Habitat Mapping of Mugger Crocodiles Along Kabini River Basin of Wayanad District, Kerala Using Geospatial Technology

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Abstract: Mugger crocodiles (Crocodylus Palustris) are the keystone species of freshwater ecosystem. Wayanad holds a considerable population of Mugger crocodiles starting from Panamaram, Mananthavady River till Kabini River at Kerala-Karnataka border. Using GIS, the habitat of Muggers was mapped and changes analyzed. The habitat was mapped from Google Earth Satellite images and the entire stretch accounted to an area of 400.11 ha. During the breeding season, areas of 157.63 were utilized by the crocodiles. Riparian cover which acts as a major sink in freshwater ecosystem were also mapped and the changes occurred to the cover between 2 time intervals 2006 and 2016) were mapped. About 36.40 per cent of very high density riparian cover has changed to 20.38 per cent in the 2016. Also, open space increased from 16.90 per cent to 47.55 per cent. Disturbance Zonation mapping were done to identify regions with high and least disturbances. Highly populated regions of Mananthavady and Panamaram had the greatest disturbance when compared to Palvelicham, Kuruva and Perikallur regions. Proper Management practices need to be implemented in these regions for the protection of the species and its habitat.

Keywords: Mugger crocodiles, Wayanad, GIS, Habitat, Riparian cover, Disturbance zonation mapping.

1. INTRODUCTION

Mugger Crocodile *(Crocodylus palustris* Lesson 1831*)* comes under Schedule I of Wildlife Protection Act 1972, Appendix I of CITES and is listed under the vulnerable category of IUCN (International Union for the Conservation of Nature and Natural Resources). In India, Mugger Crocodiles have a widespread distribution with an estimated wild population of around 2500-3000 non-hatchlings (Whitaker and Andrews, 2003). Earlier studies by Whitaker and Whitaker (1989) showed that there are more than 100 wild mugger crocodiles left in Kerala. Muggers exist in the major freshwater habitats of Kerala including Neyyar, Parambikulam and the Kabini River System of Wayanad. These three regions hold the only viable populations of wild muggers in Kerala (Jayson and Sivaperuman, 2006). Studies on Muggers have been undertaken by Rosamma (1993) and Jayson (2008, 2006) in the Neyyar Wildlife Sanctuary. The riverine ecosystem offers a suitable habitat for the crocodiles. But, the human pressure on this freshwater ecosystem is immensely increasing each year. The crocodiles in this region have high chances of encounter with humans as majority of the bank area is either used for cultivation or settlements. Although there are no reported cases of conflict, crocodiles are occasionally killed during the monsoon season when they enter the crop fields through flood waters. Also, the riparian vegetation which plays a major role in the ecosystem balance in riverine zone is thinning out gradually. Their roots provide ideal hiding place for crocodiles along the river bank. Illegal fishing activities, river pollution and other anthropogenic activities in this region cause a reduction in the prey base of crocodiles in this region. The present study discusses Mugger crocodile habitat mapping, Riparian vegetation change analysis over the past 10 years and Disturbance zonation mapping. For this study GIS techniques were used for analyzing and preparation of appropriate maps.

2. STUDY AREA

Wayanad includes parts of Western Ghats standing on the southern tip of Deccan Plateau. District is located in the northeast part of Kerala (Fig .1) at a distance of about 76 km from the seashores of Calicut and occupies a total area of 2131 sq. km. The area lies between North latitude $11°26'$ to $12°00'$ and East longitude $75°75'$ to $76°56'$.Being a hill station, the altitude of Wayanad varies between 700 and 2100 m above sea level. The Kabini River system drains almost the entire region of Wayanad Plateau. The total catchment area of the river is around 1934.50 sq.km and has a basin length of 56 km. The river has three major tributaries viz., Panamaram, Mananthavady and Bavali Rivers. The present study was carried out from the known ranges of their distribution- Mananthavady, Panamaram and Kabini Rivers till the Wayanad boundary.
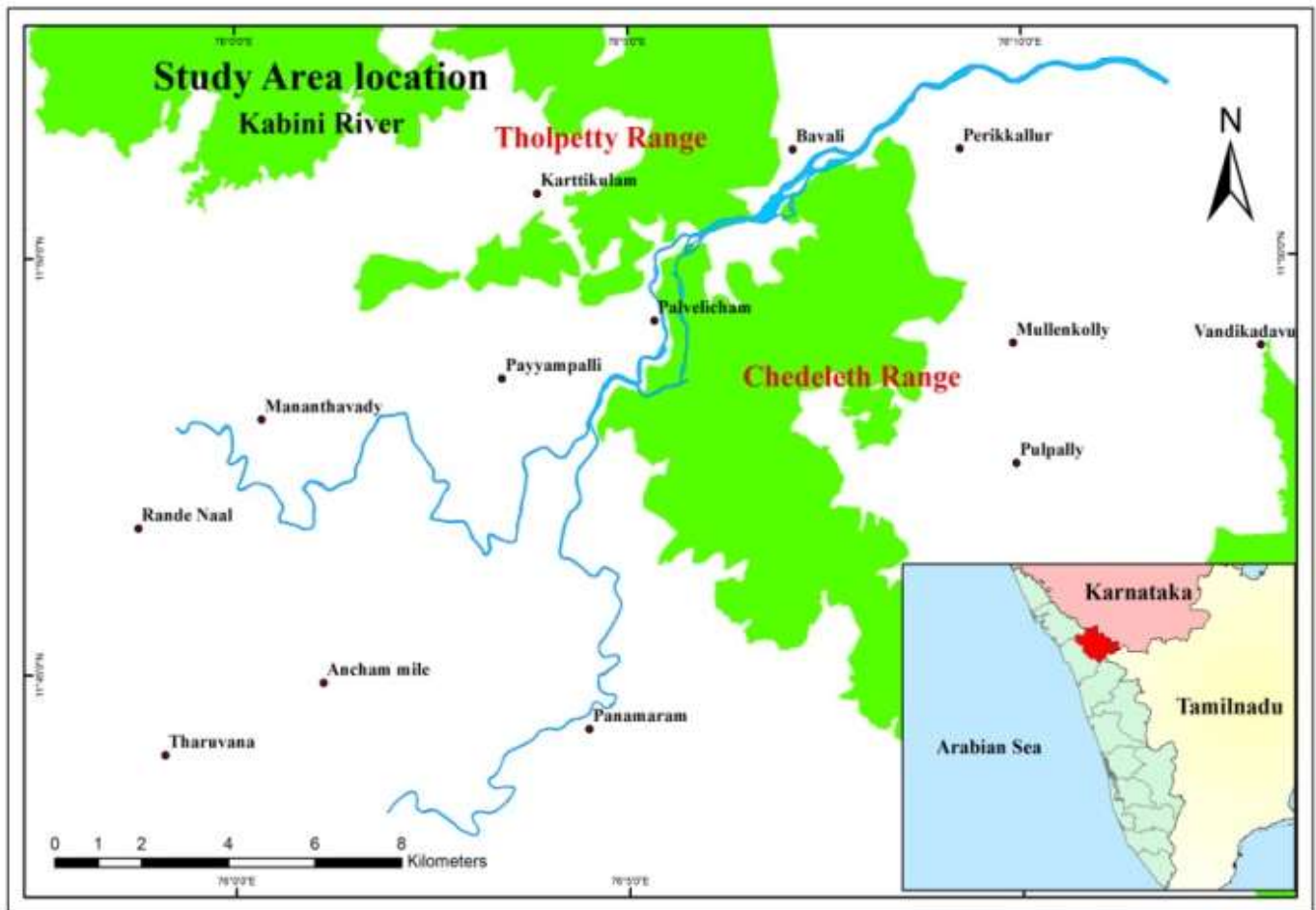
Fig.1 Study Area

3. METHODOLOGY

Muggers occupy from Panamaram, Mananthavady Rivers and extend till the Kerala- Karnataka boundary region of Kabini River system in Wayanad. The river system was mapped from Google Earth 2016 image to know the total range / extent of the species during the breeding and non-breeding seasons. Riparian stretches along the Kabini river system were vectorised from Google Earth Images of 2006 and 2016. Based on the riparian crown density 5 categories (very high, high, medium, low and open crown density) were delineated from the image to analyses the riparian cover change over the past 10 years. The riparian crown density layers of the 2 years were overlaid using union operation in ArcGIS to generate change matrix. The changed class codes of all the polygons were added to a new field in feature attribute tables of the overlaid feature classes through concatenation of crown density class codes of each overlaid year using field calculator and the spatial extent of each class changes were computed using statistical summarization and the changes were analyzed. This was done to understand the percentage change that has occurred to the riparian forests along the Kabini River system over the past 10 years. Thematic geographic layers were created from the Google Earth satellite images. The themes were vectorised in the ArcMap interface of Arc GIS software using the editing tools. Spatial distance tools were applied to develop the buffer zone around the river. Land Use/Land Cover was also vectorised from the 2016 Google Earth Image to know the anthropogenic pressure exerted on the Mugger Crocodile freshwater habitat. The major land uses identified within the buffer of 150 meters were Riparian forests, Biennial cropland, plantations, natural forest, mixed vegetation, build-ups and roads. The distance analysis was performed and reclassifies into 4 classes(River,Roads,BuildupsandLanduse).

4. RESULT AND DISCUSSION
4.1. HABITAT MAPPING

Mugger crocodile habitat along the river system in Wayanad was mapped. The total extent/range of the species in Wayanad accounts to 400.11ha. During the breeding season (December- May), they occupy an area of 157.63 ha i.e. they utilize only 39.4 % of their total range during the breeding season.
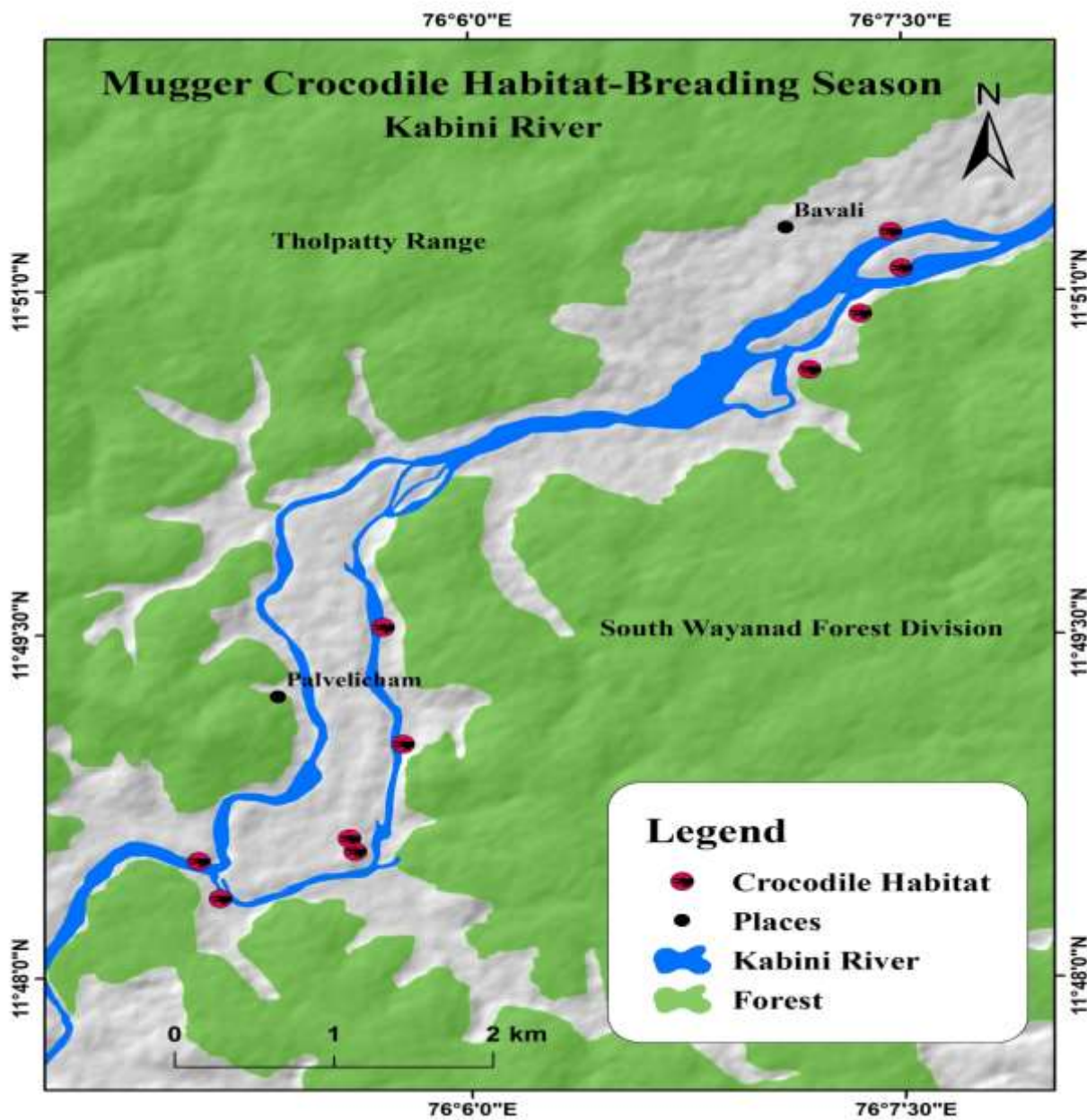

Fig.2. Map showing the freshwater habitat of *Crocodylus palustris* along the Kabini River System of Wayanad during the breeding season (Dec- May)

4.2. RIPARIAN CROWN COVER CHANGE *ANALYSIS*

Riparian cover change was analyzed for the past 10 years (2006 and 2016) along the Kabini River System starting from Mananthavady and Panamaram Rivers till Kolavalli Kabini Region of Kerala – Karnataka border. The crown density classes were categorized into 5 namely Very high, high, medium, low andopendensities.(Fig.3,Fig.4,Fig.5,Fig.6,Fig.7,Fig.8,Fig.9,Fig.10andFig.11)
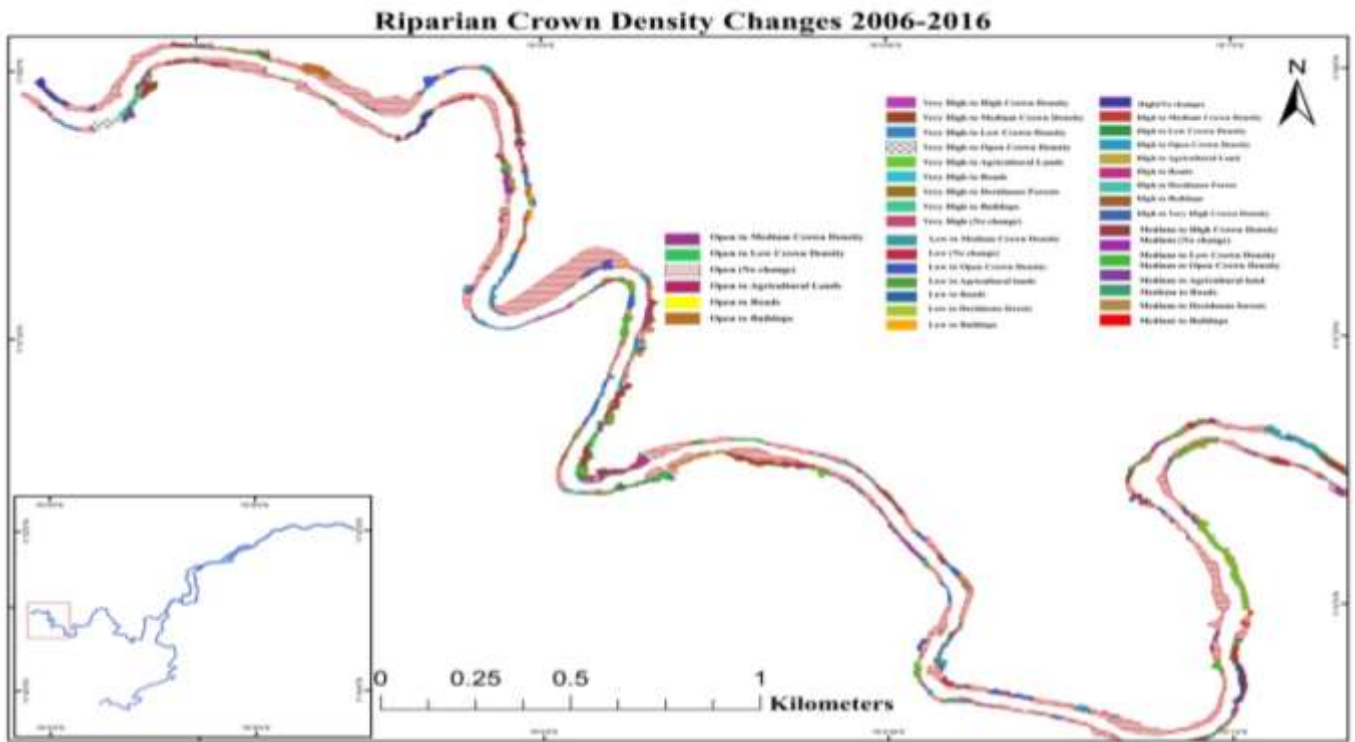
Riparian Crown Density Changes 2006-2016
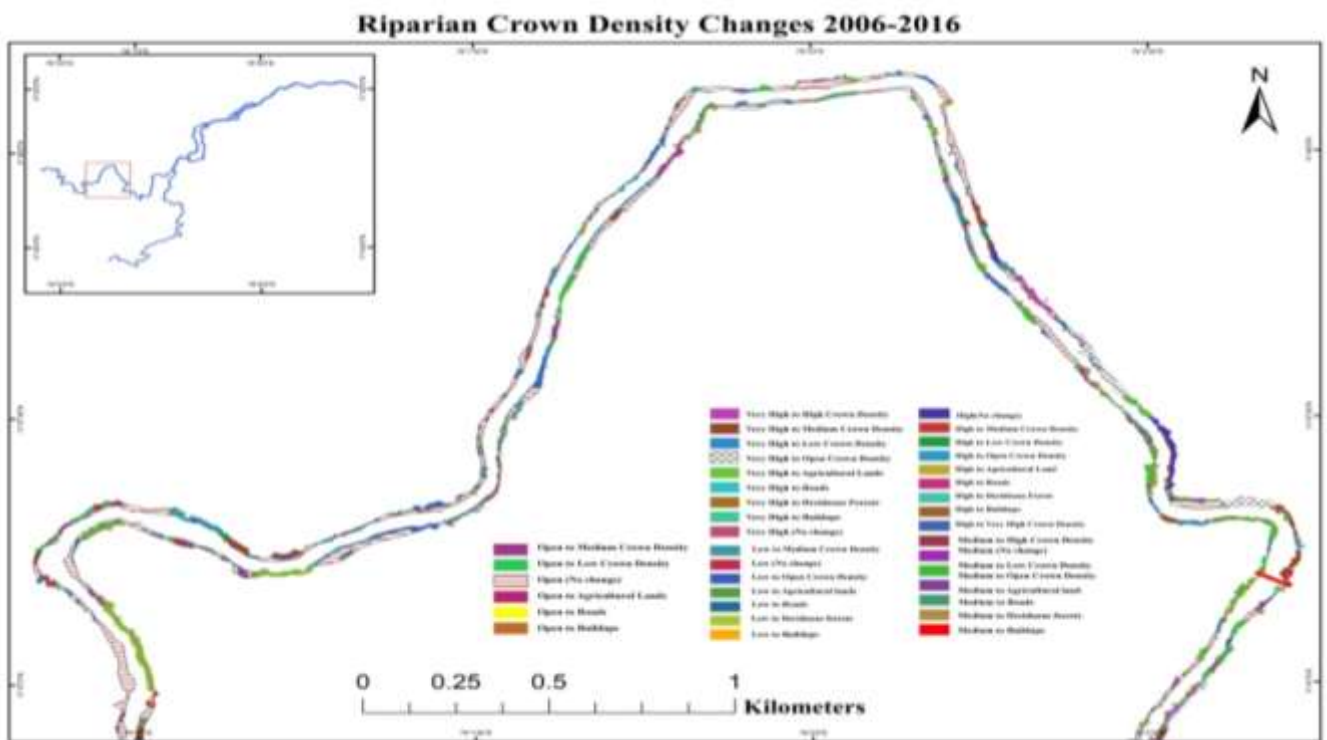
Fig.3

Riparian Crown Density Changes 2006-2016

Fig.4

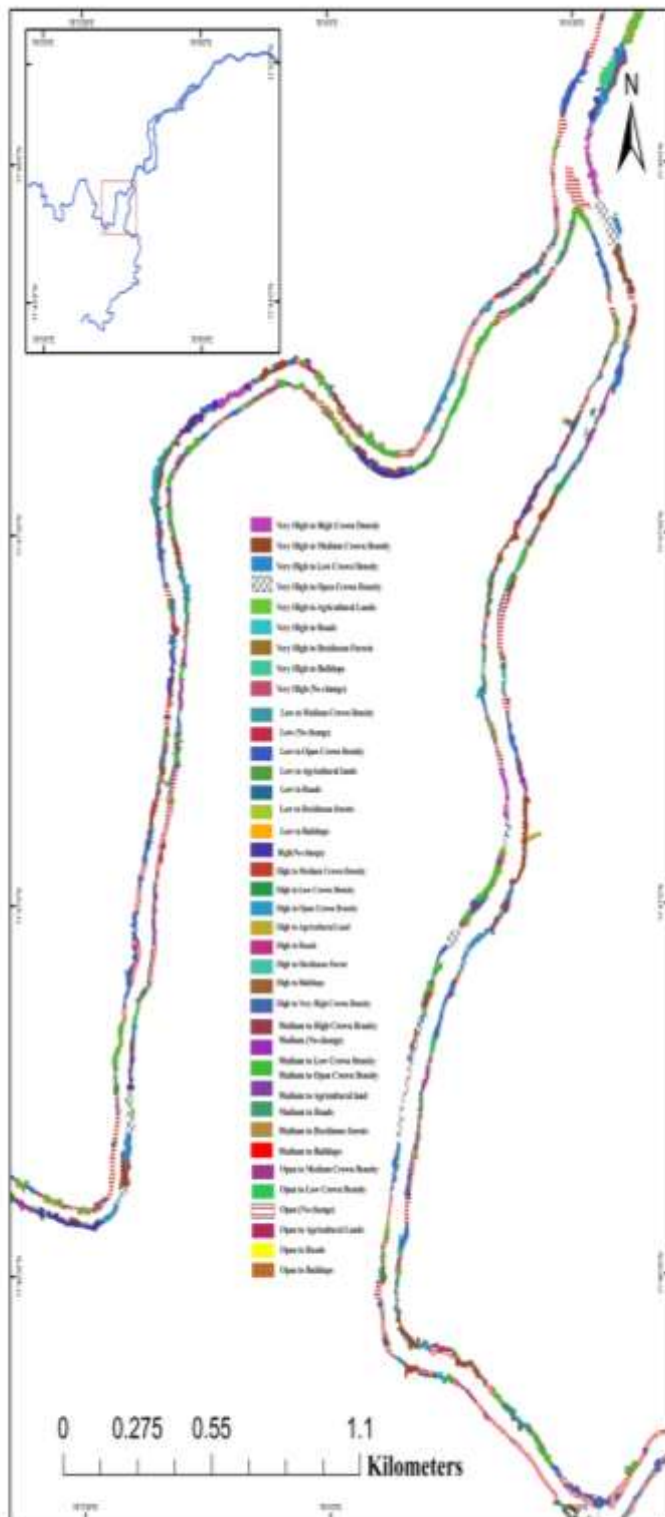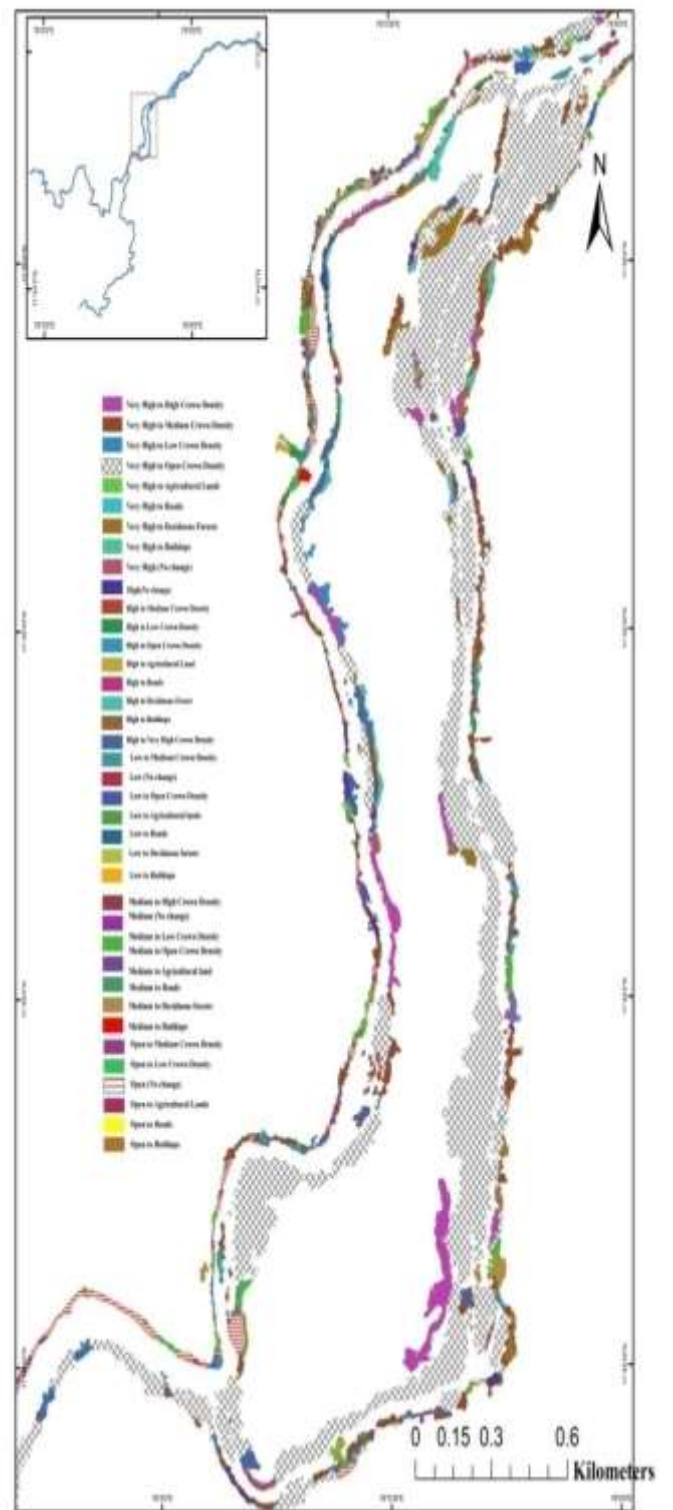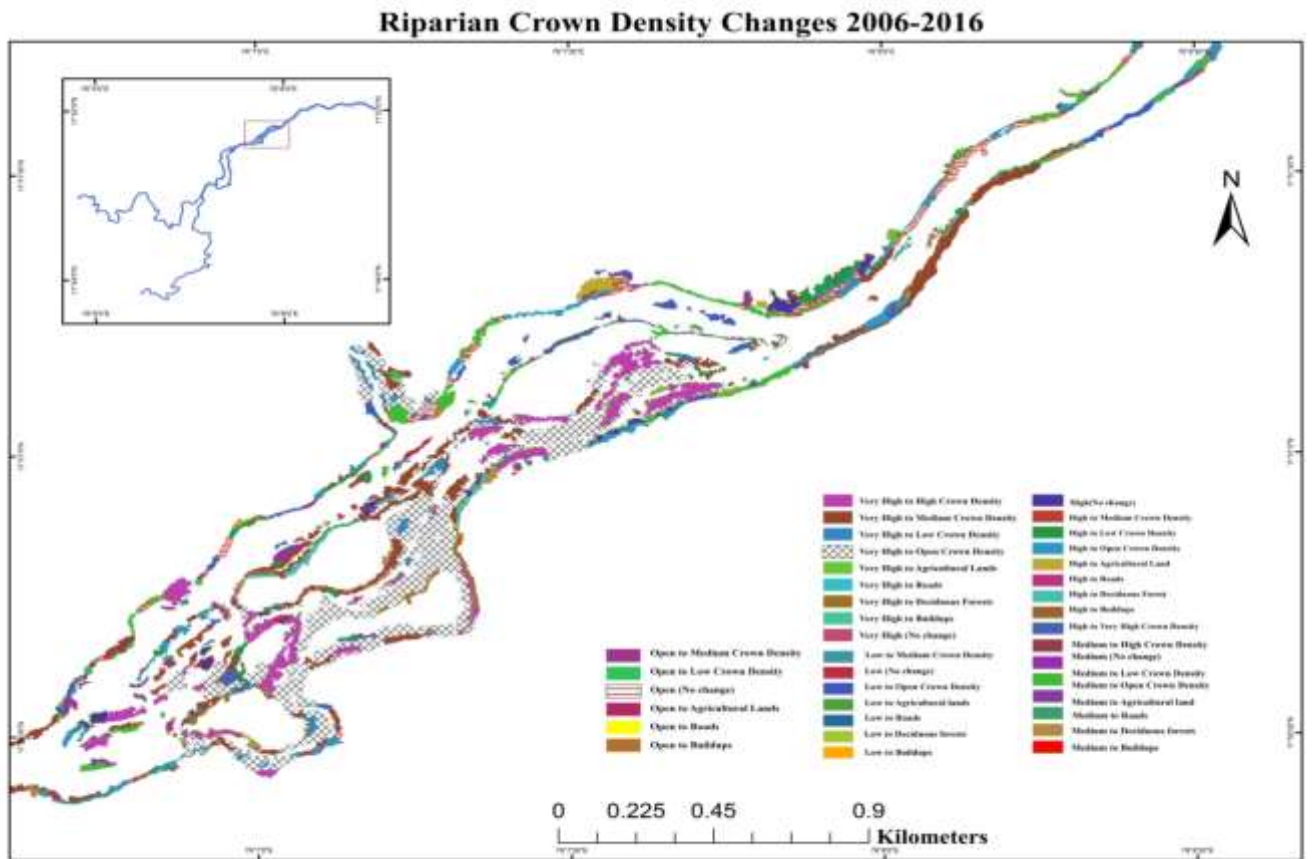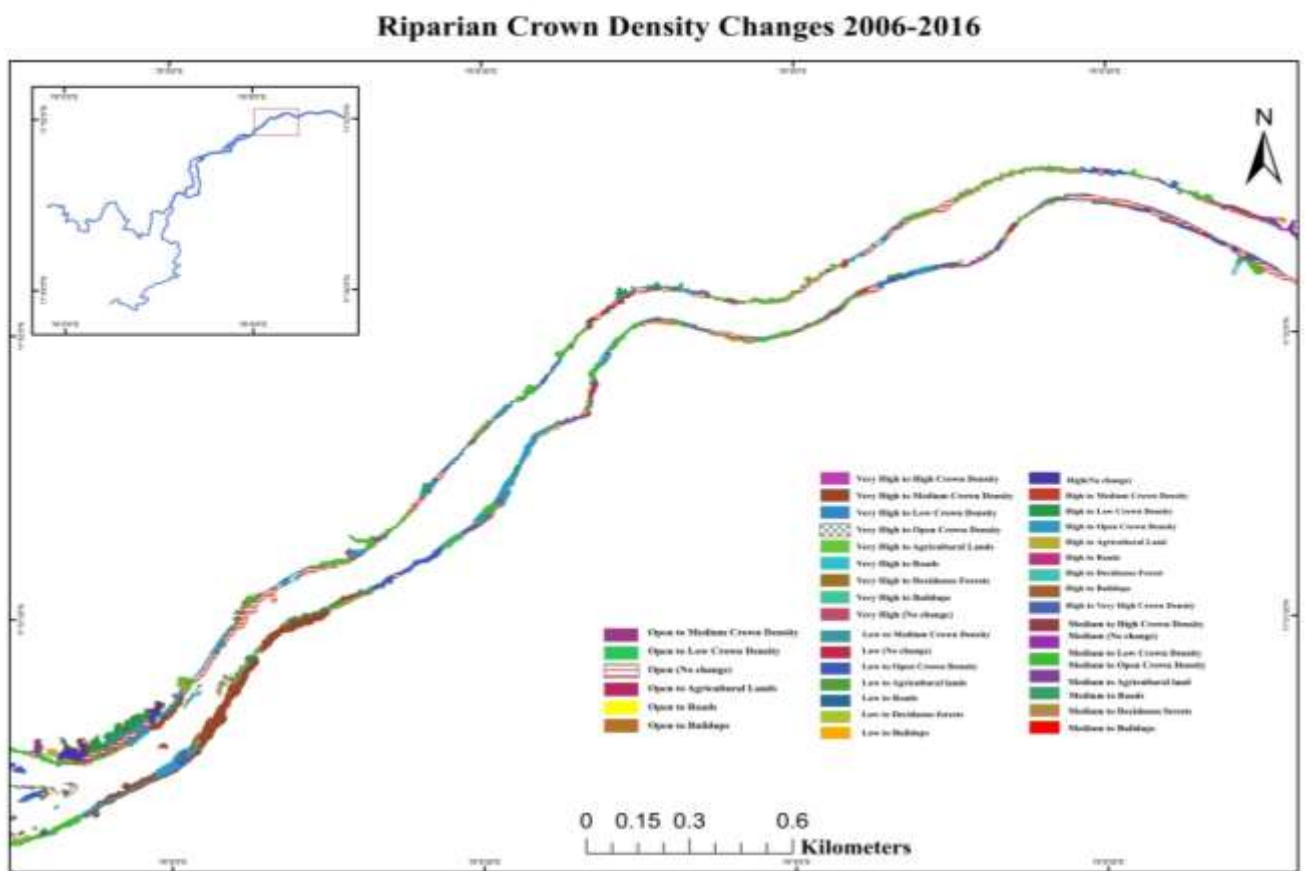Riparian Crown Density Changes 2006-2016   Riparian Crown Density Changes 2006-2016
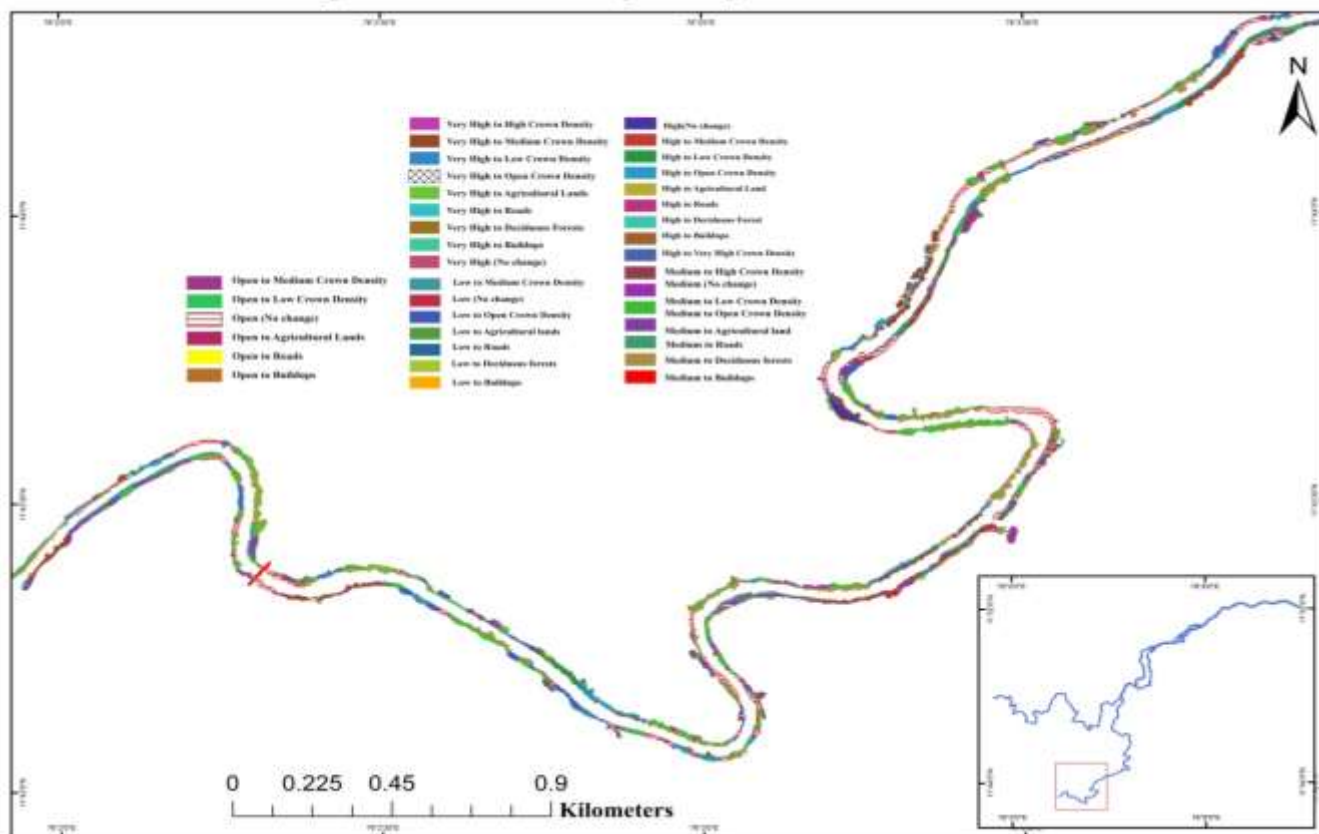

Fig.5   Fig.6
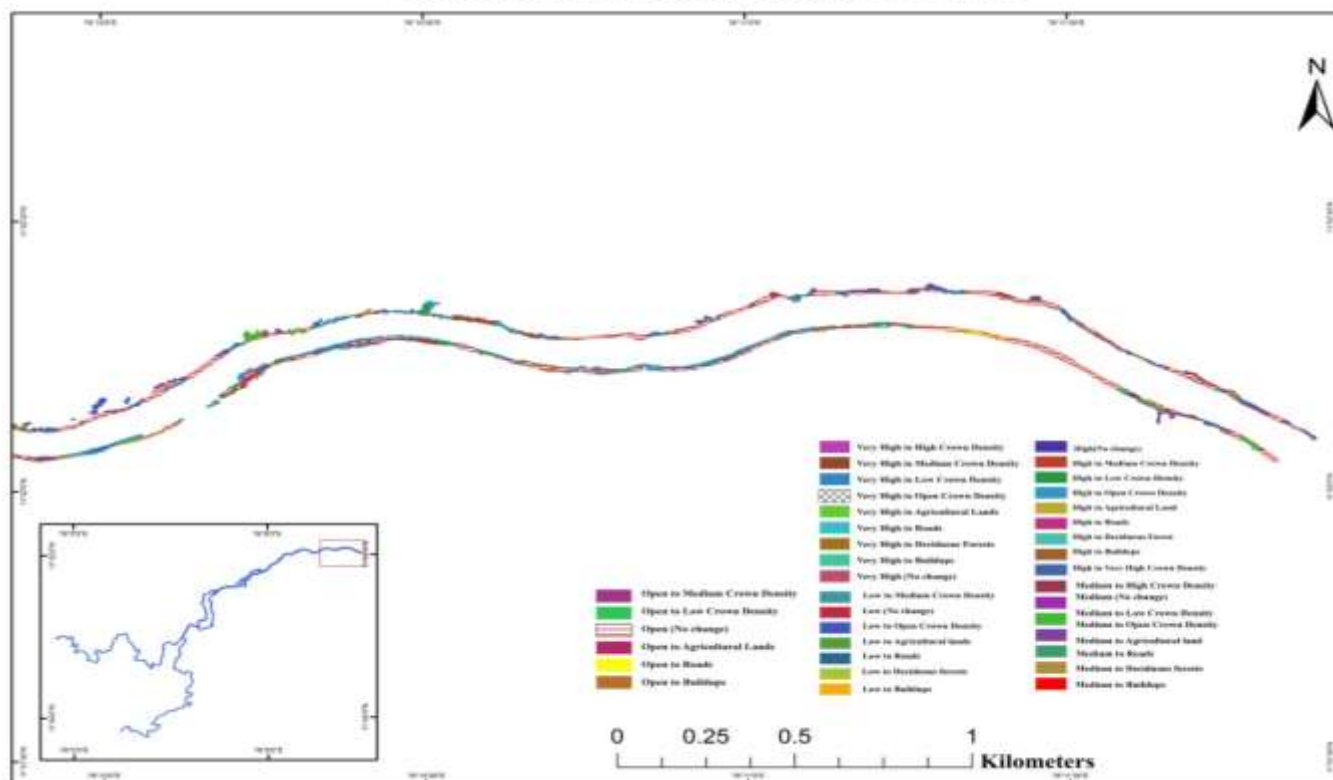
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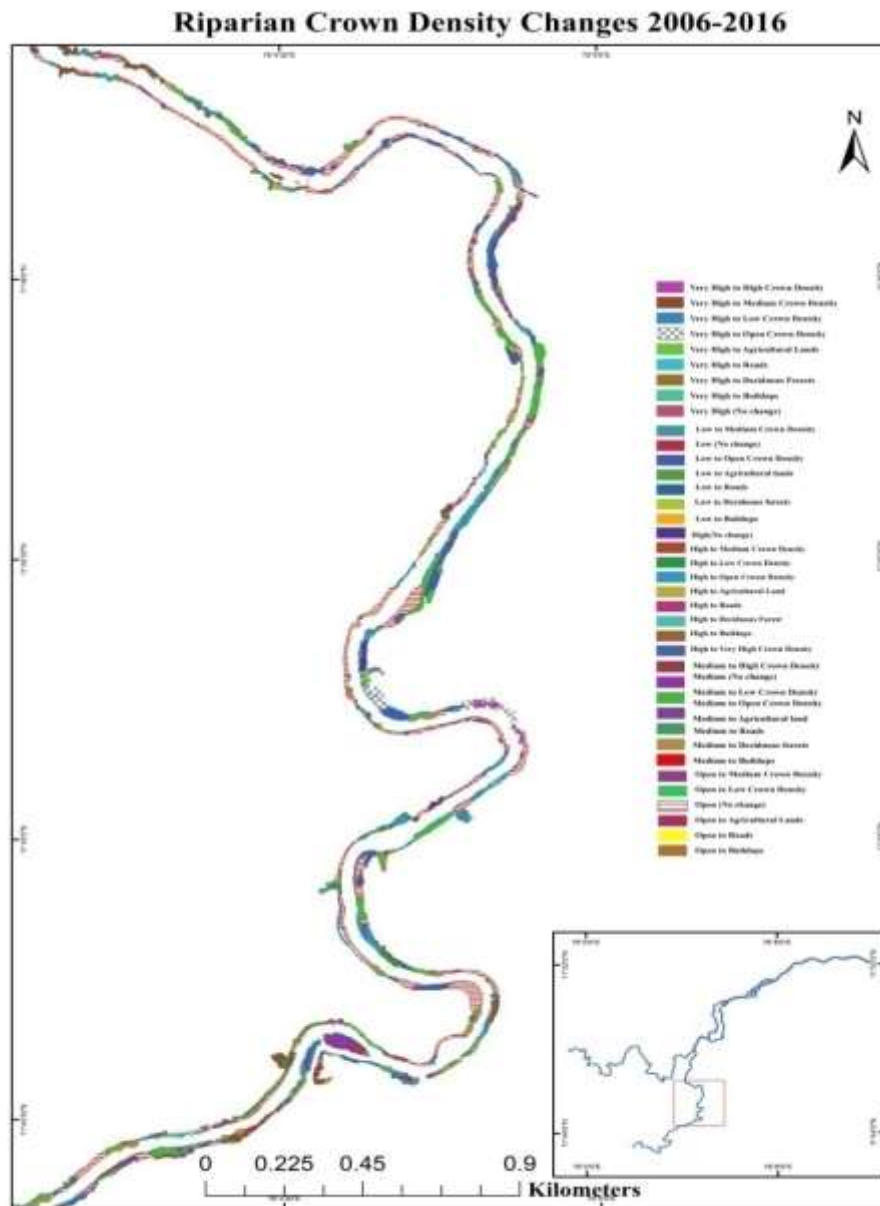
Fig.11

Table. 1 Riparian Crown Density categories along the Kabini River stretch for the years 2006 and 2016

Riparian Cover Classes	Area 2006 (Ha)	Area 2006 (%)	Area 2016 (Ha)	Area 2016 (%)
Very High Density	123.54	36.40	69.15	20.38
High Density	51.25	15.10	28.41	8.37
Medium	69.71	20.54	29.58	8.72
Low	37.50	11.05	36.77	10.84
Open	57.36	16.90	161.37	47.55
Agriculture	-	-	4.51	1.33
Road	-	-	0.39	0.11
Other Forest	-	-	7.70	2.27
Built-up	-	-	1.47	0.43
Total	**339.36**	**100.00**	**339.36**	**100.00**

Riparian zone acts as a major link between the terrestrial and aquatic environments. Riparian Crown Density of the past years (2006 and 2016) was mapped from Google Earth Satellite images. Using Geospatial tools, the area decline over the past 10 years were analyzed. Out of a total area of 339.36 ha there has been a high

change in the riparian crown densities. In the year 2006, there has been 36.4 per cent of very high crown density riparian which declined to 20.38 percent. (Table.1, Fig.12) Open cover increased from 16.9 percent in 2006 to 47.55 percent in 2016. The banks were left unprotected and devoid of vegetation which increases the chances of erosion, water pollution, surface runoff etc.26.72 per cent of very high density riparian cover has changed to open – zero canopy category in the span of 10 years. Also, 0.01 per cent of the very high density areas were transformed for the development of roads. In 2016, adjoining deciduous forest extended its range to areas having Very high, high, medium and low density riparian cover. Buildups also occupied areas having very high, high, medium, low and open riparian cover in 2016. Only 0.04 percent (very high), 1.58 per cent (high), 1.68 per cent (medium), 1.45 per cent (low) and 12.76 per cent (open) area remained unchanged from2006to 2016 (Table.2).
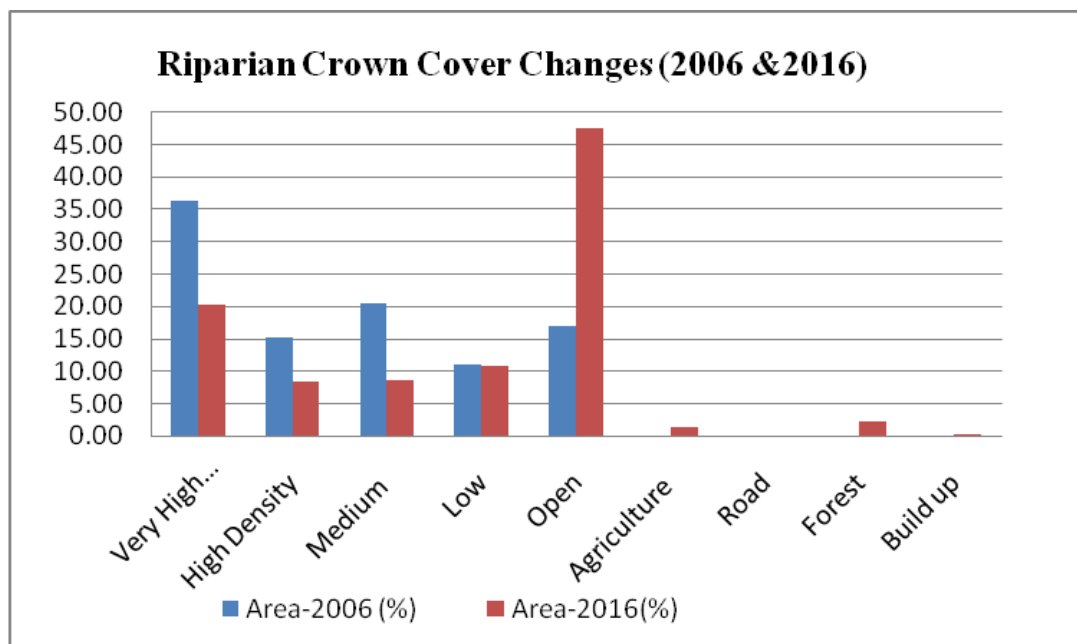

Fig.12: Distribution of different crown densities during 2006 and 2016

Table.2: Extent of riparian cover change from 2006 to 2016

Change Types	Area (Ha)	Area (%)
Very High to High Crown Density	12.92	3.81
Very High to Medium Crown Density	31.19	9.19
Very High to Low Crown Density	2.90	0.85
Very High Crown Density to Open	90.67	26.72
Very High to Agricultural Lands	0.32	0.09
Very High to Roads	0.03	0.01
Very High to Deciduous Forests	4.19	1.24
Very High to Built-up	0.06	0.02
Very High (No change)	0.12	0.04
High (No change)	5.37	1.58
High to Medium Crown Density	0.16	0.05
High to Low Crown Density	8.84	2.61
High Crown Density to Open	22.66	6.68
High to Agricultural Land	1.43	0.42
High to Roads	0.05	0.01
High to Deciduous Forest	2.60	0.76
High to Built-up	0.13	0.04
High to Very High Crown Density	2.57	0.76
Medium to High Crown Density	4.77	1.41
Medium (No change)	5.69	1.68
Medium to Low Crown Density	8.89	2.62
Medium to Open Crown Density	25.44	7.50

Medium to Agricultural land	1.32	0.39
Medium to Roads	0.10	0.03
Medium to Deciduous forests	21.19	6.24
Medium to Buildups	0.83	0.24
Low to Medium Crown Density	13.73	4.05
Low (No change)	4.91	1.45
Low to Open Crown Density	18.54	5.46
Low to Agricultural lands	0.16	0.05
Low to Roads	0.08	0.02
Low to Deciduous forests	0.05	0.02
Low to Built-up	0.12	0.04
Open to Medium Crown Density	1.08	0.32
Open to Low Crown Density	2.22	0.66
Open (No change)	43.31	12.76
Open to Agricultural Lands	0.24	0.07
Open to Roads	0.13	0.04
Open to Built-up	0.32	0.10
TOTAL	339.36	100.00

3.3. DISTURBANCE ZONATION

Stein et al., 2002 did a study on the anthropogenic pressure mapping of rivers in Australia. The author stated that human activities have a profound impact on the river systems around the world and the areas adjacent to them have the highest impact of disturbances. From the present study, the disturbance zone generated has given similar results. The regions adjacent to build-ups, roads and agricultural activities were highly disturbed and given the highest score. Panamaram and Mananthavady regions are heavily populated regions and has the maximum disturbances

The disturbed area was classified into four zones according to the intensity of disturbance. They are low disturbed zone, medium disturbed zone, moderately disturbed zone and highly disturbed zone. 26.85 per cent area comes under highly disturbed zone. Low disturbance zone had an area of 11.28 per cent (Table 3.3). Panamaram and Mananthavady regions are included under highly disturbed zones. Kuruva and Perikallur regions under medium to moderately disturbed zones. Palvelicham region under high to moderately disturbed zones.

Table 3.3: Extent of habitat disturbance zones Identified

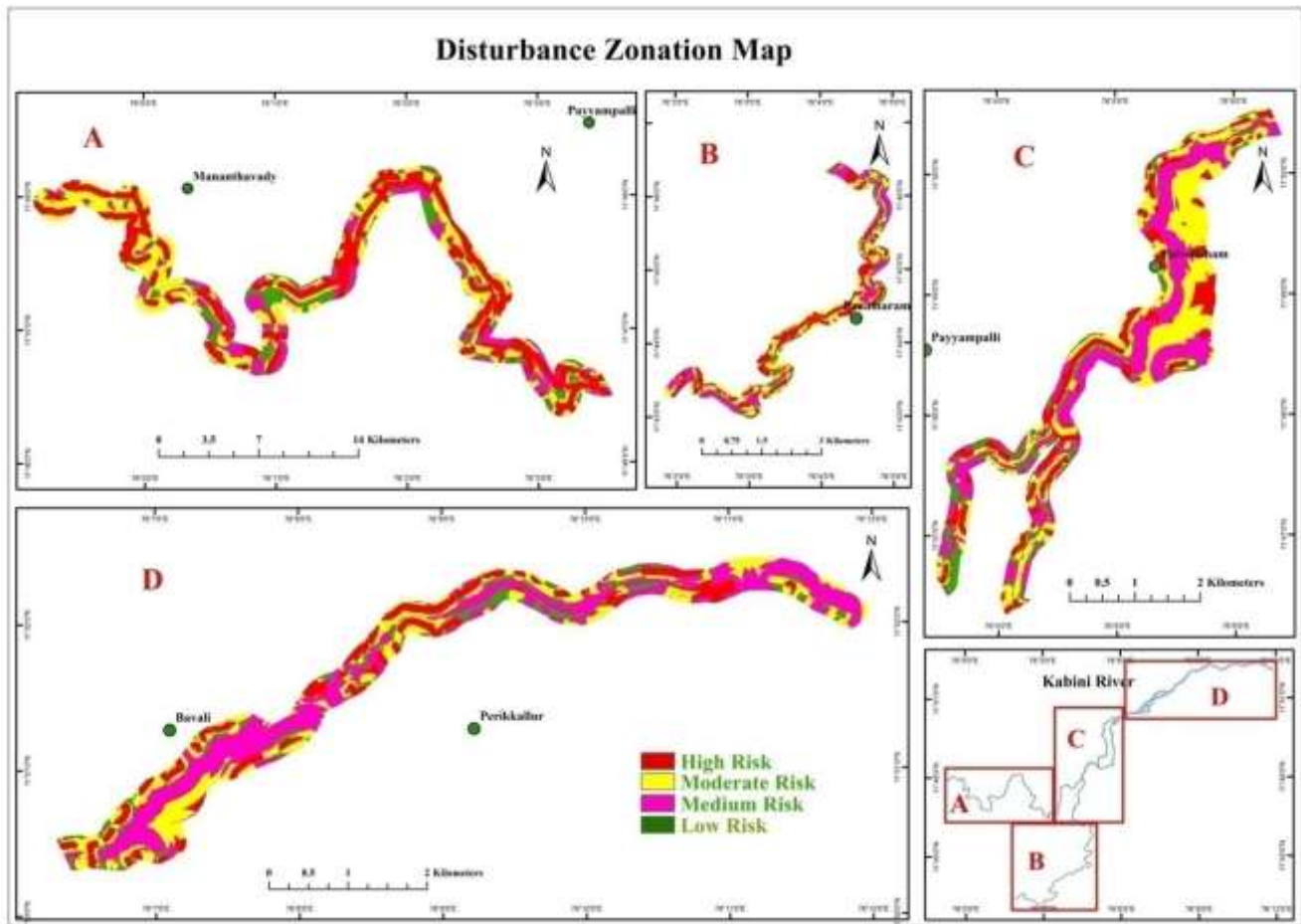| S. No.	Disturbance Zones	Area (Ha)	Area (%)
1	Low disturbed	262.83	11.28
2	Medium disturbed	689.08	29.58
3	Moderately disturbed	752.35	32.29
4	Highly disturbed	625.44	26.85

Fig.13

5. SUMMARY AND CONCLUSION

Geographical Information Systems and Remote Sensing have a widespread application in wildlife habitat studies. In the present study, GIS and Remote Sensing were applied for habitat mapping of Mugger Crocodiles along the Kabini River System. Google Earth satellite images were used as a source and the extent and range of riparian cover along the river system were delineated in accordance with their crown density. Also, disturbance zonation was carried out to identify the regions with maximum and minimum disturbances/anthropogenic pressure. Riparian zones are a major constituent of any riverine ecosystem. Disturbance caused to these filter zones can highly alter the hydrological properties of the water. There has been a drastic change in the riparian cover along the Kabini River System in the past 10 years. A high percent of riparian stretch has changed into open no vegetation banks. The riparian provide shading to the water which maintains a favorable water temperature for the fish species. The flow rate of the water is moderated by the riparian vegetation. With the loss of riparian cover, the water temperature would increase and the water flow rate would also increase, this might have a negative effect on the variety of riparian assemblage fishes and other aquatic living beings. Human activities have a profound impact on any natural habitat. Highly populated areas lead to greater and faster depletion effect to the river. The critical areas that need priority protection can be identified through the disturbance zonation mapping. These regions can be managed to reduce the pressure on the freshwater habitat of Mugger Crocodiles. Protecting a species starts with protecting their habitat. Mugger crocodiles are the keystone species of freshwater ecosystem, protecting the habitat of this species would indirectly lead to the protection of the other species as well. The anthropogenic activities in a river system might cause deteriorating effect on the species in one way or the other. Uncontrolled fishing activities, waste disposal, thinning riparian stretch *etc.* are the major threats to the Muggers in Kabini River system. Proper monitoring and making effective management strategies would be one way to help the riverine habitat of Kabini River System from getting further destroyed and depleted.

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