

**Species Assemblage and Differential Basking Habitat Use of
Freshwater Turtles in a Gradient of Mahanadi Riverine
Ecosystem, Orissa.**

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BY

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UNDER THE SUPERVISION

OF

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Wildlife Institute of India**

Because.....

He wanted me to work for them.....





Certificate

This is to certify that Mr. Chandan Jani, student of the Wildlife Institute of India has carried out original research titled “Species assemblage and differential basking habitat use of freshwater turtles in a gradient of Mahanadi riverine ecosystem, Orissa” for the partial fulfillment of the M.Sc. (Wildlife Science) degree from Saurashtra University, Rajkot, India. These investigations were carried out under our supervision from November 2008 to June 2009. We also certify that this research has not been submitted for any other degree to any university.

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Executive Summary

Of the seven species of turtles recorded in the Mahanadi River, this study recorded five species of freshwater turtles between Satkosia Gorge Wildlife Sanctuary and Khakadi (Near Cuttack city) during November 2008 to April 2009. Of these five species, four were softshell turtles (*Nilssonia gangeticus*, *Nilssonia hurum*, *Chitra indica*, *Lissemys punctata*) and one was hardshell (*Pangshura tentoria*).

Relative abundance in terms of mean number of individuals sighted per kilometre was estimated. The results showed that *Pangshura tentoria* was most abundant and was recorded over all the sampling zones, followed by *Nilssonia gangeticus*, *Nilssonia hurum* and *Chitra indica*. The latter three were not distributed as commonly as the former. *Lissemys punctata* was not included in the report as the species never sighted during the sampling secession. However, the species was found to get captured in incidental fish catch during the study period. The low abundance of *Chitra indica* and *Nilssonia hurum* might be due to degradation of their habitats. These two species are known to prefer undisturbed and wider river stretches which are diminishing in the Mahanadi River. The habitats of the river stretch between Satkosia Gorge Wildlife Sanctuary and Kakhadi varied significantly and thus, explaining the variation in the species richness as well as abundance.

The major habitat variables, which have highly influenced the turtle abundance were river flow, river width and river bank characteristics. Highest abundance of species was found in the non-riparian flow zones and river stretches with rocky and sandy banks, where the habitat heterogeneity was greater. These two sampling zones also

experienced the least anthropogenic pressures. Choice in habitat use for basking in turtles was also observed.

The choice of the habitat varied between species. *Nilssonina gangeticus* and *Nilssonina hurum* preferred areas which had greater river bank width with shallow water near the bank. *Chitra indica* preferred areas where both river depth and river width were higher whereas bank slope, river slope, ground cover, alternative basking substrate and immediate water depth was lower. *Pangshura tentoria* preferred areas with greater river and bank slope along with greater availability of alternative basking substrate and greater immediate water depth. On the other hand they also preferred the habitat more close to the river with lower bank width and moderate river depth and moderate river width.

Major threats to turtles in the Mahanadi river (sampling zones) are due to anthropogenic pressure and habitat degradation. Some of the threats were found to be consistent over the sampling zones. The study shows that *Pangshura tentoria* was highly tolerant to all prevailing threats in the Mahanadi river but, *Nilssonina hurum* and *Chitra indica* were adversely affected by these threats all along the river. This study found that there was a negative correlation between the turtle abundance and presence of threats such as sand mining, pump house, fishing and pollution. Sand mining adversely affected the basking habitat of most of the turtle species. Pump houses were largely avoided by the turtles which may be due to the vibrations or noise created at these stations. Unintentional by-catch of turtles during fishing was also observed especially in the braided flow zones and inundated static flow zones of the Mahanadi river. Sand mining and fishing are identified as the major threats to the turtles in the Mahanadi river, which should be monitored and regulated. Sand mining

should not be allowed during the breeding season of the turtles especially in the area of Non riparian flow zone and braided flow zone. These two sampling zones were identified as the Important Turtles Areas (ITAs) in the Mahanadi River. Alternate livelihood options should be identified and implemented in order to reduce people's dependency on fishing in this region. Nature education and awareness programme clearly addressing the reason for declining of turtles and their habitat in the Mahanadi river needs to be launched.

1. INTRODUCTION

1.1 The Riverine Ecosystem and chelonians

Riverine ecosystem encompasses the stream channel and portions of terrestrial landscape from the high water mark toward the uplands where vegetation may be influenced by the elevated water tables or flooding and the ability of the soils to hold water. The importance of riverine ecosystem can be analyzed from three major perspectives i.e. provision of goods and services, preservation of important floral and faunal associates, water regulation (Deloya, 1985). This ecosystem is fragile and highly exposed to change.

Anthropogenic pressures on riverine ecosystems are in the form of different activities like fishing, sand mining, pollution etc. are impacting the system. Due to these enormous and incessant pressures, the diversity and abundance of reptilians are being distorted (Burke, and Gibbons, 1995). Reptiles being one of the best indicators of ecosystem health (Jones 1986, Heyer *et al.*, 1994) could be used as a predictor of ecosystem health. Species assemblage which is an artefact of its definite habitat attribute is likely to change due to change in the habitat attributes (Schluter and Ricklefs, 1993). But, many of these factors affecting the structure of turtle assemblages in a riverine system remains poorly studied (Bury, 1979). On the other hand disturbances are important determinants of biotic community structure and function (Grime, 1977; Stanford and Ward 1983; Junk *et al.*, 1989; Pickett *et al.*, 1989; Poff and Ward, 1990; Townsend *et al.*, 1997; Sparks and Spink, 1998) and may

manifest in a hierarchical manner, affecting several levels of organization, from an individual to an ecosystem and the landscape.

It is necessary to understand the relationships and dynamics of unique species assemblages in the wake of imminent change which will help in prioritising conservation efforts in the riverine system. Accordingly the present study focuses on to investigating the species habitat relationship and differential basking habitat use by different turtle species of Mahanadi riverine ecosystem. Besides, the study also focused on the different threats to the turtle communities in the Mahanadi River.

1.2. Freshwater turtles

The species richness of turtles and tortoises in the world that have existed in modern times (since 1500 AD), and currently generally recognized as distinct, consists of approximately 324 species and 140 additional subspecies, or 464 total taxa—and of these, 10 taxa have gone extinct (Rhodin, 2008). In India, 26 species of freshwater turtles and land tortoises have been reported so far (Choudhury *et al.*, 1992, Bhupathy and Menon, 2003). Turtles are mostly aquatic and often known to occur in wetlands, especially in riverine ecosystem (Rhodin, 2008). The presence of gradients in riverine ecosystem has significant influence on the community composition and abundances of turtle communities (Shively and Jackson, 1985). The distribution of freshwater turtle species known to have significant relation with habitat attributes (Froese and Burghardt, 1975; Major, 1975; Ernst *et al.*, 1994). Earlier studies also show that chelonian assemblages are dependent upon particular habitats (Ever Mann, 1920; Donner *et al.*, 1998) and often vary between different zones of river. Thus, freshwater turtles in rivers can considered to be one of the best communities to study and test

hypothesis related to habitat relationships, differential habitat use and other ecological processes. Turtles are ectotherms, thus basking being an important physiological phenomenon, which provides an opportunity to record their presence along with their habitat condition.

Riverine ecosystem also provides a simple system to validate or explore ecological hypothesis. For example, freshwater turtles assemblages are highly site specific (Shively and Jackson, 1985) and thus, their association with habitat related hypothesis could be easily tested.

The ecology and natural history of freshwater turtles have been studied around the globe (Froese and Burghardt, 1975; Major, 1975; Ernst *et al.*, 1994) (Lovich, J.E. 1995). Some of the major findings of these studies helped in developing conservation strategies for freshwater turtles (Wright *et al.*, 1999). But, these studies mostly overlooked the distribution of species with relation to their habitat requirements. In this background, the present study aimed to understand the role of the habitat attributes in determining the present distribution of freshwater turtle species along the river stretch of Mahanadi. This study is also expected to provide a stronger predictive basis for anticipating distribution of freshwater turtle species based on their habitat requirements for conservation actions elsewhere in this river and other riverscapes.

1.3 Freshwater turtles of Mahanadi riverine ecosystem

India has a good diversity of chelonian fauna, with at least, 26 species of freshwater turtles and land tortoises (Choudhury *et al.*, 1992, Bhupathy and Menon, 2003). Of these 26 species, seven were documented to occur in Mahanadi riverine ecosystem

(Choudhury *et al.*, 1992, Bhupathy and Menon, 2003) in a study conducted during 1990 (Table 1.1.).

Common Name	Scientific Name
Narrow-headed softshell turtle	<i>Chitra indica</i> *
Indian Softshell Turtle	<i>Nilssonia gangeticus</i>
Indian Peacock Softshell Turtle	<i>Nilssonia hurum</i>
Leith's Softshell Turtle	<i>Nilssonia leithii</i> *
Indian Roofed Turtle	<i>Pangshura tecta</i>
Indian Tent Turtle	<i>Pangshura tentoria</i>
Indian Flapshell Turtle	<i>Lissemys punctata</i>

* Globally Threatened Species (IUCN Ver. 3.1)

Table 1.1. List of turtles recorded in the Mahanadi River.

All the species occur in the Mahanadi River are given protection under the Wildlife (Protection) Act, 1972. Four out of seven species are listed in the Schedule I, one in Schedule II and one in Schedule IV of WPA, 1972. Apart from this, two of them namely *Chitra indica*, *Nilssonia leithii* are listed as globally threatened species (IUCN, 2002). Even if these species are under different threat category and protected, there is little ecological information available regarding their habitat parameters, which are crucial for their long term conservation. Thus it was become imperative to understand the factors responsible for their long term survival and management.

1.4 Habitat selection and chelonians

Habitat is most fundamentally defined as the place an animal inhabits. A more rigorous definition, that ties habitat with a particular species, is that it must possess a

set of resources and environmental conditions that allow occupancy, survival and reproduction of that particular species (Morrison *et al.*, 1992). This implies that habitat is species-specific; however terms such as habitat type are often used interchangeably with biotope or ecotype.

Habitat selection can be most easily defined as use of resources disproportionate to their availability. Habitat selection is assumed to operate in a hierarchical manner (Johnson, 1980), and could hypothetically operate at four spatial levels: geographical range, macrohabitat, microhabitat and finally a specific resource or space within the microhabitat. Selection may be across habitats (i.e. based on broad differences in physiognomy) or within habitats (i.e. based on specific microhabitat cues, regardless of overall structure). Within the hierarchy of habitat selection is a complex interplay of historical factors, phylogeny, evolutionary and biological dynamics (Morrison *et al.*, 1992; Buskirk and Millspaugh, 2003). However, any current interpretations of habitat relationships are based largely on habitat attributes and extant faunal relationships. Habitat selection and use; and the specific attributes that determine species presence and abundance are highly species-specific and scale dependent in case of freshwater turtle (Bodie *et al.*, 2000). Studies aiming to determine habitat selection must have basic natural history data in order to select the scale of the study or patterns may be obscured. Data regarding their natural history of these turtle species like:- Habitat preferences, Guild has a major role in guiding the study in right direction. Earlier studies on chelonians shows that *Nilssonia gangeticus* and *N. hurum* are known to occur in lotic rivers, lakes and ponds, regarding food habit *N. gangeticus* are known to be omnivore (generalist) and *N. hurum* are known to be carnivore. *Chitra indica* known to occur in lotic sandy stretches of rivers and the

species is known to be a carnivore (generalist). *Pangshura tentoria* has a wide range of habitat i.e they prefer large lotic rivers to small streams and these are herbivore (generalist) feeders (Moll, 2004).

Habitat attributes that contribute to general freshwater turtle diversity, structural complexity and spatial heterogeneity are the most important (Wright *et al.*, 1999) factors that governs the distribution patterns of the chelonians. Habitat use is one aspect of resource partitioning, relating to the spatial resource.

1.5 Habitat use of basking chelonians

Differential habitat use by different species can also be stated as resource partitioning. Resource partitioning and niche partitioning are terms often used synonymously. An understanding of these requires a basic knowledge of what the niche of a species is. The niche can be broadly defined as the position and function of an organism in the environment (Smith, 1990). A more useful working definition was that put forward by Hutchinson (1957). The fundamental niche is simply the set of environmental factors (abiotic and biotic) within which a species is able to survive, while the realized niche is that subset of the fundamental niche that a species is restricted to by other factors including competition, predation, or disturbance (Hutchinson, 1957). That two species with identical niches, or relying on the same resources cannot coexist was first spelt out in laboratory experiments by Gause (1934). Gause's exclusion principle is based on the premise that resources are limited, and communities, or more specifically sympatric species can only coexist through resource partitioning (Schoener, 1974). It is understood that most natural communities demonstrate resource partitioning to at least some extent (Schoener,

1974). Besides competition for resources, other factors such as differential predation risk and adaptation to certain microhabitats or resources may drive resource partitioning among species. This spacing out of niches along a particular axis is related to the realized niche (Hutchinson, 1957); in that species with similar fundamental niches (for example, closely related species of a genus) may each be restricted to different realized niches when in sympatry.

Studies on differential habitat use for basking by different turtle species usually examined through space and time (Rizkalla *et al* 2006). Basking habitats or niches of turtles can further be divided (Schoener, 1974; Toft, 1985) into macro and microhabitats. Spatial or habitat occupancy in turtles is measured at various scales ranging from geographic location to more detailed descriptors of microhabitat (Congdon *et al*, 1993). Separation in time may be either within a day or across seasons. (Toft, 1985). Limited studies are available on the differential habitat use of basking freshwater turtles in the world (Schoener, 1974; Toft, 1985) and there was no study in this regard in the Mahanadi, where minimum seven species of turtles reported.

1.6 Anthropogenic threats and chelonians

Anthropogenic activities are probably one of the major threats endangering many chelonians in the world and the Mahanadi River is not exceptional to this. Besides, majority of these species are being exploited for traditional trade, there has been an increasing concern exists for these threatened populations (Claire, 1995) in India (Choudhury *et al.*, 2000). Threats to freshwater turtles may be broadly classified into direct threats, which include- removal of turtles through poaching for meat, removal of eggs for consumption, incidental catch in fishing nets. Indirect threats include-

change in habitat, pollution, disturbances that effect diurnal activity of turtles. These set of curial information would certainly help to develop conservation strategies (C.K., Jr. 1990) for the species, which would be one of the major outcomes of this study.

The present study was designed to understand the relationship of the freshwater turtle with the multiple riverine habitat types and threats that occur in a stretch of the Mahanadi river system. The study was also designed to examine the associations between different ecological settings of the Mahanadi river including anthropogenic use of the river habitats and the chelonian species diversity, abundances and their life history parameters.

1.7 Objective and research question

Objectives of this study are;

- To estimate relative abundance of freshwater turtle species in a gradient of riverine habitat in the Mahanadi River.
- To assess the habitat association of freshwater turtle species.
- To investigate differential habitat use of basking turtles, among different freshwater turtle species.
- To evaluate the impact of anthropogenic and other biotic factors on the use of basking habitats by the freshwater turtles and their conservation significance.

Research questions

- 1) Does the species diversity and relative abundance of turtle vary in the different gradients of the riverine habitats in Mahanadi?

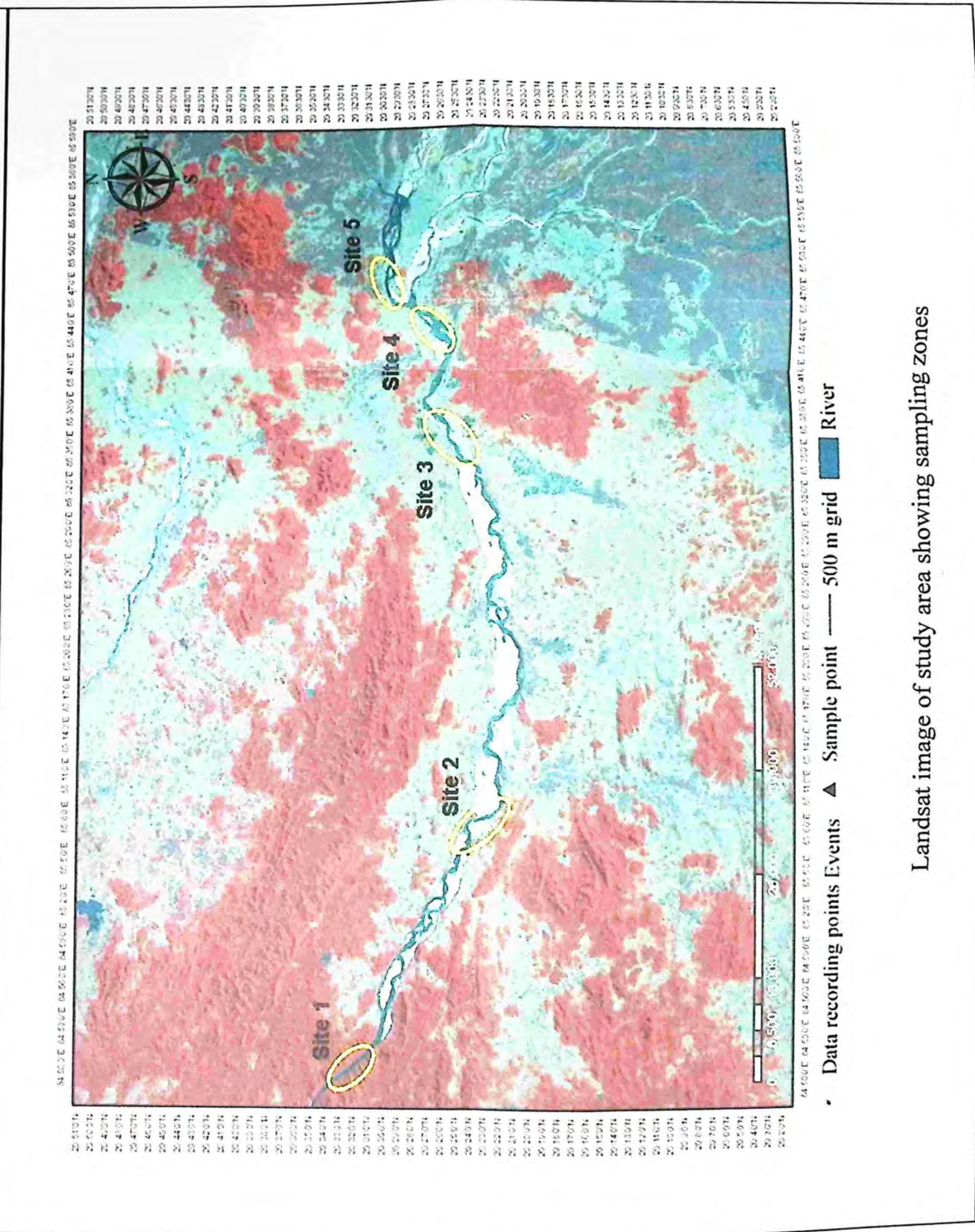
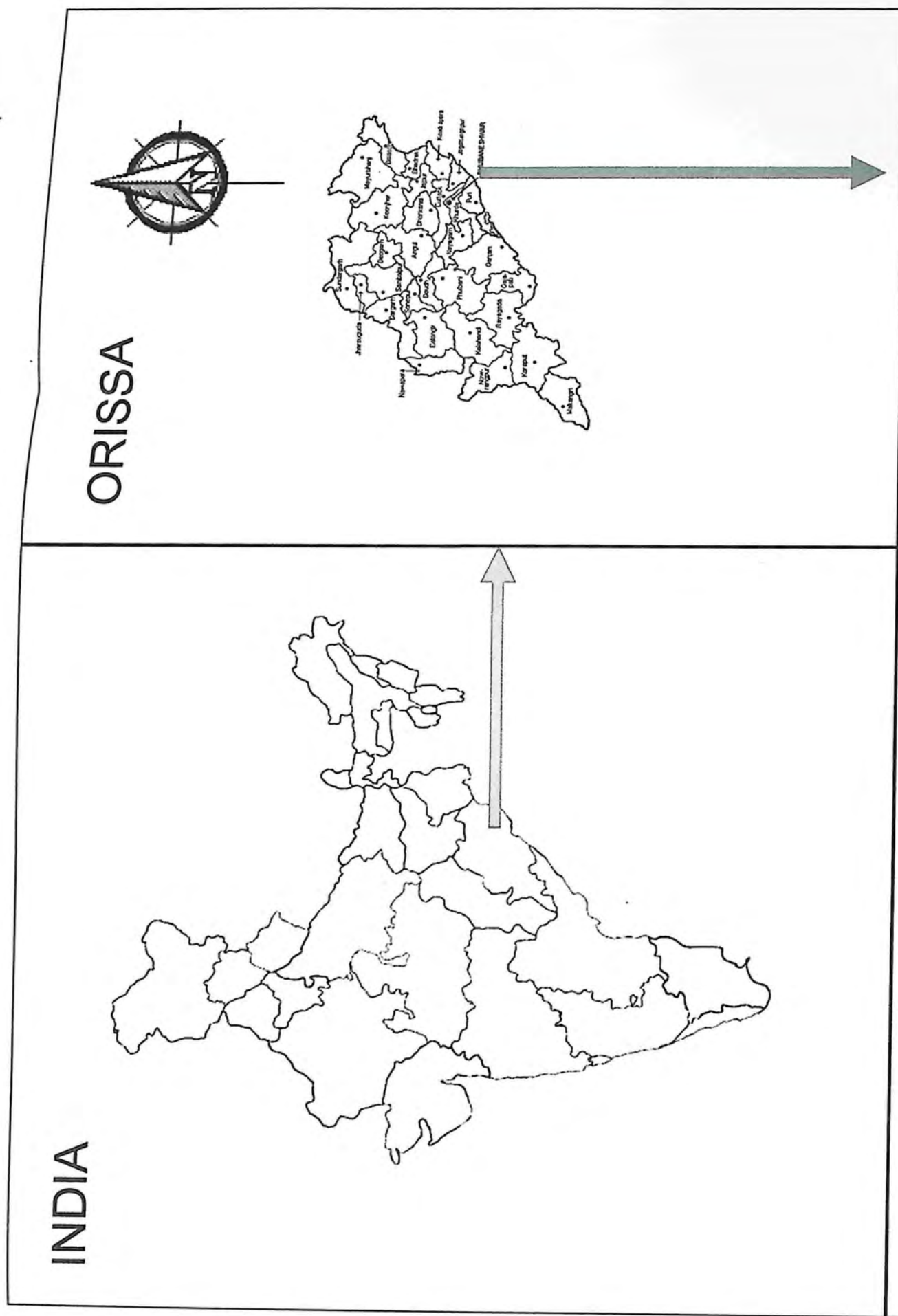
- 2) Do these turtle species require different habitat requirements in terms of basking?
- 3) What are the patterns of differential basking habitat use between turtle species?
- 4) Is there any overlap in habitat use between turtle species of basking turtles?
- 5) What are the possible anthropogenic and biotic factors impacting the diurnal basking and nesting activity of the hard and soft shell turtles in the gradient of riverine habitat of river Mahanadi?
- 6) Whether the degrees of such impacts are consistent across these different gradients of the riverine habitats.

2.1 The Mahanadi River in Orissa

Mahanadi River is one of the major rivers of India, which flow from west to east and finally drains into the Bay of Bengal. The water potential of the Mahanadi River is next to Godavari in the peninsular rivers. The Mahanadi River commences in south-eastern Chhattisgarh as a small stream draining the eastern part of the Chhattisgarh Plain. The river is about 885 km (550 miles) long in central India. The Mahanadi ("Great River") follows a total course of 900 km (560 miles) and has an estimated drainage area of 132,100 square km (51,000 square miles). It is one of the most active silt-depositing streams in the Indian subcontinent. The river supplies several irrigation canals mainly near Cuttack city.

2.1.1 Location and physical features:

The study was carried out in Mahanadi riverine ecosystem, Orissa. This lies in the Deccan peninsular (6) bio-geographic zone and Deccan Peninsular-Eastern Highlands (6C) (Rodger and Panwar, 2000). The intensive study area out of Mahanadi riverine ecosystem lies between Satkosia Gorge Wildlife Sanctuary and Cuttack (a stretch of about 120 km). This river stretch (between Satkosia gorge and Cuttack) is a unique representative of different land use with identical river characters along a riverine ecosystem (Fig.2.1).



Landsat image of study area showing sampling zones

Figure 2.1: Study area map.

2.1.2 Climate:

Rainfall:

Cuttack District has an average annual rainfall of 1536 mm (Saha, 2006) with 7.7 rainy days (Meteorological dept, O.U.A.T). The rainfall is very unpredictable, with very high variation from year to year and frequent drought years and occasional heavy rains.

Wind:

Average wind speeds are light to moderate through winter (4.11 km/h). March and April have moderate average wind speeds of between 5.69 km/h.

Temperature:

This area experiences a distinct winter and summer. Winter begins in November and continues till mid February. Early March is transitional and summer is from late March onward till the onset of the monsoon in July. The average temperature during the study period ranged from a minimum of 19.45 and maximum of 33.43°C.

(Fig.2.2)

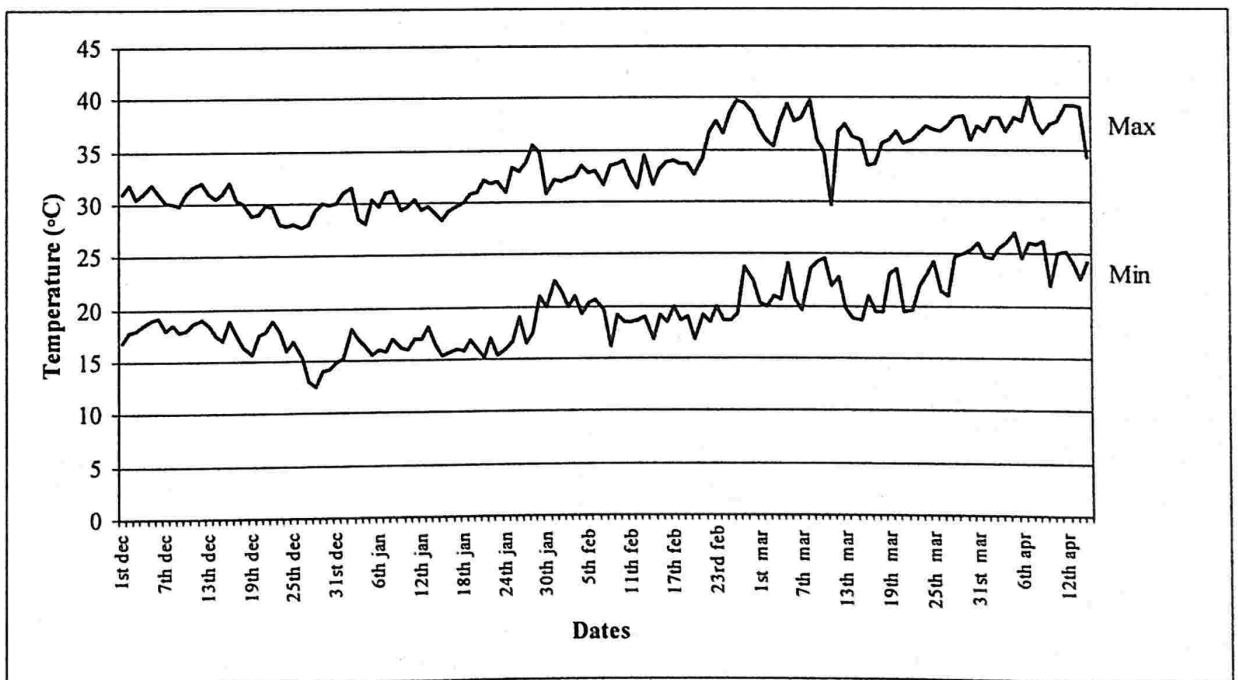


Fig. 2.2. Minimum and Maximum Temperature of the Study Area during Sampling Period

Clouds:

Winter skies are periodically overcast. In early summer (March-April) skies are generally clear except for occasional disturbances or dust storms, the frequency of which increase into May and June.

Sunshine hours:

This area experiences a distinct winter and summer. Sun used to rise between 8:00 to 9:00 AM during the study period. During December the mean sunshine hour recorded was **7.18hrs**, and increased to **8.05 hrs** till mid February. Early March was transitional and summer started from late April during this period the average sunshine hour was 8.96 hours. The average sunshine hour during the study period was recorded to be 7.86 hours (Fig 2.3).

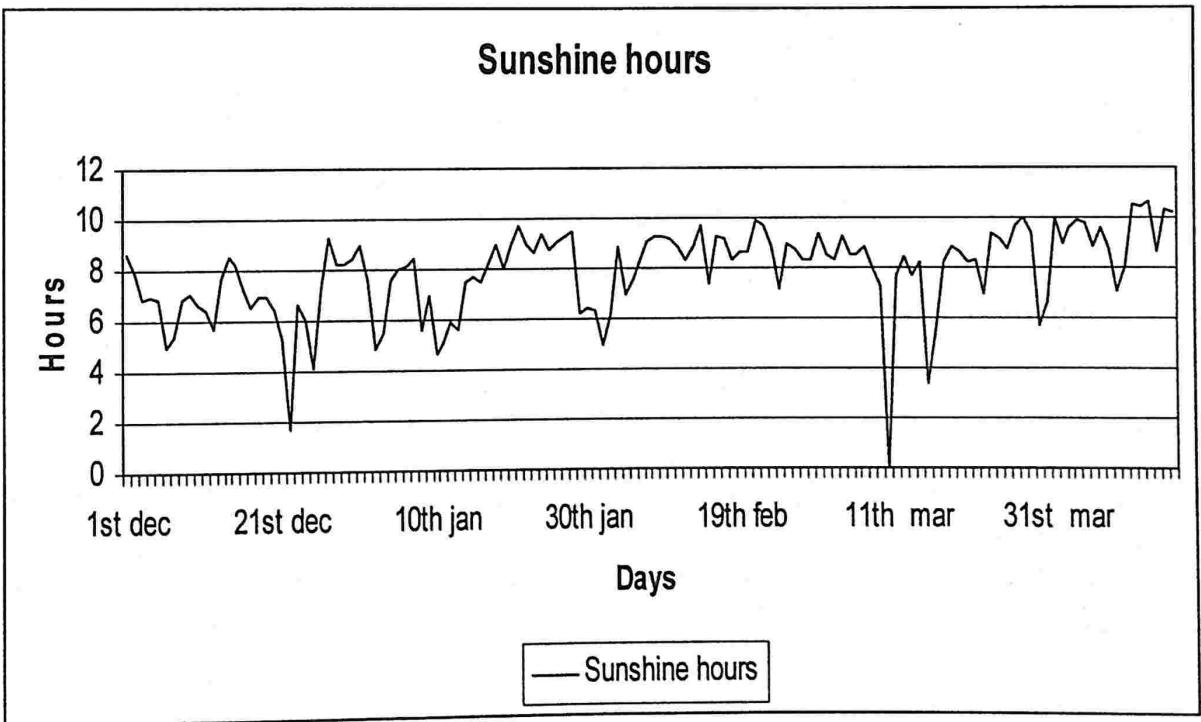


Figure 2.3: Sunshine hour during the study period

2.2 Intensive Study Area (ISA)

To address all proposed research questions and objectives, the study area of the River Mahanadi, was further divided into following five zones based on her gradients and other ecological settings;

1. Riparian flow zone. (Sampling Zone I)
2. Braided river flow zone. (Sampling Zone II)
3. Non riparian flow zone. (Sampling Zone III)
4. Inundated static flow zone. (Sampling Zone IV)
5. River with rocky and sand bank. (Sampling Zone V)

2.2.1 Riparian flow zone:

The riparian flow zone of the intensive study area had a unique bank profile with good vegetation on it. The zone has a mean ground cover of 49.05 percent and mean canopy cover of 44.18 percent. It also has a unique river character with a mean river width of 551.71m, mean river depth of 10.08m and mean bank width of 1.3m (Fig2.4). This zone lies adjoining to the south eastern boundary of the Satkosia Gorge Wildlife Sanctuary. The area is representative of Eastern Ghats with a diverse set of floral and faunal composition. This zone has a better canopy cover along the river. The existing forest types of the area are North Indian Moist Deciduous forests. Moist Peninsular Low level Sal (3C) and Northern Tropical Dry Deciduous forests. Dry Bamboo Brakes (5B) (Champion and Seth, 1968). The elevation of this area is 115 meters above Mean Sea Level. The summer temperature of the area was recorded to be 47° C and in winter the temperature was 4.5° C with an average annual rainfall of

300mm. The soil type of the area varies from older alluvial soils to red loamy and sandy lateritic soil.

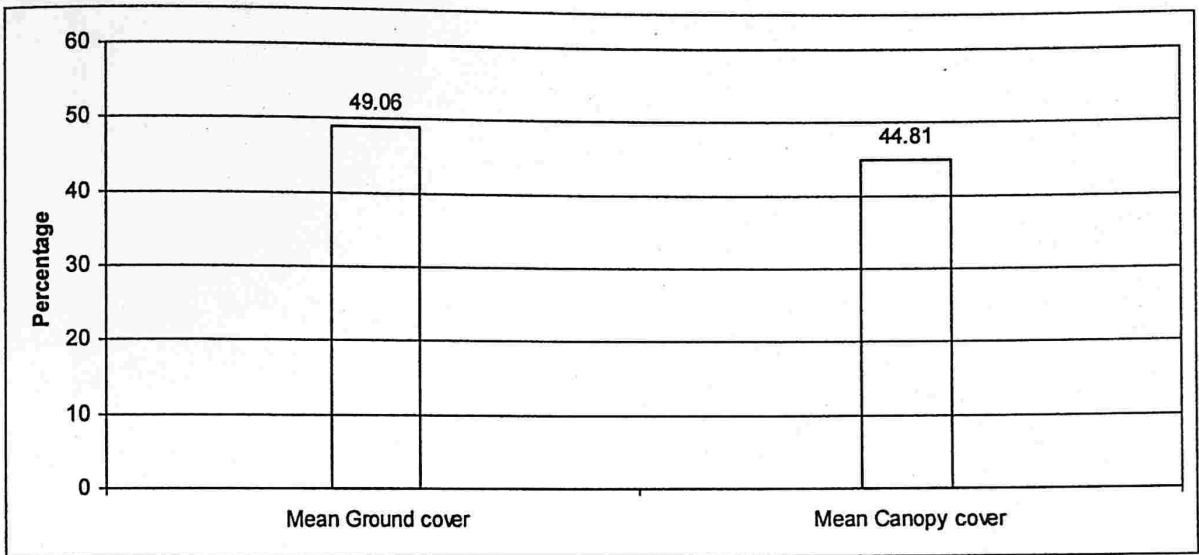


Figure 2.4: Bank vegetation characteristics of Riparian flow zone

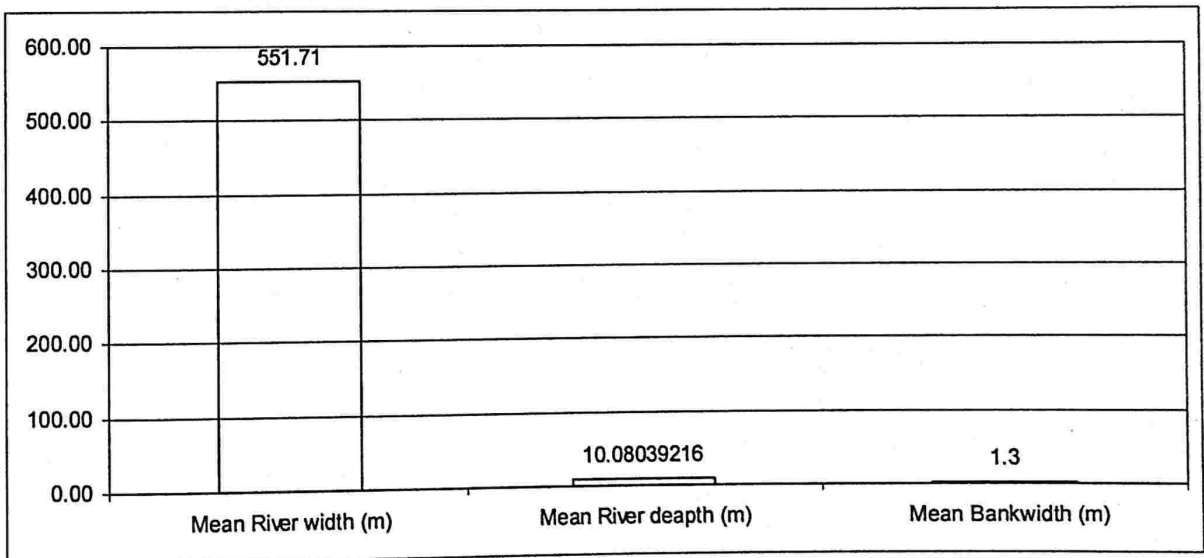


Figure 2.5: River profile of Riparian flow zone

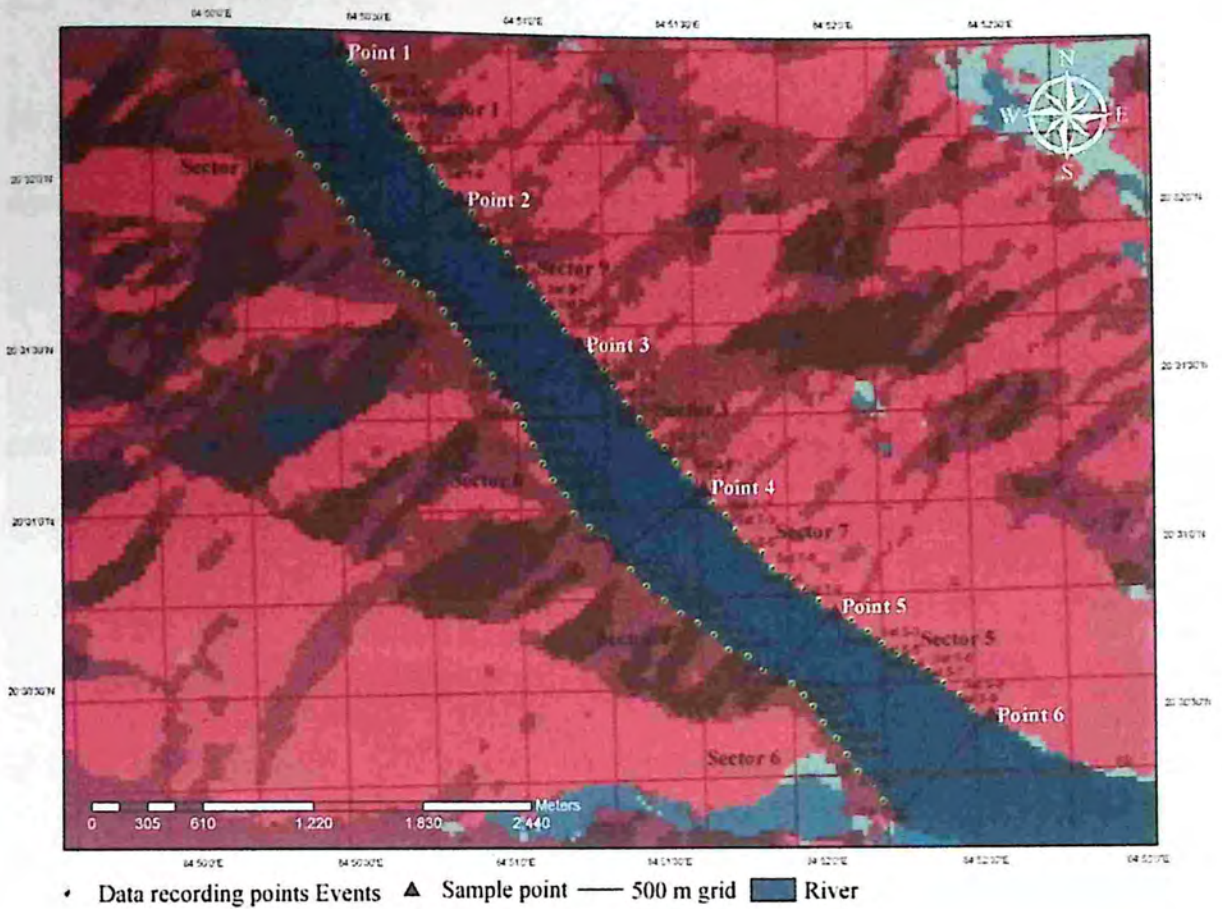


Figure 2.7: Land sat image of sampling zone I showing DRPs.



Figure 2.8: Sampling zone I (Riperian flow zone)

2.2.2 Braided river flow zone:

The braided flow zone of the intensive study area had different bank profile with less vegetation on it. The zone has a mean ground cover of 26.7 percent and mean canopy cover of 6.93 percent. It also has a unique river character with a mean river width of 977.34m, mean river depth of 14.91m, and a mean bank width of 1120.58m. This zone of the study area lies near Banapur. This was about 60 kilometres upstream of the Mahanadi river from Naraj Barrage in North West direction. The area was surrounded by rural settlements and the land use was predominantly agriculture based. This area has an elevation of 49 meters above Mean Sea Level. The slope of the bank was very gentle with certain level of anthropogenic pressure. As this area has few planted tree species along the bank which was responsible for certain degrees of canopies along the bank. The soil type is mainly composed of alluvial and sandy loam type.

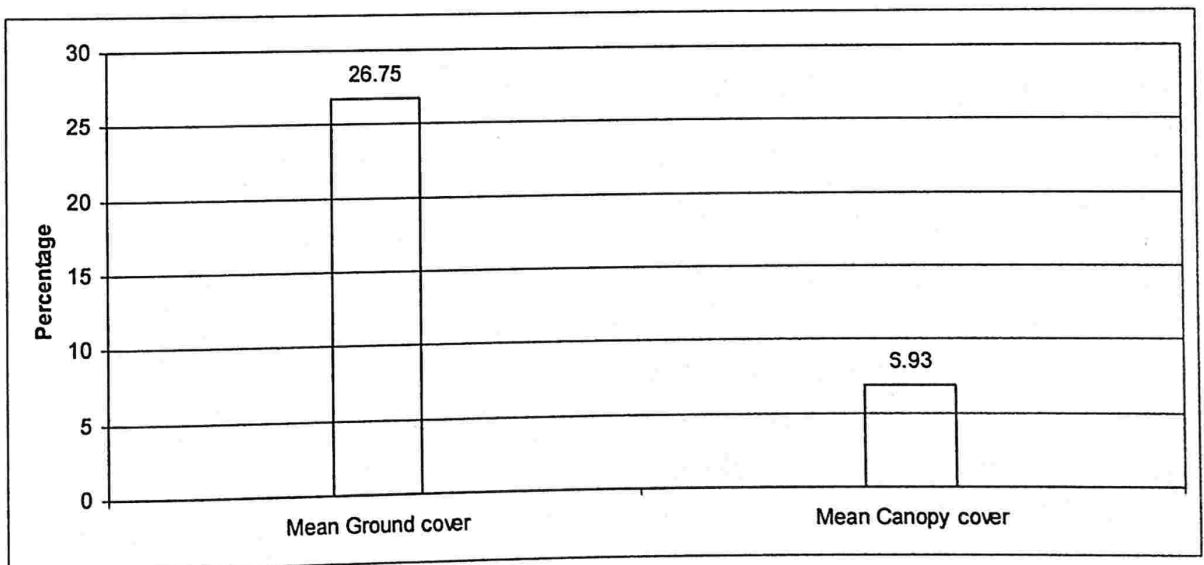


Figure 2.9: Bank vegetation characteristics of Braided river flow zone

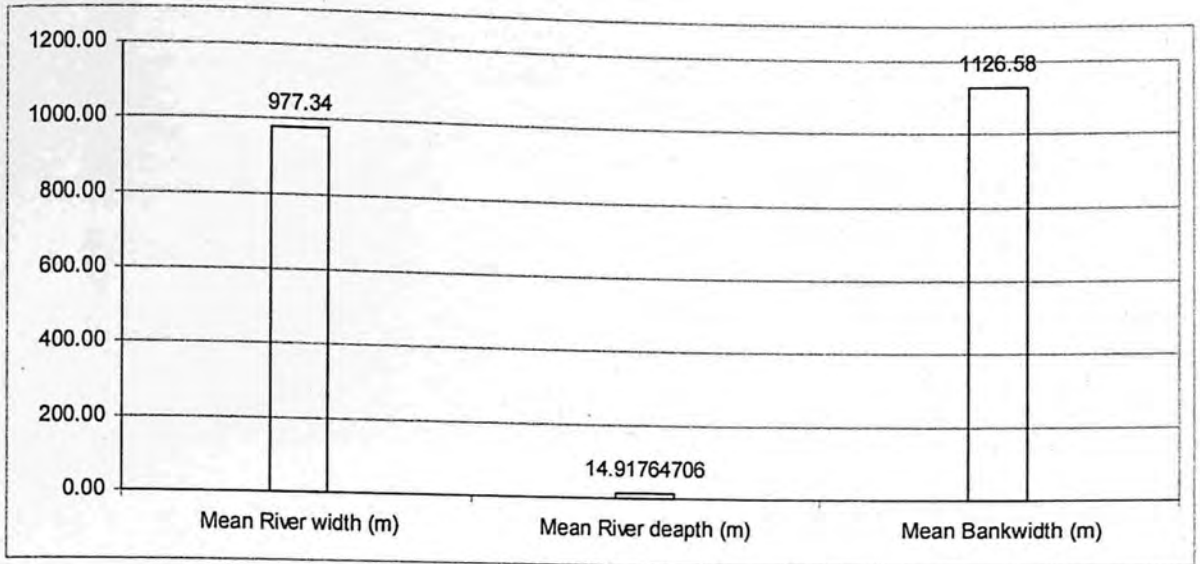


Figure 2.10: River profile of Braided river flow zone

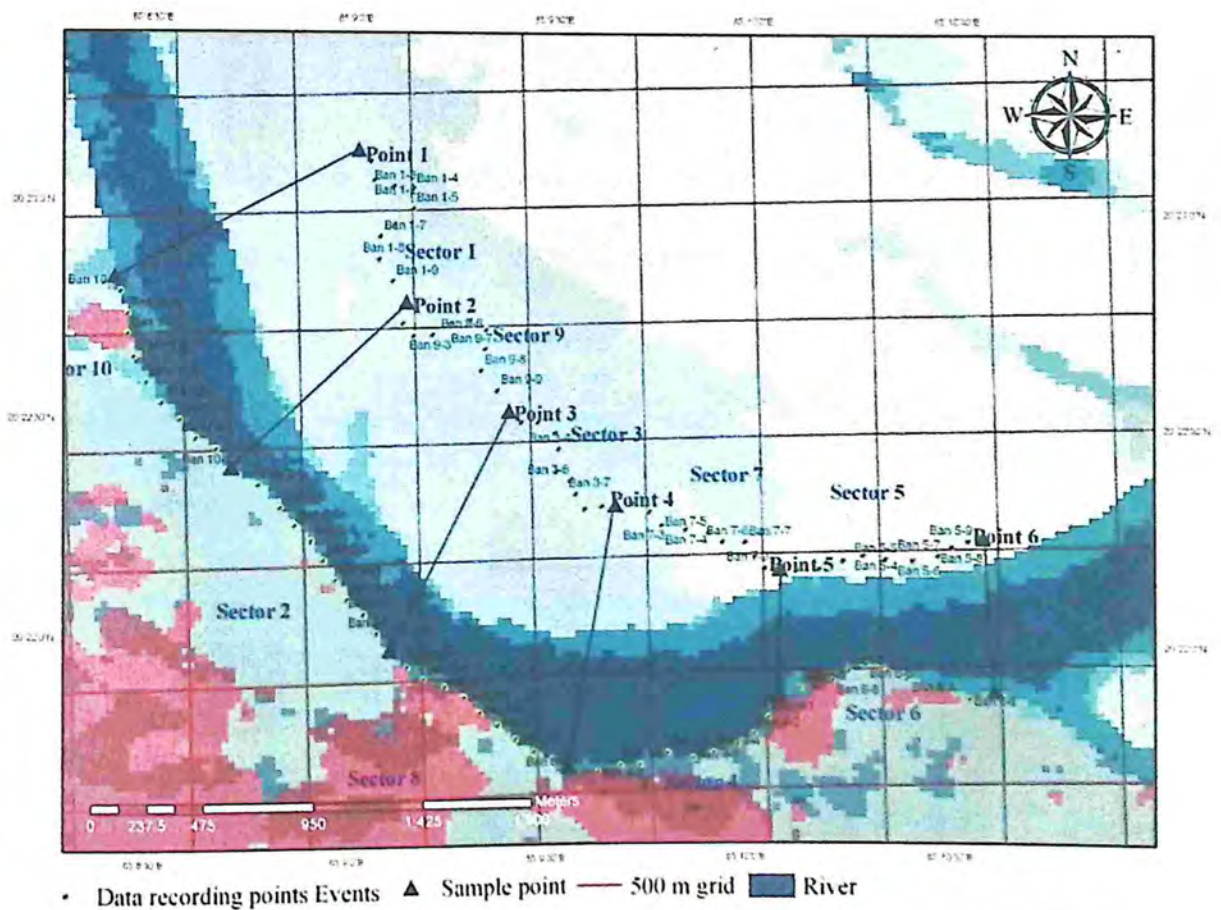


Figure 2.11: Land sat image of sampling zone II showing DRPs.



Figure 2.12: Sampling zone II (Braided flow zone)

2.2.3 Non riparian flow zone :

The Non riparian flow zone of the intensive study area differentiates from other by not having any ground cover and canopy cover on it. It also had a unique river character with a mean river width of 870.45m, mean river depth of 7.91m and mean bank width of 418.91m. This sampling zone lies near a place called as Subarnapur. The elevation of this zone was 29 meters from Mean Sea Level. The summer temperature of the area was recorded to be 40° C and in winter the temperature was recorded to be 16° C with an average annual rainfall of 144.39mm. The soil type of the area was mainly sandy.

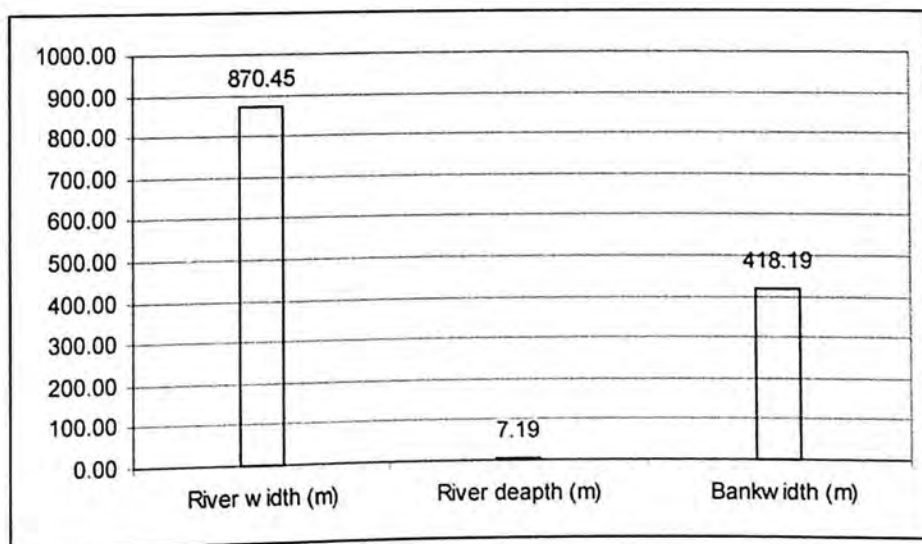


Figure 2.13: River profile of non riparian flow zone

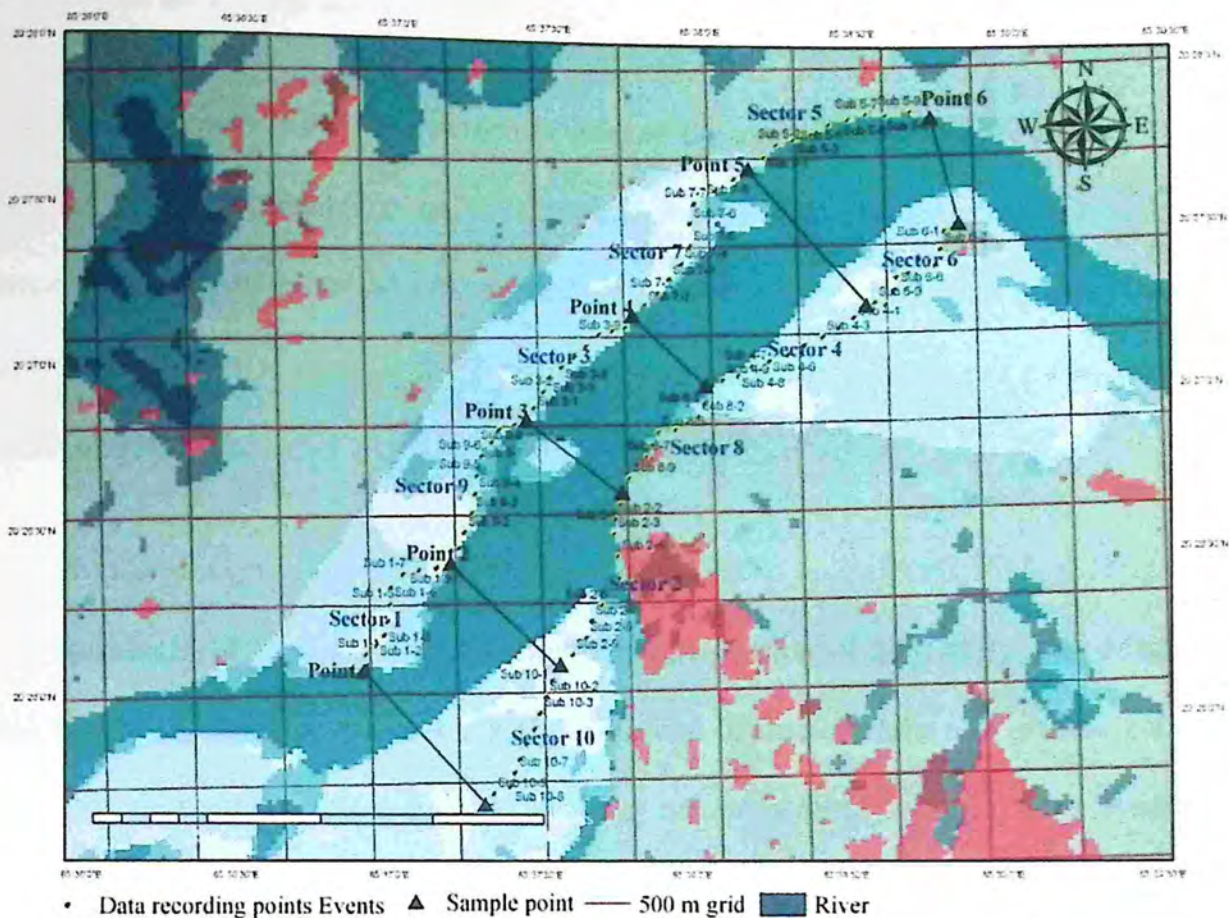


Figure 2.14: Land sat image of sampling zone III showing DRPs.



Figure 2.15: Sampling zone III (Non riparian flow zone)

2.2.4 The inundated static flow zone:

The inundated static flow zone of the intensive study area differentiates from other by having very little vegetation on it. The zone has a mean ground cover of 31.19 percent and canopy cover of 1.40 percent on it. It also had different river character with a mean river width of 1221.77m, mean river depth of 10.80m and mean bank width of 117.54m.

The inundated static flow zone of the study area lies in and around Naraj Barrage. The barrage is situated near Cuttack city with an elevation of 29 meters from Mean Sea Level. The bank of this area mainly composed of small shrubs and grasses with very few tree species which resulted in fewer canopies cover over the area. Apart from this, the water current character of this area found to be very different from other zones as the water was static in this zone. The summer temperature of the area was recorded to be 40° C and in winter the temperature was recorded to be 16° C with an average annual rainfall of 144.39mm. The soil type of the area mainly composed of alluvial soils and sandy lateritic soil.

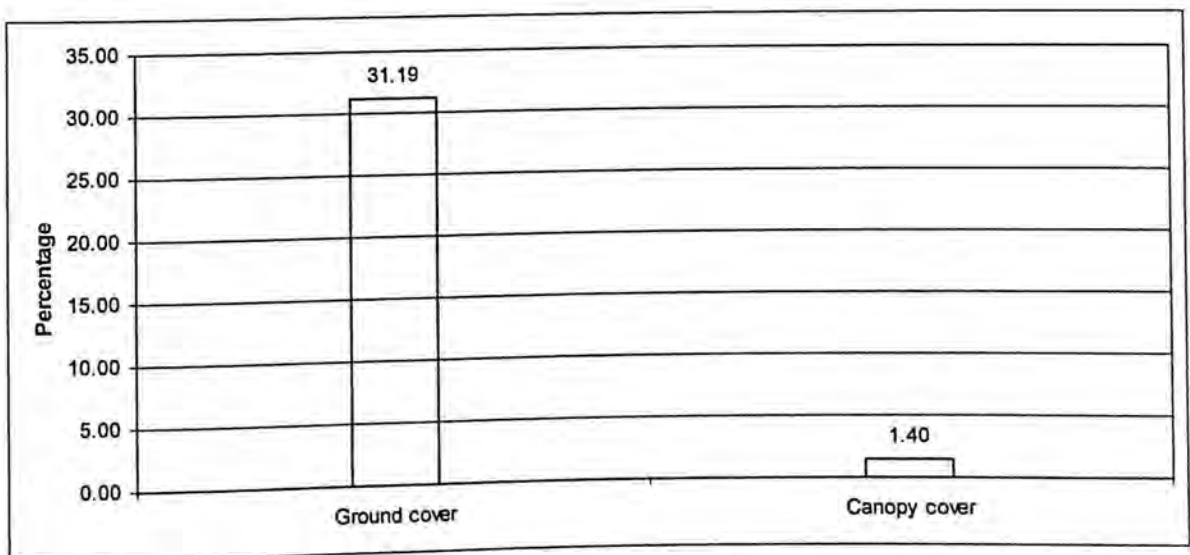


Figure 2.16: Bank vegetation characteristics of inundated static flow zone

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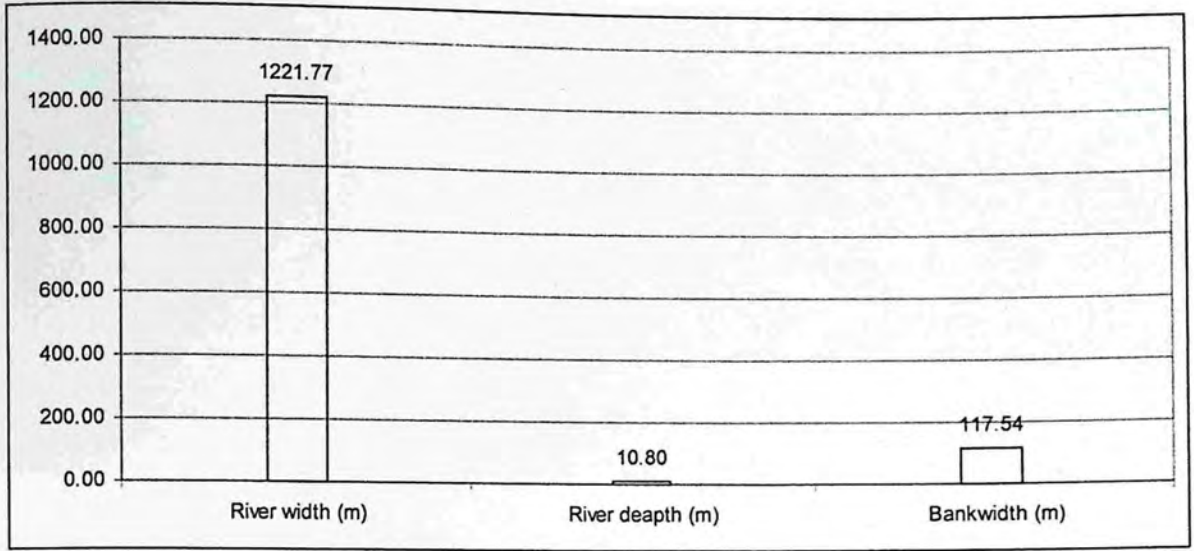


Figure 2.17: River profile of non riparian flow zone

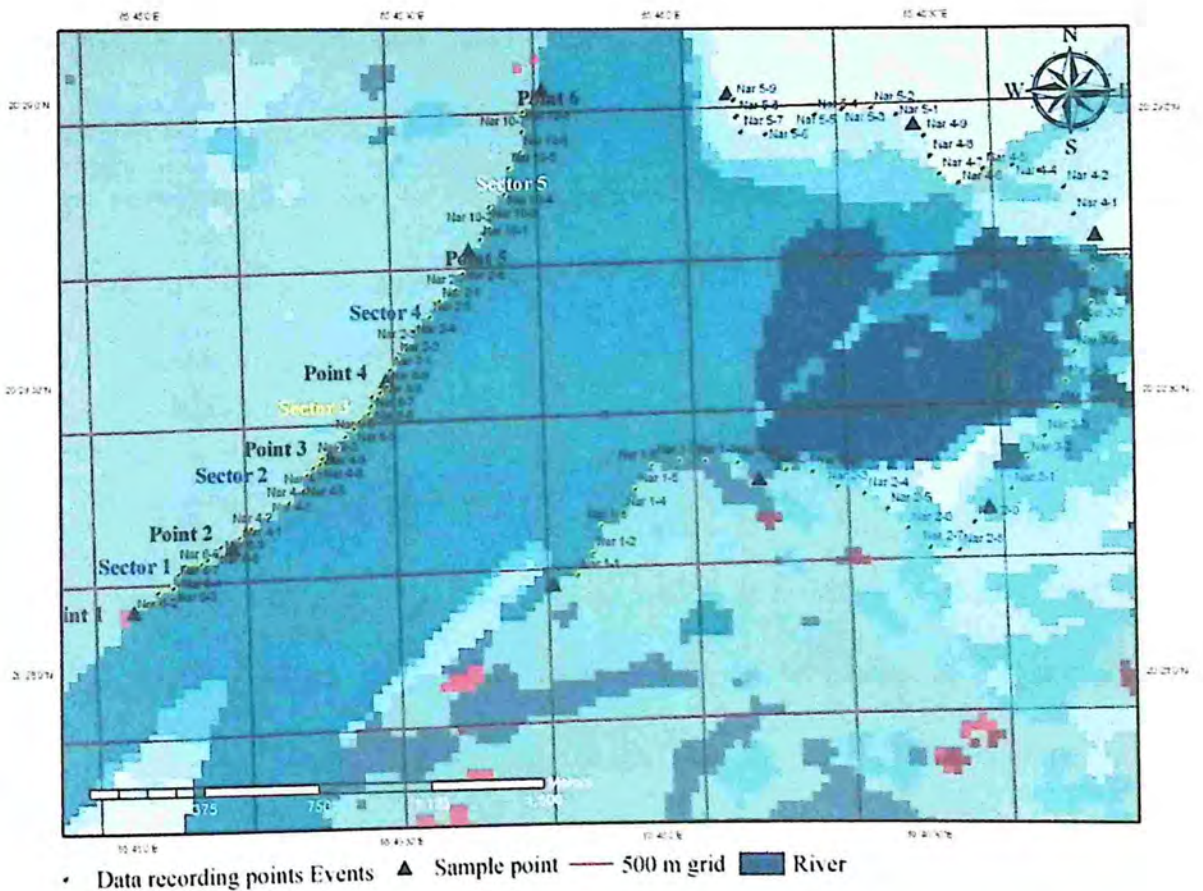


Figure 2.18: Land sat image of sampling zone IV showing DRPs.



Figure 2.19: Sampling zone IV (Inundated static flow zone)

2.2.5 River with rocky and sand bank:

This river stretch of the study area differentiates from other by not having good differential vegetation on two banks with a mean ground cover of 36 percent and canopy cover of 15.46 percent on it. It also has unique river character with a mean river width of 645.35m, mean river depth of 11.28m and a mean bank width of 178.60m. But majority of the bank width has been contributed by one side of the river bank.

This zone of the study area lies near a place called as Kakhadi situated near Cuttack with an elevation of 29 meters from Mean Sea Level. The bank of this area mainly composed of small shrubs, grasses and tree species. Apart from this, the water current character of this area was very different from other zones as the water velocity (2.10km/h) was medium in this zone. This is the eastern most sampling point of the study. The summer temperature of the area was recorded to be 40° C and in winter the temperature was recorded to be 16° C with an average annual rainfall of 144.39mm.

The soil type of the area is mainly composed of sand on one side of the bank and mud in other side of the bank.

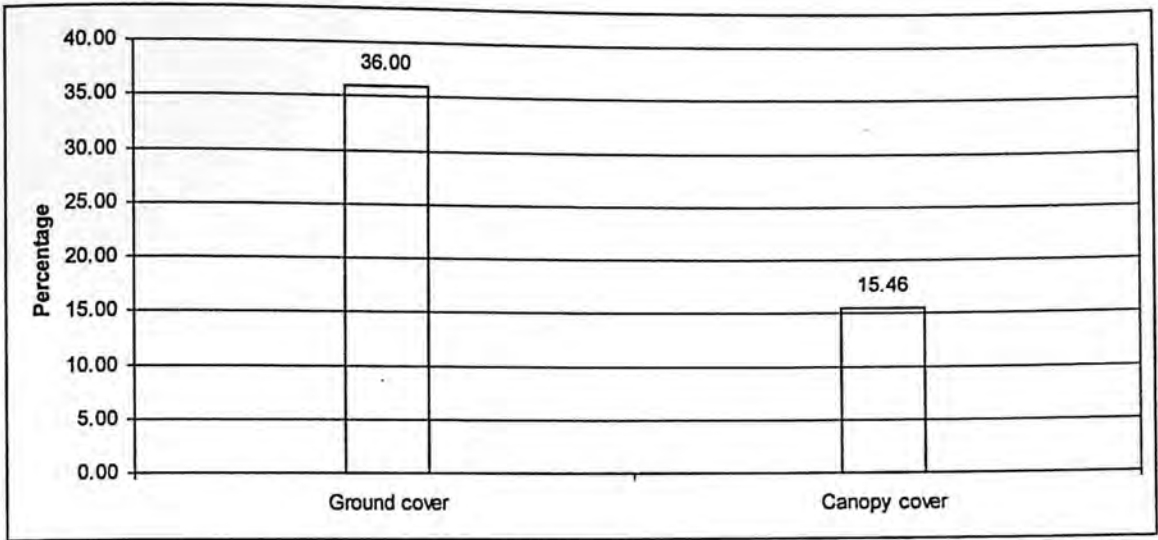


Figure 2.20: Bank vegetation characteristics of River with rocky and sand bank.

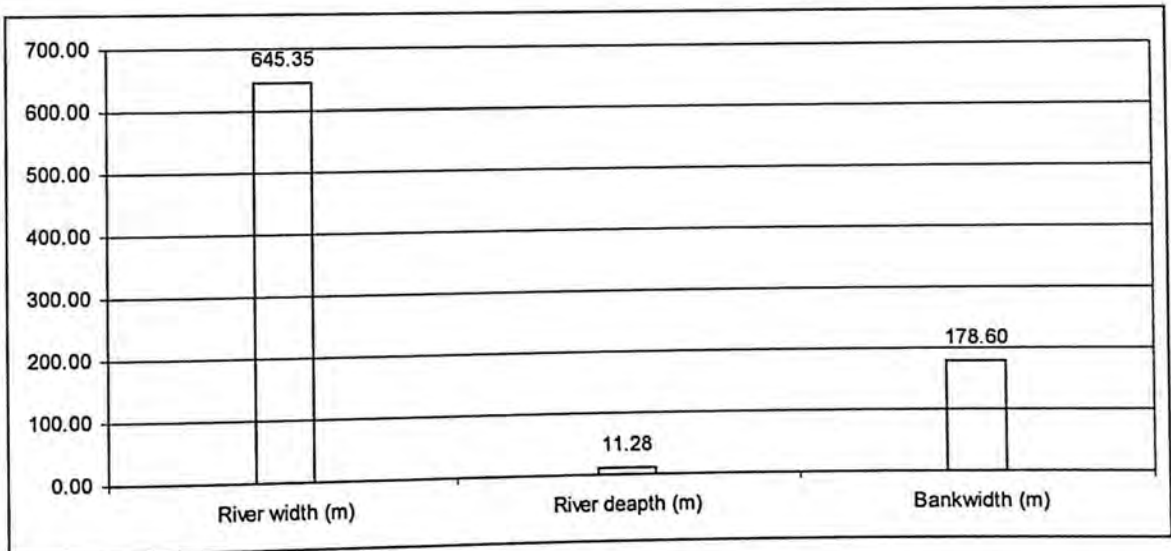


Figure 2.21: River profile of non riparian flow zone

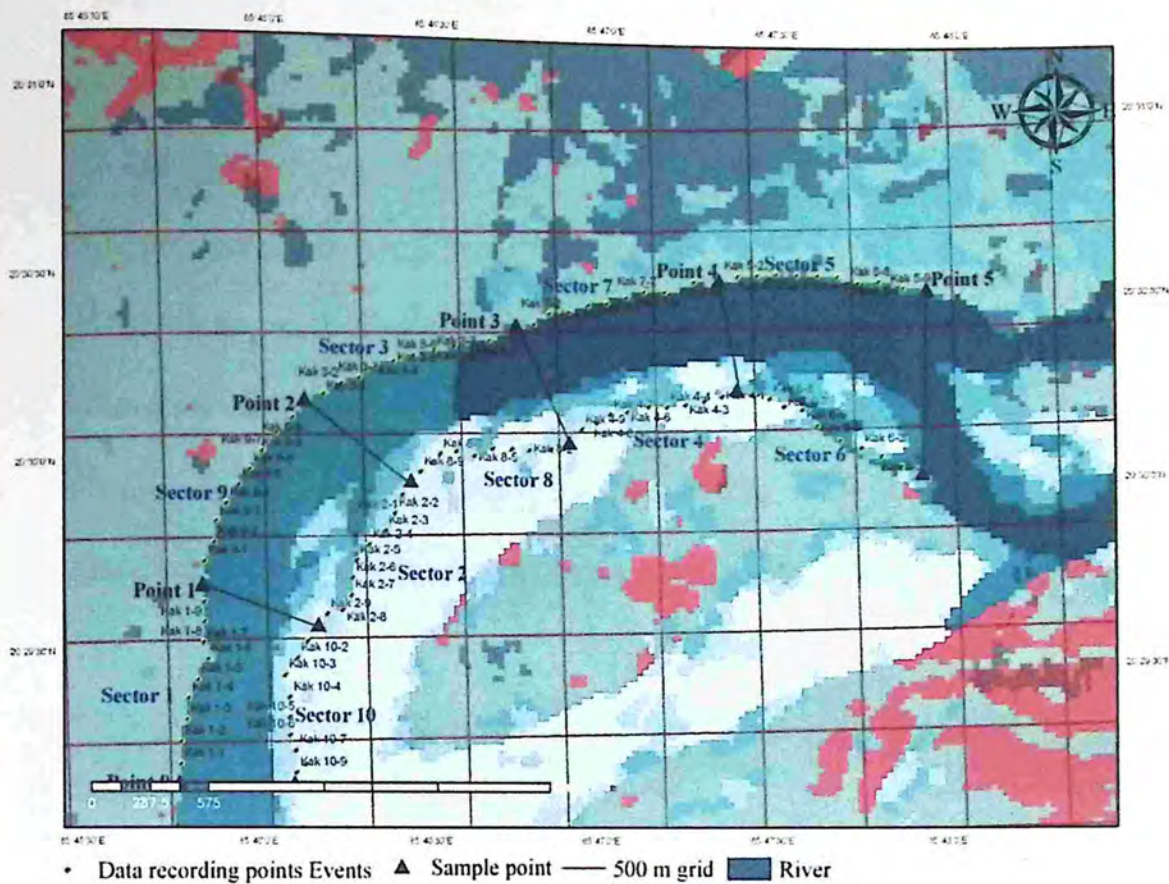


Figure2.18: Land sat image of sampling zone V showing DRPs



Figure2.19: River with sandy and rocky bank (Sampling Zone V)

2.3 Study animals

The study was on freshwater turtles. Out of 7 reported species only five has been recorded during the study period:-

1. *Nilssonia gangeticus* (Indian softshell turtle) (Cuvier, 1825)
2. *Nilssonia hurum* (Indian peacock softshell turtle) (Gray, 1831b)
3. *Chitra indica* (Indian narrow-headed softshell turtle) (Gray, 1831b)
4. *Pangshura tentoria* (Indian tent turtle) (Gray, 1834, in Gray, 1830-1835)
5. *Lissemys punctata* (Indian flapshell turtle) (Lacepède, 1788)



Figure 2.5.1: *Nilssonia gangeticus* (Indian softshell turtle)

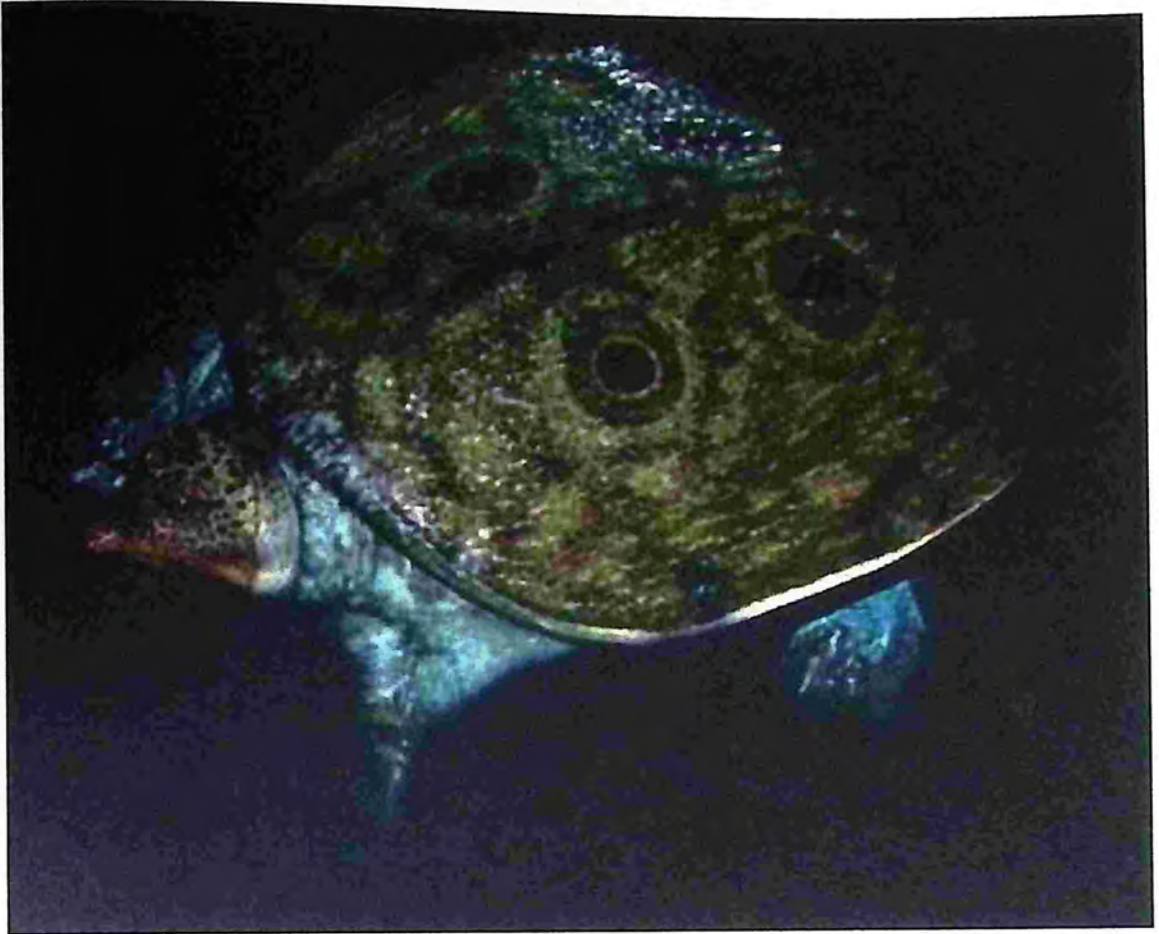


Figure 2.5.2 *Nilssonina hurum* (Indian peacock softshell turtle)



Figure 2.5.3 *Chitra indica* (Indian narrow-headed softshell turtle)



Figure 2.5.4 *Pangshura tentoria* (Indian tent turtle)



Figure 2.5.5 *Lissemys punctata* (Indian flapshell turtle)

3. METHODS AND MATERIALS

Species assemblage of different freshwater turtle species in a gradient of Mahanadi riverine habitats in Orissa was studied between December 2008 and April 2009. Stratified sampling was used for habitat characterization and for investigating the patterns of turtle diversity and their habitat association in the Mahanadi River.

3.1 Reconnaissance and selection of sampling methods

In the beginning of the study, the area was surveyed by observing the various river gradients from the sampling zone I to sampling zone V, as well as by informal interaction with the local peoples. Sampling methods to estimate the turtles abundance was also evaluated and standardised during this reconnaissance period. Turtle tracks were examined for species identification and counter checked with known tracks. This period was also used to familiarize in recognizing and locating turtles and their tracks, which were essential to maximize detections probability.

3.2 Stratification of sampling area and definitions

This study was carried out in the Mahanadi riverine ecosystem between Satkosia Gorge Wildlife Sanctuary and Cuttack city. Approximately 50 km long river stretch of the study area was further classified into to five zones. Each zone was 10 km long. In each zone a 5 km long 'sampling zone' was selected randomly for intensive sampling of turtles abundance and habitat assessment. The stretches of five kilometre sampling zones have further been divided into five blocks (sub sampling points) of one kilometres in length. Then each block (sub sampling point) was further divided

into 10 sampling units of 100 meter each. Data recording points (DRP) refers to the point between two sub-sampling units for which the habitat data were recorded. Boat survey (BS) refers to recording the number of basking turtle by moving from one end to another by a non-mechanised small boat. Indirect survey method (ISM) refers to identifying and recording the number of tracks belongs to different species, by walking along the river bank. Sampling zone I refers to “riparian flow zone” (extreme limits of north west of the study area), which lies in Satkosia Gorge Wildlife Sanctuary, sampling zone II refers to “braided flow zone” which lies near Banapur, sampling zone III refers to “river with varied bank character zone” which lies near Subarnapur, sampling zone IV refers to “Inundated static flow zone ” which lies on Naraj barrage and sampling zone V refers to “river with distinct bank zone” which lies near Kakhadi.

3.3 Sampling Methods

3.3.1. Habitat Characterization:

The five intensive sampling zones each of five kilometres length has been selected after a thorough reconnaissance survey of the area. The selection was based upon different biophysical riverine characters and levels of anthropogenic and prevailing biotic disturbance factors. The stretches of five kilometre sampling zones have further been divided into five blocks (sub sampling points) of one kilometres in length. Then each block (sub sampling point) was further divided into 10 Data Recording Points (DPR) of 100 meter each. All the DRPs of the sampling zones has been marked with bamboo pegs as well as GPS.

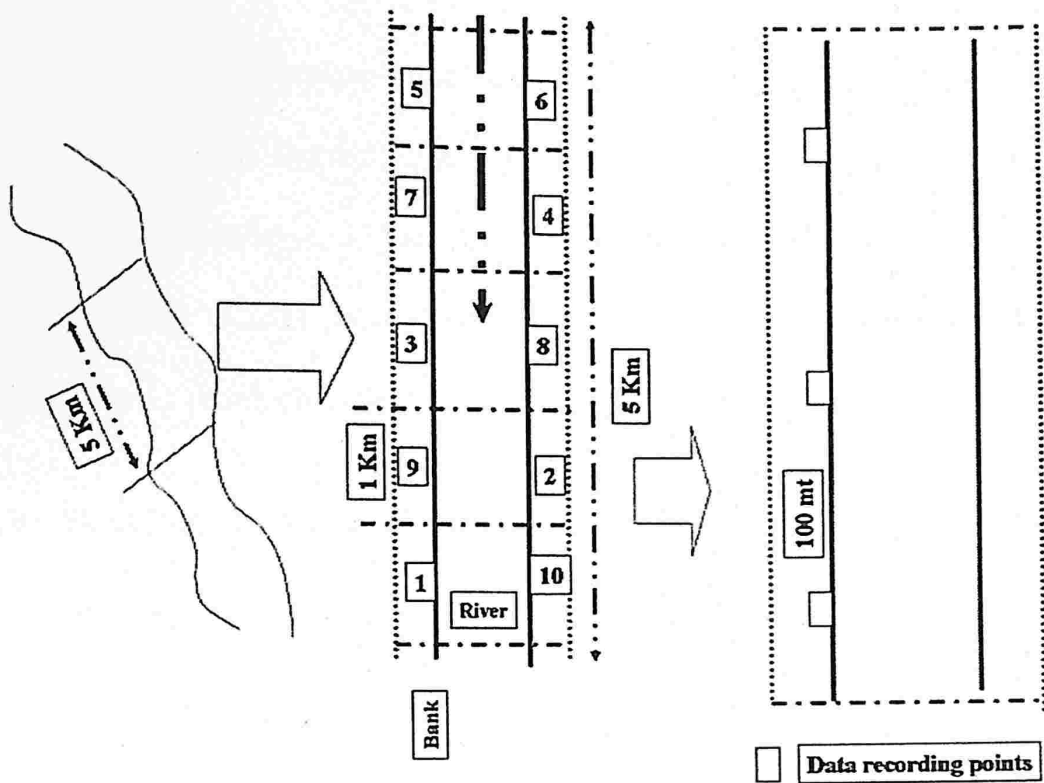


Fig. 3.1 Sampling design for collecting habitat data and doing turtle
Survey along the stream

After establishing the data recording points, the sampling zone was sampled for temperature (soil temperature, water temperature, ambient temperature), Water velocity, Water depth, River width, water turbidity, Bank profile (Slope of the bank, Soil type, Bank width) and other necessary parameters like nature of substratum, number of alternate basking substrates, vegetation character of the bank, nearby landuse pattern and level of anthropogenic disturbance.

3.3.2 Sampling design for basking turtle survey (direct sightings):

Each five km long Sampling Zone was surveyed for turtle presence using a small non-mechanised boat. During the survey, upon each sighting of turtles, the turtle was identified to species level, all the characters of immediate habitat of the turtles were recorded, which include substratum, soil temperature, soil texture, soil humidity, vegetation types, bank characters, river width etc..

3.3.3 Sampling design for basking turtle survey on the sand bank (indirect signs):

Immediately, after the direct census of turtles along the riverbank, both the banks of the river was walked by two observers and looked for indirect evidences for turtles use such as tracks signs. Based on the tracks characters, the species was later identified at species level after recording its digital image, which was later used for confirmation with digital data base. After recording a track then that track was erased from the bank to avoid double count.

3.3.4 Defining indirect evidences:

Turtle tracks have been well studied in case of marine turtles. Different turtle species has different tracks in terms of their track width, type of the tracks and other geometry of the tracks (Pritchard, 1999). A turtle track usually composed of five distinct markings such as Carapace marking, Right forelimb, Left forelimb, Right hind limb, and Left hind limb. (Fig) These markings proportionately vary between species, and hence these distinct markings have been observed carefully for species identification. Mostly, all tracks were found on sand banks and hence the variability of the tracks due to the substrate was also taken care.

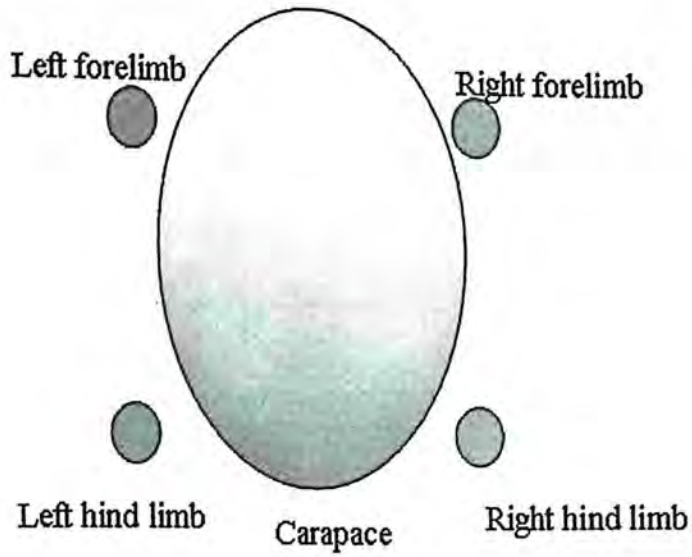


Fig. 3.2 Different components of a turtle track

3.3.5 Defining the geometry of the tracks:

Certain characters like shape of the carapace mark, distance between carapace mark to limb (straddle), distance between forelimb to hind limb, presence of belly drag mark has been used to distinguish the tracks of different species. Here I defined stride as "a" and the distance between carapace to limb (CTL) marks as "x".(Fig 3.3).

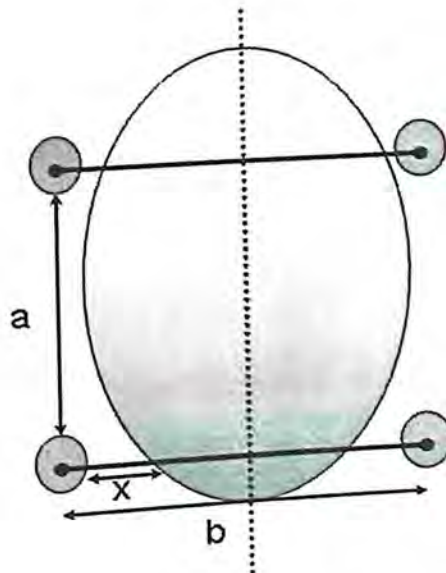


Fig.3.3 Geometry of a turtle track

Different carapace shape has been defined as circular type and oval type (Fig), which has been used as one of the criteria of species identification.

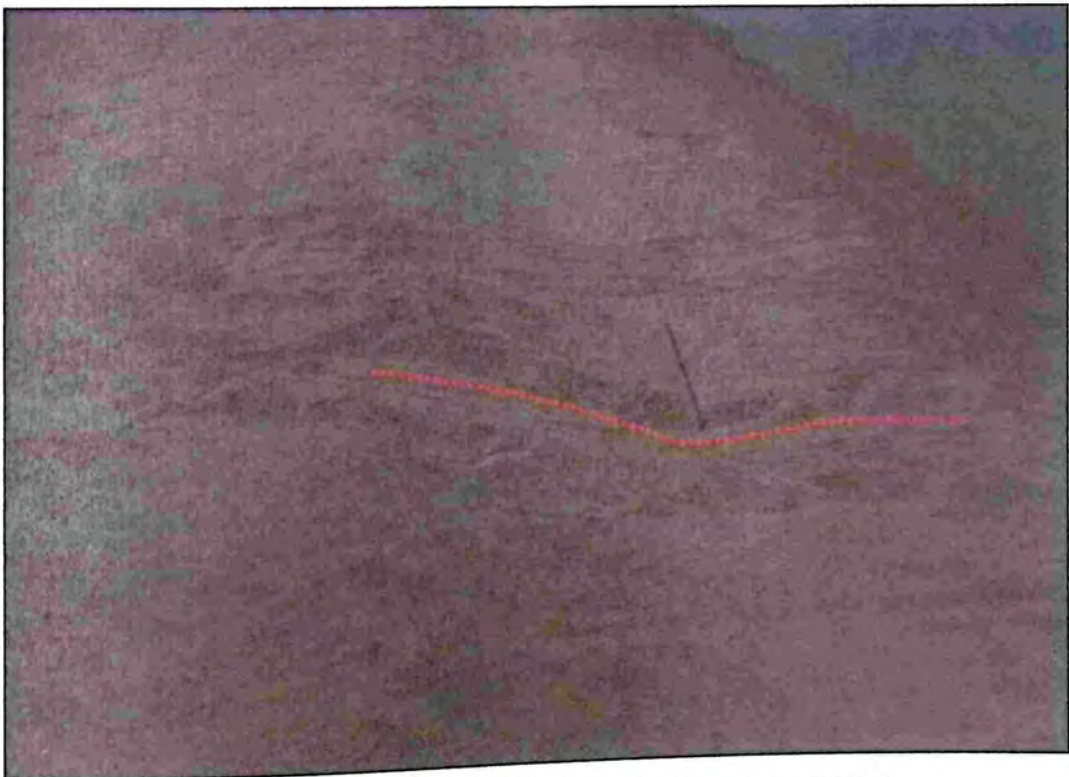


Circular shape



Oval shape

Fig. 3.4 Different shapes of carapace markings



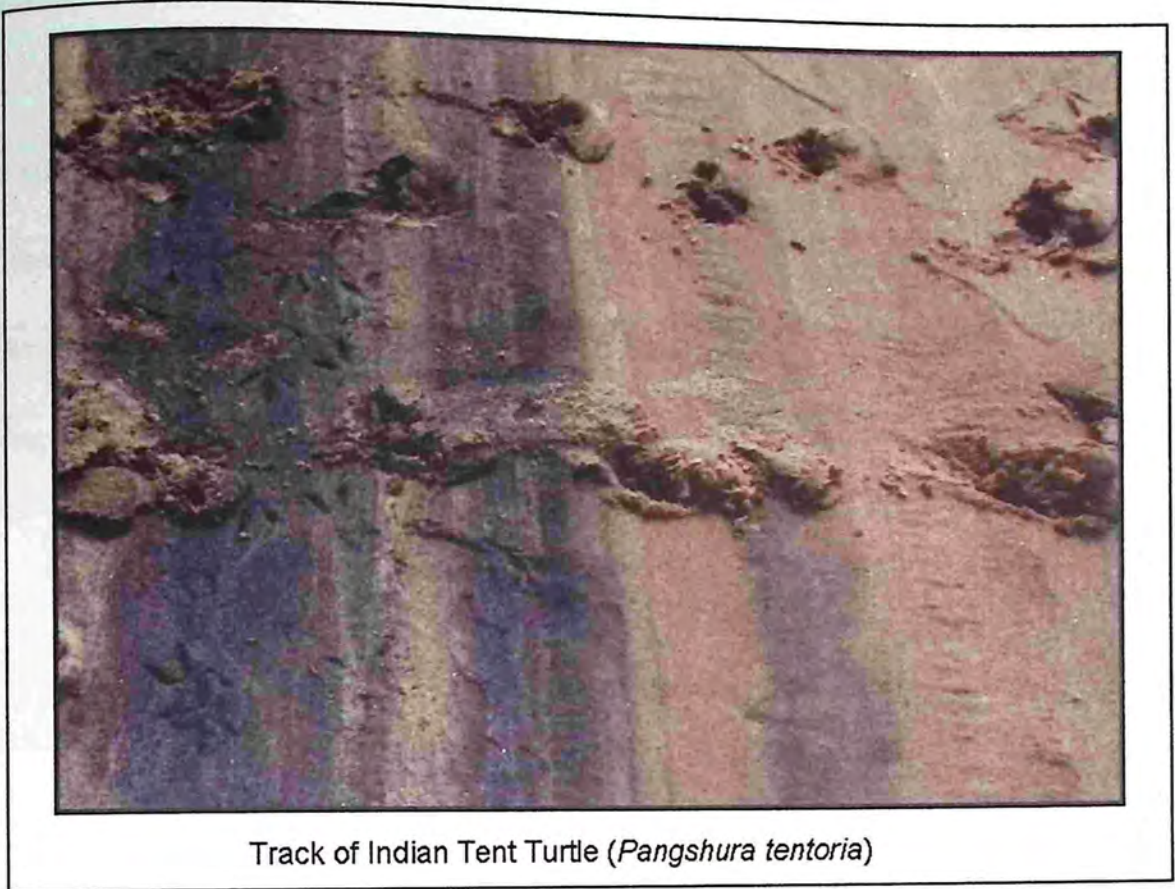
Track of Indian Softshell Turtle (*Nilssonia gangeticus*)



Track of Indian Peacock Softshell Turtle (*Nilssonia hurum*)



Track of Narrow-headed Softshell Turtle (*Chitra indica*)



When some softshells walks it leaves a belly drag mark. A definite belly dragging mark (Fig 3.5) has also been used to distinguish the tracks of different species.

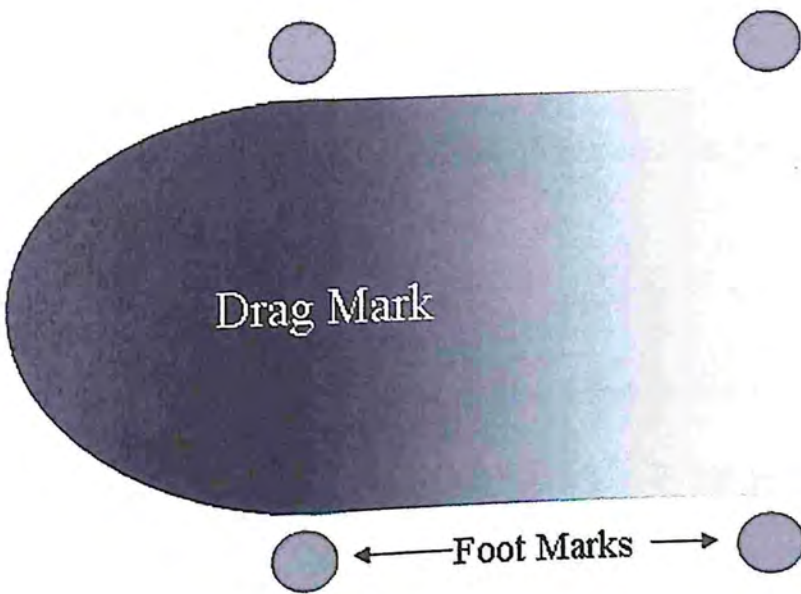


Fig.3.5 Belly dragging mark

Species	Components of track		
	Carapace shape	Belly dragging mark	Proportionate CTL
<i>Nilssonina gangeticus</i>	Oval	Present	More
<i>Nilssonina hurum</i>	Oval	Absent	Less
<i>Chitra indica</i>	Circular	Present	Less
<i>Pangshura tentoria</i>	N.A	Absent	Distinct foot mark

Table 3.1 Summary for identification of tracks.

Nilssonina gangeticus:

The track of *N.gangeticus* was distinguished from other species mainly by the virtue of its distinct belly dragging mark. Apart from this CTL is proportionately higher than compared to other species occurred in the study area. Other characteristics features of track of this species is the carapace shape marking is oval in shape..

Nilssonina hurum:

The belly dragging mark is absent in case of this species. Shape of the carapace mark in this case is also oval but the proportionate CTL is comparatively less than *Nilssonina gangeticus*. All of this above said character has been examined carefully for the species identification.

Chitra indica:

The tracks of *Chitra indica* distinguished from other species mainly by virtue of its distinct oval shape carapace marking along with belly dragging mark. Apart from this CTL is proportionately less than compared to other species occur in the sampling zones. All of this above said character has been examined carefully for the species identification.

Pangshura tentoria:

The tracks of this species have been identified by the virtue of its relatively small size, absent of belly dragging mark and carapace mark. Only distinct footmark has been observed in case of this species.

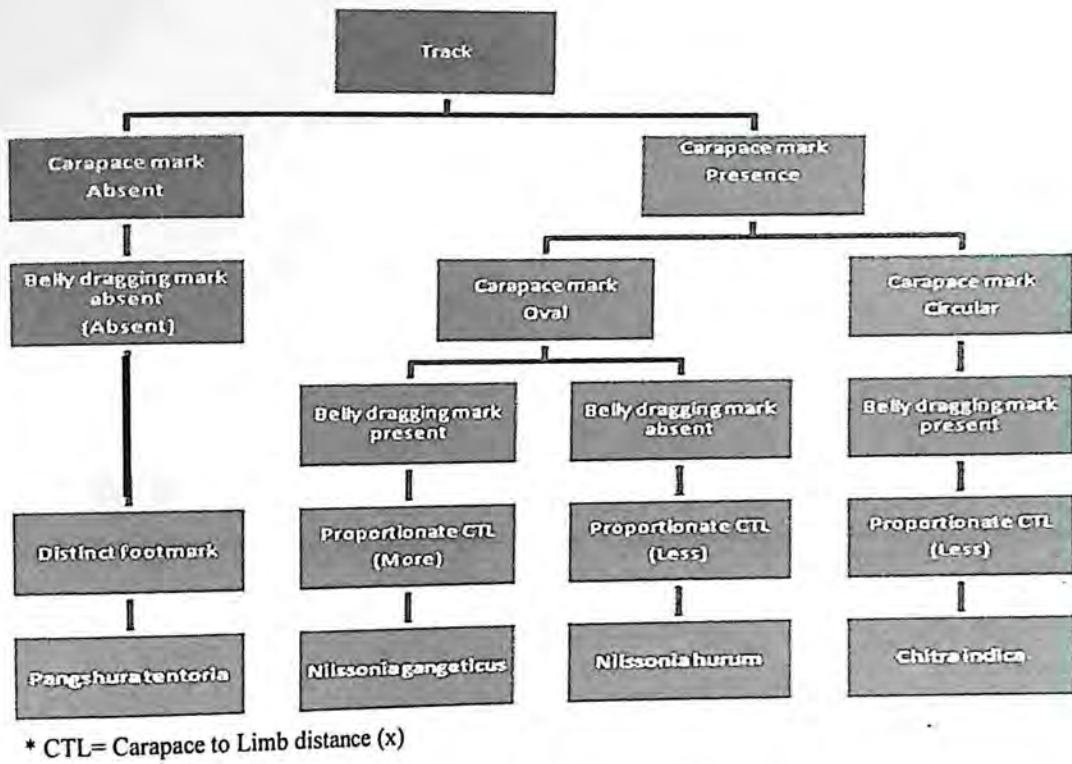


Fig. 3.6 Identification key for tracks of different species.

3.3.6 Accuracy in identification of tracks:

For testing the accuracy in identification of tracks, 50 randomly selected sites of direct evidences and 50 sites of indirect evidences were plotted in a scatter based upon their occupancy in the site. In this analysis the data has been normalized, resembled and 1D Euclidean distance method were used for analysis.

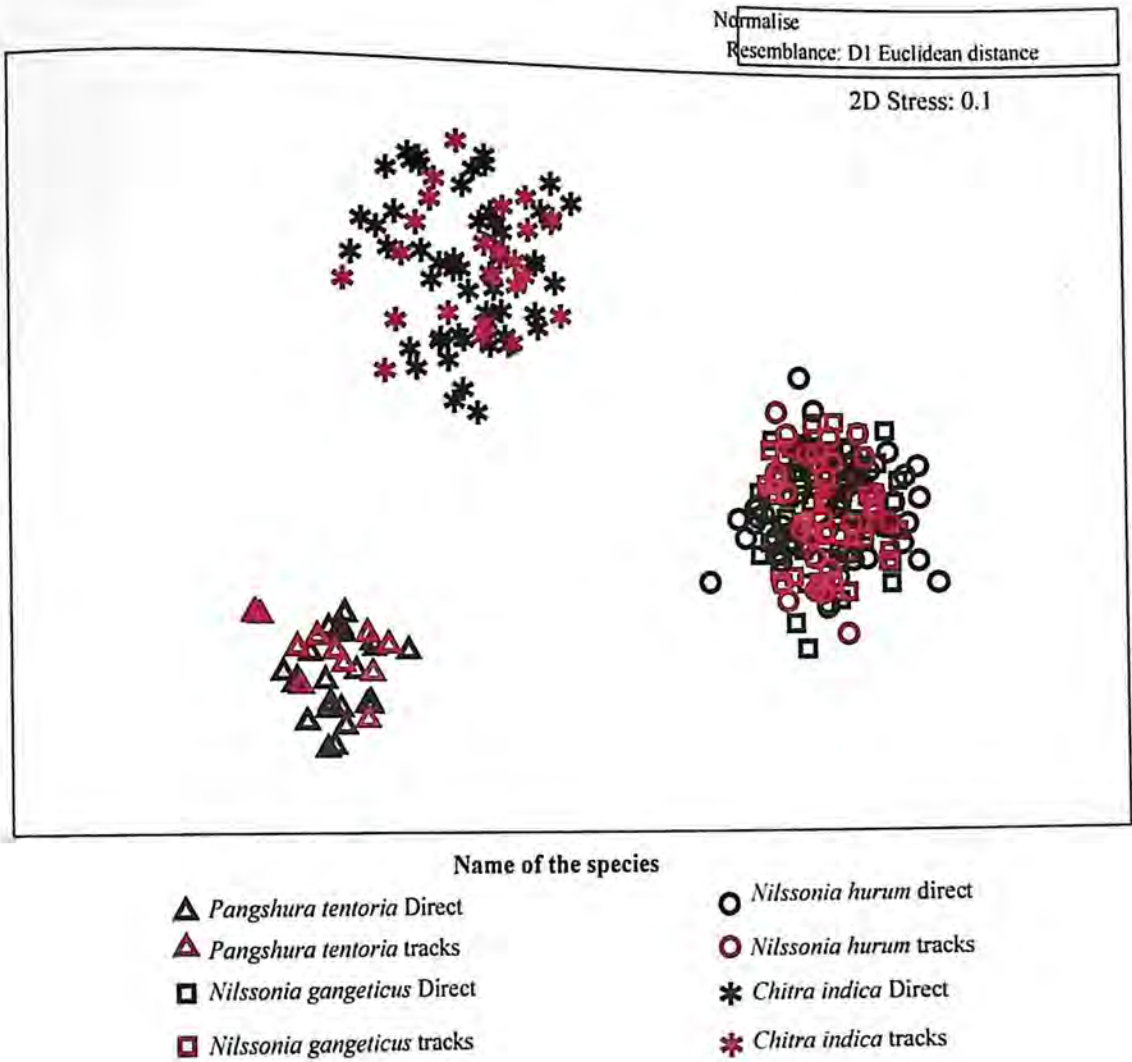


Fig. 3.7 NMDS Scatter showing classification accuracy between direct and indirect evidences.

The above NMDS Scatter shows the ordination of the sites occupied by species based upon their indirect evidences and direct evidences. Plots with same species with direct evidences and indirect evidences clumped together. This shows minimal chances of misidentification of tracks.

3.4 Sampling time

After the reconnaissance survey, the time period between 1100 hours and 1730 hours of the day was identified as the best time for basking turtles survey as most of turtles

out during this period in two sessions. Seccession I starts from 11:00 AM and ends at 02:00 PM. Seccession II starts at 03:00 PM and ends at 05:30 PM. In a day, each sampling zone was surveyed in both the sessions.

3.5 Other Characters

Temperature measurement:

Temperature of soil, water and ambient have been recorded using detachable digital temperature probes.

Water velocity:

The water velocity of the river in each sampling point has been estimated using a floater. Data of the time and distance travelled by the floater has been used to estimate the water velocity following formula $\text{speed} = \text{distance}/\text{time}$.

Water depth:

Water depth has been recorded by using a calibrated rod (ruler).

River width:

River width has been calculated by using the GPS location of all the DRPs. These GPS coordinates has further plotted on a map and the width has been calculated by using GIS tool (Arc GIS 9.2).

Water turbidity:

Categorical data of water turbidity has been collected from every DRP. References of water sample have been used for recording data on the basis of ocular judgment.

Slope of the bank:

Angle of slope of the river bank with respect to water level has been recorded by using a clinometer or by using a spirit balance($\tan\theta = \text{perpendicular} / \text{base}$).

Soil type:

Textural class of the soil has been recorded at every sub sampling point by following the standard protocols of soil textural triangle method (Brown, 2003).

Bank width:

Bank width measurement has been done in every DRPs by using a meter tape. The width has been recording by laying the meter tape perpendicular to the water level. Bank character would also be record along with the width.

Nature of bottom substrate:

Immediate reading on nature of the bottom substrate has been recorded on direct sighting of the animal from the boat.

Number of alternate basking substrate:

Number of possible alternate basking sights has been counted and recorded along the river stretch while doing turtle survey on boat and while recording habitat data.

Vegetation character of the bank:

Bank vegetation character has been recorded in every DRPs. Ten meter circular plot has been laid for tree species, and four 1m X 1m plots has been laid for quantification of grass and herb species. Data regarding canopy cover, ground cover etc has been collected from these sampling plots.

Nearby land use pattern:

Nearby land use pattern has been recorded along the entire stretch of the river during the survey.

Degree of disturbance:

Categorical data regarding degree of disturbances has been collected along the stretch of the river while doing habitat survey, as well as boat survey.

N.B:- All the above said covariates data has been recorded in each DRPs.

4.1 Species Richness And Relative Abundance Of Turtles

4.1.1 Hypothesis

The species composition and the relative abundance of different turtle species vary randomly along the five sampling zones of the river stretch.

4.1.2 Method of data analysis

4.1.2.1. Relative abundances of different turtle species throughout the study period:

All the sightings of different turtle species were combined together by using MS Excel 2003 and the mean numbers of sightings were calculated along with standard errors. The mean number of sighting per kilometre has also been calculated in order to get the relative abundances in terms of encounter rate.

4.1.2.2 Species composition along the gradient:

To investigate the difference in pattern of species composition, the abundance data have been transformed into binary data (Presence = 1, Absence = 0) for all sampling zones and Non- metric multidimensional scaling (NMDS) (Zar 1996) has been used by using programme: PRIMER 6.1 to plot them in a scatter. This method (NMDS) is a non parametric statistical tool which can be used to analyze ecological data to see the pattern how they differ from each other. In this analysis the data has been normalized, resembled and Bray curtis distance measure were used for analysis. The

groups similarity have also been tested by using Multi-response permutation procedure (MRPP) using programme BLOSSOM.

4.1.2.3 Relative abundances of turtles along the gradient:

To investigate the difference in relative abundances of different turtle species along the gradient, the turtle abundances of each sampling zones were plotted in order to show how these sampling zones are related with each other in terms of their relative abundances. Non- metric multidimensional scaling (NMDS) has been used to plot them in a scatter. In this analysis the data has been normalized, resembled and Bray curtis distance measure were used for analysis.

After observing the NMDS scatter, the relative abundances were plotted species wise against different sampling zones. Kruskal wallis H tests were done to show the difference in relative abundances of each species along the five sampling zones by using Prog: SPSS 16.

4.2 Results

4.2.1 Relative abundances of turtles along the gradient of Mahanadi River:

Throughout the study period, a total of 11656 direct sightings and 1673 tracks of turtles were recorded along different sampling zones. This includes three softshells (*Nilssonia gangeticus*, *Nilssonia hurum*, *Chitra indica*) and one hardshell (*Pangshura tentoria*).

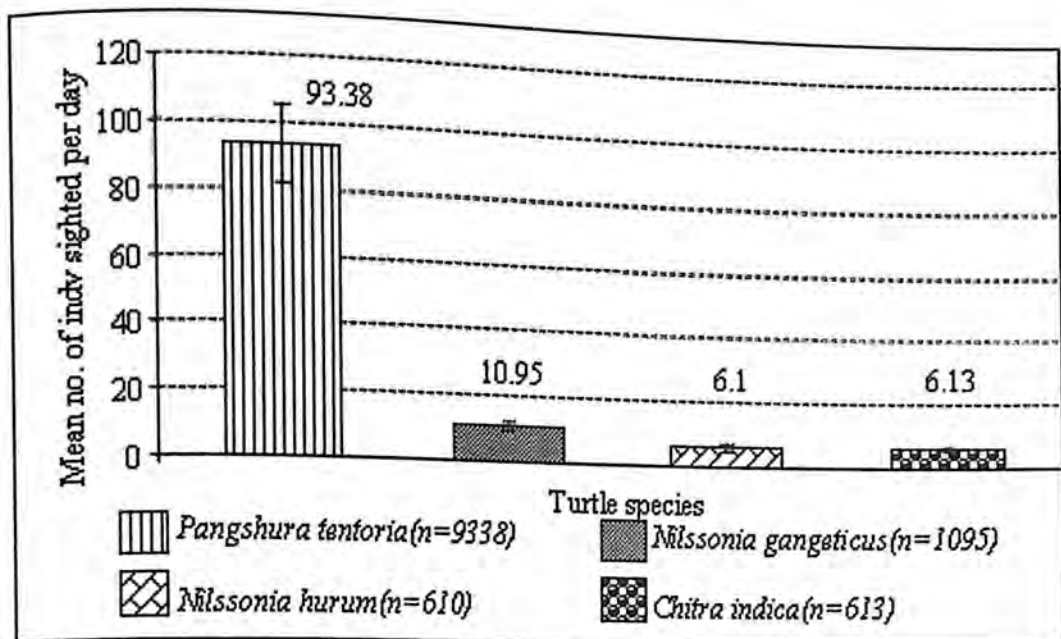


Figure 4.1 Mean number of individual sighted per day.

Among all turtle species, the relative abundance of *Pangshura tentoria* is relatively high with a mean value of 93.38 (SE ± 11.72), then *Nilssonina gangeticus* with a mean value of 10.95 (± 1.267), then *Nilssonina hurum* with a mean value of 6.10 (± 1.200), then *Chitra indica* with a mean value of 6.13 (± 0.658) (Fig 4.1).

4.2.2 Relative abundances in terms of their encounter rate (number of individual per kilometer)

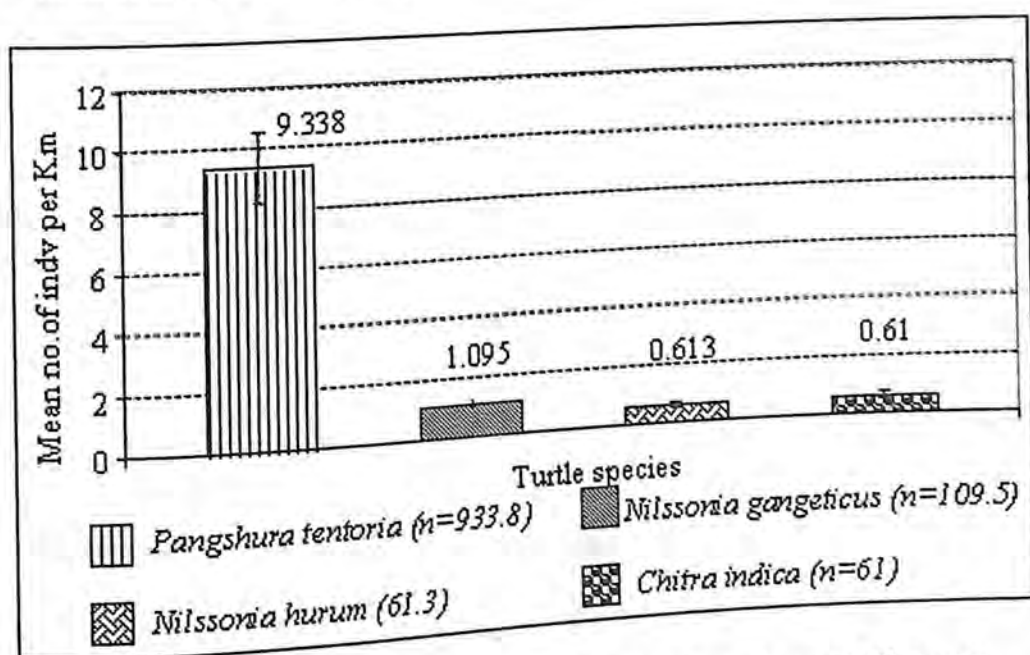


Figure 4.2 Mean number of individual sighted per day per kilometre.

Among all of the turtle species the relative abundance of *Pangshura tentoria* is relatively high with a mean value of 9.338 (± 1.172), then *Nilssonina gangeticus* with a mean value of 1.095 (± 0.1267), then *Nilssonina hurum* with a mean value of 0.610 (± 0.0658), then *Chitra indica* with a mean value of 0.61 (± 0.119).

4.2.3 Species composition along the gradient:

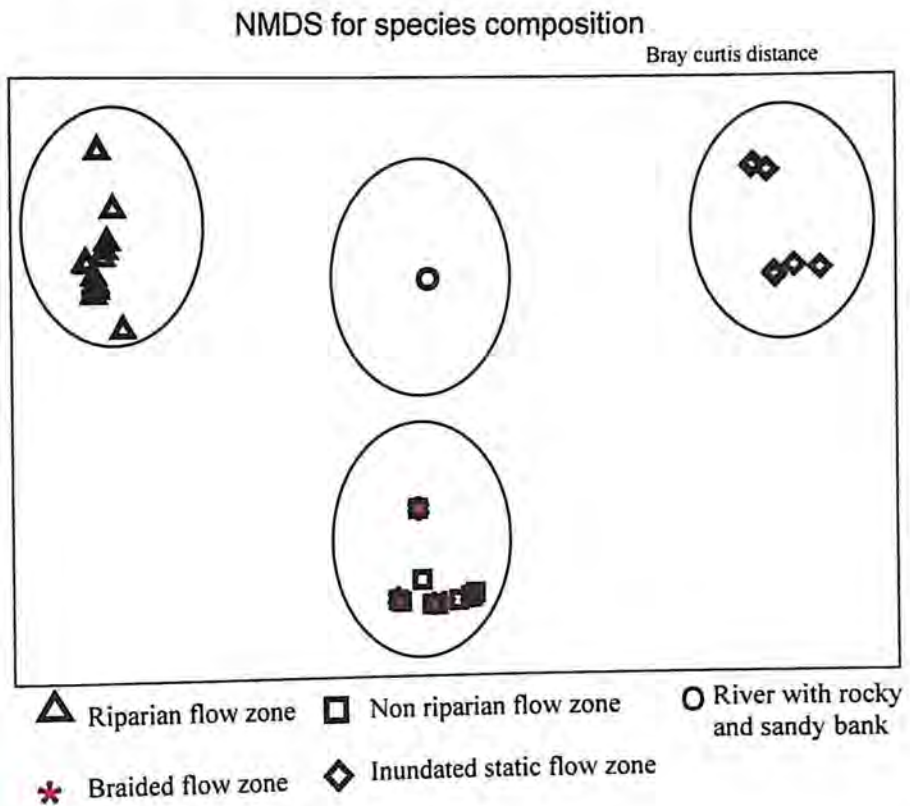


Figure 4.3 NMDS scatter showing differences in sampling zones based on species composition.

NMDS scatter (2D Kruskal Stress =0) shows all the five sampling zones are grouped in four distinct groups in terms of their species composition. All sampling zones forms distinct grouping, but sampling zone 2 and 3 has overlapping. Sampling zones 2 & 3 having similar types of species composition.

Multi-response permutation procedure (MRPP) was significantly different ($\Delta = 1.02^{-156}$, $P > 0.05$) for species composition. Hence species composition is likely to be different.

4.2.4. Relative abundances of turtles across sampling zones:

The turtle abundances of each sampling zone are plotted in order to show how these sampling zones are related with each other in terms of their relative abundances. Non-metric multidimensional scaling (NMDS) has been used to plot them in a scatter. In this analysis the data has been normalized, resealed and Bray curtis distance measure were used for analysis.

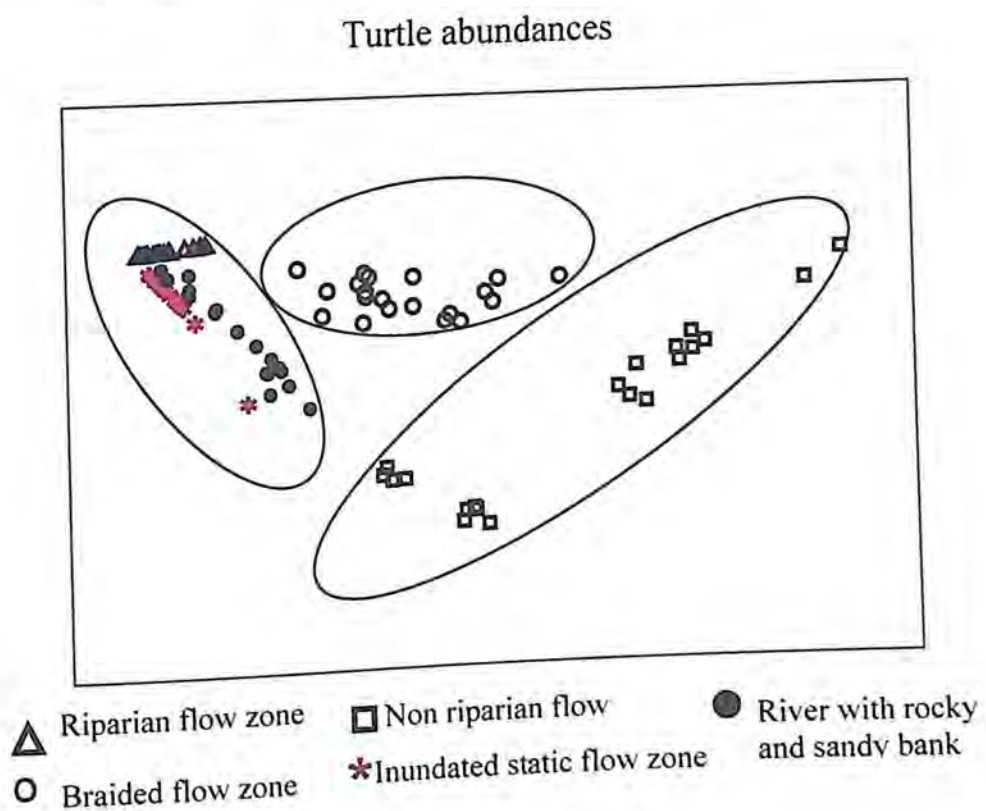


Figure 4.3 NMDS scatter showing differences in sampling zones based on relative abundances

NMDS result shows all the five sampling zones are grouped in three major groups in terms of their abundances. All sampling zones forms distinct grouping, but sampling zone 1, 4 and 5 has overlapping.

For further clarification, the relative abundances have been plotted species wise against different sampling zones. K independent sample tests were done to show the difference in relative abundances of each species along the five sampling zones by using Prog: SPSS 16. (Tab 4.1).

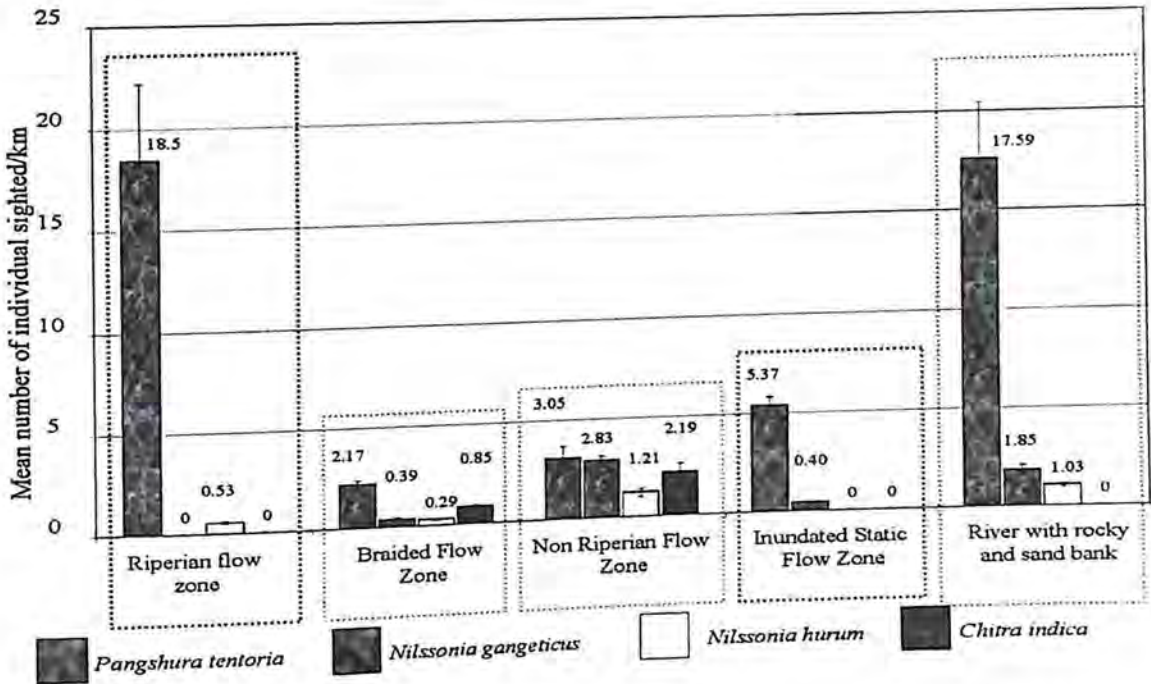


Figure 4.4 Comparison of species richness and relative abundances along the river gradient

In riparian flow zone two species has been recorded, out of which *Pangshura tentoria* has a high mean encounter rate of 18.5 individual/ km (± 3.67) and *Nilssonina hurum* with a mean encounter rate of 0.535 individual/ km (± 0.066). In braided flow zone four out of four species were recorded, *Pangshura tentoria* with mean encounter

rate of 2.175 (± 0.177), *Nilssonina gangeticus* with a mean encounter rate of 0.39 (± 0.042), *Nilssonina hurum* with a mean encounter rate of 0.29 (± 0.026) and *Chitra indica* with a mean encounter rate of 0.855 (± 0.0828). In non riparian flow zone four out of four species were recorded, *Pangshura tentoria* with mean encounter rate of 3.05 (± 0.572), *Nilssonina gangeticus* with a mean encounter rate of 2.83 (± 0.271), *Nilssonina hurum* with a mean encounter rate of 1.21 (± 0.214) and *Chitra indica* with a mean encounter rate of 2.195 (± 0.415).

In inundated static flow zone two species were recorded, *Pangshura tentoria* with mean encounter rate of 5.37 (± 0.419), *Nilssonina gangeticus* with a mean encounter rate of 0.405 (± 0.038).

In the zone of river with rocky and sandy bank three out of four species were recorded, *Pangshura tentoria* with mean encounter rate of 17.59 (± 2.85), *Nilssonina gangeticus* with a mean encounter rate of 1.85 (± 0.195), *Nilssonina hurum* with a mean encounter rate of 1.03 (± 0.0929).

K independent sample tests were done between the sampling zones for relative abundances. The test shows that, the relative abundances of *Pangshura tentoria* vary between sampling zones (Chi square= 85.391, df=4, p=0.0001), *Nilssonina gangeticus* vary between sampling zones (Chi square= 61.543, df=4, p=0.0001), *Nilssonina hurum* vary between sampling zones (Chi square= 91.433, df=4, p=0.0001), *Chitra indica* vary between sampling zones (Chi square= 67.824, df=4, p=0.0001).

To show how each of these relative abundances of different turtle species differs along the gradient of the river stretch on the five sampling zones, K independent sample tests were done separately by using Prog: SPSS 16. (Tab 4.1).

		Pairwise test			
Sampling Zone		N.gangeticus	P.tentoria	C.indica	N.hurum
1 Vs 2	Chi-Square	33.592	26.871	33.538	9.930
	df=1	Asymp. Sig.	.000	.000	.000
1 Vs 3	Chi-Square	33.480	21.808	33.458	2.929
	df=1	Asymp. Sig.	.000	.000	.000
1 Vs 4	Chi-Square	33.632	11.909	.000	33.642
	df=1	Asymp. Sig.	.000	.001	1.000
1 Vs 5	Chi-Square	33.502	.000	.000	14.179
	df=1	Asymp. Sig.	.000	.989	1.000
2 Vs 3	Chi-Square	27.407	.640	2.191	8.697
	df=1	Asymp. Sig.	.000	.424	.139
2 Vs 4	Chi-Square	.128	20.804	33.538	33.737
	df=1	Asymp. Sig.	.721	.000	.000
2 Vs 5	Chi-Square	28.271	27.567	33.538	29.301
	df=1	Asymp. Sig.	.000	.000	.000
3 Vs 4	Chi-Square	27.325	8.312	33.458	33.466
	df=1	Asymp. Sig.	.000	.004	.000
3 Vs 5	Chi-Square	6.346	22.310	33.458	.003
	df=1	Asymp. Sig.	.012	.000	.000
4 Vs 5	Chi-Square	28.593	17.482	.000	33.559
	df=1	Asymp. Sig.	.000	.000	1.000

Table 4.1 Comparison of relative abundances of different turtle species along the gradient

Conclusion:

Null hypothesis rejected. The river stretch is not uniform in terms of the river characters along the five sampling zones.

5. ECOLOGICAL SETTINGS OF DIFFERENT SAMPLING ZONES AND HABITAT USE OF FRESHWATER TURTLES

5.1 Hypothesis

The river stretch is uniform in terms of the river characters along the five sampling zones.

5.2 Method of data analysis

All together totals of 11223 replicates of habitat variables data were collected during the study period. Habitat data includes River width, River depth, Bank width, Nearby land use pattern, River Slope, Bank Slope, Alternate basking substrate, Ground cover, Canopy cover, Turbidity and Water velocity. Habitat variables were selected randomly for the ease of analyzes in multivariate statistical software (PRIMER 6) using non-metric multi dimensional scaling (MNDS). To understand the similarities between the sampling zones with respect to habitats the Analysis of similarity (ANOSIM) using program PRIMER 6. was used. In this analysis the data has been normalized, resembled and 1D Euclidean distance method were used for analysis.

5.3 Results

The NMDS Scatter Plot (Fig 5.1) clearly shows that different sampling zones are grouped and separated by virtue of their river characters. Pair wise differences has also been compared between five sampling zone (SZ) showed the significant differences ($p < 0.001$) between zones. The differences in percentage is mentioned (Tab 5.1) at a significant level of $p = 0.001$.

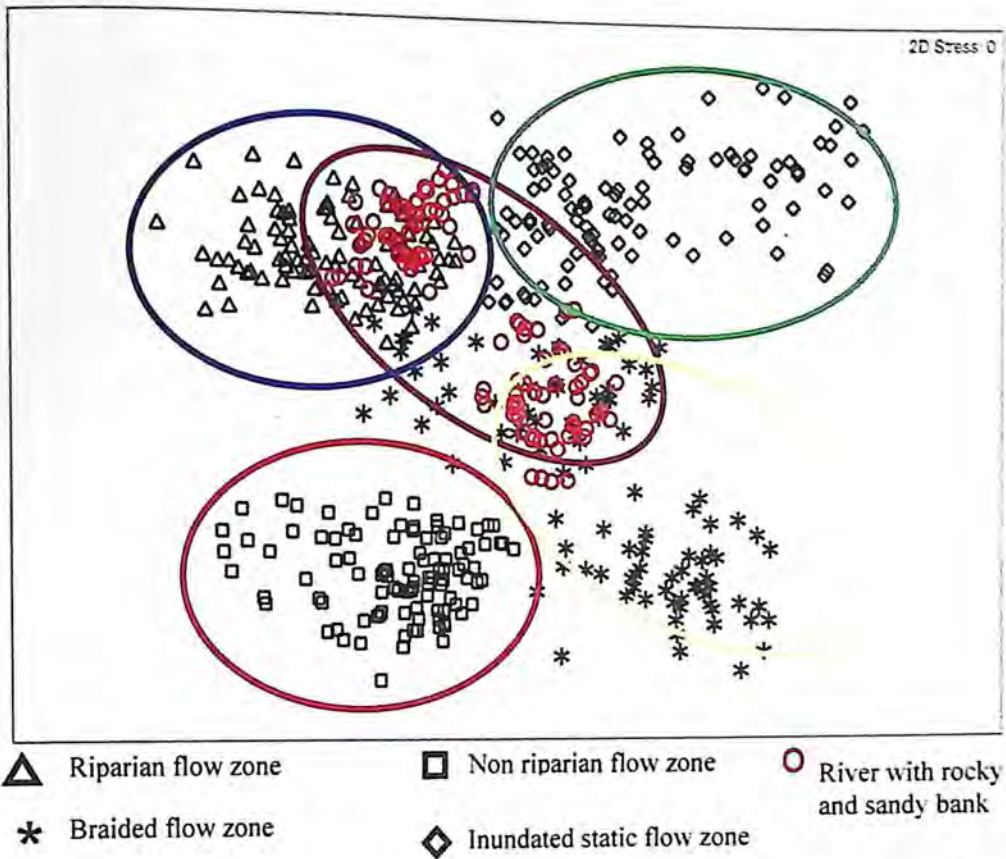


Figure 5.1. Non-metric multi-dimensional scaling ordination for river characteristics of five sampling zones along different gradient of Mahanadi Riverine Ecosystem.

Pair wise Tests		
River characters	R	P
Sampling Zone 1 Vs Sampling zone 2	0.801	0.001
Sampling Zone 1 Vs Sampling zone 3	0.993	0.001
Sampling Zone 1 Vs Sampling zone 4	0.826	0.001
Sampling Zone 1 Vs Sampling zone 5	0.351	0.001
Sampling Zone 2 Vs Sampling zone 3	0.706	0.001
Sampling Zone 2 Vs Sampling zone 4	0.683	0.001
Sampling Zone 2 Vs Sampling zone 5	0.37	0.001
Sampling Zone 3 Vs Sampling zone 4	0.984	0.001
Sampling Zone 3 Vs Sampling zone 5	0.852	0.001
Sampling Zone 4 Vs Sampling zone 5	0.472	0.001

Table 5.1. Analysis of similarity (ANOSIM) for river characteristics between five different sampling zones along different gradient of Mahanadi Riverine Ecosystem.

The river characteristics between Sampling Zone 1 and Sampling zone 2, Sampling Zone 1 and Sampling zone 3, Sampling Zone 1 and Sampling zone 4, Sampling Zone 3 and Sampling zone 4, Sampling Zone 3 and Sampling zone 5 differ from each other by R values of 0.801, 0.993, 0.826, 0.984, 0.852 respectively, Sampling Zone 2 and Sampling zone Sampling Zone 2 and Sampling zone differs from each other by R value of 3, 0.7064, 0.683 respectively, Sampling Zone 1 and Sampling zone 5, Sampling Zone 2 and Sampling zone 5, Sampling Zone 4 and Sampling zone 5 differs from each other by R value of 0.351, 0.37, 0.472 respectively.

To show how each of these habitat variables differ along the gradient of the river stretch on the five sampling zones, K independent sample tests were done by using Prog: SPSS 16.

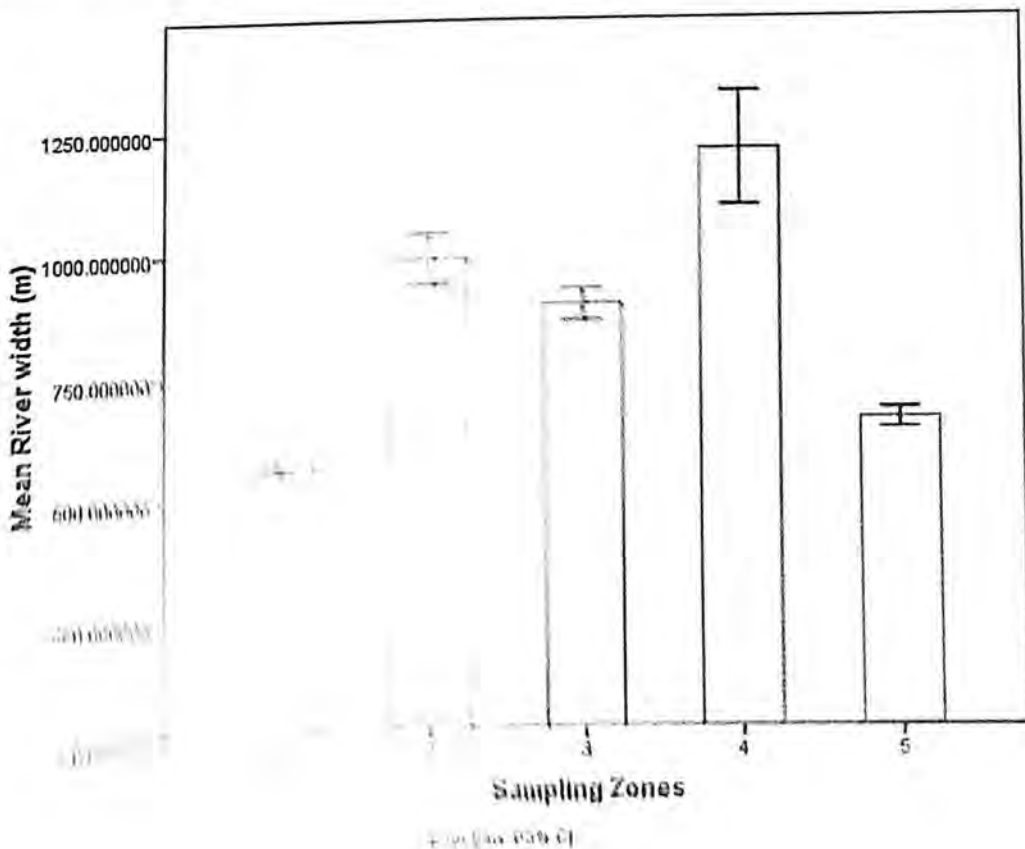


Figure 7 Differences in river width along the sampling zones

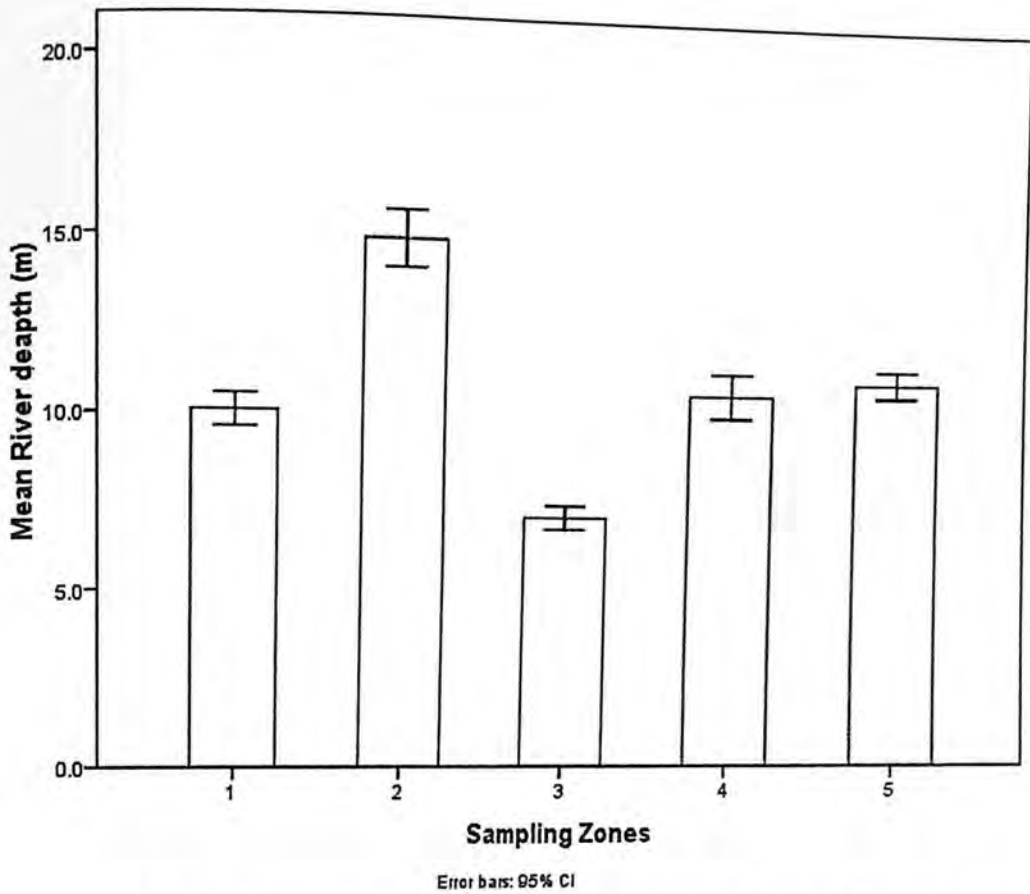


Figure 5.3 Differences in river depth along the sampling zones

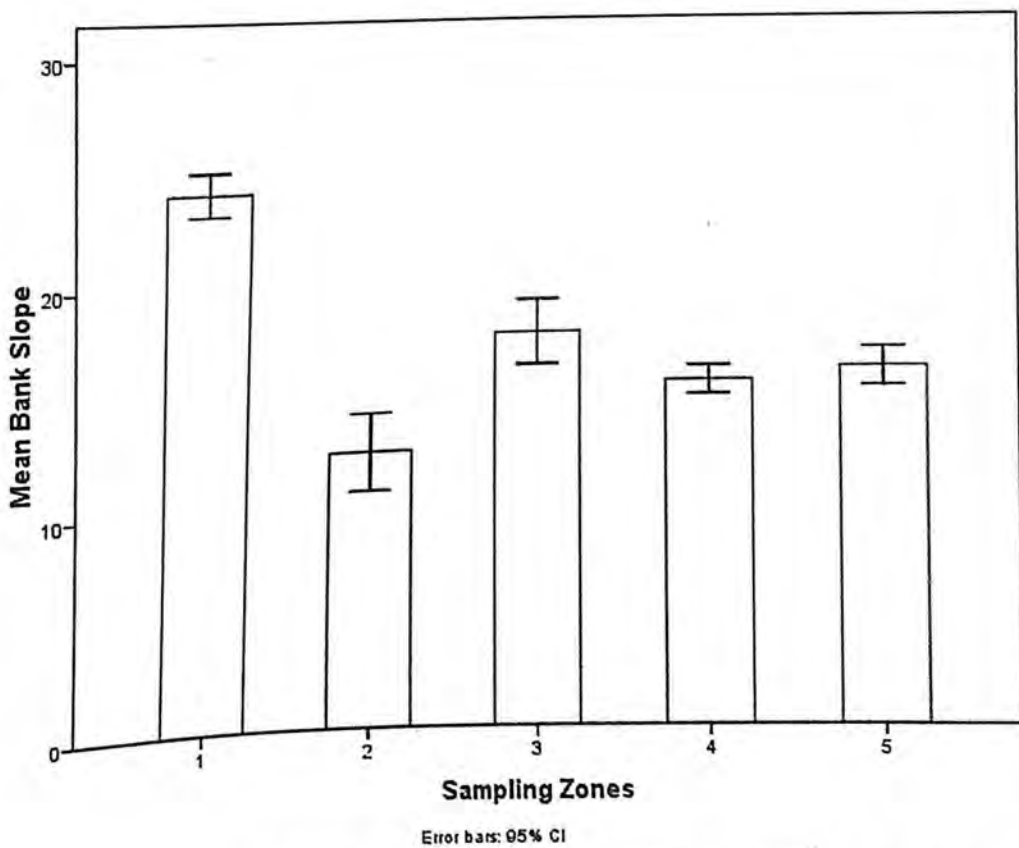


Figure 5.4 Differences in bank slope along the sampling zones

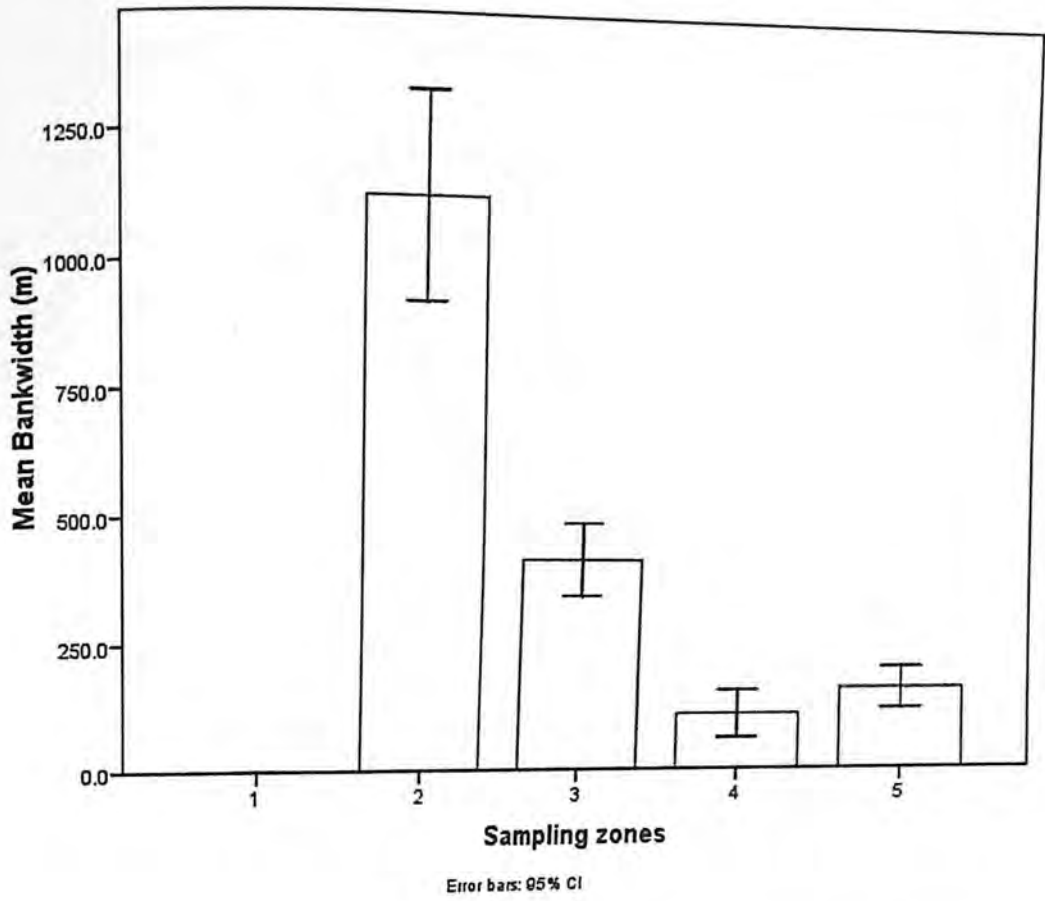


Figure 5.5 Differences in bank width depth along the sampling zones

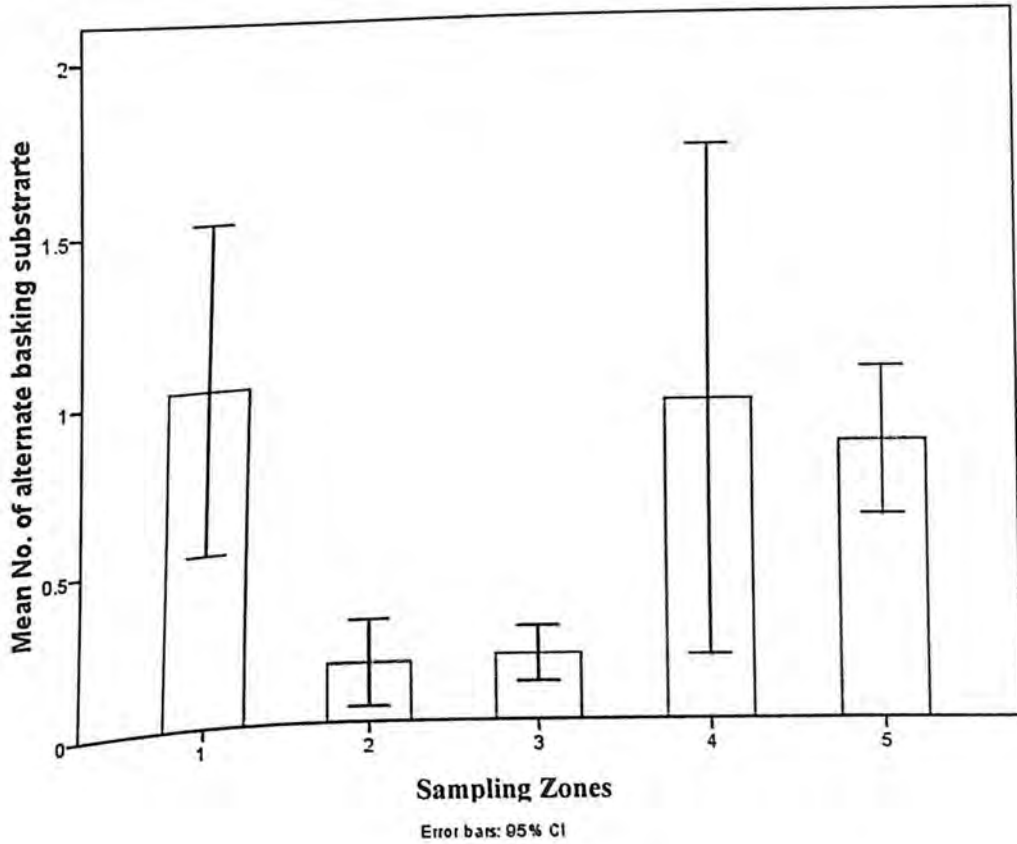


Figure 5.6 Differences in number of alternate basking sites along the sampling zones

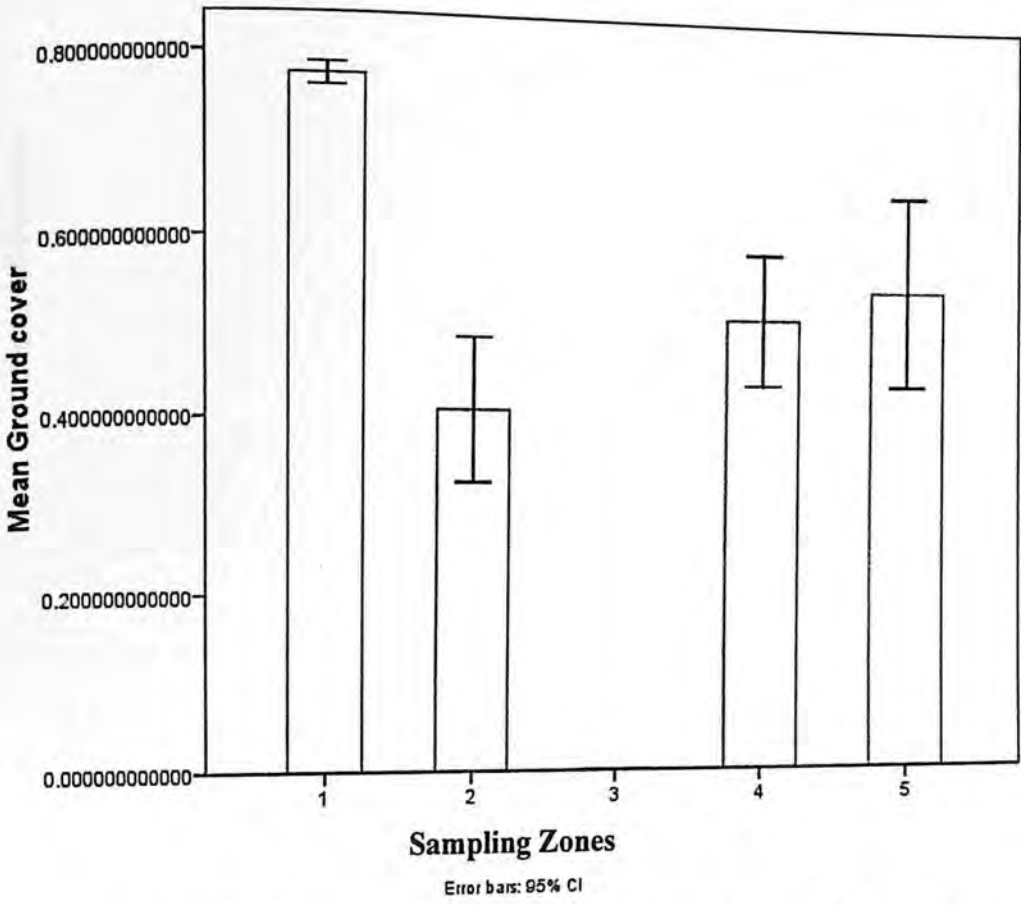


Figure 5.7 Differences in ground cover along the sampling zones

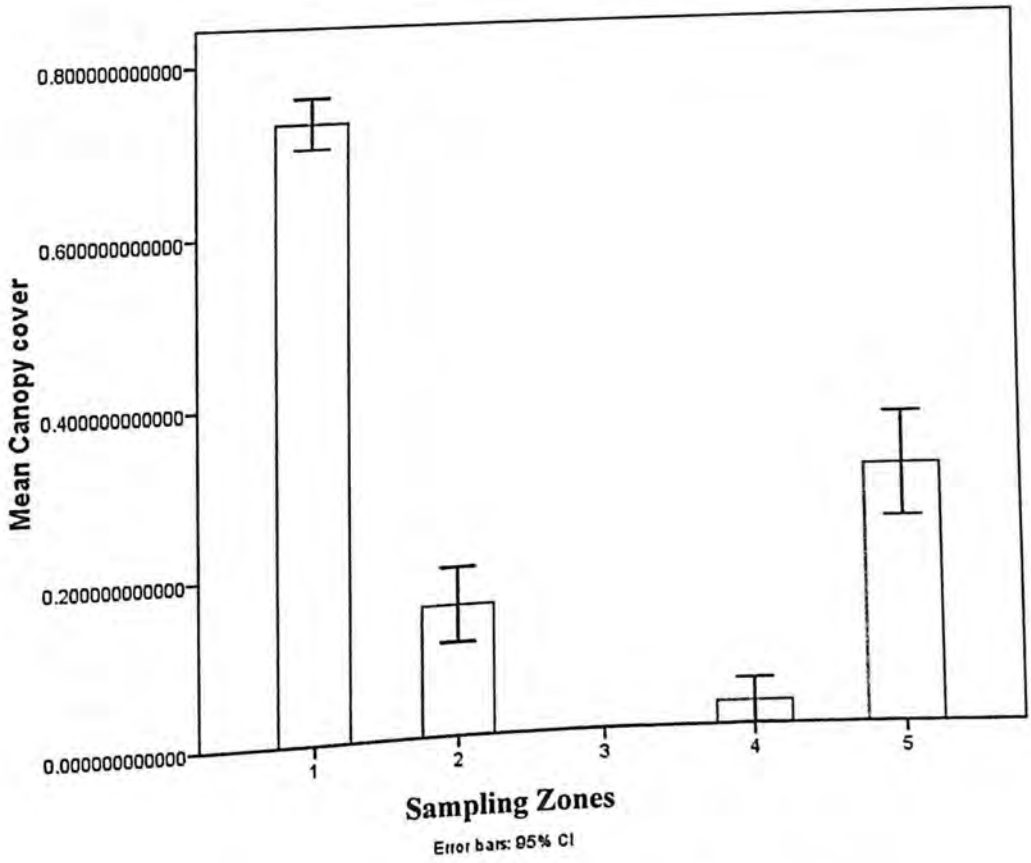


Figure 5.8 Differences in canopy cover along the sampling zones

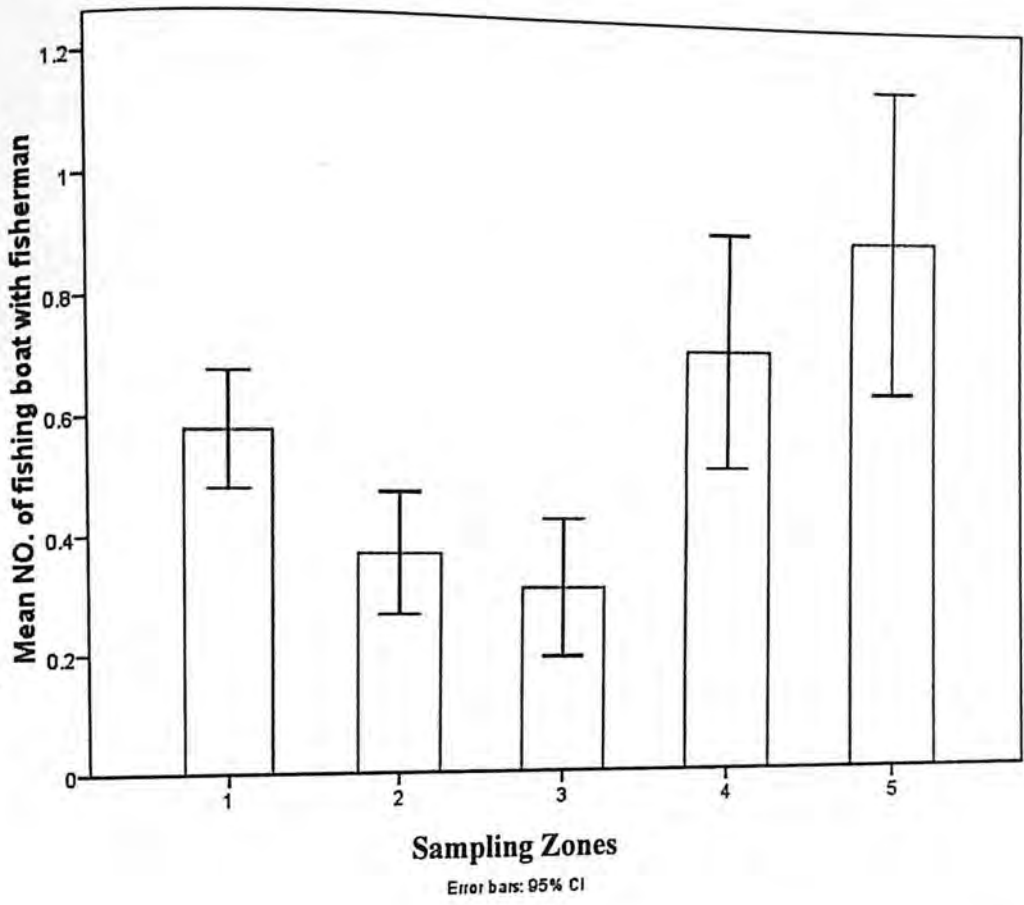


Figure 5.9 Differences in number of fishing boat along the sampling zones

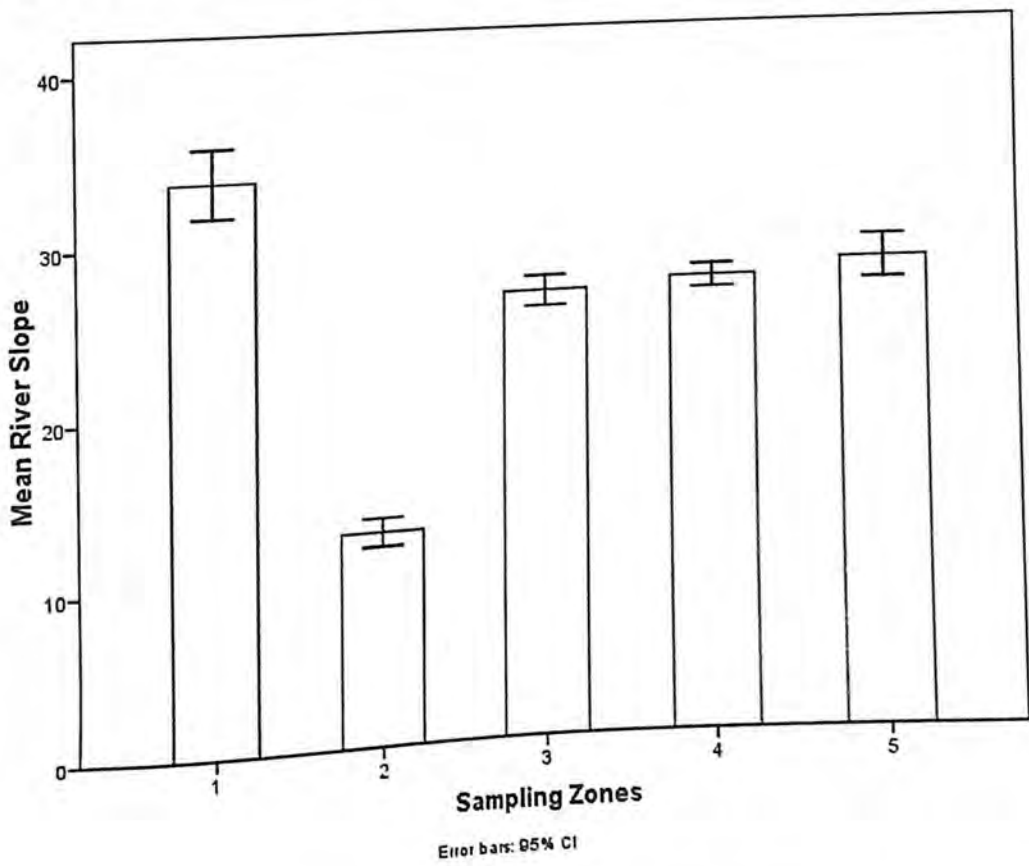


Figure 5.10 Differences in river slope along the sampling zones

River width (Fig 5.2) vary along the sampling zones (Chi sq= 265.909, df= 4, p=0.001). River depth (Fig 5.3) vary along the sampling zones (Chi sq= 216.637, df= 4, p=0.001). Bank width (Fig 5.5) vary along the sampling zones (Chi sq= 214.990, df= 4, p=0.001). River slope (Fig 5.10) vary along the sampling zones (Chi sq= 248.353, df= 4, p=0.001). Bank slope (Fig 5.4) vary along the sampling zones (Chi sq= 178.259, df= 4, p=0.001). Number of alternate basking substrate (Fig 5.6) vary along the sampling zones (Chi sq= 41.933, df= 4, p=0.001). Ground cover (Fig 5.7) vary along the sampling zones (Chi sq= 149.120, df= 4, p=0.001). Canopy cover (Fig 5.8) vary along the sampling zones (Chi sq= 328.520, df= 4, p=0.001). Water velocity vary along the sampling zones (Chi sq= 462.979, df= 4, p=0.001).

To show how each of these habitat variables differs along the gradient of the river stretch on the five sampling zones, K independent sample tests were done separately by using Prog: SPSS 16. (Tab 5.2).

PAIRWISE TEST

Sampling Zones		RW	RD	BW	NLUP	RSI	BSI	RS	BS	ALT BSK	GC	CC	T	WVEL	NO.FM
1,2	Chi sq	84.795	72.928	143.496	203.0001	145.722	73.057	86.499	121.017	15.799	17.815	146.272	102.597	122.784	9.276
	Asymp.Sig	.0001	.0001	.0001	.0001	.0001	.0001	.0001	.0001	.0001	.0001	.0001	.0001	.0001	.002
1,3	Chi sq	138.762	65.040	91.537	203.0001	24.368	65.658	47.223	160.669	10.308	174.091	174.024	105.977	165.001	17.677
	Asymp.Sig	.0001	.0001	.0001	.0001	.0001	.0001	.0001	.0001	.001	.0001	.0001	.0001	.0001	.0001
1,4	Chi sq	147.159	.951	56.276	184.545	18.551	126.697	166.792	158.930	.447	21.704	159.644	96.887	160.157	.344
	Asymp.Sig	.0001	.329	.0001	.0001	.0001	.0001	.0001	.0001	.504	.0001	.0001	.0001	.0001	.557
1,5	Chi sq	47.910	9.898	37.591	178.653	10.958	97.316	25.102	157.791	.702	.0001	.0001	.079	23.127	.088
	Asymp.Sig	.0001	.002	.0001	.0001	.001	.0001	.0001	.0001	.402	1.0001	.0001	.779	.0001	.767
2,3	Chi sq	16.840	131.757	18.638	.0001	143.812	48.015	15.159	109.249	1.295	65.844	40.157	.314	162.713	1.863
	Asymp.Sig	.0001	.0001	.0001	1.0001	.0001	.0001	.0001	.0001	.255	.0001	.0001	.575	.0001	.172
2,4	Chi sq	.073	50.639	86.619	30.786	152.565	34.087	45.534	92.826	16.450	1.055	26.525	162.631	158.001	2.823
	Asymp.Sig	.787	.0001	.0001	.0001	.0001	.0001	.0001	.0001	.0001	.304	.0001	.0001	.0001	.093
2,5	Chi sq	62.695	56.085	60.949	64.915	123.310	32.024	31.536	126.322	29.746	10.877	15.368	100.263	157.178	3.738
	Asymp.Sig	.0001	.0001	.0001	.0001	.0001	.0001	.0001	.0001	.0001	.001	.0001	.0001	.0001	.053
3,4	Chi sq	3.476	61.795	25.107	30.786	.303	.734	92.441	.579	9.220	96.165	4.060	162.431	158.285	7.398
	Asymp.Sig	.062	.0001	.0001	.0001	.582	.391	.0001	.447	.002	.0001	.044	.0001	.0001	.007
3,5	Chi sq	89.938	107.971	25.381	64.915	9.168	.454	4.180	10.226	21.661	65.852	65.841	103.766	157.460	9.013
	Asymp.Sig	.0001	.0001	.0001	.0001	.002	.500	.041	.001	.0001	.0001	.0001	.0001	.0001	.003
4,5	Chi sq	106.670	2.001	.314	4.780	7.972	1.582	114.912	2.344	3.821	4.539	51.517	98.702	153.042	.331
	Asymp.Sig	.0001	.157	.576	.029	.005	.208	.0001	.126	.051	.033	.0001	.0001	.0001	.565

Table 5.2 Pair wise comparison of river character with in sampling zones.

Conclusion:

Null hypothesis rejected. The river stretch is not uniform in terms of the river characters along the five sampling zones.

6. SPECIES HABITAT RELATIONSHIP

6.1 Hypothesis

Occurrence of the species is random, irrespective of any habitat attributes.

6.2. Methods of data analysis

Of the 11223 replicates of habitat variables and 2300 turtles were presence data, 100 sets of DRPs (Data Recording Points) where turtles present and 100 sets of DRPs where turtles were absent were randomly selected for analysis to test this hypothesis. This has been done for the ease of analysis in multivariate statistical software (PRIMER 6.1). Habitat data includes:- River width, River depth, Bank width, Nearby land use pattern, River Slope, Bank Slope, No. of alternate basking substrate, Ground cover, Canopy cover, Turbidity and Water velocity.

The data has been grouped in two different groups' i.e. Turtle presence data in one group and absent in another and analyzed for obtaining the ordination scatter. Non-metric multi dimensional scaling has been used for this (MNDS) using program (PRIMER 6.1) and for the similarities between the sampling zones using Analysis of similarity (ANOSIM) by using program PRIMER 6. In this analysis the data has been normalized, resembled and 1D Euclidean distance method were used for analysis.

6.3. Results

NMDS scatter plot (Fig 6.1) showed a distinct clumping of use and unused sites. The dotted green ellipse showed the availability of resources and the blue continuous

ellipse showed use of resources in terms of their presence in those sites. Distinct clumping of sites where the species are present and the sites where the species are absent reflects the specific habitat use by the turtle species. ANOSIM result also showed a significant difference of 75 % ($R=0.756$) between the sites where the turtles are present and the sites where they are absent ($P=0.001$).

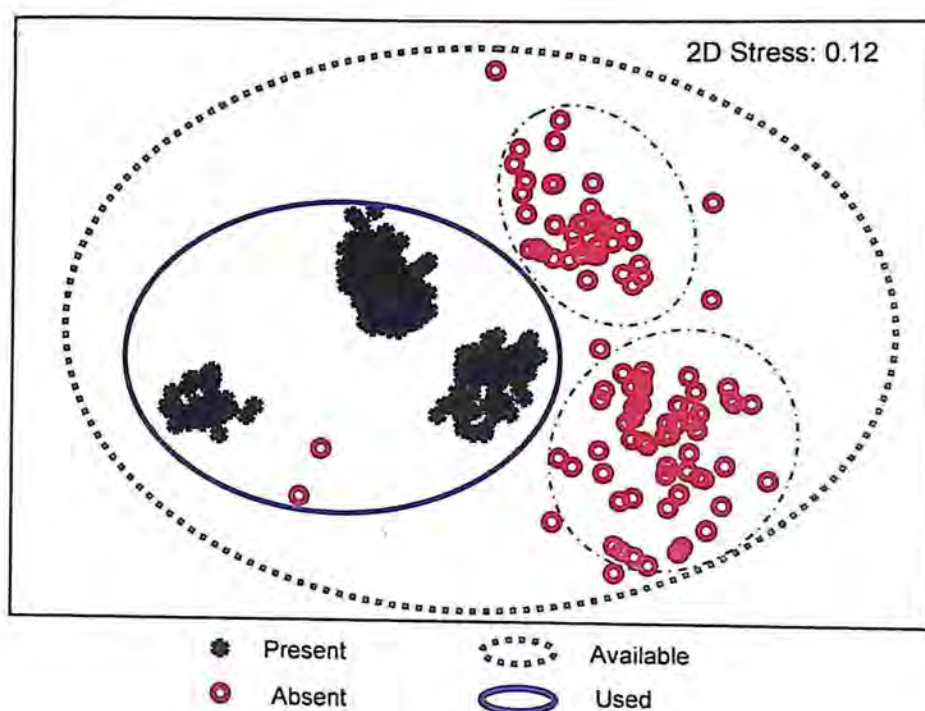


Figure 6.1 NMDS scatter showing use and availability of resources in terms of basking habitat

To explore whether there was any differential habitat use by different turtle species with respect to sampling zones and habitat, the sites which were occupied by different turtles species have been grouped with respect to their corresponding species. So that the data set has four groups now against each turtle species and analyzed for obtaining the ordination scatter. Non-metric multi dimensional scaling has been used for this (MNDS) using program (PRIMER 6.1) and for the similarities between the

sampling zones using Analysis of similarity (ANOSIM) by using program PRIMER 6. In this analysis the data has been normalized, resembled and 1D Euclidean distance method were also used for analysis.

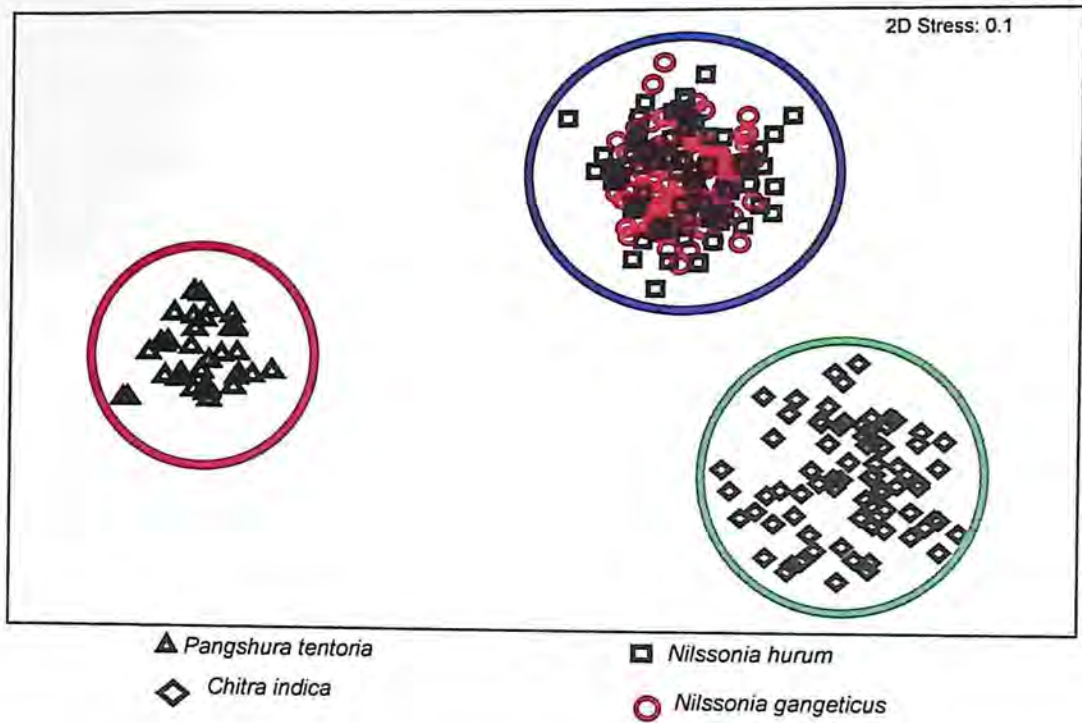


Figure 6.2 NMDS scatter showing habitat use by different turtle species

NMDS scatter (Fig 6.2) showed a distinct clumping of sites used by different turtle species, however there was an overlap between the sites which were occupied by *Nilssonina gangeticus* and *Nilssonina hurum* but other two species had a distinct clumping. This reflects that there was differential habitat use by different turtle species in the study area. ANOSIM result shows differences in the site properties that have been occupied by different turtle species.

Pair wise Tests		
Turtle species	R	P
Pangshura tentoria Vs Nilssonia gangeticus	1	0.001
Pangshura tentoria Vs Nilssonia hurum	1	0.001
Pangshura tentoria Vs Chitra indica	1	0.001
Nilssonia gangeticus Vs Nilssonia hurum	0.005	0.210
Nilssonia gangeticus Chitra indica	0.981	0.001
Nilssonia hurum Vs Chitra indica	0.976	0.001

Those sites were used for Canonical Corresponding Analysis (CCA) and the axis values were plotted for 95% CI home Kernel (Fig 6.2) range by using ARC View 3.2. The home kernel range graph shows the overlaps in habitat use between Nilssonia gangeticus and N. hurum and distinctly difference habitat use by Chitra indica and Pangshura tentoria with a definite scale value that have been extracted form the axis value.

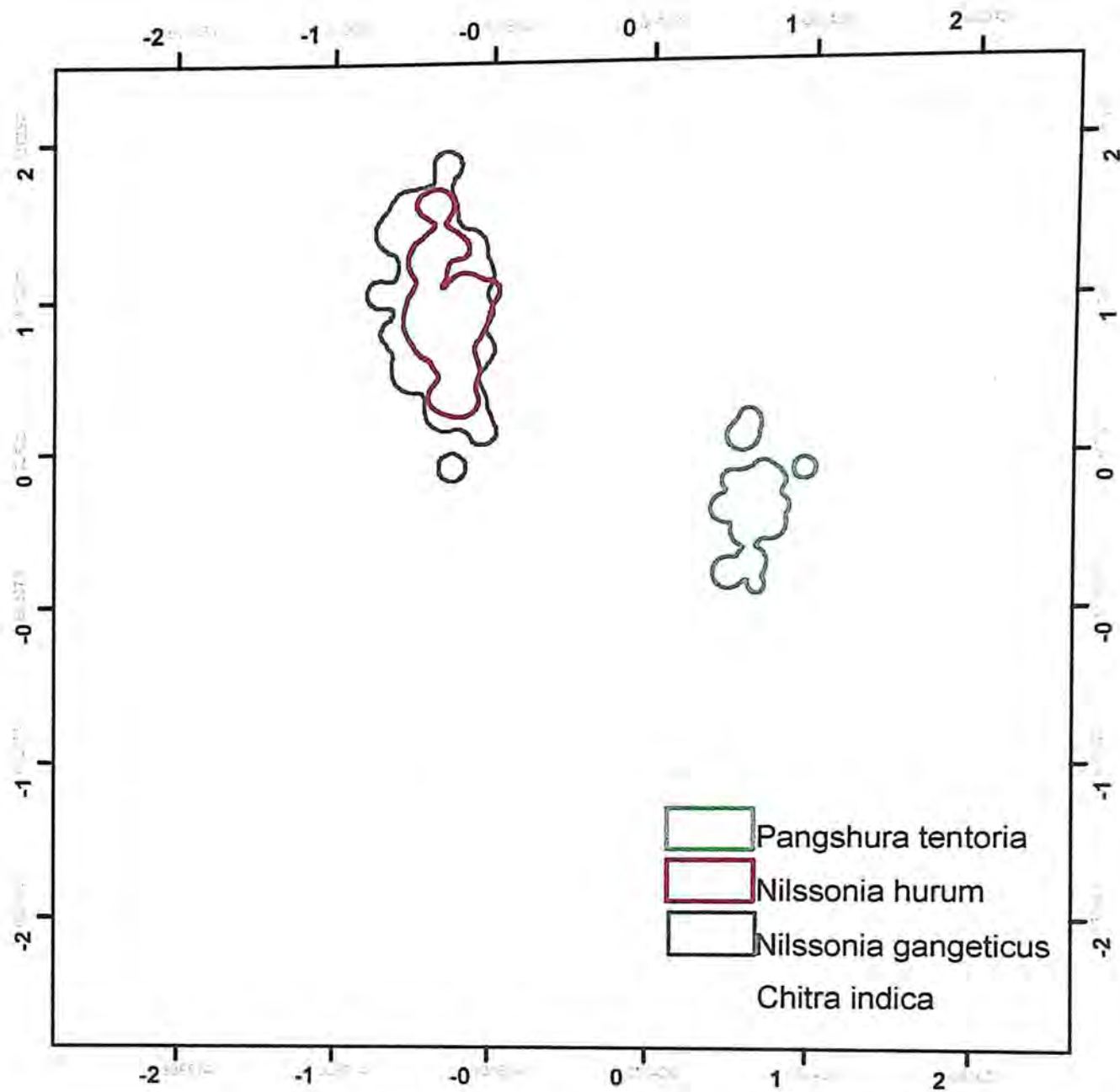


Figure 6.2 Home kernel range of different turtle species at 95% CI

6.3.1 Species habitat relationship:

The presence of four species of turtles were correlated with 11 habitat variables with the help of Canonical Correspondence Analysis (Fig 7.1) using the software PCOrd 4. Nine out of eleven variables, namely, distance from water, bank width, river depth, river width, ground cover, river slope, bank slope, alternate basking site, aquatic vegetation and immediate water depth, used were found to be significant in defining

the habitat of each of the four species. The species-environment correlation for Axis 1 and Axis 2 were 0.995 and 0.969 respectively. Monte Carlo test for significance was found to be 0.01 which was highly significant.

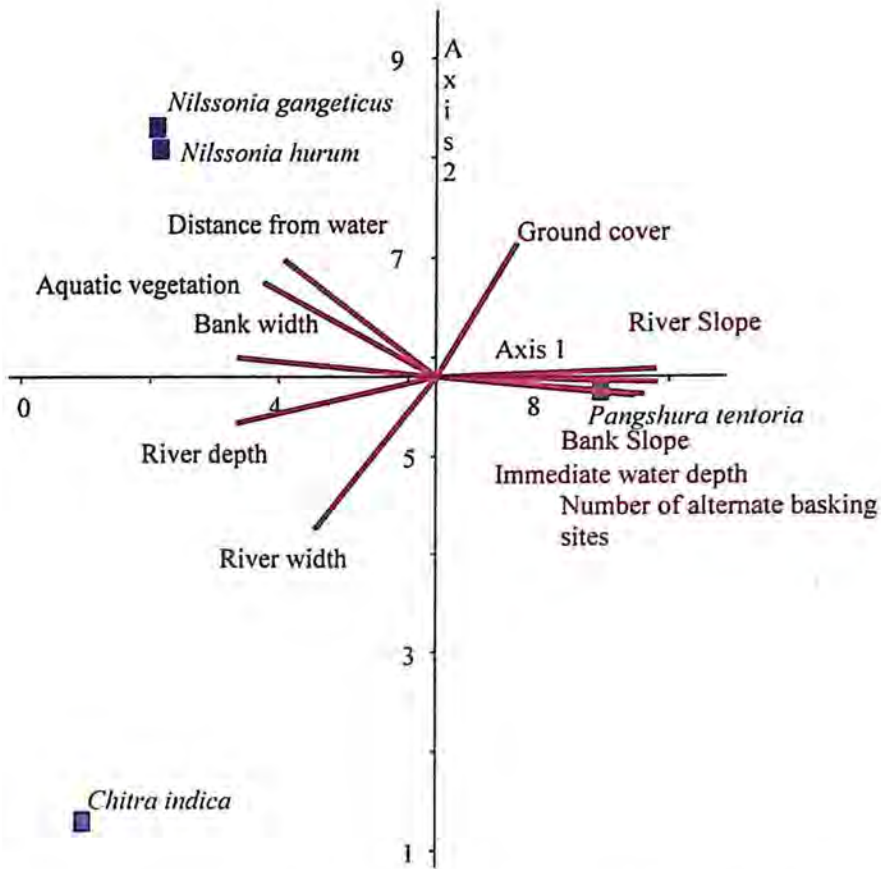


Fig. 6.3 Canonical correspondence analysis plot showing species habitat relationship

Nilssonia gangeticus and *Nilssonia hurum* prefers area which is at greater distance from the river, has greater river bank width, more aquatic vegetation and lower immediate water depth. On the other hands they also prefer an area where both river slope and lesser bank slope is lesser in comparison to other two species. Over all, these two species share a similar kind of habitat but the bank width and distance from river is more for *N. gangeticus* in comparison to *N. hurum*.

Chitra indica prefers an area where both river depth and river width and aquatic vegetation are higher whereas bank slope, river slope, ground cover, alternative basking substrate and immediate water depth is lower.

Pangshura tentoria prefers an area with greater river and bank slope along with greater availability of alternative basking substrate and greater immediate water depth. On the other hand they also prefer habitat more close to the river with lower bank width and moderate river depth and moderate river width.

The mean value of each variable preferred by the species has been provided below

INTER-SET CORRELATIONS for 11 Var

Correlations			
Variable	Axis 1	Axis 2	Axis 3
1 Distance	-0.685	0.606	0.022
2 Basking	0.918	-0.087	0.005
3 River Sl	0.970	0.043	0.003
4 Bank Slo	0.980	-0.022	0.003
5 Immediat	0.877	-0.097	-0.023
6 River wi	-0.547	-0.791	0.006
7 River de	-0.901	-0.238	-0.007
8 Bankwid	-0.900	0.104	-0.003
9 Ground c	0.356	0.691	-0.010
10 No. of a	0.069	-0.011	-0.064
11 Water ve	-0.108	0.042	-0.118

MONTE CARLO TEST RESULTS -- SPECIES-ENVIRONMENT
CORRELATIONS

Randomized data

Real data Monte Carlo test, 99 runs

Axis	Spp-Envr	Corr.	Mean	Minimum	Maximum	p
1	0.995	0.280	0.169	0.382	0.0100	
2	0.969	0.151	0.090	0.208	0.0100	
3	0.172	0.099	0.051	0.182	0.0200	

p = proportion of randomized runs with species-environment correlation greater than or equal to the observed species-environment correlation; i.e.,

$$p = (1 + \text{no. permutations} \geq \text{observed}) / (1 + \text{no. permutations})$$

6.4 Broad habitat preferences of freshwater turtles in the Mahanadi River

6.4.1 Analysis:

To explore the broad habitat was preferred by the species, 300 occupied sites for each species were selected randomly. Then mean values for each variable were calculated along with the standard errors. Mean and standard error were used to develop a range with upper limit and lower limit. This is the range of each habitat variable is specific for each species with in which they often found. The ranges of each habitat variable that has been preferred by the each species were listed in table 6.1.

6.5.2. Results:

Of the 300 randomly selected occupied sites, *Nilssonia gangeticus* and *Nilssonia hurum* were moved far away from the shore for basking, but other two species were basked close to the water. Normally all the species preferred the bank, which had flat or very gentle slope for basking, however, *Pangshura tentoria* also used slightly deep slope banks.

Pangshura tentoria was the only species that approached the sand bank from the deeper water but all other species approached the shore from the shallow water portions of the river for basking. More number of sightings of *Chitra indica* were recorded where the river width was more when compared to other three species and it revealed that *Chitra indica* used the river where the width of the river was large. *Chitra indica* also preferred the deeper water portion of the river along with *N. gangeticus* and *N. hurum*. Like wise for other character has been described bellow in graphs (6.4 to 6.12)

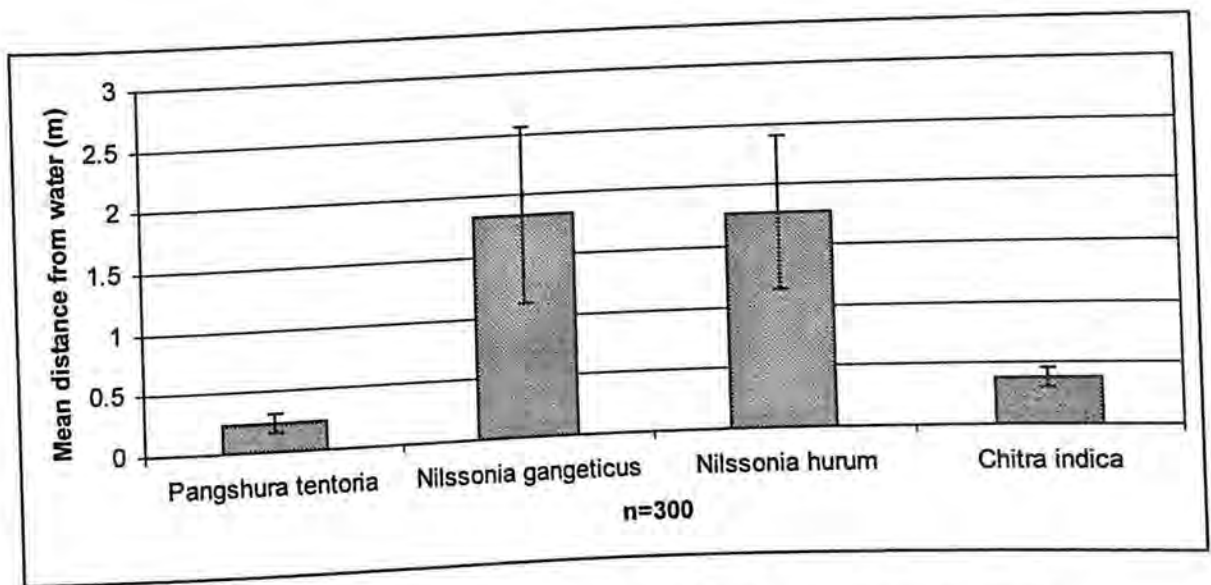


Fig. 6.4 Distance form water preferred by different turtle species

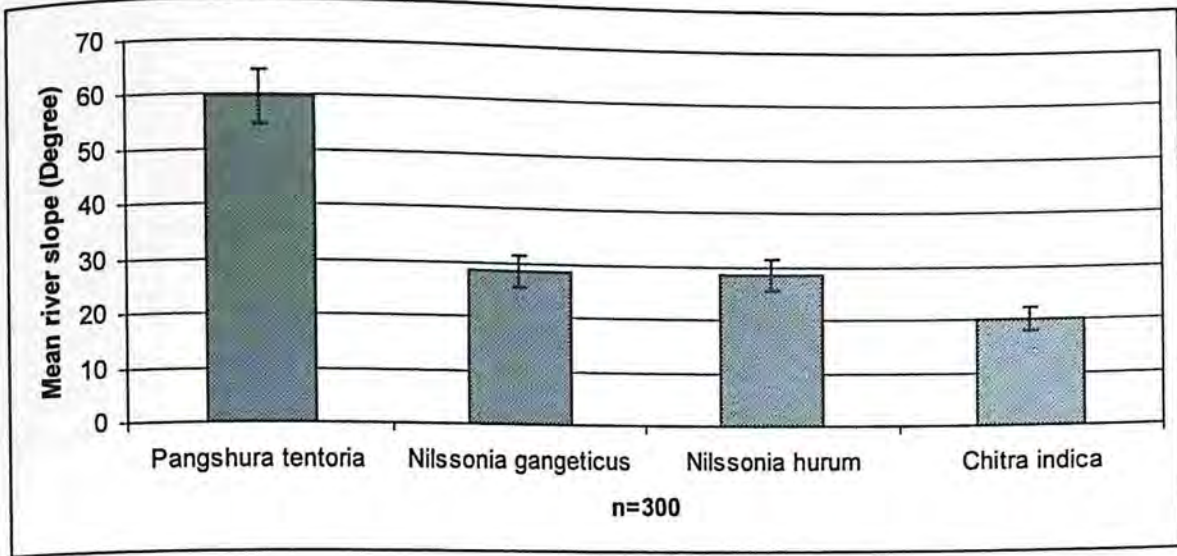


Fig. 6.5 Mean river slope preferred by different turtle species

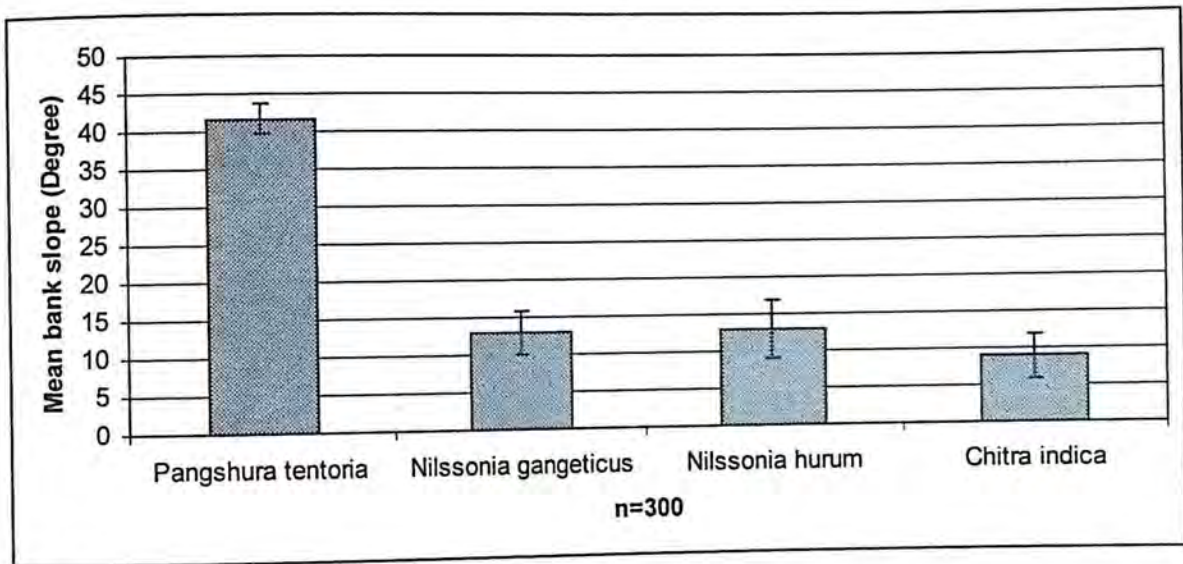


Fig. 6.6 Bank slope preferred by different turtle species

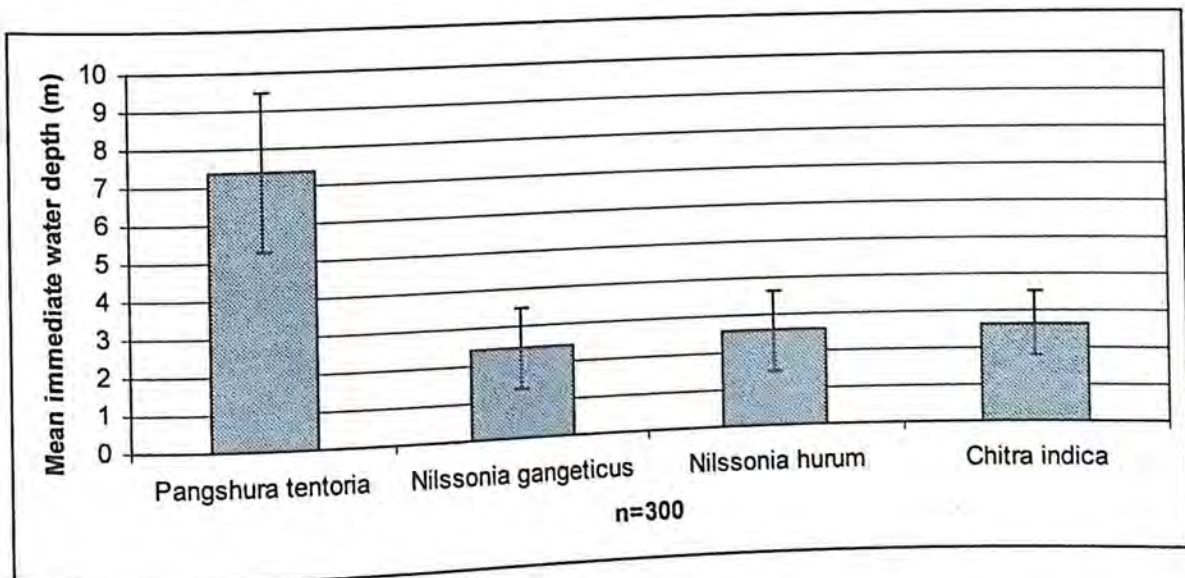


Fig. 6.7 Immediate water depth preferred by different turtle species

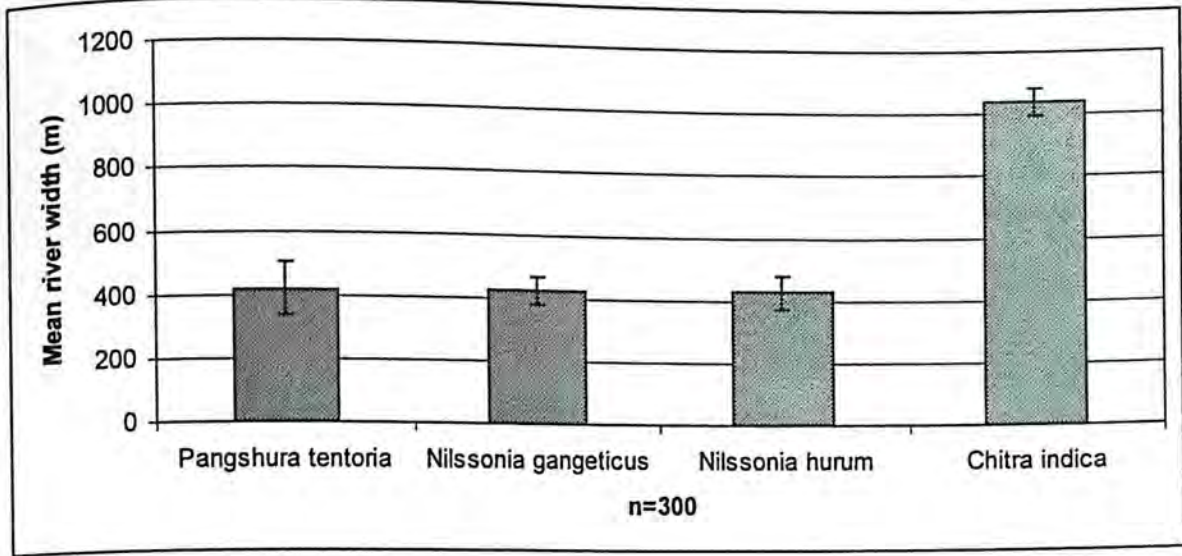


Fig. 6.8 River width preferred by different turtle species

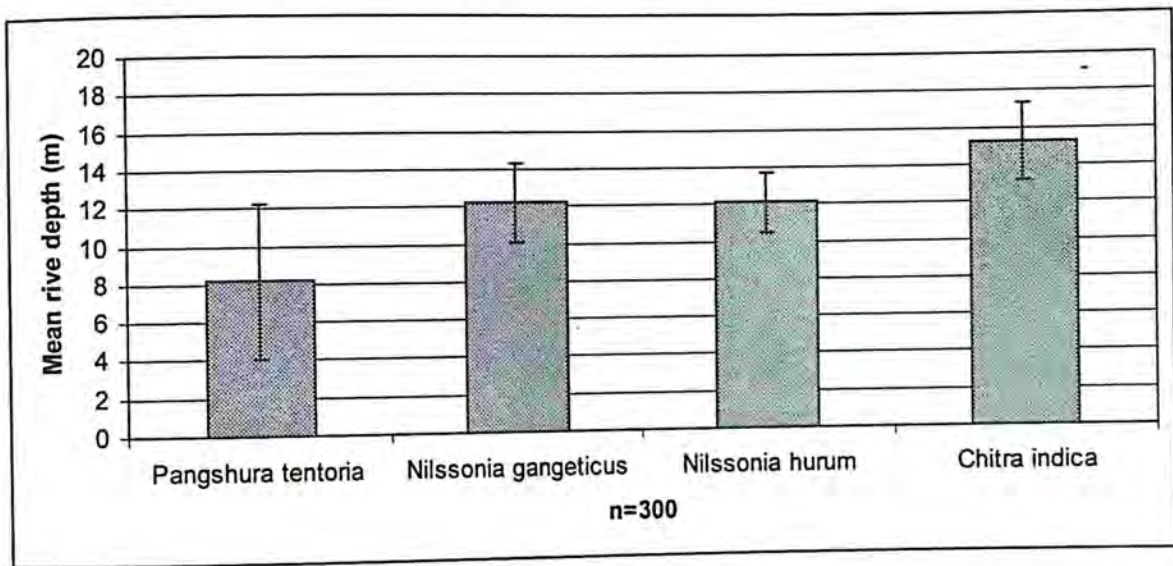


Fig. 6.9 River depth preferred by different turtle species

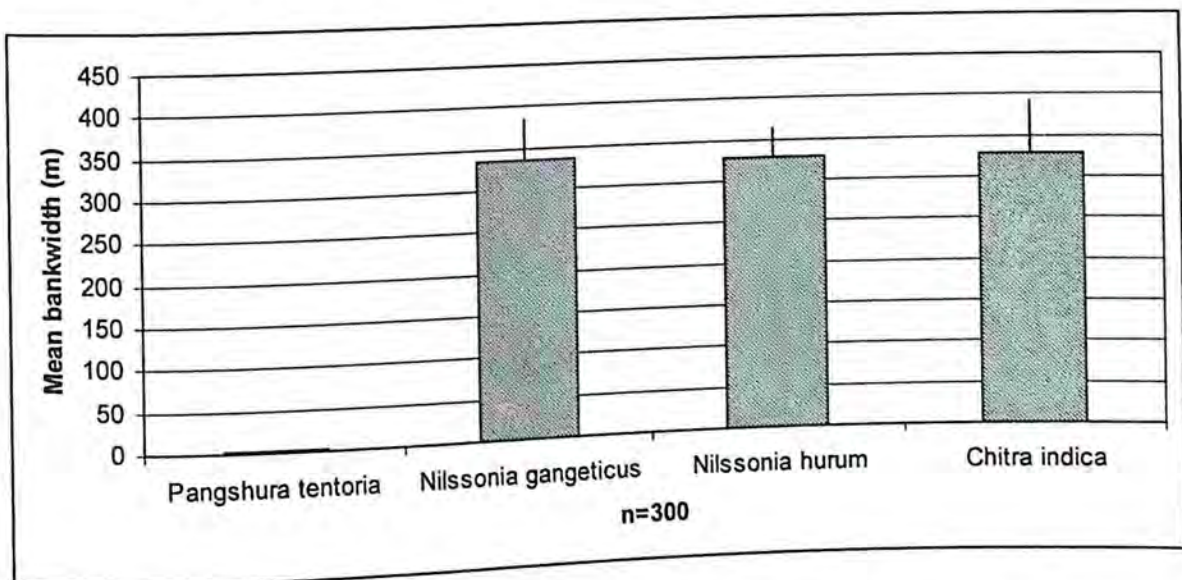


Fig. 6.10 Bank width preferred by different turtle species

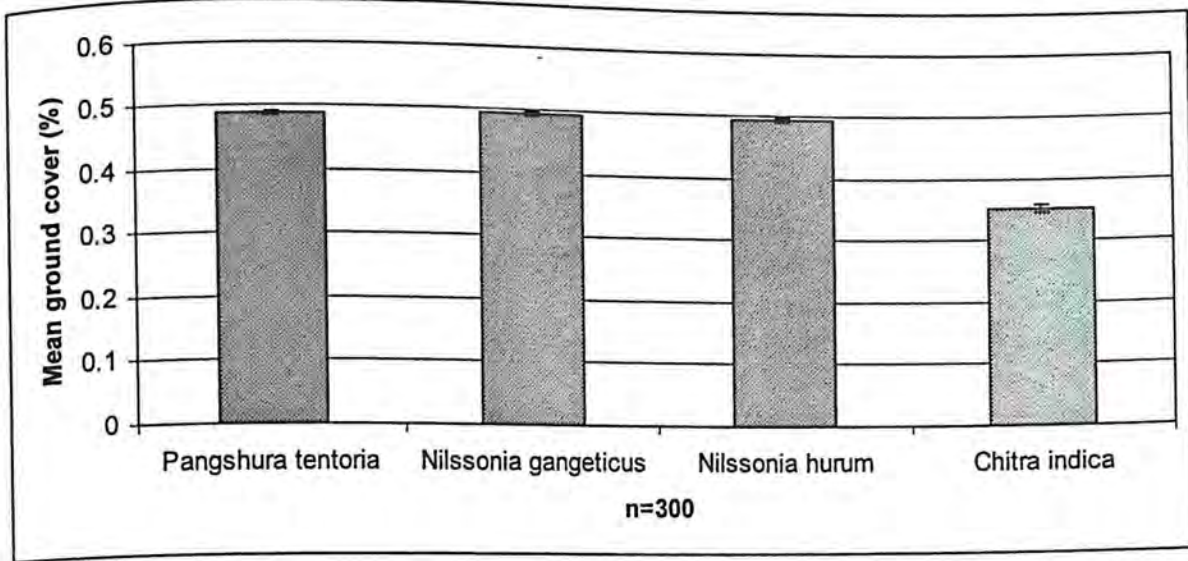


Fig. 6.11 Ground cover preferred by different turtle species

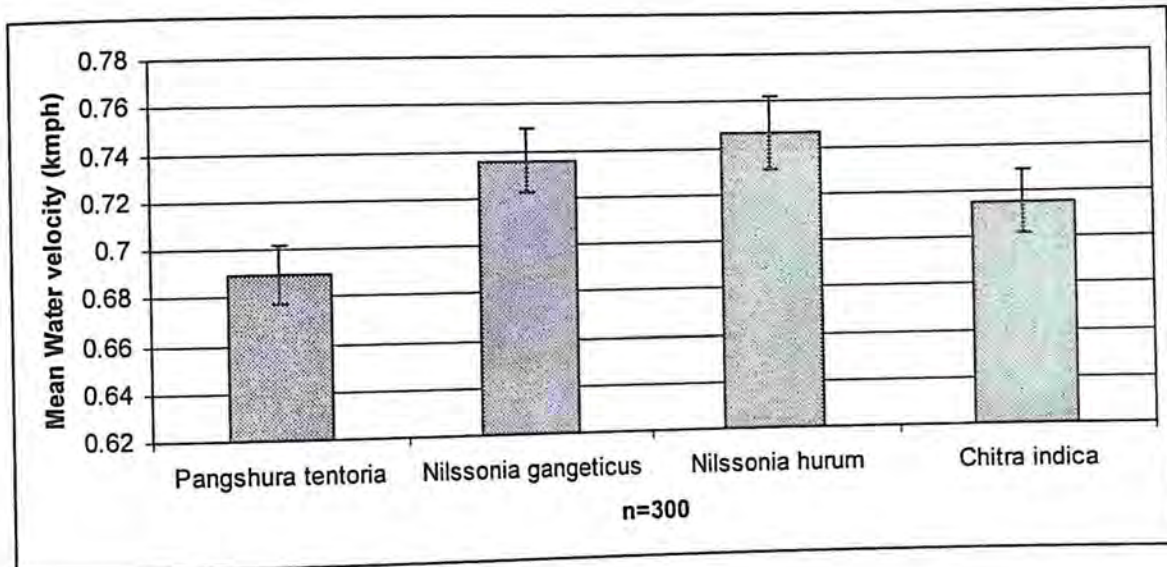


Fig. 6.12 Water velocity preferred by different turtle species

			Range	
	Mean	Standard error	From	To
Distance from water (m)				
<i>Pangshura tentoria</i>	0.231683168	0.080807523	0.15	0.31
<i>Nilssonina gangeticus</i>	1.827215901	0.727353785	1.10	2.55
<i>Nilssonina hurum</i>	1.768887208	0.637961432	1.13	2.41
<i>Chitra indica</i>	0.374257426	0.078131489	0.30	0.45
River slope (Degree)				
<i>Pangshura tentoria</i>	59.65346535	4.990122435	54.66	64.64
<i>Nilssonina gangeticus</i>	28.56435644	2.875223021	25.69	31.44
<i>Nilssonina hurum</i>	28.3960396	2.923326076	25.47	31.32
<i>Chitra indica</i>	20.07920792	2.131768751	17.95	22.21
Bank slope(Degree)				
<i>Pangshura tentoria</i>	41.69306931	1.885001869	39.81	43.58
<i>Nilssonina gangeticus</i>	12.78217822	2.885361312	9.90	15.67
<i>Nilssonina hurum</i>	12.83168317	3.992495937	8.84	16.82
<i>Chitra indica</i>	8.851485149	2.934279927	5.92	11.79
Immediate water depth (m)				
<i>Pangshura tentoria</i>	7.368316832	2.130079417	5.24	9.50
<i>Nilssonina gangeticus</i>	2.414851485	1.083302932	1.33	3.50
<i>Nilssonina hurum</i>	2.554455446	1.090461137	1.46	3.64
<i>Chitra indica</i>	2.651485149	0.885429768	1.77	3.54
River width (m)				
<i>Pangshura tentoria</i>	418.4930693	84.67882523	333.81	503.17
<i>Nilssonina gangeticus</i>	421.6415842	45.46830458	376.17	467.11
<i>Nilssonina hurum</i>	426.9554455	52.24197897	374.71	479.20
<i>Chitra indica</i>	1036.012871	43.90713295	992.11	1079.92
River depth (m)				
<i>Pangshura tentoria</i>	8.159405941	4.101212239	4.06	12.26
<i>Nilssonina gangeticus</i>	12.18217822	2.113829785	10.07	14.30
<i>Nilssonina hurum</i>	12.0970297	1.615110411	10.48	13.71
<i>Chitra indica</i>	15.21683168	2.091554986	13.13	17.31

			Range	
	Mean	Standard error	From	To
Bank width (m)				
<i>Pangshura tentoria</i>	1.815841584	0.112819252	1.70	1.93
<i>Nilssonia gangeticus</i>	336.1326733	48.60637856	287.53	384.74
<i>Nilssonia hurum</i>	327.9168317	36.48320139	291.43	364.40
<i>Chitra indica</i>	328.7445545	63.59416279	265.15	392.34
Ground cover (%)				
<i>Pangshura tentoria</i>	0.48795833	0.002586094	0.49	0.49
<i>Nilssonia gangeticus</i>	0.494818345	0.002573432	0.49	0.50
<i>Nilssonia hurum</i>	0.495471912	0.002720709	0.49	0.50
<i>Chitra indica</i>	0.352286839	0.007158043	0.35	0.36
Water velocity(kmph)				
<i>Pangshura tentoria</i>	0.689218922	0.012451549	0.68	0.70
<i>Nilssonia gangeticus</i>	0.735819582	0.013888208	0.72	0.75
<i>Nilssonia hurum</i>	0.746424642	0.015668025	0.73	0.76
<i>Chitra indica</i>	0.715071507	0.013734864	0.70	0.73

Table 6.1 Habitat preference range of different turtle species

Conclusion

Null hypothesis rejected. Occurrence of the species is not random, they are characteristically differing. Different turtle species use characteristically different sites.

7. IMPACT OF HABITAT GRADIENT AND OTHER THREATS ON THE DISTRIBUTION OF TURTLES IN THE MAHANADHI RIVER

7.1 Hypothesis

River stretch associated with intensive degree of likelihood threats is expected to have low species diversity and low relative abundance.

7.2 Methods of data analysis

Score was given to each threat which occurred near to each sampling zone. Recorded threats were plotted against turtle abundance of respective sampling zones.

7.3 Results

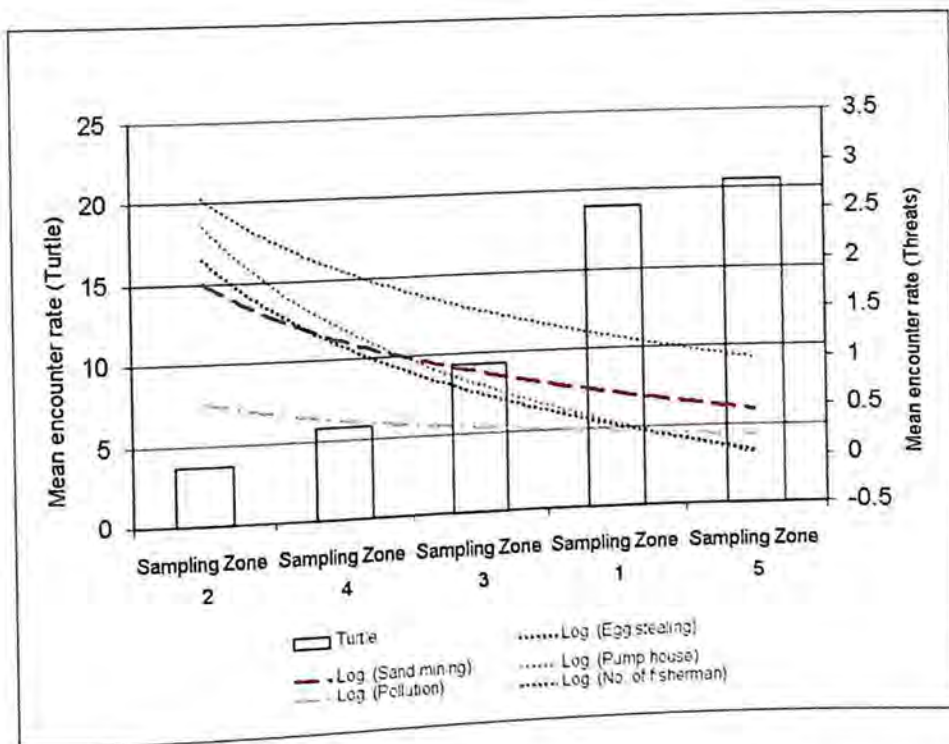


Fig. 7.1 Comparison between turtle abundances and threat categories

Threats	<i>P.tentoria</i>	<i>N.gangeticus</i>	<i>C.indica</i>	<i>N.hurum</i>
Egg collection	0.769118	-0.45604	-0.4192	0.041633
Fishing	0.40632	-0.7423	-0.84039	-0.75012
Pollution	-0.4979	-0.32864	0.142624	-0.35819
Pump house	0.309742	-0.6489	-0.76039	-0.55012
Sand mining	0.12440	-0.55451	-0.64972	-0.51957

Table 7.1 Correlation matrix between Turtle species and threats ($p > 0.001$)

The figure suggests that where threat prevails, turtle abundance were low. Prevailing threats along the Mahanadhi River were influence the abundance of turtles during the study period but different threat categories clearly showed a negative correlation with turtle abundance (Fig 7.1.). Threats such as Fishing ($R^2 = 0.4161$), presence of pump houses ($R^2 = 0.7624$), sand mining ($R^2 = 0.8297$), pollution ($R^2 = 0.0542$) and egg collection activities were negatively impacted the abundances ($R^2 = 0.6062$) of freshwater turtles in the Mahanadi river. Sand mining along the banks, pump houses and nest predation were the major threats which highly determined the turtle abundance in the Mahanadi River.

To investigate the consistency of these threats along the five sampling zones, different threat categories that has been recorded has clumped zone wise and the cumulative threats score were calculated. The mean encounter rate of these threats was then transformed by ranking them, into relative intensity to show how the intensity of these threats differs along the sampling points.

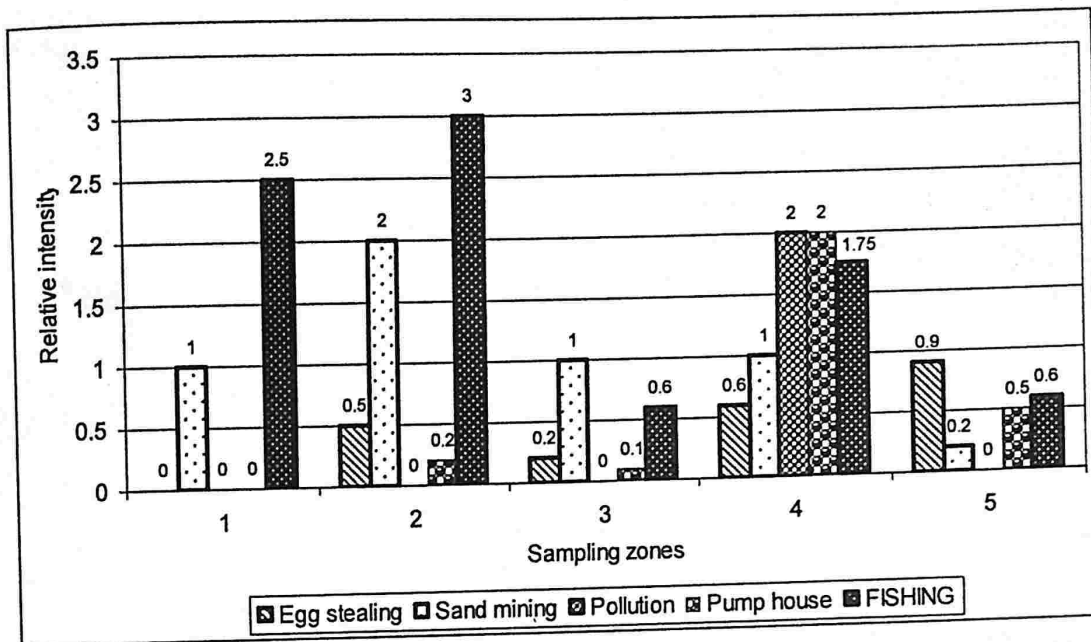


Figure 7.2 Different threats along the sampling zones.

Some of the threats were found to be consistent over the sampling zones and some were not. Egg stealing was found to occur in sampling zone 2, 3, 4 and 5 with a relative intensity of 0.5, 0.2, 0.6 and 0.9 respectively. Egg stealing was very less in the sampling zone 1, which is very close to the Wildlife Sanctuary. Sand mining has been recorded all over the five sampling zones with relative intensity of 1, 2, 1, 1 and 0.2 respectively. There were no records of pollution all over the sampling zones except sampling zone 2 with a relative intensity of 2. Presence of pump house has been recorded in sampling zones 2, 3, 4, 5 with relative intensity of 0.2, 0.1, 2, and 0.5 respectively. Fishing being a major threat has been recorded all over all sampling zones, with relative intensity of 2.5, 3, 0, 6, 1.75, and 0.6 respectively.

Conclusion:

Null hypothesis accepted. River stretch associated with intensive degree of likelihood threats has low species diversity and low relative abundance.

8.1 Species richness & relative abundance

Although, seven species of turtles have been recorded in the Mahanadi River (Choudhury *et al.* 1992, Bhupathy and Menon, 2003), this study could record only five species of freshwater turtles between Satkosia Gorge Wildlife Sanctuary and Cuttack Barrage during November 2008 to April 2009. Of the five species, four were softshell turtles (*Nilssonia gangeticus*, *Nilssonia hurum*, *Chitra indica*, *Lissemys punctata*) and one was hardshell (*Pangshura tentoria*). (* Due to no sighting of *Lissemys punctata* during the sampling session it has not been used in analysis) Two species namely *Pangshura tecta* and *Nilssonia leithii* were not sighted during study period which might due to various reasons for example, the sampled area may not be a habitat of these species, study period might be too short to record these two species or study area might be too small to detect these species or due to anthropogenic pressures, these two species may have disappeared from this region.

Relative abundance in term of mean number of individuals per kilometre, *Pangshura tentoria* was found to be higher and this species has been recorded in all sampling zones, followed by *Nilssonia gangeticus* which was recorded in only four sampling zones. *Nilssonia hurum* and *Chitra indica* were not common when compared to other two species. These two species were sighted rarely in the study area and their abundance was also low. Relative abundance of *Chitra indica* and *Nilssonia hurum* was found to be almost similar, but *Chitra indica* has been recorded from two sampling zones ie braided flow zone and non riparian flow zone where as *Nilssonia*

hurum has been recorded from four sampling zones. Low abundance of *Chitra indica* and *Nilssonia hurum* might be due to degradation of their habitats. These two species always preferred undisturbed but widened river stretch which is becoming very rare in the Mahanadi River.

8.2 Habitat use of freshwater turtles in the Mahanadi river

a. Heterogeneity in the habitat of the study area

Habitat attributes govern the occurrences of turtle species, greater heterogeneity in habitat can support higher species richness (Froese and Burghardt, 1975; Major, 1975; Ernst *et al.*, 1994). The river character of the five selected sampling zones were profiled and analyzed to understand the variation in river profile along the five sampling zones. They were found to differ significantly from each other. They differed from each other by forming four major clumps when they were clustered. All of the sampling zones were having unique river characters and accordingly unique species composition. The major habitat variable which differentiated these five sampling zones were river flow, river width and river bank characteristics.

b. Variations in the abundance of the turtles in relation with habitat.

Since the habitat attributes governs the occurrences of turtle species and greater heterogeneity in habitat can support higher species richness (Froese and Burghardt 1975; Major 1975; Ernst *et al.*, 1994), more number of species were found in the sampling zones 3 & 4, where the habitat heterogeneity was high when compared to other sampling zones. It has also been observed that there is a distinct variation in species composition between the sampling zones. The relative abundances also vary between sampling zones with respect to their habitat heterogeneity. Sampling zones

that had least anthropogenic pressure, good sandbanks and higher habitat heterogeneity had higher species richness with higher relative abundances.

c. **Basking habitat use of different species**

Turtles are very specific in terms of their habitat use (Shively and Jackson, 1985). This study also cleared exhibits that there was a selection in habitat use by the turtles. The choice of the basking habitat varied between species. *Nilssonina gangeticus* and *Nilssonina hurum* highly used area are at a greater distance from the water and had greater river bank width and lower immediate water depth. They have also preferred an area where both river slope and lesser bank slope was lesser in comparison to other two species. Over all, these two species shared almost a similar kind of habitat but the bank width and distance from river is more for *N. gangeticus* in comparison to *N. hurum*. *Chitra indica* preferred an area where both river depth and river width were higher whereas bank slope, river slope, ground cover, alternative basking substrate and immediate water depth was lower. *Pangshura tentoria* preferred an area with greater river and bank slope along with greater availability of alternate basking substrate and greater immediate water depth. On the other hand they also preferred the habitat more close to the river with lower bank width and moderate river depth and moderate river width.

8.3 Impact of landsuse patterns and other threats on the distribution of turtles in the Mahanadhi river

Major threats to turtles in the Mahanadi river (sampling zones) are due to anthropogenic pressure and habitat degradation. Some of the threats were found to be consistent over the sampling zones and some were not. Egg stealing was found in

sampling zone 2, 3, 4 and 5 (Braided flow zone, Nonriperian flow zone, Inundated static flow zone and river stretch with rocky and sand bank) with a relative intensity of 0.5, 0.2, 0.6 and 0.9 respectively. Egg stealing was very less in the sampling zone 1 (Riperian flow zone), which is very close to the Wildlife Sanctuary. Sand mining has been recorded all over the five sampling zones with relative intensity of 1, 2, 1, 1 and 0.2 respectively. There were no records of pollution all over the sampling zones except sampling zone 2 (Braided flow zone) with a relative intensity of 2. Presence of pump house has been recorded in sampling zones 2, 3, 4, 5 with relative intensity of 0.2, 0.1, 2, and 0.5 respectively. Fishing being a major threat has been recorded all over all sampling zones, with relative intensity of 2.5, 3, 0, 6, 1.75, and 0.6 respectively. Some species have tolerance to these threats categorise but some are not. The study shows *Pangshura tentoria* is somehow tolerant to all these threats prevailing in the Mahanadi River but *Nilssonia hurum* and *Chitra indica* appears to be highly affected by these threats all along the river. This study found that there was a negative correlation between the turtle abundance and presence of threats such as sand mining, pump house, fishing and pollution. Sand mining adversely affected the basking habitat of most of the turtle species. Pump houses were largely avoided by the turtles perhaps due to vibration or noise created by these stations. Some amount of fishing was also observed in the Mahanadi river especially sampling zone 2 (Braided flow zone) and 4 (Inundated static flow zone), which were close to fishing community villages.

9. IMPLICATIONS

1. Sand mining and fishing are identified as the major threats to the turtles in the Mahanadi River, which need to be monitored and regulated. Sand mining activity need to be controlled during the breeding season of the turtles especially in the area of sampling zone 3 and 4. These two sampling zones were identified as the Important Turtles Area (ITAs) in the Mahanadi river.
2. Alternate livelihood options should be identified and implemented in order to reduce people's dependency on fishing in this region. Nature education and awareness programme clearly addressing the reason for declining of turtles and their habitat in the Mahanadi river needs to be launched.
3. The river stretch of Subarnapur and Kakhadi of the Mahanadi may be declared as the 'Conservation Reserve' for conservation of freshwater turtles. This part of the river stretch recorded all five species of turtles with maximum encounter rate.
4. Ecotourism projects may be launched in this region targeting turtle watch.

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Programs used:

BLOSSOM

MS Excel 2003

PCOrd 4

PRIMER 6.1

SPSS 16

Arc GIS 9.2

GPS Trackmaker

Erdas 3.0

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