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Assessing the patterns of fish assemblages in the Rupnarayan River, West Bengal in India

Harshali Patkar
Bhavan's College, Andheri
Vidyadhar Atkore
freshwater.biologist@gmail.com

Sálim Ali Centre for Ornithology and Natural History
Gaurav Shinde
Wildlife Institute of India
Priyankar Chakraborty
Wildlife Institute of India
Shovana Ray
Wildlife Institute of India
Qamar Qureshi
Wildlife Institute of India
Vishnupriya Kolipakam
Wildlife Institute of India

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Abstract

Tropical rivers, are highly biodiverse yet they face significant threats from human activities, impacting overall their ecological health. We studied fish diversity (richness and abundance) and its relationships with environmental factors, understanding size class distribution and the role of land use land cover in a Rupnarayan river in east India. Using a hierarchical nested design and space-for-time replacement method to sample fishes from January 2024 to March 2024 over a 30 km stretch of the river.

We recorded 40 species, comprising 774 individuals from 14 orders and 25 families. Multiple linear regression indicated that channel type, water temperature, river width and depth, and time spent on fish sampling were significantly associated with species richness and abundance. Flow-ecology relationships demonstrated a preference for slower currents among selected species. The fishing gears influences the body size class of fish species.

Land Use Land Cover analysis showed that cropland (44%) dominates the study area followed by vegetation (25%), built-up areas (18%) etc. Despite the absence of immediate threats, the Rupnarayan River plays a crucial role in supporting significant riverine biodiversity which may be helpful for future ecological research and conservation efforts in similar tropical rivers in the world.

Introduction

Fish comprise the most diverse group of vertebrates, and exhibit a considerable richness of about 34000 species (Klimpel et al., 2019). Fish diversity in the riverine ecosystem has great significance in terms of livelihood and socio-economic importance (Ghorai, 2018). Fishes are substantial size consumers and possess long lifespans, that assimilate information about conditions throughout the food web. Their intricate ecological needs make river-dwelling fishes a suitable indicator of habitat conditions (Schiemer 2000). Various aspects of their abundance, species composition, age-class distribution, and reproductive patterns are reflective of the overall health of the river ecosystem (Schmutz et al., 2007). According to bioassessment research, fishes are important in indicating many characteristics of anthropogenic ecosystem degradation, particularly in rivers and streams (Schmutz et al., 2007; Hering et al., 2006, Poikane et al., 2017).

Although fish represent the most diverse group of vertebrates, freshwater fish are also the most threatened. After amphibians, fish may be the most vulnerable group of vertebrates (Bruton, 1995; Duncan and Lockwood, 2001). Increasing anthropogenic pressure in the form of illegal fishing and the use of indiscriminate fishing practices such as dynamiting, fish poisoning, electrofishing and river substate mining have drastically decimated the world’s freshwater fishes (Atkore et al., 2011; Hughes, 2021). Human activities pose numerous threats to river ecosystems, including damming, urbanisation, and agricultural expansion which adversely affect water quality and biodiversity (Vörösmarty et al., 2010)

The freshwater ecosystem comprises of numerous community metric to assess the ecosystem health which includes diversity, community structure, and species assemblages in streams and rivers. Fish

diversity is a measure of scale. The growth or decline of fish species assemblage within the spatial distribution limit is determined by biotic and abiotic factors (Minns, 1989; Olden et al., 2000). And the study of fish species composition and distribution helps in the identification of endangered or threatened species as well as the assessment of their population size and health.

Global patterns in fish diversity within tropical rivers are shaped by a complex interaction of environmental, geographical, and anthropogenic factors. Large tropical river basins, such as the Amazon, Congo, and Mekong, have the highest fish diversity due to their extensive and varied aquatic habitats (Van der Sleen and Albert, 2022). Environmental gradients, such as temperature, dissolved oxygen, and nutrient levels, significantly influence fish assemblage structures, as seen in the Mekong and Narmada rivers (Chea et al., 2017; Shukla and Bhat, 2017). Also, the seasonal variations and local environmental conditions, including stream order and forest cover, are crucial in shaping fish diversity patterns (Shukla and Bhat, 2017; Larre-Campuzano et al., 2023)

Globally, riverine ecosystems are increasingly threatened by hydrological regulation and the rapidly growing demands for irrigation, fisheries and industrial facilities (Davis et al., 2010; Suski and Cooke, 2007). So, understanding the interactions between different fish species within community helps to predict the potential impacts of environmental changes and designing effective conservation and management strategies (Mondal and Bhat, 2020). Environmental factors such as precipitation, topography, stream width, depth, altitude, temperature variation and scale of the study play crucial roles in shaping fish assemblages (Brown, 2000; Askeyev et. al., 2014; Dubey et al., 2012).

India is recognized as a hotspot of freshwater fish diversity and has a substantial degree of endemism that significantly contributes to the World's biological resources (Kottelat and Whitten, 1996; Dahanukar et al., 2003). Recent estimates indicate that India harbours about 2667 species, securing its position among the top 25 countries globally in terms of endemism. Additionally, India holds the third position in Asia concerning overall freshwater fish diversity (Thakur et al., 2021).

In India, researchers have drawn to study fish diversity, distribution and highlighted the role of environmental variables and anthropogenic factors in shaping fish diversity. Johnson and Arunachalam (2009) studied fish diversity in streams of the southern Western Ghats, recording 60 species across four orders, 13 families, and 27 genera, with Cyprinids being the most dominant. They observed that fish diversity varied among streams, with the highest diversity in the third-stream order (Thalayanai), and noted similarities in faunal assemblage among nearby basins. Dwivedi and De (2024) reported that in the Bhima River basin of the Deccan Plateau – a part of northern WG, fish communities show significant spatial variations. Another study from this region, Mohite and Sawant (2013) noted that the land use pattern transformation and riparian habitat loss, negatively affected fish diversity in the Warna River Basin. Study in rivers of central Western Ghats (States of Karnataka and Goa) found that water chemistry significantly influences fish guild composition and species richness, particularly at the sub-basin scale (Atkore et. al., 2020). Similar studies in streams across central and eastern India reveal that water flow is a common driver of fish richness and diversity, with no significant seasonal effects observed. This

suggest that abiotic factors consistently influence fish communities across different regions (Mondal and Bhat. 2020). According to Damseth et. al. (2024), the practice of riverbed mining directly threatens the survival of many aquatic species. Sand mining is a common practice in most parts of the river, which is the major cause of the threat to fish fauna (Rao et al., 2013).

The previous studies conducted in east India especially in the state of West Bengal did not receive adequate ecological except the few studies such as the study by Kar et al., 2016 documented 45 fish species in the Kangsabati River where fish abundance and richness were influenced by various physicochemical parameters like pH, dissolved oxygen, salinity, and suspended solids (Kar et al (2016). Another study conducted in 14 major Indian rivers, including Damodar River found that the surface area of river basin and availability of fish habitat were the most influential factors affecting the species richness (Das et al., 2012). A study documented the 38 fish species but also found that the disposal of fly ash mixed with hot wastewater from the Kolaghat Thermal Power Station into the Rupnarayan river of West Bengal state had adverse effects on fish diversity (Ghorai et al., 2015; Ghorai, 2018). Although the Rupnarayan River harbours a rich diversity of riverine fish species, the influence of ecological and anthropogenic parameters on fish assemblage remains inadequately understood and lacks further investigation. In this study we aim to explore the relation between fish diversity and environmental and anthropogenic factors and also assessed the land use and land cover (LULC) along the sampled stretch of Rupnarayan river.

Objectives

1. To study the diversity and relative abundance of fish species in the Rupnarayan river, West Bengal.

2. To assess the relationship between fish diversity and environmental factors including stream flow and anthropogenic activities.
3. To evaluate the effect of fishing gears on size-class distribution of select fish species.
4. To quantify land use and land cover along the study stretch of Rupnarayan river.

Materials and Methods

Study Area

The study was conducted in the Rupnarayan River a tributary of the Hooghly River and is situated in the state of West Bengal, northeastern India. Originating as the Dhaleshwari (Dhalkisor) in the foothills of the Chota Nagpur plateau northeast of Purulia, the river follows a meandering southeasterly course. The union of the Dwarkeswar and Shilabati near the Ghatal town of Paschim Medinipur district got its name as the Rupnarayan River. The Rupnarayan River holds significance as the primary watercourse in both Purba Medinipur and Paschim Medinipur districts. Stretching approximately 80 km, it is a tidal freshwater zone without a forest patch along its course. The river is not wide near the confluence of Dwarkeshwar and Shilabati but gradually widening after receiving discharges from Mundeshwari channel near Pansiuli (Khanakul block, Hooghly district) The river receives a very high discharge by the

Mundeshwari stream/ channel near Gopiganj and Bakshi, with the bank from Bakshi to Gadiara (Howrah district) situated at 45 km before joining the Hooghly River at Gadiara. (Das, 2023).

Field surveys

The systematic fish sampling was carried out during January 2024 to March 2024 following the hierarchical nested study design where in the river habitat (main channel, meander, pool etc) was nested in the stream segment of the main channel (Frissell et. al., 1986). The space for time replacement was used across the 30 km stretch from Ghatal to Mankur to capture environmental gradients, allowing us to infer broader ecological trends within a single sampling period. Different sets of fishing nets (4-gill nets of different mesh sizes, viz., 14 mm, 30 mm, 60mm, and 70 mm, were deployed for a minimum of 2 hours at each selected sampling point. The cast nets of 3 different mesh sizes, i.e., 11 mm, 25 mm, and 30 mm, were thrown up to 30 times) for fish sampling at the same sampling point within a river segment. The catch per unit effort (CPUE) was estimated as number of individuals of fish collected by different fishing gears per site per day.

Basic morphometric measurements like total length (cm), standard length (cm), and weight (g) were measured for individual fish. Fishes were kept in the glass tanks, and photographed using a Nikon P900 camera. Soon after the measurements, all the fishes were released unharmed back to the site except a few individuals of complex groups (loaches, and catfishes).

We recorded the geographic coordinates of each sampling unit using Garmin eTrex 30x handheld GPS (Table 1). At each site, we also recorded key river characteristics such as water temperature (°C), water depth (m), flow (m/s), width of the channel (m), salinity (ppt) using refractometer (SIMMANS), bank habitat type, channel type, and weather condition. We noted down the anthropogenic activities such as sand mining, agriculture, embankment, boat traffic that might influence the fish diversity directly or indirectly. The fish species were identified using standard taxonomic literature (Talwar and Jhingran, 1991; Jayram, 1999; 2010) and Eschmeyer’s catalog (Van der Laan et al 2014).

Table 1
Sampling sites with coordinates, LULC types, and disturbances.

Site	Latitude	Longitude	Elevation (m)	LULC Type	Disturbance
Ghatal	22.6707	87.77328	6.33	Built up Area, Vegetation	Fishing activity
Harispur	22.6537	87.7921	1.93	Vegetation	Fishing activity
Ghoradaha	22.637	87.80174	5.09	Crop Land	Fishing activity, Embankment, Sand mining
Garerghat	22.6333	87.81481	0	Crop Land	Not detected
Ranichak	22.6163	87.82433	6.18	Crop Land	Fishing activity
Dhaldanga	22.6051	87.83861	5.33	Crop Land	Not detected
Kaijuri	22.5884	87.85595	8.03	Vegetation	Not detected
Benai	22.5743	87.84722	0	Built up Area, Crop Land	Embankment
Dakshin Bhatora	22.5535	87.84724	7.32	Built up Area, Crop Land	Sand mining
Kultikari	22.5415	87.86021	5.37	Built up Area	Not detected
Dudhkomra	22.5298	87.87785	4.27	Built up Area	Embankment, Sand mining
Mankur	22.5176	87.89637	1.9	Built up Area	Embankment

Land Use and Land Cover classification

To create the LULC map, we downloaded Sentinel-2 imagery from March 2023 (10 m resolution) from the Copernicus Open Access Hub (https://scihub.copernicus.eu/). ArcMap 10.8 software was used to completed the entire mapping process. The study area was then extracted by clipping the image to required boundary. For classification, training samples were collected for different land cover types, such as vegetation, crop land, water bodies and built-up areas. A supervised classification approach using the Maximum Likelihood Classifier in ArcGIS was applied to categorised the land cover, and compared with Google Earth Pro (Ver 7.3.6) and analysed to understand the spatial distribution of different land cover types (Purkis and V Klemas, 2011).

Ethical guidelines

We followed standard ethical guidelines to study fish as per the (American Fisheries Society 2014) and The Committee for Control and Supervision of Experiments on Animals (CCSEA), Government of India. Additionally, we also sought ethical permission from the West Bengal Forest Department (Letter No. 3659/WL/4R-28/2016, dated- 27/12/2023) before commissioning the study. All fishes were captured using conventional fishing gears at every sampling site. They were measured (total body length in cm), weighed, photographed and released unharmed at the site of capture except a few complex groups which were euthanized using clove oil and preserved in 70% ethanol.

Statistical Analysis

Assessing species diversity is an important aspect in ecology. Recently, Chao et al (2015; 2022) and Hsieh et al (2016) have assessed the species diversity based on Hill numbers using interpolation and extrapolation (iNEXT) method. We analysed fish diversity at two scales, one at small scale (n = 36 sites), representing individual sampling points, and at large scale (n = 12), representing 2.5 km river reaches by using iNEXT in R (Hsieh et al 2024; R core Team, 2023).

Based on exploratory data analysis, we used a large-scale dataset to perform multiple regression using fish richness and fish abundance as response variables against environmental data (predictor variables) across sampling sites. We followed the model selection procedure for both richness and abundance data (Burnham and Anderson 2004). For species richness and fish abundance, we built ten models each. Of them, a top model was selected based on Akaike Information Criteria (AICc) (Johnson and Omland 2004). We used the sum of Akaike weights of each candidate model in which each predictor appeared. We chose the model with the delta AIC value to indicate that the model describes the data well compared with the best-fit model (Burnham and Anderson 2004). The model averaging using AICc was done to select the best predictor model that explains fish richness and fish abundance. Also, we evaluated basic flow-ecology relationships for a few select fish species. Subsequently, we explored the basic relationship between the body size and fishing gears. All statistical analysis and modelling were performed using the R software (R Core Team 2023; Hammer et al., 2001).

Results

Fish Diversity and Distribution

A total of 774 individuals were recorded across 12 sites (Mean abundance 64.5 individuals/Site), representing 40 species (mean richness 3.33 species/site) distributed in 14 orders and 25 families. Among the total collected fish species, the order Cypriniformes (54%, n = 414) was dominant, followed by Gobiiformes (27%, n = 210) and Perciformes (6%, n = 44). There were 38 species 95% classified as Least Concerned (LC), 1 species (2.5%) as Data Deficient (DD), and 1 species (2.5%) as Not Evaluated (NE) (Table 2)

Table 2
Fish species and conservation status (IUCN) in Rupnarayan River.

Order	Family	Scientific Name	No of Individuals	IUCN Status
Acanthuriformes	Leiognathidae	*Equulites* cf. *elongatus* (Günther 1874)	1	NE
Anabantiformes	Badidae	*Badis badis* (Hamilton 1822)	1	LC
	Channidae	*Channa punctata* (Bloch 1793)	3	LC
	Nandidae	*Nandus nandus* (Hamilton 1822)	1	LC
	Osphronemidae	*Trichogaster bejeus* (Hamilton 1822)	6	LC
Beloniformes	Adrianichthyidae	*Oryzias* cf. *dancena* (Hamilton 1822)	1	LC
	Belonidae	*Xenentodon cancila* (Hamilton 1822)	1	LC
Clupeiformes	Ehiravidae	*Corica soborna* (Hamilton 1822)	3	LC
	Dorosomatidae	*Gonialosa manmina* (Hamilton 1822)	12	LC
	Dorosomatidae	*Gudusia chapra* (Hamilton 1822)	17	LC
	Dorosomatidae	Tenualosa illisha (Hamilton 1822)	3	LC
	Engraulidae	*Setipinna phasa* (Hamilton 1822)	14	LC
Cypriniformes	Cyprinidae	*Amblypharyngodon mola* (Hamilton, 1822)	6	LC
	Cyprinidae	*Labeo calbasu* (Hamilton 1822)	5	LC
	Danionidae	*Laubuka laubuca* (Hamilton 1822)	2	LC
	Danionidae	*Opsarius* cf. *barna* (Hamilton 1822)	1	LC
	Cyprinidae	*Osteobrama cotio* (Hamilton 1822)	1	LC
	Cyprinidae	*Pethia ticto* (Hamilton 1822)	17	LC

Order	Family	Scientific Name	No of Individuals	IUCN Status
	Cyprinidae	*Puntius chola* (Hamilton 1822)	12	LC
	Cyprinidae	*Puntius sophore* (Hamilton 1822)	147	LC
	Danionidae	*Salmostoma bacaila* (Hamilton 1822)	221	LC
	Cyprinidae	*Labeo bata* (Hamilton 1822)	2	LC
Gobiiformes	Gobiidae	*Apocryptes bato* (Hamilton 1822)	186	LC
	Butidae	*Butis butis* (Hamilton 1822)	1	LC
	Gobiidae	*Glossogobius giuris* (Hamilton 1822)	13	LC
	Gobiidae	*Mugilogobius* cf. *mertoni* (Weber 1911)	1	LC
	Gobiidae	*Odontamblyopus rubicundus* (Hamilton 1822)	8	LC
	Butidae	*Prionobutis* cf. *microps* (Weber 1907)	1	LC
Mugiliformes	Mugilidae	*Rhinomugil corsula* (Hamilton 1822)	26	LC
	Ambassidae	*Chanda nama* (Hamilton 1822)	19	LC
	Ambassidae	*Parambassis ranga* (Hamilton 1822)	8	LC
Perciformes	Platycephalidae	*Platycephalus indicus* (Linnaeus 1758)	17	DD
Carangiformes	Cynoglossidae	*Cynoglossus cynoglossus* (Hamilton 1822)	5	LC
Siluriformes	Sisoridae	*Erethistes pusillus* (Müller & Troschel 1849)	1	LC
	Horabagridae	*Pachypterus atherinoides* (Bloch 1794)	1	LC
	Ailiidae	*Silonia silondia* (Hamilton 1822)	1	LC
Acanthuriformes	Sparidae	*Acanthopagrus berda* (Fabricius 1775)	1	LC

Order	Family	Scientific Name	No of Individuals	IUCN Status
Synbranchiformes	Mastacembelidae	*Macrognathus pancalus* (Hamilton 1822)	6	LC
Syngnathiformes	Syngnathidae	*Microphis* cf. *cuncalus* (Hamilton 1822)	1	LC
Tetraodontiformes	Tetraodontidae	*Leiodon cutcutia* (Hamilton 1822)	1	LC

The species diversity accumulated at 800 individuals both for small and large scale (Fig. 2) and this was also true for sample coverage plot whereas the species diversity increased sharply at the small scale than large scale (Fig. 2). Maximum number of species and individuals were recorded in Kaijuri sampling site, while low number of species and individuals were recorded in Mankur site.

Effect of environmental variables on fish richness and abundance

Multiple regression analysis of fish richness and abundance against environmental data showed that the fish richness was best explained by the channel type, time spent (hour per site), and water temperature in the Rupnarayan river (Table 3, 4). The effect size plots suggest that the fish richness was higher at the narrow channel, meander, and confluence (Fig. 3) and it increased with time spent for fishing (no. of hours spent for fishing). Whereas fish richness show decline with increasing temperature.

Table 3
The candidate model tested for predicting fish richness in Rupnarayan River.

Model terms	AICc	dAICC.	df	weight
Richness ~ Channel type + Elevation + Time spent + Water temperature + Flow	**79.9**	**0**	**9**	**0.512**
Richness ~ Elevation + Width + Depth	80.7	0.8	5	0.34
Richness ~ Tidal type + Time spent	83.4	3.4	4	0.092
Richness ~ Time spent + Width + Depth	84.6	4.6	5	0.051

Table 4
Coefficient estimates of explanatory variables for the best multiple linear regression models for species richness in the study area.

Variables	Beta estimates	Standard error	2.5%	97.50%	p-value	Multiple R2	Adjusted R2	p-value
Intercept	-10.4	27.44	-86.6	65.8	0.72	0.84	0.52	0.13
Channel type narrow channel, confluence	-1.68	4.18	-13.3	9.93	0.7			
Channel type narrow channel, meander*	-20.97	6.61	-39.3	-2.59	0.03			
Channel type narrow channel, meander, confluence	-4.85	6.05	-21.7	11.94	0.46			
Elevation	-1.28	1.15	-4.48	1.91	0.32			
Time spent*	7.6	2.15	1.28	12.25	0.02			
Water temperature	-0.99	0.8	-3.23	1.24	0.28			
Flow	-10.86	18.6	-62.5	40.79	0.59			

Fish abundance in the Rupnarayan River is best predicted by time spent for fishing, and tide type which is supported by the model selection (Table 5, 6). The effect size plot suggests that, the fish abundance was strongly positively associated with time spent (Fig. 4) and higher during the high tide as compared to low tide.

Table 5
Model selection based on AICc showing top one model for fish abundance.

Model terms	AICc	dAICC.	df	Weight
Abundance ~ Tidal type + Time spent	**97.9**	**0**	**4**	**0.531**
Abundance ~ Time spent + Width + Depth	98.3	0.4	5	0.434
Abundance ~ Elevation_ + Width + Depth	103.4	5.5	5	0.034
Abundance ~ Number of irrigation pump + number of fishing activity + Sand mining	110.6	12.7	5	< 0.001
Abundance ~ Channel type + Flow	120.2	22.3	6	< 0.001
Abundance ~ Number of fishing activity + Channel type	120.8	23	6	< 0.001

Table 6
Coefficient estimates of explanatory variables for the best multiple linear regression models for species abundance.

Variables	Beta estimates	Standard error	2.5%	97.50%	*P* value	Multiple R^2	Adjusted R^2	p-value
Intercept*	-71.82	27.04	-133	-10.64	0.02	0.87	0.84	< 0.0001
Tidal type Low	-12.44	7.97	-30.5	5.58	0.15			
Time spent***	16.5	2.73	10.3	22.68	0.0001			

Response of common fishes to the stream flow The relation of flow and, selected a key dominant species such as *Apocryptes bato* (Hamilton 1822), *Puntius sophore* (Hamilton 1822), *Salmostoma bacaila* (Hamilton 1822) consistently declined with the rise of streamflow (Fig .5) whereas other rare species such as *Chanda Nama* (Hamilton 1822) *and Platycephalus indicus* (Linnaeus 1758) declined similarly except *Gudusia chapra (Hamilton 1822)* which showed a slight increase with the rise of flow (Fig. 6).

The gear size influence on size class distribution

In this study the overall size class distribution of all captured fishes was 2.8 cm (1.6 cm to 25.2 cm). The largest fish sampled was *Glossogobius guiris* (25.2 cm) whereas the smallest fish sampled was *Badis badis* (2.9 cm). The fishing gear used in sampling clearly shows the variation in fish size classes. Hand net primarily tended to captures smaller-sized fish, with median size below 5 cm, showing a narrow range with minimal variation. Gill nets tend to capture fish within the 7.5 to 10 cm range, indicating preference for medium-sized individuals.

Cast nets, on the other hand, also capture fish in similar range but show slightly lower median values compared to gill nets. The distinct separation between hand nets and the other two suggests that each gear type plays a specific role in targeting different fish sizes (Fig. 8).

Land use and Land cover Analysis

The LULC analysis revealed that 44% of the total area is dominated by cropland, amounting to 16.38 km^2. Vegetation covers 25% of the region with an area of 9.76 $km^{2,}$ while built-up area accounts for 18%, totalling 6.86 km^2. River system constitutes 12% of the land, and pond occupy 1% of the region, with and area of 0.20 km^2 (Table 7, Fig. 9).

Table 7
Land Use Land Cover distribution along Rupnarayan River.

Built up Area	**Sum of Area (km^2)**	**Percentage (%)**
	6.86	**18**
Crop Land	16.38	44
Ponds	0.20	1
River	4.38	12
Vegetation	9.76	25
Grand Total	37.58	100

Normalised Difference Vegetation Index (NDVI) Analysis:

The vegetation distribution map (Fig. 10) represents the spatial changes along the Rupnarayan River based on NDVI analysis. The dense riparian vegetation is shown by the high NDVI values (0.43 to 0.67), which are displayed in green. The medium regions 0.16 to 0.43 (yellow) form a buffer zone between dense vegetation and anthropologically impacted areas whereas the low NDVI values – 0.17 to 0.16 (red) are scattered and fragmented patches, representing agricultural and urban settlements.

Discussion

Fish diversity patterns and associated environmental factors

The tropical rivers are highly rich in its biodiversity (Dudgeon 2006; Dudgeon, 2000; Zhou and Li, 2024). The Rupnarayan River one of the tributaries of Ganga exhibited a very high fish diversity with 40 species. The family Cyprinidae is the most dominant in this study area and also in the southeast Asian streams (Lowe McConnell,1987). Numerous studies demonstrated that the diversity patterns in streams and rivers are shaped by variety of factors at different scales (Olden et al 2001; Oberdorff et al., 2011). At the large scale, the relative difference between the number of individuals and species among sites indicated

a consistent pattern across spatial scales. While, at smaller scale species diversity tends to more variable and shaped by local factors such as habitats (Gorman and Karr 1978. At smaller spatial scale demonstrated that the fish diversity was largely driven by microhabitat features (pools, run, riffles) river substrate composition (Gorman and Karr 1978). But at the river basin or catchment level, fish diversity was governed by hydrology, river characteristics, and human activities (Olden et al 2001; Atkore et al 2020). Hydrodynamics and tidal type also influence native fish assemblages (Huntsman et al 2023; (Caroline et al., 2023; Ma et al., 2024). The present study found that channel type, elevation, water temperature, flow, and time spent for fish sampling and tidal type driven the fish diversity patterns. However, we did not encounter any non-native species but presence of these species could not be ruled out. (Sandilyan, 2022). This study found a negative relationship between diversity and channel depth, width, contrasting with past research suggesting larger, diverse habitats increase species diversity (Angermeier and Schlosser, 1989; Taylor et al., 2006).

In this study, fish diversity showed a negative relationship with water temperature and stream flow, suggesting these variables shapes fish assemblage in tropical regulated rivers (Mondal and Bhat, 2020; Bice et al., 2014). Optimum water temperature is essential for physiological reactions and impacts fish growth and abundance (Chapman, 1996; Chaudhary et al., 2020). Stream flow variation is important in governing the distribution as well as reproductive behaviour of fish species in tropical rivers (Poff et al 1997; Fang-Fang Li et al 2019). A few dominant species such as *Apocryptes bato (Hamilton 1822)*, *Puntius sophore (Hamilton 1822), Salmostoma bacaila (Hamilton 1822)* showed negative responses to the rise in the streamflow condition whereas other species *Gudusia chapra (Hamilton 1822)* showed positive or neutral response to the flow condition suggesting different species may adapt or behave differently to the flow condition during their life cycle (Mims & Olden, 2012; Stratford et al., 2016). We could not establish a relationship between flow and fish reproductive behaviour due to the time constraints of the study but long-term studies should explore such patterns in the future. Of the habitat studied, narrow channel confluence and meander influenced the fish richness than the other channels suggesting surface dweller fishes preferred confluence habitat may be due to meet their demand for the fresh dissolved oxygen and as a migration route to other habitats at the confluence and refugia or completion of their life cycle at the meanders (Stoffers et al 2022; Liu et al 2024). Generally, large-body size fishes tend to prefer slower water bodies with deeper pools whereas smaller to medium-sized fishes prefer shallower and fast to medium streamflow (Akbaripasand et al., 2011). Such insights are more important in hydrological studies. The flow regulation especially below the dam during the summer season, significantly affects the migratory species when flow is reduced significantly (Vaidya et al., 2008). Although Rupnarayan is a free-flowing tributary of the Hooghly River, the flow rate was not disrupted due to the absence of hydrological barriers. We observed that, during the high salinity period (afternoon in each day at 1:55 hrs), fish were higher whereas during at lower salinity period (morning 07:15 hrs), fish were lower in their relative abundances. A previous study in Slocun River estuary, U. S. A also reported that salinity levels influenced species composition and diversity of fish species (Hoff and Ibara, 1977).

The sand mining, embankment, and agriculture are some of the main threats to the river habitat and its fauna (Paukert 2008; Fischer 2012). Although this study was of a short duration but the results indicates

that the fish diversity showed a negative relationship with sand mining and, the number of fishing activities. Out of 36 sites sampled three sites were exposed to sand mining activities. At two sites manual sand mining was present and at one site near Mankur, mechanized sand mining was observed. The higher intensity of sand mining, and water withdrawals using a greater number of irrigation pumps may further threaten the fish life of this river.

Land use changes, particularly the conversion of land for agriculture and human habitation, pose significant threats to riverine ecosystems. In the Marapanim River watershed, Brazil's deforestation for agriculture and urban development has led to the loss of 1,614.72 km² of forest, negatively affecting water-related ecosystem services such as carbon sequestration and soil moisture regulation (Beltrão & Gomes, 2023). Similarly, agricultural expansion in the Tonle Sap Floodplain, Cambodia, has resulted in a drastic decline in scrubland and grassland, contributing to habitat loss, decreased fish productivity, and a 12% reduction in carbon stocks (Mahood et al., 2020). This study shows that in 2024, cropland dominates 44% of the total study area, while built-up areas account for 18%, leaving only 25% of the landscape covered by vegetation in the Rupnarayan River region. These findings align with broader patterns of land use change observed in other river basins, such as the Upper Yamuna Basin, which has also experienced rapid urbanisation and agricultural expansion, leading to a decline in green spaces and increasing pollution levels in the river (Neenu & Kansal, 2024).

The Rupnarayan River hold a significant fish diversity. Future work should consider studying the long-tern influence of environmental, temporal and anthropogenic factors along with parameters of water quality to monitor the health of the river.

Declarations

Author Contribution

HP – Data collection, analysis and written the original draft, VA- Designed, Conceptualised, Supervised, Analysis, edited the original manuscript, GS – Data collection. PC-Data collection, edited the manuscript, SR-Data collection, QQ-Designed, Conceptualised, Supervised, Analysis, edited the original manuscript, VK- Designed, Conceptualised, Supervised, edited the original manuscript.

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Data Availability

Data will be made available from the corresponding author on a reasonable request.

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Figures

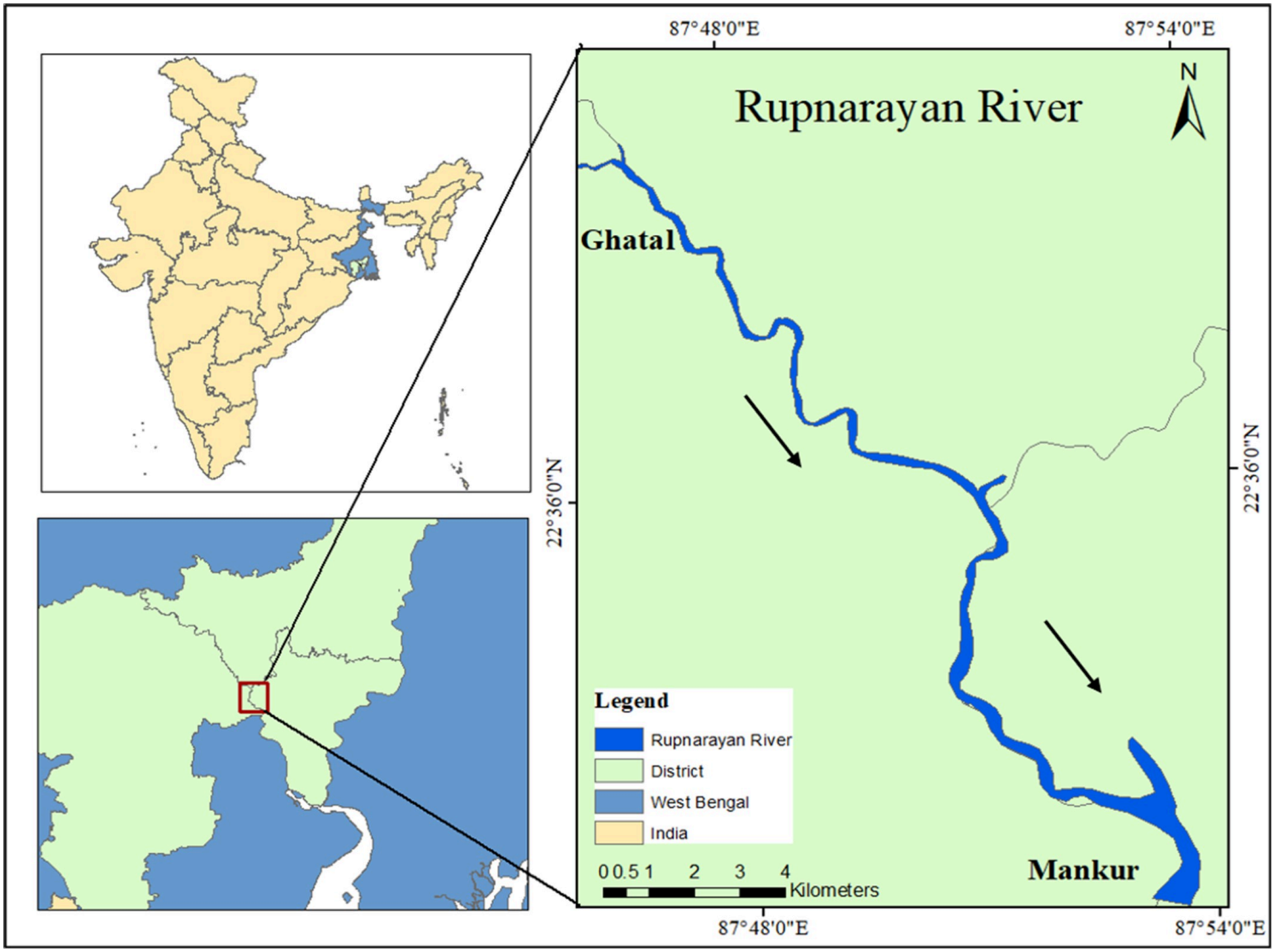


Figure 1

Study area map of Rupnarayan River, West Bengal.

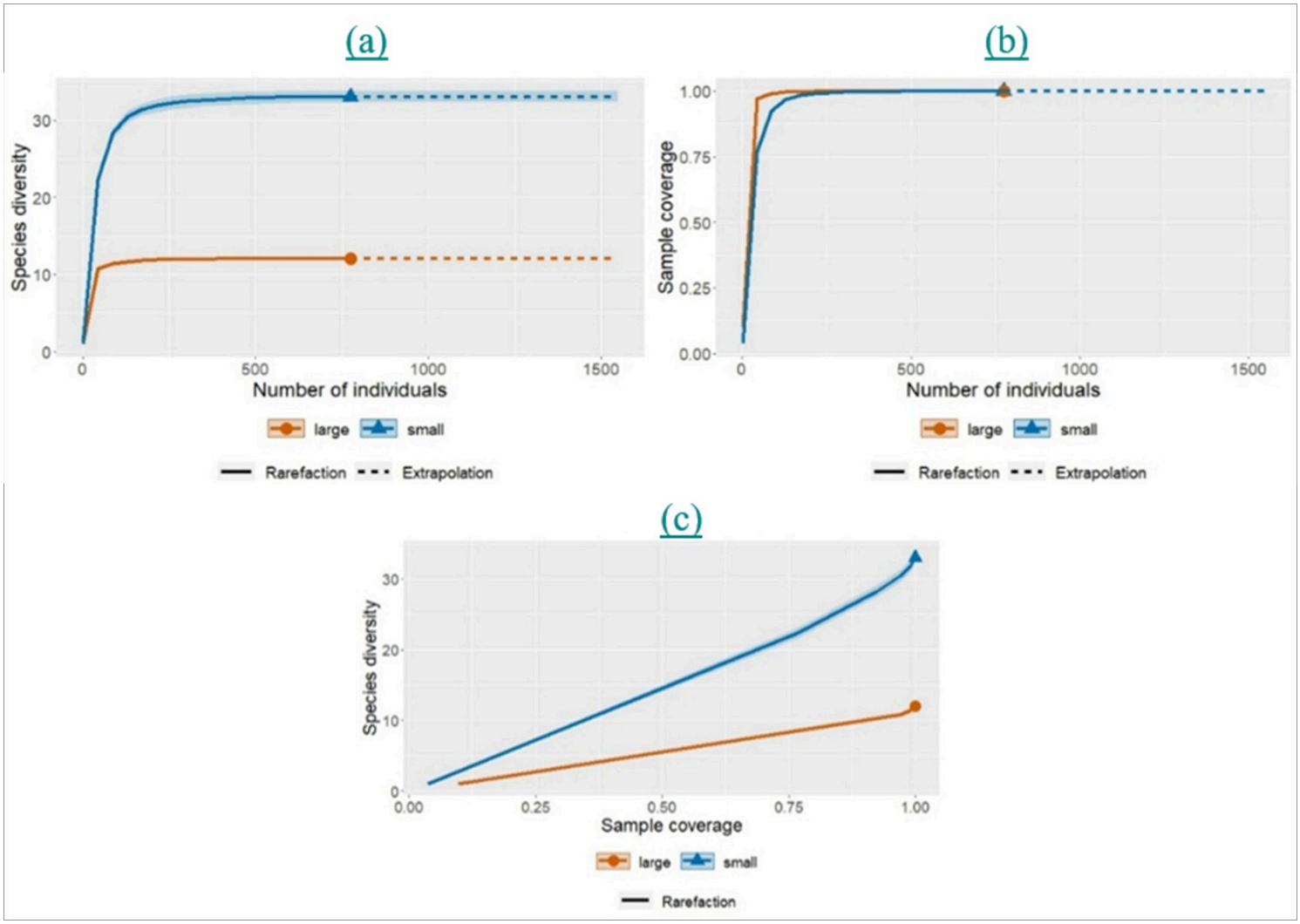


Figure 2

(a) Sample size-based rarefaction and extrapolation sampling curve at two scales, (b) Depict the sample completeness curves and (c) figures indicate coverage-based rarefaction and extrapolation sampling curve at two scales in Rupnarayan river.

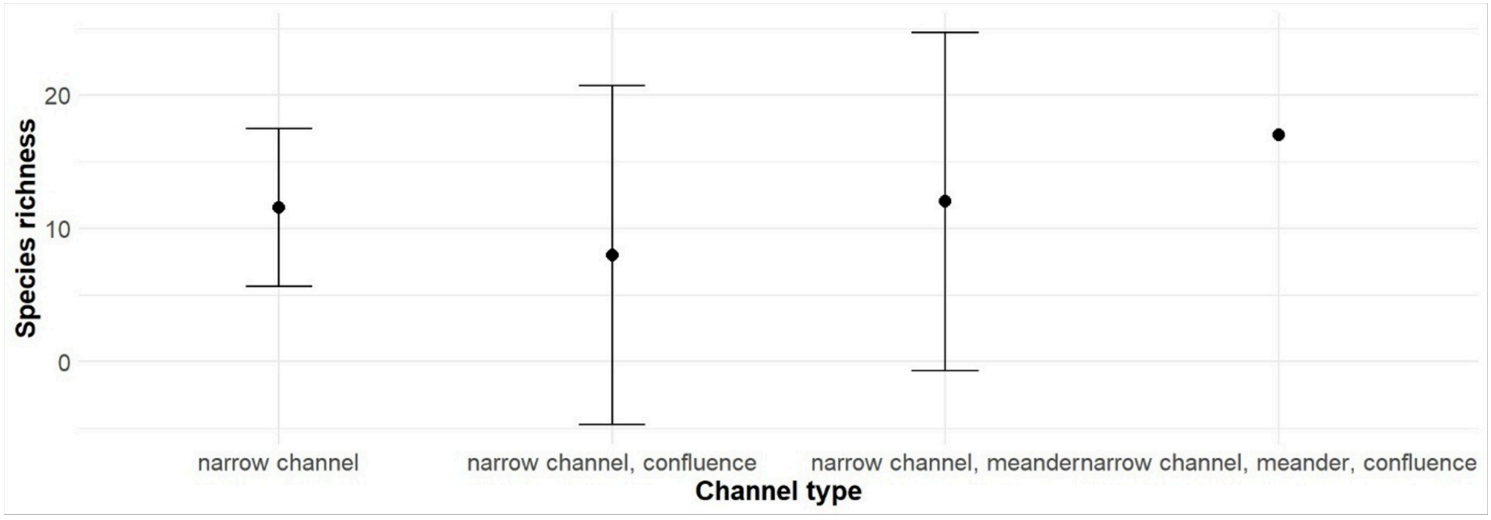


Figure 3

The effect size plots for the model best predicting fish richness by channel types.

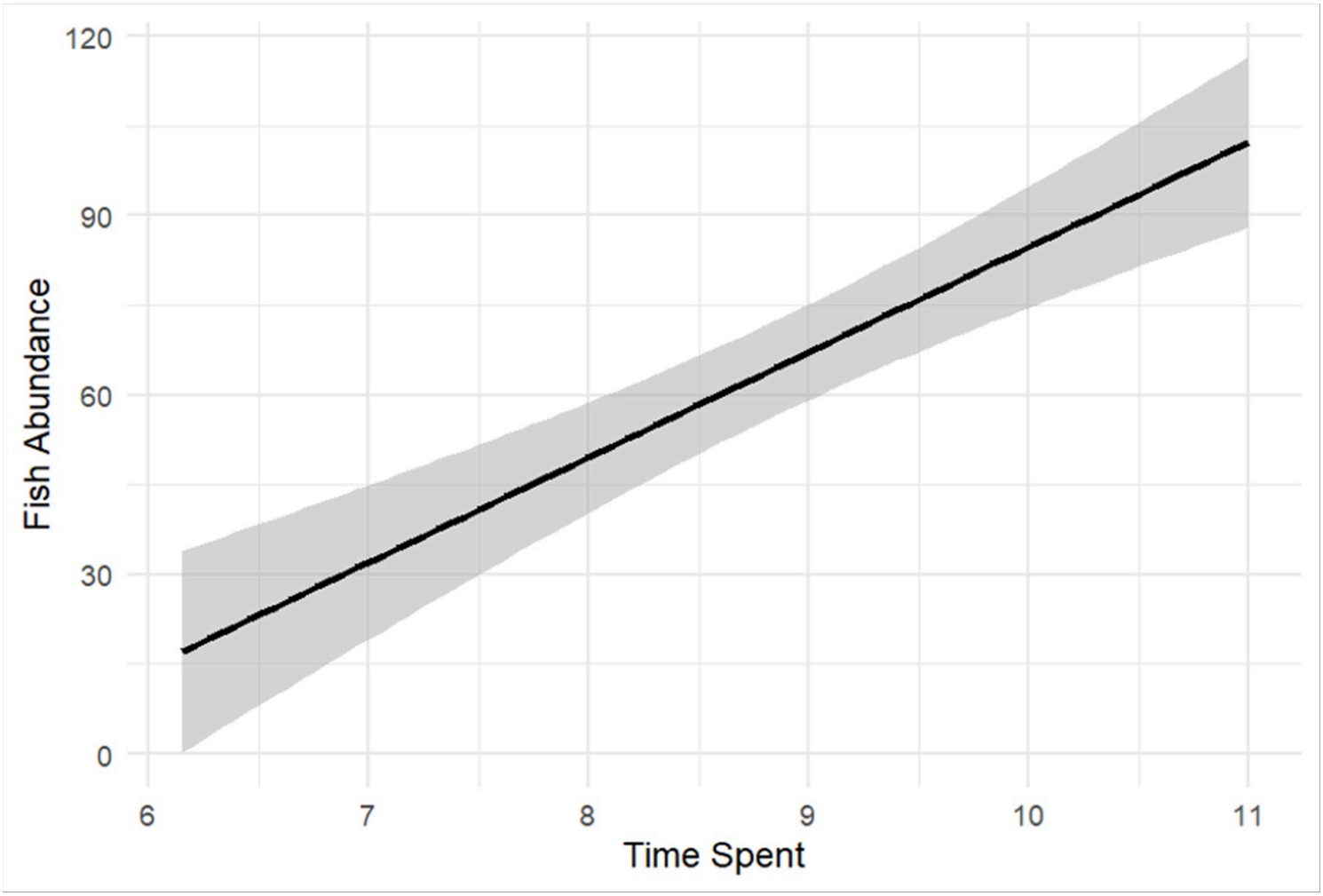


Figure 4

The higher fish abundance is predicted by high tide than low tide.

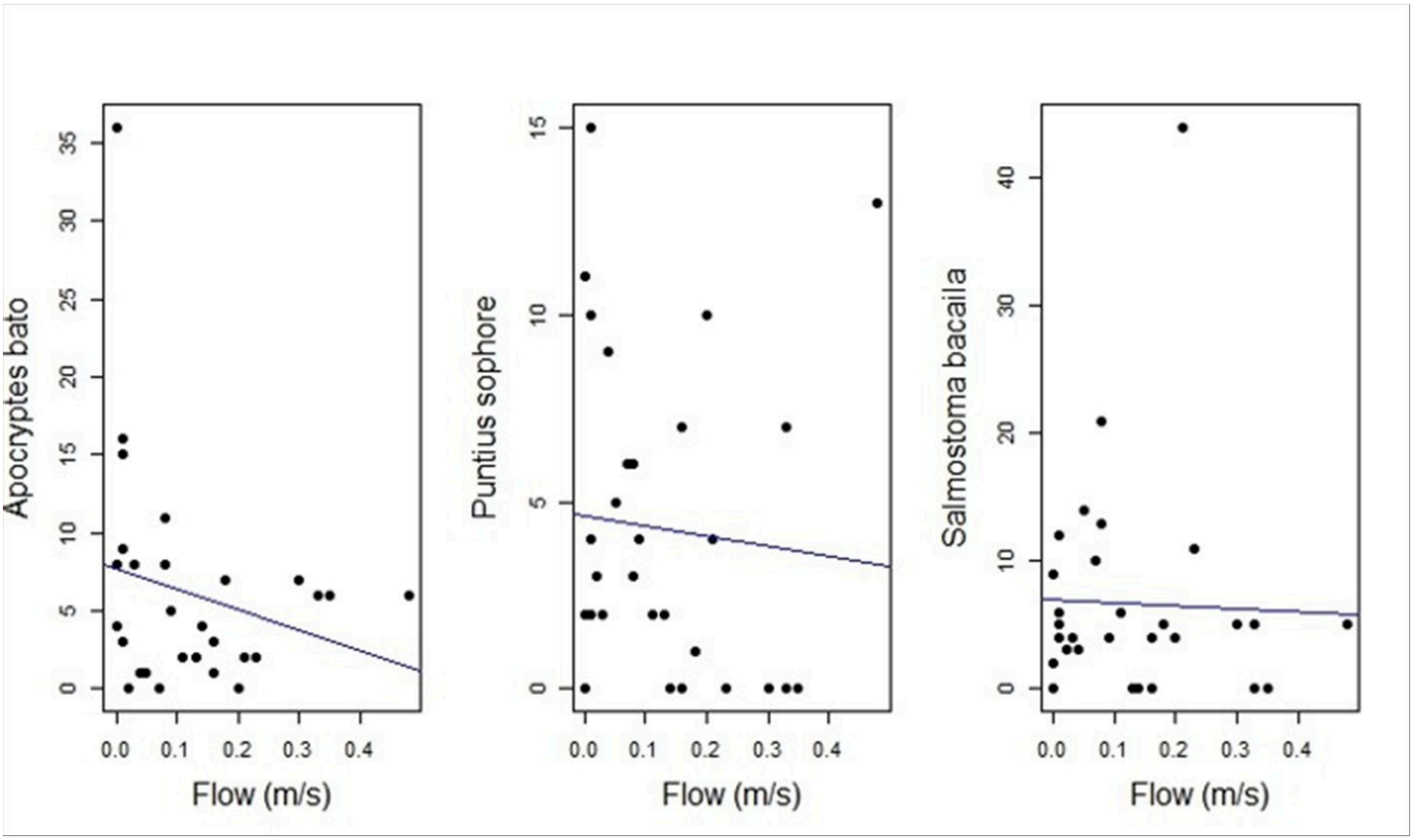


Figure 5

The select common fish species declined with stream flow.

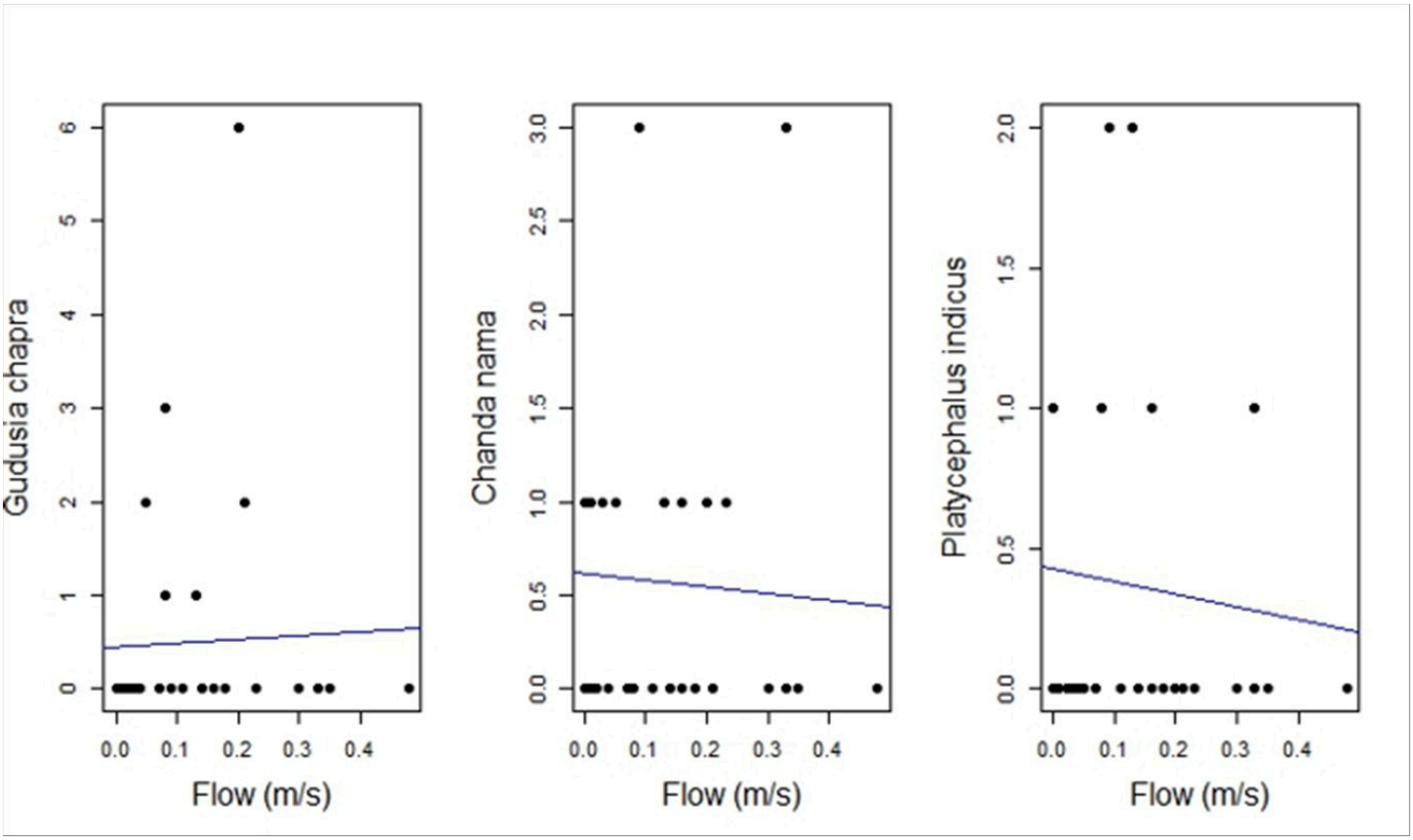


Figure 6

The select rare fish species showed negative relationship with stream flow except *Gaducia chapra*.

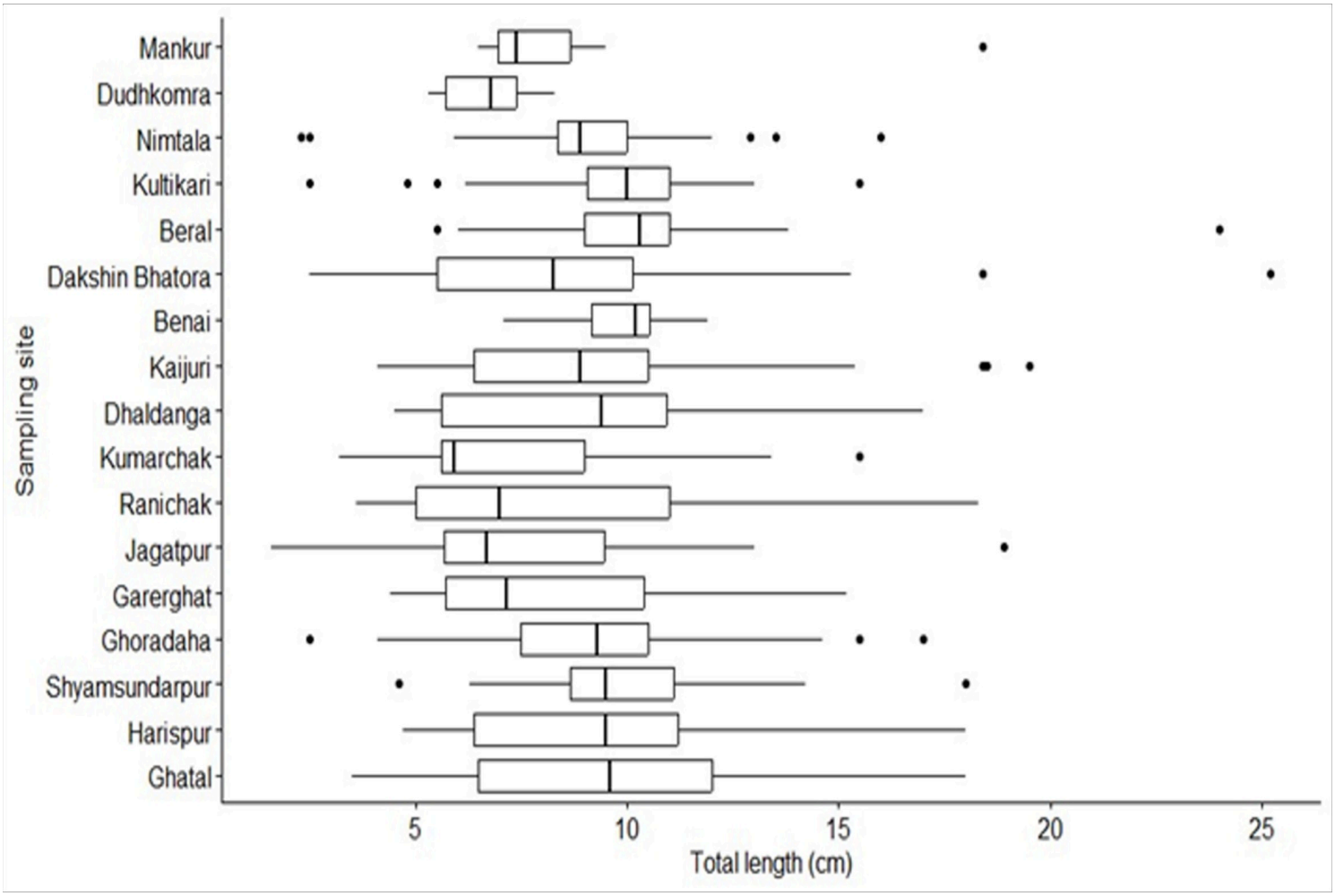


Figure 7

Size class distribution of fish species across the sampling sites.

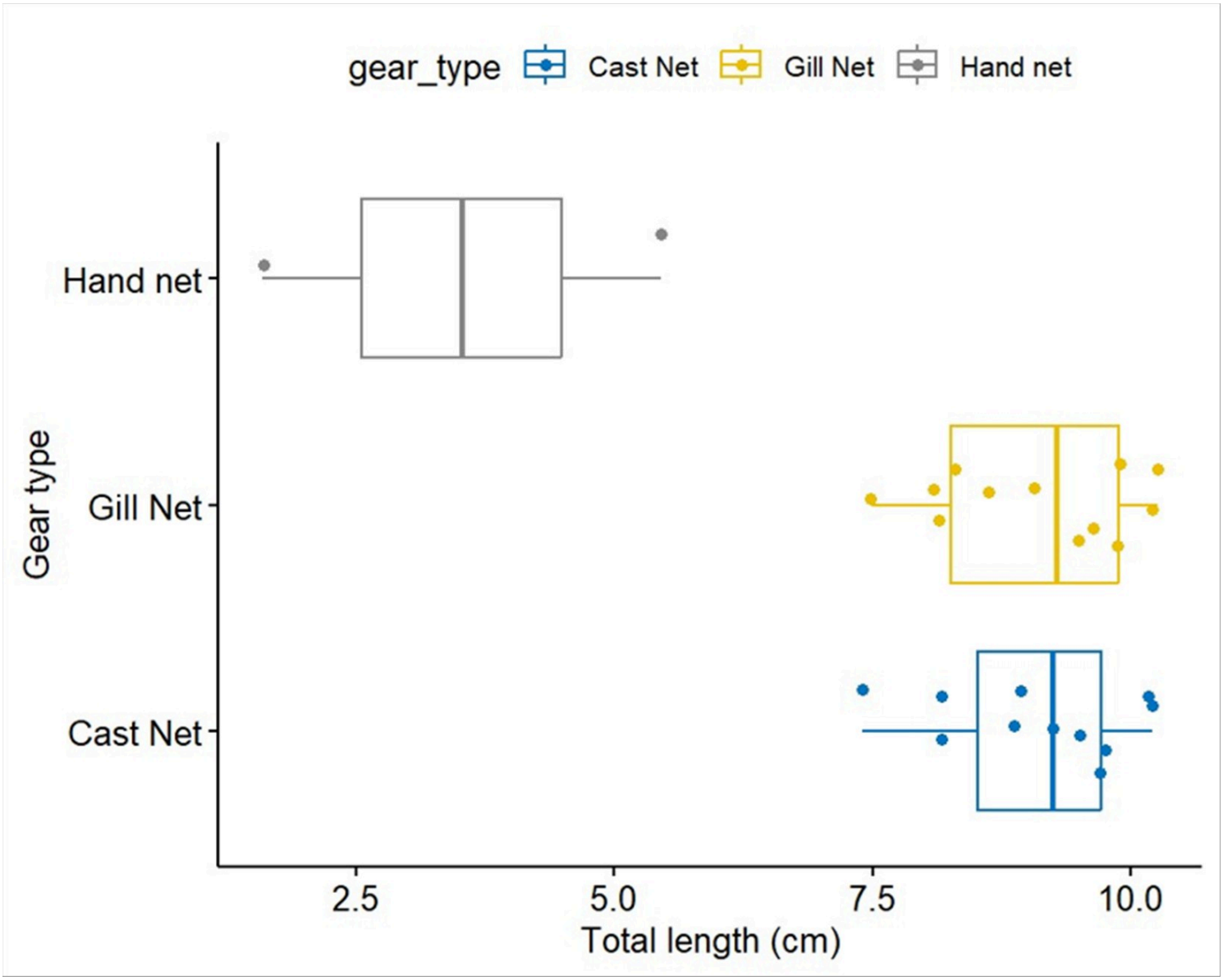


Figure 8

The gear size influenced the fish size class distribution.

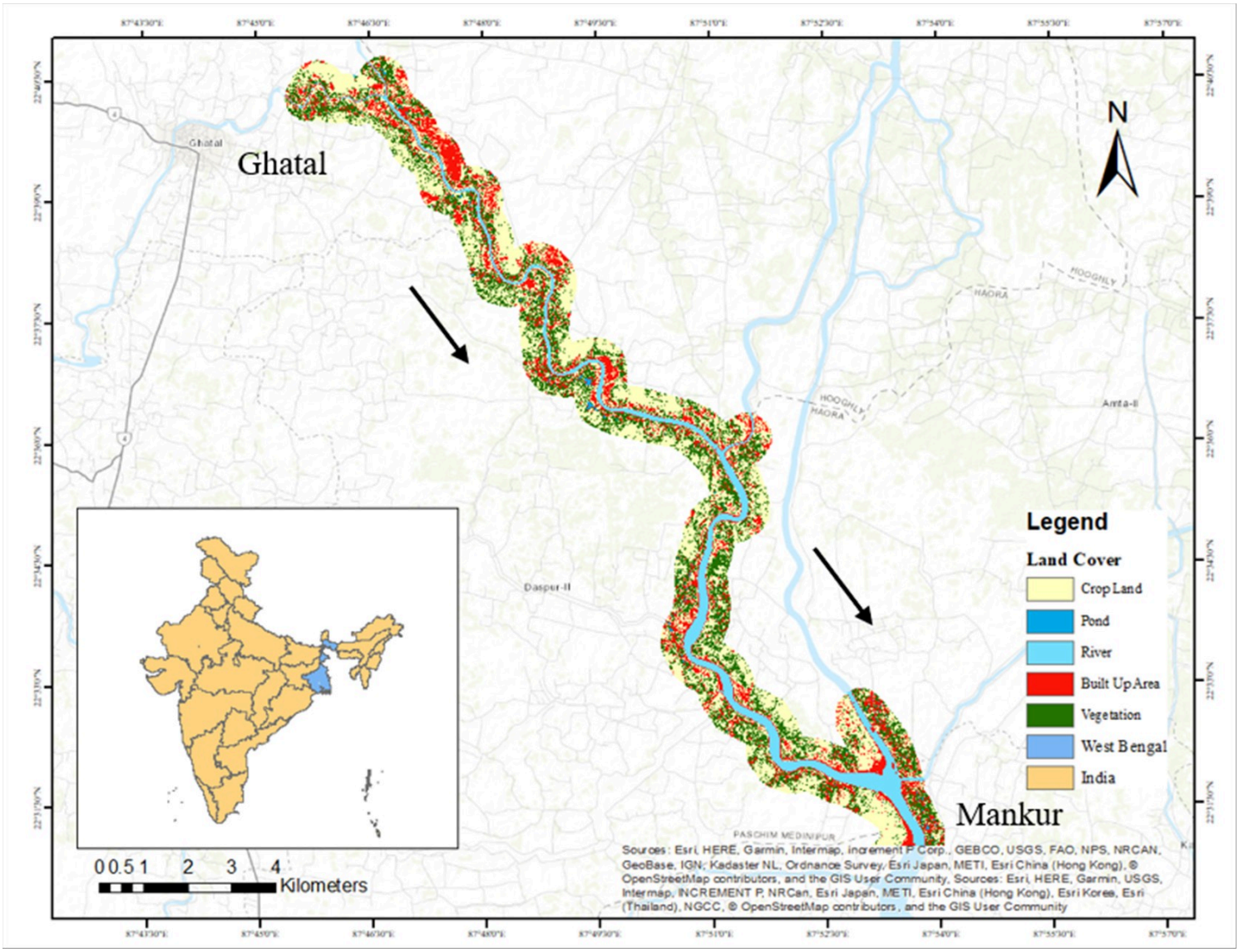


Figure 9

LULC classification of Rupnarayan River in West Bengal.

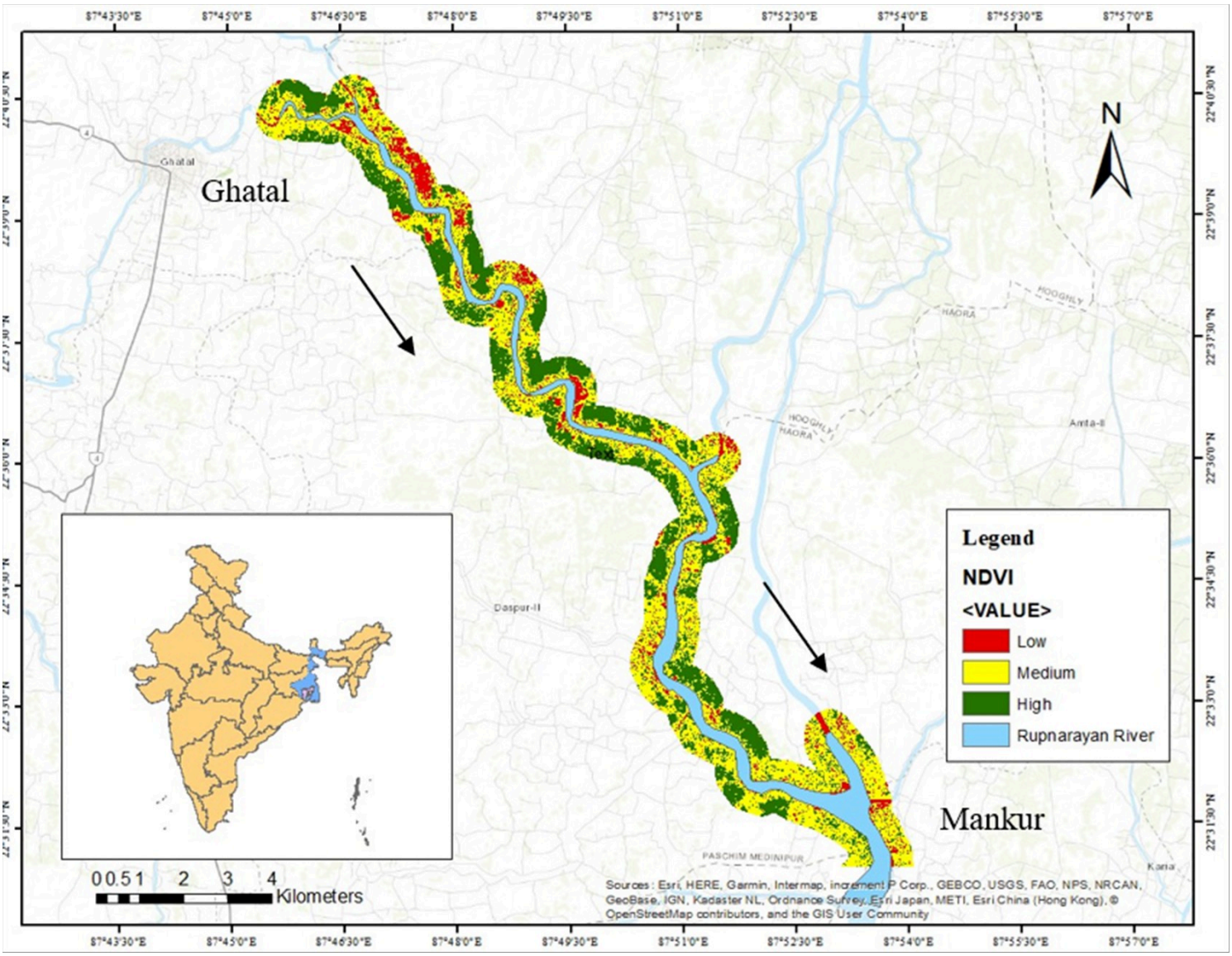


Figure 10

Vegetation Distribution along Rupnarayan River.