Report of Ecological Surveys between Sakaleshpura and Gundya region

PREPARED FOR CTII/JICA

GUBBI LABS LLP

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PREAMBLE

Gubbi Labs is a private research collective having its expertise in mapping besides studying cities and ecology. The Labs works on a host of domains ranging from sustainable ecosystems to livable settlements. The Labs is powered by a collective with interdisciplinary expertise and focus on research, development and consultancy. The Labs has an extreme focus for taking theory to practice and vice-versa with expertise in geospatial science and technologies, field ecology, urban and regional planning, and transportation. Gubbi Labs is also expanding into realms of communicating research and hence has established the Science Media Center at IISc under the Research Media Services Division of Gubbi Labs.

Japan International Cooperation Agency (JICA) is closely working with the Public Works, Ports, Inland Water Transport Department of Government of Karnataka on Road Improvement / Construction Project for Shiradi Ghats stretch. This report presents the results obtained from an objective assessment for amphibians, flora, bird and fishes. It also notes the challenges and potential threat for the habitat at large due to the proposed construction.

INTRODUCTION

The Shiradi and Gundya forest area is a natural unit of mountain system in Hassan and Dakshina Kannada districts of southern part of Karnataka. It has large tract of wet evergreen forests of Western Ghats. The pristine forest area lies within the catchment area of Yettinahole and Kemphole river, which originates from the valleys of this territory. The terrain is undulating with the elevation ranging from 100 to 700m which is characterized by steep slopes, beautiful grasslands and rocky outcrops at the crestline of the mountains.

THE ISSUE

There is a proposal to construct a bypass to the existing Shiradi Ghat stretch between Sakaleshpura and Gundya. This bypass would be a mix of tunnels and bridges that aims to ease the movement of automobile traffic. The proposed track is about 20 km long and passes through five reserve forests, Kanchankumari, Kagineri, Kombar, Konaje and Mujur.

This proposed development work being in the Biodiversity Hotspot of the Western Ghats, naturally causes concern among ecologists and conservation practitioners. Vast expanses of the Western Ghats have already been converted to non-forestry purposes, like mines, dams, roads and railway lines. Several small hydro power stations have already been established along River Kemphole, which is one of the major rivers of this region.

ECOLOGICAL ASSESSMENTS

Any further expansion of such human modified landscapes can potentially have profound effects on the ecosystems. Though the forest loss is accountable only along the access routes and appears benign, it is critical to understand the potential implications across different key taxa in this region. Accordingly, it was commissioned by CTII/JICA to go about an ecological assessment for Amphibians (Frogs and Toads), Flora, Fishes and Birds. A brief background of the four key groups are discussed.

AMPHIBIANS

India harbours about 414 species (5% of the total) of amphibians belonging to three orders namely, anura, gymnophiona and caudata. Among them 17 are critically

endangered, 33 are endangered, 24 are vulnerable as per IUCN status. However, for nearly 225 species, IUCN status is unknown. The Western Ghats and the Eastern Himalayas are two amphibian hotspots in India. The Western Ghats has about 227 amphibian species. Interestingly, 149 of them are discovered in last 16 years showing the list of species in the Western Ghats are still not complete. This clearly indicates the requirement of systematic studies on species diversity and population on amphibians in the Western Ghats, in particular and in India, in general.

FLORISTICS

The forest in Shiradi Ghat exhibit considerable variation in floristic composition and structure. These are due to variation in climatic, altitudinal and geographical aspects. This region is also representing pristine paleotropic region with very high Western Ghats floral endemics. The vegetation ranges from tropical moist deciduous to southern subtropical evergreen forests and has some specialized or critical habitats like Myristica swamps.

Shiradi and Gundya range of forest types from moist deciduous to southern tropical evergreen forests. The vegetation shows a good representation of specialized groups of flowering plants such as endemic evergreen trees, swampy species along with shrubs, climbers and lianas.

FISHES

Tropical Asian rivers rank only third richest after Latin America and Afro-tropical region in terms of number of fish species with more than 3272 fish species (Brosse et al. 2013; Lévêque et al. 2008). Extensive surveys conducted in India till date has resulted more than 850 fish species. Of which more than 520 are found in the North Eastern Himalayan Biodiversity Hotspot region and more than 330 fishes are found in the Western Ghats Biodiversity region (Molur 2014). Approximately 189 fishes are endemic to this region alone (Kumar et al. 2013).

The state of Karnataka is rich in its fish diversity with more than 213 fish species. Of which 86 are Western Ghats endemic whereas 13 are endemic to the state alone (Rema Devi et al. 2013). Earlier study conducted in the tributaries of west flowing Yettinhole River reported about 20 fish species (Rao 2016).

Numerous studies have shown that, any habitat alteration to the stream habitat can negatively influence fish community structure and if persist it may lead to species extinction (Muneepeerakul et al. 2007; Ricciardi 1999; Theophilus 2014; Whitney et al. 2015; Zhong et al. 1996).

Fishes are highly susceptible to change in physico-chemical parameters (Matthews 1998). A rise in 1 to 2°C temperature might affect feeding as well as migratory behaviour in turn delaying their reproductive cycle (Buisson et al. 2008). Similarly, a change in salinity gradient could affect fish distribution within a river system (Higgins et al. 2005).

BIRDS

Birds show enormous diversity and complexity. They are one of the most distinctive classes in the animal kingdom, characterized by their ability to fly. They can be defined as feathered bipeds (Ali, 1998). They are warm-blooded vertebrates, highly mobile and found from snow-capped mountains to deserts to seas and various types of habitats. When monitoring habitat transformations, bird communities could give valuable information. A variety of development interventions lead to these transformations and hence the objective is to appraise them in terms of biodiversity values. Though bird communities are less sensitive to the rapid habitat changes (Pramod et al, 1997), the bird diversity indicates the habitat quality of the area. The study area, which is part of the Western Ghats region has recorded 586 bird species. Various studies have been done under the Western Ghats Biodiversity Network (WGBN).

OBJECTIVES

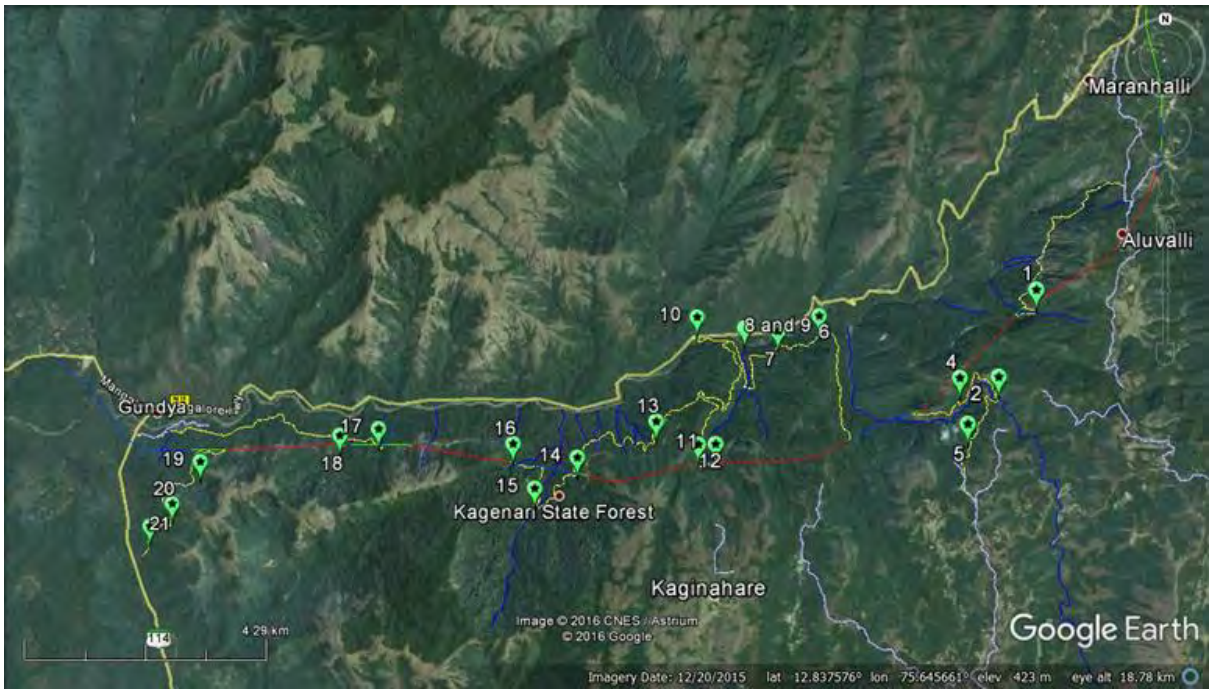
The key objectives of the proposed assessments are:

1. List of species from sampling points where the proposed alignment and/or access roads passes through the terrain.
2. To provide IUCN status, endemicity and / or habitat, micro-habitat condition of the listed species.

STUDY AREA AND METHODS

STUDY AREA

The proposed work is in the catchment area of Kemphole river and downstream. It starts close to Donigal (near Sakaleshpura) and terminates near Gundya on the left bank of Kemphole river (See Map 1). JICA provided the list of sampling points (21 points, given in Map 4), where the proposed alignment and/or access roads passes through the terrain. We could not access locality 3 due to weather, terrain, wildlife and logistic reasons. Map A sampling points where amphibians, plants, fishes and birds were surveyed. Map 6 provides additional sampling points (A-G, explained in map) for amphibians. General description of 20 sampling points is provided in Plates (Annexure B). Sampling points 4, 6, 7, 8, 9, 21 have thick growth of Ochlandra reeds and we have observed active resting places of elephants in these sampling points. Annexure C depicts micro-habitats of sampling points.



MAP A. Actual surveyed sampling points (Image source: Google Earth).

METHODS

AMPHIBIANS

A time constrained survey (1-person hour each) is adapted for amphibian survey in the sampling points marked (Heyer et al., 1994; Sutherland 2006; Dodd Jr 2010). Survey was carried out between May 2016 till October 2016. Streams of order 1, 2, 3 and 4 were surveyed for amphibians. List of species, IUCN status, endemism (endemic to Western Ghats or not) habitat requirement of adult, micro-habitat requirement of tadpoles and functional ecology of tadpoles were provided.

ECOLOGICAL STATUS

The IUCN Red List Assessment (Ver 3.1) was used to categorize a species as CR-Critically Endangered (5); EN-Endangered (4); VU-Vulnerable (3); NT-Near Threatened (2); LC-Least Concerned (1) and DD-Data Deficient (2.5). The values in the parenthesis indicate the weightage given to the categories that was eventually used to calculate conservation index. Presence of species exclusive to the study area considered as point endemics, to the Western Ghats are considered as endemics (2) and species that are non-exclusive to the Western Ghats are considered as non-endemics (1). For functional ecological aspects of tadpoles and adult breeding habitats Duellman and Trueb (1994) and McDiarmid and Altig (1999) was used. Habitat of adults are classified as A-Aquatic (3); T-Terrestrial (1); SA-Semi-aquatic (2) and AR-Arboreal (4), while their breeding habitat as LOTIC (2) -Running water, streams; LENTIC (1) -Standing water, pools, puddles, lakes; and AR-Arboreal (3). The functional ecology of tadpole is categorised into Benthic (1) -Bottom dwelling; Suctorial (7) -With suckers to cling on to rocks; neustonic (2) -Feeding on free floating organisms; clasping (3) – inhabit slow flowing streams; phytotelmous (5)-embryos develop within the tree holes/cavities; psammonic (6) -sand dwelling; nektonic (4)-rasping on rock surface; direct development (8) -species without free-living tadpole stage.

CONSERVATION INDEX

Based on sum of the weightage given to each criterion namely, the IUCN Red List Assessment; Endemism and Ecological Status; and number of Species of each site,

conservation index for each site was arrived at. A conservation index of over 100 for a given locality is considered as relatively high conservation priority site.

FLORA

Based on the Google Earth images, the sampling points for data collection have been defined. Total 21 sampling points were identified and marked on the Google map for sampling the floristics of those points. To document the tree species in each proposed sampling point, quadrat method of 25 x 25 m size is laid. Girth at breast height (GBH) at the level of 1.37m of each species was recorded. While the documentation, trees at 30 and more than 30 cm GBH were considered for the tree sampling (growing stock). To assess the regeneration status of the species, two 25 m^2 (5x5m) nested plots were laid randomly in each tree plots. All the regenerating species including trees, shrubs, climbers and liana were counted. All the species were identified to the species level by referring standard regional floras and floristic keys.

IMPORTANT VALUE INDEX (IVI)

Important value index is the sum of the relative density, relative frequency and relative basal area of a species. It is estimated by calculating density, frequency and basal area of a species. This index is a significant parameter in ecological assessment indicating ecological success of the species. A species can get value between 0-300, 0- being least IVI and 300- being highest IVI.

Important Value Index = R. density + R. frequency + R. basal area

DENSITY AND RELATIVE DENSITY

Density of plant species is number of individuals of a species divided by the area of the quadrat. Relative density of a species calculated as density of a species to the total density of all the species and represented in percentage.

Density = No. of individuals of Species A / Area sampled
Relative Density = Density of Species A / Total density of all species) * 100

FREQUENCY AND RELATIVE FREQUENCY

Frequency of a plant species is number of quadrats in which the species occurred to the total number of quadrat sampled. While relative frequency is calculated as frequency of a species to the total frequency of all species and expressed in percentage.

Frequency = No. of quadrats with Species A / Total No. of quadrats sampled
Relative Frequency = (Frequency of Species A / Total frequency of all species) * 100

BASAL AREA AND RELATIVE BASAL AREA

The basal area is estimated that indicates the occupancy of a species over an area which in turn can also be inferred for the dominance of the species. It is estimated as:

$$\textbf{Basal area } (\mathbf{m^2}) = \frac{(\mathbf{GBH})^2}{4\pi}\textbf{; where GBH is girth at breast height.}$$

Relative Basal area = (Basal area of Species A / Total basal area of all species) * 100

FISHES

Fishes were sampled by using non-destructive fishing method i.e. cast net and dragnet in each sampled unit (stream segment) until no additional species is caught in the net. Sampling span from July 2016 to October 2016.

BIRDS

Sampling was carried out in 20 points where the access roads are proposed to build the bypass. At/near the points sampling was carried out and a checklist of all birds observed was prepared. Several nest cavities in trees and nests on trees were located. Two observers were involved in this assessment. The primary objective of this survey was to identify the different species of birds found in all the marked sites and marking the nest cavities that would succumb to the proposed project.

RESULTS

AMPHIBIANS

RICHNESS

27 sampling points were sampled, of which 20 were from JICA's proposed alignment. In the study period, 37 species of amphibians were observed, from 9 families and 17 genera and listed in Table 1. Conservation Index (CI) values for each species is also given in Table 1. Conservation Index for *Raorchestes ponmudi* is highest (22), while it is least for *Duttaphrynus melanostictus* (5).

TABLE 1. List of amphibian species with IUCN status, Endemism, habitat requirement of adult and tadpoles and the functional ecology of tadpoles.

Family	Species	IUCN	END	1	2	3	CI
Bufonidae							
	Duttaphrynus melanostictus	LC	NE	T	LENTIC	Benthic	5
	Ghatophryne ornata	EN	EN	T	LOTIC	Suctorial	16
Microhylidae							
	Microhyla ornata	LC	NE	SA	LENTIC	Neustonic	7
	Microhyla sholigari	EN	EN	SA	LENTIC	Neustonic	11
	Uperodon triangularis	VU	EN	T	LENTIC	Phytotelmous	12
	Uperodon mormoratus	EN	EN	T	LENTIC	Phytotelmous	13
Micrixalidae							
	Micrixalus elegans	DD	EN	SA	LOTIC	Psammonic	14.5
	Micrixalus saxicola	VU	EN	SA	LOTIC	Psammonic	15
	Micrixalus kottigeharensis	CR	EN	SA	LOTIC	Psammonic	17
Nyctibatrachidae							
	Nyctibatrachus kumbara	DD	EN	A	LOTIC	Benthic	10.5
	Nyctibatrachus grandis	DD	EN	A	LOTIC	Benthic	10.5
	Nyctibatrachus kempholeyensis	DD	EN	A	LOTIC	Benthic	10.5
	Nyctibatrachus sanctipalustris	EN	EN	A	LOTIC	Benthic	12
Dicroglossidae							
	Fejervarya granosa	DD	EN	SA	LENTIC	Benthic	8.5
	Fejervarya mudduraja	DD	EN	SA	LENTIC	Benthic	8.5
	Fejervarya caperata	DD	EN	SA	LENTIC	Benthic	8.5
	Fejervarya sahyadris	EN	EN	SA	LENTIC	Benthic	10
	Fejervarya rufescens	LC	EN	SA	LENTIC	Benthic	7
	Euphlyctis cyanophlyctis	LC	NE	A	LENTIC	Benthic	7
	Euphlyctis mudigere	DD	EN	A	LENTIC	Benthic	9.5
	Sphaerotheca breviceps	LC	NE	SA	LENTIC	Benthic	6
Ranidae							
	Indosylvirana intermedius	DD	EN	SA	LENTIC	Benthic	8.5
	Indosylvirana montanus	DD	EN	SA	LENTIC	Benthic	8.5
	Clinotarsus curtipes	NT	EN	SA	LOTIC	Nektonic	11
Ranixalidae							
	Indirana semipalmata	LC	EN	SA	LENTIC	Nektonic	10
	Indirana gundia	CR	EN	SA	LENTIC	Nektonic	14
Rhacophoridae							
	Raorchestes ochlandrae	DD	EN	AR	AR	Direct development	19.5
	Raorchestes luteolus	DD	EN	AR	AR	Direct development	19.5
	Raorchestes tuberohumerus	DD	EN	AR	AR	Direct development	19.5

	Raorchestes charius	EN	EN	AR	AR	Direct development	21
	Raorchestes glandulosus	VU	EN	AR	AR	Direct development	20
	Pseudophilautus wynaadensis	EN	EN	AR	AR	Direct development	21
	Raorchestes ponmudi	CR	EN	AR	AR	Direct development	22
	Rhacophorus malabaricus	LC	EN	AR	LENTIC	Benthic	9
	Rhacophorus lateralis	EN	EN	AR	LENTIC	Benthic	12
	Polypedates occidentalis	DD	EN	AR	LENTIC	Benthic	10.5
Ichthyophiidae							
	Ichthyophis kodaguensis	DD	EN	SA	LENTIC	Benthic	8.5

Note: 1-Habitat of adult; 2-Breeding habitat and 3-functional ecology of tadpole. CI-Conservation Index. Please refer text for details.

ECOLOGICAL STATUS

Among 37 species observed in the study, 3 are critically endangered, 8 are endangered, 3 are vulnerable and 15 species are data deficient. Figure 1 depicts the pie chart of ecological status of amphibians observed in the study. Thirty species are endemic to the Western Ghats, while 4 are non-endemic to the Western Ghats.

LOCALITY SPECIFIC AMPHIBIAN RICHNESS

Table 2 details the number of amphibian species observed in each of the 27 sampling points. Locality 10 has highest number of species with 21 species, while only two species at IPCL was observed. There was no locality which had all species observed in the study and there was no single species which was observed all sampling points. Figure 2 illustrates the frequency of species occurrence in 27 sampling points. Table 3 provides the distance of occurrence of species from the point of survey. Within stream (0-5m), there are 27 species of amphibians and within 10m, there are 17 species.

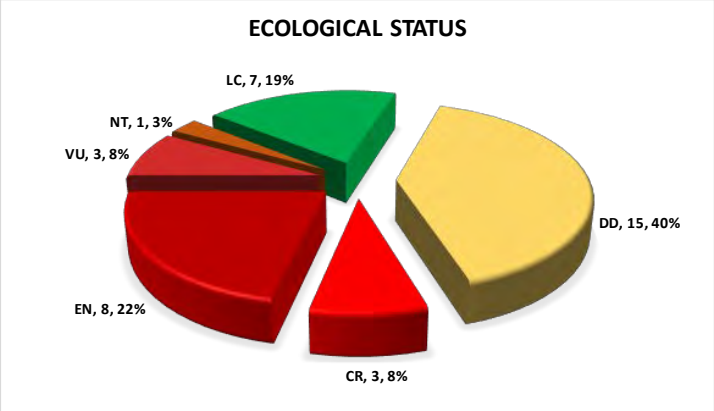


FIGURE 1. Ecological status (IUCN ver. 3.1) of amphibians in the study area.

SPECIES PROFILE

There were 24 species which had conservation index of 10 or more. Plates in Annexure D illustrates the 16 of them. Below are the description 17 species with greater than 10 Conservation index value.

• RAORCHESTES PONMUDI (PONMUDI BUSH FROG)

It is an arboreal frog that inhabit high evergreen tree canopies, endemic to the Western Ghats. It is a critically endangered species and has direct development in its life stage. It has a conservation index value of 22. In the present study, it was observed from sampling points 2, 12, 15 and 16.

• PSUEDOPHILAUTUS WYNAADENSIS (WAYNAD BUSH FROG)

It is an arboreal frog, endemic to the Western Ghats found in bushes. It is an endangered species and has direct development in its life stage. It has a conservation index value of 21. In the present study, it was observed from sampling points 1,2,4-10, 13,14, 16-21.

• RAORCHESTES CHARIUS (SESHACHAR'S BUSH FROG)

It is an arboreal frog, endemic to the Western Ghats found in higher altitudes and grass lands. It is an endangered species and has direct development in its life stage. It has a conservation index value of 21. In the present study, it was observed from sampling points 5 and 13.

• RAORCHESTES GLANDULOSUS (GLANDULAR BUSH FROG)

It is an arboreal frog, endemic to the Western Ghats. It is a vulnerable species and has direct development. It has a conservation index value of 20. In the present study, it was observed from sampling points 1,6,8-10,12 and 13.

- RAORCHESTES LUTEOLUS (COORG YELLOW BUSH FROG)

It is an arboreal frog, endemic to the Western Ghats found in bushes. We do not know the ecological status of this species (DD). It has a conservation index value of 19.5. In the present study, it was observed from sampling points 1,2,4-14, 17 and 18.

- RAORCHESTES OCHLANDRAE (OCHLANDRA REED-BUSH FROG)

It is an arboreal frog, endemic to the Western Ghats found inside Ochlandra reed bushes (Hence the name). It has direct development in its life stage, we do not know it's ecological status. It has a conservation index value of 19.5. In the present study, 1, 8, 9 and 10.

- MICRIXALUS KOTTIGEHARENSIS (KOTTIGEHARA DANCING FROG)

It is an aquatic frog, endemic to the Western Ghats found along the torrential streams. It is a diurnal species with unique foot flagging behaviour, lay eggs inside streams and has sand burrowing tadpoles. It is a critically endangered species. It has a conservation index value of 17. In the present study, it was found in sampling points 2, 4-13 and 15-21.

- GHATOPHRYNE ORNATA (MALABAR TORRENT TOAD)

It is a torrential stream dwelling toad, endemic to the Western Ghats. It is an endangered species. Not much is known about the species, however the tadpoles of the species are highly adapted (sectorial) to fast flowing streams. It has a conservation index value of 16. In the present study, it was found in sampling points 1, 12-14, 17, 18 and 20.

- MICRIXALUS SAXICOLA (WAYNAD DANCING FROG)

It is an aquatic frog, endemic to the Western Ghats found along the torrential streams. It is a diurnal species exhibiting foot flagging behaviour. It is a vulnerable species. It has a conservation index value of 15. In the present study, it was found in sampling points 1, 16 and 19.

- MICRIXALUS ELEGANS (ELEGANT DANCING FROG)

It is a very small, aquatic frog, endemic to the Western Ghats found along the torrential streams. It is a diurnal species with unique foot flagging behaviour having a silvery white webbing. Ecological status is not known. It has a conservation index value of 14.5. In the present study, it was found in sampling points 1, 5-10, 12, 13, 15, 17-21.

- INDIRANA GUNDIA (GUNDIA LEAPING FROG)

It is a semi-aquatic frog, endemic to the Western Ghats found along streams and stream edges. It has a unique semi-aquatic tadpole stage and primitive inguinal amplexus. It is a critically endangered species. It has a conservation index value of 14. In the present study, it was found in all sampling points except 4.

- UPERODON MORMORATUS (RAO'S MARBLED BALLOON FROG)

It is an endemic frog from the Western Ghats. It is an endangered species. It has a conservation index value of 13. In the present study, it was found in locality 10.

- RHACOPHORUS LATERALIS (SMALL TREE FROG)

It is an arboreal frog, endemic to the Western Ghats. It has a unique breeding behaviour wherein individuals build purse nest to protect eggs from desiccation. It is an endangered species. It has a conservation index value of 12. In the present study, it was found in sampling points 1, 5 and 12.

- NYCTIBATRACHUS SANCTIPALUSTRIS (COORG NIGHT FROG)

It is an aquatic frog, endemic to the Western Ghats. It inhabits torrential streams. It is an endangered species. It has a conservation index value of 12. In the present study, it was found in sampling points 5, 8, 9, 14, 16 and 19.

- UPERODON TRIANGULARIS (TRIANGULAR BALLOON FROG)

It is a semi-aquatic frog, endemic to the Western Ghats. It is a vulnerable species. It has a conservation index value of 12. In the present study, it was found in locality 20.

- CLINOTARSUS CURTIPES (BI-COLORED FROG)

It is a semi-aquatic frog, endemic to the Western Ghats. It is found in streams. Tadpoles exhibit kin recognition. It is a near threatened species. It has a conservation index value of 11. In the present study, it was found in sampling points 6, 10, 12 and 16.

- MICROHYLA SHOLIGARI (SHOLIGA'S NARROW-MOUTHED FROG)

It is a small, semi-aquatic frog, endemic to the Western Ghats. It is an endangered species. It has a conservation index value of 11. In the present study, it was found in sampling points 1 and 10.

CONSERVATION INDEX

Table 4 detail the number of species and conservation index for each locality. Conservation Index was highest for locality 10 (265.5), while least for check post (27.5). Of 27 sampling points, 21 have conservation index value over 100, all of which are proposed sampling points of JICA. There was no locality which had all species observed in the study and there was no single species which was observed all sampling points.

TABLE 2. Number of Amphibian species in 27 surveyed sampling points. Sampling points 1-21 as per JICA's list and A-E are other sampling points surveyed. A-Maranahalli; B-Pilikatte; C-Checkpost; D-Kemphole; E-IPCL; F-Kanchankumri and G-Kerehole.

Species	Sampling points																										
	1	2	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	A	B	C	D	E	F	G
Duttaphrynus melanostictus		+		+	+				+			+								+	+		+	+		+	
Ghatophryne ornata	+										+	+	+			+	+		+								
Microhyla ornata									+																		+
Microhyla sholigari	+								+																		+
Uperodon triangularis																				+						+	
Uperodon mormoratus									+																		
Micrixalus elegans	+		+	+	+	+	+	+	+		+	+		+		+	+	+	+	+						+	
Micrixalus saxicolas	+														+			+								+	
Micrixalus kottigeharensis		+	+	+	+	+	+	+	+	+	+	+		+	+	+	+	+	+	+						+	
Nyctibatrachus Kumbara	+				+	+			+			+		+	+	+	+			+						+	
Nyctibatrachus grandis		+		+						+	+							+									
Nyctibatrachus kempholeyensis	+	+	+	+	+	+	+	+	+		+	+	+	+	+	+	+			+	+	+		+		+	+
Nyctibatrachus sanctipalustris				+			+	+					+		+			+									
Fejervarya granosa				+	+	+						+								+							
Fejervarya mudduraja			+	+					+							+					+					+	+
Fejervarya caperata		+			+				+			+								+							+
Fejervarya sahyadris	+								+										+	+		+					
Fejervarya rufescens	+																		+								
Euphlyctis cyanophlyctis		+			+	+	+	+	+											+							+
Euphlyctis mudigeri			+	+						+																	
Spaherotheca breviceps										+																+	
Indosylvirana intermedius	+	+	+	+			+	+	+		+					+				+			+	+		+	+
Indosylvirana montanus							+	+		+	+									+							
Clinotarsus curtipes					+				+		+				+						+	+					
Indirana semipalmata		+	+				+	+	+				+			+											

Indirana gundia	+	+		+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+		+	+	+	+	+	+	
Raorchestes ochlandrae	+						+	+	+												+				+			
Raorchestes luteolus	+	+	+	+	+	+	+	+	+	+	+	+	+				+	+				+						
Raorchestes tuberohumerus	+	+	+	+	+	+	+	+	+	+	+	+	+		+		+	+	+			+	+					
Raorchestes charius				+								+																
Raorchestes glandulsosus	+				+		+	+	+		+	+											+					
Pseudophilautus wynaadensis	+	+	+	+	+	+	+	+	+			+	+		+	+	+	+	+	+	+	+			+		+	
Raorchestes ponmudi		+									+			+	+													
Rhacophorus malabaricus	+			+							+				+					+								
Rhacophorus lateralis	+			+							+																	
Polypedates occidentalis											+				+										+		+	
Ichthyophis kodaguensis																											+	

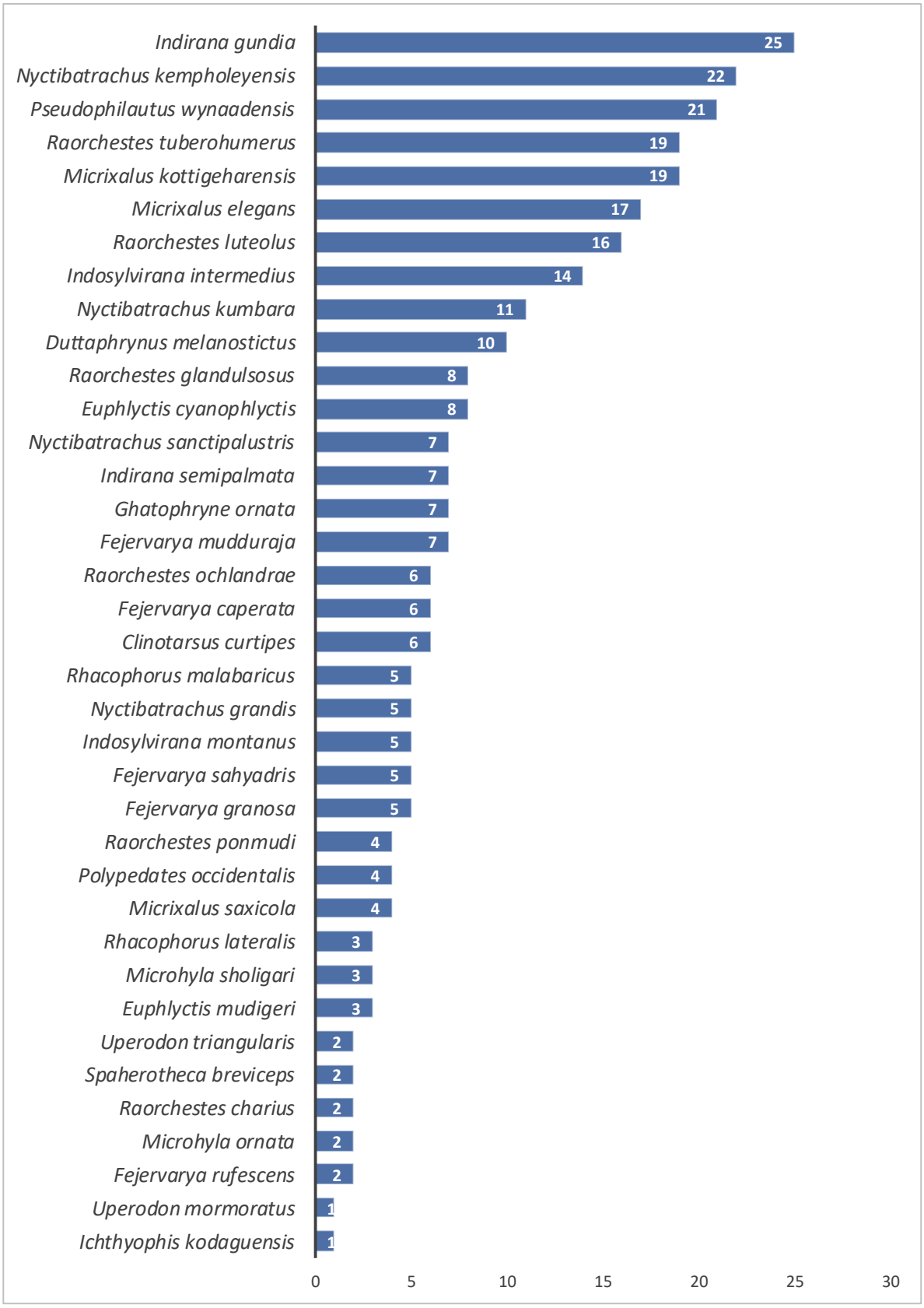


FIGURE 2: Frequency of occurrence of species in all the sampling points.

TABLE 3. Species occurrence from point of survey (distance in meters).

SPECIES	0.0-5.0	5.0-10.0	10.0-25.0	25.0-50.0	50.0-100.0
Duttaphrynus melanostictus		+	+	+	+
Ghatophryne ornata	+	+			
Microhyla ornata		+	+	+	
Microhyla sholigari		+	+	+	
Uperodon triangularis			+	+	
Uperodon mormoratus			+	+	+
Micrixalus elegans	+	+			
Micrixalus saxicolas	+	+			
Micrixalus kottigeharensis	+	+			
Nyctibatrachus kumbara	+				
Nyctibatrachus grandis	+				
Nyctibatrachus kempholeyensis	+				
Nyctibatrachus sanctipalustris	+				
Fejervarya granosa			+	+	+
Fejervarya mudduraja			+	+	+
Fejervarya caperata		+	+	+	
Fejervarya sahyadris	+	+			
Fejervarya rufescens			+	+	+
Euphlyctis cyanophlyctis	+				
Euphlyctis mudigere	+				
Sphaerotheca breviceps		+			
Indosylvirana intermedius	+	+			
Indosylvirana montanus	+	+			
Clinotarsus curtipes	+	+			
Indirana semipalmata	+				
Indirana gundia	+				
Raorchestes ochlandrae	+	+			
Raorchestes luteolus	+	+	+		
Raorchestes tuberohumerus	+	+	+		
Raorchestes charius	+				
Raorchestes glandulosus	+				
Pseudophilautus wynaadensis	+	+			
Raorchestes ponmudi	+				
Rhacophorus malabaricus	+				
Rhacophorus lateralis	+				
Polypedates occidentalis	+				
Ichthyophis kodaguensis	+				
Number of species	**27**	**17**	**11**	**9**	**5**

TABLE 4: Number of species and Conservation Index in the sampling points.

Sampling points	Number of Species	Conservation Index
1	17	237.5
2	13	173
4	10	138.5
5	17	220.5
6	14	186.5
7	10	142
8	14	201.5
9	14	201.5
10	21	265.5
11	8	104.5
12	16	223
13	14	205.5
14	8	122.5
15	6	88.5
16	12	172
17	12	169.5
18	9	142.5
19	8	123.5
20	8	108.5
21	15	175
A	9	134.5
B	5	66.5
C	3	27.5
D	6	69.5
E	2	33.5
F	14	165
G	9	83.5

UNIQUE FEATURES OF SAMPLING POINTS

20 sampling points (SP) were surveyed for study the floristc composition. Most sampling points fall in steep slope terrain. The information regarding uniqueness of each sampling points are given in the following Table 5.

Table 5: Unique features of the plot

SAMPLING POINT	FOREST TYPE	% ENDEMICS	% RET SPECIES
1	Evergreen forest	75.4	23.2
2	Evergreen valley forest	75.6	20.0
4	Evergreen forest	85.7	26.2
5	Semi-evergreen forest	70.0	12.5
6	Evergreen forest	84.3	22.9
7	Evergreen forest	88.6	34.3
8	Evergreen riparian forest	86.7	33.3
9	Evergreen riparian forest	84.0	32.0
10	Moist deciduous forest	50.0	16.7
11	Evergreen forest	89.1	32.8
12	Evergreen forest	74.0	24.0
13	Semi-evergreen forest	76.9	23.1
14	Evergreen forest	86.1	25.0
15	Evergreen forest	88.6	34.1
16	Evergreen forest	76.9	30.8
17	Evergreen forest	73.5	8.8
18	Evergreen riparian forest	70.0	20.0
19	Evergreen riparian forest	46.8	14.9
20	Evergreen riparian forest	73.2	17.9
21	Myristica swamp forest	88.0	28.0

SIGNIFICANT FINDINGS

FLORISTICS

The flora of this area is considerably diverse in terms of taxa, habit and growth forms. There were 254 species within 175 genera of 62 families of angiosperm were recorded.

Among the species documented, 77.17 percent of the species were found to be Western Ghats endemics and 16.93% species are RET (Rare Endangered and Threatened) category. In the entire study area, trees and palms were the major life forms of about 157 species followed by shrubs and herbs (62 species) and least was liana and climbers (35 species) (Figure 3). Among all the species, the highly endemic and threatened species include *Dimorphocalyx beddomei, Dipterocarpus indicus, Dysoxylum malabaricum, Hopea erosa, H. parviflora, H. ponga, Kingiodendron pinnatum, Madhuca neriifolia, Nothopegia beddomei, Psychotria macrocarpa, Syzygium travancoticum, Syzygium zeylanicum and Vateria indica* were found in this relic forest.

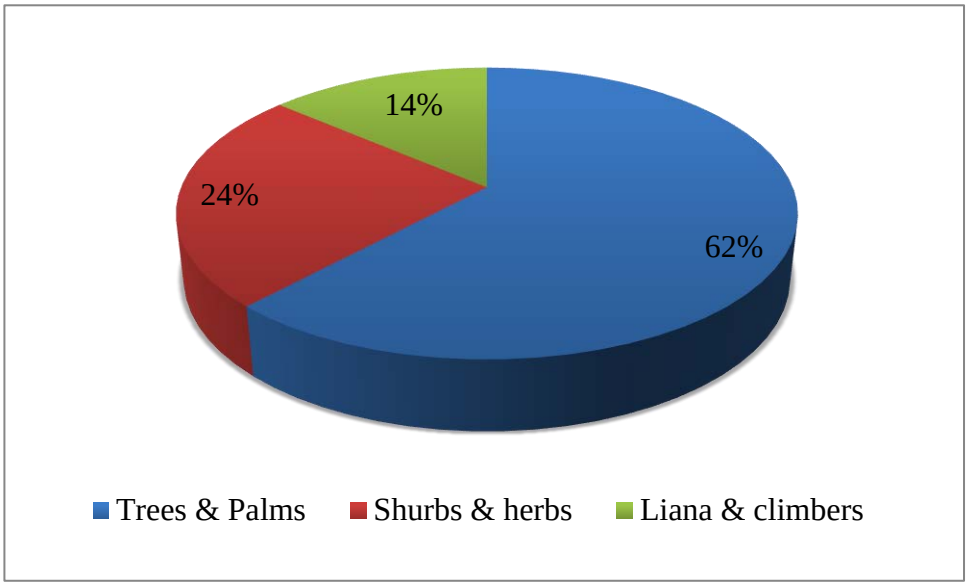


Figure 3: Life form distribution

PHYTOSOCIOLOGICAL ANALYSIS OF TREE PLOTS (GROWING STOCK)

The detailed information on growing stock composition are presented in Table 6. The overall sampling pointwise results on total number angiosperm species were ranged from 12 to 51 with highest number of species were recorded in SP (sampling point) 6 and 20 (51 species) and least was in SP-10 (12 species). The average basal area of all the species of entire sampling points were 134.95 m^2 with maximum basal area was found in SP-7 (480.23 m^2) followed by SP-8 (305.86 m^2), SP-16 (219.52 m^2) and least was in SP-10 (21.35 m^2).

The diversity analysis for each sampling points revealed that, the Number of species (D_{Mn}) and Shannon diversity index were ranged from 2.69 (SP-9) to 7.14 (SP-20) and

from 2.35 (SP-10) to 3.75 (SP-1). The average evenness of the species of all the sampling points were 92.42% with maximum evenness was found in SP-1 (98.01%) indicating all the species are equally abundant in the locality.

The Importance Value Index (IVI) of tree species in the study area represented by *Vateria indica, Lophopetalum wightianum, Dimocarpus longan, Hopea ponga, Kingiodendron pinnatum, Bischofia javanica, Dipterocarpus indicus* and *Elaeocarpus tuberculatus* were found to be most dominant species with respect to IVI value whereas *Cinnamomum macrocarpum, Diospyros sylvatica, Polyalthia fragrans, Knema attenuate, Madhuca neriifolia* (Figure 4).

PHYTOSOCIOLOGICAL ANALYSIS OF REGENERATION

The detailed data of regenerating species are given in the Table 7. The regenerating species represented by 164 species including trees, shrubs, climbers and liana of 115 genera belonging to 44 diverse families with an overall density of 30970 stems/ha. The numbers of species in the identified sampling points were ranging from 14 to 51 plant species. The highest number species of 51, 41 and 38 were recorded in SP-13, SP-1 and SP-11 respectively, however the lowest number of species were recorded in SP-9 (16 species) and SP-21 (14 species).

The diversity analysis of regenerating plots of each sampling point exhibited, the species richness (D_{Mn}) and Shannon diversity index(D) were ranged from 1.53 (SP-9) to 5.29 (SP-13) and from 1.9 (SP-21) to 3.71 (SP-13). The average evenness of the species of all the sampling points were 85.25% with maximum evenness was found in SP-5 (97%). However, the overall evenness in the regenerating plots suggesting that all the species are not equally abundant because regenerating plots are dominated by shrubby species such as, *Psychotria dalzellii, Psychotria flavida, Atalantia racemose, Dichapetalum gelanoides, Ixora nigricans, Memecylon malabaricum,* and *Octotropis travancorica.*

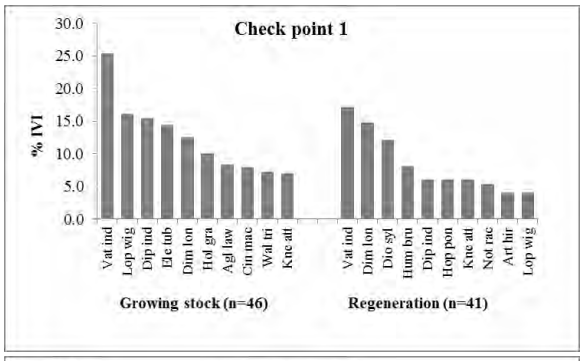
As like tree plot, the IVI of regenerating species followed a similar pattern of dominance where *Vateria indica, Hopea ponga,* ***Dimocarpus longan,*** *Kingiodendron pinnatum, Mesua ferrea* and *Dipterocarpus indicus* were dominants. However, ***Diospyros buxifolia,*** *Knema attenuate* and *Madhuca neriifolia* were the co-dominants species (Figure 4).

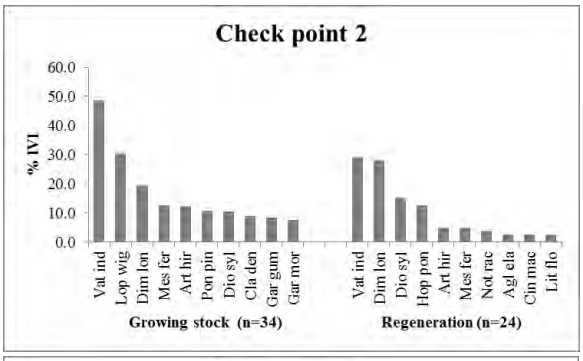
Table 6: Sampling point wise Phytosociological analysis of tree plots (growing stock)

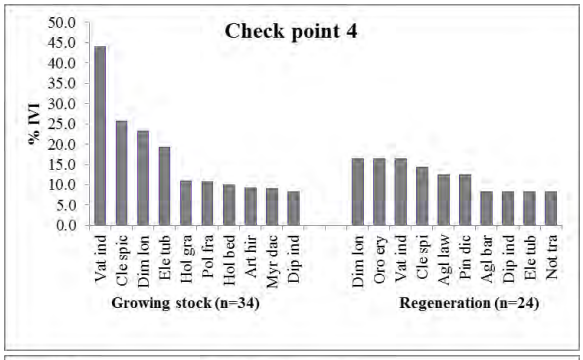
Sampling points	Family	Genus	Species	Species richness	Shannon Index	Simpson index	Evenness (%)	Basal area/ha
1	29	43	46	5.80	3.75	0.03	98.01	68.98
2	21	31	34	4.86	3.39	0.04	96.08	74.72
4	18	30	34	4.19	3.30	0.05	93.63	105.96
5	20	26	31	4.57	3.35	0.04	97.67	41.38
6	22	37	51	5.81	3.73	0.03	94.91	152.28
7	14	22	24	3.15	2.52	0.17	79.17	480.23
8	15	18	18	2.85	2.54	0.11	87.91	305.46
9	13	15	15	2.69	2.39	0.12	88.20	84.28
10	10	10	12	2.83	2.35	0.11	94.62	21.35
11	20	39	41	5.05	3.50	0.04	94.18	189.10
12	18	26	29	4.02	3.15	0.06	93.45	117.29
13	23	38	44	5.46	3.64	0.03	96.26	119.73
14	15	21	23	4.00	3.02	0.06	96.27	89.42
15	17	24	28	4.32	3.19	0.05	95.81	107.21
16	16	23	27	3.86	3.08	0.06	93.40	219.52
17	17	26	28	4.00	3.14	0.05	94.23	84.86
18	18	27	29	3.88	3.16	0.05	93.71	127.49
19	28	35	38	4.45	3.40	0.04	93.43	103.94
20	25	35	51	7.14	3.56	0.03	90.49	58.26
21	14	17	18	3.04	2.66	0.08	92.09	147.60

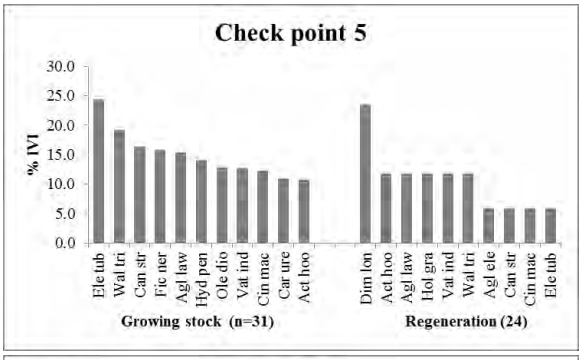
Table 7: Sampling point wise phytosociological analysis of regeneration plots

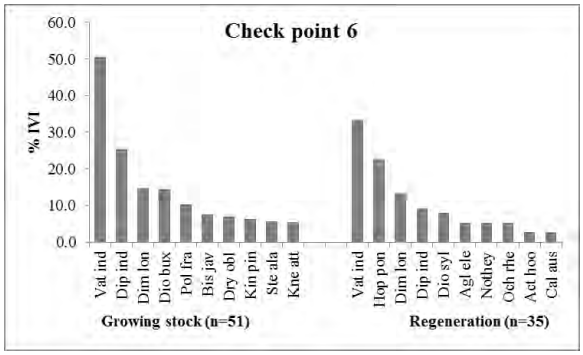
Sampling points	Genus	Species	Family	Species richness	Shannon Index	Simpson index	Evenness (%)
1	37	41	25	2.99	3.11	0.07	84
2	23	24	18	2.25	2.68	0.09	84
4	22	24	14	2.87	2.87	0.07	90
5	22	24	18	3.89	3.09	0.05	97
6	33	35	21	3.38	2.86	0.1	80
7	21	23	13	2.07	2.23	0.2	71
8	19	20	13	1.71	2.27	0.14	76
9	16	16	10	1.53	1.96	0.2	71
10	21	23	21	2.08	2.24	0.2	84
11	32	38	21	3.26	3.19	0.05	88
12	34	36	24	3.73	3.25	0.05	91
13	45	51	28	5.29	3.71	0.03	94
14	28	30	17	3.49	3.27	0.04	96
15	26	27	20	3.82	3.14	0.05	95
16	21	24	17	2.34	2.73	0.08	86
17	22	23	15	2.41	2.78	0.07	89
18	18	21	14	2.38	2.64	0.09	87
19	26	27	20	2.86	2.78	0.09	84
20	30	32	24	4.13	3.23	0.05	79
21	14	14	13	1.55	1.9	0.2	79

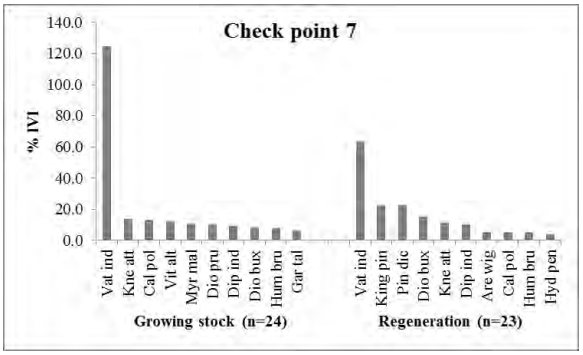

Check point 1
% IVI
Growing stock (n=46)
Regeneration (n=41)

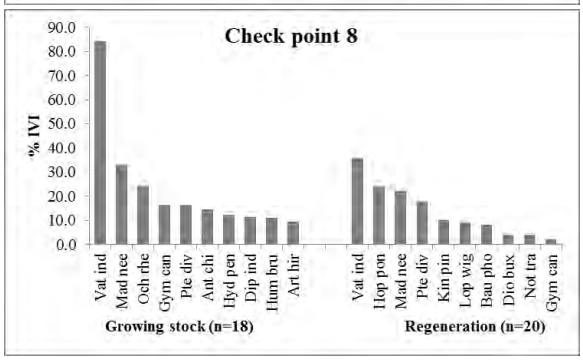

Check point 2
% IVI
Growing stock (n=34)
Regeneration (n=24)

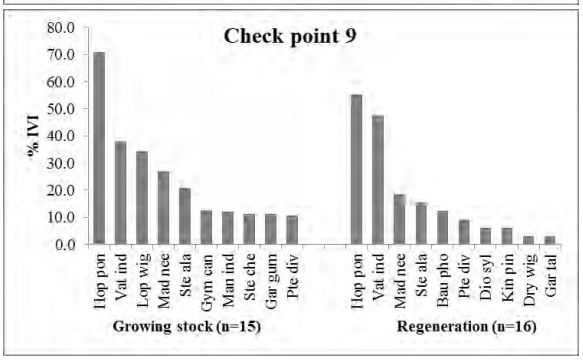

Check point 4
% IVI
Growing stock (n=34)
Regeneration (n=24)

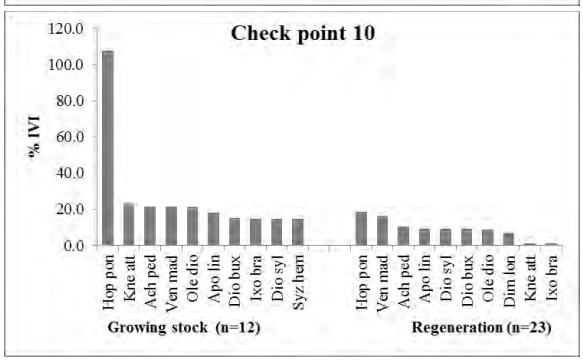

Check point 5
% IVI
Growing stock (n=31)
Regeneration (24)

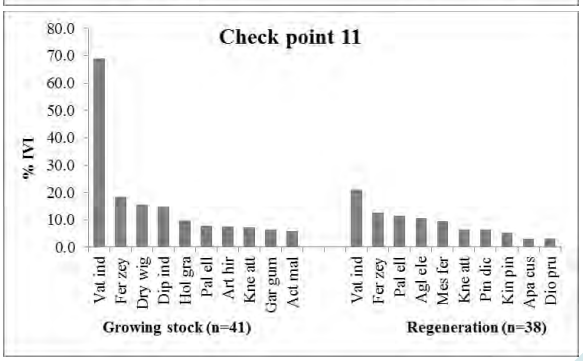

Check point 6
% IVI
Growing stock (n=51)
Regeneration (n=35)


Check point 7
% IVI
Growing stock (n=24)
Regeneration (n=23)


Check point 8
% IVI
Growing stock (n=18)
Regeneration (n=20)


Check point 9
% IVI
Growing stock (n=15)
Regeneration (n=16)


Check point 10
% IVI
Growing stock (n=12)
Regeneration (n=23)


Check point 11
% IVI
Growing stock (n=41)
Regeneration (n=38)

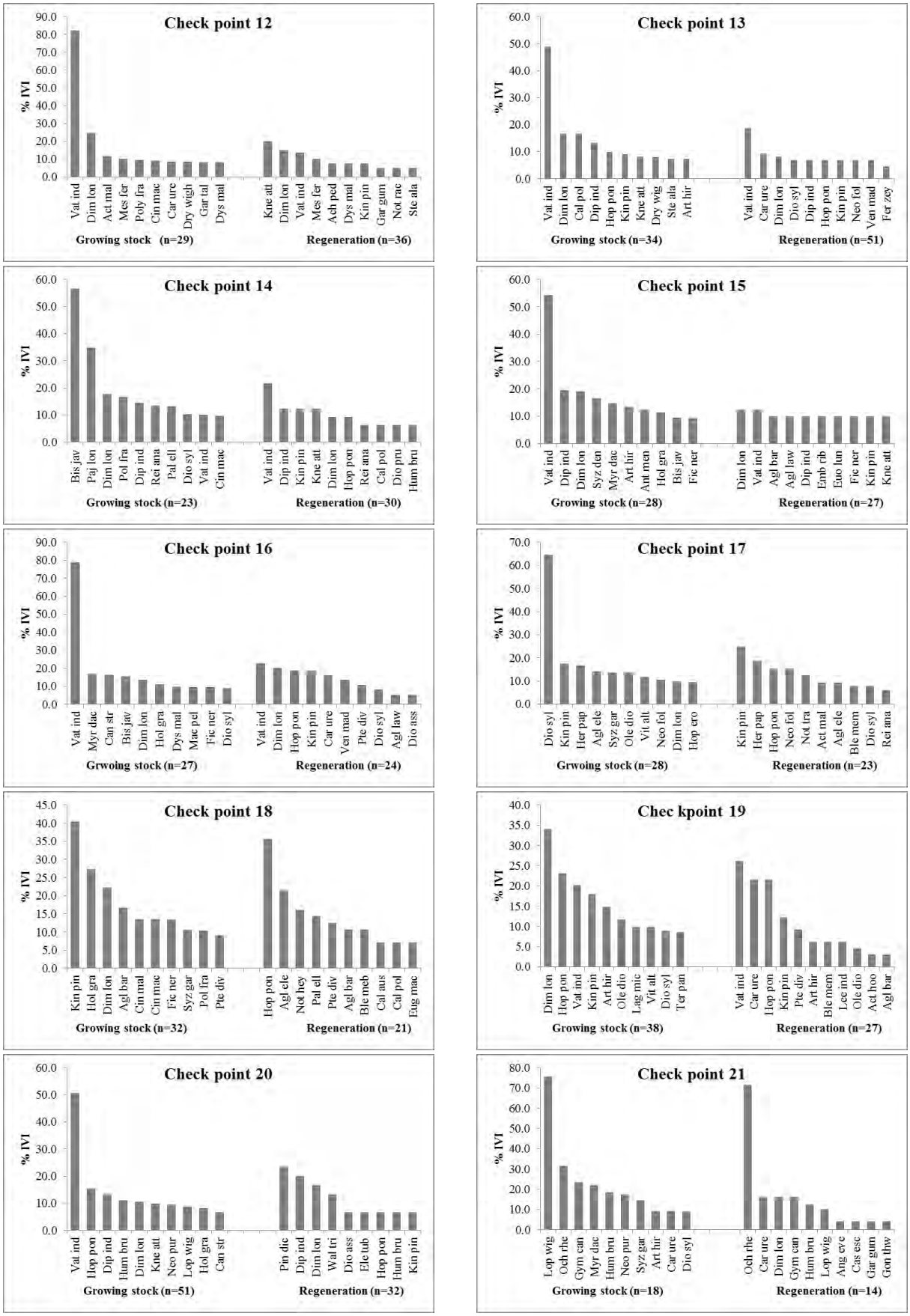


Figure 4: Sampling pointwise dominant species (% IVI) in tree plots and regeneration plots

FISHES

In total ten fish species were sampled in 14 sampling points (they are streams of Kemphole River catchment). Family Cyprinidae was dominant with seven species followed by Balitoridae with three species. First five dominant fish species were *Barilius bakeri* (33.33 %), Nemacheilus sp (17.51 %), Devario malabaricus (14.12%), Bhavania australis (12.99%), and Garra mullya (6.78%). However, across the region where sampling was carried out beyond the specified sampling points there were about 30 species. The details of fish species sampled is presented in Table 8.

Table 8: Details of fish species recorded in sampling points.

Fish Species	IUCN Status	Habit	Posi-tion	Ecol. status	Habitat preference
*Barilius bakeri**	Least concern	Specialist	SD	Common	run, riffle, pool
Barilius canarensis*	Endangered	Specialist	SD	Common	run, riffle, pool
Devario malabaricus*	Least concern	Generalist	SD	Common	run, riffle, pool
Garra mullya*	Least concern	Generalist	BD	Common	run, riffle, pool
Garra stenorhynchus*	Least concern	Specialist	BD	Rare	run, riffle, pool
Haludaria melanampyx	Least concern	Generalist	MCD	Rare	run, pool
Tor khudree*	Endangered	Specialist	MCD	Rare	run, riffle, pool
Balitora mysorensis*	Vulnerable	Specialist	BD	Rare	riffle, cascades
Bhavania australis*	Least concern	Specialist	BD	Common	riffle, cascades
Nemacheilus* spp 1	Not evaluated	Specialist	BD	Common	run, riffle, pools

* Endemic to the WG, SD = Surface dweller, MCD = Mid coloum dweller, BD = Bottom dweller

Figures 5 and 6 present the proportion of fish species and number of species across all the sampling sites. Table 9 presents the list of fish observed across sampled sites. Table 10 presents the number of species across all the sampling sites. The Shannon-Wiener diversity index was 1.89 whereas Simpson index of diversity for this fish community was 0.81. Site-wise description of the sampling species found is discussed in Annexure G.

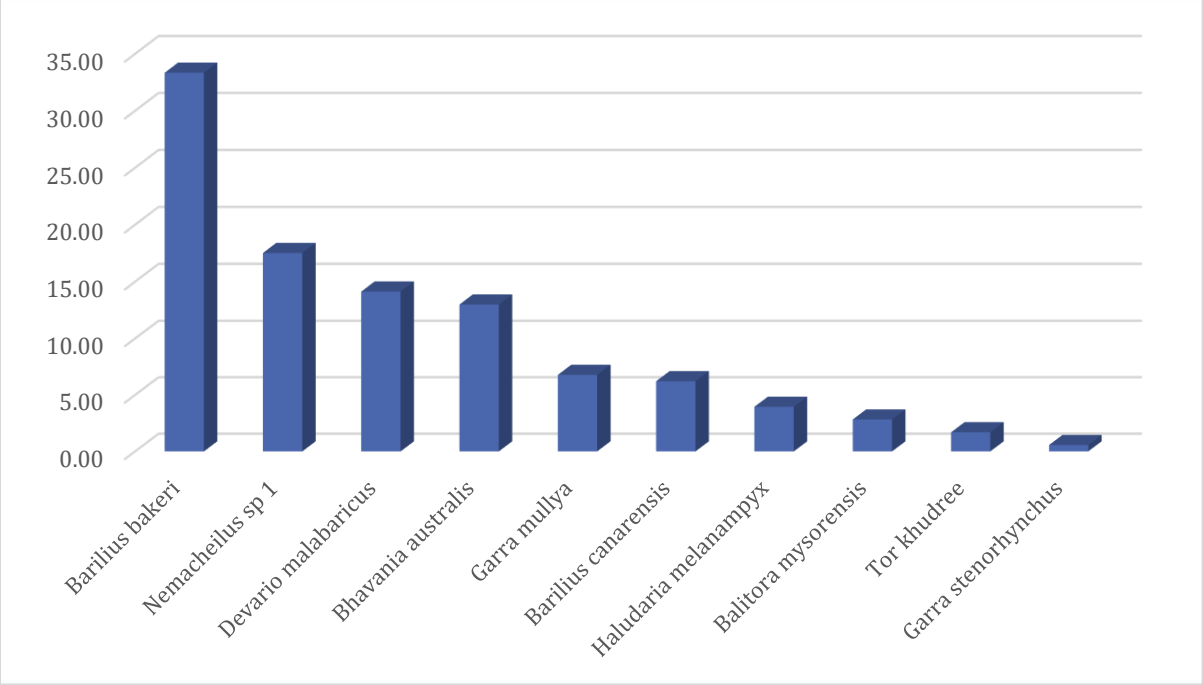


Figure 5: Proportion of fish species across all the sampled points

Figure 6: Number of species per sampling sites.

Table 9: Occurrence of fish species across sample sites (1-21)

SPECIES AND FAMILY	SAMPLING POINTS																				
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21
CYPRINIDAE																					
Barilius bakeri				5				21	15		15	3									
Barilius canarensis								5	5			1									
Devario malabaricus			2					16	7												
Haludaria melanampyx				6				1													
Garra mullya			6					2	1		2	1									
Garra stenorhynchus												1									
Tor khudree								3													
BALITORIDAE																					
Bhavania australis	4			1								4		11			2	1			
Balitora mysorensis												5									
Nemacheilus spp1	5		1					2							2		1	1	4	6	9
FISH COUNT	9		9	12				50	28		17	15		11	2		3	2	4	6	9
RICHNESS	2	0	3	3	0	0	0	7	4	0	2	6	0	1	1	0	2	2	1	1	1

Table 10: Number of species and total fish count across sampled sites.

SAMPLED SITES	NUMBER OF SPECIES PER SITE	FISH COUNT
S.001	2	9
S.002	0	0
S.003	3	9
S.004	3	12
S.005	0	0
S.006	0	0
S.007	0	0
S.008	7	50
S.009	4	28
S.010	0	0
S.011	2	17
S.012	6	15
S.013	0	0
S.014	1	11
S.015	1	2
S.016	0	0
S.017	2	3
S.018	2	2
S.019	1	4
S.020	1	6
S.021	1	9

HABITAT ECOLOGY OF KEY FISH SPECIES

TOR KHUDREE (DECCAN MAHSEER): ENDANGERED - EN

This species is widely distributed in the peninsular rivers. It prefers run, riffle and pool habitat. Juveniles were commonly found preferring shallower run- pool habitat that were rich in dissolved oxygen with gravel substrate. Optimum temperature required for breeding is 10-20 0C. Adults were found occupying deeper pools covered with overhanging vegetation. This species is most sensitive to anthropogenic disturbance (pollution, sand-gravel mining etc.). It is mid-column dweller and omnivorous in diet. Being a migratory fish it usually travels higher stream reaches for feeding and spawning purpose during April-June. Any hydrological regulation (check dams, impoundment) is likely to affect their migration.

Tor khudree, Image by Sudhira H.S.

BARILIUS BAKERI (MALABAR BARIL): LEAST CONCERN -LC

This species is endemic to the Western Ghats region. Found in hill streams, it prefers run, riffle and pool habitat with clear water. It was generally found in gravel and pebble dominated substratum across many sites. It is surface dweller, migrate smaller distance within and across stream habitats and likely to get affected due to any river barrier.

Barilius bakeri

BARILIUS CANARENSIS (JERDON'S BARIL): ENDANGERED - EN

It is found in the southern Karnataka and northern Kerala state. This species was found in site 8, 9 and 13 wherein it utilises riffle, run and pool habitat in shaded environment. This species prefer habitat that are rich in dissolved oxygen, dominated with gravel substrate. Feed on canopy fallen insects. (Insectivores in diet). It is a local migratory fish.

Barilius canarensis Image by Vidisha Kulkarni

DEVARIO MALABARICUS (MALABAR DANIO): LEAST CONCERN - LC

It is the endemic to the WG region and the most abundant fish found in the study sites. Insectivorous in its diet, prefer run, riffle and pools. It is adapted to the disturbed habitat. It is a surface dweller and a migratory fish known to travel smaller distances within and across main river channels and adjacent habitats. It spawns during the April-June season.

Devario malabaricus Image by Mittal Gala

GARRA MULLYA (MULLYA GARRA): LEAST CONCERN - LC

Endemic to the WG region. Generalist in its habit. It was found in most of the sampled river habitats. It is algivorore in its food preference found abundant in run-pool habitats. It is a local migrant. Breeds during June-September.

Garra mullya

GARRA STENORHYNCHUS (NILGIRI GARRA): LEAST CONCERN - LC

Endemic to the WG region. Prefer run, riffle and pools with shaded environment. It was found in rocky and gravel dominated substratum. It is local migrant. Breeding is not known.

Garra stenorhynchus Image by Vidisha Kulkarni

HALUDARIA MELANAMPYX (MELON BARB): LEAST CONCERN - LC

It is one of the most common fish found in WG streams and rivers. I found it in run and pool habitats. Young fish prefer stream edge that are shallower in its depth with least water velocity. It is generalist in habit known to feed on insect, fruits etc. (omnivorous). It is a local migrant. Breeding time is during April-June. For spawning purpose, it prefers water temperature of 22-26 ^{0}C in the control environment.

Haludaria melanampyx

BALITORA MYSORENSIS (SLENDER STONE LOACH): VULNERABLE- VU

It is widely present in hill-streams of Karnataka and Kerala. In the sampled sites, it was only found in riffle & cascades habitats (fast flowing habitat) that were rich in dissolved oxygen. It prefers rocky & gravel substratum found at the headwater region thus a resident fish does not migrate large distance. Breeding information is not known but I found many young ones' in site number 13 in July. It is highly sensitive to disturbance.

Balitora mysorensis Image by Vidisha Kulkarni

BHVANIA AUSTRALIS (WESTERN GHAT'S LOACH): LEAST CONCERN – LC

It is common fish found in the torrential stream habitats of the WG region. It prefers headstream sections dominated with rocky and gravel substratum with adequate vegetation cover. It also prefers clear water with rich dissolved oxygen. Many young ones of this species were observed during sampling period i.e. July-September. It is benthic omnivore in diet.

Bhavania australis Image by Vidisha Kulkarni

***NEMACHEILUS* SP (LOACH):** IUCN STATUS IS NOT AVAILABLE

This is endemic fish to the WG region found abundant in all the sampled sites. It prefers shallower pools dominated with gravel substratum under shaded environment. It is resident fish feeds on detritus and insect larvae. Breeding time is during July-September.

Nemacheilus spp Image by Gururaja K.V.

BIRDS

A total of 81 species of birds, belonging to 35 families were observed. 15 of them were endemic to the Western Ghats. Several nest cavities in trees were observed at the survey sites. The occurrence of bird nest cavities varied with the habitat. The nearest nest was about 1 m and the farthest being about 20 m away from the survey point. Several trees had multiple nest cavities and were invariably large trees with wide girth. 23 of the 81 species are frugivores. They form the key source for the dispersal of seeds and hence regeneration of the forest. 20 of the 81 species have a globally declining population. Two of which is listed as near threatened and one as endangered by the IUCN.

Table 10: List of bird species across different Families.

Family	Species	Scientific name
Accipitridae	Crested Serpent Eagle	*Spilornis cheela*
	Black Eagle	*Ictinaetus malaiensis*
	Short-toed snake Eagle	*Circaetus gallicus*
	Shikra	*Accipiter badius*
	Black Kite	*Milvus migrans*
	Brahminy Kite	*Haliastur indus*
Aegithinidae	Common Iora	*Aegithina tiphia*
Alcedinidae	White Breasted Kingfisher	*Halcyon smyrnensis*
	Stork billed Kingfisher	*Pelargopsis capensis*
	Small blue Kingfisher	*Alcedo atthis*
Apodidae	Indian Swiftlet	*Aerodramus unicolor*
	Alpine Swift	*Tachymarptis melba*
	Asian Palm Swift	*Cypsiurus balasiensis*
Ardeidae	Great Egret	*Ardea alba*
Bucerotidae	Malabar Grey Hornbill	*Ocyceros griseus*
	Malabar Pied Hornbill	*Anthracoceros coronatus*
Campephagidae	Orange Minivet	*Pericrocotus flammeus*
Cisticolidae	Common Tailor Bird	*Orthotomus sutorius*
Chloropseidae	Jerdon's Leafbird	*Chloropsis jerdoni*
	Golden fronted leafbird	*Chloropsis aurifrons*
Columbidae	Western Spotted Dove	*Spilopelia suratensis*
	Grey fronted green Pigeon	*Treron sp.*
	Yellow-footed green Pigeon	*Treron affinis*
	Eurasian Collared Dove	*Streptopelia decaocto*
Cuculidae	Greater Coucal	*Centropus sinensis*
	Lesser Coucal	*Centropus bengalensis*
Corvidae	White bellied Treepie	*Dendrocitta leucogastra*
	Jungle Crow	*Corvus macrorhynchos*
	White- bellied Treepie	*Dicaeum erythrorhynchos*
Dicaeidae	Tickel's Flower Pecker	*Dicrurus paradiseus*
Dicruridae	Greater racket tailed Drongo	*Dicrurus hottentottus*
	Spangled Drongo / Hhair crested Drongo	*Dicrurus aeneus*

	Bronze Drongo	*Lonchura striata*
Estrildidae	White rumped Munia	*Irena puella*
Irenidae	Aisan Fairy-Bluebird	*Turdoides subrufa*
Leiothrichidae	Rufous babbler	*Pomatorhinus horsfieldii*
	Schimittar Babbler	*Pellorneum ruficeps*
	Puff-throated Babbler	*Rhopocichla atriceps*
	Dark fronted Babbler	*Psilopogon viridis*
Megalaimidae	White cheeked Barbet	*Psilopogon haemacephalus*
	Copper Smith Barbet	*Psilopogon malabaricus*
	Malabar Barbet	*Psilopogon zeylanicus*
	Brown headed Barbet	*Merops orientalis*
Meropidae	Small green Bee-eater	*Motacilla cinerea*
Motacillidae	Grey Wagtail	*Motacilla madaraspatensis*
	White browed Wagtail	*Motacilla flava*
	Yellow Wagtail	*Myophonus horsfieldii*
Muscicapidae	Malabar Whistling Thrush	*Copsychus saularis*
	Oriental Magpie Robin	*Cyornis pallipes*
	White-bellied blue flycatcher	*Muscicapa dauurica*
	Asian brown flycatcher	*Cinnyris asiaticus*
Nectariniidae	Purple Sunbird	*Nectarinia minima*
	Crimson backed Sunbird	*Nectarinia zeylonica*
	Purple rumped Sunbird	*Nectarinia lotenia*
	Loten's Sunbird/ Long-billed Sunbird	*Arachnothera longirostra*
	Little Spiderhunter	*Oriolus oriolus*
Oriolidae	Golden oriole	*Alcippe poioicephala*
Pellorneidae	Brown Cheeked Fulvetta	*Microcarbo niger*
Phalacrocoracidae	Little Cormorant	*Gallus sonneratii*
Phasianidae	Grey Jungle Fowl	*Galloperdix spadicea*
	Red Spurfowl	*Picoides nanus*
Picidae	Pygmy Woodpecker	*Hemicircus canente*
	Heart Spotted Woodpecker	*Chrysocolaptes guttacristatus*
	Greater Flameback	*Dinopium javanense*
	Common Flameback	*Dinopium benghalense*
	Lesser flameback Woodpecker	*Psittacula columboides*
Psittaculidae	Malabar Parakeet	*Loriculus vernalis*
	Vernal Hanging Parrot	*Iole indicIole indicaa*
Pycnonotidae	Yellow Browed Bulbul	*Pycnonotus jocosus*
	Red Whiskered Bulbul	*Pycnonotus gularis*
	Flame throated Bulbul	*Pycnonotus luteolus*
	White-browed Bulbul	*Pycnonotus priocephalus*
	Grey headed Bulbul	*Sitta frontalis*
Sittidae	Velvet fronted Nuthatch	*Gracula indica*
Sturnidae	Southern Hill Myna	*Hemipus picatus*
Tephrodornithidae	Barwinged flycatcher shrike	*Harpactes fasciatus*
Trogonidae	Malabar Trogon	*Zosterops palpebrosus*
Zosteropidae	Oriental White Eye	

OBSERVATIONS AT SAMPLING POINTS

SAMPLING POINT 1

With a great diversity, this point had 30 species of birds. 11 species among them have declining population trends mainly due to the ongoing deforestation. 10 species of frugivores were found. Frugivores are also known to be the architects of the forests. They play a vital role in regeneration of forests. Species like the Malabar grey hornbill found in most of these points are tree hole nesters which prefer trees with a large canopy and larger trunks. Species such as the heart spotted woodpeckers are of rare sighting. They seem to have gone extinct from Bangladesh.

Key sightings: Crested serpent eagle, Black eagle, heart-spotted woodpecker

SAMPLING POINT 3

16 species of birds were identified at this point. Several species have not been evaluated for their population trends. Any further damages will lead to increase in the knowledge gap about these species.

Key sightings: Short-toed snake Eagle, Crested serpent eagle

SAMPLING POINT 4

20 species of birds were identified. Species like Malabar whistling thrush which is endemic to the Western Ghats are found at this point as well nest in cavities on the stream side. Damage to the streams will lead to loss in nesting sites for such birds.

Key Sightings: Malabar Whistling thrush, Crested serpent eagle, Malabar parakeet

SAMPLING POINT 5

18 species of birds were identified, 8 of which have a globally declining population trend. Several of them are insectivorous. These birds help in keeping a control on the insect population.

Key Sightings: Black eagle, White-bellied treepie, Malabar parakeet, Asian fairy-blue bird

SAMPLING POINT 6

50 species of birds were identified, 12 of which have a globally declining population trend. Species such as Malabar barbet, Malabar grey hornbill, Coppersmith barbet require large trees to nest. Habitat loss will lead to further decline in their population. This site also has active nest holes of hornbills.

Key findings: Crested serpent eagle, Shikra, Fairy blue bird, Grey jungle fowl, Bar-winged flycatcher shrike, Malabar pied hornbill

SAMPLING POINT 7

13 species of birds were identified. Species such as the Greater flameback have a declining population trend. They are responsible in creating nest holes for species like mynas. They require trees with large and strong trunks.

Key findings: Asian fairy blue bird, Greater flameback, Stork billed kingfisher

SAMPLING POINT 8

14 species of birds were identified. Grey headed bulbul found in this site is near threatened and owing to the habitat loss the population seems to be declining further.

Key findings: Grey headed bulbul, Black eagle, Heart spotted woodpecker

SAMPLING POINT 9

16 species of birds were identified. Large raptors such as Black eagle require trees with large canopies in order to build nests. Any loss in trees will affect their nesting behavior greatly.

Key findings: Black eagle, Malabar Parakeet, Grey headed bulbul.

SAMPLING POINT 10

29 species of birds were identified. Indian swiftlets are birds which nest in caves or under large rocks. They build nests using mud and saliva and spend most of their lives in flight. Any damage to their nesting sites will lead to further decline in their population.

Key findings: White bellied blue flycatcher, Indian swiftlet, Malabar parakeet

SAMPLING POINT 11

14 species of birds were identified. Grey headed bulbul is listed as near threatened species by the IUCN and is endemic to the Western Ghats. Owning to the habitat destruction the population is under great pressure.

Key findings: Grey headed bulbul, White-bellied treepie, Greater racket tailed drongo

SAMPLING POINT 12

11 species of birds were identified. Two key woodpeckers, the greater flameback and the common flameback is found here. Common flameback is very rarely sighted. Woodpeckers help in controlling the insect population.

Key findings: Greater flameback, Common flameback

SAMPLING POINT 13

10 species of birds were identified. Dark fronted babblers found in this sight are endemic to Western Ghats and Sri Lanka. They nest in small bushes. Under growth and leaf litter plays a vital role in supporting the insect population.

Key findings: Grey Wagtail, dark fronted babbler, Short- toed snake eagle

SAMPLING POINT 14

9 species of birds were identified. Although the endemic species like the Malabar barbet is adaptable and survives well in plantations and farmed areas, the population is nevertheless suspected to be undergoing some declines owing to ongoing habitat destruction and fragmentation.

Key findings: Greater flameback, Malabar parakeet

SAMPLING POINT 15

11 species of birds were identified. White bellied blue flycatcher is always a rare sighting. Being insectivorous in nature they help in controlling the insect population. Their population seems to be decreasing globally.

Key findings: Flame throated Bulbul, White-bellied blue flycatcher

SAMPLING POINT 16

13 species of birds were identified. Greater racket tailed drongos are knows to be the mimicking artists. They can mimic upto 30 calls of different birds, using them as a defense strategy to protect their nests as well as other nests from predatory birds or animals.

Key findings: Greater flameback, Asian brown flycatcher

SAMPLING POINT 17

13 species of birds were identified. 6 of them have a globally declining population trend owing to habitat loss. Red spur fowl are ground swelling species that feed mostly on worms and insects.

Key findings: Red spurfowl, Brown cheeked fulvetta

SAMPLING POINT 18

13 species of birds were identified. 6 amongst them are endemic to Western Ghats. Birds such as sunbirds which feed on nectar in plants are responsible in pollination.

Key findings: Malabar Whistling thrush, Crimson backed sunbird

SAMPLING POINT 19

13 species of birds were identified. Two species of hornbills, the Malabar pied and Malabar grey hornbills were found here. Malabar pied hornbill is responsible in dispersal of seeds of Strychnos nux-vomica which is poisonous to many vertebrates.

Key findings: Malabar trogon, Malabar pied hornbill, Malabar Grey hornbill

SAMPLING POINT 20

20 species of birds were identified. 8 of them have a globally declining population trend. Grey headed are rare birds which are hard to be spotted. Majority of their diet consists of fruits.

Key findings: Black eagle, Dark fronted babbler, grey headed bulbul, Jerdon's leafbird

SAMPLING POINT 21

30 species of birds were identified. Grey Jungle Fowl which is an endangered species is found in this site. They are threatened by hunting for food and habitat loss.

Key findings: Grey jungle fowl, Crested serpent eagle, Vernal hanging parrot

DISCUSSIONS

AMPHIBIANS

This survey has listed 37 species of amphibians from the region with 36 species frogs and toads and one species of caecilian. Of the 37 species, 33 species are endemic to the Western Ghats, which clearly indicates the exclusive species composition of the region. In 1937, 12 new species to science were described (Rao, 1937) and few of them were re-discovered in 2011 (Gururaja et al, 2011). The list of species observed is based on multiple visits and systematic sampling between May to October 2016, however, it is felt that the list is non-exhaustive and needs a minimum of two more seasonal surveys. The presence of critically endangered species like *Indirana gundia* (Semi-aquatic), *Micrixalus kottigeharensis* (Aquatic) and *Raorchestes ponmudi* (Arboreal) indicates the diverse habitats and presence of micro-habitat for these species. Presence of 27 species within 0-5m from stream in a clear indication of stream dependency in these amphibians.

Amphibian richness in the study area clearly indicates

- Perennial streams
- Diverse micro-habitats
- Closed canopy
- Least human impacts in the area.

The conservation index as well as presence of critically endangered species categorically explains this aspect. The sites with a conservation index value of 100 or above needs to be prioritized for conservation. This means that all the sampling points (1-21) provided by JICA possess not only high number of species but also holds critically endangered, stream dependent and endemic species of amphibians of the Western Ghats. Hence, any modification in any of the streams and/or micro-habitats and/or canopies without proper mitigation measures can be detrimental in-order to maintain the current amphibian richness.

FLORA

Among the species documented, 77.17 % of the species were found to be Western Ghats endemics and 16.93% species are RET (Rare Endangered and Threatened) category.

Among all the species, the highly endemic and threatened species include *Dimorphocalyx beddomei, Dipterocarpus indicus, Dysoxylum malabaricum, Hopea erosa, H. parviflora, H. ponga, Kingiodendron pinnatum, Madhuca neriifolia, Nothopegia beddomei, Psychotria macrocarpa, Syzgygium travancoticum, Syzygium zeylanicum and Vateria indica* were found in this relic forest.

The evergreen forest is multi-storeyed forest in which top stratum is represented by tall evergreen trees in association with giant woody climbers (liana). The tall trees like *Vateria indica, Dipterocarpus indicus, Dysoxylum malabaricum, Kingiodendron pinnatum, Lophopetalum wightianum, Bischopia javanica* etc., are common in the forests. The woody climbers like *Ventilago madarapatana, Gnetum ula, Combretum latifolium, Embelia ribes, Bauhinia phoenecia* are formed a canopy in association with the major trees. The canopy cover in these forest areas is 85-90%.

The regenerating species represented by 164 species including trees, shrubs, climbers and liana of 115 genera belonging to 44 diverse families with an overall density of 30970 stems/ha. Species such as *Vateria indica, Hopea ponga, Dimocarpus longan, Kingiodendron pinnatum* and *Palquium ellipticum* were found in highest density throughout the forest. However, these species along with endemic species like *Dipterocarpus indicus* and *Gymnacranthera canarica* were also found most dominant and frequently occurring species in the forest.

The regenerating plots suggested that all the species are not equally abundant because regenerating plots are dominated by shrubby species. As like tree plot, the IVI of regenerating species followed a similar pattern of dominance where *Vateria indica, Hopea ponga,* ***Dimocarpus longan,*** *Kingiodendron pinnatum, Mesua ferrea* and *Dipterocarpus indicus* were dominants. In all, the floristics does establish the importance of the habitat and status based on the higher degree of composition of endemic species.

FISHES

In the entire region, approximately 30 fish species were found across all the sampling sites. The current threatened status as per the IUCN criteria indicated that 1 species each as 'Critically Endangered' & 'Data deficient', 2 species were 'Endangered', 3 species were 'Vulnerable' category and more than 15 species were 'Least concern' (Dahanukar et al. 2013). Since many fishes' spawn during onset of monsoon, they prefer least disturbed

stream reaches for breeding purpose which often are rich in dissolved oxygen, river substratum with adequate canopy cover. Critically endangered species such as Wynaad mahseer prefer shallow as well as deeper pools for feeding & breeding purpose. This indicates that fishes have been utilizing diverse habitats depending upon their life-stages. In the present study, this species was present only at two sites i.e. Abibru hole and Shiradi gadi. Similarly, other sites with presence of threatened species demand a high level of conservation measures. Most generalist species found at lower elevation floodplain area are specially adapted due to their life-history strategies making them adapt to varied environments (low, medium & high disturbance areas). Species in this general category include, *Devario malabaricus*, *Rasbora daniconius*, *Garra mullya*, *Xenentodon cancila*.

The current study only document species list. The data on species abundance forms a backbone of any ecological study. Such information aid in making population level assessment of key indicator species. Future studies should incorporate this information for every species.

One of the threats with any anthropogenic intervention in these habitats is the increase in turbidity and sedimentation in these streams. Most of the endemic fishes are sensitive to the anthropogenic disturbance such as stream habitat alteration in the form of removal of river substrate, riparian vegetation and pollution. Removal of riparian vegetation is known to hasten soil erosion. Thus, sediment flow in the streams is likely to affect navigation ability of many migratory stream fishes. Heavy sediment is also change water quality, decreases dissolved oxygen and modify prime river habitat (gravel bed changes into muddy habitat with sediment cover). Fishes responds differently to the water quality & stream related characteristics (Matthews 1998). For instance, headwater stream fishes are mostly habitat specialist feed on canopy insect, detritus and benthic insect. These fishes require rich dissolved oxygen, dense canopy cover and adequate substratum for feeding & breeding. The sampling points 1, 4, 12, 14, 17, 18 have habitat specialist fishes such as *Balitora mysorensis* and *Bhavania australis*. High level of precautionary measures with minimum damage to the stream habitat is therefore required. Selective logging or narrow strip cutting might cause minimum damage to the stream habitat.

The presence of dams is a cause of concern as they are a barrier for fish migration. Only after detail site inventory, constructing a fish passage structure and adopting required

measures would be useful for migratory fish species like *Tor khudree* at sampling point 8.

Though the study was conducted for a short duration, the results suggest that the stream fish fauna was approximately 10 % of the total WG's fish fauna (330 species) known so far. But, in terms of endemism it represents more than 20 % of the endemic fish fauna of the WG region (89 species). The higher degree of endemism again warrant conservation oriented action.

BIRDS

With about 18% of the bird species endemic, two near threatened and one endangered species being observed in the study, the region does gather significance in terms of conservation priorities. Further, with about 25% of them having a globally declining trend, threat to the habitat at large could be potentially regressive. With 23 of 81 species being frugivores, they play a key role in dispersal of seeds and hence regeneration of the forests.

MITIGATION MEASURES

We foresee the following alterations to the existing habitats; however, this may not be exhaustive list:

1. Habitat modification (Conversion)
2. Habitat fragmentation
3. New Access Roads
4. Dumping yards
5. Stream degradation
6. Stream diversion
7. Heavy Vehicle traffic during construction
8. Increased frequency of vehicles
9. Human settlement (temporary vs. permanent)
10. Pre- and post-project impacts

Adaptive management plans considering the feedback on successes and failures of ongoing management practices are strongly recommended. It should incorporate new information that becomes available over time, to modify and adapt management plans. Some of the earlier research in the Western Ghats on the impacts of habitat fragmentation, selective logging, land-use land-cover changes, mining and disturbance, roads, and large dams on amphibian diversity and distribution, indicated significant negative impacts (Vasudevan, 2000; Vasudevan et al 2001; Vijayakumar et al 2001; Gururaja, 2002; Krishnamurthy 2003; Ramachandra et al 2007; Gururaja et al 2008; Seshadri et al 2009; Seshadri and Ganesh, 2011; Aravind and Gururaja 2011; Naniwadekar and Vasudevan, 2014; Seshadri 2014). Similar negative impacts about fish in the Western Ghats are detailed in Bhat, 2003; Sreekantha etal 2007; Dahanukar et al 2011. We propose below a list of mitigation measures based on previous studies in this region (above references) and elsewhere in the world (Pilliod and Wend, 2008; Dodd Jr, 2010), however a detailed environmental impact assessment is required to arrive at more systematic mitigation plans.

1. Habitat modification or conversion is one among the major threats to endemic amphibians of the Western Ghats. Mitigation measures suggested for habitat

modification or conversion is to maintain immediate surroundings of a converted habitat as a buffer zone with least use. This reduces edge effects on amphibians.

2. Habitat fragmentation or attrition that happens during the construction phase will lead to extinction of a frog population locally. The fragmentation must be to the least possible measure. To maintain the connectivity with the fragmented habitats native species of trees or with bridges and tunnels must be constructed to allow easy movement of amphibians.
3. Find alternative routes if the proposed alignment is going through intact forest patches. This might escalate financial burden on the proponents of the project; however, the damage to ecosystem by constructing through intact forests are much more than the financial equations. In the present study, areas on the right side of the highway (Kadumane estate) can be looked at as an alternative plan.
4. Construction activity must be carried out in the lean period of activity for amphibians.
5. It would also be useful to limit the road construction adjacent to hill-streams particularly for fishes and amphibians.
6. Access roads and new roads that are not in use should be deactivated or abandoned after their stipulated usage. This should be carried out in a systematic manner (replanting, removal of asphalt, and so on) and without leaving any trace of construction mark.
7. Tunnels (underpasses) and fencing, specifically designed for amphibians, must be installed to help in easy movement of amphibians across roads and streams. These structures should also be installed in known cross over regions along amphibian corridors (streams/wetlands); places of frequent roadkills and heavy traffic areas. Design culverts, underpasses, and overpasses to accommodate a variety of species.
8. During construction, minimize the use of contaminants (e.g. salts, petrochemicals, and herbicides) and unnecessary spill overs. It is highly recommended to use materials that are biodegradable. There shall not be any dumping of muck and debris of construction materials in streams and forest valleys. Utmost care should be taken in construction activities near streams to minimize any damage to amphibians, in particular, and stream ecosystem in general.

9. There must be a systematic and objective monitoring of activities during construction phase and operation phase. Monitoring should not be biased towards construction and it should be done to minimize damage to ecosystem.
10. Settlements for construction workers should be eco-friendly and must be dismantled immediately after stipulated use.

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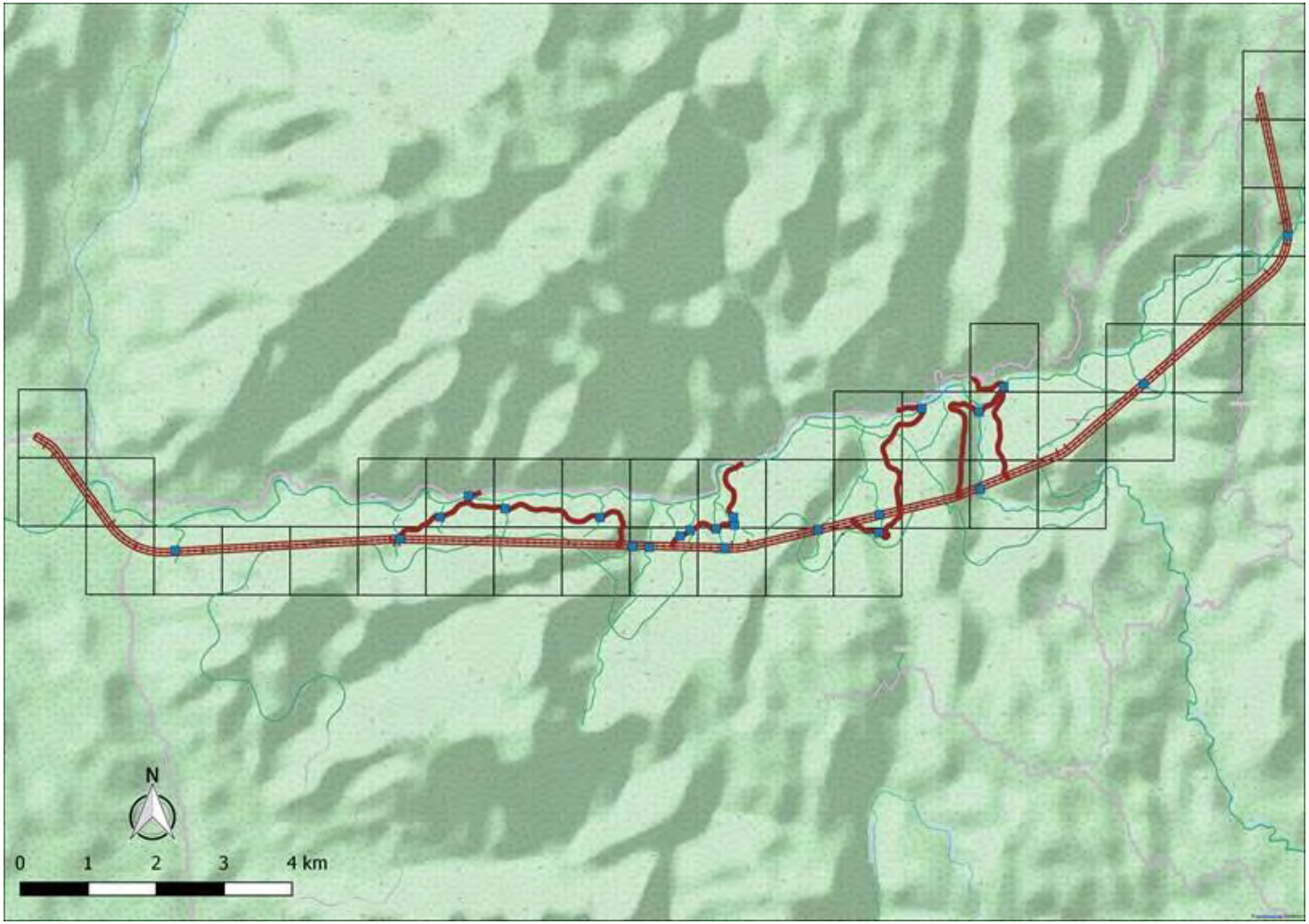
REFERENCES

1. Dodd Jr. CK. 2010. Amphibian Ecology and Conservation: A Handbook of Techniques. Oxford University Press.
2. Duellman WE and Trueb L. 1994. Biology of Amphibians. Johns Hopkins University Press
3. Frost DR. 2016. Amphibian Species of the World: an Online Reference. Version 6.0 (Date of access). Electronic Database accessible at http://research.amnh.org/herpetology/amphibia/index.html. American Museum of Natural History, New York, USA.
4. Aravind NA and Gururaja KV. 2011. Amphibians of the Western Ghats. Commissioned paper for Western Ghats Ecology Expert Panel, MoEF.
5. Bhat, A. 2003. Diversity and Composition of Freshwater Fishes in River Systems of Central Western Ghats, India. Environmental Biology of Fishes, 68:25-38.
6. Sreekantha, Subash Chandran MD, Divakar KM, Rao GR, Gururaja KV and Ramachandra TV. 2007. Fish diversity in relation to landscape and vegetation in central Western Ghats, India. Current Science, 92(11):1592–1603.
7. Dahanukar, N., Raghavan, R., Ali, A., Abraham, R. and Shaji, C.P., 2011. The status and distribution of freshwater fishes of the Western Ghats. The Status and Distribution of Freshwater Biodiversity in the Western Ghats, India, 3, pp.21-48.
8. Gururaja KV. 2002. Effect of habitat fragmentation on diversity and ecology of some anurans in the central Western Ghats of India. Phd Thesis. Kuvempu University.
9. Gururaja KV, Sameer Ali and Ramachandra TV. 2008. Influence of land-use changes in river basins on diversity and distribution of amphibians. In: Environment Education for Ecosystem Conservation (Ed. T.V. Ramachandra). Capital Publishing Company, New Delhi. Gururaja KV, Dinesh KP and Biju SD. 2011. In search of Rao's lost species. http://www.lostspeciesindia.org/LAI2/blog.php
10. Gururaja KV. 2012. Pictorial guide to frogs and toads of the Western Ghats. Gubbi Labs Publication. 154+xviii pages, ISBN 978-81-924461-0-3
11. Heyer WR, Donnelly MA, McDiarmid RW, Hayek LC, Foster MS. 1994. Measuring and Monitoring Biological Diversity: Standard Methods for Amphibians. Smithsonian Institution Press.

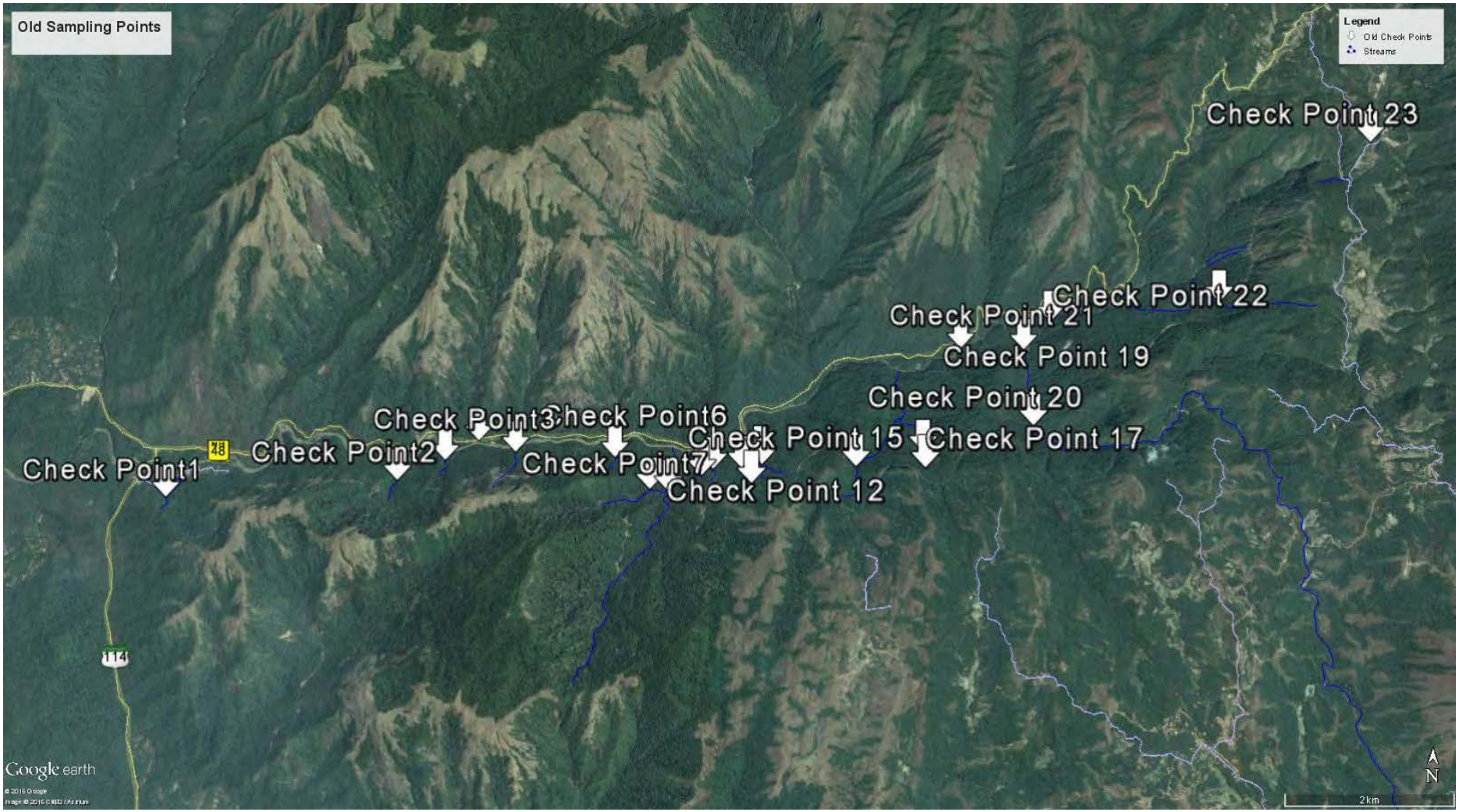
12. Krishnamurthy SV. 2003. Amphibian assemblages in undisturbed and disturbed areas of Kudremukh National Park, central Western Ghats,India. Environ. Conserv. 30: 274 –282
13. McDiarmid RW and Altig R. 1999. Tadpoles: The biology of anuran larvae. The University of Chicago Press.
14. Rao CRN. 1937. On some new forms of Batrachians from S. India. Proceedings of the Indian Academy of Sciences - Section B (1937) 6: 387. doi:10.1007/BF03051434
15. Sutherland WJ. 2006. Ecological Censusing Techniques: A handbook (2e). Cambridge University Press.
16. The IUCN Red List of Threatened Species. 2016-2. < http://www.iucnredlist.org/>
17. Brosse, S., O. Beauchard, S. Blanchet, H. H. Dürr, G. Grenouillet, B. Hugueny, C. Lauzeral, F. Leprieur, P. A. Tedesco, S. Villéger & T. Oberdorff, 2013. Fish-SPRICH: a database of freshwater fish species richness throughout the World. Hydrobiologia 700(1):343-349 doi:10.1007/s10750-012-1242-6.
18. Buisson, L., W. Thuiller, S. Lek, P. U. Y. Lim & G. Grenouillet, 2008. Climate change hastens the turnover of stream fish assemblages. Global Change Biology 14(10) doi:10.1111/j.1365-2486.2008.01657.x.
19. Dahanukar, N. & R. Raghavan, 2013. Freshwater fishes of the Western Ghats: Checklist v1.0 August 2013. Min 01:6-16.
20. Naniwadekar R and Vasudevan K. 2014. Impact of dams on Riparian frog communities in the southern western ghats, India. Diversity. 6, 567-578; doi:10.3390/d6030567
21. Higgins, C. L. & G. R. Wilde, 2005. The Role of Salinity in Structuring Fish Assemblages in a Prairie Stream System. Hydrobiologia 549(1):197-203 doi:10.1007/s10750-005-0844-7.
22. K. Rema Devi, T. J. Indra, B.E. Yadav, M. B. Raghunatahn, S. K. & & S. S. Jadhav, 2013. Freshwater fishes In 'State Fauna Series. Fauna of Karnataka' In Editor-Director, Z. S. I. (ed) State Fauna Series. vol 21. Zoological Survey of India, Kolkata, 1-595.
23. Kumar, R. & K. R. Devi, 2013. Conservation of freshwater habitats and fishes in the Western Ghats of India. International Zoo Yearbook 47(1):71-80 doi:10.1111/izy.12009.
24. Lévêque, C., T. Oberdorff, D. Paugy, M. L. J. Stiassny & P. A. Tedesco, 2008. Global diversity of fish (Pisces) in freshwater. In Balian, E. V., C. Lévêque, H. Segers & K. Martens (eds) Freshwater Animal Diversity Assessment. Developments in Hydrobiology, vol 198. Springer Netherlands, 545-567.
25. Matthews, M. J., 1998. Patterns in freshwater fish ecology. Kluwer Academic publisher., Massachusetts, USA.
26. McGill, B. J., M. Dornelas, N. J. Gotelli & A. E. Magurran, 2015. Fifteen forms of biodiversity trend in the Anthropocene. Trends in Ecology & Evolution 30(2):104-113 doi:http://dx.doi.org/10.1016/j.tree.2014.11.006.
27. Molur, S., Priyanka Iyer, Neelesh Dahanukar & Rajeev Raghavan, 2014. Protected area analysis with respect to freshwater biodiveristy and reptile assessment & development of National Policy for inclusion in legilslation. Zoo Outreach Organization, Coimbatore, India, 136.
28. Muneepeerakul, R., J. S. Weitz, S. A. Levin, A. Rinaldo & I. Rodriguez-Iturbe, 2007. A neutral metapopulation model of biodiversity in river networks. Journal of

Theoretical Biology 245(2):351-363 doi:http://dx.doi.org/10.1016/j.jtbi.2006.10.005.
29. Rao, S., 2016. Responses of stream fish assemblages to small hydro-power induced flow alteration in the Western Ghats, India. A thesis submitted to the Tata Institute of Fundamental Research, Mumbai.
30. Ramachandra TV, Subash Chandran MD, Gururaja KV and Sreekantha. 2007. Cumulative Environmental Impact Assessment. Nova Science Publication, USA.ISBN 978-15-945495-1-9
31. Ricciardi A, J. B. R., 1999. Extinction rates of north American freshwater fauna. Conservation Biology 13:1220-12222 doi:10.1046/j.1523-1739.1999.98380.x.
32. Seshadri KS. 2014. Effect of historical selective logging on anuran communities in a Wet evergreen forest, South India. Biotropica. 10.1111/btp.12141
33. Seshadri KS, Amit Yadav and Gururaja KV. 2009. Road kills of amphibians in different land – uses from central Western Ghats, India. Journal of Threatened Taxa, 1(11): 549-552.
34. Seshadri KS and Ganesh T. 2011. Faunal mortality on roads due to religious tourism across time and space in protected areas: A case study from south India. Forest Ecology and Management. 262: 1713-1721. http://dx.doi.org/10.1016/j.foreco.2011.07.017
35. Theophilus, E., 2014. Headwater Extictions- Hydropower projects in the Himalayan reaches of the Ganga and the Beas: A closer look at impacts on fish and river ecosystems. SANDRP, New Delhi, 80.
36. Vasudevan, K. Amphibian species assemblages of the Wet evergreen forests of southern Western Ghats of India and the effect of forest fragmentation on their diversity. PhD thesis, Utkal University.
37. Vasudevan, K., A. Kumar, and R. Challam. 2001. Structure and composition of rainforest floor amphibian communities in Kalakkad Mundanthurai tiger reserve. Current Science, 80(3): 406-412.
38. Vijayakumar, S. P., K. Vasudevan, and N. M. Ishwar. 2001. Herpetofaunal mortality on roads in the Anamalai hills, southern Western Ghats. Hamadryad, 26(2): 265-272.
39. Whitney, J. E., K. B. Gido, E. C. Martin & K. J. Hase, 2015. The first to arrive and the last to leave: colonisation and extinction dynamics of common and rare fishes in intermittent prairie streams. Freshwater Biology:n/a-n/a doi:10.1111/fwb.12668.
40. Zhong, Y. & G. Power, 1996. Environmental impacts of hydroelectric projects on fish resources in China. Regulated Rivers: Research & Management 12(1):81-98 doi:10.1002/(SICI)1099-1646(199601)12:1<81::AID-RRR378>3.0.CO;2-9.

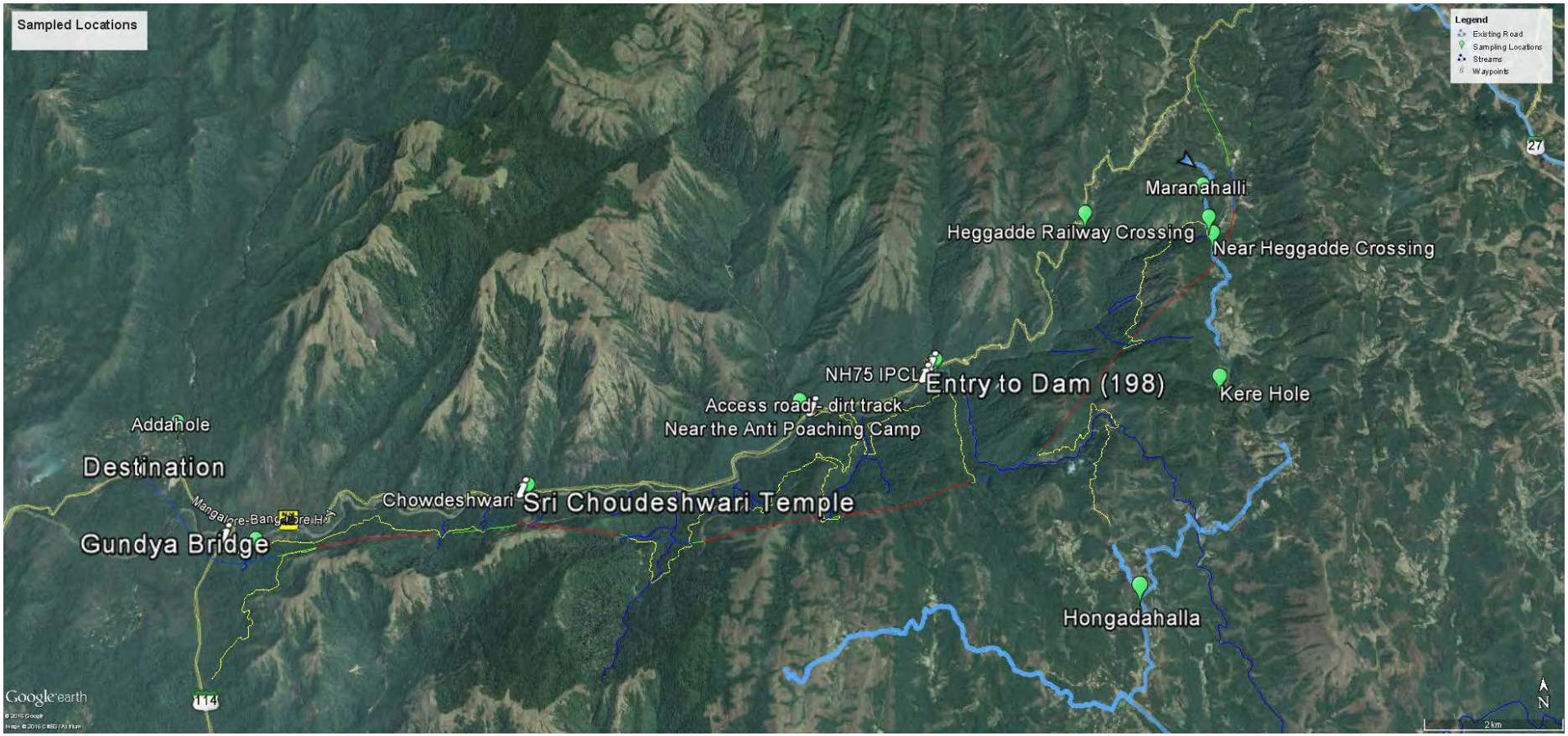
ANNEXURE A: MAPS



Map 1: Map of alignment with 1 sq km grids (also indicates earlier sampling points provided by JICA).

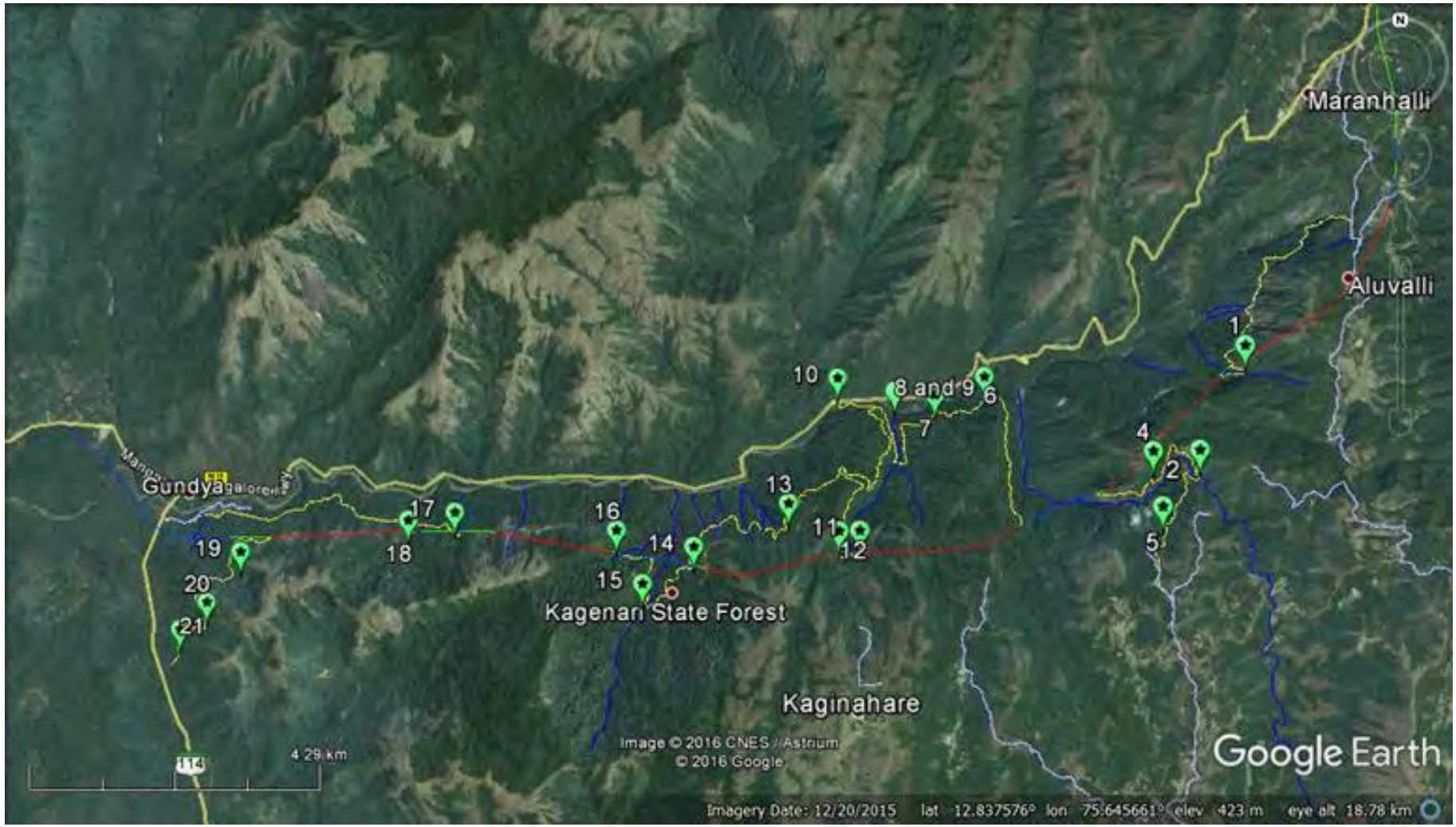


Map 2: Initial sampling points (check point) suggested by JICA for sampling.

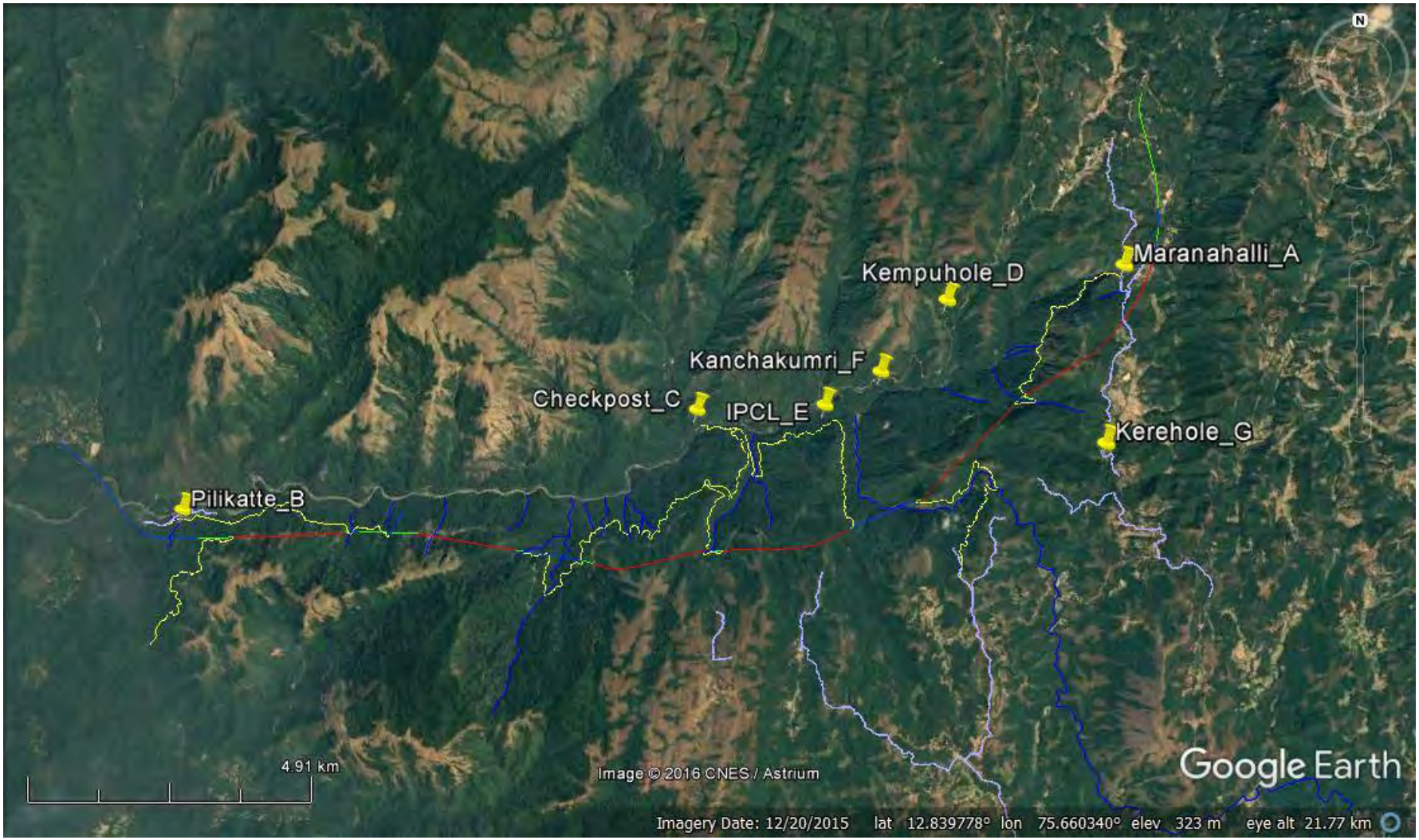


Map 3: Sampling points during Phase 1.

Map 4: New sampling points suggested by JICA.



Map 5: Actual surveyed sampling points (Image source: Google Earth).



Map 6: Additional amphibian sampling points A-G: A-Maranahalli; B-Pilikatte; C-Checkpost; D-Kemphole; E-IPCL; F-Kanchankumri and G-Kerehole. (Image source: Google Earth).

ANNEXURE B: IMAGES AND MICRO-HABITATS CHARACTERISTICS OF SAMPLING POINTS

1. Perennial stream, 3°, evergreen vegetation

2. Perennial stream, 4°, evergreen vegetation

4. Perennial stream, 2°, Evergreen+Ochlandra

5. Perennial stream, 2°, evergreen vegetation

6. Evergreen vegetation, 1° stream

7. Perennial stream, 2°, evergreen vegetation

8. Perennial stream, 4°, evergreen+Ochlandra

9. Perennial stream, 4°, evergreen+Ochlandra

10. Perennial stream, 4°, evergreen vegetation

11. Perennial stream, 2°, evergreen vegetation

12. Perennial stream, 3°, evergreen vegetation

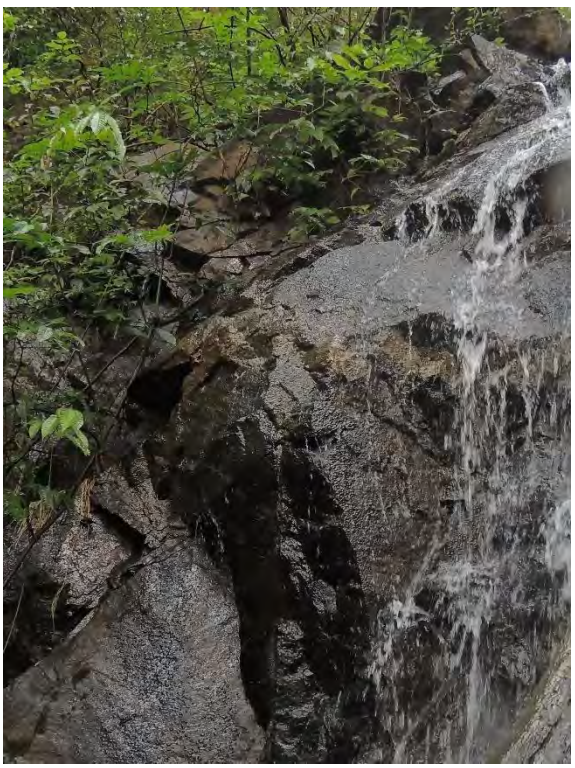
13. Perennial stream, 3°, evergreen vegetation

14. Perennial stream, 3°, evergreen vegetation

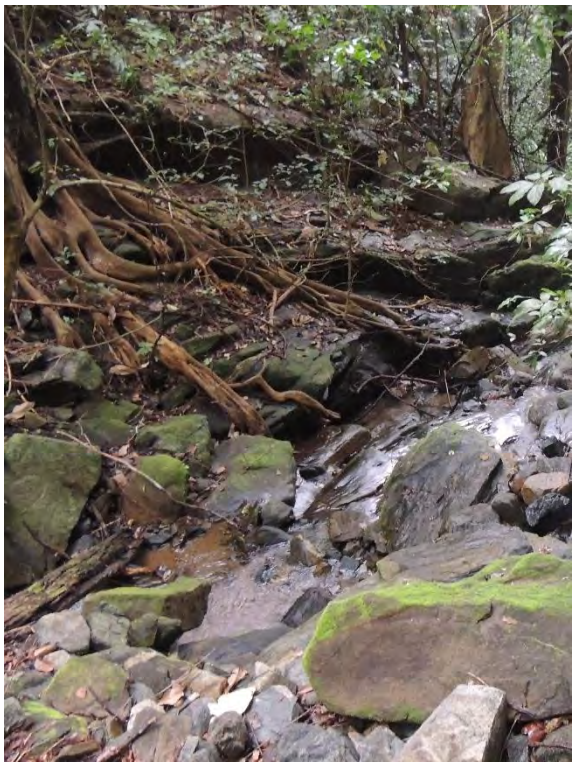
15. Perennial stream, 4°, evergreen vegetation

16. Perennial stream, 3°, evergreen vegetation

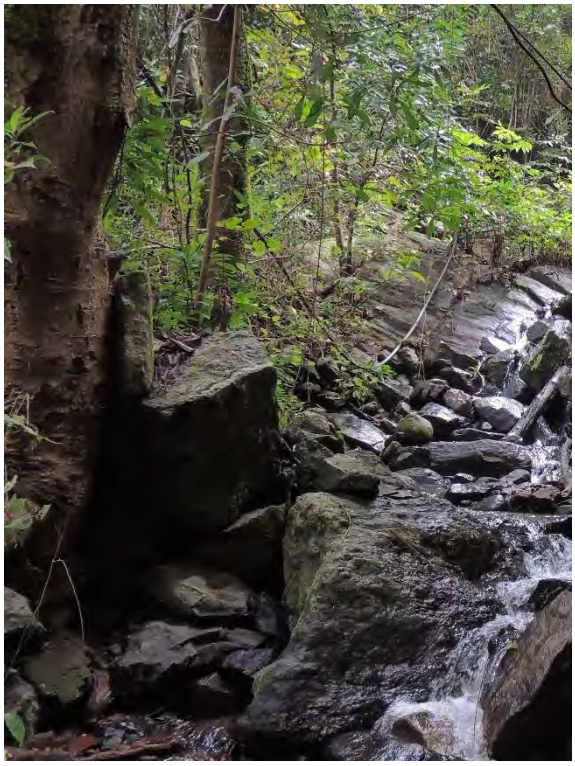
17. Perennial stream, 1°, evergreen vegetation



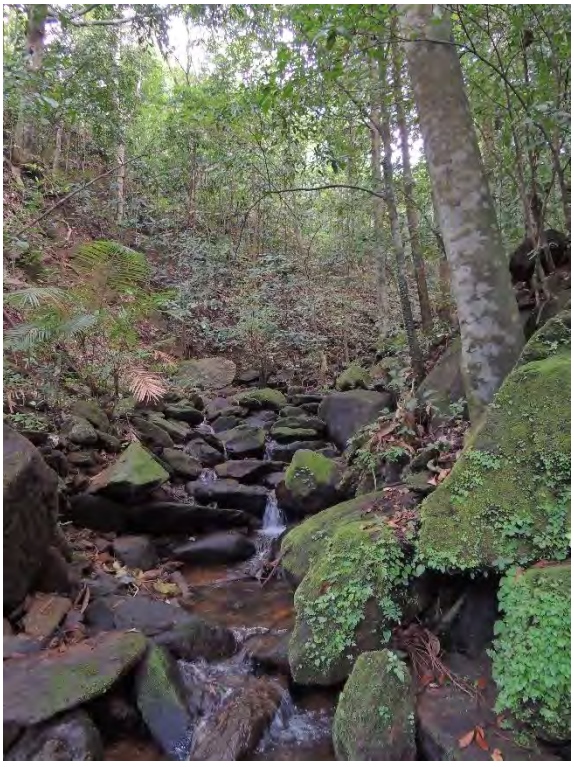
18. Perennial stream, 2°, evergreen vegetation



19. Perennial stream, 2°, evergreen vegetation



20. Perennial stream, 2°, evergreen vegetation



21. Perennial stream, 3°, evergreen+Ochlandra

ANNEXURE C: PHOTOGRAPHS FROM THE FIELD

Photos taken near Maranahalli

Photos from the field: In and around Kagineri and Heggade Railway crossing.

Elephant dung on the street, a common sighting in the area. This one was a fresh dung indicating the passage of elephants in the past six hours or so.

ANNEXURE D: PLATES OF AMPHIBIAN SPECIES OBSERVED DURING THE FIELD SURVEY.

Raorchestes ponmudi

Pseudophilautus wynaadensis

Raorchestes charius

Raorchestes glandulosus

Raorchestes luteolus

Raorchestes ochlandrae

Micrixalus kottigeharensis

Ghatophryne ornata

Micrixalus saxicola

Micrixalus elegans

Indirana gundia

Uperodon mormoratus

Rhacophorus lateralis

Nyctibatrachus kempholeyensis

Indosylvirana intermedius

Microhyla sholigari

ANNEXURE E: SAMPLING POINTWISE LIST OF SPECIES WITH THEIR PRESENCE AND ABSENCE DATA.

Note: 1 –Presence, T- Tree, S- Shrub, P- Palm, H- Herb, C- Climber, L- Liana, E- Endemic

SL. NO	SPECIES	ABBRVN	HABIT	FAMILY	STATUS	DISTBN	1	2	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21
1	*Acronychia pedunculata*	Acr ped	T	Rutaceae				1			1				1		1	1				1		1		
2	*Actinodaphne hookeri*	Act hoo	T	Lauraceae		E				1	1							1						1		
3	*Actinodaphne malabarica*	Act mal	T	Lauraceae		E					1		1			1	1					1			1	
4	*Aglaia barberi*	Agl bar	T	Meliaceae		E			1											1	1		1	1		
5	*Aglaia elaegnoidea*	Agl ela	T	Meliaceae		E	1	1		1	1					1		1				1	1			
6	*Aglaia lawii*	Agl law	T	Meliaceae	Lower Risk/least concern ver 2.3	E	1		1	1	1					1	1	1		1	1					
7	*Agrostistachys indica*	Agr ind	T	Euphorbiaceae		E										1										
8	*Albizia chinensis*	Alb chi	T	Fabaceae																			1			
9	*Allophylus cobbe*	All cob	S	Sapindaceae			1	1																1		
10	*Alstonia scholaris*	Als sch	T	Apocynaceae			1		1								1		1		1			1	1	
11	*Anamirta cocculus*	Ana coc	L	Menispermaceae		E	1																			
12	*Ancistrocladus heyneanus*	Anc hey	L	Ancistrocladaceae		E											1									
13	*Angiopteris evecta*	Ang eve	S	Marattiaceae		E																				1
14	*Anthocephalus chinensis*	Ant chi	T	Rubiaceae							1		1			1										
15	*Antidesma menasu*	Ant men	S	Euphorbiaceae		E													1	1						
16	*Apama siliquosa*	Apa sil	S	Aristolochiaceae		E					1					1		1	1				1		1	
17	*Aphanamyxis polystachya*	Aph pol	T	Meliaceae	Vulnerable	E					1							1	1							
18	*Aphananthe cuspidata*	Aph cus	T	Ulmaceae		E					1					1										
19	*Apodytes dimidiata*	Apo dim	T	Icacinaceae												1	1									
20	*Aporosa lindleyana*	Apo lin	T	Euphorbiaceae							1				1			1						1		
21	*Archidendron monadelphum*	Arc mon	T	Fabaceae			1																		1	
22	*Arenga wightii*	Are wig	P	Arecaceae	Vulnerable B1+2c ver 2.3	E					1	1				1		1	1	1			1			
23	*Aristolochia tagala*	Ari tag	C	Aristolochiaceae		E				1																
24	*Artocarpus heterophyllus*	Art het	T	Moraceae				1			1							1					1	1		
25	*Artocarpus hirsutus*	Art hir	T	Moraceae	Vulnerable	E	1	1	1		1		1			1	1	1		1				1	1	1
26	*Artocarpus lakoocha*	Art lak	T	Moraceae						1																
27	*Atalantia racemosa*	Ata rac	S	Rutaceae		E			1	1																
28	*Atalantia wightii*	Ata wig	S	Rutaceae		E					1					1										
29	*Bauhinia phoenicea*	Bau pho	L	Fabaceae	Vulnerable	E	1					1	1	1												
30	*Beilschmiedia wightii*	Bei wig	T	Lauraceae		E	1		1		1					1				1	1					1
31	*Bischopia javanica*	Bis jav	T	Euphorbiaceae					1		1					1	1	1	1	1	1	1				

32	***Blachia denuadata***	**Bla den**	**S**	**Euphorbiaceae**		**E**														**1**			**1**				
33	***Blachia reflexa***	**Bla ref**	**S**	**Euphorbiaceae**		**E**	**1**						**1**									**1**						
34	***Blepharistemma membranifolius***	**Ble mem**	**S**	**Rhizophoraceae**		**E**																**1**	**1**	**1**	**1**		
35	***Cajanus lineatus***	**Caj lin**	**S**	**Fabaceae**																				**1**			
36	***Calamus pseudotenius***	**Cal pse**	**S**	**Arecaceae**		**E**			**1**		**1**	**1**	**1**				**1**		**1**						**1**	**1**	
37	***Calamus thwatesii***	**Cal thw**	**S**	**Arecaceae**												**1**											
38	***Calicarpa tomentosa***	**Cal tom**	**S**	**Verbenaceae**		**E**					**1**																
39	***Calophyllum apetalum***	**Cal ape**	**T**	**Clusiaceae**	**Vulnerable A2cd ver 3.1**	**E**																					
40	***Calophyllum austro-indicum***	**Cal aus**	**T**	**Clusiaceae**		**E**					**1**						**1**						**1**				
41	***Calophyllum polyanthum***	**Cal pol**	**T**	**Clusiaceae**		**E**	**1**		**1**		**1**	**1**				**1**		**1**	**1**				**1**				
42	***Calycopteris floribunda***	**Cal flo**	**L**	**Combretaceae**																				**1**	**1**		
43	***Canarium strictum***	**Can str**	**T**	**Burseraceae**		**E**			**1**	**1**											**1**				**1**		
44	***Canthium angustifolium***	**Can dic**	**S**	**Rubiaceae**		**E**					**1**														**1**		
45	***Canthium dicocum***	**Can dic**	**T**	**Rubiaceae**		**E**	**1**	**1**																			
46	***Carallia brachiata***	**Car bra**	**T**	**Rhizophoraceae**		**E**	**1**											**1**									
47	***Caryota urens***	**Car ure**	**P**	**Arecaceae**			**1**	**1**	**1**	**1**	**1**		**1**	**1**			**1**	**1**			**1**	**1**			**1**	**1**	**1**
48	***Casearia escelanta***	**Cas esc**	**T**	**Flacourtiaceae**		**E**	**1**	**1**				**1**		**1**		**1**						**1**		**1**	**1**	**1**	**1**
49	***Casearia ovata***	**Cas ova**	**T**	**Flacourtiaceae**		**E**					**1**					**1**											
50	***Cassine glauca***	**Cas gla**	**L**	**Celastraceae**																				**1**			
51	***Celtis philippensis***	**Cel phi**	**T**	**Ulmaceae**																							
52	***Celtis timorensis***	**Cel tim**	**T**	**Ulmaceae**						**1**																	
53	***Chasalia ophioxiloides***	**Cha oph**	**S**	**Rubiaceae**		**E**					**1**					**1**				**1**							
54	***Chionanthus malabaricus***	**Chi mal**	**S**	**Oleaceae**		**E**							**1**														
55	***Chionanthus mala-elengi***	**Chi mal-ele**	**S**	**Oleaceae**		**E**			**1**	**1**																	
56	***Chonemorpha fragrans***	**Cho fra**	**C**	**Apocynaceae**		**E**																					
57	***Chrysophyllum lanceolatum***	**Chr lan**	**T**	**Sapotaceae**		**E**		**1**										**1**									
58	***Cinamomum macrocarpum***	**Cin mac**	**T**	**Lauraceae**		**E**	**1**	**1**		**1**	**1**	**1**				**1**	**1**	**1**	**1**	**1**		**1**	**1**				
59	***Cinnamomum heyneana***	**Cin hey**	**T**	**Lauraceae**		**E**	**1**																				
60	***Cinnamomum malabatrum***	**Cin mal**	**T**	**Lauraceae**		**E**	**1**																**1**				
61	***Clausena dentata***	**Cla den**	**T**	**Rutaceae**		**E**		**1**																			
62	***Cleidon spiciflorum***	**Cle spi**	**T**	**Euphorbiaceae**		**E**			**1**																		
63	***Cleistanthus malabaricus***	**Cle mal**	**S**	**Euphorbiaceae**												**1**											
64	***Clerodendron viscosum***	**Cle vis**	**S**	**Verbenaceae**							**1**													**1**			
65	***Combretum latifolium***	**Com lat**	**L**	**Combretacaee**							**1**													**1**			
66	***Combretum ovalifolium***	**Com ova**	**L**	**Combretaceae**					**1**								**1**			**1**				**1**	**1**		

67	***Connarus wightii***	**Con wig**	**L**	**Connaraceae**		**E**	**1**																					**1**		
68	***Croton malabaricus***	**Cro mal**	**T**	**Euphorbiaceae**		**E**					**1**	**1**		**1**																
69	***Cynometra iripa***	**Cyn iri**	**T**	**Fabaceae**	**Least Concern ver 3.1**	**E**						**1**	**1**			**1**														
70	***Debregeasia longifolia***	**Deb lon**	**S**	**Euphorbiaceae**		**E**			**1**																					
71	***Derris breviceps***	**Der bre**	**L**	**Fabaceae**													**1**													
72	***Derris heyneana***	**Der hey**	**L**	**Fabaceae**					**1**							**1**												**1**	**1**	
73	***Derris scandans***	**Der sca**	**L**	**Fabaceae**											**1**															
74	***Desmos lawii***	**Des law**	**L**	**Anonaceae**		**E**																	**1**						**1**	
75	***Dichapetalum gelanoides***	**Dic gel**	**S**	**Dichapetalaceae**		**E**	**1**	**1**		**1**	**1**					**1**	**1**													
76	***Dillenia pentagyna***	**Dil pen**	**T**	**Dilleniaceae**			**1**																			**1**				
77	***Dimocarpus longan***	**Dim lon**	**T**	**Sapindaceae**		**E**	**1**	**1**	**1**	**1**	**1**	**1**	**1**	**1**		**1**	**1**	**1**	**1**	**1**	**1**	**1**	**1**	**1**	**1**	**1**	**1**	**1**	**1**	**1**
78	***Dimorphocalyx beddomei***	**Dim bed**	**T**	**Euphorbiaceae**	**Endangered B1+2c ver 2.3**	**E**																								
79	***Diospyros angustifolia***	**Dio ang**	**T**	**Ebenaceae**		**E**					**1**			**1**																
80	***Diospyros assimilis***	**Dio ass**	**T**	**Ebenaceae**	**Data Deficient ver 2.3**	**E**														**1**	**1**		**1**		**1**				
81	***Diospyros buxifolia***	**Dio bux**	**T**	**Ebenaceae**							**1**	**1**	**1**		**1**			**1**												
82	***Diospyros candolleana***	**Dio can**	**T**	**Ebenaceae**	**Vulnerable A2cd ver 3.1**	**E**					**1**																			
83	***Diospyros crumenata***	**Dio cru**	**T**	**Ebenaceae**	**Endangered B1+2c ver 2.3**	**E**					**1**																			
84	***Diospyros montana***	**Dio mon**	**T**	**Ebenaceae**						**1**																				
85	***Diospyros oocarpa***	**Dio ooc**	**T**	**Ebenaceae**		**E**						**1**																		
86	***Diospyros paniculata***	**Dio pan**	**T**	**Ebenaceae**	**Vulnerable A2cd ver 3.1**	**E**										**1**														
87	***Diospyros pruriens***	**Dio pru**	**T**	**Ebenaceae**		**E**			**1**		**1**	**1**				**1**		**1**	**1**											
88	***Diospyros saldhane***	**Dio sal**	**T**	**Ebenaceae**		**E**									**1**															
89	***Diospyros sylavtica***	**Dio syl**	**T**	**Ebenaceae**		**E**	**1**	**1**	**1**		**1**			**1**	**1**	**1**		**1**	**1**	**1**	**1**	**1**			**1**				**1**	
90	***Diploclisia glaucascens***	**Dip gla**	**S**	**Menispermaceae**		**E**											**1**													
91	***Dipterocarpus indicus***	**Dip ind**	**T**	**Dipterocarpaceae**	**Endangered A1cd+2cd, B1+2c ver 2.3**	**E**	**1**		**1**		**1**	**1**	**1**			**1**	**1**	**1**	**1**	**1**	**1**						**1**			
92	***Drypetes confertiflorus***	**Dry con**	**T**	**Euphorbiaceae**		**E**																								
93	***Drypetes oblongifolia***	**Dry obl**	**T**	**Euphorbiaceae**		**E**					**1**					**1**														
94	***Drypetes wightii***	**Dry wig**	**T**	**Euphorbiaceae**	**Vulnerable B1+2c ver 2.3**	**E**								**1**		**1**	**1**	**1**						**1**						
95	***Dysoxylum malabaricum***	**Dys mal**	**T**	**Meliaceae**	**Endangered A2cd ver 3.1**	**E**			**1**							**1**	**1**					**1**								
96	***Elaeagnus conferta***	**Ela con**	**S**	**Elaeagnaceae**	**Vulnerable**																							**1**	**1**	
97	***Elaeocarpus serratus***	**Ela ser**	**T**	**Elaeocarpaceae**														**1**								**1**				

98	*Elaeocarpus tuberculatus*	Ela tub	T	Elaeocarpaceae		E	1		1	1	1			1											1		
99	*Embelia ribes*	Emb rib	L	Myrsinaceae	Endangered	E														1							
100	*Ensette superbum*	Ens sup	S	Mussaceae																							
101	*Entada pursaetha*	Ent pur	L	Fabaceae				1																	1		
102	*Eugenia codyensis*	Eug cod	S	Myrtaceae		E	1	1								1		1							1		
103	*Eugenia macrocephala*	Eug mac	S	Myrtaceae		E																1					
104	*Eugenia thwaitesii*	Eug thw	S	Myrtaceae		E	1	1	1		1						1										
105	*Euodia lunu-ankenda*	Euo lun	T	Rutaceae	Endangered B1+2c ver 2.3	E	1		1							1				1							
106	*Euonymus angulatus*	Euo ang	T	Celastraceae	Vulnerable B1+2c ver 2.3	E		1												1							
107	*Exacum tetragonum*	Exa tet	H	Gentianaceae																							
108	*Fagraea ceilanica*	Fag cei	L	Loganiaceae																							
109	*Fahrenheitia zeylanica*	Fah zey	T	Euphorbiaceae		E										1	1	1	1		1						
110	*Ficus callosa*	Fic cal	T	Moraceae													1			1				1			
111	*Ficus hispida*	Fic his	T	Moraceae							1																
112	*Ficus nervosa*	Fic ner	T	Moraceae			1			1								1	1	1	1		1	1	1		
113	*Desmodium gangeticum*	Des gan	H	Fabaceae										1													
114	*Garcinia gummi-gutta*	Gar gum	T	Clusiaceae	Vulnerable	E	1	1	1	1	1	1	1	1		1	1	1			1			1	1	1	
115	*Garcinia indica*	Gar ind	T	Clusiaceae	Vulnerable A2cd ver 3.1	E	1	1		1																	
116	*Garcinia morella*	Gar mor	T	Clusiaceae	Vulnerable	E	1	1			1					1	1	1			1				1		
117	*Garcinia talbotii*	Gar tal	T	Clusiaceae		E		1			1	1		1			1	1		1			1				
118	*Glochidion ellipticum*	Glo ell	T	Euphorbiaceae	Endangered	E														1							
119	*Glochidion jhonstonei*	Glo jho	T	Euphorbiaceae	Vulnerable	E	1										1										
120	*Glochidion malabaricum*	Glo mal	T	Euphorbiaceae								1															
121	*Gluta travancorica*	Glu tra	T	Anacardiaceae	Lower Risk/near threatened ver 2.3	E										1											
122	*Gnetum ula*	Gne ula	L	Gnetaceae	Least Concern ver 3.1	E		1			1					1								1			
123	*Gompandra tetrandra*	Gom tet	S	Icacinaceae		E	1	1										1	1								
124	*Goniothalamus thwaitesii*	Gon thw	S	Anonaceae		E																					1
125	*Gouania microcarpa*	Gou mic	L	Rhamnaceae		E										1											
126	*Grewia serrulata*	Gre ser	S	Tiliaceae													1										
127	*Grewia tilifolia*	Gre til	T	Tiliaceae			1																				
128	*Gymnacranthera canarica*	Gym can	T	Myristicaceae	Vulnerable B1+2c, D2 ver 2.3	E	1						1	1													1
129	*Habenaria crinifolia*	Hab cri	H	Orchidaceae																							

130	***Helicteres isora***	**Hel iso**	**S**	**Tiliaceae**			**1**																						
131	***Heritiera papilio***	**Her pap**	**T**	**Sterculiaceae**		**E**																	**1**						
132	***Holigarna arnottiana***	**Hol arn**	**T**	**Anacardiaceae**		**E**						**1**									**1**							**1**	**1**	
133	***Holigarna beddomei***	**Hol bed**	**T**	**Anacardiaceae**		**E**			**1**		**1**		**1**				**1**	**1**			**1**	**1**	**1**							
134	***Holigarna feruginea***	**Hol fer**	**T**	**Anacardiaceae**		**E**				**1**																			**1**	
135	***Holigarna grahamii***	**Hol gra**	**T**	**Anacardiaceae**		**E**	**1**		**1**	**1**	**1**	**1**					**1**	**1**				**1**	**1**			**1**	**1**	**1**		
136	***Hopea erosa***	**Hop ero**	**T**	**Dipterocarpaceae**	**Critically Endangered A1d+2d, B1+2e, C1, D ver 2.3**	**E**																	**1**	**1**	**1**				
137	***Hopea parviflora***	**Hop par**	**T**	**Dipterocarpaceae**	**Endangered A1cd+2cd, B1+2c ver 2.3**	**E**																							**1**	
138	***Hopea ponga***	**Hop pon**	**T**	**Dipterocarpaceae**	**Endangered A1cd+2cd, B1+2c ver 2.3**	**E**	**1**	**1**			**1**	**1**	**1**	**1**	**1**	**1**	**1**	**1**	**1**			**1**	**1**	**1**	**1**	**1**	**1**		
139	***Humboltia brunonis***	**Hum bru**	**T**	**Fabaceae**		**E**	**1**				**1**	**1**	**1**	**1**					**1**	**1**							**1**	**1**	
140	***Hydnocarpus alpina***	**Hyd alp**	**T**	**Flacourtiaceae**	**Endangered**	**E**			**1**			**1**																	
141	***Hydnocarpus pentandra***	**Hyd pen**	**T**	**Flacourtiaceae**		**E**		**1**	**1**	**1**	**1**	**1**	**1**						**1**	**1**									
142	***Impatiens acaulis***	**Imp aca**	**H**	**Balsaminaceae**		**E**																							
143	***Impatiens gardneriana***	**Imp gar**	**H**	**Balsaminaceae**		**E**																							
144	***Ixora nigricans***	**Ixo nig**	**S**	**Rubiaceae**		**E**				**1**								**1**					**1**				**1**	**1**	
145	***Ixora brachiata***	**Ixo bra**	**S**	**Rubiaceae**						**1**					**1**														
146	***Kingiodendron pinnatum***	**Kin pin**	**T**	**Fabaceae**	**Endangered A1cd ver 2.3**	**E**	**1**				**1**	**1**	**1**	**1**		**1**	**1**	**1**	**1**	**1**	**1**	**1**	**1**	**1**	**1**				
147	***Knema attenuata***	**Kne att**	**T**	**Myristicaceae**	**Lower Risk/least concern ver 2.3**	**E**	**1**		**1**		**1**	**1**			**1**	**1**	**1**	**1**	**1**	**1**	**1**					**1**	**1**		
148	***Kydia calycina***	**Kyd cal**	**T**	**Malvaceae**						**1**								**1**					**1**						
149	***Lagerstroemia microcarpa***	**Lag mic**	**T**	**Lythraceae**																								**1**	
150	***Lagerstroemia speciosa***	**Lag spe**	**T**	**Lythraceae**																								**1**	
151	***Lannea coromandelica***	**Lan cor**	**T**	**Anacardiaceae**																			**1**						
152	***Leea crispa***	**Lee cri**	**S**	**Leeaceae**		**E**									**1**	**1**													
153	***Leea indica***	**Lee ind**	**S**	**Leeaceae**																								**1**	
154	***Lepisanthes tetraphylla***	**Lep tet**	**T**	**Sapindaceae**		**E**																	**1**						
155	***Litsea floribunda***	**Lit flo**	**T**	**Lauraceae**		**E**	**1**	**1**			**1**					**1**		**1**											
156	***Litsea ghatica***	**Lit gha**	**T**	**Lauraceae**		**E**																**1**							
157	***Litsea insignis***	**Lit ins**	**T**	**Lauraceae**		**E**																							
158	***Litsea laevigata***	**Lit lae**	**T**	**Lauraceae**		**E**				**1**																		**1**	
159	***Litsea mysorensis***	**Lit mys**	**T**	**Lauraceae**		**E**	**1**			**1**	**1**		**1**						**1**	**1**	**1**	**1**					**1**		

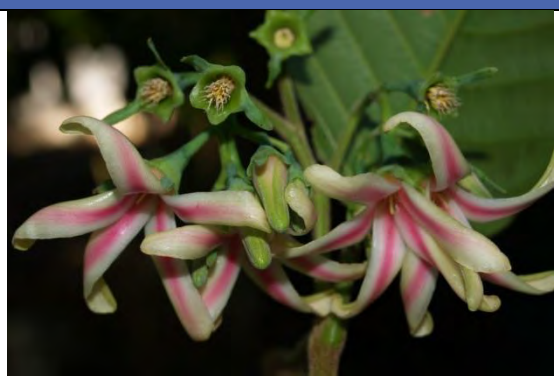
160	***Litsea stocksii***	**Lit sto**	**T**	**Lauraceae**																				1					
161	***Lophopetalum wightianum***	**Lop wig**	**T**	**Celastraceae**		**E**		1	1					1	1												1		1
162	***Luvunga sarmentosa***	**Luv sar**	**L**	**Rutaceae**		**E**																							
163	***Macaranga peltata***	**Mac pel**	**T**	**Euphorbiaceae**						1							1					1	1	1		1			
164	***Madhuca neriifolia***	**Mad ner**	**T**	**Sapotaceae**	**Endangered B1+2c ver 2.3**	**E**								1	1													
165	***Mallotus philippensis***	**Mal phi**	**T**	**Euphorbiaceae**																			1						
166	***Mallotus tetracoccus***	**Mal tet**	**T**	**Euphorbiaceae**				1		1												1							
167	***Mangifera indica***	**Man ind**	**T**	**Anacardiaceae**				1							1					1		1				1			
168	***Margaritaria indica***	**Mar ind**	**T**	**Euphorbiaceae**														1											
169	***Meiogyne ramarowii***	**Mei ram**	**S**	**Anonaceae**		**E**					1												1						
170	***Memecylon angustifolium***	**Mem ang**	**S**	**Melastomaceae**		**E**																							
171	***Memecylon gracile***	**Mem gra**	**S**	**Melastomaceae**		**E**										1													
172	***Memecylon malabaricum***	**Mem mal**	**S**	**Melastomaceae**		**E**		1	1		1					1		1			1								
173	***Memecylon terminale***	**Mem ter**	**S**	**Melastomaceae**		**E**											1												
174	***Mesua ferrea***	**Mes fer**	**T**	**Clusiaceae**		**E**		1	1							1	1			1	1								
175	***Mimusops elengi***	**Mim ele**	**T**	**Sapotaceae**								1																	
176	***Mitragyna tubulosa***	**Mit tub**	**S**	**Rubiaceae**		**E**																							
177	***Moullava spicata***	**Mou spi**	**L**	**Fabaceae**		**E**																							
178	***Myristica dactyloides***	**Myr dac**	**T**	**Myristicaceae**	**Vulnerable A2cd ver 3.1**	**E**		1		1		1				1				1	1	1							1
179	***Myristica malabarica***	**Myr mal**	**T**	**Myristicaceae**	**Vulnerable B1+2c ver 2.3**	**E**						1				1													
180	***Neolitsea foliosa***	**Neo fol**	**T**	**Lauraceae**		**E**												1					1						
181	***Neonauclea purpurea***	**Neo pur**	**T**	**Rubiaceae**		**E**		1																			1		1
182	***Nothapodytes nimmoniana***	**Not nim**	**S**	**Icacinaceae**		**E**		1			1											1	1						
183	***Nothopegia beddomei***	**Not bed**	**T**	**Anacardiaceae**		**E**				1						1											1		
184	***Nothopegia heyneana***	**Not hey**	**T**	**Anacardiaceae**	**Lower Risk/near threatened ver 2.3**	**E**					1	1	1			1								1					
185	***Nothopegia racemosa***	**Not rac**	**T**	**Anacardiaceae**		**E**		1	1		1	1	1					1	1	1	1				1				
186	***Nothopegia travancorica***	**Not tra**	**T**	**Anacardiaceae**		**E**				1	1			1									1				1		
187	***Ochlandra rheedii***	**Och rhe**	**S**	**Poaceae**		**E**		1				1		1							1								1
188	***Octotropis travancorica***	**Oct tra**	**S**	**Rubiaceae**		**E**		1	1	1		1								1									
189	***Olea dioica***	**Ole dio**	**T**	**Oleaceae**		**E**		1	1	1	1	1			1	1		1	1			1	1	1	1	1			
190	***Orophea erythrocarpa***	**Oro ery**	**S**	**Anonaceae**		**E**				1																			
191	***Otonephelium stipulaceum***	**Oto sti**	**T**	**Sapindaceae**		**E**							1																
192	***Pajanelia longifolia***	**Paj lon**	**T**	**Bignoniaceae**					1											1							1		
193	***Palaquium ellipticum***	**Pal ell**	**T**	**Sapotaceae**		**E**										1	1	1	1			1			1				
194	***Paramignya monophylla***	**Par mon**	**S**	**Rutaceae**		**E**						1					1												

195	***Pecteilis gigantea***	**Pac gig**	**H**	**Orchidaceae**																					
196	***Persea macrantha***	**Per mac**	**T**	**Lauraceae**		**E**											**1**	**1**							
197	***Pinanga dicksonii***	**Pin dic**	**P**	**Arecaceae**		**E**			**1**			**1**				**1**									**1**	
198	***Pittosporum dasycaulon***	**Pit das**	**T**	**Pittosporaceae**			**1**																		
199	***Polyalthia fragrans***	**Pol fra**	**T**	**Anonaceae**		**E**			**1**		**1**	**1**					**1**	**1**	**1**	**1**			**1**	**1**	
200	***Pongamia pinnata***	**Pon pin**	**T**	**Fabaceae**			**1**	**1**																	
201	***Porana malabarica***	**Por mal**	**C**	**Convolvulaceae**																				**1**	
202	***Prunus ceilanica***	**Pru cei**	**T**	**Rosaceae**		**E**	**1**																		
203	***Psychotria dalzellii***	**Psy dal**	**S**	**Rubiaceae**		**E**					**1**													**1**	**1**
204	***Psychotria flavida***	**Psy fla**	**S**	**Rubiaceae**		**E**							**1**												
205	***Psychotria macrocarpa***	**Psy mac**	**S**	**Rubiaceae**	**Endangered B1+2c ver 2.3**	**E**										**1**			**1**	**1**			**1**	**1**	
206	***Psychotria nigra***	**Psy nig**	**S**	**Rubiaceae**		**E**	**1**	**1**								**1**	**1**	**1**			**1**	**1**			
207	***Psychotria truncata***	**Psy tru**	**S**	**Rubiaceae**		**E**										**1**		**1**			**1**				
208	***Pterocarpus marsupium***	**Pte mar**	**T**	**Fabaceae**				**1**																	
209	***Pterospermum diversifolium***	**Pte div**	**T**	**Sterculiaceae**		**E**							**1**	**1**					**1**	**1**	**1**	**1**	**1**	**1**	**1**
210	***Pterospermum rubiginosa***	**Pte rub**	**S**	**Sterculiaceae**		**E**																		**1**	
211	***Randia rugulosa***	**Ran rug**	**L**	**Rubiaceae**		**E**										**1**									
212	***Rhaphidophora laciniata***	**Rha lac**	**L**	**Araceae**		**E**				**1**														**1**	
213	***Reinderditiodendron anaimaleiense***	**Rei ana**	**T**	**Meliaceae**		**E**												**1**	**1**		**1**				
214	***Salacia macrosperma***	**Sal mac**	**L**	**Celastraceae**																					
215	***Sarcostigma kleinii***	**Sar kle**	**L**	**Icacinaceae**		**E**				**1**														**1**	
216	***Schefflera micrantha***	**Sch mic**	**L**	**Aralliaceae**		**E**																			
217	***Schefflera wallichiana***	**Sch wal**	**L**	**Aralliaceae**				**1**																	
218	***Schliechera oleosa***	**Sch ole**	**L**	**Aralliaceae**																				**1**	
219	***Scolopia crenata***	**Sco cre**	**T**	**Flacourtiaceae**		**E**													**1**						
220	***Sideroxylon tomentosum***	**Sid tom**	**T**	**Sapotaceae**																					
221	***Spatholobus parviflorus***	**Spa par**	**L**	**Fabaceae**	**Least Concern ver 3.1**	**E**			**1**																
222	***Spondias pinnata***	**Spo pin**	**T**	**Anacardiaceae**																		**1**			
223	***Sterculia alata***	**Ste ala**	**T**	**Sterculiaceae**		**E**					**1**			**1**		**1**	**1**	**1**			**1**				
224	***Sterculia guttata***	**Ste gut**	**T**	**Sterculiaceae**						**1**							**1**						**1**	**1**	**1**
225	***Stereospermum chelonoides***	**Ste che**	**T**	**Bignoniaceae**										**1**											
226	***Strychnos colubrina***	**Str col**	**L**	**Loganiaceae**		**E**																			
227	***Symplocos cochinchinensis***	**Sym coc**	**T**	**Symplocaceae**		**E**							**1**				**1**								
228	***Symplocos racemosa***	**Sym rac**	**T**	**Symplocaceae**		**E**		**1**					**1**			**1**									
229	***Syzygium cumini***	**Syz cum**	**T**	**Myrtaceae**			**1**																	**1**	

230	***Syzygium gardneri***	**Syz gar**	**T**	**Myrtaceae**		**E**												**1**			**1**	**1**	**1**		**1**	**1**
231	***Syzygium hemisphericum***	**Syz hem**	**T**	**Myrtaceae**		**E**					**1**				**1**												
232	***Syzygium lanceolatum***	**Syz lan**	**T**	**Myrtaceae**		**E**						**1**															
233	***Syzygium densiflorum***	**Syz den**	**T**	**Myrtaceae**	**Vulnerable B1+2c ver 2.3**	**E**														**1**							
234	***Syzygium travancoricum***	**Syz tra**	**T**	**Myrtaceae**	**Critically Endangered C2a ver 2.3**	**E**																					**1**
235	***Syzygium zeylanicum***	**Syz zey**	**T**	**Myrtaceae**	**Critically Endangered**	**E**																					
236	***Tabernaemontana heyneana***	**Tab hey**	**S**	**Apocynaceae**	**Lower Risk/near threatened ver 2.3**	**E**	**1**	**1**																			
237	***Terminalia paniculata***	**Ter pan**	**T**	**Combretacaee**			**1**											**1**						**1**			
238	***Tetrameles nudiflora***	**Tet nud**	**T**	**Datiscaceae**						**1**												**1**	**1**				
239	***Toddalia asiatica***	**Tod asi**	**L**	**Rutaceae**																			**1**				
240	***Toona ciliata***	**Too cil**	**T**	**Meliaceae**													**1**	**1**									
241	***Tragia hispida***	**Tra his**	**C**	**Urticaceae**							**1**										**1**						
242	***Trema orientalis***	**Tre ori**	**T**	**Urticaceae**																							
243	***Trewia polycarpa***	**Tre pol**	**T**	**Euphorbiaceae**					**1**																		
244	***Tricalysia spherocarpa***	**Tri sph**	**S**	**Rubiaceae**		**E**											**1**										
245	***Trichilia connaroides***	**Tri con**	**T**	**Meliaceae**		**E**		**1**														**1**			**1**		**1**	
246	***Tylophora pauciflora***	**Tyl pau**	**C**	**Asclepiadaceae**																							
247	***Vateria indica***	**Vat ind**	**T**	**Dipterocarpaceae**	**Critically Endangered A1cd ver 2.3**	**E**	**1**	**1**	**1**	**1**	**1**	**1**	**1**	**1**			**1**	**1**	**1**	**1**	**1**	**1**			**1**	**1**	
248	***Ventilago maderaspatana***	**Ven mad**	**L**	**Rhamnaceae**			**1**	**1**		**1**			**1**		**1**			**1**	**1**			**1**			**1**		**1**	
249	***Vepris bilocularis***	**Vep bil**	**T**	**Rutaceae**		**E**		**1**					**1**				**1**						**1**				
250	***Vitex altissima***	**Vit alt**	**T**	**Verbenaceae**			**1**					**1**											**1**		**1**		
251	***Walsura trifolia***	**Wal tri**	**T**	**Meliaceae**		**E**	**1**		**1**	**1**	**1**	**1**														**1**	
252	***Wendlandia thyrsoidea***	**Wen thy**	**S**	**Rubiaceae**		**E**	**1**																		**1**		
253	***Xylopia parviflora***	**Xyl par**	**S**	**Anonaceae**			**1**	**1**															**1**			**1**	
254	***Zanthoxylum rhetsa***	**Zan rhe**	**T**	**Rutaceae**																		**1**	**1**				

ANNEXURE F: GLIMPSES OF FLORAL DIVERSITY OF SHIRADI AND GUNDYA FOREST RANGE

Dipterocarpus indicus (Endangered)



Dipterocarpus indicus flower

Gymnacranthera canarica (Endagered)

Gymnacranthera canarica fruit

Arenga wightii (Endangered)

Canarium strictum (Vulnerable)

Dysoxylum malabaricum (Endangered)

Garcinia gummi-gutta (Vulnerable)

Vateria indica (Endangered)

Vateria indica flower

Nothopegia beddomei (Endangered)

Habeneria crinifolia (a rare ground orchid)

Bischopia javanica

Aglaia lawii

Cinnamomum macrocarpum

Elaeocarpus serratus

Ensete superbum (wild rock Banana)

Orophea erythrocarpa

Lophopetalum wightianum (a rare spindle tree)

Impatiens acaulis

Litsea laevigata

Syzygium lanceolatum

Slicheira oleosa

Pecteilis gigantea (Ground orchid)

ANNEXURE G: SITE DESCRIPTION AND FEATURES BASED ON FISH SAMPLING

Sampling point 001:

This is a seasonal & first stream order forming a headwater stream. The stream composition was dominated with rocks and boulders. Stream habitat was comprise of fast flowing riffles and pools. Two species caught here such as *Bhavania australis* – a habitat specialist, feed on insect larvae and detritus and *Nemacheilus* sp.

Sampling point 003:

This is a seasonal & first order stream forming a part of headstream. Rocky substratum led to form a fast flowing riffle habitat. Two species caught here includes *Devario malabaricus* and *Garra mullya*.

Sampling point 004:

This is rocky stream forming a third order. Mainly riffle & pool habitats were dominant. Species caught here mainly comprises of *Bhavania australis*, *Haludaria melenampyx*, and *Brilius bakeri*.

Sampling point 008:

This is third order stream flowing through thick Oclandra bamboo forest dominated with rocks and boulders. Riffle, run and pools are dominant habitat types. This site was the highest in number of fish species with total seven species i.e. resulted *Barilius bakeri*, *Barilius canarensis*, *Tor khudree*, *Devario malabaricus*, *Garra mullya* G. stenorhynchus and *Nemacheilus* spp.

Sampling point 009:

This site was sampled in third order stream dominated with Ochlandra bamboo forest. Riffle and pools were dominated habitats. This was the third richest in fish richness with total four species such as *Barilius bakeri*, B. canarensis, *Devario malabarcius* and *Garra mullya*.

Sampling point 011:

This site was situated in first order stream. Rocks, boulder and gravel substratum resulted *Barilius bakeri* and *Garra mullya*.

Sampling point 012:

This site was sampled in Donne habbe stream, a second order stream. Riffle was main habitat type. This site was second highest in fish richness with 6 species. Species captured here were, *Balitora mysorensis*, *Bhavania australis*, *Barilius bakeri, B. canarensis*,*Garra mullya & G. stenorhynchus.*

Sampling point 014:

First order stream comprises of rocks and boulders; Riffle and cascade was main habitat type. Only *Bhavania australis* was found here.

Sampling point 015:

This is a third order stream. Rocks, boulders & gravels were main substratum. *Nemacheilus* spp was captured here.

Sampling point 017:

First order rocky stream. Riffle & pool was main habitat types. *Bhavania australis* and *Nemacheilus* spp were captured.

Sampling point 018:

First order stream with rocks as a main substratum. *Bhavania australis* and *Nemacheilus* spp were captured in pool & riffles habitat.

Sampling point 019:

This site is situated in the second order stream dominated with Ochlandra bamboo mix forest. Rocks & boulder were main substratum dominated with riffles and pools. Only *Nemacheilus* spp was present here.

Sampling point 020:

This site is situated in first order stream. Rocky habitat resulted in riffles. *Nemacheilus* spp was present in this habitat.

Sampling 022:

This is first order stream dominated with rocks & riffle, pool habitats. I captured *Nemacheilus* spp alone.

ANNEXURE H: FISH SPECIES

Bhavania australis Image by Vidisha Kulkarni

Barilius canarensis Image by Vidisha Kulkarni

Balitora mysorensis Image by Vidisha Kulkarni

Garra stenorhynchus Image by Vidisha Kulkarni

Aplocheilus lineatus Image by Ramya Badrinath

Dawikinsia assimillis Image by Mittal Gala

Garra mullya

Devario malabaricus Image by Mittal Gala

Tetraodon travancoricus Image by Madhushree Mudake

Xenentodon cancila Image by Madhushree Mudake

Parambassis ranga Image by Madhushree Mudake

Hypselobarbus kurali Image by Madhushree Mudake

Etroplus suratensis Image by Madhushree Mudake

Pehtia sp Image by Madhushree Mudake

Rasbora daniconius Image by Mittal Gala

Nemacheilus spp Image by Gururaja K.V.

Barbodes wynaadensis Image by Ramya Badrinath

Tor khudree Image by Sudhira H.S.

Haludaria melanampyx

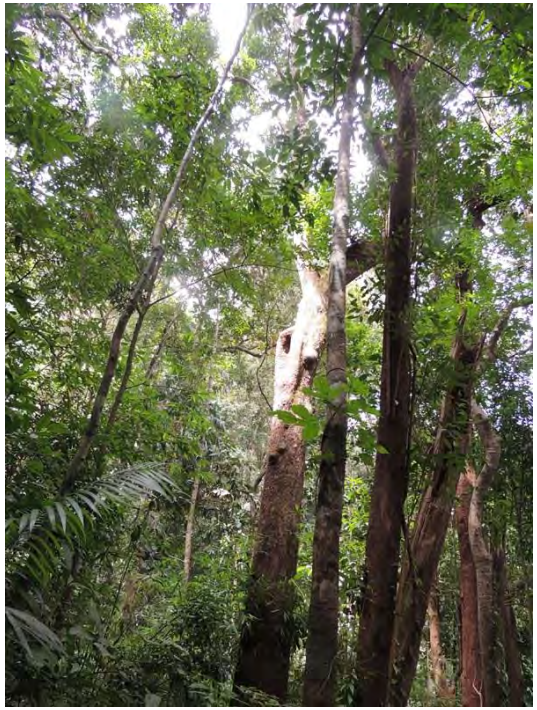
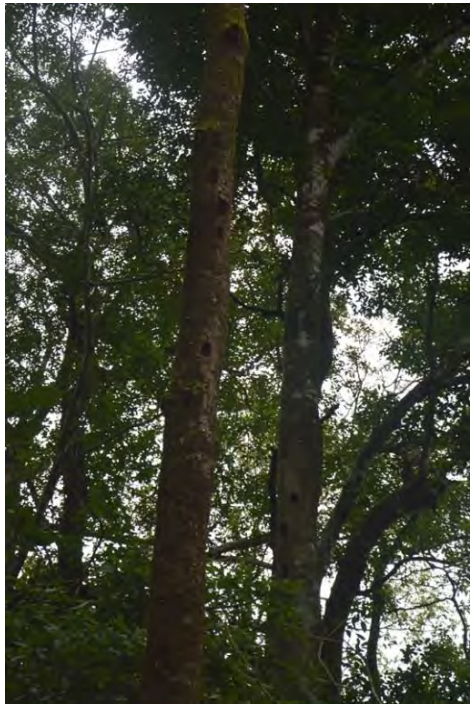
ANNEXURE I: BIRDS SIGHTED AND NEST HOLES

Greater Flameback

Malabar Parakeet

Malabar Whistling Thrush

Velvet fronted nuthatch

Nest Holes