Pascal, 1997). Trees of them grow up to 25 m high, with rounded and dense canopy (Nair et al., 2002). They inhabit forests at altitudes up to 2000 m (Tissot et al., 1994). They possess a smooth brown bark, which exudes yellow latex. The branchlets are horizontal, slightly drooping towards the end and are glabrous. They possess simple leaves which are oblong or elliptic, entire, glossy and glabrous (Nair et al., 2002). This species is androdioecious whose flowers are pollinated by weevils (Rai and Uhl, 2004). The male and hermaphrodite trees are present in equal proportions in the forests (Rai, 2003). Fruits are deep green when unripe, pale yellow when ripe, acidic, possessing 6-8 grooves, depressed globose with 6-8 seeds covered by a succulent, and white-pale brown aril (Nair et al., 2002).

Garcinia gummi-gutta (*Uppage* in the study area) popularly called as Malabar tamarind (*Kodam-puli*) is historically used as souring agent in soups in Kerala state in addition to being used as fish preservative (*Meen-puli*). Demand for the fruits increased commercially after medicinal properties were discovered from hydroxy citric acid present in the rind of the fruit (Majeed et al., 2004). It was soon considered as a 'wonder drug' to treat obesity (Sergio, 1988). As a result of international demand for exporting the drug, prices of dried and processed rind increased dramatically over the years. The higher demand led to higher extraction due to increase in prices which was initiated around 1990s (Rai and Uhl, 2004). The conventional method of harvesting and processing involves enormous amounts of labour and risk in bringing the fruits, deseeding them and drying on metal mesh or bamboo mats with large quantity of firewood (Rai, 2003; Rai and Uhl, 2004; Hegde and Vasudeva, 2010; Kumara and Santhosh, 2013). Saibaba et al. (1996) and Rai (2003) estimated the firewood consumption for processing but the results highly varied. Hegde and Vasudeva (2010) indicated the different types of ovens existing in the area for processing of *Garcinia gummi-gutta* and described their efficacies and firewood consumption. However, most of the households in the district are agriculture based and could not afford the highly efficient driers for processing. Kumara and Santhosh (2013) predicted that there could be negative impacts on the dependent fauna leading to adverse ecological changes on the long run with the existing mechanisms of harvesting and trade especially in reference to *Garcinia gummi-gutta.* The fruits of *Garcinia gummi-gutta* are one of the major foods of lion-tailed macaques during the wet season and important NTFP tree for the local people, thus the understanding of its status, harvesting of fruits by local people and their processing, and its impact on the forest is indeed very crucial to manage the forest.

Ripe and unripe fruits (green) in harvests

Meetings with people

Methods

The details of methods followed for the assessment of vegetation and its stand structure are provided in the chapter –II. The status and girth class characteristics of *Garcinia gummi-gutta* across different study sites were extracted from the previous chapter, and provided separately here.

We collected the data on quantity of harvest, price obtained, number of trees harvested and marketing of the dried fruits from previously identified 73 families (Kumara and Santhosh, 2013). The meetings were held with the help of forest department in the selected villages. During the meetings, local villagers were conveyed about a right time of harvest and sustainable harvesting techniques, and meanwhile villages where the Village Forest Committees (VFCs) was not formed there they were promoted to establish a newer VFCs to streamline the marketing of NTFPs extracted from the forest. In addition to this, randomly once or twice 58 households were visited during the harvest season, and assessed the quality (proportion of unripe fruits) of their harvest. The count of different stages of fruits harvested was established. Four categories were considered for collection of data namely (i) Areas with VFC and awareness for proper harvest, (ii) Areas with VFC without awareness for proper harvest, (iii) Areas without VFC and with awareness for proper harvest and (iv) Areas without VFC and awareness for proper harvest. We considered the villages that were visited regularly and conducted awareness meetings were considered as villages with awareness for harvest.

A total of 20 trees were tagged in the study site, and they were monitored for their phenology. The height of the tree was visually estimated, GBH was measured, and number of branches in the tree was counted. Every tree was visited in the first week of every month, and recorded the phenophases of flowers and fruits in the tree. If the species was flowering or fruiting, the quantity was estimated. The quantity of flowers and fruits in the tree were counted by counting the number of flowers or fruits per branchlets and branches, and using this, the mean number was calculated for the sampled branchlets. This mean number available for each fixed length branch was multiplied with the total number of branchlets and branches in the tree that have reproduced, which provided the total crop available for each tree. Stage of fruit, number of fruits harvested, weight of raw fruits, weight of deseeded rind, time taken for processing, weight of processed rind were noted down after the harvesting. The firewood required for processing an unit kilogram of *Garcinia gummi-gutta* and the type of oven used by the family was collected from randomly selected households (n=10) across the study sites.

Results

The mean absolute frequency (24.44±5.48), abundance (1.30±0.18), density (0.32±1.00), relative frequency (3.62±0.69), relative abundance (1.46±0.30), relative density (2.98±0.89), basal area (2.67±1.45) and IVI (8.06±1.82) of *Garcinia gummi-gutta* provided in the Table 3.1. The basal area varied from 0.68 in Kodagi to 4.76 in Kanthota, where the IVI also show variation from 5.05 in Kodagi to 9.97 in Hosthota. The number of individuals per hectare in different girth classes is provided in the Table 3.2. The mean number of juvenile tree was 1408.00±980.88 ha^{-1}, however number of individuals varied from 480 ha^{-1} in Hosthota to 2980 ha^{-1} in Chiksuli. The large percent of trees were in the girth class of 30 to 120 cm girth class, and very few trees were in the higher girth class

Table 3.1 Absolute, relative frequency, abundance, density and basal area, Importance value index of *Garcinia gummi-gutta* across study sites

Area	Frequency	Abundance	Density	Relative Frequency	Relative Abundance	Relative Density	Basal area	IVI
Hosthota	31.82	1.40	0.45	4.44	1.61	3.93	2.70	9.97
Chiksuli	27.34	1.29	0.35	3.91	1.37	3.21	2.80	8.49
Kanthota	21.88	1.32	0.29	3.57	1.54	3.03	4.76	8.14
Kodgi	17.35	1.00	0.17	2.54	1.00	1.52	0.68	5.05
Devgaar	23.81	1.47	0.35	3.63	1.79	3.22	2.42	8.64
MEAN	**24.44**	**1.30**	**0.32**	**3.62**	**1.46**	**2.98**	**2.67**	**8.06**
SD	**5.48**	**0.18**	**0.10**	**0.69**	**0.30**	**0.89**	**1.45**	**1.82**

The number of trees flowering and fruiting highly varied between 2012 and 2013 (Fig. 3.1). All the 20 trees flowered in the year 2012 and only 18 gave a ripe fruits, while only five of them produced the flowers in 2013 and of them only 2 gave ripe fruits. The mean number of flowers in a tree varied from 24093.23 (6241.15 SE) in 2012 to 5007.83 (3724.30 SE) in 2013, while the mean number of unripe fruits in 2012 and 2013 were 925.36 (218.55 SE) and 517.03 (445.57 SE) and mean number of ripe fruit varied from 339.22 (77.48 SE) and 139.23 (103.00 SE) in 2012 and 2013 respectively as shown in Figure 3.2a,b,c.

Table3.2 The number of individuals of *Garcinia gummi-gutta* per hectare in different girth classes across study sites

Girth Class (cm)	**Hosthota**	**Chiksuli**	**Kanthota**	**Kodgi**	**Devgaar**	**Mean ± SD**
<10	480.00	2980.00	800.00	1120.00	1660.00	1408.00 ±980.88
10-30	210.00	131.00	112.00	68.00	83.00	120.80 ±55.58
30-60	16.41	11.45	2.24	2.92	6.32	7.87 ±6.00
61-90	5.31	5.22	1.99	2.60	1.77	3.38 ±1.75
91-120	4.83	1.74	0.25	0.00	1.77	1.72 ±1.92
121-150	0.24	1.00	0.25	0.32	0.25	0.41 ±0.33
151-180	0.48	0.75	0.75	0.00	0.76	0.55 ±0.33
181-210	0.00	0.00	0.50	0.00	0.25	0.15 ±0.22
>210	0.24	0.25	0.00	0.00	0.00	0.10 ±0.13

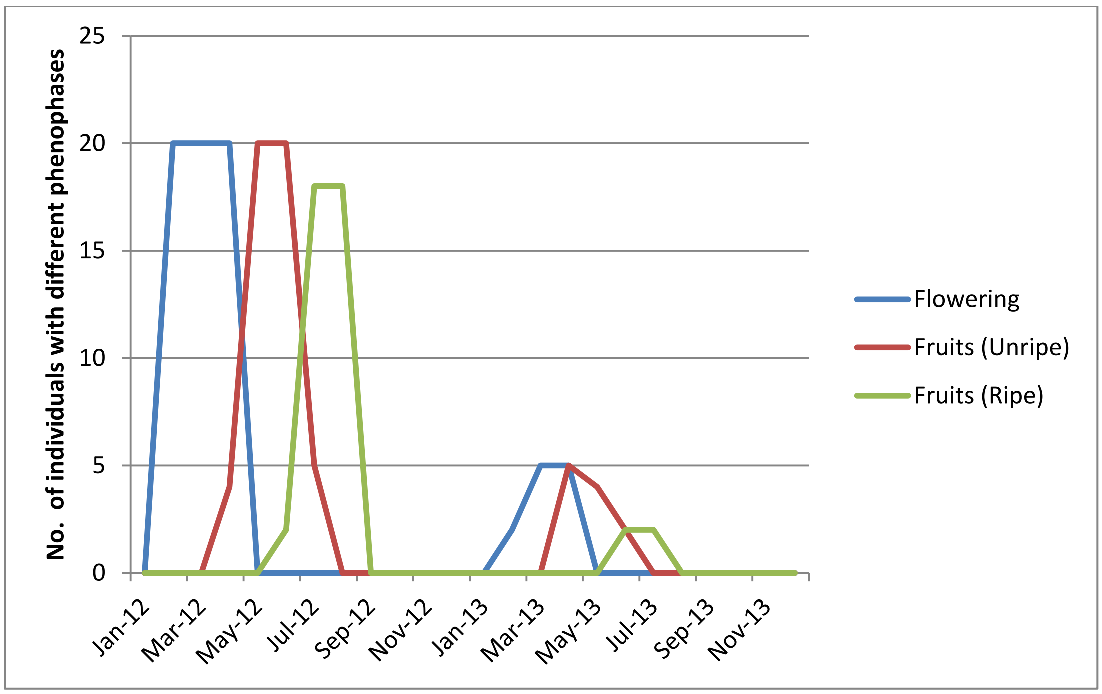
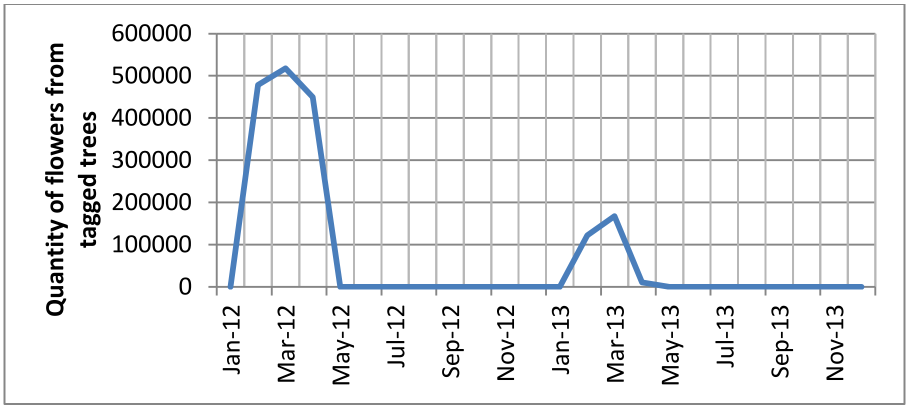
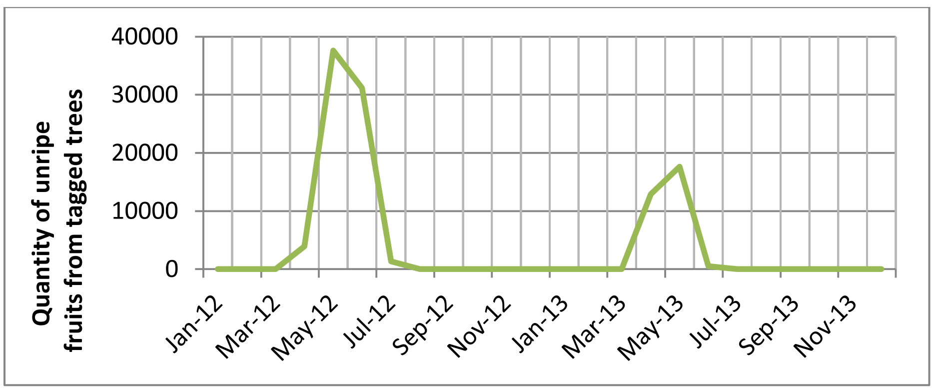


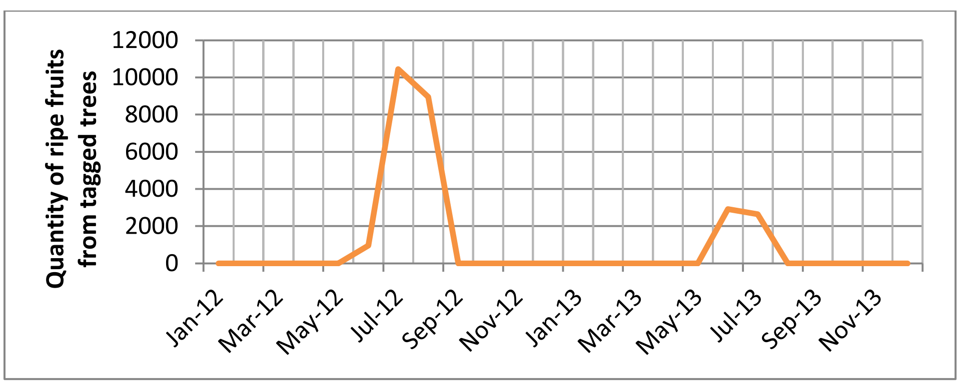
Figure 3.1 Number of trees of *Garcinia gummi-gutta* (N=20) having flowers, unripe and ripe fruits during different months of the study period



a. Flowers



b. Unripe fruits



c. Ripe fruits

Figure 3.2 The mean number of flowers, unripe fruits and ripe fruits produced by tagged trees (N=20) of *Garcinia gummi-gutta* during the study period

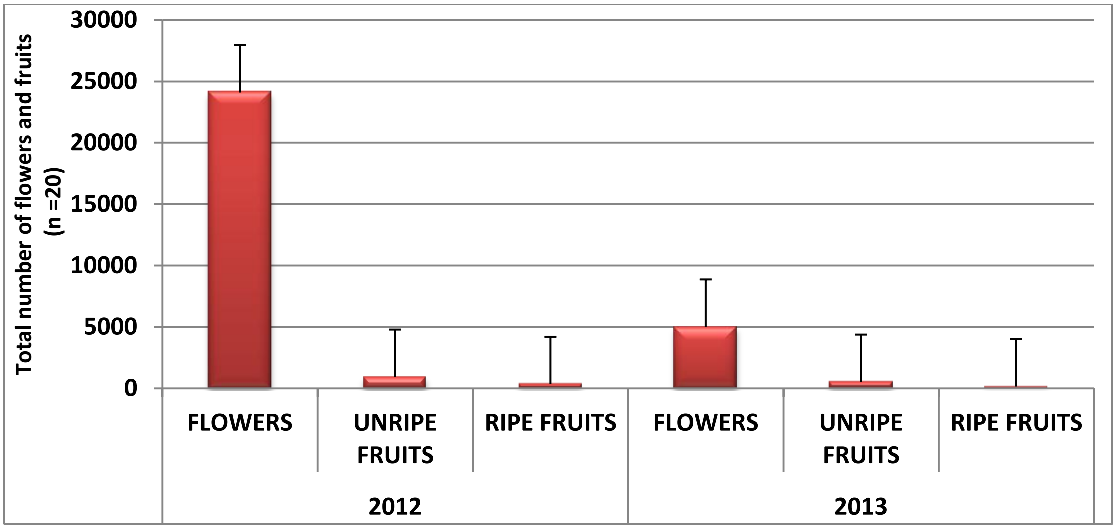


Figure 3.3 The mean number of flowers, unripe fruits and ripe fruits of *Garcinia gummi-gutta* in the tagged trees (N=20) between the years

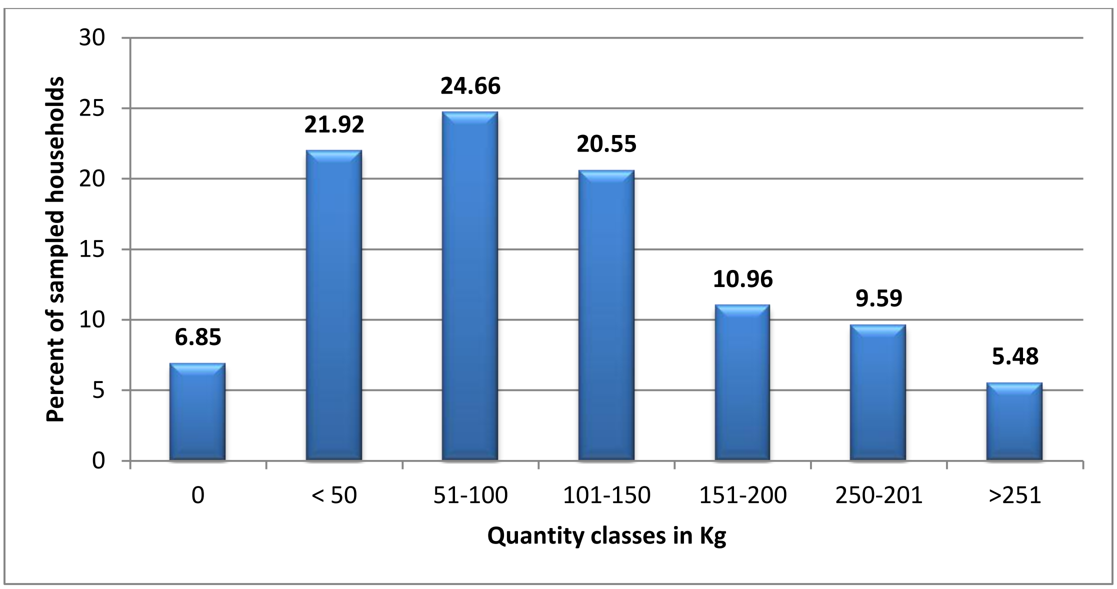


Figure3.4 The percent of sampled households harvesting *Garcinia gummi-gutta* in different quantity classes

The number of unripe fruits harvested did not differ with the presence or absence of VFC, however, the awareness significantly decreased the proportion of harvest of unripe fruits ($t = 2.138$, $df = 55$, $p<0.05$). The mean unripe fruit harvested by the families with awareness was 1.38±1.86 SD where it was 2.4±1.71 SD with families without awareness. Percent families collected the fruits of *Garcinia gummi-gutta* at different quantity classes are provided in the Figure 3.4. About 7 % of the families in and around the ACR do not go for harvest the *Garcinia* *gummi-gutta*, and about 65 % of the families annually harvest between few kg to 150 kg, however only about 27% of the families opt intensive harvesting of >150 kg. Among the sampled families, all the families used the conventional self-made open fire oven for processing of *Garcinia gummi-gutta.* The average quantity of firewood required to dry a kilogram of rind was 22.00±5.24 SD. We estimate the firewood consumption per year in the ACR to be 79, 87,013.94 kg.

Garcinia gummi-gutta fruits processed in traditional open fire open.

Discussion

Garcinia gummi-gutta forms an important NTFP and one among 59 species collected by people in evergreen zones of Uttara Kannada district (Murthy et al., 2005). The quantity of *Garcinia gummi-gutta* harvested and its income forms one of the major contributions to the yearly income of the local people (Kumara and Santhosh, 2013). Unstable markets (Padoch, 1992), controlled trade by elite (Ribot, 2000) and fluctuating quantities in the forest (Bhat et al., 2003) always makes more challenges to the harvesters.

Although, the findings show little variation in the status of *Garcinia gummi-gutta* with different girth class across study sites, but the variation was not that significant. However, the quantities of ripe fruit turn over highly varied between the years. The harvest quality was higher in households with awareness. The estimated quantity of firewood consumed yearly in ACR was enormous which was obtained at free of cost.

The mean IVI (8.06) and relative density (2.98±0.89) of *Garcinia gummi-gutta* in the present sites is on par with the status in southern ACR (7.91 IVI and 2.65 relative density) (Roy et al., 2010). The number of seedlings (<10 cm) varied across sites with high variation (the mean density was 1408.00±980.88 ha^{-1}). The gradual decrease in the number from lower girth class to higher class indicates sustained regeneration of the species across the sites. Fewer individuals in the lower size classes than in the higher size classes reported for Kodagu is due to intense commercial extraction of fruits, which affected the regeneration of the species (Kushalappa et al., 2010). We presume that the regeneration in ACR is relatively better than in the Kodagu district.

The phenology studies are important in understanding regeneration potential, community level interactions and to evolve management strategies (Fox, 1976) for a species or dependent community. Many studies have ascertained that the phenology of a species is determined by variables such as water stress, moisture availability and many other climatic factors (Bhat and Murali, 2001). The phenology pattern of *Garcinia gummi-gutta* also shows a high degree of variation in productivity across years, which is apparent for the species as reported earlier by Bhat et al. (2003). This may has to be considered as an important factor for decision making while developing the marketing strategies in the future.

The proportion of families opting harvesting large quantity may be dependent on the number of members in the family and the effort invested to harvest (Kumara and Santhosh, 2013). Thus, optimization between resource availability, manpower and effort decided the quantity harvested every year. VFCs did not play any role in harvest quality but awareness through meetings had a positive impact on timing or quality of harvesting. Attempts for VFC-mediated marketing of *Garcinia gummi-gutta* have all been very sporadic and inconsistent, thus we presume they may not be playing a major role in the quality of harvest. There is a need to stress the relevance of kind of societies for harvester to mediate people's participation in resource management. Such initiatives in other areas have been very successful in the past. For instance, as in BRT Tiger Reserve where Soliga inhabitants continue to take part in participatory resource mapping, fruit estimations and promotion of proper harvesting techniques for *Phyllanthus* spp. for more than a decade (Setty et al. 2008).

All families used traditional open fire oven made conventionally whose efficiency was 22.00±5.24 kg, which was very much in accordance with the estimate of 25 kg reported by Saibaba et al. (1996) and 22 kg by Hegde and Vasudeva (2010), but it was much higher than the estimate of 10.5 kg made by Rai (2003). The high variation in estimation of firewood consumption could be attributed to the differences in their size, quality of materials used to build the oven, mode of construction and design, which decides the efficacy of the oven for firewood consumption. Hegde and Vasudeva (2010) have estimated the consumption of 4, 40, 00,000 kg of firewood for Canara forest circle for processing *Garcinia gummi-gutta.* Our estimate of 79, 87, 014 kg of firewood required per year in ACR landscape which is 299.52 km^2 (Kumara, 2011) with the 15,041 human population (Kumar and Santhosh, 2013) should certainly pose the threat to the reserve. Kumara et al. (2011) has pointed out that there is an annual loss of 1.9% of evergreen forests for the reserve, which is happening due to an increasing human population and their dependency on the forest in the reserve. We presume that in absence of immediate mitigation measures, there would be a loss of habitat due to severe fragmentation leading to isolated fragments without canopy connectivity. The interventions required for mitigating the challenges are discussed in detail in the following chapter.

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Chapter IV

Synthesis and Interventions

Introduction

Aghanashini Lion-tailed macaque Conservation Reserve (ACR) was considered as a critical habitat and declared as a protected area by the state government of Karnataka. The purpose of notification was to "protect, propagate and develop" this habitat for the inhabiting endangered and endemic flora and fauna keeping lion-tailed macaque (LTM) as a flagship species. This population of LTM, which contains more than 31 estimated groups with more than 650 individuals (Santhosh et al., 2013), is one of the largest known populations in the wild. Additionally, a large human population inhabits the area that is highly dependent on these forests for a variety of resources including Non-Timber Forest Produce (NTFP, Kumara and Santhosh, 2013). These forests were selectively logged for several years for industrial purposes and large areas of forest have been sacrificed for developmental activities by the government (Gadgil and Chandran, 1989; Kumara and Santhosh, 2013). Thus, there was an immediate need to know the fodder plant species used by the monkeys for the purpose of prioritization for conservation and management. Therefore, the study on feeding ecology listed the important species for the monkeys and the NTFPs extracted by people, which reveals that a great degree of overlap between the food resources of LTM and NTFP collected by people i.e. 11 species out of 15 species collected were used by LTM as food (Kumara and Santhosh, 2013). *Garcinia gummi-gutta* was the most important NTFP collected by more than 90% of the sampled households in the area was also an important species of food in the monsoon (5.93% of its total diet in the monsoon) for LTM (Kumara and Santhosh, 2013). On this background of high overlap of resource use between humans and LTM, sustainability in resource extraction was postulated as a management strategy in view of long term benefits for both of them (Kumara and Santhosh, 2013). The present study provided required information on stand structure of plant species and resource availability (Chapter-II), with special reference to the status of *Garcinia gummi-gutta* productivity, harvesting and processing of the fruits for the market (Chapter-III).

Village Forest Committees (VFC) were established by the government of India in 1988 on the priority of managing forests with the association of local community who share the resources with the forest department. Local people and forest department jointly take the decisions regarding the management of forests. Presently some VFCs are also collecting the rind of *Garcinia gummi-gutta* and auctioning, but it has not been taken up on large scale. Added to this fact to constitute the new VFCs, there are many criteria set by the government like the percent of forest and number of houses in the village. Many of the villages in ACR do not pass this criteria thus formation of VFC is lower.

Multipurpose ASTRA driers Processing firm in the district

The process of existing marketing of *Garcinia gummi-gutta* is that the tenders are issued from the forest department on yearly basis. The harvesters are expected to sell their produce only to the agents of the bidder either in villages or through VFC. The produce that is marketed through this channel is considered 'legal'. In some cases, the agents of the middlemen from neighboring areas involve in collection of the produce by increasing the buying prices and luring the harvesters. They establish themselves in the trade by providing loan to harvesters and buy the produce in exchange of money given. They mostly reside at towns by opening inlets in the market during the harvest season. They sometimes send agents to villages to buy the produce directly from harvesters. Additionally, harvesters also exchange their produce with fish, lime and blanket sellers at their doorstep. All these modes of selling are considered as 'illegal' or black market sale by the forest department.

Although, some of the interventions were conceived to reduce the firewood usage by people for drying the fruits and streamlining of the marketing of the dried fruits, they have not been implemented on large scale in the area. Application of Science and Technology for Rural Areas (ASTRA) from Indian Institute of Science designed the driers and disseminated information locally through Technology Demonstration Center in Sirsi. Training was given to people on the details of manufacturing and distributed locally by trained people for fuel-efficient drying of materials of which most were used for only agricultural purposes. Organizations and government departments with subsidy have also distributed it locally but it has all been on experimental basis. There remains a lacuna in conveying of effectiveness of information about ASTRA driers. Thus, there are less than 10 ASTRA ovens installed in the ACR presently. Added to this fact, cost of ASTRA driers vary from 35,000 INR to 1,30,000 INR based on the quantity output produced. This remains out of reach for even average income households. Some of the organizations installed few community ovens in few villages, which were also monitored to understand the sharing oven between many households. Attempts to extract juice from *Garcinia gummi-gutta* fruits and supply to the industry have also failed for the reasons of its decomposition in the weather condition and concerns over transportation.

In the present chapter, we present the gist of interviews with all stakeholders in the view of reducing the burden on forest and considering the interests of sustained harvester's income. We discuss the possibilities and potential of different models for sustainable harvesting, marketing of *Garcinia gummi-gutta* and the interventions required from the governance and stakeholders to achieve this goal.

Methods

During our earlier study, we identified households (N=73) for the long-term monitoring of NTFP collection and their livelihood in the study site (Kumara and Santhosh, 2013). We continued data collection on livelihood, agricultural land holdings, yearly income, quantity of harvests and marketing of those NTFPs from those households.

Questionnaire survey was carried out for households that fell under three VFC jurisdiction (N=31) for opinion on VFC functioning mechanism, advantages and limitations of VFC mediated *Garcinia gummi-gutta* trade, knowledge and preference of ASTRA ovens and their willingness and conditions to use the oven in the future. Additionally, questionnaire survey was carried out for two deputy range officers of the forest department handling VFC mediated auctions (N=10). Information was collected on the challenges faced during auctioning of *Garcinia gummi-gutta* and the expected interventions required from higher officials for achieving expected results. Questionnaire survey was carried out for ASTRA oven users of the area (N=14) and information was collected on purpose of installations, usage, fuel wood efficiency for drying *Garcinia gummi-gutta* and the overall advantages and drawbacks of ovens.

Personal meetings were held with the concerned officials of leading industries (N=3) that use the *Garcinia gummi-gutta* rind as a raw material about value addition and marketing the products made of *Garcinia gummi-gutta.* Data on their perspectives of *Garcinia gummi-gutta* marketing, challenges and limitations in the existing mechanism and its mitigation was also collected. Detailed discussions were held and inputs collected on the possibilities of streamlining the trade of *Garcinia gummi-gutta.*

Existing and suggested strategies for harvesting-marketing of the *Garcinia gummi-gutta*:

Existing marketing dynamics of Garcinia gummi-gutta: The mechanism of marketing of the products in the study area is enunciated Fig. 4.1. The harvesters from the villages with VFC sell the produce through VFC (55.00% of the households) and through intermediaries at villages (45.00% of the households). On the other hand, harvesters in a villages without VFC sell the produce directly to the bidder or through the village intermediaries (100.00% of households) or sometimes directly to the shoppers in nearby town. A small part of the produce reaches the market for domestic consumption. Majority reaches the supplier who does the value addition by extracting Hydroxy Citric Acid and sells it to the industry. Some industries have their own supply unit present internally and some of them get from external suppliers.

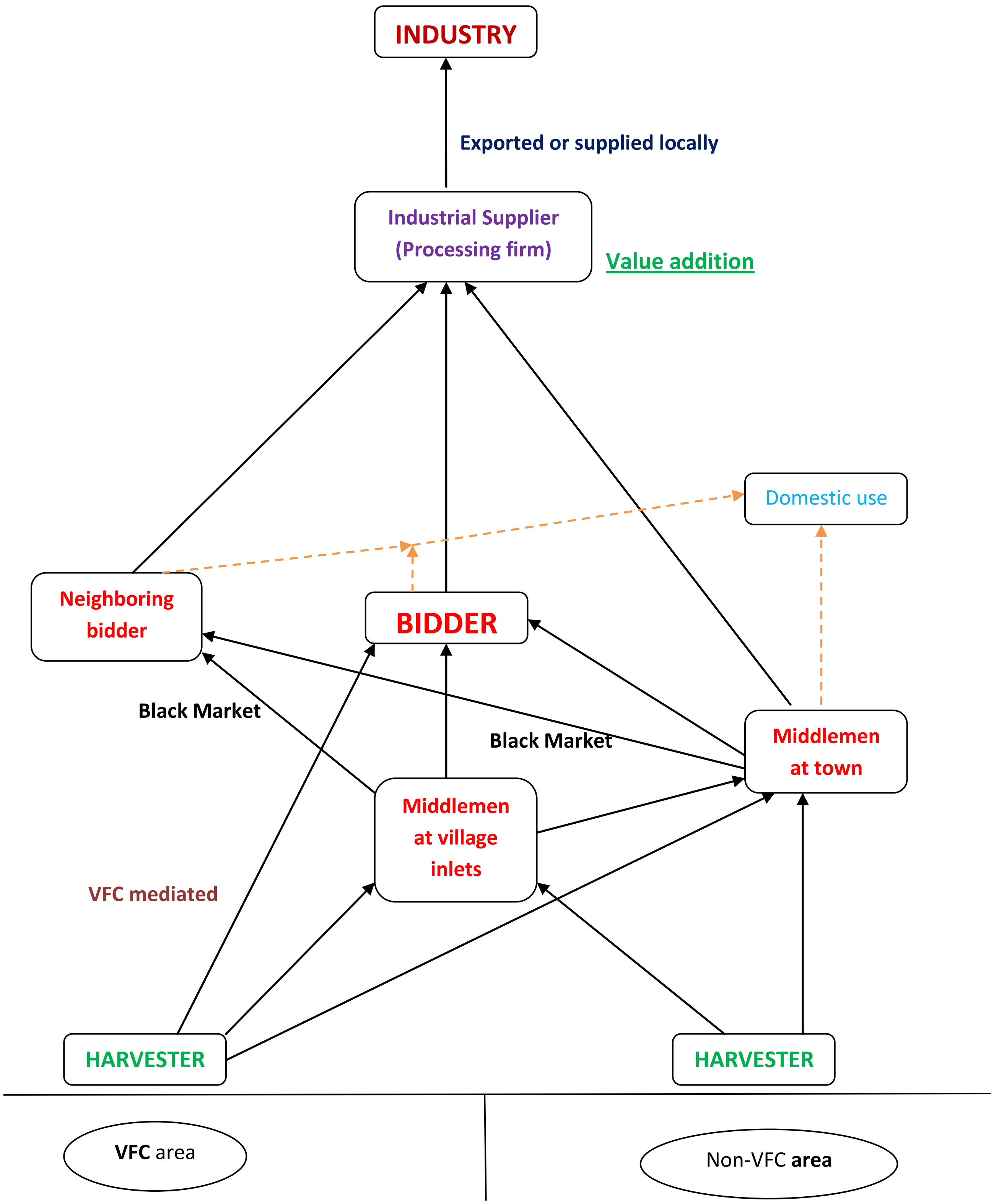


Figure 4.1 Existing mechanism of marketing of *Garcinia gummi-gutta*

Limitations of present harvesting, role of VFC, tenders and industry

A. *Harvesting*

1. An average of ~ 80 lakh kg/year of firewood is used to dry the rind in ACR, since majority of harvesters are using traditional open fire oven (See results in Chapter-III)
2. 24.00% of harvest from the forests is unripe fruits in villages without awareness as compared to villages with awareness (13.63%, See the results in Chapter-III). This is due to intense competition for getting higher harvests due to inconsistent market prices (Kumara and Santhosh, 2013).
3. Harvesters cannot take the produce at large scale to nearby town expecting higher prices. The products will be confiscated at forest check posts for illegal trading with black market (Forest Department Sources)
4. Interaction with local people confirmed that storage of produce at households is risky due to fungal infestation and loss in gross rind weight.

B. *Village Forest Committees* (VFC):

1. Since the tendering happens separately for VFC area and non-VFC area, bidders do not show interest in VFC tenders due to relatively less produce collected by VFC in comparison with non-VFC area as opined by the forest personnel on ten VFC.
2. Among three VFCs monitored, auctioning has never happened in one VFC, and in other two VFCs it was irregular or regular auctioning happens.
3. One of the deputy range officer opines that there is a need for de-centralising of auctions to the range offices for effective management of auction.
4. Twelve members belonging to two VFCs expressed that the functioning of VFC is not transparent while eight members informed it is transparent. The other 10 members of other VFC said that there is no VFC mediated auctions.
5. One of the deputy range officer representing managing five VFC opines that there is no constancy for the price in all the areas.

6. Both the forest department personnel admit that VFCs do not prioritize the implementation of sustainable harvesting techniques by harvesters
7. We observed that tendering did not happen during our study period for some of the VFCs and forest ranges at right time. This triggered the black market operations to monopolize on trading.
8. Miscommunication exists between local people in VFC and forest department in some of the area creating friction between the two. People sampled from two VFC opine that regular meetings are not held through the VFC.
9. Three VFCs among the sample do not have seed money to buy products on daily basis from harvesters
10. Among 10 VFC sampled, one of the VFC expressed that they were unable to compete with open market and convince harvesters to sell products through them.
11. VFCs cannot be established in many villages, as they do not qualify the basic criteria for VFC establishment. Therefore, there are a large number of villages harvesting *Garcinia gummi-gutta*, which do not come under VFC.

C. *Tenderer*

1. There is no tenure security for buying products, as there is no surety of winning the tender next time. Thus, they do not stress on the need of sustainable harvesting by harvesters (Rai and Uhl, 2004). The prices fixed for different quality products vary marginally.
2. The prices fixed for the product varies across years (Kumara and Santhosh, 2013). Prices also vary many times in the same season (95.65% of households)
3. Tenderers have information of both the productivity from the forest and the projected demand from the industry in a particular year, which turns out to be advantageous for them (Rai and Uhl, 2004)
4. Some tenderers in the past have done adulterations by adding salt, sand and iron filings to the dried rind for increasing the weight of the product as opined by one of the industry.

D. *Industry*

1. Industries are highly dependent on suppliers for the raw material.
2. They incur loss in buying adulterated products
3. The cost of production regularly varies due to instability in the market that implies on the selling price affecting their margin. This makes them susceptible to fluctuations in market
4. All of the industries sampled opine that they cannot take part in VFC auctions and win tenders competing with others.

Possible mitigations

1. Usage of ASTRA ovens reduces the fuel consumption to less than one fourth of consumption from traditional oven (Hegde and Vasudeva, 2010). The fuel wood can be further reduced by using dry agricultural biomass for processing which is available in abundance. Among the interviewed oven users, 61.00% of them used it to process *Garcinia gummi-gutta* rind of whom all users confirmed that their fuel wood usage has gone down to less than 4 kg to dry a unit kg of dry rind. Additionally, they claimed it to be multipurpose (63.00%), with less smoke (38.00%), no fire accidents (38.00%), ease in processing (38.00%), good quality product produced (25.00%) and more value for the product in market (13.00%). Most households are willing to buy ASTRA driers (96.77%) if given in subsidized rate with the facility of installment paying. Community driers were not successful for drying *Garcinia gummi-gutta* as none of the families agreed that they could share it equally with other families during harvest season. This was because of the short time available for processing the rind due to high competition.

2. 57.14% of the people of villages doing VFC mediated marketing have the opinion that VFC marketing is advantageous due to high financial security. Thus, it confirms that some people have confidence towards the potential of VFC. There is a need to convince harvesters towards timely and sustainable harvests by meetings by VFC. In areas where VFCs are not established, forest department personnel around harvest season should

initiate meetings. The frequency of untimely fruit harvest and unsustainable practices of harvesting can be lowered by forest department with the support of VFC by effective scrutiny and monitoring of harvests. Regular meetings need to happen to bridge the gap between forest department and people.

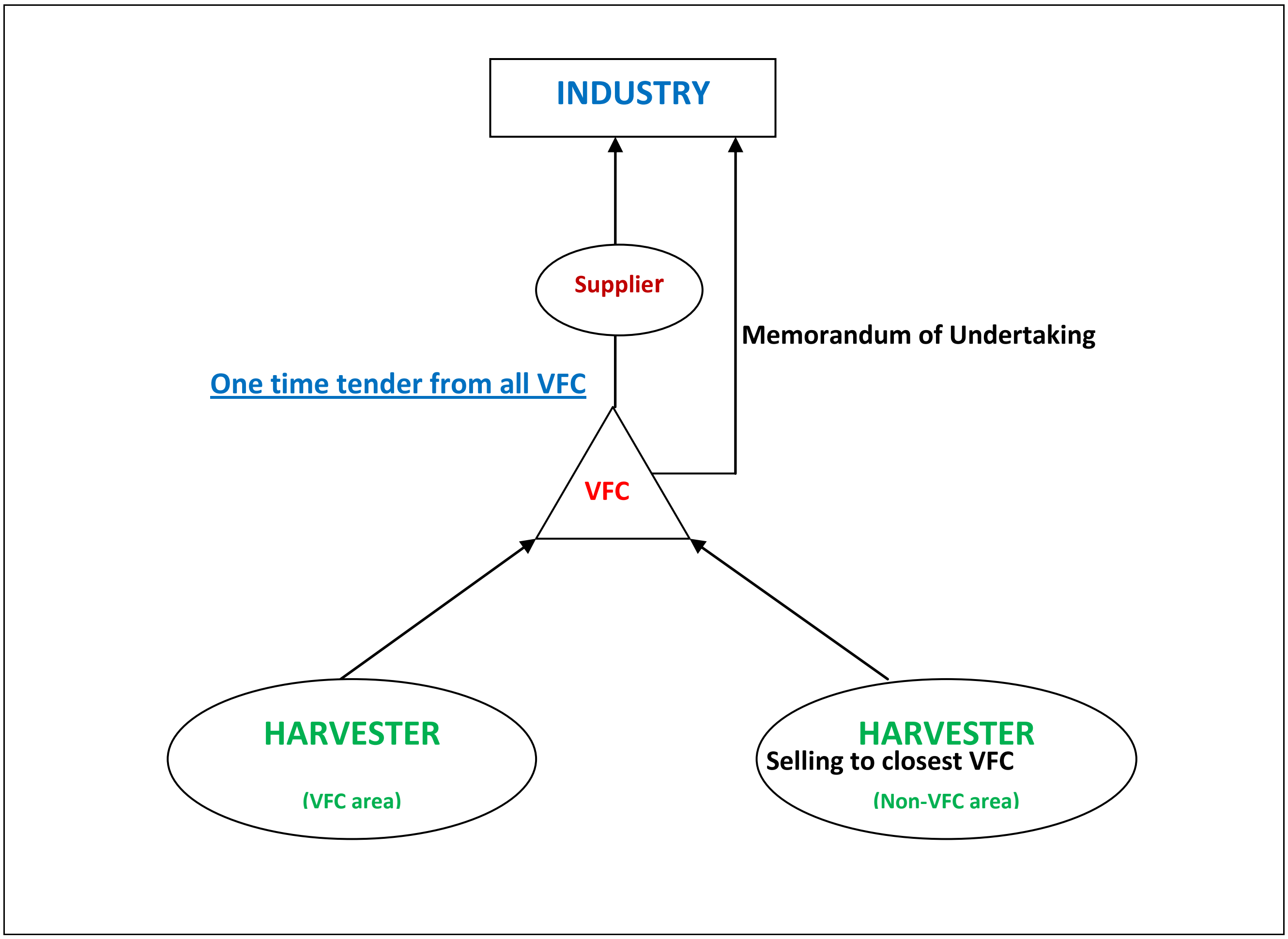
3. Auctions need to happen at one instance in a particular place for produce from all the VFCs of the range. This will not only increases the quantity auctioned but also increases the buyer's interest in VFC auction. This may lead to constancy and regularity in auction every year.

4. There is an urgent need to install VFCs in maximum number of villages possible. In places where it cannot be established, nearest VFC should take up the responsibility to collect the produce. Following this, capacity building of all VFCs is one of the most critical steps in sustainable harvest mechanism. Most villages lack common warehouses for storing their forest products. The present priorities of VFCs of the area need to be critically analyzed and needed interventions are to be taken up to bring transparency. The absence of seed money for many of the already installed VFCs is however a serious drawback for smooth functioning. There is a need to win the confidence of harvesters, especially the ones with low income towards the possibilities of VFC marketing. A prompt business initiative by the VFC such as immediately paying back money in exchange of received harvest is a simple, yet effective way to achieve success.

5. There is a need for consulting the industry by the forest department for initiating negotiations for direct sale of products eliminating the middlemen. Industries are open for entering a memorandum of understanding (one of the industries) with the VFC groups (need to constitute a cooperative society) for constantly buying products. Necessary administrative interventions need to be addressed.

Based on our interaction with local people, resource personnel and forest department we developed two models for sustainable extraction and marketing of *Garcinia gummi-gutta* namely 1. Harvester- VFC-Industry model and 2. Harvester- VFC processing-Industry model

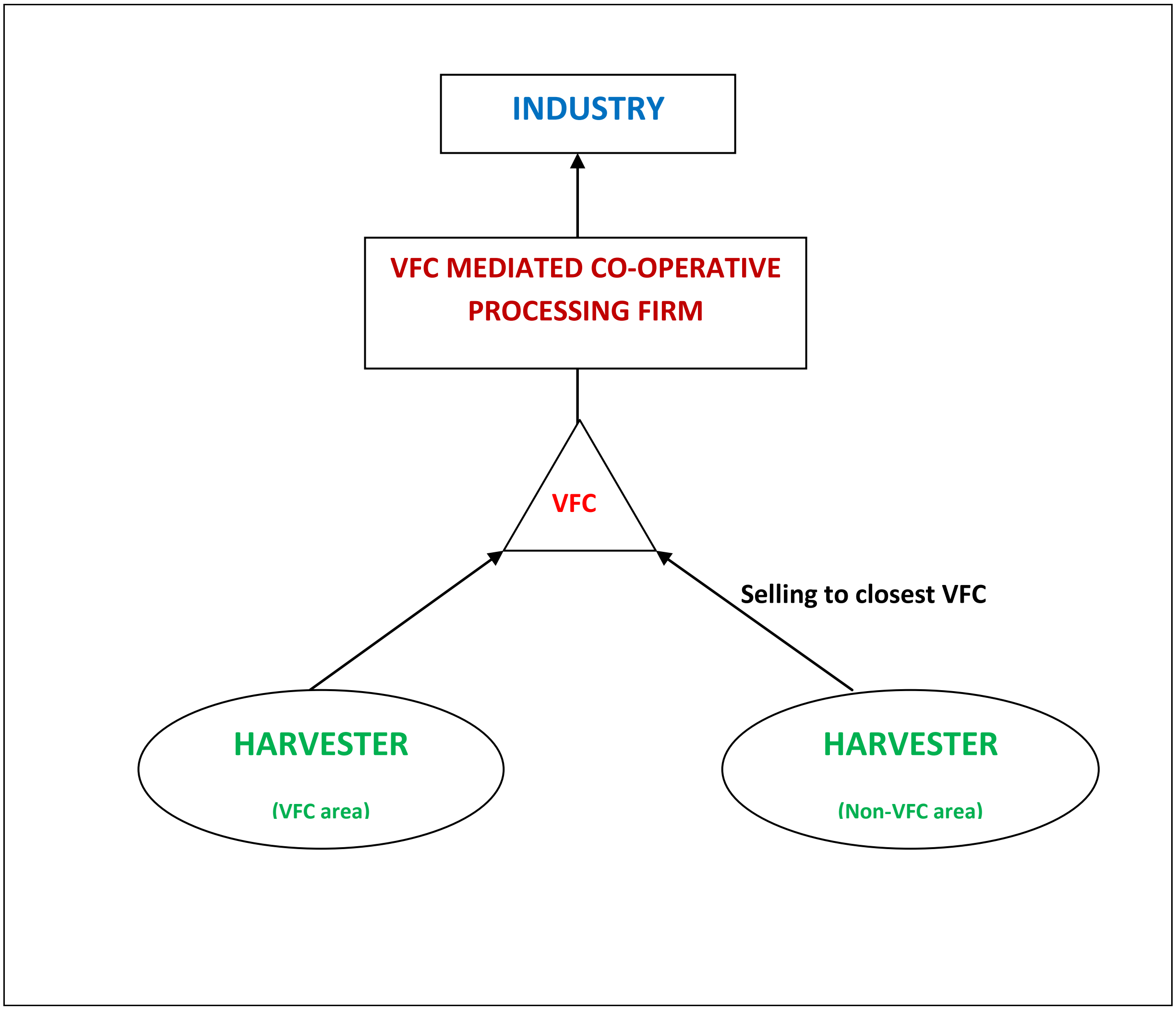
Harvester- VFC- Industry model



The harvester from VFC area sells his products to the VFC. All neighboring villages that do not fall in the jurisdiction of VFC also sell to the nearest VFC. The VFC maintains a separate account for the villages of non-VFC area. One time tender is given after stocking of all the produce in the administrative range. Produce is sold directly to the industry for the negotiated price. The rest of the produce is auctioned to suppliers who quote the highest price for the product.

Harvester- VFC processing-Industry model

The mechanism of selling by the harvester is similar to previous model except that the value addition is done by processing firms co-operatively mediated by VFC and forest department and sold to the industry through the proper channel.



Conclusions

1. The forests of ACR which inhabits the largest population of LTM in contiguous forest (Santhosh et al., 2013) also has the highest rate of deforestation with loss of 11.50% of

evergreen forests at the rate of 1.90% loss yearly (Kumara et al., 2011). The reason for this is the high dependence of people for firewood to process the rind of *Garcinia gummi-gutta* conventionally. This may lead to severe fragmentation of habitat creating largest population to smaller sub-populations. To mitigate severe fragmentation there is a need for decreasing firewood usage of people. We strongly recommend distribution of ASTRA ovens to people that decreases the rate of utilization of firewood.

2. Additionally restoration of the degraded areas also has been undertaken. The species important for both LTM and humans needs raised stage wise in existing nurseries of the forest department and used.
3. Streamlining the process of harvesting and marketing will also have a large impact in decreasing pressure on the forest. The suitable models are also suggested for proper marketing strategy to have a control over the harvesters on the collection of appropriate crop and process of the fruits.

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Appendix 4.1 Questionnears that was used during the study to understand the harvesting, processing and marketing of *Garcinia gummi-gutta*

VFC Data Sheet (Family Level)

Name: Village:

Number of people residing: No. of Kg of *Garcinia gummi-gutta* extracted:

*Garcinia gummi-gutta m*arketing place: Most Advantageous place for marketing:

Do you market through VFC: Are you willing to do marketing through VFC:

Benefits received from VFC: Benefits of marketing through VFC:

Is marketing by VFC is transparent: Extra earnings received from VFC:

Is the market price is given to you immediately after the goods are delivered?

Market price per kg in open market during the time of you selling the goods:

Time delay to receive extra earnings

Do you have information of different ovens used for Uppage processing?

Type of oven that may be preferable to you: Individual Community

Are you willing to pay the money required for drier installation?

VFC data sheet (Forest Department)

VFC name: Year established:

No. of Families/ Members in VFC:

No. of Seasons/Years marketing NTFP through VFC:

No of NTFP auctioned by VFC every year:

Quantity of NTFP sold by VFC year wise:

Amount of Rupees VFC benefitted in the tendering:

No. of ovens of different types installed in VFC by forest department:

Challenges faced during the process of marketing:

Improvements needed for marketing through VFC:

Oven (Family level)

Name: Village: VFC name:

Oven type: Purpose: Installed Department:

Amount paid by the family for installation: Time taken for installation:

Capacity of the Oven/process in Kg:

Do you process Uppage in the Oven: Yes No

Fuel wood needed in Kg for drying Uppage:

Advantages of the Drier:

Disadvantages of the Drier:

Do you suggest Drier to everyone: Reasons?

Suggestions for improvement of Drier: