BIODIVERSITY AND ECOLOGICAL SIGNIFICANCE OF GUNDIA RIVER CATCHMENT

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Summary: The Western Ghats of India is identified as one of the richest regions in terms of biodiversity and it is often referred to as a "biodiversity hotspot". The Western Ghats is the source of 38 east flowing and 37 west flowing river systems. The ecosystem has experienced tumultuous changes due to river valley and other developmental projects in the last 60 years. Inventorying and monitoring the biodiversity and ecology of river basins would help in the formulation and implementation of appropriate conservation and management strategies in the Western Ghats. This report documents the biodiversity and ecological significance of the Gundia river catchment. This region harbours nearly 36% of plant species, 87% of amphibians, and 41% of fishes, which are endemic to Western Ghats. The presence of four critically endangered and 14 endangered animal species in the region further emphasises the need for conservation of this region on priority as it provides a unique habitat and ecological niche. Considering the ecological significance and rich biodiversity, this region can 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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INTRODUCTION

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 one among the 34 global hotspots of biodiversity and it lies in the western part of peninsular India in a series of hills stretching over a distance of 1,600 km from north to south and covering an area of about 1,60,000 sq.km. It harbours very rich flora and fauna and there are records of over 4,000 species of flowering plants with 38% endemics, 330 butterflies with 11% endemics, 156 reptiles with 62% endemics, 508 birds with 4% endemics, 120 mammals with 12% endemics (Daniels, 2003), 289 fishes with 41% endemics (Sreekantha et al., 2007) and 135 amphibians with 75% endemics (Gururaja, 2004). Such biodiversity coupled with the higher endemism could be credited to the prevailing climate (higher rainfall, evapotranpiration, etc.), location (mid latitude), topographic, and geological characteristics of the region.

Generally, the conservation importance of an area is determined by assessing its ecological values and functions. Assessments are based on the unique habitats and species composition, but in recent times it has been advocated to consider the catchment of a river basin for assessment involving the distribution and abundance of plants and animals within a catchment. This is in a way to bring the linkages between aquatic and terrestrial ecosystems, such an approach was lacking in earlier studies. An important step is to understand the variation in relation to soil type, water status, altitude, etc. This necessitated inventorying, mapping and monitoring of the ecosystem, to arrive at viable conservation and sustainable management strategies. The Gundia River is one of the most important tributaries of river Kumarashara, which in turn is a tributary of Netravathi River. Gundia River is formed by the streams namely Yettinaholé and Kempholé to which the streams Kadumaneholé and Hongadahallé join in the course. More importantly, with a proposal of a power project in Gundia, wherein Karnataka Power Corporation Limited is contemplating to harness the water in the upper reaches of Gundia and Kumaradhara river and their tributaries with an installed capacity of 300 MWs and an annual energy generation of 616

MU, this region requires a detailed investigation on the present status of its biodiversity and ecological status.

This report focuses on the biodiversity of Gundia river basin, carried out by a multidisciplinary team, which helps to diagnose the adverse effects of the ongoing land use changes on the ecology. This study also addresses the issues like environmental management, restoration of natural ecosystems, restitution of corridors of animal migration and quality of aquatic ecosystems. These are an addition to the benchmark database on existing biodiversity and ecology of the basin. The survey and systematic study was carried out for two days (17^{th} and 18^{th} January 2007) in the catchment area.

The main objective of the study was to enlist the species diversity in the region, to highlight the ecological sensitivity of the region. The floral components included are trees, shrubs, herbs, orchids, etc., whereas fauna comprised of butterflies, odonates, fish, amphibians, reptiles, birds and mammals.

Study Area

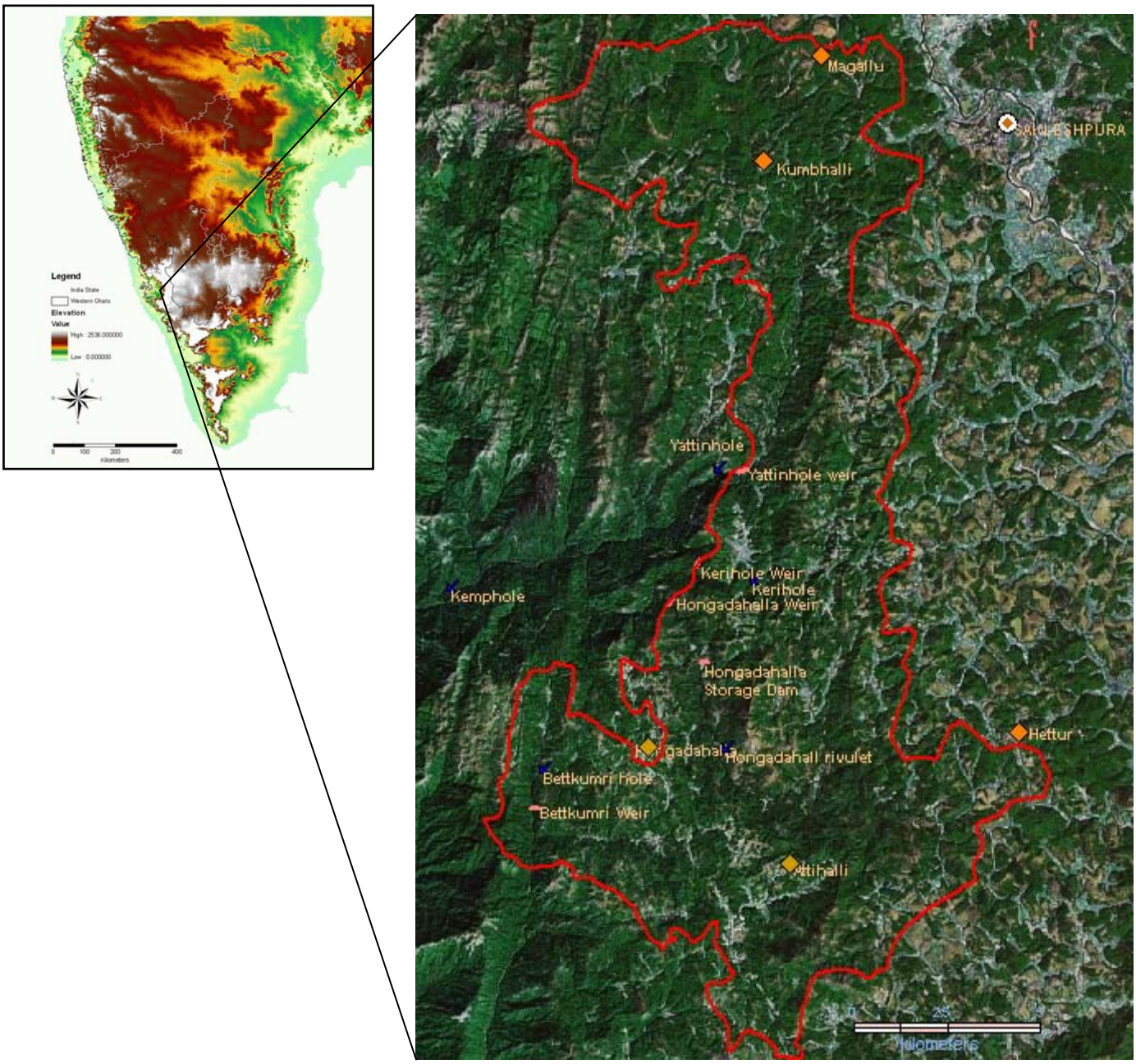

Figure 1. Gundia catchment area.

Figure 2. a) Hongadahalla valley view – asset of next generation

b) Road creation for the movement of HMV's.

c) Great carvings! Approach roads made through a hillock

d) *Vateria* tree logs - more than 60 years old .

Netravathi River and Kumaradhara Rivers of Central Western Ghats, Karnataka are two west flowing rivers. The river systems with numerous perennial streams with typical tropical evergreen forested catchment areas are the regions of high conservation value. Highlights of the riparian vegetation are the naturally grown *Vateria indica* trees in the upper Ghat region and the presence of *Gymnacranthera canarica* in the lower reaches of the Ghats. Over 5000 mm of annual rainfall complement to the ecological rich habitats.

History of exploitation

The Malnad part of the district has seen large scale land cover changes with the overexploitation of vegetation during the last two centuries. It was probably during the direct British rule of the district from 1831 to 1881 that several parts of Malnad was thrown open to the British planters often ex-army men who had changed over to civilian occupation at the end of the Anglo-Mysore wars. Kadamane, Biccodu, Cognur, Karadi-betta, Barchinhullu, Matsagar are only few of the estates dating from this period. The early planters gradually cleared forest tracks and planted them with the shade loving coffee and cardamom, the tall areca and the bushy orange. Tea was introduced at Kadamane in the early twentieth century and now it constitutes one of the major produces of this estate (Saldanha, et al. 1978).

Since 1945 there has been a spurt in the plantation industry so that the original vegetation had been greatly altered. There is scarcely any virgin forest in private hands. Major state forests have also been subjected to selective felling of hard structural timbers as well as soft woods for the plywood and matchstick industries. Large tracts of revenue lands with dense evergreen to semi-evergreen forests are being swiftly and completely logged to pave way for other land uses such as plantations.

Materials and Methods

Random opportunistic sampling of flora and fauna carried out in different habitats in Gundia river catchment (Figure 1 and 2) is listed in Table 1. .

Table 1: Sampling locations of biodiversity survey

Location	° N	° E	Elevation
Basappan kere	12.76604	75.74252	907
Hongadahalla	12.79995	75.71161	838
Aithalla	12.77285	75.69973	804
Bettakumri halla	12.77362	75.68271	779
Mogerahalli (Heradanahalli)	12.81471	75.71136	756
Kempholé	12.83262	75.65120	277
Kempholé stream	12.83074	75.59398	184

Rare and unidentified specimens were collected for herbaria using dry method. Photographs were taken and geographical co-ordinates of occurrence using global positioning system (GPS) were noted. Fresh specimens were identified with the help of regional and other floras. Apart from primary data, we have also collected secondary data in terms of research papers published, interview and interaction with knowledgeable local people and scientists who earlier worked in the region. This helped in a better understanding of the ecological sensitiveness of the region.

Vegetation: The region inherits luxuriant forests, which can be divided broadly into the following types:

1 **Tropical wet evergreen to semi-evergreen rain forests**: These were extensively found in most of the studied areas with a minimum to various amounts of disturbances. The canopy trees in these forests were over 30 m tall and covered with innumerable climbers and epiphytes. However, the canopy tends to be slightly open with no distinct stratification probably due to removal of old trees (Figure 2d). Some of the trees include

Callophyllum apetalum, Lophopetalum wightianum, Dipterocarpus indicus, Myristica dactyloides, Gordonea obtusa, Artocarpus hirsutus, Canarium strictum, Garcinia talbotii, Bischopia javanica, Syzygium gardneri, Holigarma grahamii, etc. Huge trees of *Vateria indica* had a dominant presence in most of the places along with a large number of seedlings and saplings. Hanging and draping along the trees were climbers such as *Gnetum ula, Ancistrocladus heyneanus, Allophylus cobe, Rhaphidophora laciniata, Bauhinia phoenicea,* etc.

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. In many places stream banks were dominated by reeds such as *Cyperus pangorie, Ochlandra scriptoria, etc*. 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. *Balanophora fungosa* occurs as a root parasite on plants such as *Euonymus indica, Syzygium sp,* etc.

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.

Results

People of the region have from time immemorial depended on the forest ecosystem for most of their needs including water. The forest harbours plants collected for spice such as *Piper nigrum, Myristica dactyloides, Cinnamomum sps*., etc. People regularly harvest non timber forest products (NTFP's) such as *Phyllanthus emblica, Flacourtia Montana, Artocarpus sps., Garcinia sps., Mangifera indica, Canarium strictum,* etc. Large amounts of medicinal plants also exists such as *Terminalia bellirica, Alpinia malaccensis, Alstonia scholaris, Anamirta cocculus, Anthocephalus cadamba, Antidesma menasu, Ardisia solanaceae, Asparagus racemosus, Bischopia javanica, Salamalia malabarica, Eleocarpus tuberculatus, Canscora sps., Embelia sps., Holarrhena antidysentrica,* etc. Sedges such as *Cyperus pangorie* are used for making mats, leaves of palms such as *Caryota urens* and *Arenga wightii* are used for thatching houses. Trees such as *Artocarpus hirsutus, Lagerstroemis microcarpa, Mangifera indica, Calophyllum sps., Terminalia sps*., etc., provide the necessary timber for construction of houses and equipments. Forest leaf manure from *Terminalia, Vateria indica,* etc., is used for paddy cultivation. These forests act as watershed areas collecting the rain water and letting it to the myriads of tiny streamlets which in small amounts join and form large streams and rivers, thereby assuring their perenniality.

Floral diversity: Total of 184 plant species from 72 families were enumerated during the random opportunistic survey in the river basin. The sampling locations harboured large number of plants evident from 90 trees, 25 shrubs, 15 climbers, 50 herbs, 2 palms, and 2 ferns. Herbs also included orchids such as *Flinkingeria nodosa, Dendrobium aquem, D.ovatum, Trias stoksii*, etc. Many of these and *Cyperus pangorie* was almost common along the stream. 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. However, huge trees of *Vateria indica* and their saplings were observed in most of the localities in large numbers as compared to the other species. This evergreen tree is almost rare or absent in the northern districts such as North Kanara and Shimoga but it is found growing profusely here. The other common trees observed were *Mangifera indica, Mallotus Philippensis, M.tetracoccus, Polyalthia fragrans, Aglaia sp., Bischopia javanica, Cinnamomum*

macrocarpum, Diospyros sps., Garcinia cambogia, Ficus sps., Linoceira malabarica, Olea dioca, etc. *Dipterocarpus indicus* was observed in one locality.

Endemic canes such as *Ochlandra scriptoria* and palm *Arenga wightii* were common undergrowths. Another palm *Caryota uren* was also commonly encountered in most localities.

Riparian vegetation was also a varying characteristic with species such as lofty trees of *Eleocarpus tuberculatus Carallia brachiata, Hydnocarpus laurifolia, Madhuca neriifolia, Pongamia pinnata, Vateria indica, Anthocephalus cadamba,* etc.

Endemic flora: During recent years, the forest area in the district is dwindling at an alarming rate with causes directly or indirectly related to excessive extraction of forest resources and often large-scale disturbance to forest ecosystems due to developmental activities. Already extensive damage to forests and depletion of biodiversity has taken place due to some of the factors such as clearing of forest lands, urbanisation, encroachment on vast areas of forest lands for extention of arable land for tea, coffee plantations, etc., logging, mining operations, etc. The construction activities such as small and large-scale hydroelectric dams, buildings and roads also contributed extensively for the above cascade of dwindling forest area. The most hard-hit ones are the endemic plants, which are entirely dependent on a specific habitat for survival, bringing into play the “doctrine of ultimate responsibility” (McNeely et al 1990). Additionally, endemic species, by virtue of their more restricted ranges, are often among the more vulnerable components of any particular community (Balmford, A., and Long A, 1994). These restricted range species confined to highly threatened ecosystems will almost certainly hit by extinction episodes (Pimm et al., 1995) and are most in need of rapid and effective conservation action (Russel et al., 1998). In this region, of 67 endemic species, 46 species were restricted to South-West India and 10 to South-West India and Sri Lanka. The rest were endemic to India. Species wise distribution and ecological status is provided in Table 1. Hence, endemic species such as *Vateria indica, Dipterocarpus indicus, Myristica dactyloides,* etc., which occur in this region but are rare or absent in more northern limit should be conserved on priority with the stringent management approaches curtailing any further anthropogenic activities that is likely to disturb the forest ecosystem.

Table 1. Endemic plant species found in the study area.

Species	Family	Habit	Distribution	Ecological status
Aglaia anamalayana	Meliaceae	Tree	S W India	Rare
Ancistrocladus heyneanus	Ancistrocladaceae	Climber	S W India	Common
Antidesma menasu	Euphorbiaceae	Tree	S W India	Common
Apama siliquosa	Aristolochiaceae	Shrub	S W India, Sri Lanka	Common
Ardisia solanacea	Myrsinaceae	Shrub	India	Common
Arenga wightii	Arecaceae	Palm	S W India	Rare
Artocarpus hirsutus	Moraceae	Tree	S W India	Common
Artocarpus integrifolia	Moraceae	Tree	S W India	Common
Bauhinia phoenicea	Fabaceae	Climber	S W India	Common
Bridelia crenulata	Euphorbiaceae	Tree	India	Common
Callicarpa tomentosa	Verbenaceae	Shrub	S India	Common
Callophyllum apetalum	Clusiaceae	Tree	S W India	Common
Canarium strictum	Burseraceae	Tree	S W India	Rare
Canscora deccurens	Gentianaceae	Herb	S W India	Rare
Canthium dicoccum	Rubiaceae	Tree	S W India	Common
Dalbergia sympethetica	Fabaceae	Climber	S W India	Rare
Dendrobium aqueum	Orchidaceae	Herb	S W India	Rare
Diospyros assymilis	Ebenaceae	Tree	S W India	Common
Diospyros nigrescens	Ebenaceae	Tree	S W India	Common
Dipterocarpus indicus	Dipterocarpaceae	Tree	S W India	Rare
Elaeocarpus serratus	Elaeocarpaceae	Tree	India	Common
Ervatamia heyneana	Apocynaceae	Tree	S W India	Common
Euonymus indicus	Celastraceae	Tree	S W India	Rare
Ficus arnottiana	Moraceae	Tree	S W India, Sri Lanka	Common
Flacourtia montana	Flacourtiaceae	Tree	S W India	Rare
Flickingeria nodosa	Orchidaceae	Herb	India	common
Garcinia cambogia	Clusiaceae	Tree	S W India, Sri Lanka	Common
Garcinia talbotii	Clusiaceae	Tree	S W India	Rare
Gnetum ula	Gnetaceae	Climber	S India	Rare
Gordonia obtuse	Theaceae	Tree	S W India	Rare
Holigarna arnottiana	Anacardiaceae	Tree	S W India	Common
Holigarna ferruginia	Anacardiaceae	Tree	S W India	Rare
Holigarna grahmii	Anacardiaceae	Tree	S W India	Rare
Hopea ponga	Dipterocarpaceae	Tree	S W India	Common
Hydnocarpus laurifolia	Flacourtiaceae	Tree	S W India	Rare
Ixora arborea	Rubiaceae	Tree	S W India	Rare
Knema attenuate	Myristicaceae	Tree	S W India	Common
Lagerstroemia microcarpa	Lythraceae	Tree	S W India	Common
Ligustrum gamblei	Oleaceae	Shrub	S W India	Rare
Linociera malabarica	Oleaceae	Tree	S W India	Rare
Macaranga peltata	Euphorbiaceae	Tree	S W India, Sri Lanka	Common
Madhuca nerifolia	Sapotaceae	Tree	S W India, Sri Lanka	Rare

Mangifera indica	Anacardiaceae	Tree	S W India	Common
Memycylon malabaricum	Melastomataceae	Tree	S W India	Common
Memycelon terminale	Melastomataceae	Shrub	S W India	Rare
Myristica dactyloides	Myristicaceae	Tree	S W India	Common
Neonauclea purpurea	Rubiaceae	Tree	S W India	Rare
Nothopegia colebrookeana	Anacardiaceae	Tree	S W India	Rare
Ochlandra scriptoria	Poaceae	Shrub	S W India	Common
Olea dioca	Oleaceae	Tree	S India	Common
Persea macrantha	Lauraceae	Tree	S W India, Sri Lanka	Rare
Phoenix humilis	Arecaceae	Shrub	S W India	Common
Piper nigrum	Piperaceae	Herb	S India	Common
Pithecolobium monadelphum	Fabaceae	Tree	India	Common
Polyalthia fragrans	Annonaceae	Tree	S W India	Rare
Rhaphidophora laciniata	Araceae	Climber	S W India, Sri Lanka	Common
Rubus fockei	Rosaceae	Climber	S W India	Common
Sterculia guttata	Sterculiaceae	Tree	S W India, Sri Lanka	Common
Symplocos racemosa	Symplocaceae	Tree	S W India	Common
Syzygium gardneri	Myrtaceae	Tree	S W India, Sri Lanka	Common
Syzygium laetum	Myrtaceae	Tree	S W India	Common
Terminalia paniculata	Combretaceae	Tree	India	Common
Trias stocksii	Orchidaceae	Herb	S W India	Rare
Vateria indica	Dipterocarpaceae	Tree	S W India	Common
Vepris bilocularis	Rutaceae	Tree	S W India	Rare
Vitex altissima	Verbenaceae	Tree	S India	Common
Zeuxine longilabris	Orchidaceae	Herb	S W India, Sri Lanka	Rare

Faunal diversity

Butterfly: Opportunistic sampling has been done in the six localities of the proposed project area catchment. Forty-four species of butterflies (Table 2) are found in this area belonging to five families: Family Nymphalidae is dominated 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 emphasising the ecological significance of the region. Many species are found mud-puddling close to the streams and some species are basking in the open canopy areas. Evening browns and Bush browns of family nymphalidae, are found in the thick litter covered areas and in the vicinity of *Ochlandra scriptoria*, *Calamus* spp. Few species like, Common Jezebel, Daniad Eggfly, Commander and Crimson rose are found

foraging on *Gordonia obtusa*, *Mangifera indica*, *Wendlandia thyrsoidea* and *Lantana camara*. Lycaenidae members are found mud-puddling close to the streams.

Table 2. Checklist of Butterflies found in a region

Scientific Name	Common Name	Ecological status
Family: Papilionidae		
Troides minos Cramer	Southern Birdwing (PI)	Rare
Pachliopta hector L.,	Crimson Rose (PI&SL)	Endangered
Graphium sarpedon L.,	Common Bluebottle	Common
Graphium agamemnon L.,	Tailed Jay	Common
Papilio polytes L.,	Common Mormon	common
Family: Pieridae		
Catopsilia pomona Fabricius	Common Emigrant	Common
Eurema hecabe L.,	Common Grass Yellow	Common
Delias eucharis Drury	Common Jezebel (PI & SL)	Common
Leptosia nina Fabricius	Psyche	common
Cepora nerissa Fabricius	Common Gull	common
Appias albina Boisduval	Common Albatross	Rare
Hebomoea glaucippe L.,	Great Orange Tip	Rare
Family: Nymphalidae		
Melanitis leda L.,	Common Evening Brown	Common
Mycalesis perseus Fabricius	Common Bushbrown	Rare
Mycalesis patnia Moore	Glad-eye Bushbrown (PI&SL)	Common
Ypthima asterope Klug	Common Three-ring	Common
Cethosia nietneri C&R Felder	Tamil Lacewing (PI&SL)	Common
Cupha erymanthis Drury	Rustic	Rare
Polyura athamas Drury	Common Nawab	Common
Phalanta phalantha Drury	Common Leopard	Common
Cirrochroa thais Fabricius	Tamil Yeoman (PI&SL)	Common
Neptis hylas Moore	Common Sailer	Common
Pantoporia hordonia Stoll	Common Lascar	Common
Athyma perius L.,	Common Sergeant	Common
Moduza procris Cramer	Commander	Common
Ariadne merione Cramer	Common Castor	Common
Junonia lemonias L.,	Lemon Pansy	Common
Junonia atlites L.,	Grey Pansy	Common
Junonia iphita Cramer	Chocolate Pansy	Common
Hypolimnas bolina L.,	Great Eggfly	Common
Hypolimnas misippus L.,	Danaid Eggfly (PI&SL)	Endangered
Tirumala limniace Cramer	Blue Tiger	Common
Parantica aglea Stoll	Glassy Tiger	Common
Danaus genutia Cramer	Striped Tiger	Common
Euploea core Cramer	Common Indian Crow	Common
Castalius rosimon Fabricius	Common Pierrot	Common
Actolepis puspa Horsfield	Common Hedge Blue	Rare
Zizula hylax Fabricius	Tiny Grass Blue	Common
Chilades laius Stoll	Lime Blue	Common
Lampides boeticus L.,	Pea Blue	Common

Jamides celeno Cramer	Common Cerulean	Common
Prosotas nora C & R Felder	Common Lineblue	Common
Arhopala amantes Hewitson	Large Oakblue	Common
Family: Hesperiidae		
Hasora chromus Cramer	Common Banded Awl	Common

Note: * indicates Endangered species

Damsel and dragonflies: Four species of Odonates are found in this area (Table 3). The species are Clear-winged Forest glory (*Vestalis gracilis*), Stream ruby (*Rhinocypha bisignata*), Stream glory (*Neurobasis chinensis*) and Ground skimmer (*Diplocodes trivailis*). The three speices are found along the streams of Hongadahalla, Battekumri halla and Kempholé whereas, the *Diplocodes trivailis* is found in the forest undergrowth of Hongadahalla area.

Table 3. Checklist of Dragon and Damselflies found in the region

Scientific Name	**Common Name**
Rhinocypha bisignata	Stream Ruby
Neurobasis chinensis	Stream Glory
Vestalis gracilis	Clear-winged Forest Glory
Diplocodes trivailis	Ground Skimmer

Fishes: Random surveys were carried out in selected locations of these two river systems for assessing the diversity of fishes. From the three samplings, we recorded 14 freshwater fish species with 174 individuals. Table 4 details the localitywise species list and number of individuals of each species collected on a single sampling event. Of the 14 species two are endemic to the Western Ghats and two are having ‘Endangered' status as per IUCN.

Collections of two individuals of *Tor khudree*, during the night sampling reveals that undoubtedly Mogerahalli river stretch and its tributaries with the combination of landscape elements like deep rocky pools, swift water current, with a canopy cover of pristine riparian vegetation is the ideal breeding grounds of this species. Sampling, distributing all over the river systems might further highlight the need for conservation of aquatic ecosystems. Table 5 provides species and its distribution based on the published literatures.

Table 4. Localitywise species list and number of individuals collected on a single sampling effort.

Species name	Hongadahalla	Betta Kumri	Mogerahalli
Rasbora daniconius [3]	11		
Danio aequipinnatus [3]	1		
Puntius fasciatus [1]	20	4	7
Puntius ticto [3]		2	1
Puntius sophore [3]	17	3	8
Puntius amphibius [3]		10	
Barilius bakeri [*2]	12	19	4
Brachydanio rerio [3]			1
Garra gotyla stenorhynchus [*1]	24	1	1
Tor khudree [2]			2
Channa striatus [3]			1
Schistura denisonii denisonii [2]	7	10	
Lepidocephalus thermalis [3]	2	4	
Glossogobius giuris [3]	2		
Total individuals	**96**	**53**	**25**
Number of species	**9**	**8**	**8**
Total number of species from three samplings			**14**

'*' - Endemic to Western Ghats, '1' – Endangered, '2' – Vulnerable, and '3' – lower risk.

Table 5. Checklist of freshwater fishes of Nethravathi River and Kumaradhara Rivers.

Species name	Distribution	IUCN Status
Anguilla bengalensis (Gray)	India	VU
Aplocheilus blocki (Arnold)	India	DD
Aplocheilus lineatus (Val.)	India	LR
Barilius bakeri (Day)	Endemic	VU
Barilius canarensis (Jerdon)	Endemic	DD
Barilius gatensis (Val.)	Endemic	DD
Brachydanio rerio (Ham.)	India	LR
Channa orientalis (Bl. & Schn.)	India	VU
Channa striatus	India	LR
Cirrhinus reba (Ham.)	India	VU
Clarias dussumieri (Val.)	Endemic	VU
Cyprinus carpio communis (Linne.)	India	Intro
Danio aequipinnatus	India	LR
Danio malabaricus (Jerdon)	India	LR
Esomus thermoicos (Val.)	India	LR
Etroplus canarensis	Endemic	CR
Etroplus maculatus (Bloch)	India	LR
Garra gotyla stenorhynchus	Endemic	EN

Garra mullya (Sykes)	India	LR
Glossogobius giuris	India	LR
Horabagrus brachysoma (Gunther)	Endemic	CR
Hyporhamphus limbatus (Val.)	India	DD
Hypselobarbus kurali Menon and Rema Devi	Endemic	EN
Labeo kontius (Jerdon)	Endemic	EN
Lepidocephalus thermalis (Val.)	India	LR
Mastacembelus armatus Lacepede	India	LR
Mesonemacheilus petrubanarescui	Endemic	DD
Mystus cavasius (Ham.)	India	LR
Mystus malabaricus (Jerdon)	Endemic	EN
Oreochromis mossambica (Peters)	India	Intro
Osteochilichthys nashii Day	Endemic	VU
Poecilia reticulata (Peters)	India	Intro
Pristolepis marginata (Jerdon)	Endemic	VU
Pseudosphromenus cupanius (Val.)	India	DD
Puntius amphibius (Val.)	India	LR
Puntius arulius arulius (Jerdon)	Endemic	EN
Puntius bimaculatus (Bleeker)	India	DD
Puntius conchonius (Ham.)	India	VU
Puntius filamentosus (Val.)	India	DD
Puntius melanampyx (Day)	Endemic	LR
Puntius melanostigma (Day)	Endemic	EN
Puntius sarana subnasutus (Val.)	Endemic	LR
Puntius setnai Chhapgar and Sane	Endemic	DD
Puntius sophore	India	LR
Puntius ticto (Ham.)	India	LR
Puntius vittatus Day	India	VU
Rasbora daniconius (Ham.)	India	LR
Salmostoma acinaces (Val.)	India	LR
Salmostoma boopis (Day)	Endemic	LR
Schistura denisonii denisonii	India	VU
Schistura kodaguensis Menon	Endemic	DD
Schistura nilgiriensis Menon	Endemic	EN
Schistura semiarmatus Day	Endemic	VU
Tetraodon (M.) *tavancoricus* Hora & Nair	Endemic	EN
Tor khudree (Sykes)	India	VU
Xenentodon cancila (Ham.)	India	LR

Note: CR – Critically Endangered, EN – Endangered, VU – Vulnerable, LR – Lower risk, DD – Data deficient, Intro: Introduced species

- ***Etroplus canarensis***: This species was first described in 1877 - and never seen since, and then re-discovered in 1997. This is the third Cichlid species from Asia along with other two common species *Etroplus maculatus* and *Etroplus suratensis.* Unlike these two

species, *Etroplus canarens*is is purely a freshwater dweller. The species is restricted only to a short river stretch of 2-3 km of the Nethravathi River. Presently, nothing much is known about the ecology, life cycle, and evolutionary aspects of this species.

- ***Mahseers***: Several species have been reported from India and from southern India, the *Tor khudree* and *Tor mussullah*. Mahseers prefer running water with deep pools and rocky substrate. They rule the Indian waters like tiger do the jungle. Three protected sites for fishes along downstream region of Kumaradhara and Nethravathi, indicates the fish richness of the region as well as the conservation priority given to these rivers.
- ***Mesonemacheilus petrubanarescui***: A species, belonging to Balitoridae family has been reported from Dharmasthala of Nethravathi River and so far it has not been reported from any other region.

Shishila fish sanctuary:

A stretch of about 2 km across the river Kumaradhara near Shishila of Dakshina Kannada district is one of the very few places outside of wildlife sanctuaries and National Parks, where fish enjoy any measure of protection.

Predicted impacts: Usually the species vulnerable to fragmentation are those with limited distribution, and naturally rare species with low population densities. Metapopulation dynamics suggest that even widespread population of any species is also susceptible to the effects of habitat alteration and fragmentation. Isolated local populations face higher possibility of extinction. *Tor khudree* is one among such species with its distribution all over southern India, but facing the threat of population decline as well as habitat shrinkage.

Amphibians

Amphibians are one of the best biological indicators of ecosystem health. In the present study, opportunistic surveys were carried out in four localities. This region being biologically rich and Table 6 enlists the previous records of amphibians from the region.

Table 6. Checklist of amphibians found in the region

Species	Endemism	Ecological status
Family: Bufonidae		
Bufo parietalis Boulenger, 1882	Endemic	Near threatened
*Bufo brevirostris** Rao, 1937	Endemic	
Family: Microhylidae		
*Ramanella mormorata** Rao, 1937	Endemic	Endangered
*Ramanella triangularis** (Günther, 1876)	Endemic	Vulnerable
*Ramanella minor** Rao, 1937	Endemic	
Family: Micrixalidae		
Micrixalus saxicola (Jerdon, 1853)	Endemic	Vulnerable
*Micrixalus elegans** (Rao, 1937)	Endemic	
Family: Petropedetidae		
Indirana semipalmatus (Boulenger, 1882)	Endemic	Least concern
*Indirana gundia** (Dubois, 1986)	Endemic	Cr. Endangered
*Indirana longicrus** (Rao, 1937)	Endemic	
*Indirana tenuilingua** (Rao, 1937)	Endemic	
Family: Dicroglossidae		
Sub-family: Dicroglossinae		
Fejervarya limnocharis Gravenhorst, 1829		Least concern
Fejervarya rufescens (Jerdon, 1853)	Endemic	Least concern
Euphlyctis cyanophlyctis (Schneider, 1799)		Least concern
Minervarya sahyadris Dubois, Ohler & Biju, 2001	Endemic	Endangered
Fejervarya sp.		
Family: Rhacophoridae		
Sub-family: Rhacophorinae		
Philautus cf. *leucorhinus* Lichenstein & Martin, 1857	Endemic	Extinct in Sri Lanka
*Philautus flaviventris** Boulenger, 1920	Endemic	
Family: Nyctibatrachidae		
Nyctibatrachus aliciae Inger, Shaffer, Koshy & Bakde, 1984	Endemic	Endangered
*Nyctibatrachus kempholeyensis** (Rao, 1937)	Endemic	
*Nyctibatrachus sylvaticus** Rao, 1937	Endemic	
Family: Ranidae		
Clinotarsus curtipes Jerdon, 1854	Endemic south India	Near threatened
Sylvirana temporalis Gunther 1864	Endemic south India	Near threatened

* records from previous studies (http://wgbis.ces.iisc.ernet.in/biodiversity/sahyadri_database/revisedlist/rev_index.htm)

As many as 23 species have been observed from the region. A critically endangered species *Indirana gundia* has been discovered from this region in 1986. In the present study, two

endangered species *Nyctibatrachus aliciae* and *Minervarya sahyadris* were recorded, which further highlights the ecological significance of the region. Availability of perennial sources of water has provided ample habitats for amphibians; hence they are persisting in this region even during non-monsoon periods (our sampling period).

Reptiles

A checklist of reptiles observed from the region is provided in Table 7. This list adds to the richness of the species in the region. Rat snake and Indian ornate flying snake were sighted in the Hongadahalla area.

Table 7. Checklist of Reptiles found in the region.

Scientific Name	Common Name	IUCN Status
Varnus bengalensis (Daudin, 1802)	Common Indian Monitor Lizard	VU
Calotes sp.	Lizard	
Ophiophagus hannah (Cantor, 1836)	King Cobra	LRnt
Naja naja (Linnaeus, 1758)	The Cobra	LRnt
Hypnale hypnale (Merrem, 1820)	Common hump-nosed pit viper	LRnt
Trimersurus malabaricus (Jerdon, 1853)	Malabar Pit Viper	LRnt*
Echis carinatus carinatus (Schneider, 1801)	South Indian Saw-scaled Viper	LRnt**
Chrysopelea ornata ornata (Shaw, 1802)	Indian Ornate Flying Snake	LRnt
Xenochrophis piscator piscator (Schneider, 1799)	Water Snake	Lrlc
Ahaetulla nasuta (Lacepede, 1789)	The Vine Snake	LRlc
Ptyas mucosus mucosus (Linnaeus, 1758)	The Rat Snake	LRnt
Python molurus molurus (Linnaeus, 1758)	Python	LRnt

* Endemic to Western Ghats, ** Endemic to South India

Birds

Twenty-nine species of birds (Table 8) are found in this region. Riparian vegetation of Hongadahalla, Battekumri halla and Kempholé harbours most of the species. Riparian and disturbed Semi-evergreen patches of Hongadahalla area harbour more species. Tree pie (*Dendrocitta vagabunda*), Malabar pied hornbill (*Anthracoceros coronatus*) and Racket-tailed Drongo (*Dicrurus paradiseus*) are found in the Semi-evergreen forest areas of Hongadahalla. Paradise Flycatcher (*Terpsiphone paradise*), Blueheaded Rock Thrush (*Monticola cinclorhynchus*) and Orange-headed Ground Thrush (*Zoothera citrina citrine*) are found in the steam vegetation of Kempholé.

Table 8. Checklist of Birds found in the region

Scientific Name	Common Name
Phalacrocorax niger (Vieillot)	Little Cormorant
Ardeola grayii (Sykes)	Paddybird or Pond Heron
Falco tinnunculus L.,	Kestrel
Gallus sonneratti Temminck	Grey Junglefowl
Amaurornis phoenicurus (Pennant)	Whitebreasted Waterhen
Streptopelia chinensis (Scopoli)	Spotted Dove
Chalcophaps indica (L.,)	Emerald Dove
Psittacula cyanocephala (L.,)	Blossomheaded Parakeet
Apus affinis (J.E. Gray)	House Swift
Halcyon smyrnensis (L.,)	Whitebreasted Kingfisher
Merops orientalis Lantham	Small Green Bee-eater
Anthracoceros coronatus (Boddaert)	Malabar Pied Hornbill*
Megalaima zeylanica (Gmelin)	Large Green Barbet
Dinopium benghalense (L.,)	Lesser Goldenbacked Woodpecker
Dicrurus paradiseus (L.,)	Racket-tailed Drongo
Acridotheres tristis (L.,)	Indian Myna
Dendrocitta vagabunda (Lantham)	Tree Pie
Corvus macrorhynchos Wagler	Jungle Crow
Chloropsis cochinchinensis (Gmelin)	Goldmantled Chloropsis
Irena puella (Lantham)	Fairy Bluebird
Pycnonotus cafer (L.,)	Redvented Bulbul
Hypsipetes indicus (Jerdon)	Yellowbrowed Bulbul
Rhopocichla atriceps	Blackheaded Babbler
Terpsiphone paradisi (L.,)	Paradise Flycatcher
Zoothera citrine cyanotus Lantham	White throated Ground Thrush
Monticola cinclorhynchus (Vigors)	Blueheaded Rock Thrush
Motacilla flava L.,	Yellow Wagtail
Nectarinia zeylonica (L.,)	Purplerumped Sunbird
Lonchura malacca (L.,)	Blackheaded Munia

* Endemic to Western Ghats and Srilanka.

Mammals

Mammals are listed by surveying the localities in Hongadahalla and Battekumri halla in addition to querying local people. About 19 species of Mammals are listed (**Table 9**) from the surveyed areas. Hanuman Langur was sighted during the fieldwork.

Table 9. Checklist of Mammals found in the region.

Bos gaurus (H. Smith, 1827)	The Gaur	VU
Cervus unicolor (Kerr, 1792)	Sambar	LRlc
Elephas maximus L., 1758	Asian Elephant	VU
Felis chaus (Schreber, 1777)	Jungle Cat	LRnt
Funambulus palmarum Linnaeus	Three-striped Palm Squirrel	LRlc
Herpestes edwardsi (E. Geoffroy Saint-Hilaire, 1818)	Common Indian Mongoose	LRlc
Hystrix indica (Kerr, 1792)	Indian Porcupine	LRlc
Lepus nigricollis (F. Cuvier, 1823)	Black-naped Hare	LRlc
Macaca radiata (E. Geoffroy, 1812)	Bonnet Macaque	LRlc
Manis crassicaudata (Gray, 1827)	Indian Pangolin	LRnt
Melursus ursinus (Shaw, 1791)	Sloth Bear	VU
Muntiacus muntjak (Zimmermann, 1780)	Barking deer	LRlc
Panthera pardus (Linnaeus, 1758)	Leopard	VU
Panthera tigris (Linnaeus, 1758)	Tiger	EN
Presbytis entellus (Prater, 1971)	Hanuman Langur	LRlc
Ratufa indica indica (Erxleben, 1777) *	Indian Giant Squirrel	VU
Sus scrofa cristatus Wagner	Wild Boar	LRlc
Tragulus meminna (Erxleben, 1777)	Mouse Deer	LRnt
Viverricula sp.	Civet Cat	

Note: * indicates Endemic to Western Ghats.
EN – Endangered, VU – Vulnerable, Lr-lc – Lower risk least concerned,
Lr-nt – Lower risk near threatened

Table 10 details the overall diversity, endemism and threat status of the species found in Gundia region. It is evident from both flora and fauna, that this region indeed harbours many endemic and endangered species. Nearly 36% of the plant species are endemic to Western Ghats (Figure 2), similarly among animals 87% amphibians, 41% fishes are endemic to Western Ghats (Figure 3). More importantly, the presence of four critically endangered and 14 endangered animal species in the region emphasises the unique habitats and ecological niches provided in Gundia region for these animals. This region also falls into the high priority conservation zones of the Western Ghats (Das, et al., 2006), primarily based on the species irreplacability values (>0.8). Systematic sampling of flora and fauna covering all parts of the catchment would further substantiate higher species diversity, more endemics (both in flora and fauna), etc.

Table 10. Flora and faunal diversity in Gundia region with their ecological status.

Group	Diversity	Endemic	Rare	Cr. Endangered	Endangered	Vulnerable	Threatened
Tree	48	43	19				
Shrubs	7	4	2				
Climbers	6	5	2				
Herbs	6	4	4				
Total	**67**	**56**	**27**				
Butterfly*	44	7	6		2		
Fish	56	23		2	8	12	
Amphibians	23	20		2	3	2	1
Reptiles	12	2				1	8
Aves	29	1					
Mammals	19	1			1	5	3
Tota1	**183**	**54**	**6**	**4**	**14**	**20**	**12**

* Endemic to Peninsular India and Sri Lanka

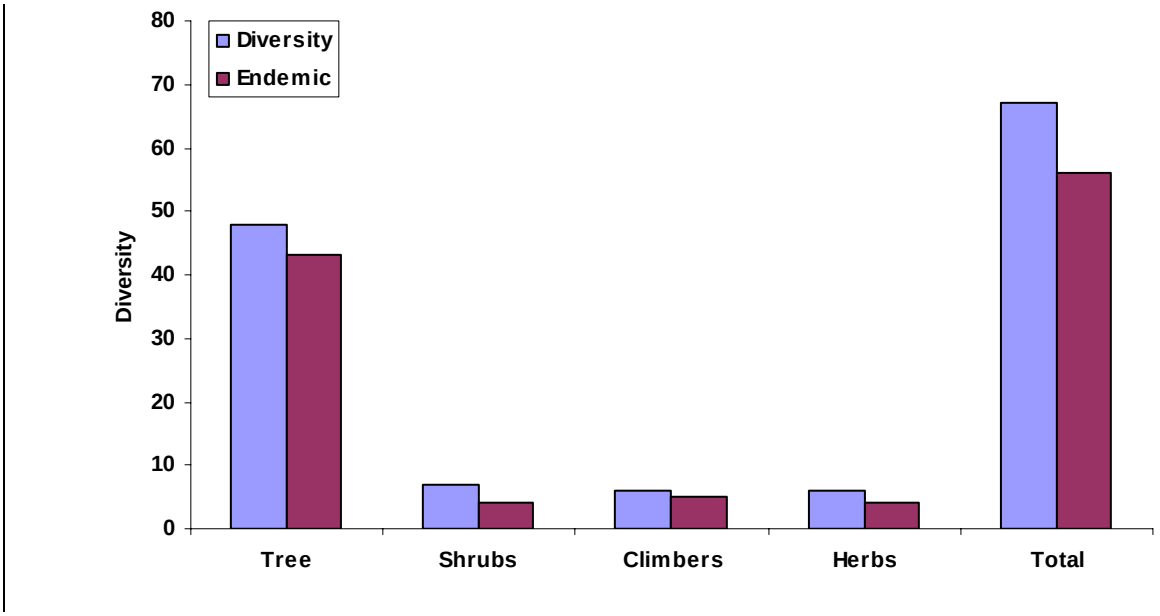

Figure 2. Exclusive endemics Western Ghats among the endemic flora observed in Gundia region

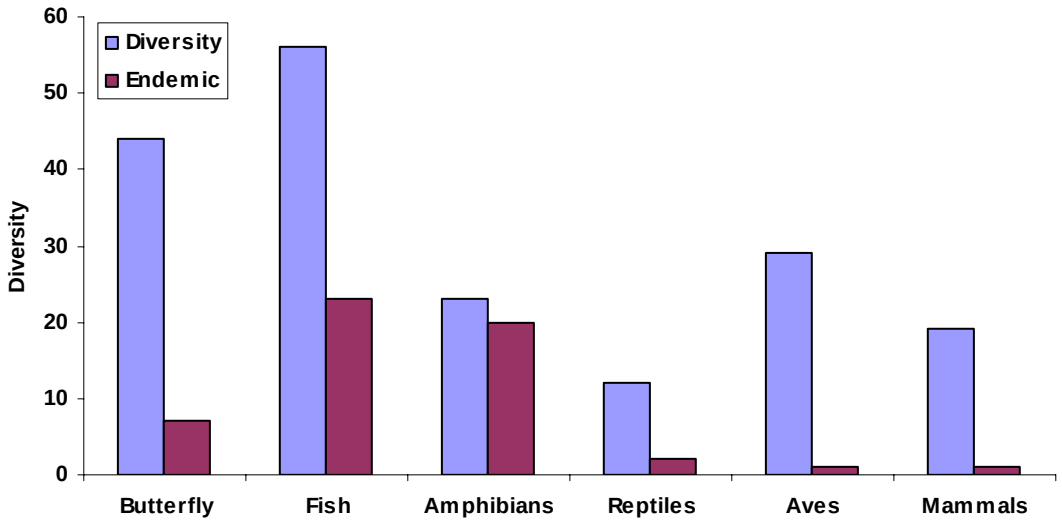

Figure 3. Faunal diversity and endemism from Gundia catchment

Seismicity in the region

This region falls in Zone II of Seismic map and seismicity is still active with two active faults namely Kodangeri-Naravi fault (Yettinholé river) and Bhagamandala-Sulya (Kumardhara and Gundia holé) fault (Valdiya, 2001). The magnitude of earthquakes could be about M 5.5 in this region.

Conclusions:

This region harbours many endemic and endangered species. Nearly 36% of the plant species are endemic to Western Ghats, similarly among animals 87% amphibians, 41% fishes are endemic to Western Ghats. More importantly, the presence of four critically endangered and 14 endangered animal species in the region emphasises the unique habitats and ecological niches provided in Gundia region for these animals.

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. These areas have already lost vast area of virgin forests as evident from barren hill tops, seasonal streams, local extinction of species, etc. with many still existing as revenue

lands waiting to be logged and gone for ever. Unplanned developmental activities in the region will further diminish the biodiversity (most importantly to the endemic and endangered species), hydrology and ecology of the region. It is high time for us to understand nature, its importance for our sustainable living and for future generations to come than taking *ad hoc* decisions to build dams across rivers and inundate the natural resources forever.

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