LAKE 2014: *Conference on Conservation and Sustainable Management of Wetland Ecosystems in Western Ghats*
Date: 13th -15th November 2014
Symposium Web: http://ces.iisc.ernet.in/energy

THREATENED TREE SPECIES OF SWAMPS AND RIPARIAN HABITATS OF CENTRAL WESTERN GHATS

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ABSTRACT

The Riparian forests with rich biodiversity are distinct, productive ecosystems, conferring valuable ecosystem services. Therefore, maintenance of riparian forest has become integral to stream biodiversity conservation and management. This paper focus on tree composition, structure, diversity and their conservation aspects of the riparian forests along different streams of Uttara Kannada and Shimoga districts in Karnataka (part of Central Western Ghats). The present study reveals 109 tree species with 16 species exclusive to riparian habitat. Basal area, evergreenness and endemism was high in most swampy riparian transects (such as Thorme and Kathlekan transects) which had escaped earlier large scale deforestation compared to secondary riparian forests of Shirgunji and Hulgod. These relic riparian forests had nearly 10 species coming under different threatened status as per IUCN Red list category. Hence we propose water shed based forest management approach which is critical for both hydrology and conservation of these rare threatened species.

Keywords: Riparian, Biodiversity, Endemism, Threatened, Conservation

INTRODUCTION

Riparian forests are important as regulators of stream hydraulics, substrate characteristic, light and thermal regimes, water chemistry, and organic matter supply (Iwata et al., 2003). The fresh water swamp forest is considered a very productive ecosystem, also harbours rich biodiversity, including of threatened species, conferring also much benefits to the people (Agbagwa and Ekeke, 2011). Riparian areas, having distinct ecological characteristics, have their boundaries marked by changed soil conditions, vegetation, and other factors reflecting their aquatic–terrestrial interaction (Naiman et al., 2000). *Riparius*, meaning in Latin "belonging to the bank of a river," refers to biotic communities on the banks and shores of streams, rivers, ponds, lakes, and some wetlands. Riparian zones strongly influence the organization, diversity, and dynamics of communities associated with aquatic ecosystems (Gregory et al., 1991, Décamps 1996, Naiman et al., 2000). Riparian deforestation would impact

stream habitats profoundly, in turn affecting various ecological assemblages in the stream communities (Iwata et al., 2003). Therefore, maintenance of riparian forest has become integral to stream biodiversity conservation and management (Naiman et al., 2000; Naiman and De´camps 2005). Riparian forest varies from pristine old growth swamp forest (Meli et al., 2014) to disturbed secondary forests. Tropical swamps, often considered relics of the original rain forest, emerge as prime places deserving conservation, in view of these riparian areas sheltering several threatened species, the very 'relics' of the original forest, whose survival depends on conservation of such habitats (Chandran, et al., 2010). Uttara Kannada and Shimoga districts, parts of the central Western Ghats, make northernmost limits of some relic riparian forests including forest swamps (Chandran et al., 2008; Ray, et al., 2014). Their continuation in further north latitude is probably halted by diminishing rainy months. The springs and streams of these pristine forest habitats are much unlike the secondary forests with dry stream courses. Most such riparian forests, along with their rare and endemic flora, due to the water security afforded by them, are under threats of clearance from humans, being targeted for expansion of garden cultivation. This paper is meant to bring out the tree composition, structure and diversity of the riparian forests, dwelling on threats and conservation aspects.

STUDY AREA AND METHOD

The study was carried out in four taluks of Uttara Kannada district (13.9220º N to 15.5252º N lat. and 74.0852º E to 75.0999º E long.), and in one of Shimoga district, (14˚ 08´ 27 N to 14˚ 25´ 40 N lat. and Longitude 74˚ 24´ 31E to 74˚ 52´ 10 E) Karnataka State (figure 1, table 1). Uttara Kannada is one of the coastal districts of the state stretches itself alongside the Arabian Sea. It is the most forested district forest of Karnataka and known for its rich fauna and flora. Uttara Kannada and Shimoga district harbors following important type of forests

i. Evergreen forests
ii. Semi-evergreen forests
iii. Moist deciduous forests
iv. Dry deciduous forests
v. Scrub-savannah and thorny forests

A total of 16 transects were laid for the study, 14 alongside Sharavathi River and one each in Aghanashini and Gangavali River basins. A transect had 5 quadrats, (each 20 x 20 m) with inter quadrat distance of 20m. In each quadrat, trees and lianas with GBH of ≥ 30 cm were enumerated. At two diagonal corners of the tree quadrat two sub-quadrats of 5 m × 5 m were laid for shrubs and tree saplings (< 30 cm girth). Within each of these, two 1 x 1 m herb layer plot were also laid for herbs and tree seedlings. Climbers and other associated species were also noted down. The data was analyzed for species diversity using Shannon-Weiner's diversity index, Simpson dominance index, IVI, basal area, etc. Trees were sorted as evergreen or deciduous, and transect-wise percentage of evergreenness (% evergreen trees among total) and percentage of endemic trees of Western Ghats were calculated.

RESULTS

A total of 109 tree species were recorded from 36 families; Euphorbiaceae was leading with 12 species followed by Anacardiaceae (10 sp), and Clusiaceae (7 sp). 16 tree species were exclusively riparian (Exclusive Riparian Species -ERS). Sapotaceae, Myristicaceae, Anacardiaceae, and Euphorbiaceae had 2 ERS each. About 8 families had one ERS each while the rest had none. Many non-ERS, but usual occurrences in riparian habitats were *Hopea ponga, Dipterocarpus indicus, Lophopetalum wightianum, Myristica malabarica, M.dactyloides, Democarpus longana, Ficus nervosa* etc.

Riparian forest structure and diversity: Most of the swamps (10 transects) had higher average tree heights of 16m or more. Average height of riparian forest was highest for Thorme-Hemgar swamp transect (21.1 m) followed by Halsolli swamp (20.5 m). Kathlekan swamps also had higher trees heights, while lowest average height was recorded in disturbed riparian forest of Shirgunji-T3 (13.5m). Basal area (basal area/ha) was highest for Thorme-Hemgar (72 Sq.m/ha) followed by Rameshwar-1 Kan (71 Sq.m/ha) (figure 2). Lowest basal area was recorded for Halsolli (30.6 Sq.m/ha). Shannon diversity was highest for Kathlekan swamp 7 (3.08) and lowest in (1.62) (figure 3). Most of the swamps (in 14 transects) had Shannon diversity above 2.5. Species dominance was highest for Halsolli (Simpson diversity index of 0.26), followed by Kathlekan swamp 4 (0.15). In 14 transects atleast one ERS species was represented in first three highest Important Value Index (IVI) (table 2). *Gymnacranthera canarica* had highest IVI in 5 transects, followed by *Hopea ponga* (3), *Syzygium travancoricum* (2) and *Dipterocarpus indicus* (2).

Evergreeness and Endemism: 15 transects were high evergreen forests with evergreeness more than 90%, while for one riparian forest (Shirgunji T3) it was lesser (85.3%) (figure 4). Nearly 57% of trees were endemic to India, Western Ghats and Sri Lanka combined. 39.4 % tree species were exclusively endemic to Western Ghats. Except Shirgunji T3 and Halgodu all other riparian transects had endemism above 50%. Highest endemism seen in Kathlekan swp 8 (81.7%), followed by Kathlekan swp 4 (80.1%) and Halsolli (79.07%).

Presence of Threatened and Rare tree species: 14 species came under threatened status (Rare, Vulnerable, Endangered, to Critically Endangered etc.) when both IUCN and Indian Red data book were considered (IUCN 2009, Ahmedullah and Nayar 1987; Nayar 1997) (table 3). 10 species were threatened as per IUCN status of which 6 are ERS. Among the riparian transects *Dipterocarpus indicus* was more frequently occurring threatened species, and *Madhuca bourdilloni* and *Semecarpus kathlekanensis* were the least occurring. Other important threatened species includes *Myristica fatua* and rare endemic *Gymnacrantherea canarica*. Most of the transects (14) had atleast one of these threatened species. However in Shirgunji and Hulgod riparian transects no threatened species were recorded.

DISCUSSION

Species-habitat linkages: Most swamps except Halgod and Shirgunji T3, were having at least one relic tree species. Here 'relic forests' are referred to those ancient forest patches, which have no history of wholesale clearance or major alterations by humans so that the original composition

persists to some degree (Chandran et al., 2010). A *Myristica* relic swamp is a fresh water swamp dominated by members of the family Myristicaceae. *Myristica fatua* var. *magnifica* and *Gymnacranthera canarica* of this family are exclusive to such swamps. Members of Dipterocarpaceae and Myristicaceae, with most members characterised recalcitrant seeds and hygrophilous in nature, seldom occur beyond the limits of these tropical rain forest (Ashton 1964; Fedorov 1966; Chandran and Mesta 2001). The swamp associated species like *Myristica fatua* and *Gymnacranthera canarica, Syzygium travancoricum, Madhuca bourdillonii* and the recently discovered *Semecarpus kathalekanensis* may occur along with some other, usually flood tolerant, though not swamp exclusive evergreens and primary forest species *Palaquium ellipticum, Mesua ferrea* and *Vateria indica* and *Dipterocarpus indicus* (Table 3). Other riparian associates are *Calophyllum apetalum, Elaeocarpus tuberculatus, Holigarna grahamii, Hopea ponga, Hydnocarpus laurifolia, Mastixia arborea, Myristica malabarica, etc.* The *Myristica* swamps may be considered as some of the last relics of the primeval vegetation of the Western Ghats. High levels of Western Ghats endemism are found in these swamps (Chandran et al., 2008). The Kathlekan, Thorme, Halsolli and Asolli swamps are fine examples. The destruction of primary swamps due to anthropogenic activities (e.g. shifting cultivation in the past, clear felling) might give rise to secondary riparian forests as seen in Shirgunji T3 and Halgodu which have no primary forest relics. Generalist riparian species like *Madhuca neerifolia, Lophopetalum wightianum, Hydnocarpus wightianum, Holigarna spp* occur here.

Evergreeness and endemism: Most of the swamp forests had higher basal area/ha (figure 1), as was also found in an earlier study depicting swamps with higher basal areas compared to non-swamp forest (Chandran et al., 2010). These swamps having higher basal areas, however, showed lower diversity in comparison to adjoining non-swamp forest. This is due to higher dominance of riparian swamp exclusives *Myristica fatua, Gymnacranthera canarica* and *Syzygium tracancoricum*; for instance, Halsolli has high Simpson dominance due to dominance of *G. canarica* (IVI 102.3). However the larger swamps had higher Shannon diversity (3.08 in Kathlekan swamp 8) due to habitat micro-heterogeneity. These have higher canopy, particularly when trees like *Dipterocarpus indicus, Calophyllum apetalum* etc. are present. The primary forest swamps have greater endemism and more percentage of threatened species (IVI table 2). Chandran and Mesta (2001) also reported higher tree endemism in the *Myristica* swamps than in adjoining forests. The situation in the secondary riparian forest e.g. Shirgunji T3 is just the opposite. Relic riparian forests of the Western Ghats could be the remains of the primeval forests, survivals that escaped agricultural clearances (Chandran 2010). Despite the fact that the central Western Ghats have five to six dry months, the water stored and released by the relic forests, cause the streams to flow perennially. Hence these endemic rich swamp forests have higher conservation value.

Riparian forests-Management and conservation aspects: The fast pace of growth of Indian economy, especially Industrial and urban developments, have been too exacting especially on fresh water ecosystems and high diversity of threatened species they contain (Mollur et al.,

2008). The bulk of primeval forest fragments in whose conservation the pre-colonial farmers appear to have played key role, have perished during the period of modern forestry, whose foundations were laid by the British *(*Chandran and Gadgil 1993; Chandran 1997). Menon and Bawa (1997) estimated that between 1920 and 1990, 40% of the original natural vegetation of the Western Ghats were lost or converted to other land uses. *Myers* et al., (2000) estimated that only 6.8% of the 182,500 sq.km of primary forest vegetation of Western Ghats-Sri Lanka biodiversity hotspot had only survived. The ecological significance of these riparian forests includes:

Presence of rare and threatened riparian biodiversity: *Semecarpus kathalekanensis*, newly discovered tree species from the swamps of Siddapur, is an ideal case deserving threat status as Critically Endangered as it is with less than 50 breeding individuals (Vasudeva et al., 2001). *Syzygium travancoricum*, once considered extinct in its original home range of Travancore was rediscovered recently in some of the swamps of Uttara Kannada. It is included as Critically Endangered in the IUCN Red List (Chandran et al., 2008). Yet another tree species with similar history Red Listed as Endangered is that of *Madhuca bourdilloni*. *Dipterocarpus indicus* and *Hopea ponga* are Endangered. The swamp exclusive *Myristica fatua* is Endangered and *Gymnacranthera canarica* Vulnerable. Notable of the amphibian diversity of Kathalekan swamps is the presence of 35 species of frogs of which 26 were endemic (74 %) to Western Ghats. These pristine riparian habitats also host large number of endemic fishes, hornbills, and Endangered Lion tailed Macaque (Chandran et al., 2010; Srikantha et al., 2007). Swamps dominated by *Syzygium travancoricum* were also located in Thirthahalli area of Shimoga district. These were the swamps almost hidden inside the secondary evergreen to even moist deciduous forests with the legacy left behind by our ancestral peoples in the form of Kans or sacred groves. In another study Kumaradhara river riparian forests (Dakshina Kannada,Karnataka) also had high endemism coupled with many endangered and endemic species tree species such as *Madhuca insignis, Syzygium travancoricum, Vateria indica, Kingiodendrum pinnatum, Hopea spp*., etc., indicating the high sensitivity of the area (Ramachandra et al., 2012; Ramachandra et al., 2012b).

Swamps and hydrology: Because the bottom of the swamp is at or below the water table, it serves to channel runoff, into the ground water supply, helping to stabilize the water table. During the period of very heavy rains, a swamp can act as a natural flood control device (*Columbia Encyclopaedia*, 1978).

Association with sacred groves: The close links between sacred groves and water bodies have been brought out in earlier observations by the British foresters (Anonymous, 1923); The practice of conservation of primeval forest patches as sacred

kans was an important practice in Uttara Kannada (Chandran and Gadgil 1993). Kathalekan, studded with *Myristica* swamps, is one such sacred forest.

Medicinal plants and NTFP species: These riparian habitats are also treasure trove with diverse medicinal plant species such as *Hydnocarpus wightiana, Calophyllum apetalum, Myristica* spp, wild pepper, *Zingiber* spp., *Curcuma* spp. etc.

CONCLUSION

It may be stated that water shed based forest management approach is critical for both hydrology and conservation of rare species. The relic riparian forests, studded with swamps and sheltering patches of primeval vegetation of rare biodiversity are of high conservation value. Not only they conserve much water and release it in regulated stream flow they as well hold the hope as gene banks for restoration of rain forests in the South Indian Western Ghats. Mapping of all relic forests is an important priority today so that such patches are not lost for ever out of default. The threats such prime forest relics are facing from spread of arecanut gardens, as in Halsolli and Asolli swamps are an insidious one to be countered through participatory forest management than policing them as people in the interior villages of central Western Ghats, where such relics still survive, could be as well partners in conservation through awareness programmes. Overall, the riparian forests bordering rivers, fringing streams and overgrowing swamps need to be conserved holistically along with their buffer areas covering their entire drainage basis, as individual mega-watersheds.

ACKNOWLEDGEMENT

We are grateful to (i) NRDMS division, the Ministry of Science and Technology, Government of India, (ii) The Ministry of Environment and Forests, Forest department, Government of India and (iii) Indian Institute of Science for the financial and infrastructure support. We thank Dr. Prakash Mesta for technical assistance and Mr. Vishnu Mukri and Mr. Sreekanth Naik for the assistance during field data collection.

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Annexure : Checklist of tree species with their distribution and threatened status in the riparian transects studied

Sn	Family	Tree species	Distribution	IUCN status	Red data book of Indian plants	Exclusively Riparian species (ERS)
1	Lauraceae	*Actinodaphne angustifolia*	Endemic			
2	Meliaceae	*Aglaia roxbhurgii*				
3	Euphorbiaceae	*Agrogristachys meeboldii*	Endemic			ERS
4	Apocynaceae	*Alstonia scholaris*				
5	Euphorbiaceae	*Antidesma menasu*				
6	Euphorbiaceae	*Aporosa lindleyana*				
7	Arecaceae	*Arenga wightii*	Endemic	Vulnerable		
8	Annonaceae	*Artabotrys zeylanicus*	India and Sri Lanka			
9	Moraceae	*Artocarpus hirsutus*	Endemic			
10	Lauraceae	*Beilschmiedia wightii*	Endemic		Rare and Threatened	
11	Euphorbiaceae	*Bischofia javanica*				
12	Euphorbiaceae	*Blachia denudata*	Endemic			
13	Anacardiaceae	*Buchanania lanzan*				
14	Clusiaceae	*Calophyllum apetalum*	Endemic			ERS
15	Clusiaceae	*Calophyllum polyanthum*				
16	Burseraceae	*Canarium strictum*				
17	Rubiaceae	*Canthium dicoccum*				
18	Rhizophoraceae	*Carallia brachiata*				
19	Lecythidaceae	*Careya arborea*				
20	Arecaceae	*Caryota urens*				
21	Flacourtiaceae	*Caseria bourdillonii*	India and Sri Lanka			
22	Ulmaceae	*Celtis cinnamomea*				

23	Oleaceae	*Chionanthus mala-elengi*	Peninsular India			
24	Sapotaceae	*Chrysophyllum roxburghii*				
25	Meliaceae	*Chukrasia tabularis*				
26	Lauraceae	*Cinnamomum malabatrum*	Endemic			
27	Rutaceae	*Clausena indica*	India and Sri Lanka			
28	Euphorbiaceae	*Cleidion javanicum*				
29	Combretaceae	*Combretum latifolium*				
30	Leguminosae	*Derris scandens*				
31	Dilleniaceae	*Dillenia pentagyna*				
32	Sapindaceae	*Dimocarpus longan*				
33	Euphorbiaceae	*Dimorphocalyx lawianus*	Endemic			ERS
34	Ebenaceae	*Diospyros buxifolia*				
35	Ebenaceae	*Diospyros candolleana*	Endemic			
36	Ebenaceae	*Diospyros crumenata*	Western Ghats and Sri Lanka			
37	Ebenaceae	*Diospyros oocarpa*	South India and Sri Lanka			
38	Ebenaceae	*Diospyros paniculata*	Endemic			
39	Ebenaceae	*Diospyros saldanhae*	South India			
40	Dipterocarpaceae	*Dipterocarpus indicus*	Endemic	Critically Endangered		
41	Euphorbiaceae	*Drypetes elata*	Endemic			
42	Meliaceae	*Dysoxylum binectariferum*				
43	Elaeocarpaceae	*Elaeocarpus serratus*				
44	Elaeocarpaceae	*Elaeocarpus tuberculatus*				ERS
45	Leguminosae	*Entada rheedei*				

46	Celastraceae	*Euonymus indicus*	Endemic			ERS
47	Moraceae	*Ficus callosa*				
48	Moraceae	*Ficus nervosa*				
49	Flacourtiaceae	*Flacourtia montana*	Peninsular India			
50	Clusiaceae	*Garcinia gummi-gutta*	South Indian and Sri Lanka			
51	Clusiaceae	*Garcinia indica*	Endemic			
52	Clusiaceae	*Garcinia morella*				
53	Clusiaceae	*Garcinia talbotii*	Endemic			
54	Euphorbiaceae	*Glochidion zeylanicum*				
55	Gnetaceae	*Gnetum ula*	Peninsular India			
56	Myristicaceae	*Gymnacranthera canarica*				ERS
57	Anacardiaceae	*Holigarna arnotiana*	Endemic			
58	Anacardiaceae	*Holigarna beddomii*	Endemic		Vulnerable	
59	Anacardiaceae	*Holigarna ferruginea*	Endemic			ERS
60	Anacardiaceae	*Holigarna grahamii*	Endemic		Rare	
61	Anacardiaceae	*Holigarna nigra*	Endemic			
62	Flacourtiaceae	*Homalium ceylanicum*	Endemic			
63	Dipterocarpaceae	*Hopea ponga*	Endemic	Endangered		
64	Flacourtiaceae	*Hydnocarpus pentandra*	Endemic			ERS
65	Rubiaceae	*Ixora nigricans*				
66	Rubiaceae	*Ixora brachiata*	Endemic			
67	Myristicaceae	*Knema attenuata*	Endemic			
68	Lythraceae	*Lagerstroemia microcarapa*	Endemic			
69	Anacardiaceae	*Lannea coromandelica*				

70	Sapindaceae	*Lepisanthes deficiens*				
71	Lauraceae	*Litsea floribunda*	Endemic			
72	Celastraceae	*Lophopetalum wightianum*				
73	Euphorbiaceae	*Macaranga peltata*	Oriental-Western Ghats, Sri Lanka			
74	Sapotaceae	*Madhuca neriifolia*	Western Ghats, Sri Lanka			ERS
75	Sapotaceae	*Madhuca bourdillonii*	Endemic	Critically Endangered		ERS
76	Euphorbiaceae	*Mallotus philippensis*				
77	Anacardiaceae	*Mangifera indica*				
78	Cornaceae	*Mastixia arborea*	Endemic			ERS
79	Annonaceae	*Meiogyne pannosa*	Endemic			
80	Clusiaceae	*Mesua ferrea*				
81	Sapotaceae	*Mimusops elengi*				
82	Myristicaceae	*Myristica dactyloides*	South India and Sri Lanka			
83	Myristicaceae	*Myristica fatua*	Endemic	Endangered		ERS
84	Myristicaceae	*Myristica malabarica*	Endemic	Vulnerable		
85	Anacardiaceae	*Nothopegia racemosa*	Endemic			
86	Rubiaceae	*Ochreinauclea missionis*	Endemic	Vulnerable		ERS
87	Oleaceae	*Olea dioica*	Western Ghats, Deccan plateau			
88	Bignoniaceae	*Pajanalia longifolia*				ERS
89	Sapotaceae	*Palaquium ellipticum*	Endemic			
90	Lauraceae	*Persea macrantha*	Western Ghats, Sri Lanka			
91	Annonaceae	*Polyalthia fragrans*	Endemic			

92	Sterculiaceae	*Pterospermum diversifolium*				
93	Meliaceae	*Reinwardtiodendron anamalaiense*	Endemic			
94	Euphorbiaceae	*Sapium insigne*				
95	Anacardiaceae	*Semecarpus kathlekanensis*	Endemic	Critically Endangered		ERS
96	Bignoniaceae	*Steriospermum personatum*				
97	Symplocaceae	*Symplocos racemosa*				
98	Myrtaceae	*Syzygium gardnerii*	Western Ghats, Sri Lanka			
99	Myrtaceae	*Syzygium laetum*	Endemic			
100	Myrtaceae	*Syzygium caryophyllatum*	Western Ghats, Sri Lanka			
101	Myrtaceae	*Syzygium cumini*				
102	Myrtaceae	*Syzygium hemisphericum*	South India, Sri Lanka			
103	Myrtaceae	*Syzygium travancoricum*	Endemic	Critically Endangered		ERS
104	Apocynaceae	*Tabernaemontana heyneana*	Endemic	Near Threatened		
105	Combretaceae	*Terminalia bellirica*				
106	Combretaceae	*Terminalia paniculata*	Peninsular India			
107	Rhamnaceae	*Ventilago maderaspatana*				
108	Rutaceae	*Vepris bilocularis*	Endemic		Rare	

Table 1: Transect localities with their river drainage.

Sn.	Transect locality	Taluk	District	River drainage
1	Rameshwar kan-Hulkod_1	Sagar	Shimoga	Sharavathi
2	Halgodu	Sagar	Shimoga	Sharavathi
3	Thorme-Hemgar kan	Siddapur	Uttara Kannada	Sharavathi
4	Shirgunji-Mastikallu-T3	Kumta	Uttara Kannada	Aghanashini
5	Halsolli	Honnavar	Uttara Kannada	Sharavathi
6	Asolli_2	Ankola	Uttara Kannada	Gangavali
7	Kathlekan-swp 1-T6	Siddapur	Uttara Kannada	Sharavathi
8	Kathlekan-swp 2-T4	Siddapur	Uttara Kannada	Sharavathi
9	Kathlekan-swp 3-T9	Siddapur	Uttara Kannada	Sharavathi
10	Kathlekan-swp 4-T2	Siddapur	Uttara Kannada	Sharavathi
11	Kathlekan-swp 5-T1	Siddapur	Uttara Kannada	Sharavathi
12	Kathlekan-swp 6-T8	Siddapur	Uttara Kannada	Sharavathi
13	Kathlekan-swp 7-T7	Siddapur	Uttara Kannada	Sharavathi
14	Kathlekan-swp 8-T3	Siddapur	Uttara Kannada	Sharavathi
15	Kathlekan-swp 9-T5	Siddapur	Uttara Kannada	Sharavathi
16	G8-Kathalekan with S.trav	Siddapur	Uttara Kannada	Sharavathi

Table 2: Important Value Index (IVI) of first three highest trees in different study localities.

Locality	Tree species with high IVI (First three)
Thorme-Hemgar kan	*Semecarpus kathlekanensis (45.5), Elaeocarpus tuberculatus (34.8), Dipterocarpus indicus (30.3)*
Rameshwar_1	*Syzygium travancoricum (56.5), Holigarna ferruginea (30.7), Knema attenuata (19.5)*
Shirgunji-T3	*Holigarna ferruginea (30.9), Lophopetalum wightianum (29.2), Madhuca neerifolia (28.3)*

Halsolli	*Gymnacranthera canarica (102.3), Myristica fatua (81.2), Bischofia javanica (30.8)*
Asolli_2	*Dipterocarpus indicus (41.8), Knema attenuata (30.7), Holigarna grahamii (26.2)*
Kathlekan-swp1-T6	*Gymnacranthera canarica (45.26), Mastixia arborea (35.74), Myristica fatua (33.53)*
Kathlekan-swp2-T4	*Mastixia arborea (52.04), Myristica fatua (28.1), Hopea ponga (27.8)*
Kathlekan-swp3-T9	*Gymnacranthera canarica (64.3), Hopea ponga (41.8), Callophyllum apetalum (39.2)*
Kathlekan-swp4-T2	*Gymnacranthera canarica (99.2), Myristica fatua (29.2), Mastixia arborea (26.3)*
Kathlekan-swp5-T1	*Gymnacranthera canarica (47.6), Semecarpus kathlekanensis (42.4), Hopea ponga (29.3)*
Kathlekan-swp6-T8	*Hopea ponga (62.7), Syzygium travancoricum (25.8), Garcinia gummigutta (19.2)*
Kathlekan-swp7-T7	*Dipterocarpus indicus (41.8), Dimocarpus longana (31.3), Syzygium gardenerii (28.9)*
Kathlekan-swp8-T3	*Syzygium travancoricum (54.8), Myristica fatua (40.8), Mastixia arborea (37.1)*
Kathlekan-swp9-T5	*Hopea ponga (35.7), Syzygium travancoricum (25.8), Olea dioca (22.6)*
G8-Kathalekan_S.trav	*Hopea ponga (45.1), Olea dioca (36.5), Syzygium travancoricum (33.7)*

Halgodu	*Elaeocarpus tuberculatus (69.9), Mastixia arborea (53.3), Olea dioca (49.9)*

Table 3: Presence of threatened and rare trees in different study localities. (Note: *Myrfat-Myristica fatua, Dipind-Dipterocarpus indicus, Semkath-Semecarpus kathlekanensis, Madbou-Madhuca bourdilloni, Syztra-Syzygium travancoricum, Gymcan-Gymnacranthera canarica*).

Transects	*Myrfat*	*Dipind*	*Semkath*	*Madbou*	*Syztra*	*Gymcan*
Kathlekan-swp8-T3	P	P			P	P
Kathlekan-swp6-T8		P			P	
Kathlekan-swp9-T5	P	P			P	
Kathlekan-swp1-T6	P	P				P
Kathlekan-swp4-T2	P	P	P	P		P
Kathlekan-swp2-T4	P	P				P
Kathlekan-swp7-T7		P				
Kathlekan-swp5-T1	P	P	P			P
Kathlekan-swp3-T9		P				P
G8-Kathalekan_S.trav	P	P	P			P
Thorme-hemgar kan		P				P
Halsolli	P					P
Halgodu						
Asolli_2		P		P		P
Rameshwar_1					P	
Shirgunji-T3						

Figure 1: Study area map with transect localities

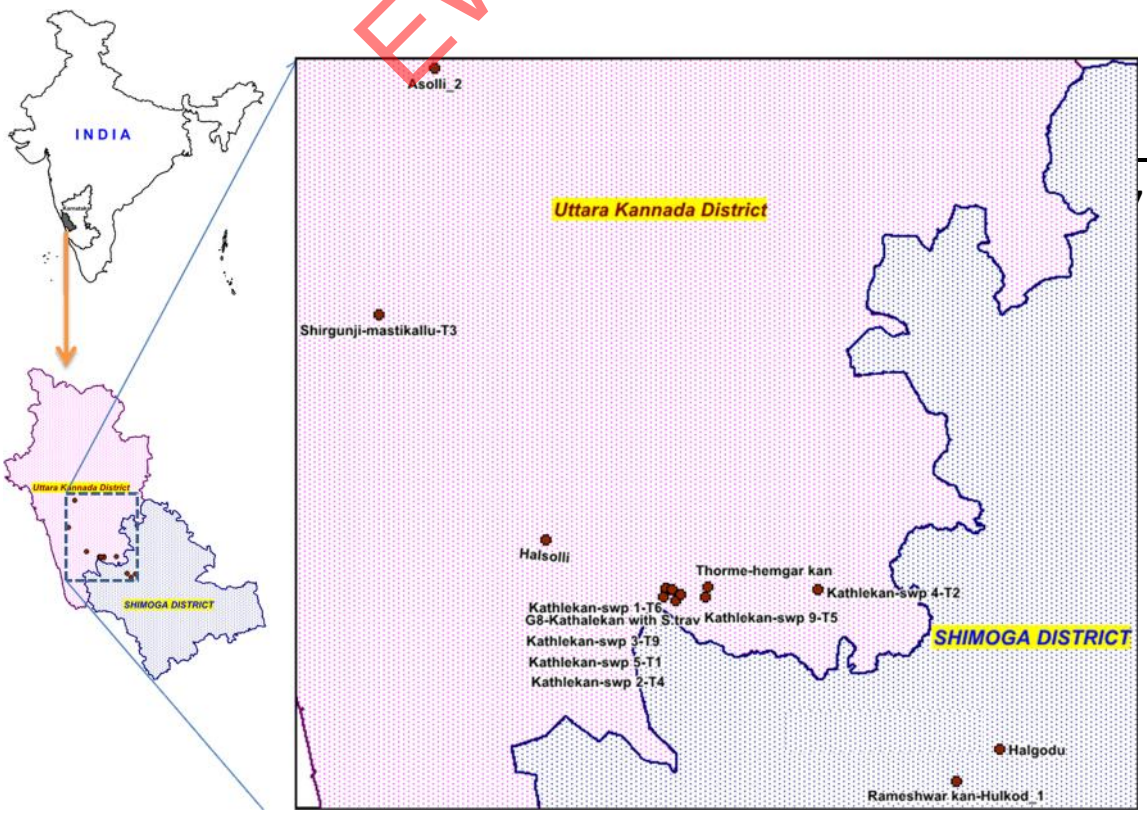

Figure 2: Transect-wise basal area/ha

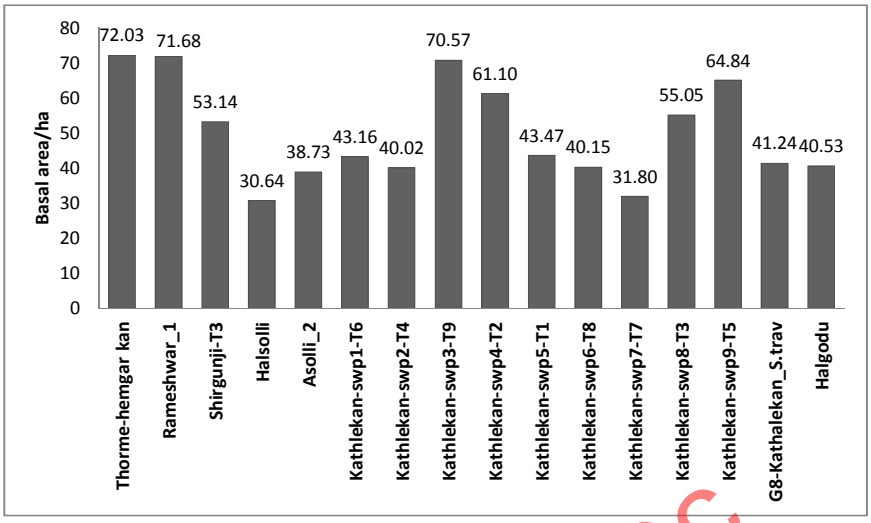

Figure 3: Shannon diversity in different study localities

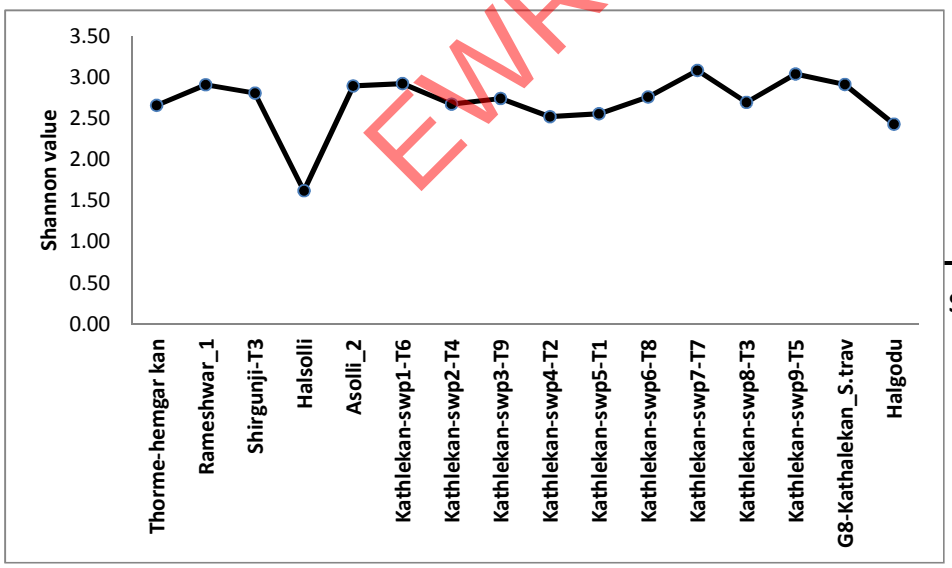

Figure 4: Percentage evergreeness and endemism in different study localities.