Vegetation studies in Sacred Groves and Adjacent Non-Sacred Forests of Central Western Ghats

G. R. Rao[1], M. D. Subash Chandran[1] , and T. V. Ramachandra[1]
[1]*Energy and Wetlands Research Group, Centre for Ecological Sciences, Indian Institute of Science, Bangalore – 560 012*
Email: grrao1@gmail.com; mds@ces.iisc.ernet.in; cestvr@ces.iisc.ernet.in

***Abstract*– This study was carried out in different Sacred groves (SG) and Non-Sacred groves (Non-SG) of Central Western Ghats, Karnataka. The study shows that sacred groves have higher evergreenness, endemism, and carbon sequestration potential compared to non-sacred grove (Non-SG) forest. However Non-SG in Malnad areas are more conserved having higher endemism compared to coastal and plain area having low endemism due to high anthropogenic disturbance. Regeneration of endemic species and carbon sequestration is also higher in SG compared to Non-SG forest. Major threats include cultivation within SG, encroachment, fire, grazing, lopping apart from unplanned developmental activities.**

INTRODUCTION

Sacred groves belong to the traditional practice of protecting patches of vegetation, mostly of the primeval kind, on religious grounds subtended by cultural practices. They have been identified all over the world and in all shades of cultures (Ramachandra *et al*., 2012; Ramakrishnan *et al*., 1998). In India, the groves have been reported from the forest ranges in the hills, arid regions like the deserts and along agricultural plains as well. Whereas larger groves are considered mini-biosphere reserves, the smaller ones are also of biological value as they harbour some old and magnificent specimens of trees and climbers (Gadgil and Vartak, 1975). The genesis of sacred groves in the Western Ghats may go back to hunting gathering societies which attributed sacred values to patches of forests within their territories as they did to several other topographic or landscape features like mountain peaks, rocks, caves, springs and rivers (Chandran *et. al*., 1998). But the practice of setting aside patches of forests as sacred groves would have strengthened with the spread of agriculture, involving widespread slashing and burning of forests. The groves, in addition to their role as the abodes of gods, would have also protected a range of landscape elements with their characteristic biodiversity (Chandran *et. al*., 1998).

The sacredness, religious beliefs and taboos play a significant role in promoting sustainable utilization and conservation of flora and fauna of the region. However, with the passage of time, considerable changes have taken place in the extent of the sacred groves, in their vegetation structure, peoples' perception towards them and the religious beliefs and taboos (Khan *et al*., 2008). Whereas the SGs of the plains underwent rapid changes being relinquished to the backyards of cultural history, the groves or their relics persisted in the Indian highlands, either eroded in importance or lost in identity altogether, merging with state forests. Ongoing cultural transformations in the mountains are reducing groves into mere symbols as centres of biodiversity and ecosystem service; many remain to be rediscovered altogether (Chandran and Ramachandra, 2012). Therefore, a holistic understanding of the current status, structure and function of sacred grove is essential for assessing their ecological role and formulating strategies for their conservation. Hence the present paper highlights the importance of SG's in maintaining the high level of evergreeness and endemism compared to surrounding forest in the plain areas along with their regeneration aspects and conservation.

STUDY AREA AND METHODOLOGY

The work was carried out in Uttara Kannada district of Karnataka State and part of Shimoga district. Uttara Kannada district lies between 74^0 9' to 75^0 10' east longitude and 13^0 55' to 15^0 31' north latitude and extends over an area of 10,327 sq. km. Uttara Kannada is one of the two coastal districts of the state and stretches itself along the coastline of the Arabian sea. It extends to about 328 km north-south and about 160 km east-west. Uttara Kannada and Shimoga districts harbor mainly following important types of forests

1. Evergreen forests
2. Semi-evergreen forests
3. Moist deciduous forests
4. Dry deciduous forests
5. Scrub-Savannah and thorny forests

In this study a total of 8 sacred groves and 7 non-sacred forest patches were studied using 47 transect cum quadrats, the localities of which are given in Table 1.

*Transect survey***:** For this study, modified belt transects with a total length of 180 m with 5 quadrats each consisting of alternate 20 x 20 m quadrats were used. In each quadrat all the trees with ≥30 cm. GBH, at 1.3 m height and lianas with ≥ 10 cm were enumerated. Other features like epiphytes, small climbers, etc., were also noted. Shrubs (GBH less than 30 cm and height more than 1 m) were enumerated in two shrub quadrats of 5 x 5 m laid diagonally inside the 20 x 20 m quadrat. Inside each shrub quadrat two 1 x 1 m herb plots (height less than 1 m) were laid diagonally. General information such as ground control points using a Global Positioning System (GPS), name of the locality, range, human activities such as lopping, logging, NTFP, fuel and litter collections, fire incidence, grazing etc. were noted down.

Data analysis: Analysis of data was carried out using various ecological parameters. To access species diversity, dominance and equitability, Shannon diversity, Simpson dominance, and Pielou's eveness index were used. To analyse the vegetation characteristics (dominant and co-dominant species), Importance Value Indices (IVI) were calculated for each species considering the number of individuals (density) belonging to each species, their basal area (dominance) and distribution (frequency) in the plot. As regards the tree community percentage of evergreen trees and percentage of endemic trees transect-wise have been calculated. Regeneration status of endemic tree species,

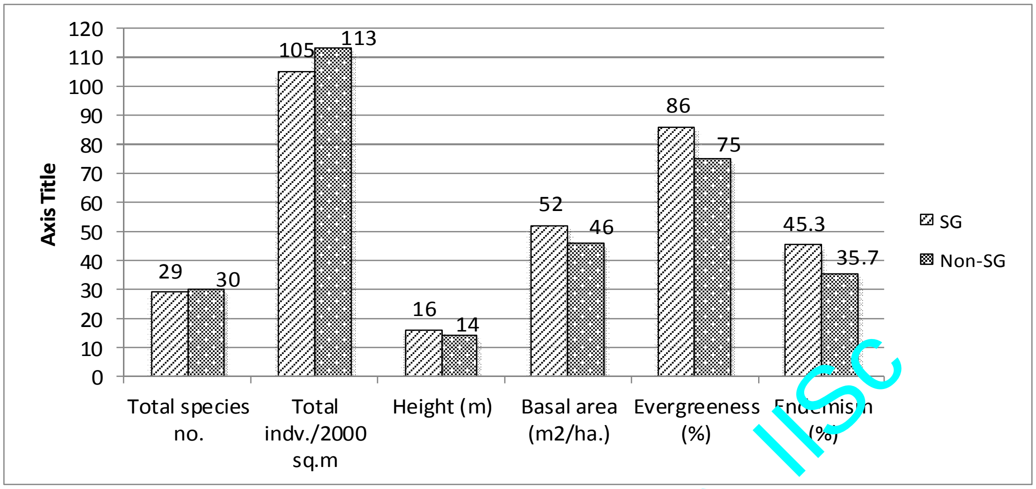
Table 1: Location wise total area studied in SG and adjoining non-SG forests

Study locations	SG/Non SG	Area sampled (m^2)	Forest type
Yana	SG	6000	Evergreen
	Non SG	4000	Evergreen
Vibuthi	SG	4000	Evergreen
	Non SG	6000	Evergreen
Thorme	SG	6000	Evergreen
	Non SG	4000	Evergreen
Hulkod	SG	4000	Evergreen
	Non SG	4000	Evergreen
Hosgunda	SG	6000	Evergreen to moist deciduous
	Non SG	4000	Moist deciduous
Heravalli	SG	8000	Semi-Evergreen
Kathlekan	SG	16000	Evergreen
	Non SG	6000	Evergreen to semi-evergreen
Barur	SG	10000	Evergreen to moist deciduous
	Non SG	6000	Semi-evergreen to Moist deciduous

RESULTS AND DISCUSSION

Both transect and opportunistic survey led to a total of 320 species recorded for 8 SG localities; these were under 85 families having 185 trees, 53 shrubs, 46 climbers and 36 herbs. 7 Non-SG forests had lesser number of species (253 species from 79 families with 144 trees, 40 shrubs, 47 climbers, and 22 herbs). Average tree species per transect was almost equal for Non-SG (30) and SG localities (29). But average canopy height and basal area of SG localities were higher compared to non-SG. Percentage of endemic trees in the total tree population were also higher in SG localities with 45.3 % endemism compared to 35.7% in non-SG (Figure 1).

Figure 1: **Average total species, total individuals/transect, height, basal area, percentage evergreeness,**



and endemism in all SGs versus Non-SG forests.

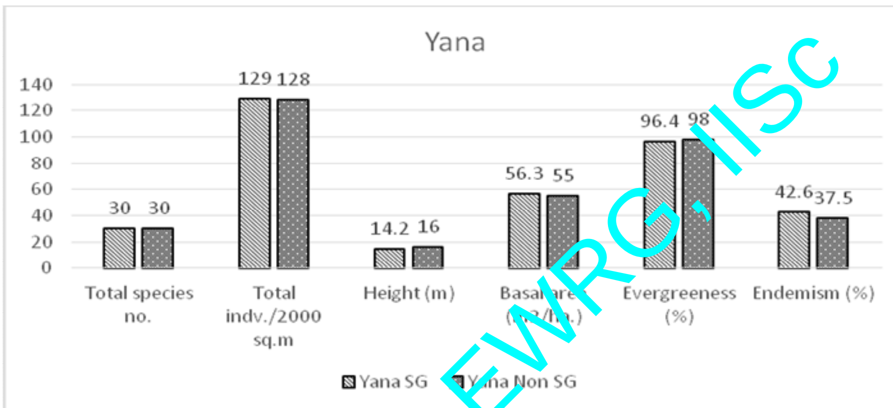
As regards Shannon diversity of trees it was notably higher in the NSG forests of Thorme, and Kathalekan. This could be due to the swampy nature of parts of these forests where there is limitation of trees adapted to swampiness. Otherwise no notable differences in diversity exist. However, in some places the tree diversity may be marginally more in NSG due to the disturbances which bring in open area species in otherwise basically evergreen vegetation (Table 2). Such is noticeable in Yana NSG and Barur NSG, which have a mixture of deciduous trees in a matrix of evergreens.

Table 2: Average diversity values in various SG and Non SG areas

Location	**Species richness**	**Shannon diversity**	**Simpson dominance**	**Simpson diversity**	**Pielou's evenness**
Yana SG	6.01	2.87	0.08	0.92	0.84
Yana Non SG	6.08	2.83	0.09	0.91	0.83
Vibhuti SG	7.17	3.13	0.06	0.94	0.86
Vibhuti Non SG	7.04	3.08	0.07	0.93	0.86
Thorme SG	6.39	2.93	0.08	0.92	0.86
Thorme Non SG	6.87	3.05	0.07	0.93	0.86
Hulkod SG	7.22	3.04	0.08	0.92	0.85
Hulkod Non SG	7.36	3.07	0.07	0.93	0.85
Hosgunda SG	4.80	2.30	0.19	0.81	0.74
Hosgunda Non SG	2.93	1.89	0.25	0.75	0.73
Heravalli SG	5.10	2.62	0.11	0.89	0.84
Kathlekan SG	6.83	2.92	0.09	0.91	0.83
Kathlekan Non SG	7.18	3.11	0.06	0.94	0.87
Barur SG	4.61	2.50	0.12	0.88	0.85
Barur Non SG	5.29	2.59	0.13	0.87	0.82

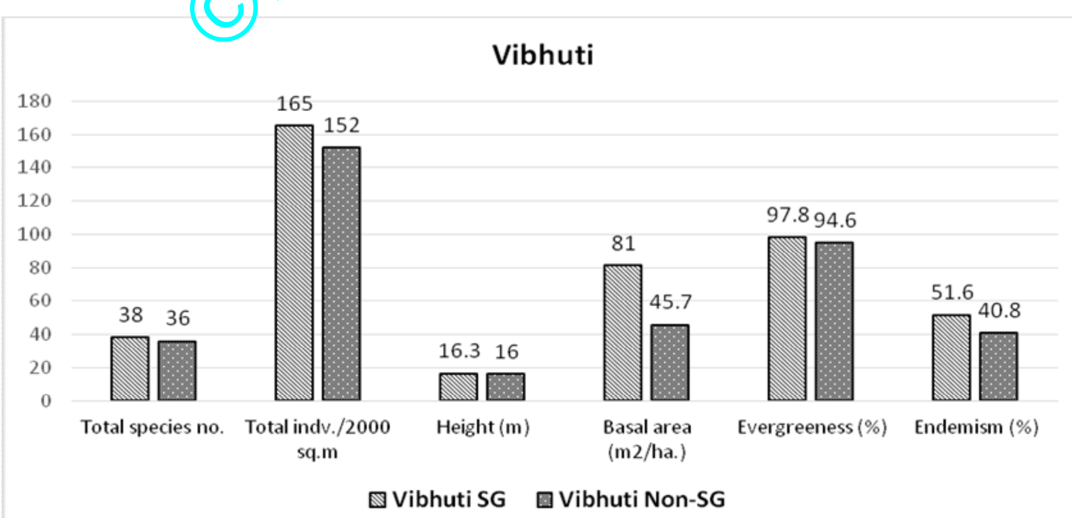
Yana SG and Non-SG: Yana is a rugged thickly forested area. Hence both SG and Non-SG have good vegetation structure and diversity as seen from figure 2. Both Yana SG and Non-SG have average 30 species each with later having higher tree height. However basal area is slightly higher in Yana SG (56.3 sq.m^2). Higher basal area was more contributed by lofty trees of *Syzygium gardneri* and *Garcinia talbotii*, the latter an endemic species of Western Ghats. Though evergreeness is slightly less in SG (96.4%), endemism is high (42.6%) compared to Non-SG. This higher endemism is partly due to the higher protection which favoured important endemics such as *Garcinia talbotii, Garcinia gummi-gutta*, etc., *Hopea ponga and Knema attenuata*. Non-SG is notable for higher populations of non-endemic evergreens like *Dimocarpus longan* and *Garcinia morella*. Non-SG areas are notable for the rare congregations in the world of the Talipot palm *Corypha umbrecullifera*, which in all probability flourished in the erstwhile shifting cultivation clearances.

Figure 2: Average total species, total individuals/transect, height, basal area, percentage evergreeness, and endemism in Yana SG and Non SG.



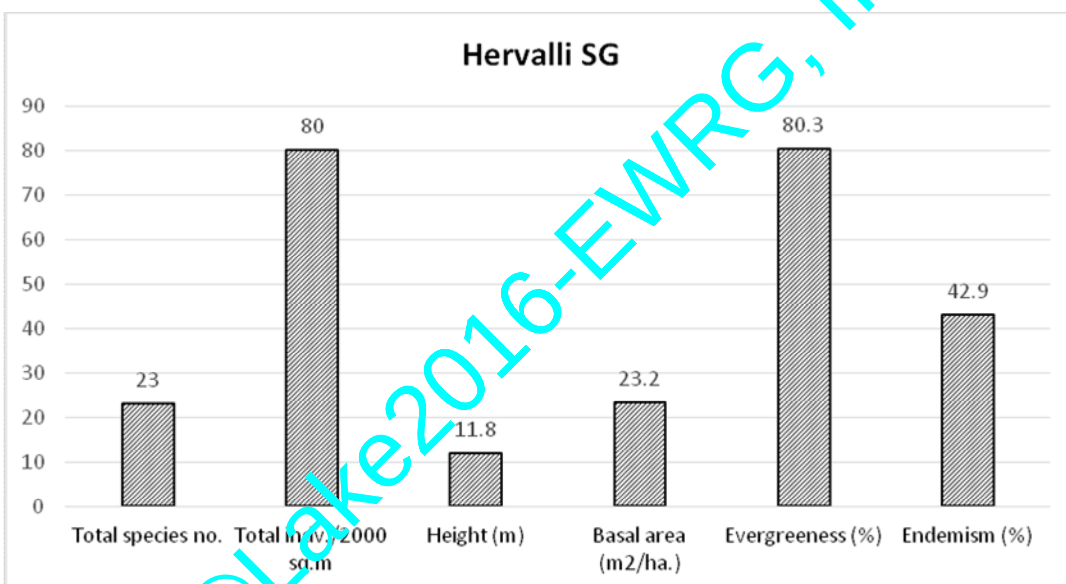
Vibhuti SG and Non-SG: Vibhuti area is also equally rugged like Yana area with evergreen to semi-evergreen forest. Forest height, basal area and evergreeness are higher in SG localities (Figure 3). Basal areas were mostly contributed by endemic species such as *Garcinia talbotii, Garcinia gummi-gutta*, and *Knema attenuata*. Evergreeness and endemism were also higher in SG area (97.8% and 51.6% respectively) compared to non-SG localities. SG areas with less anthropogenic pressure had more endemic species which included the endangered *Madhuca bourdilloni*, *Diospyros candolleana, Polyalthia fragrans* etc.

Figure 3: Average total species, total individuals/transect, height, basal area, percentage evergreeness, and endemism in Vibhuti SG and Non-SG



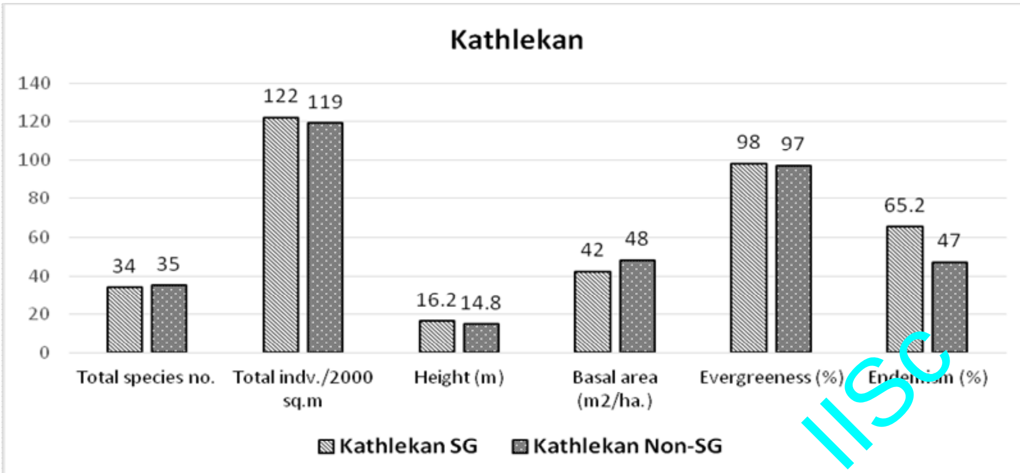
Heravalli SG: Heravalli sacred grove in continuum with Kangod reserve forest of Honavar is an examples of a large sacred grove in the densely populated coastal Karnataka. This SG devoted to the mother goddess Kamakoteshwari, installed in a temple, also has a local deity 'Jataka'. As the SG for many years was in a neglected state it underwent considerable degradation. However, recently the Forest Department, with the involvement of the village community made fencing around this SG, promoting flush of regeneration, which in due course will pave for re-establishment of the evergreen forest. Basal areas, as such was very low (23.2 m^2/ha) and the forest is intermingled with the exotic *Acacia auriculiformis* planted in patches by the Forest Department, when the SG was in a neglected state (Figure 4). Some endemics which prevail in the SG are *Holigana arnottiana,* and *Flacourtia montana*, in relatively good numbers raising the endemism to 43%. Notable of the non-endemics are *Schleichera oleosa* and *Strycnos-nux vomica*. The forest which suffered from timber and fuel extraction, grazing, and encroachments is on the road to recovery following departmental protection with community involvement. As neighboring areas were scrub and vestiges plantations no forest was studied for comparison.

Figure 4: Average total species, total individuals/transect, height, basal area, percentage evergreeness, and endemism in Heravalli SG.



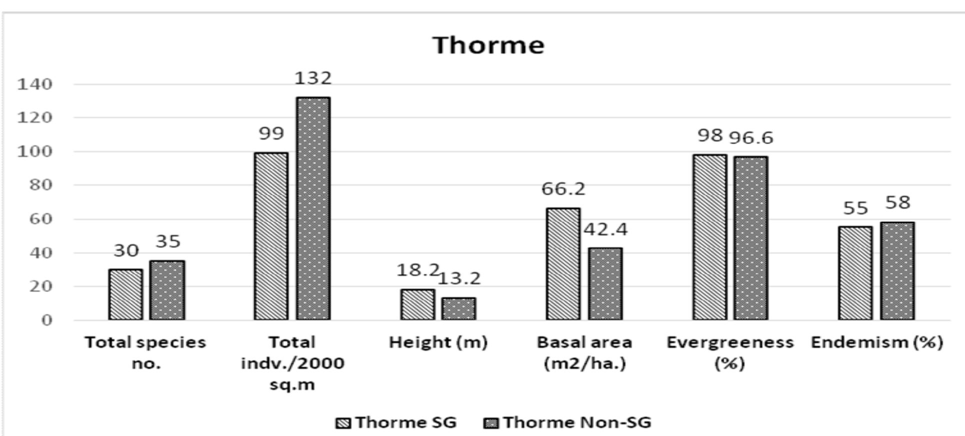
Kathlekan SG and Non-SG: Kathalekan landscape is one of well wooded hills and valleys with *Myristica* swamps. Kathlekan SG had basal areas slightly less (42 m^2/ha) compared to Non-SG (48 m^2/ha) (Figure 5). However endemism was very high (65.2%) compared to Non-SG as SG were dominated by rare and endemic tree species such as *Gymnacranthera canarica* (Vulnerable)*, Myristica fatua* (Endangered)*, Mastixia arborea,* endangered *Dipterocarpus indicus* (Endangered) etc. Endemics that require wetter conditions tend to congregate in the streams and swamp habitats of the relic forest. Earlier, Chandran and Mesta (2001) had also observed higher tree endemism in the *Myristica* swamps than in adjoining forests. Vasanthraj and Chandrashekar (2006) recorded 37 endemic species in their investigation in Charmady Reserve Forests of Western Ghats with >10 cm GBH in an area of 5000 m^2. The dominant vegetation type was *Hopea parviflora-Dipterocarpus indicus – Vateria indica*. In Kathlekan SG tree species *Semecarpus kathalekanensis* that merits inclusion in the IUCN Red List as Critically Endangered, is a newly discovered tree species from Kathalekan. It has, according Vasudeva *et al.*, (2001) less than 50 breeding individuals. *Syzygium travancoricum* noted in Kathalekan is Critically Endangered and *Hopea ponga* Endangered. The NonSG, also situated in a very high rainfall area, has predominantly evergreen forest, but endemism was significantly lower at 47% compared to 65.2% of the SG.

Figure 5: Average total species, total individuals/transect, height, basal area, percentage evergreeness, and endemism in Kathlekan SG and Non SG.



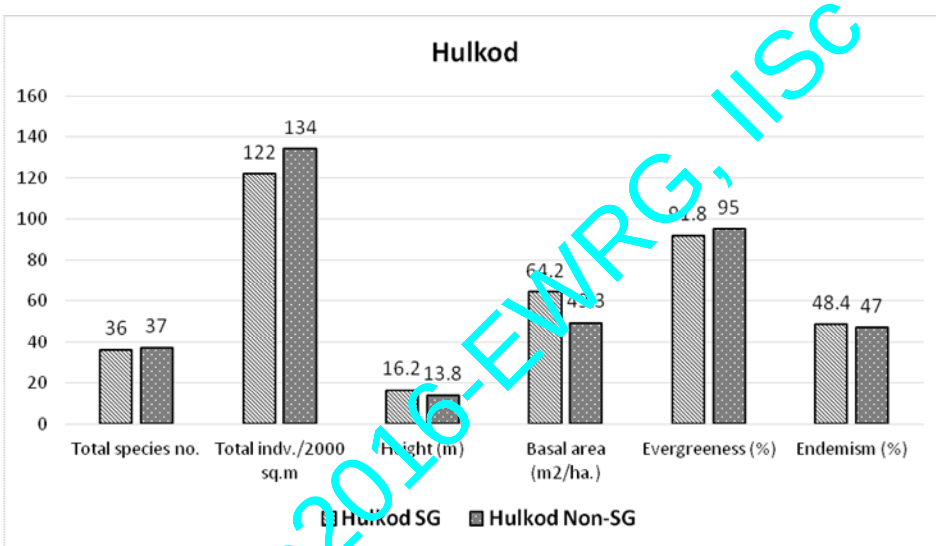
Thorme SG and Non SG: Thorme-SG being *Dipterocarpus* forest with swampy portions has high forest canopy height (18.2 m) (Figure 6) with high basal area (66.2 m^2/ha) compared to Non-SG forest (42.4 m^2/ha). Basal area of SG were mainly contributed by lofty trees of *Dipterocarpus indicus, Hopea parviflora* etc. Along with these trees other species such as *Knema attenuata* and *Garcinia gummi-gutta* were also seen. Percentage evergreeness and endemism were higher in Thorme SG with 98% and 55% respectively. This high endemism was contributed mainly by *Semecarpus kathlekanensis*, *D. indicus*, and *Mastixia arborea*. The forest slopes inside the SG were covered with huge trees of *Hopea parviflora* (Endangered), *and Lophopetalum wightianum*. Other plants include *Arenga wightii, Calophyllum apetalum* (Vulnerable), *Garcinia talbotii, Holigarna arnottiana, Hopea ponga, Hydnocarpus laurifolia, Linociera malabarica, Mastixia arborea, Myristica malabarica* (Vulnerable), *Ochlandra scriptoria, Pandanus sp, Pinanga dicksonii, Vepris bilocularis* etc. The stream inside these swamps are perennial indicating the importance of these forests in watershed conservation. This particular swamp water also sustain extensive *Areca* plantation downstream, which however was found expanding into the swamps through encroachment by the farmers. Thorme Non-SG had slightly higher endemism compared to SG (58%) but mainly contributed by widely distributed endemics such as *Holigarna grahamii, Hopea ponga* etc. These forests also lacked relic species and composed more of secondary evergreen species.

Figure 6: Average total species, total individuals/transect, height, basal area, percentage evergreeness, and endemism in Thorme SG and Non SG.



Hulkod SG and Non SG: This study area in the backdrop of Linganamakki reservoir catchment area hosts evergreen to semi-evergreen forest. Anthropogenic pressure was observed as high in SG also. Basal area was highest for SG-areas with 64.2 m^2/ha (Figure 7), mainly due to large sized *Syzygium travancoricum* and *Holigarna ferruginea*, although evergreen percentage was higher for Non-SG (95 %) compared to about 92% of SG. Hulkod Non-SG would have been once a high statured forest as could be seen from the remaining individuals of *Dipterocarpus indicus*. Other important trees in Hulkod-SG consist of *Lophopetalum wightianum, Saraca asoka, Myristica malabarica*, *Holigarna spp., Aglaia roxbhurghii, Diospyros spp.*, etc. Most streams are seasonal. Some notable endemic species are *Hopea ponga, Holigarna spp, Knema attenuata, Myristica spp* etc. Some of these streams are encroached for Areca cultivation and nearby forests are degraded due to heavy NTFP collection.

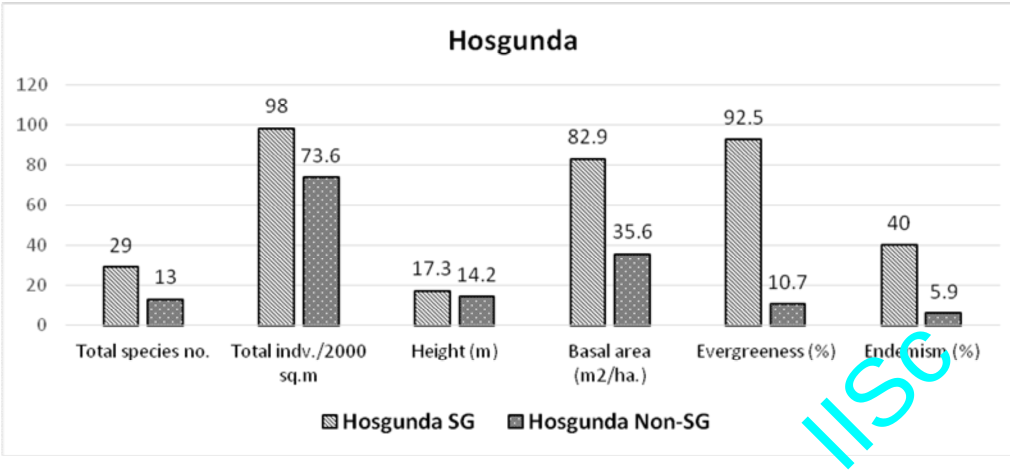
Figure 7: Average total species, total individuals/transect, height, basal area, percentage evergreeness, and endemism in Hulkod SG and Non SG.



Hosgunda SG and Non SG: Hosagunda SG can be regarded a very fine example of semi-evergreen forest with large basal area (82.9 m^2/ha) amidst otherwise, relatively moist deciduous species dominated forest belt. The forest is associated with a well known temple inside it. Many of the lianas such as *Gnetum ula* have also attained huge mass scaling the heights of lofty trees of *Alstonia scholaris* and *Tetramelus nudiflora* increasing the overall basal area of the forest. Other important trees in this SG were *Diospyros sylvaticus*, *D. oocarpa, Holigarna grahamii, Myristica spp., Knema attenuata, Chrysophyllum roxbhurgii* etc. Though this area has no perennial streams the temple pond has water to its brim even in summer months highlighting the good hydrological conditions. In addition two lakes are also found in the vicinity of the SG, benefitting the agricultural areas nearby with good irrigation facility. However the forests surrounding the SG are highly degraded mostly with deciduous elements like *Terminalis* dominating.

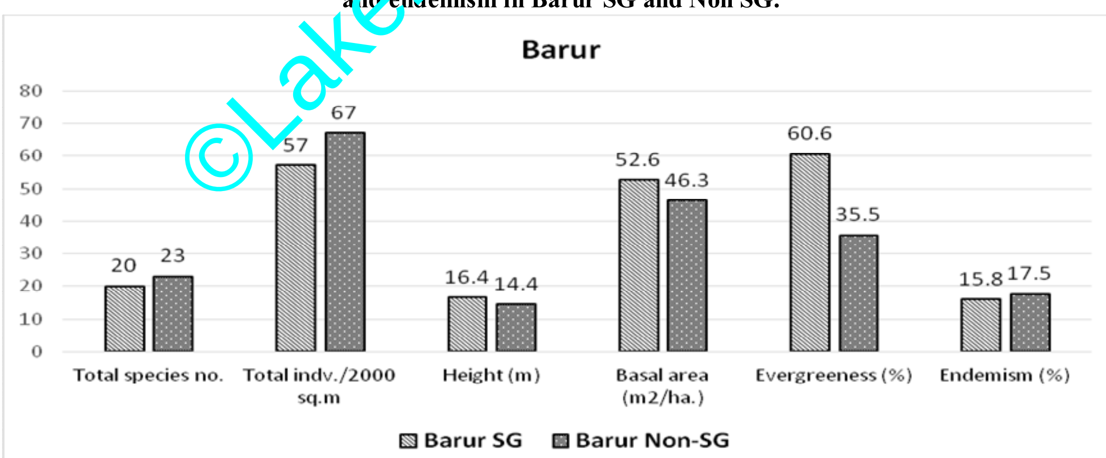
In comparison with the SG the non-SG had only 35.6 m^2/ha basal and very low evergreeness (10.7%), and endemism (5.9%).

Figure 8: Average total species, total individuals/transect, height, basal area, percentage evergreeness, and endemism in Hosgunda SG and Non SG.



Barur SG and Non SG: Barur SG was having good basal area (52.6 m²/h) compared to Non-SG area (46.3 m²/h) owing to its protected status (Figure 9). Evergreeeness was also better (60.6%) compared to Non-SG (35.5%). Endemism was less in both SG (15.8%) and Non-SG (17.5%) areas owing to the strengthening human impacts. Swathes of forests are getting encroached for cultivation of cotton and ginger. Many forest trees were found girdled and burnt to make way for agriculture. Except huge trees surrounding the temple, other areas are under severe threat. Barur SG has some large trees of *Aglaia roxbhurgii*, *Beilschmiedia roxburghiana, Diospyros sp.*, etc. Forest patches away from the SG but within the bounds of SG itself are deciduous, dominated by the fire tolerant species like *Teminalias*, *Lagerstroemia microcarpa, Randia* sp., etc., along with hardy evergreens such as *Olea dioica* and *Aporosa lindleyana etc.* Barur Non-SG, needless to say, is also highly disturbed with very low evergreeness and endemism except in isolated spots. Most of the forest is scrub-thickets or moist deciduous.

Figure 9: Average total species, total individuals/transect, height, basal area, percentage evergreeness, and endemism in Barur SG and Non SG.



Forest biomass and carbon sequestration in Thorme and Hosgunda SG and Non-SG: SG forests had higher biomass highlighting their greater potential in carbon sequestration (Table 3). However lesser biomass and carbon sequestration was seen in Non-SG's. Higher carbon sequestration in SG can be attributed for their higher protection and less anthropogenic pressures compared to Non-SG's. Developing a watershed based forest management system is suggested in which the SG's and water course forests have huge scope for carbon sequestration. Such services while serving the cause of biodiversity conservation can mitigate global climatic change and uplift the livelihoods of local population due to carbon credits. As the bulk of forests come under governmental jurisdiction, the prime task is to initiate steps for identification of relic forests (such as SG's), which lie unknown otherwise amidst human impacted secondary forests, and preserve such precious heritage for posterity. Small farmers and tribal population can be more fruitfully used as guardians of watershed forests and partners in more restrained use of water resources for agriculture.

Table 3: Transect-wise estimated basal area/ha and biomass-carbon sequestration

Sn.	Location	Basal area/ha	Above ground Biomass (t/ha)	Below Ground biomass (t/ha)	Total Biomass	Carbon (t/ha)
1	SG-Yana-temple	62.95	423.96	110.23	534.19	267.10
2	SG-Yana-kan-checkpost	68.17	459.41	119.45	578.86	289.43
3	SG-Yana-after cross	37.91	254.20	66.09	320.29	160.15
4	Non-SG-Nanalli-yana-nonkan	59.26	398.95	103.73	502.67	251.34
5	Non-SG-Gummangadde-Nanalli-Yana non kan	51.64	347.32	90.30	437.62	218.81
6	SG-Hosgeri-sampgemane-vibhuti kan	86.86	586.09	152.38	738.48	369.24
7	SG-Vaddi-near falls	75.28	507.59	131.97	639.57	319.78
8	Non-SG-Mabgi-vaddi	48.27	324.48	84.36	408.84	204.42
9	Non-SG-Kalgudda-manigadde	30.17	201.72	52.45	254.17	127.08
10	Non-SG-Manigadde-manigadde-NK	58.75	395.50	102.83	498.33	249.16
11	SG-Thorme-hemgar kan	72.03	485.56	126.25	611.80	305.90
12	SG-Thorme kan 2-near areca	81.05	546.68	142.14	688.82	344.41
13	SG-Thorme-kaballi-kan	45.52	305.82	79.51	385.33	192.67
14	Non-SG-Thorme-kanalli-non kan	48.72	327.48	85.14	412.62	206.31
15	Non-SG-Kannalli-thorme nonkan	36.19	242.58	63.07	305.65	152.83
16	SG-Rameshwar kan Hulkod_1	71.68	483.16	125.62	608.78	304.39
17	SG-Rameshwar kan-Hulkod_2	56.75	381.96	99.31	481.27	240.64
18	Non-SG-Pandavarkodlu-nonkan	57.68	388.25	100.94	489.19	244.60
19	Non-SG-Pandavara kodlu-non kan 2	41.19	276.44	71.87	348.32	174.16
20	SG-Hosgunda kan 1	79.02	532.94	138.56	671.50	335.75
21	SG-Hosgunda kan 2	86.95	586.72	152.55	739.26	369.63
22	SG-Hosgunda kan-E- line	39.80	267.05	69.43	336.49	168.24
23	Non-SG-Hosgunda nonkan1-betta	29.07	194.26	50.51	244.77	122.38
24	Non-SG-Hosgunda nonkan2	38.12	255.64	66.47	322.10	161.05
25	SG-Heravalli-kan	25.43	169.60	44.10	213.70	106.85
26	SG-Heravalli-kan 2	18.87	125.11	32.53	157.64	78.82
27	SG-Heravalli-south end-kan	24.30	161.98	42.11	204.09	102.05
28	SG-Heravalli-kan-near plnt	24.53	163.49	42.51	206.00	103.00
29	SG-G4-Kathalekan-obove	35.87	240.42	62.51	302.93	151.46

	settlement -slope					
30	SG-G5-Kathalekan-board	39.84	267.28	69.49	336.77	168.39
31	SG-G7-katlekan-1	28.22	188.49	49.01	237.50	118.75
32	SG-G8-Kathalekan-swp with S.trav	41.24	276.80	71.97	348.77	174.38
33	SG-Kathlekan swamp G4	61.10	411.45	106.98	518.43	259.21
34	SG-Kathlekan swamp G5	43.47	291.92	75.90	367.81	183.91
35	SG-Kathlekan swamp G7	31.80	212.78	55.32	268.10	134.05
36	SG-Kathlekan swamp G8	55.05	370.41	96.31	466.71	233.36
37	Non-SG-Mavingundi evergreen	47.97	322.42	83.83	406.25	203.12
38	Non-SG-Kodkani-mavingundi	64.68	435.74	113.29	549.03	274.51
39	Non-SG-Mavingundi-Vidyanagar	31.90	213.49	55.51	269.00	134.50
40	SG-Barur kan-temple	65.06	438.31	113.96	552.26	276.13
41	SG-Barur-kan-near field	76.85	518.20	134.73	652.94	326.47
42	SG-Barur-kan-near acacia pln	48.20	323.99	84.24	408.23	204.11
43	SG-Barur-kan kalkoppa-m.dec	39.68	266.21	69.22	335.43	167.72
44	SG-Barur-T3-M. dec	33.32	223.08	58.00	281.09	140.54
45	Non-SG-Barur-lavigere	27.31	182.38	47.42	229.81	114.90
46	Non-SG-Barur-Lavigere-SE	61.90	416.90	108.39	525.30	262.65
47	Non-SG-Lavigare-lakeside	49.77	334.63	87.00	421.63	210.81

Table 4: Distribution of IUCN listed threatened tree species in the study localities

Threatened tree species	**Yana**		**Vibuthi**		**Thorme**		**Hulkod**		**Hosgunda**		**Hera valli**	**Kathlekan**		**Barur**	
	SG	**Non SG**	**SG**	**Non SG**	**SG**	**Non SG**	**SG**	**Non SG**	**SG**	**Non SG**	**SG**	**SG**	**Non SG**	**SG**	**Non SG**
Vateria indica (CE)												P			
Syzygium travancoricum (CE)					P		P					P			
Semecarpus kathlekanensis (Res)					P							P			
Dipterocarpus indicus (E)	P				P			P				P	P		
Hopea ponga (E)	P	P	P	P	P	P	P	P			P	P	P		-
Hopea parviflora (E)												P			
Diospyros crumenata (E)	P				P				P			P			
Madhuca bourdillonii (E)	P		P									P			
Arenga wightii (V)	P	P	P	P	P	P	P	P			P	P	P		
Cryptocarya beddomei (V)	P		P		P							P			
Myristica malabarica (V)	P	P	P	P	P	P	P				P	P	P		

Pterospermum reticulatum (V)	P	P	P	P	P	P	P				P	P	P	P	
Gymnacranthera canarica (V)			P		P							P			
Ochreinauclea missionis (V)	P		P		P							P	P		

Regeneration of endemic species: Regeneration of endemic and endangered species such as *Dipterocarpus indicus*, *Gymnacranthera canarica*, *Semecarpus kathalekanensis*, is mainly found in swamp and relic forest such as Thorme SG, Kathlekan SG, etc. These relic species along with many other endemic species such as *Myristica malabarica Beilschmiedia roxburghiana, Diospyros saldanhae, Garcinia gummi-gutta* etc., have good regeneration only inside these SG whereas they are almost totally absent outside the SG area. None of these relic species exist in Non-SG which have good regeneration of broader endemic such as *Knema attenuate, Beilschmiedia roxburghiana, Hopea ponga* etc. Many SG's such as Heravalli, Yana, and most of the Non-SG's might have lost sensitive relic species long before due many anthropogenic disturbances as they are outside community protection. SG's such as Barur, Hosgunda are even more exploited being in extreme vicinity of humans and more accessible areas. They due long history of anthropogenic pressures are left with less endemic species and more of generalist species. Non-SG areas such as Barur, Hosgunda are the worst hit in plain areas with little evergreen species left although coming in good rainfall area. Due to rampant fire and encroachment regeneration of evergreen endemic species is almost nil. Distribution of IUCN listed threatened tree species in the study localities is given in table 4.

CONCLUSION

This study shows that the SG forest patches harbour rich and sensitive endemic species compared to other secondary evergreen to deciduous forest (Non-SG) emphasising the importance of conservation of such forests both in the interest of water shed importance and presence of climax species with many threatened ones still sheltered in them. These forest patches still have value as models for forest restoration, and themselves would play key role in restoration of natural vegetation around but for human impacts. Sacred groves should be conserved as an important element of the bio-cultural landscape and should not be looked at as a means of generating revenue (Kushalappa and Raghavendra, 2012). Better protection, resource management and habitat restoration need to go alongside efforts to reinforce the links between the integrity of sacred forests and religious and cultural values (Osuri *et al*., 2014). Sacred groves in more places should be documented, mapped and the status of their medicinal and other economically and ecologically important plants documented for strengthening community based conservation of these ancient relics of forests in the rural areas. It is essential to devise a mechanism for joint forest planning and management of sacred groves involving all the major players, such as government departments, temple committees, community leaders, researchers and nongovernment organizations (Kushalappa and Raghavendra, 2012). Regeneration of relic and endemic species can only occur in these areas through Government support for community based protection programmes for SGs. Most of the SGs are fading away from the landscape of Western Ghats and there is aneed for policy interventions to restore and protect them through involvement of the local communities.

ACKNOWLEDGEMENT

We are grateful to the Ministry of Environment, Forests and Climate change, Government of India, Karnataka Forest Department, and Indian Institute of Science for the financial and infrastructure support. We thank Mr. Vishnu D.M., Mr. Srikanth Naik for the assistance during the field work.

REFERENCES

1. Chandran, M. D. S., Gadgil, M. and Hughes, J. D. (1998). Sacred groves of Western Ghats of India. In: *Conserving the sacred for Biodiversity Management*, (eds), P. S. Ramakrishnan, K.G. Saxena and U. M. Chandrasekhara. Oxford and IBH Publishing Company Private Limited.
2. Chandran, M. D. S., Mesta, D. K., (2001). On the conservation of the *Myristica* swamps of the Western Ghats. In: Shanker.U.R, Ganeshaiah K.N, Bawa K.S (*Eds*) *Forest Genetic Resources: Status, Threats and Conservation Strategies*, Oxford & IBH, New Delhi, pp 1-19.
3. Chandran, M. D. S., and Ramachandra T.V. (2012). Sacred groves of Western Ghats: awaiting policy interventions. 3rd Sacred Grove Festival of IGRMS 14-16 Dec. Bhopal.
4. Ramachandra T.V., Subash Chandran M.D., Joshi N.V., Sooraj N.P., Rao, G.R., and Vishnu Mukri, (2012). Ecology of Sacred *Kan* Forests in Central Western Ghats., Sahyadri Conservation Series 15, ENVIS Technical Report : 41, Energy & Wetlands Research Group, Centre for Ecological Sciences, Indian Institute of Science, Bangalore 560 012.
5. Ramakrishnan, P.S., Saxena, K.G. and Chandrasekhara, U. M. (1998). Conserving the sacred: For Biodiversity Management, UNESCO, Oxford and IBH Publishing, New Delhi.
6. Gadgil, M. and Vartak, V.D. (1975). Sacred groves of India: a plea for continued conservation. *Journal of Bombay Natural History Society*, 72: 314-320
7. Khan, M. L., Ashalata Devi., Khumbongmayum, and R.S. Tripathi. (2008). The Sacred Groves and their Significance in Conserving Biodiversity: An Overview. *International Journal of Ecology and Environmental Sciences* 34 (3): 277-291, National Institute of Ecology, New Delhi.
8. Kushalappa, C.G., Raghavendra, S., (2012). Community-linked conservation using Devakad (sacred groves) in the Kodagu Model Forest, India. Forest. Chron. 88, 266–273.
9. Osuri, A. M. Madhusudan, M. D., Kumar, V. S., Chengappa, S. K., Kushalappa. C. G., Sankaran, M. (2014). Spatio-temporal variation in forest cover and biomass across sacred groves in a human-modified landscape of India's Western Ghats. *Biol Conserv*., 178:193–9.
10. Vasanthraj, B. K. & K. R. Chandrashekar. (2006). Analysis of the structure of Charmady Reserve Forest. *Tropical Ecology* **47**: 279-290.