BIODIVERSITY, ECOLOGY AND SOCIO-ECONOMIC ASPECTS OF GUNDIA RIVER BASIN

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Abstract - The Western Ghats is one of most important 'Biodiversity Hotspots" of the world and forms a source of many important east and west flowing river systems. Gundia river basin is situated along the narrow belt of evergreen and semi-evergreen climax and potentially related forests, which is of two categories: *Dipterocarpus indicus – Kingiodendron pinnatum- Humboldia brunonis* type of low elevation (0-850 m elevation) and Mesua ferrea – Palacuim ellipticum type of medium elevation (650-1400 m). Gundia River which is one of most important tributaries of Kumaradhara River is formed by the streams namely Yettinaholé and Kempholé to which the streams Kadumaneholé and Hongadahallé join in the course. A study has been carried out to understand the ecology, biodiversity and socio-economic aspects in this region through, random opportunistic sampling for biodiversity in Bettakumbri, Kaginahare forest, Malahalli waterfalls and Yettinahollé forest sites along with interactions with the forest department officials and local people. Field survey indicates the presence of a total of 293 plant species, of which 239 were angiosperms and 54 were pteridophytes, whereas the faunal diversity consisted of 44 butterfly species, four odonates species, 56 fish species, 23 amphibians, 32 reptiles, 91 birds and 22 mammal species. This region is a very rich centre of endemism with almost 36% of plant species, 87% of amphibians and 41% of fishes endemic to Western Ghats being present here. Gundia basin forms an important link of two Traditional Elephant Migratory paths and Bisle reserve forest forms a vital part of the Mysore Elephant Reserve. However large scale anthropogenic activities in this region has fragmented vital migratory path of wild fauna leading to enhanced human-animal conflicts. This region is also rich in cardamom and coffee plantations which form an important activity for many small and big farmers in this region. Quantification of tangible and intangible benefits, the value of eco-services and goods provided by the Gundia basin works out to be 195 billion Rs./year (with food and water security) and aids as a vital life line for Karntaka state, India. This study re-affirms 'hottest hotspot' status of the Gundia Basin in central Western Ghats, a repository of biological wealth of rare kind, both in its aquatic and terrestrial ecosystems and indicates strongly the need for adoption of holistic eco-system management for conservation of particularly the rare and endemic fauna of the Western Ghats. The premium should be on conservation of the remaining evergreen and semi-evergreen forests, which are vital for the water security

(perenniality of streams) and food security (sustenance of biodiversity). Through appropriate management there still exists a chance to restore the lost natural evergreen to semi-evergreen forests.

Key words – Gundia, Hotspot, Biodiversity, Ecology, Elephant

Introduction:

The Biodiversity refers to the different genera and species of organisms in an area, the degree of which varies from one ecosystem to another. India is very rich in terms of the rich flora and fauna present in the natural ecosystems which is due to the presence of different kinds of forests, variability in climatic conditions, rainfall and topography. Biodiversity through time and space has provided the panorama of the genesis and diversification of various life forms, their interdependence, and link between life and life support systems, triggering a holistic approach to knowledge-building focused on various aspects of human affairs. The natural ecosystems in the country have already lost a vast area of virgin forests and unplanned developmental activities will further diminish the biodiversity, hydrology and ecology of the region. The freshwater ecosystems of the tropics and sub-tropics are undergoing rapid deterioration due to developmental pressures, opportunistic exploitation and neglect. The challenging issues here are to improve the current knowledge of its biodiversity so that it would aid in sustainable management of the ecosystem through suitable conservation approaches.

The Western Ghats is a chain of mountains which stretches from Tapti valley in south of Gujarat to Kanyakumari in Tamil Nadu for about 1,600 km, harbouring a rich flora and fauna and is one among 34 global biodiversity hotspots (Myers *et al.*, 2000, Sreekantha *et al.*, 2007). Over 4,000 species of flowering plants (38% endemics), 330 butterflies (11% endemics), 289 fishes (41% endemics), 135 amphibians (75% endemics), 156 reptiles (62% endemics), 508 birds (4% endemics) and 120 mammals (12% endemics) are among the known biodiversity of the Western Ghats (Daniels, 2003., Dahanukar *et al*, 2004., Gururaja, 2004., Sreekantha *et al*, 2007). The Western Ghats also forms an important watershed for the entire peninsular India, being the source of 37 west flowing rivers and three major east flowing rivers and their numerous tributaries. The stretch of Central Western Ghats ranging from 12^{o} to 14^{o} covering areas of Coorg district, Hassan, Chikmagalur, Shimoga upto south of Uttara Kannada is exceptionally rich in biodiversity.

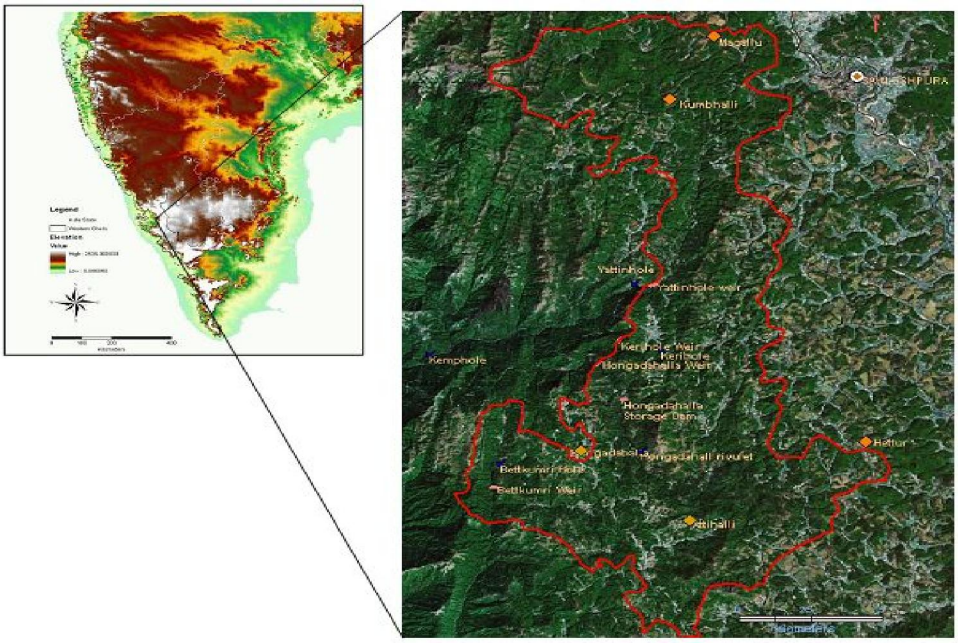
Generally, the conservation importance of an area is determined by assessing its ecological values and functions. This necessitated inventorying, mapping and monitoring of the ecosystem, to arrive at viable conservation and sustainable management strategies. The Gundia River is an important tributary of the Kumaradhara part of Netravathi River. This paper focuses on the Biodiversity, Ecological significance and Socio-economic aspects of the Gundia river basin, carried out by a multidisciplinary team, which helps to diagnose the ecological, social and economic importance of the region.

Study area:

Netravathi and Kumaradhara rivers are two west flowing rivers of the Central Western Ghats in Karnataka. The Netravathi River originates at an altitude of 1720 m in the Western Ghats region of Kudremukh hill ranges in Chikmagaloor district whereas Kumaradhara river originates in the Coorg district. These two rivers join in in Uppinangadi and then flow westwards merging with the Arabian Sea near Mangalore. Before joining Kumaradhara river, Netravathi river forms some important tributaries namely - Charmudi hole, Neria hole, Shishla hole, Belthangdi hole, etc. whereas Gundia hole forms an important tributary of Kumaradhara part of Netravathi.

The Gundia River is one of the most important tributaries of river Kumaradhara originating at an elevation of about 1400 m in Saklasheshpura taluka in Hassan district and is formed by the streams namely Yettinaholé and Kempholé to which the streams Kadumaneholé and Hongadahallé join in the course. The Gundia catchment region is surrounded Hemavathi River water-shed on its right, Barapole river catchment on its left and Netravathi River on downstream side.

Figure 1: Gundia River Basin



Materials and Methods:

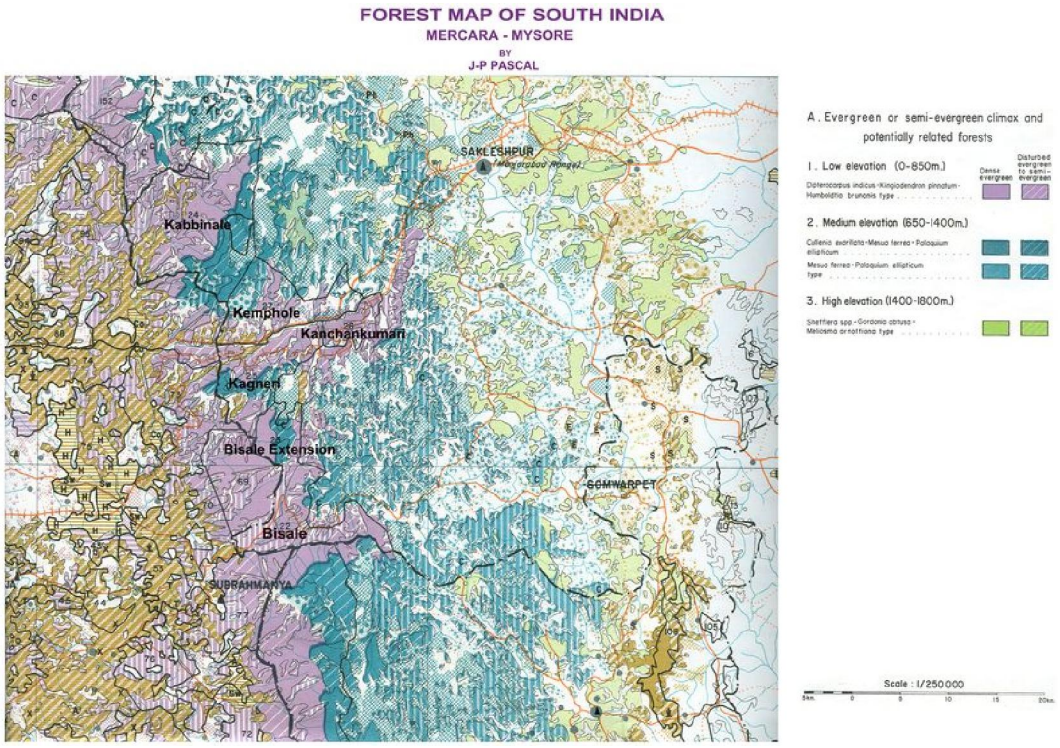
Random opportunistic sampling of flora and fauna carried out at the Bettakumbri dam site, Kaginahare forest, Malahalli waterfalls and Yettinahollé forest sites. The plants were identified using different floras (Saldanah and Nicolson, 1976; Manickam and Irudyaraj, 1992). Rare and unidentified specimens were collected for herbaria using dry method. The photographs of the important species were taken and geographical co-ordinates using Global

Positioning System (GPS) were also noted down. Apart from primary data, the secondary data was also collected in terms of research papers published, interviews and interactions with knowledgeable local people and scientists who earlier worked in the region.

Results and Discussion:

- **Vegetation:** Gundia river basin is situated along the narrow belt of evergreen and semi-evergreen climax and potentially related forests (Figure 1.1), which is of two categories according to Pascal *et al* (1982). The first category is *Dipterocarpus indicus – Kingiodendron pinnatum- Humboldia brunonis* type of low elevation (0-850 m elevation). The second type is Mesua ferrea – Palacuim ellipticum type of medium elevation (650-1400 m).

Figure 1.1: Evergreen and semi-evergreen climax and potentially related forests of Gundia basin



The survey yielded the presence of total 239 plant species in the region out d of which 119 are trees (Table 1) belonging to 88 genera and 42 families, 63 are shrubs and climbers belonging to 53 genera and 34 families and 57 are herbs belonging to 49 genera and 28 families. Along with this 54 pteridophytes (Table-2) belonging to 31 genera and 20 families were also recorded from this area. Endemic species such as

Holigarna grahmii, H.arnottiana, Myristica dactyloides, Vateria Indica, Gordonia obtuse, Canarium strictum, Artocarpus hirsutus etc., were found in most of the localities. The region inherits luxuriant forests which can be divided broadly into the following types:

1. **Tropical wet evergreen to semi-evergreen rain forests:** The canopy trees in these forests were over 30 m tall and covered with innumerable climbers and epiphytes. The tallest evergreens exceeding 30 m in height include *Dipterocarpus indicus, Vateria indica, Bischofiajavanica, Calophyllum tomentosum, Elaeocarpus tuberculatus, Diospyros* spp., *Holigarna* spp., *Mangifera indica, Lophopetalum wightianum, Syzygium* spp., *Polyalthia fragrans, Mesua ferrea* etc. The evergreen forests are rich in palms such as *Arenga wigthii, Caryota urens* and *Pinanga dicksonii* in addition to the straggler palms of *Calamus* spp. (canes).
2. **The riparian vegetation:** Along the streams and rivulets, species such as *Carallia brachiata, Madhuca neriifolia, Euonymus indica, Vateria indica, Calophyllum apetalum, Eleocarpus tuberculatus,* etc. were found. Herbs such as *Cryptocoryne retrospiralis, Dichanthium huegeli, Rotula aquatica,* covered the sandy banks. *Homonea riparia*, *Osmunda regalis,* occurs scattered along the stream flow. *Cyathea gigantea,* occurs in shaded parts of the streams.
3. **Tropical wet deciduous forests:** Occurred along more disturbed areas with species such as *Careya arborea, Mallotus tetracoccus, Mallotus philippensis, Celtis sp., Aporosa lindleyana, Lagerstroemia lanceolate, Terminalia paniculata,* etc.
4. **Scrub jungles:** Most of the places surrounding the hilltops were scrub jungles with species such as *Phyllanthus emblica, Careya arborea, Terminalia bellirica,* etc.
5. **Grasslands and savannas:** Most of the hilltops were grasslands with scattered shrubs of *Wendlandia thyrusoide, Venguria spinosa, Canthium parviflorus,* etc. Small stunted trees have orchids such as *Trias stocksii*, species of *Oberonia*, *Dendrobium,* etc.
6. **Scattered trees along plantations and abandoned fields:** Large areas of land are being under this type with many native lopped evergreen species standing scattered along the coffee plantations as shades for coffee plants.

- **Fauna:**
    - **Butterflies** – A total of 44 species of butterflies belonging to five families were found to be present in this region. Family Nymphalidae was found to be dominating by 23 species followed by Lycaenidae 8 species, Pieridae 7, Papilionidae 5 species and Hesperiidae one species. Two endangered species namely Crimson rose and Danaid eggfly are found in this region emphasizing the ecological significance of the region.

- **Dragons and damselflies** – Four species of Odonates namely Clear-winged Forest glory (*Vestalis gracilis*), Stream ruby (*Rhinocypha bisignata*), Stream glory *Neurobasis chinensis*) and Ground skimmer (*Diplocodes trivailis*) were found in this area.
- **Fishes** – 56 different fishes were recorded from the Kumaradhara and Netravathi rivers of which 23 are endemics. 11 species are assigned as Vulnerble and 8 species have been assigned as Endangered by the IUCN and feature in the Red List of Threatened species. *Horabagrus brachysoma* (Gunther) and *Etroplus Canadensis* are endemic species found in this region and are featured as Critically Endangered species in the Red List.
- **Amphibians** – 23 species of amphibians (Table-3) distributed in 8 families have been observed in this region out of which 20 species are endemics. A critically endangered species ***Indirana gundia*** has been discovered from this region in 1986. In this study, two endangered species ***Nyctibatrachus aliciae*** and ***Minervarya sahyadris*** were recorded, which further highlights the ecological significance of the region.
- **Reptiles** – 2 types of lizards and 30 different types of snakes (Table-4) are found in this region contributing to its biological richness. Snake species like Phipson's Shieldtail, Montane Trinket Snake, Beddome's Keelback, Ceylon Cat Snake, Forsten's Cat Snake, Brown Vine Snake**,** Striped Coral Snake, Beddome's Cat Snake, King Cobra, Hump Nosed Pit Viper, Bamboo Pit Viper, Malabar Pit Viper are endemic to Western Ghats and are quite well represented in this region**.**
- **Avifauna** – A total of 91 different types of birds were found to be occurring in this region. Of these during the current field work, birds like Nilgiri Wood Pigeon, Malabar Parakeet, Rufous Babbler, White Bellied Blue Flycatcher, Malabar Grey Hornbill which are endemic to Western Ghats region were sighted in Gundia and peripheral regions. One of the near threatened birds which is endemic to Western Ghats – the Malabar pied hornbill (*Anthracoceros coronatus*) protected under schedule III of WPA 1972was observed in the region. Indian peafowl (*Pavo Cristatus*) which belongs to the Scheduled I of protected animals according to the Indian Wild life protection act 1972 was observed in the region.
- **Mammals** – 22 different types of mammalian species (Table-5) were found to be present in this region, most of which are protected under the Schedule-1 of the Indian Wildlife Protection Act, 1972. The Nilgiri Martin, Travancore Flying Squirrel, Slender Loris, Lion tailed Macaque, Tiger, Asian Elephant, Barking deer and Sloth Bear are some very important animals and their presence indicates that this region is highly ecologically sensitive.

Gundia Basin – vital part of Mysore Elephant Reserve and linking Prime Elephant Corridors

The Elephant is largest animal on earth's surface and the Asian elephant forms an important part of various traditions and customs of Indian people. The elephants occupy very large areas and are regarded as 'Umbrella

species' because if they are conserved, a lot of other species occupying that same area will also be conserved. The Asian elephants have been described as endangered by the Wildlife Protection Act, 1972 (Appendix-1) and by Appendix 1 of the Convention of International Trade of Endangered Species of Flora and Fauna (CITES) in 1975.

The Elephant Reserves are the protected areas recognized by the state governments and managed by the forest departments, meant for the conservation of elephants. Till now, 24 Elephant Reserves have been officially notified by the State governments and 6 others are in the process. The Mysore Elephant Reserve covering an area of 6,724 sq.km. was notified by the Karnataka Government in November, 2002 (Vide GO FEE 231 FWL 2000, 25/11/2002). The Bisle Reserve Forest of Gundia Basin, vide the said GO, constitutes a vital part of the Mysore Elephant Reserve and covers an area of 3,339 ha.

The movement of elephants from one reserve to another allows the exchange of genetic materials between populations and thereby, prevents inbreeding depression. Such movements of elephants from one reserve to the other require adequate forest cover connecting the two, which are referred to as 'Elephant Corridors'. In India, 88 elephant corridors have been identified. The corridors enhance the connectivity between important conservation sites and increase the associated biodiversity. Ten Elephant landscapes covering contiguous reserves in adjacent states have been recommended by the Elephant Task Force (Gajah, 2010), Ministry of Environment and Forests, Government of India. The Brahmagiri-Nilgiri-Eastern Ghats elephant landscape connects the Gundia river basin with Bandipur, Nagarholé national park and Mudumalai wild life sanctuary constituting one vital elephant corridor in South India.

Mudumalai – Nagarholle – Brahmagiri – Muttodi Migratory Path (Figure 1.2) extends from Mudumalai National park in Tamil Nadu upto Muttodi region in Karnataka including Mudumalai National park, Bandipur National Park, Nagarholé National park, Anechaukur, Thithimathi, Dubare, Somwarpet, Brahmagiri and Pushpagiri Wildlife Sanctuaries, Bisale RF, Kaginahare, Kachinkumari, Charamadi, Kempholé, Mudigere and Muttodi. This migratory path is composed of diverse vegetation types ranging from wet evergreen forests to semi-evergreen forests, moist deciduous forests, swamps, riverine vegetation, shola forests and grasslands. Such rich and diverse pattern of vegetation provides ample resources for elephants moving on this route.

Figure 1.2: Mudumalai – Nagarholle – Brahmagiri – Muttodi Migratory Path

The second migratory path extends from Nagarhole National park and passes via Tithimati, Annakadu, Banavre, Malambi reserve forest, Bysur, Kattepura, Dodabetta reserve forest upto Hemavati reservoir near Hassan district in Karnataka (Figure 1.3). A majority of this corridor passes through the Kodagu district of Karnataka which is very rich in coffee and cardamom plantations. The Dodabetta and Kattepura Reserve forests are largest forest patches in this area and contain dry deciduous to moist deciduous forests which are preferred by the elephants, but due to fragmentation their sizes have been reduced to 325 and 250 ha respectively. This is due to construction of Harangi and Hemavathy dams which submerged the elephant habitat and disrupted the migratory path from Nagarholé National park upto Hemavathi reservoir including Dodabetta and Kattepura Reserve forests. The development of agriculture and coffee plantations also supported in this cause. Apart from Dodabetta and Kattepura no major reserve forest patches for elephant habitat are found in reasonable distance.

Figure 1.3: Nagarhole – Malambi – Dodabetta – Hemavati Migratory Path

Habitat fragmentation and human-animal conflicts

When an organism's preferred habitat develops discontinuities or fragments it is referred to as fragmentation. It results in breaking of one big patch into many smaller patches, the total area of the habitat decreases and each habitat fragment becomes isolated from other habitats. The animals like Asian elephant and Tiger require a large landscape cover in order to survive and fulfill their requirements. But, the increasing unplanned developmental activities like construction of roads, railways, hydroelectric projects, cause disturbance in the natural ecosystem and lead to the breaking of large forest areas into small fragments which is referred to as Habitat fragmentation. As a result of this, the wild animals do not find enough resources in the fragmented habitats and often come in contact with human settlements leading to conflicts between humans and animals.

The Gundia river catchment and its surrounding areas are eco-sensitive region. The presence of endangered animals like Tiger and Elephants highlight the importance of these regions. However, in last some years large scale land cover changes have occurred due to mini hydel power project, construction of roads, monoculture plantations of ginger and rubber, etc. Large scale land conversions for coffee and cardamom plantations have further added to large scale disturbance and fragmentation of natural habitats of wild animals. Due to this there have been incidents of conflicts between humans and animals like tiger and elephants in this region.

A Forest Department Report (2007) reports the problem caused by the elephants in 38 villages in four forest ranges - Yeslur, Alur, Sakaleshpur and Arkalud in the Hassan district. During the period of 1986-2006, 276 occasssions of elephant attack on humans have been recorded which caused 33 deaths and 243 people injured. Over an amount of Rs. 25 lakhs has been paid towards compensation in death cases. However it has been also noted that number of conflicts between elephants and humans have increased substantially in last few years. In 2006-2007, 3 deaths and 12 injuries were reported. In 2007-2008 itself 3 deaths were caused - by the elephants a stated by forest officials.

While in 2008-2009, 4 deaths and 22 injuries were reported. Table-6 shows the statistics related to human deaths and injuries, crop and property damages caused by the Elephants and the compensation paid towards these losses.

One other major problem caused by the elephants is the damaged of crops and properties. The poorer sections which are dependent on crops like paddy, ragi, jowar etc. have been largely affected by such incidents. According to the report a sum of Rs. 63.8 lakhs has been paid as compensation towards the crop damage during period 1986-2006. According to forest officials, from 2006-2009 a total of 4650 applications for compensation in crop damage cases have been filed. According to the estimate of forest department these problems are caused by 23-24 elephants present in this area. he elephants have also caused injuries to domestic cattle and the compensation of amount Rs. 4.58 lakhs has been paid in this regard during 1986-2006. Such incidents have caused fear in hearts of people living in these areas and many of them are afraid to go for cultivation or work in estates as they fear for their lives.

Socio-Economic aspects of Gundia River Basin

The Kukke Subrahmanya Temple, dedicated to Lord Subrahmanya, is one of the pristine pilgrimage centers of India, located amidst the hills of Western Ghats in a small rural village of Subrahmanya. It is situated on the banks of 'Kumaradhara River' which originates in 'Kumara Parvatha' and flows westwards towards the Arabian Sea. God Subrahmanya is worshipped for his divine power as a Snake and this temple is famous for 'Sarpa Dosha' pujas. According to Hindu Mythology Lord Kumaraswamy killed the demon rulers Taraka, Shoorapadmasura and others in a war; and the Lord washed his Shakti Ayudha (Axe in the shape of a bayonet) in this river. Hence forth the name Kumaradhara was given to the river. The pilgrims who visit the Temple have to cross the Kumaradhara River and take a Holy bath in it before they go to the temple for darshan. However, large scale land cover changes involving conversion of forest land to other land uses will alter the hydro regime in this region. Streams that are perennial currently will become seasonal apart from drastic reduction in catchment yield. Also, diversion of stream connecting to Kumaradhara will deprive localities close to the Subrahmanya temple and the temple a perennial source of water. Kumaradhara River will lose the water source which would affect the religious sentiments of the people in India.

A large number of people living in this area are dependent upon cardamom and coffee plantations. These are the economic crops of this region and give high returns. The livelihood of a large number of people depends upon these plantations. The construction of this project will also affect these crops and hence, affecting the economy of the people dependent on it.

The forests are most important natural resources and have been of great importance to human beings since prehistoric days. It is an important source of raw materials, food and other services for human population and hence, we are largely dependent on it. Besides this, the forests serve as the centers of rich biodiversity and repository of genetic wealth providing excellent opportunities for research activities and eco-tourism. They are also key players in environment purification as they contribute largely in carbon sequestration. They are economically, ecologically and socially important to us in many ways. However, due to increasing burden of population on forests, they have

suffered large scale destructions in past many years and their area has also decreased considerably. This has created a debate and concern all over the world about its protection and conservation.

The forests have various protective, productive, regulative and accessory functions. They generate a large variety of goods and services which are beneficial to the mankind. The economic valuation of these services is related to the individual's willingness to pay for these services. However, the willingness to pay is determined by various motivations which may range from self-interest to concern for future generations and concern for environment and other living beings. These values can be classified as

1. Goods: Direct usage of services - consumptive and non-consumptive usage, e.g. timber, fuel wood, tourism;
2. Services: Indirect usage - watersheds, groundwater recharge, oxygen production, carbon storage, etc.

Forests have both tangible and intangible effects which should be covered in any kind of impact assessment. But, it is not easy to assign economic values to intangible effects. There have also been some attempts to quantify and evaluate the environmental costs of loss of forests. The notional values assigned to some parameters contributing to ecological balance (Das, 1980) are given in the Table-7. Considering the tangible and intangible benefits derived from fifty year old forests, based on the vales in Table-7, the value of eco-services provided by the forests in Gundia basin works out to be 195 billion Rs./year (with food and water security) while aiding the livelihood of ecosystem people.

Conclusion: This study re-affirms 'hottest hotspot' status of the Gundia Basin in central Western Ghats, a repository of biological wealth of both aquatic and terrestrial ecosystems and indicates strongly the need for adoption of holistic eco-system management for conservation of particularly the rare and endemic fauna of the Western Ghats. The premium should be on conservation of the remaining evergreen and semi-evergreen forests, which are vital for the water security (perenniality of streams) and food security (sustenance of biodiversity). Considering the ecological significance and rich biodiversity, this region should be declared as an *Eco-sensitive region* as per sub-section (1) with clause (v) of sub-section (2) of section 3 of the Environment (Protection) Act, 1986 (29 of 1986) and clause (d) of sub-rule (3) of rule 5 of the Environment (Protection) Rules, 1986 in concurrence with the provisions of the Indian Forests Act, 1927 (16 of 1927) and Forest (Conservation) Act, 1980 (69 of 1980) the Wildlife (Protection) Act, 1972 (53 of 1972).

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Weblinks:

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3. The Indian Forest Act (1927) – http://envfor.nic.in/legis/forest/forest4.html
4. The Forest (Conservation) Act (1980) – http://envfor.nic.in/legis/forest/forest2.html
5. The Environment Protection Act (1986) – http://envfor.nic.in/legis/env/env1.html
6. The IUCN Red List of Threatened Species – http://www.iucnredlist.org/
7. Wildlife Trust of India – http://www.wildlifetrustofindia.org/

8. Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES) - http://www.cites.org/
9. Energy and Wetlands Research Group – http://wgbis.ces.iisc.ernet.in/energy
10. EWRG Gundia Report 2010 http://wgbis.ces.iisc.ernet.in/biodiversity/pubs/ces_tr/TR122/index.htm
11. Sahyadri – Western Ghats Biodiversity Information System - http://ces.iisc.ernet.in/biodiversity

Table 1: Trees of Gundia region

Sl	Family	Genera	Species	Distribution
1	Lauraceae	*Actinodaphne*	*hookeri*	Western Ghats
2	Meliaceae	*Aglaia*	*anamalayana*	Western Ghats
3	Meliaceae	*Aglaia*	*roxbhurgii*	
4	Simaroubaceae	*Ailanthus*	*excelsa*	
5	Fabaceae	*Albizzia*	*sp*	
6	Apocynaceae	*Alstonia*	*scholaris*	
7	Rubiaceae	*Anthocephallus*	*cadamba*	
8	Euphorbiaceae	*Antidesma*	*menasu*	Western Ghats
9	Euphorbiaceae	*Aporosa*	*lindleyana*	
10	Moraceae	*Artocarpus*	*heterophyllus*	Western Ghats
11	Moraceae	*Artocarpus*	*hirsuta*	Western Ghats
12	Moraceae	*Artocarpus*	*gomezianus*	Western Ghats, Sri Lanka
13	Fabaceae	*Bauhinia*	*sp*	
14	Lauraceae	*Beilsmedia*	*fagifolia*	
15	Euphorbiaceae	*Bischofia*	*javanica*	

16	Bombacaceae	*Bombax*	*ceiba*	
17	Euphorbiaceae	*Bridelia*	*crenulata*	Peninsular India
18	Fabaceae	*Butea*	*monosperma*	
19	Verbenaceae	*Callicarpa*	*tomentosa*	South India
20	Clusiaceae	*Calophyllum*	*apetalum*	Western Ghats
21	Clusiaceae	*Calophyllum*	*polyanthum*	
22	Burseraceae	*Canarium*	*strictum*	
23	Rubiaceae	*Canthium*	*dicoccum*	
24	Rhizophoraceae	*Carallia*	*brachiata*	
25	Lecythidaceae	*Careya*	*arborea*	
26	Arecaceae	*Caryota*	*urens*	
27	Ulmaceae	*Celtis*	*cinnamomea*	
28	Sapotaceae	*Chrysophyllum*	*roxburghii*	Western Ghats
29	Lauraceae	*Cinnamomum*	*macrocarpum*	Western Ghats
30	Lauraceae	*Cinnamomum*	*zeylanicum*	Western Ghats, Sri Lanka
31	Arecaceae	*Corypha*	*umbreculifera*	Western Ghats, Sri Lanka
32	Dillleniaceae	*Dillenia*	*pentagyna*	
33	Sapindaceae	*Dimocarpus*	*longan*	
34	Ebenaceae	*Diospyros*	*candolleana*	Western Ghats
35	Ebenaceae	*Diospyros*	*crumenata*	Western Ghats, Sri Lanka
36	Ebenaceae	*Diospyros*	*montana*	
37	Ebenaceae	*Diospyros*	*assymilis*	Western Ghats
38	Ebenaceae	*Diospyros*	*nigrescens*	Western Ghats
39	Dipterocarpaceae	*Dipterocarpus*	*indicus*	Western Ghats

40	Meliaceae	*Dysoxylum*	*binectariferum*	Western Ghats, Sri Lanka
41	Elaeocarpaceae	*Elaeocarpus*	*serratus*	India, Sri Lanka
42	Elaeocarpaceae	*Elaeocarpus*	*tuberculatus*	
43	Apocynaceae	*Ervatamia*	*heyneana*	Western Ghats
44	Celastraceae	*Euonymus*	*indicus*	Western Ghats
45	Euphorbiaceae	*Fahrenheitia*	*zeylanica*	Western Ghats, Sri Lanka
46	Moraceae	*Ficus*	*arnottiana*	India, Sri Lanka
47	Moraceae	*Ficus*	*tsjahela*	South India, Sri Lanka
48	Moraceae	*Ficus*	*hispida*	
49	Moraceae	*Ficus*	*sp.*	
50	Flacourtiaceae	*Flacourtia*	*montana*	Western Ghats
51	Clusiaceae	*Garcinia*	*gummi-gutta*	Western Ghats
52	Clusiaceae	*Garcinia*	*morella*	
53	Clusiaceae	*Garcinia*	*talbotii*	Western Ghats
54	Clusiaceae	*Garcinia*	*xanthochymus*	
55	Euphorbiaceae	*Glochidion*	*johnstonei*	Western Ghats
56	Euphorbiaceae	*Glochidion sp*		
57	Verbenaceae	*Gmelina*	*arborea*	
58	Theaceae	*Gordonia*	*obtusa*	Western Ghats
59	Tiliaceae	*Grewia*	*tiliaefolia*	
60	Anacardiaceae	*Holigarna*	*arnotiana*	Western Ghats
61	Anacardiaceae	*Holigarna*	*grahamii*	Western Ghats
62	Anacardiaceae	*Holigarna*	*beddomii*	Western Ghats
63	Anacardiaceae	*Holigarna*	*ferruginia*	Western Ghats

64	Dipterocarpaceae	*Hopea*	*ponga*	Western Ghats
65	Flacourtiaceae	*Hydnocarpus*	*laurifolia*	Western Ghats
66	Rubiaceae	*Ixora*	*arborea*	Western Ghats
67	Myristicaceae	*Knema*	*attenuata*	Western Ghats
68	Lythraceae	*Lagerstroemia*	*microcarpa*	Western Ghats
69	Oleaceae	*Ligustrum*	*neilgherrensis*	
70	Oleaceae	*Linoceira*	*malabarica*	Western Ghats
71	Lauraceae	*Litsea*	*floribunda*	Western Ghats
72	Lauraceae	*Litsea*	*sp*	
73	Celastraceae	*Lophopetalum*	*wightianum*	
74	Euphorbiaceae	*Macaranga*	*peltata*	Western Ghats, Sri Lanka
75	Sapotaceae	*Madhuca*	*neriifolia*	Western Ghats, Sri Lanka
76	Euphorbiaceae	*Mallotus*	*philippensis*	
77	Euphorbiaceae	*Mallotus*	*tetracoccus*	
78	Anacardiaceae	*Mangifera*	*indica*	
79	Anacardiaceae	*Mastixia*	*arborea*	Western Ghats
80	Annonaceae	*Meiogyne*	*ramarowii*	South India
81	Melastomaceae	*Memycelon*	*malabarica*	Western Ghats
82	Melastomaceae	*Memycelon*	*umbellatum*	
83	Clusiaceae	*Mesua*	*ferrea*	
84	Sapotaceae	*Mimusops*	*elengi*	
85	Myristicaceae	*Myristica*	*dactyloides*	South India, Sri Lanka
86	Rubiaceae	*Neonauclea*	*purpurea*	Western Ghats
87	Anacardiaceae	*Nothopegia*	*colebrookeana*	Western Ghats

88	Icacinaceae	*Nothopodytes*	*foetida*	
89	Oleaceae	*Olea*	*dioica*	Western Ghats, Deccan plateau
90	Sapotaceae	*Palaquium*	*ellipticum*	Western Ghats
91	Lauraceae	*Persea*	*macrantha*	Peninsular India, Sri Lanka
92	Euphorbiaceae	*Phyllanthus*	*emblica*	
93	Fabaceae	*Pithecellobium*	*monadelphum*	India
94	Pittosporaceae	*Pittosporum*	*dasycaulon*	Western Ghats
95	Annonaceae	*Polyaltha*	*fragrans*	Western Ghats
96	Fabaceae	*Pongamia*	*pinnata*	
97	Sterculiaceae	*Pterospermum*	*diversifolium*	
98	Sterculiaceae	*Pterospermum*	*reticulatum*	
99	Rubiaceae	*Randia*	*dumetorum*	
100	Bombacaceae	*Salmalia*	*malabarica*	
101	Sterculiaceae	*Sterculia*	*guttata*	Western Ghats, Sri Lanka
102	Bignoniaceae	*Steriospermum*	*personatum*	
103	Symplocaceae	*Symplocos*	*racemosa*	Western Ghats
104	Symplocaceae	*Symplocos*	*cochinchinensis*	
105	Myrtaceae	*Syzygium*	*laetum*	Western Ghats
106	Myrtaceae	*Syzygium*	*gardneri*	Western Ghats, Sri Lanka
107	Myrtaceae	*Syzygium*	*cumini*	
108	Myrtaceae	*Syzygium*	*sp*	
109	Verbenaceae	*Tectona*	*grandis*	
110	Combretaceae	*Terminalia*	*paniculata*	India
111	Combretaceae	*Terminalia*	*bellirica*	

112	Ulmaceae	*Trema*	*orientalis*	
113	Euphorbiaceae	*Trewia*	*nudiflora*	
114	Dipterocarpaceae	*Vateria*	*indica*	Western Ghats
115	Rutaceae	*Vepris*	*bilocularis*	Western Ghats
116	Verbenaceae	*Vitex*	*altissima*	South India
117	Rubiaceae	*Wendlandia*	*thyrsoidea*	South India, Sri Lanka
118	Fabaceae	*Xylia*	*xylocarpa*	
119	Rutaceae	*Zanthoxylum*	*rhetsa*	

Table 2: Pteridophytes of Gundia region

Sl	**Botanical name**	**Family**	**Status**
1	*Adiantum lunulatum* Burm.F.	Adiantaceae	
2	*Adiantum capillus-veneris* L.	Adiantaceae	
3	*Angiopteris evecta* (Forst.) Hoff.	Angiopteridaceae	
4	*Asplenium indicum* Sledge	Aspleniaceae	
5	*Asplenium cheilosorum* Krge	Aspleniaceae	
6	*Asplenium crinicaule* Hance	Aspleniaceae	
7	*Athyrium hohenackeranum* Kuntz.	Athyriaceae	
8	*Athyrium falcatum* Bedd.	Athyriaceae	
9	*Athyrium solenopteris* Kuntz.	Athyriaceae	
10	*Blechnum orientale* L.	Blechnaceae	
11	*Cyathea gigantean* Holttum	Cyatheaceae	
12	*Araiostegia pulchra* (D.Don) Copel	Davalliaceae	

13	*Pteridium aquilinium* (L.) Kunth	Dennstaedtiaceae	
14	*Microlepia speluncae* (L.) Moore	Dennstaedtiaceae	
15	*Arachniodes cordifolia* Moore	Dryopteridaceae	
16	*Dryopteris chrysocema*	Dryopteridaceae	
17	*Dryopteris cochleata* D.Don	Dryopteridaceae	
18	*Dryopteris marginata*	Dryopteridaceae	
19	*Bolbitis subcrenata* (Benth & Hook.)var. *prolifera* (Rev.)	Elaphoglossaceae	Endemic to South India
20	*Bolbitis semicordata* (Bak.) Ching	Elaphoglossaceae	Endemic to South India
21	*Gleichenia linearis* Burm.F.	Gleicheniaceae	
22	*Gramites medialis* (Bak) Ching	Grammitidaceae	
23	*Egenolphia asplenifolia* (Bory) Fee	Lomariopsidaceae	
24	*Lycopodium hamiltonii* Spreng.	Lycopodiaceae	
25	*Lycopodium cermum* L.	Lycopodiaceae	
26	*Lycopodium squarrosum* Forst.	Lycopodiaceae	
27	*Lycopodium subulifolium* Wall. Ex. Hook. And Grev.	Lycopodiaceae	
28	*Nephrolepis multiflora* (Roxb.) Jarret.	Oleandraceae	
29	*Nephrolepis undulata*	Oleandraceae	
30	*Oleandra musifolia* Kz.	Oleandraceae	
31	*Oleandra neriiformis* Cav.	Oleandraceae	
32	*Ophioglossum nudicaule* L.F.	Ophioglossaceae	
33	*Ophiglossum gramineum* L.	Ophioglossaceae	Cr.En.
34	*Aleuritopteris anceps* Blanf.	Pteridaceae	
35	*Cheilanthes farinose* (Forsk) Kault	Pteridaceae	
36	*Cheilanthes opposita* syn. *Cheilanthes mysurensis*	Pteridaceae	

37	*Doryopteris concolor*	Pteridaceae	
38	*Lygodium microphyllum* (Cav.) R.Br.	Schizaeaceae	
39	*Lygodium flexosum* (L.) Sw.	Schizaeaceae	
40	*Selaginella tenera* (Hook and Grev)	Selaginellaceae	
41	*Selaginella ciliaris* (Retz) Spring	Selaginellaceae	
42	*Selaginella longipila* Hieron	Selaginellaceae	
43	*Selaginella reticulate*	Selaginellaceae	
44	*Selaginella proniflora* (Lamk) Bak	Selaginellaceae	
45	*Selaginella radicata* Hook and Grev.	Selaginellaceae	Endemic to South India
46	*Ampelopteris prolifera* (Retz) Copel.	Thelypteridaceae	
47	*Amphineuron terminans* (Hooker) Holftam	Thelypteridaceae	
48	*Christella dentata* (Forsk) Brownsey and Jermy	Thelypteridaceae	
49	*Christella parasitica* (L.) Lev.	Thelypteridaceae	
50	*Macrothelypteris ornate* (Wall ex Bedd)	Thelypteridaceae	
51	*Macrothelypteris torresiana* (Gaud)	Thelypteridaceae	
52	*Pronephrium articulatum* Holttum	Thelypteridaceae	
53	*Pseudocyclosorus ochthodes* Kuntze	Thelypteridaceae	
54	*Trigonospora ciliate* (Benth)	Thelypteridaceae	

Table 3: Amphibians found in Gundia basin

Sl.	Species	Endemism	Ecological status
	Family: Bufonidae		
1	*Bufo parietalis* Boulenger, 1882	Endemic	Near threatened

2	*Bufo brevirostris** Rao, 1937	Endemic	
	Family: Microhylidae		
3	*Ramanella mormorata** Rao, 1937	Endemic	Endangered
4	*Ramanella triangularis**(Günther, 1876)	Endemic	Vulnerable
5	*Ramanella minor** Rao, 1937	Endemic	
	Family: Micrixalidae		
6	*Micrixalus saxicola* (Jerdon, 1853)	Endemic	Vulnerable
7	*Micrixalus elegans** (Rao, 1937)	Endemic	
	Family: Petropedetidae		
8	*Indirana semipalmatus* (Boulenger, 1882)	Endemic	Least concern
9	*Indirana gundia**(Dubois, 1986)	Endemic	Cr. Endangered
10	*Indirana longicrus**(Rao, 1937)	Endemic	
11	*Indirana tenuilingua**(Rao, 1937)	Endemic	
	Family: Dicroglossidae		
	Sub-family: Dicroglossinae		
12	*Fejervarya limnocharis* Gravenhorst, 1829		Least concern
13	*Fejervarya rufescens* (Jerdon, 1853)	Endemic	Least concern
14	*Euphlyctis cyanophlyctis* (Schneider, 1799)		Least concern
15	*Minervarya sahyadris* Dubois, Ohler & Biju, 2001	Endemic	Endangered
16	*Fejervarya* sp.		
	Family: Rhacophoridae		
	Sub-family: Rhacophorinae		
17	*Philautus* cf. *leucorhinus* Lichenstein & Martin, 1857	Endemic	Extinct in Sri Lanka
18	*Philautus flaviventris** Boulenger, 1920	Endemic	
	Family: Nyctibatrachidae		
19	*Nyctibatrachus aliciae* Inger, Shaffer, Koshy & Bakde, 1984	Endemic	Endangered

20	*Nyctibatrachus kempholeyensis**(Rao, 1937)	Endemic	
21	*Nyctibatrachus sylvaticus** Rao, 1937	Endemic	
	Family: Ranidae		
22	*Clinotarsus curtipes* Jerdon, 1854	Endemic south India	Near threatened
23	*Sylvirana temporalis* Gunther 1864	Endemic south India	Near threatened

Table 4: Reptiles of Gundia basin

Sl.	Scientific Name	Common Name	IUCN Status
1.	*Varnus bengalensis* (Daudin, 1802)	Common Indian Monitor Lizard	VU
2.	*Calotes* sp.	Lizard	
3.	*Ophiophagus hannah* (Cantor, 1836)	King Cobra	LRnt
4.	*Naja naja* (Linnaeus, 1758)	Spectacled Cobra	LRnt
5.	*Hypnale hypnale* (Merrem, 1820)	Common hump-nosed pit viper	LRnt
6.	*Trimersurus malabaricus* (Jerdon, 1853)	Malabar Pit Viper	LRnt*
7.	*Echis carinatus carinatus* (Schneider, 1801)	South Indian Saw-scaled Viper	LRnt**
8.	*Chrysopelea ornata ornata* (Shaw, 1802)	Indian Ornate Flying Snake	LRnt
9.	*Xenochrophis piscator piscator* (Schneider, 1799)	Water Snake	Lrlc
10.	*Ahaetulla nasuta* (Lacepede, 1789)	The Vine Snake	LRlc
11.	*Ptyas mucosus mucosus* (Linnaeus, 1758)	The Rat Snake	LRnt
12.	*Python molurus* molurus (Linnaeus, 1758)	Python	LRnt
13.	*Uropeltis phipsonii (Mason, 1888)*	Phipson's Shield Tail	
14.	*Python molurus molurus (Linnaeus, 1758)*	Indian Rock Python	
15.	*Gongylophis conicus (Wagler, 1830)*	Common Sand Boa	
16.	*Coelognathus Helena Helena (Daudin, 1803)*	Common Indian Trinket snake	
17.	*Coelognathus Helena monticollaris (Daudin, 1803)*	Montane Trinket snake	

18.	*Argyrogena fasciolata (Shaw, 1802)*	Banded Racer	
19.	*Oligodon arnensis (Shaw, 1802)*	Banded Kukri Snake	
20.	*Lycodon aulicus* (Linnaeus, 1758)	Common Wolf Snake	
21.	*Sibynophis subpunctatus* (Duméril & Bibron, 1854)	Dumeril's Black Headed Snake	
22.	*Xenochrophis piscator* (Schneider, 1799)	Checkered Keelback Water Snake	
23.	*Amphiesma stolatum* (Linnaeus, 1758)	Buff - Striped Keelback	
24.	*Macropisthodon plumbicolor* (Cantor, 1839)	Green Keelback	
25	*Amphiesma beddomei* (Günther, 1864)	Beddome's Keelback	
26.	*Atretium schistosum* (Daudin, 1803)	Olive Keelback	
27.	*Boiga trigonata* (Schneider, 1802)	Common Indian Cat Snake	
28.	*Boiga ceylonensis* (Günther, 1864)	Ceylon Cat Snake	
29.	*Boiga forsteni* (Duméril, Bibron & Duméril, 1854)	Forsten's Cat Snake	
30.	*Ahaetulla pulverulenta* (Duméril & Bibron, 1854)	Brown Vine Snake	
31.	*Daboia russelii* (Shaw & Nodder 1797)	Russel's Viper	
32.	*Trimeresurus gramineus* (Shaw, 1802)	Bamboo Pit Viper	

Table 5: Mammals of Gundia basin

Sl. No.	***Scientific Name***	**Common Name**	**Status**
1.	*Bos gaurus* (H. Smith, 1827)	The Gaur	Vu
2.	*Cervus unicolor* (Kerr, 1792)	Sambar	LRlc
3.	*Elephas maximus* L., 1758	Asian Elephant	Vu
4.	*Felis chaus* (Schreber, 1777)	Jungle Cat	LRnt
5.	*Petinomys fuscocapillus* (Jerdon, 1847)	Travancore Flying Squirrel	Vu
6.	*Funambulus palmarum* Linnaeus	Three-striped Palm Squirrel	LRlc

7.	*Herpestes edwardsi* (E. Geoffroy Saint-Hilaire, 1818)	Common Indian Mongoose	LRlc
8.	*Hystrix indica* (Kerr, 1792)	Indian Porcupine	LRlc
9.	*Lepus nigricollis* (F. Cuvier, 1823)	Black-naped Hare	LRlc
10.	*Macaca radiata* (E. Geoffroy, 1812)	Bonnet Macaque	LRlc
11.	*Macaca silenus* (Linnaeus, 1758)	Lion tailed Macaque	En
12.	*Manis crassicaudata* (Gray, 1827)	Indian Pangolin	LRnt
13.	*Melursus ursinus* (Shaw, 1791)	Sloth Bear	Vu
14.	*Loris lydekkerianus malabaricus*	Sender Loris	NT
15.	*Muntiacus muntjak* (Zimmermann, 1780)	Barking deer	LRlc
16.	*Panthera pardus* (Linnaeus, 1758)	Leopard	
17.	*Panthera tigris* (Linnaeus, 1758)	Tiger	En
18.	*Presbytis entellus* (Prater, 1971)	Hanuman Langur	LRlc
19.	*Ratufa indica indica* (Erxleben, 1777) *	Indian Giant Squirrel	Vu
20.	*Sus scrofa cristatus* Wagner	Wild Boar	LRlc
21.	Tragulus meminna (Erxleben, 1777)	Mouse Deer	LRnt
22.	*Viverricula* sp.	Civet Cat	

Table 6: Number of cases and compensation claims for damages, injuries and deaths in Human-Elephant Conflicts

Year	Crop Damage		Injury to humans		Human deaths		Cattle killed/injured		Total	
	# Cases	Amt.(lakhs)	# Cases	Amt.(lakhs)	# Cases	Amt.(lakhs)	# Cases	Amt.(lakhs)	# Cases	Amt.(lakhs)
1986-87	112	0.511	11	0.078	1	0.05	28	0.142	162	0.782
1987-88	88	0.542	3	0.002	0	0	29	0.079	120	0.641
1988-89	93	0.378	1	0.002	1	0.1	16	0.168	111	0.668

1989-90	25	0.249	0	0	0	0	48	0.401	73	0.65
1990-91	81	0.445	1	0.05	1	0.1	17	0.109	99	0.66
1991-92	153	1.989	2	0.13	0	0	63	0.49	218	2.609
1992-93	89	1.09	6	0.615	0	0	24	0.118	119	1.742
1993-94	84	0.43	5	0.07	0	0	34	0.017	123	0.67
1994-95	48	0.629	13	0.271	0	0	35	0.02	96	1.101
1995-96	64	0.414	12	0.088	4	0.65	22	0.207	102	1.36
1996-97	167	1.232	20	0.194	5	1.05	39	0.346	231	2.823
1997-98	128	1.17	31	0.184	3	0.95	42	0.352	204	2.656
1998-99	215	1.779	25	0.313	2	0.75	66	0.553	308	3.396
1999-2000	149	1.037	15	0.271	1	1	29	0.258	194	2.566
2000-01	160	1.111	11	0.416	1	1	10	0.069	182	2.596
2001-02	92	0.558	1	0.02	3	2.3	0	0	96	2.878
2002-03	229	2.24	14	0.139	0	0	19	0.278	263	2.72
2003-04	372	4.454	14	0.413	2	3	13	0.186	401	7.053
2004-05	609	8.269	17	0.687	5	5	27	0.354	658	14.31
2005-06	1459	23.53	29	1.37	1	1	17	0.33	1506	26.24
2006-07 (Dec 06)	1073	11.782	12	0.792	3	3	5	0.105	1093	15.68
TOTAL	5490	63.839	243	6.105	33	18.95	583	4.582	6359	93.799
*Information provided by Conservator of forest, Hassan Circle										

Table 7- Environmental benefits derived from a medium sized tree of 50 tonnes during its 50 years life span, excluding values of timber, fruit and flowers

		Single tree	**FOREST**	**TYPE**
Sr.No		**Rs. (Lakh)**	**Tropical Rs/ha (lakh)**	**Sub-tropical Rs/ha (lakh)**
1.	Oxygen production	2.50	22.50	20.50
2.	Conservation of Animal protein	0.20	1.80	1.64
3.	Control of soil erosion	2.50	22.50	20.50
4.	Recycling of water and control of humidity	3.00	27.00	24.60
5.	Shelter for birds, squirrels, insects, plants	2.50	22.50	20.50
6.	Control of air pollution	5.00	45.00	41.00
	Total	15.70	141.30	128.74