III. MATERIALS AND METHODS
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The investigation was aimed at asserting ecological changes and differences and its impact on the diversity and fish population in four major rivers of Uttara Kannada district, which has been greatly affected due to human interference.

Uttara Kannada Rivers

Uttara Kannada district has four major rivers having different ecological characteristics. In order to study the fish fauna in all the four rivers study locations were marked out, so that at regular intervals, the study can be undertaken in these specified locations. A total of 24 sites were selected, six on each river. These sites were marked all along the river from up stream to down stream.

The locations are identified in such a way that two locations in down stream, two locations in middle stream and two more locations on up stream for each of the river. While choosing the locations the following criteria were also considered.

1) Diversity of the habitat
2) Accessibility of the location in all seasons
3) Human interference
4) Impact of different types of vegetation on the river
5) Dams, industries and pollution.

This would help to compare the fish fauna from location to location and river to river. To study the impact of natural vegetation, anthropogenic pressure and pollution few of the locations were selected either at the source of pollution or near human habitation or right below the dam site, and at different vegetation types.
For each river up stream location was selected at higher altitudes, middle stream locations along the slopes, more or less in the middle of the river course. i.e at lesser altitude and down streams location below the Ghats. They were considered in such a way that location above the slopes of the Western Ghats are considered up stream locations, along the Western Ghats slopes middle stream locations and below the Ghats down stream locations.

**Habitat:**

Each river has different habitat types based on width, depth, velocity, topography, terrain and geography of the riverbed. As these habitats are very important for the fish fauna an attempt was made to classify these habitats in each locations. Even while selecting the locations care was taken to include habitat heterogeneity. The habitats that can be seen in any river can be classified as Pools, Runs, Riffles and cascade.

**Pools:**

These were deep portions of the water body with standing water or with very low current velocity. These locations were usually found below the cascade or fall and provide shelter for the fishes during summer when most parts of the river dry up. Pools were natural and having enough water due to depth even during dry months. At the same time they store lot of nutrients in them and most of the carps are found here.

**Runs:**

This was the stretch of fast and swift flowing water with very little turbulence and agitation and flow was more or less uniform. Runs were observed where the river width is
high and riverbed is smooth. Runs were common expect in slopes. Runs were useful for navigation also.

**Riffles:-**

Where the water turbulence and surface water agitation was higher, pebbles and boulders were found on the river bed riffles were common. This was usually seen in shallow water where stone out crops were on the riverbed and the river flows along the slopes. Riffles help in enriching the Dissolved oxygen and nutrient mixing. Water velocity was high.

**Cascade:-**

This was common in all hill streams. Cascades were characterized by highly turbulent flow, where water flows through rocks and boulders along the slopes. The steep gradient may result in the formation cascade. Only certain well-adapted fishes to this high water velocity were found here (Genus *Garra*).

**Description fishing locations: -**

**Fishing Locations in Kali river:**

**Location –1 (Kadra) down stream**

Latitude- 14° 54' N
Longitude- 74° 19' E
Altitude-20m
Air Temperature -26° -34° C
Water Temperature -250 - 32°C
Flow rate-60seconds / 5 Metre
Depth- too deep to measure.
Width- more than200 m.
Here the river was flowing slowly and the width was about 200m. Right bank was thickly vegetated with semi evergreen forest and the left bank by Kadra village. The riverbed was muddy and silts deposition. Run was the only habitat here.

**Location -II (Nujje)- Down Stream**

- Latitude- 15° 06' N
- Longitude-74° 22' E
- Altitude-560m
- Air Temperature- 25°-33°C
- Water temperature- 25°- 32°C
- Flow Rate- 23 Seconds / 5m
- Depth- 0.18 – 1.45m
- Width- 30m

It was a hill stream 16 km west of Kali and joins Kali river. Width of the stream was small and is about 50m. Rocky River beds forming cascade, riffle and pools. Water was very less during summer.

**Location-III (Dandelappa temple)- Middle Stream**

- Latitude- 15° 14' N
- Longitude-74° 38' E
- Altitude- 440m
- Air temperature – 26°-35°C
- Water temperature-26°-33°C
Flow rate - 11 Second/5 M (Varies considerably based on water discharge from Ganesh gudi reservoir)

Flow rate - 27 Sec/5m

Depth - Not possible to measure

Width - Appears to be more than 150m

Water was highly polluted due to the effluents of Dandeli paper factory. Rocky outcrops was common, forming small islands in the riverbed. River bank was cultivated. Human impact was very high by being on the out skirts of Industrial township Dandeli. The habitat types identified were runs and pools.

**Location IV-(Moulangi) – Middle stream**

Latitude - 15° 15' n

Longitude - 74° 35'E

Altitude - 460m

Air temperature - 19°-34°C

Water temperature - 20°-32°C

Flow rate - 34 Sec/5 m (Varies considerably based on water discharge from Ganesh gudi reservoir.)

Flow rate - 9Sec/5m

Flow rate - 12sec /5 m

Width - 112m

Depth - Not accessible
Hydropower project controlled water flow. Black granite out crops were seen exposed in the river. One sides of the river a good forest and on the other side human habitation was seen. Riverbed was full of large stones and pebbles. The habitat identified here was run.

**Location V- (Bommana halli pick up dam (Upper streams))**

Latitude-15°09'N
Longitude-74°42' E
Altitude-427m
Air temperature-28°-36°C
Water Temperature-24°-31°C
Water flow-stagnant water
Width-approximately- 160m
Depth- 0.12m to 1.23m

Natural flow was obstructed due to the dam. Water flow in large quantity only if the gates were opened. Only during rainy season if the water level increases in the dam the gates were opened. But there was a perennial flow of water due to the leakage of water from the dam. Stored in pools, Both sides of the river a good moist deciduous forest was seen. Lot of granite out crops as the riverbed was exposed due to the lack of water. Habitat type here was the pool.

**Location VI- (Ganesh gudi)- UP streams:-**

Latitude-15°16' N
Longitude-74°32' E
Altitude-450m
Air temperature- 23°-36°C
Water temperature- 19°-31°C
Depth- Not Accessible
Width- 123m
Flow rate- 6 Sec/5m

This location was just below the dam. Flow depends on the water discharge from the dam. But water flow was continuous. Human influence on the river was seen. The only habitat type was run.

**Fishing location in Bedti river:-**

**Location I (Down stream) (Ramana guli)**

Latitude-14° 47' N
Longitude- 74° 36' E
Altitude- 60m
Air Temperature -28°-35°C
Water Temperature -25°-33°C
Flow rate-63 seconds/5m
Depth-2.6 to 4.73m
Width-15 Sec/5m

Lot of anthropogenic pressure from the local settlements was seen. River partially covered by bamboo and riparian vegetation on one side. River bank muddy. A small hill stream joins the river. Local people leave the Gillnets in the night and collect the fish early morning for subsistence. The habitat types were Run and Pool.
**Location II-(Down streams) (Hosa Kambi)**

Latitude- 14°40’ N  
Longitude-74° 29 E  
Altitude-20m  
Air Temperature - 28°-34°C  
Water temperature-25°-33°C  
Flow rate-60Sec/5m  
Depth- 1.6 to 3.8 m  
Width-45m

On one side of the river thick evergreens forests, and on the other side kali hydal project rehabilitation center were the salient features of the location. River forms flow, pools and riffle. River bed sandy and filled with pebbles. Local people collect the fish.

**Location III (Middle stream) Pattana Hole**

Latitude-14° 42’ N  
Longitude- 74° 42; E  
Altitude- 472m  
Air Temperature -24° to 32°C  
Water Temperature -25° to 31°C  
Flow rate- at run-27Sec/5m  
At riffle-5Sec/5m  
Depth-0.16m to 0.52m  
Width- 20m
This was a tributary to Bedti river near Sirsi. River bed full of aquatic vegetation.

River beds with small pebbles. Thickly vegetated river bank. Rotting woods and leaf litter fills the river bed. The riverbed partly exposed during summer, but the stream is perennial.

The habitat types here were runs and riffles.

**Location IV – (Middle stream)-( Ganesh pal)**

- **Latitude**: 14° 46’N
- **Longitude**: 74° 45’ E
- **Altitude**: 395m
- **Air Temperature**: -24° to 32°C
- **Water Temperature**: -23° to 31°C
- **Depth**: 0.23m to 2.18m
- **Flow rate**: 23 Sec/5m at run
  
- **And 7 Sec/5m at riffle**
- **Width**: 112m

This was a tributary to the Bedti river. The location consist of run, riffle, pool and a small cascade as habitat types. Thickly vegetated on both the sides by Evergreen forest. Black granite boulders are exposed on the river bed. Lot of litter falls in the river. No human activities accept by occasional tourists. River bank muddy. River flows in a deep gorge.

**Location V-(UP stream) – Bedti Bridge)**

- **Latitude**: 14° 53’N
- **Longitude**: 74° 47’ E
- **Altitude**: 422m
- **Air Temperature**: -28° to 30° C
- **Water Temperature**: -26° to 31°C
Flow rate- 34Sec /5M

Depth- 0/18 to 2.02m

Width-125m

The location consists of pool, riffle and flow. River bank covered by thick Moist deciduous forest. River sides muddy and river bed with lot of big black boulders. Fewer humans impact. River flows in deep gorge. River bottom full of organic litter.

**Location-VI (Up stream)- Kubri-**

Latitude-14° 54’ N

Longitude- 74° 48’ E

Altitude- 428m

Air Temperature –28° to 34°C

Water t Temperature - 26° to 33°C

Depth-0.46 to 2.10m

Flow rate- 48 Sec /5m

Width- 45m

The location was in the middle of the thick moist deciduous forest, very difficult to access. A small helmet of *Kumbi Marathi people* was established near the location. They under take fishing for subsistence. Location has pools, riffles and run. Riverbank was muddy. Riverbed sandy and with few huge boulders. Lot of leaf litter falls in the river.

**Fishing location in Aghanashini river:-**

**Location-I (Down stream)-Keertigadde**

Latitude- 14° 25’ N

Longitude-74° 36’ E
Altitude 28m

Air Temperature -28°- 35°C

Water Temperature -25°- 32°C

Flow rate - 7 Sec/5m

Depth - 0.12m to 2.8m

Width - 112m

This was the first down stream location. The location was covered by good riparian (Semi evergreen) vegetation. The location exhibited pools, runs, riffles and cascade in it. River bed was sandy in a small patch and rocky in other places. People collect the sand from this area. River bank was full of small stones. On one side of the river human habitation and agricultural activities were seen.

**Location -II- (Down stream)- Hulidevara Kodlu**

Latitude -14° 26’ N

Longitude - 74° 38’ E

Altitude 38m

Air Temperature -28°- 35°C

Water Temperature -26°- 32°C

Flow rate 8 Sec /5m

Depth 1.5m to 2.85m

Width 150m

The location was in the middle of the thick Evergreen forest on foothills of Doddamane Ghats. River was wide. Lots of forest litter reach the river. Trees over arch the
river. River bed had lots of large black boulder and some of them expose out of water. The location had Pools, run, riffle and cascade. Good micro habitat for fishes.

**Location-III (Middle stream) Bilagi Bridge**

Latitude: 14° 21' N  
Longitude: 74° 47' E  
Altitude: 630m  
Air temp: 23.5°C – 34°C  
Water temp: 22°C – 30°C  
Depth: 0.24m to 2.05m  
Width: 80m  
Flow rate: 7Sec/5m at run  
5Sec/5m at flow

The river flows through the slopes of Western Ghats in the midst of thick Evergreen forest. The location had pools, riffle and run. Good vegetation (Evergreen) on one side, and Aracanut orchard on the other side of the location. Lot of medium sized black boulders in river bed. Muddy river bank. Aquatic vegetation on sides. River bed organically rich. Water was extensively used for irrigation.

**Location-IV-(Middle stream)- Mani hole**

Latitude: 14° 26' N  
Longitude: 74° 47' E  
Altitude: 603m  
Air Temperature: 29°C–33°C  
Water Temperature: 26°C– 31°C
Width- 65m 
Flow rate- 23 Sec/ 5m 
Depth- 0.24 to 1.98m 

This was a perennial tributary to Aghanashini river. Good vegetation on both sides. The location had pools and run. River bed is with small stones and sides are muddy. Lot of humus in the river and sides also. Trees over arch the river. Rotting woods and leaf litter enrich the organic content in the river.

**Location - V (Up-stream) - Baloor**

Latitude- 14° 28' N 
Longitude- 74° 48’ E 
Altitude- 633m 
Air Temperature - 28°-33°C 
Water Temperature - 25.5° to 30°C 
Width- 30m 
Depth- 0.48 to 2.13m 
Flow rate- 21 Sec/5m 

Location was having pools, riffles, and run. Good evergreen vegetation on both sides. Human influence was seen. Riverbed and sides are muddy. Litter deposition in the river bed was a common feature. Water was used for agriculture.

**Location - VI (Up-stream) - Sarkuli**

Latitude- 14° 30’ N 
Longitude- 74° 45’ E 
Altitude- 500m
Air Temperature -25° to 31°C
Water Temperature -23.5° to 29.5° C
Flow rate- 52 Sec/5m at run
5Sec/5m at flow
Width-15.750m
Depth-0.16 to 1.91m

Location was having only run and flow. Good evergreen vegetation on one side and Araca garden on the other side. River bottom was muddy and full of silt. Sides were sandy. River bed vegetation common. Few trees over arch the river. Water was used for Agriculture.

**Fishing locations of Sharavati river:-**

**Location-I-(Down stream)- Allanki**

Latitude-14° 14’ N
Longitude- 74° 34’E
Altitude-30m
Air Temperature -32° to 35°C
Water Temperature -27° to 33°C
Flow rate-18 Sec/5m
Depth-0.45 to 3.67m
Width- 85m

Location had only flow. Both side paddy cultivation and human habitation, thus high human influence. Riverbed muddy, sandy and with silt. River banks Sandy. Local people take out sand from the location. Here the water was flowing slowly due to its width. Only runs and pools were the habitats here.
Location –II (Down stream)- Gerusoppa bate

Latitude-14° 14’ N
Longitude-74° 38’ E
Altitude-40m
Air Temperature -27°- 34°C
Water Temperature -26.5° – 32°C
Flow rate- 12 Sec/5m
Depth- 0.56m to 4.79m
Width- 94m

Location had only one habitat the run. River bed sandy and river sides full of small stones. Human influence was very high due to habitation on both sides of the river. Navigable. Water was regulated by the power station.

Location-III (Middle stream)- Gerusoppa Nursery

Latitude-14° 14’ N
Longitude-74° 40’ E
Altitude- 42m
Air Temperature -28.5° – 34°C
Water Temperature -27° – 31°C
Flow rate- 4Sec/5m

Width and depth of the river not recorded due to high velocity of the water current.

The location had run and riffle. Water velocity was very high. Sampling done only on one side. The river bottom appeared to be full of stones, River bank was muddy and stony.
Location –IV- (Middle stream)- Jog falls

Latitude- 14° 13’ N
Longitude- 74° 49’ E
Altitude- 496m
Air t Temperature - 27° – 33°C
Water Temperature - 27° – 31°C
Water flow 28Sec/5m
Width- 25m
Depth- 0.15 to 1.10m

This was the middle stream location lying on the Western Ghats slopes. The location had run, pool and small cascade as habitats. Exposed rocky out crops were seen. Small amount of water flows through out the year. Poorly vegetated.

Location V- (Up stream)- Jogina Math

Latitude- 14° 13’ N
Longitude- 74° 50’ E
Altitude- 476m
Air Temperature -21° – 32°C
Water Temperature -26° to 30°C
Water flow- Nil
Width- 115m
Depth- 0.34 to 4.92m
The Location had only pool, Covered by good Evergreen forest. Lot of litter in the pool. Bottom and Sides were muddy. Flows only during rains This was the original part of the river, but after the construction of the Linganamakki dam water course was changed.

**Location- VI- (UP Stream) Chaingate**

Latitude-\(14^\circ\ 11'\) N  
Longitude- \(74^\circ\ 49'\) E  
Altitude-374m  
Air Temperature -24\(^\circ\) - 31\(^\circ\) C  
Water Temperature - 23\(^\circ\) to 32\(^\circ\) C  
Water flow- 28Sec/5m  
Width- 132m  
Depth- 0.12 to 1.34m

The location was the original course of the river, but now water was less due to Linganamakki dam. Still small amount of water flows due to leakage in the dam. The location had pools, run, riffles and cascade. Lot of rocky boulders were exposed in the river bed. On one side thin vegetation was seen.

**Fish sampling method:**

Fish sampling was the major fieldwork at all the specified locations in all the seasons. Fish sampling was conducted three times a year i.e. Pre Mansoon, Post monsoon and at the end of the winter for two years. Totally six samplings were made in all the locations of all
four rivers. Sampling was done early morning 6.30 am to 11.00 a.m. and in the afternoon from 3.30 p.m to till evening. This was the time when more fishes can be caught. One night sampling was also made in all the locations. Usually minimum one hour was spent in each location. The effort continued for more time if the fishes were abundant in the location.

For collecting the fish variety of methods were involved. The use of different types of nets, hooks, and other traditional methods like plant based fish poisons and trapping etc. were employed. Though there were many methods were used major collection was by the use of nets. Here we have used Gill nets, Cast Nets and dragnets of different mesh size. The net fishing was one of the most popular fishing methods. Nets were an effective way of catching the fishes though there are several drawbacks to using them. The descriptions of the various methods used during the investigation are given below.

**Gill nets:-**

Gill nets work by snagging fish behind their gill cover (That is were the name gillnet comes from). Gillnets are panels or sheets of netting either mono filament or nylon. A number of floats are threaded on to a line and fixed to upper portion of the sheet net while a lead line is attached to the bottom portion of the net. This keeps the net afloat and the lead line keeps the invisible sheet net vertically in water. The net can be either anchored or dragged along the bottom. The size of the mesh and way the sheet netting is fixed to the float and lead line is important when determining the species and size of fish that will be caught. Small mesh nets generally catch small fish. If a large mesh net is loosely fixed to the float and headline, this will also catch small fish by tangling rather than gilling the fish. During the investigation I used four gill nets with following specifications.
Generally gillnets were used in runs and pools across the course of water. These nets were left in water for a minimum period of one hour in each location.

**Cast Nets:**

It is made up of nylon with a very small mesh. Conical in shape. A rope is attached to the net apex for retrieving. This is used by one person, usually in a shallow area of a sandy or muddy bottom, with a little or no rough substrate to destroy the net. This was a good method to catch small schools of fish. In each locality near the river bank fisher cast the net very quickly to avoid scaring the fish and to ensure the net open fully. It takes a lot of practice to use the cast net efficiently. During fishing we had taken the help of professional fishermen for the perfect casting. Here we have used two cast nets. The cast net-1 was having a height of 2.5m with circumference of 12m and mesh size of 1 cm. The cast net-2 is slightly larger with a height of 2.4m, circumference 14.2m and mesh size was 1.1 cm. At every location a minimum of 10 casts were made. The effort continued beyond 10 casts only if new species of fish is caught in each successive cast.

**Drag Net:-**

Drag nets were used for sampling the fish in shallow water near the river bank or where the water is lees deep. This net is made up of nylon sheet and lead line tied to the
The nylon sheet is porous. Two persons have to operate it by dragging in shallow water scooping the small sized fishes. During collection we have used two dragnets with length of 6m and 1m breadth.

Hooks:-

This is one of the oldest method of catching the fish. Hooks are made from steel and monofilament or nylon as fishing line. A lead ball is attached to hook as sinker. The 'J' shaped hook is baited and thrown in water. The fisher must jerk the hook when he feels a fish taking the bait. Here we have used two hooks for catching the fish.

Traditional Methods: -

Local people of Uttara Kannada district use many traditional methods to catch fish. As many as 28 species of plant based fish poisons are used to catch the fish. The plants parts are crushed and mixed with water especially during summer where water flow is small or in pools.

Bamboo traps were also used to catch the fish. During the investigation we have not tried any of these methods, but few fishes were collected by the local people caught by either of the methods.

Fish Preservation:-

The fishes caught alive or narcotised state were preserved in 4% Formaldehyde. The fishes caught in the net are immediately separated from the net and the number of fishes caught are counted and representative sample of every specimen was preserved in plastic jars using 4% formaldehyde solution. All colours, colour patterns, spots blotches number and design were
carefully noted in the field note book as soon as the fishes are caught and when they are fresh.

For all fishes of length 10 cm an incision was made on left abdominal wall. For fishes larger than 30 cm. undiluted concentrated formaldehyde was syringe and needle, in several places along the abdomen. Also 2 or 3 incisions of 2.5 cm. is made along the belly injected through hypodermic

**Identification of the fishes:**

Classification of the fishes for the study was done through taxonomy or systematics. Some of the very common fishes were identified in the field itself. Those, which could not be identified in the field, were brought to lab and identified. For identification we used the identification keys from “The fresh water fishes of India, Pakistan, Bangladesh, Burma and Sri Lanka —A hand book” (1981) by K.C. Jayaram, and “Inland Fishes Of India and adjacent countries” by Talwar and Jhingran (1991). For identification following morphological characters were considered.

1) **Total Length:** The distance between the anterior most part of the snout and posterior most tip the caudal fin.

2) **Standard Length:** The straight distance from the anterior most part of the snout to end of the vertebral column.

3) **Body depth:** Vertical distance from the dorsal to the ventral side at the highest point of the specimen.

4) **Head length:** A straight measurement of the distance from tip of the snout to base of operculum.
5) Head Width: The distance straight across the head in a vertical position

6) Eye Diameter: The distance between the margin of the two eye balls.

7) Position of mouth: Supra terminal, terminal, sub terminal and Ventral.

8) Presence or absence of barbels, number of barbels, and location and length of barbels

9) Height and length of Dorsal fin

10) Length of Pectoral and Pelvic fins

11) Length and height of Caudal peduncle

12) Length of longest fin ray

13) The number and position of spines and rays

14) Lateral line scale count

15) Spots, Blotches, bands and marks etc.

Considering the above information with the help of the identification keys the fishes were classified into respective orders, families and genus and identified up to species level. Initially some of the fishes were identified by Dr. K.C. Jayaram Rtd. Join Director of Zoological Survey of India and taught the art identification and subsequently I learnt the technique and continued the identification under his guidance.

Species Diversity Analysis:

Species diversity or species heterogeneity, a characteristic, unique to the community level of biological organisation, is an expression of community structure. A community is said to have high species diversity if many equally or nearly equally abundant species are present. On the other hand, if a community of composed is very few species or if only a few species are abundant, then species diversity is low. High species diversity indicates a highly
complex community. The ecologists agree that the concept of species diversity as measure of community stability (the ability of community structure to be unaffected by the disturbance of its components.)

This indicates the extent of Biodiversity in the ecosystem. The species diversity is made up of two components- Species richness and species abundance. The diversity is often represented in the form of indices. These diversity indices attempt to incorporate both richness and abundance into a single numerical value. A given value of diversity index can result from different combinations of species richness and abundance. A large number of measures of diversity have been proposed and many are in contemporary use. Of those available I used Simpson’s index and Shannon – Weiner’s diversity index.

Simpson’s diversity index:-

Simpson (1949) considered not only the number of species and total number of individuals, but also the proportion of the total that occurs in each species. This gives the probability with which, when two individuals selected at random, from a habitat, will belong to different species.

Simpson’s index (Ds) is calculated as follows.

\[
Ds = 1 - \sum_{i=1}^{s} (p_i)^2
\]

Ds—Diversity index

pi --- the proportion of \(i^{th}\) species in a sample

s---- number of species
The value of Simpson’s index varies from 0 to 1. A value of 0 indicates the presence of only one species, while that of 1 means that all species are equally represented.

**Shannon – Weiner’s Index:**

This index represents the average degree of uncertainty in predicking, to which particular species or individuals chosen at random from a sample. This index considers total number of individuals of all species, the number of individuals of every species and the proportion of individuals of each species, in the total number of individuals of all species.

The Shannon – Weiner’s index is represented as follows.

\[ H' = -\sum p_i \log p_i \]

Where

- \( p_i \) – Proportion of total number of individuals that occur in the species: i.e \((n_i/N)\)
- \( n_i \) – Number of individuals of a species \( i \) and \( I = 1 \) to \( K \)
- \( K \) – Total number of species
- \( N \) – Total number of individuals of all species in the sample.

The value of Shannon - Weiner index varies from 0 to \( K \). A value of 0 indicate the presence of only one species, while that of \( K \) means all species are equally represented.

During the analysis of the fish data that we had collected, the diversity indices were mainly used to compare the different at different periods of time. It is also used to compare the Down stream, Middle stream and up stream location of each river and all rivers.