ABUNDANCE, DISTRIBUTION AND PATTERN OF HUMAN IMPACTS ON RIVER DOLPHIN (PLANTANISTA GANGETICA GANGETICA), ASSAM

THESIS

SUBMITTED TO THE

FOREST RESEARCH INSTITUTE (DEEMED) UNIVERSITY

DEHRADUN, INDIA

FOR

THE AWARD OF THE DEGREE OF

DOCTOR OF PHILOSOPHY

IN FORESTRY

(Wildlife Science)

BY

SUNNY DEORI

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2018

भारतीय वन्यजीव संस्थान
Wildlife Institute of India

CERTIFICATE

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Place: Dehradun
Date: 27th Aug., 2018

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DECLARATION

I hereby declare that the thesis entitled "**Abundance, distribution and pattern of human impacts on river Dolphin** ***(Plantanista gangetica gangetica)***"submitted by **Ms. Sunny Deori** (Reg. no. 11Ph.D208) to Forest Research Institute (Deemed) University, Dehradun, for the award of the degree of **Doctor of Philosophy in Forestry (Wildlife Science),** is a record of original research work carried out by me under the supervision of Prof. Qamar Qureshi and co-supervision of Dr. Abdul Wakid, Project Scientist, Wildlife Institute of India, Dehradun and it has not formed the basis for the award of any other degree or diploma. I also declare that the thesis embodies my own work, observation and analysis and in that respects the investigation appears to advance knowledge in the subject.

[Sunny Deori]

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Date: 27th Aug., 2018

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Scientific Transactions in Environment and Technovation

PINGERS: can be the eyes of blind ganges dolphins (*Platanista Gangetica Gangetica,* Roxburgh 1801)

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Wildlife Institute of India, Chandrabani, Dehradun-248 001.

Abstract

The growing need for fish extraction for livelihood is resulting in the by-catch mortality and injury of the aquatic mammals through fishing gear entanglement. It is one of the most significant issue of conservation of Ganges Dolphin. The inability of Ganges dolphins to identify the presence of monofilament gill nets results in entanglement and death due to suffocation. In this study, the interactions of Ganges dolphin with fishing gear (Gill net) by attaching Pingers have been investigated. It was assumed that the proximity zone around the fishing gear is the risk zone for the Ganges dolphin. A visual observation was made in an experimental set up of: Control Net (Without reflectors or Pingers), Net with reflectors (used locally to attract fish), Pinger with frequency and source level lower than what is used by Ganges dolphins (10KHz and 132 decibel) and Pingers with Ganges dolphin frequency (70KHz and 145 decibel). A significant difference in mean sighting distance of Ganges dolphins from different experimental set upss has been estimated. Nearest proximity in control net was <1m with a sighting rate of 1.41 sightings/hr whereas for Dolphin Pingers it was 5 to 10m with a sighting rate of 0.12 sightings/hr. Dolphins seem to avoid fishing gear with active Pingers and hence the experiment was to be carried forward to the next level of estimation for determining whether there was any attraction or change in catch per unit effort (CPUE) of fish or habituation of dolphin. Popularising the efficiency of Pingers among management stakeholders and introducing it to the fisher communities can be the next significant step to conserve the species.

Key words: Ganges dolphin, echolocation, entanglement, Pingers, reflectors.

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INTRODUCTION

Interaction of aquatic mammals and commercial fisheries is an age-old history (Reeves *et al.*, 2001). However, increasing demand for fish in the market with growing human population caused depleting fish population for aquatic mammals as well as for humans. The increasing fishing pressure results in the by-catch mortality and injury of the aquatic mammals and becoming the most significant issue of conservation of these animals (Mitchell, 1975; Woodley and Lavigne, 1991; Perin*et al.*, 1994; Broadhurst, 1998; Secchi and Vaske, 1998; Read *et al.*, 1998; Donoghue *et al.*, 2002; Noke and Odell, 2002; Cox *et al.*, 2004; Laurianoet *al.*, 2004; Read *et al.*, 2006; Brotons*et al.*, 2008; Read, 2005; Sigler *et al.*, 2008; Read, 2008). Hall (1996) defined it in a more negative connotation for the fishers or environmentalists, who says 'it is that part of the capture that is discarded in the water, dead (or injured to the extent that death is the result).' The incidences came to the notice when millions of dolphins got killed in tropical eastern Pacific (NRC, 1992) with the growing commercial fishing industries and the evolved purse seines fishing of the pelagic fishes (IWC, 1980).

Since then various experiments were carried out with passive and active methods to reduce the fishery interactions in marine fisheries (reviewed in Jefferson and Curry, 1996). The passive methods include net modification (Barham *et al.*, 1977; Leatherwood *et al.*, 1977; Norris, 1978; Pryor and Norris, 1978, Coe *et al.*, 1985) and some add-on-reflectors (Au and Jones, 1991; Au, 1994) which make them detectable to dolphins. Although few experiments showed some behavioural responses of small cetaceans towards passive reflectors (Goodson *et al.*, 1994; Silber *et al.*, 1994), however, the sample sizes and absence of controlled experiments to compare with the reality, made studies inconclusive (Hasegawa *et al.*, 1987). Most of the trials did not end up with any significant differences (Snow *et al.*, 1988; Jones, 1990; Goodson and Datta, 1992; Dawson, 1994; Goodson *et al.*, 1994; Hatakeyama*et al.*, 1994) or work only other way round (Hembree and Harwood, 1987; Goodson, 1990) or too expensive to continue (Peddemors*et al.*, 1991).

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The active methods do not rely on animal echolocation behaviour but produce sounds which are audible to the animal to deter them from the gears. People have tested gunshots to keep Australian Fur seals (Pemberton and Shaughnessy, 1993), dolphins in the Mediterranean (Ravel, 1963), Killer whales of Alaskan waters (Matkin, 1986; Dahlheim, 1988) at bay from the fish farms or explosives such as "seal bombs, Thunderflash, Beluga firecrackers, Cracker shells", etc. were manufactured commercially (Mate and Miller, 1983; Awbrey and Thomas, 1987) to deter seals or pinnipeds. These techniques however never worked out and were found that the animals got habituated to them with time (Shaughnessy, 1981; Mate and Miller, 1983; Matkin, 1986; Matkin*et al.*, 1987; Awbrey and Thomas, 1987; Scholl and Hanan, 1987; Steiner, 1987; Dahlheim, 1988). Eventually, by 1990s, these methods have been banned from US waters on the basis that it could cause serious harms to the animals (Myrick *et al.*, 1990; Myrick *et al.*, 1990).

Other active methods were more mechanical like playing biological sounds (Cummings *et al.*, 1971; Fish and Vania, 1971; Anderson and Hawkins, 1978; Shaughnessy *et al.*, 1981) or placing mechanical sound generators like non- electronic clangers, rattles, bell bouys and bang pipes (Kasuya, 1985; Peddemors*et al.*, 1991; Nasaka, 1979) underwater. They showed the minimum or no- response and were considered outdated (Fish and Vania, 1971; Anderson and Hawkins, 1978; Shaughnessy *et al.*, 1981; Coe *et al.*, 1985; Matkin*et al.*, 1987; Dahlheim, 1988).

The recent development in the technology is the production of electronic active sound generators which were previously categorized under two sets, viz. acoustic deterrent devices (ADDs) to address the problem of bycatch and acoustic harassment devices (AHDs) to mitigate depredation (Dawson, 2013). These devices are more abrasive emitters and hence were used initially in commercial fisheries to deter pinnipeds (Johnston and Woodley, 1998; Quick *et al.*, 2004) or harbour seals (Mate and Greenlaw, 1987). The effectiveness of the technology was experimented and the significant reduction in depredation and bycatches were observed later (Kraus *et al.*, 1997; Tripple*et al.*, 1999; Barlow and Cameron, 2003; Leeney, 2007; Carretta*et al.*, 2008; Gazo*et al.*, 2008; Buscaino*et al.*, 2009; Carretta and Barlow, 2011). With the increasing concerns about bycatch and depredation (Read, 2008), its use has become mandatory in some of those commercial fisheries (Anderson *et al.*, 1996; Bordino*et al.*, 2002). However, 100% efficacy of Pingers on Commercial fisheries is still questioned (Dawson *et al.*, 1998; Dawson *et al.*, 2013). There are also incidents which suggest no complete elimination of by-catch or depredation interactions (Brontons *et al.*, 2008b; Wapples*et al.*, 2013) and two other incidences when entanglement happened in nets loaded (Northridge *et al.*, 2003; Read and Wapples, 2010) with active Pingers.

This article, deals with the efficacy of Pingers on freshwater Ganges dolphins for the first time. Since the animal is almost blind (Herald *et al.*, 1969) and relies continuously on sonar clicks for echolocation, get entangled very often in fishing gears (Sinha, 2002; Mansur *et al.*, 2008) which were made of materials acoustically transparent, in this case, monofilament gillnets. Although, the intensity of getting entangled is not comparable to the marine odontocetes, the entire remaining population of Ganges dolphins, which is about 3000 individuals, is to be considered. (Sinha and Kannan, 2014). In 2008, out of 21 dolphin mortality reported from Brahmaputra, 20 were the victims of gillnet entanglement (Wakid, 2010). Hence, gillnet entanglement can be considered as a serious concern for the conservation of the species. In a developing country like India, with growing competition for resource extraction, where the socio-economic condition and awareness levels among fishers community are so low, that logistical loss of gear damage due to dolphin entanglement, is given priority to dolphin life. Hence it is essential to work out to reduce the interactions of fisheries and dolphins for the conservation of the species, and this is an attempt towards that goal.

Study area

Kulsi River flows through the lower Kulsi basin (extends latitudinally from 25°45'N along the Northern foothills of the Meghalaya Plateau to 26°10'N along the southern bank of Brahmaputra and longitudinally from 90°55'E to 91°35'E) in the western part of Kamrup rural district in Assam. The river originates on the West Khasi Hills ranges of Meghalaya (25°38' N and 91°38' E) at an elevation of about 1500m from the sea level and flows down to finally discharge into the Brahmaputra at Nagarbera. The length of the river is about 120 km in Meghalaya, and about 135km in Assam (Kalita, 1991). In Meghalaya, the river comprised of three important streams, viz., the Khri, the Krishniya and the Umsiri which originate on the same hill ranges. These three streams again joined with several hilly rills, streams and rivulets, and meet at Umkiam*beel* (25°38' N and 91°38' E) and is known as Kulsi from this point.

The experiment was carried out with a group of 4-5 dolphins at Kulsi River in a 3.95km stretch of Kulsi River near Malibari village (from N 26°3'36.22" and E 91°7'46.7" to N 26°3'19.04" and E 91°9'40.43"). The stretch is also frequently used by the fishers of the area.

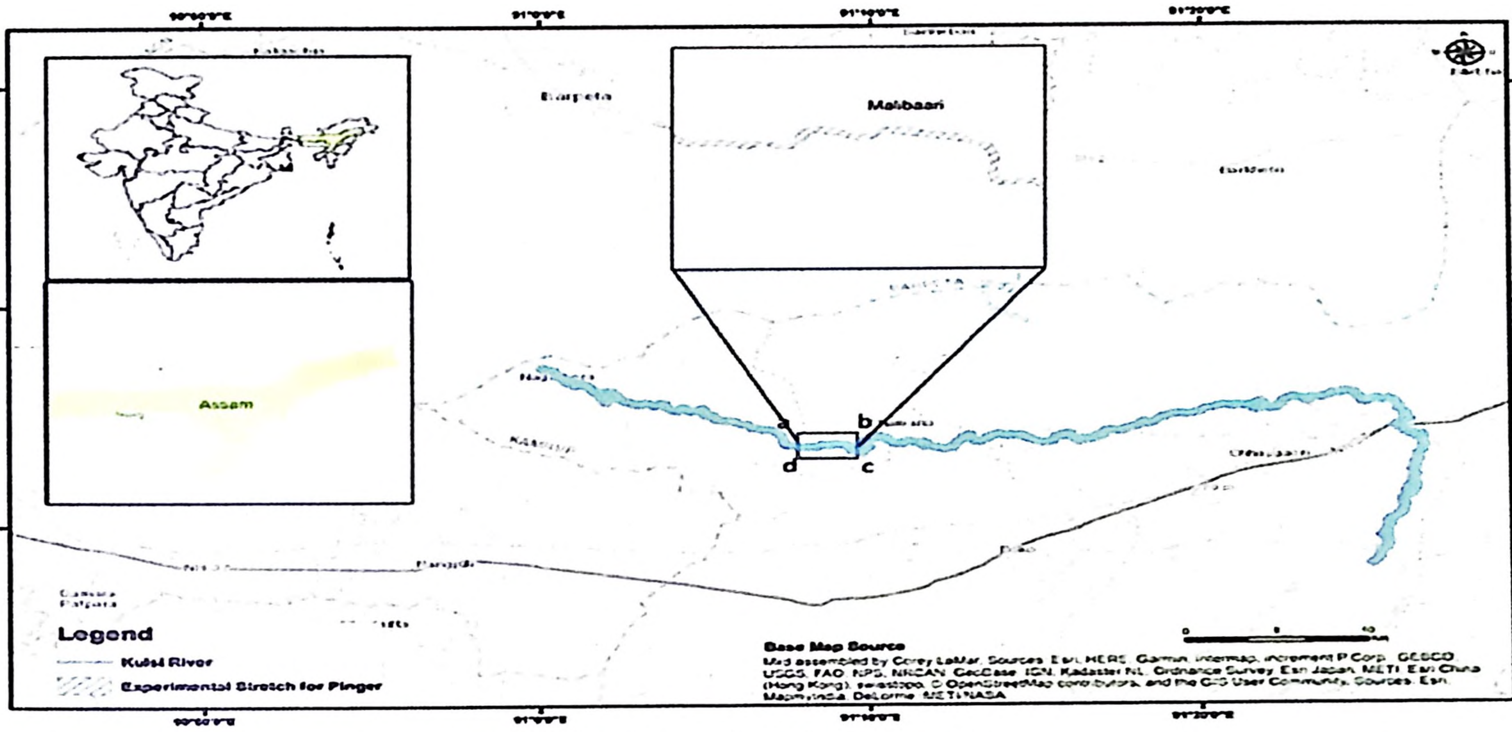

Fig. 1. Kulsi river and study area (Box)

MATERIALS AND METHODS

Field Methods and Data Analyses

A monofilament gill net of 150m length and 4cm mesh size was used for the experiment, which is also a commonly used dimension of gillnet by the fishers' community of Kulsi River. The study was carried out from January- March 2017. Four fishing gear set ups were made to test the interaction of Ganges dolphin:

(i) Gill net without any reflectors or Pingers loaded on it (Control)

(ii) Gill net loaded with different reflectors used locally by the fishermen, which could make noise in water (thermocol pieces/ empty plastic bottles/ banana plant bark).

(iii) Gill net loaded with active Pingers with frequency and sound source level (10kHz, 132 decibels) lower than used by Ganges dolphins (70kHz, 145 decibels)

(iv) Gill net loaded with active Pingers with frequency and sound source level similar to Ganges dolphins.

The Pingers were developed by the group of Future Oceans Pingers (www.futureoceans.com) (Fig.2). The power supply to the Pinger was a 3.6volts, 8500mAh lithium-ion non- rechargeable battery. Pingers turn on automatically when submerged in water and within 60 seconds of start-up delay. In each 100m of the net one Pinger was loaded to maintain the covering range of the Pinger (100m radius). The Pinger emits the signal at 4 seconds interval.

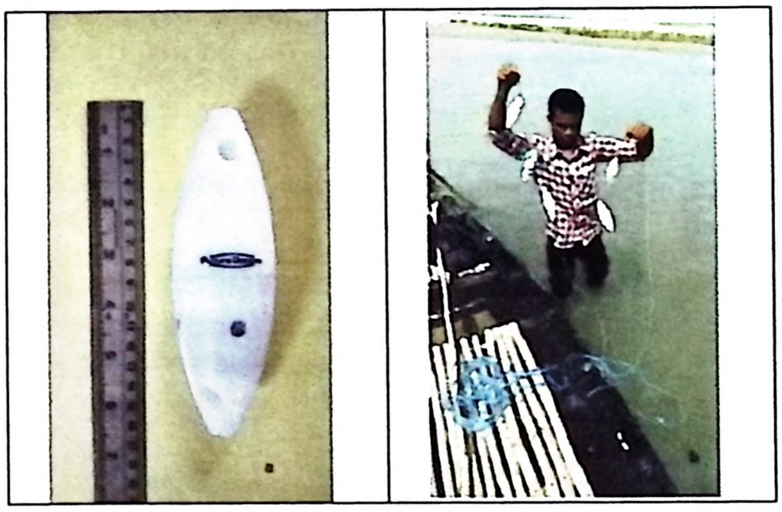

Fig. 2 a. Pinger,b. deploying in Freshwater

The gill net in each set up was fixed in a position, and the dolphin movement was observed with the help of two experienced observers on both upstream and downstream of the net (Fig. 3). Since in case of Ganges dolphin, the entanglement rate is lower to that of Marine cetaceans, the proximity of the dolphins to the fishing gear was considered as the line of threat in this study. With every dolphin sighting the observer recorded the time of the sighting, the distance of the individual from the net, age structure of the individual (new-born/calf/non- calf) and surfacing patterns (away/towards/along the line) (Dawson and Lusseau, 2005). The surfacing pattern of Ganges dolphin was recorded to understand the movement of the dolphin towards or away from the net, or turning away from or towards the net. The direction of the appearance of the rostrum of the dolphin confirms the position of the dolphin around the net. Along with these other anthropogenic activities occurring in the area were also recorded with each sighting.

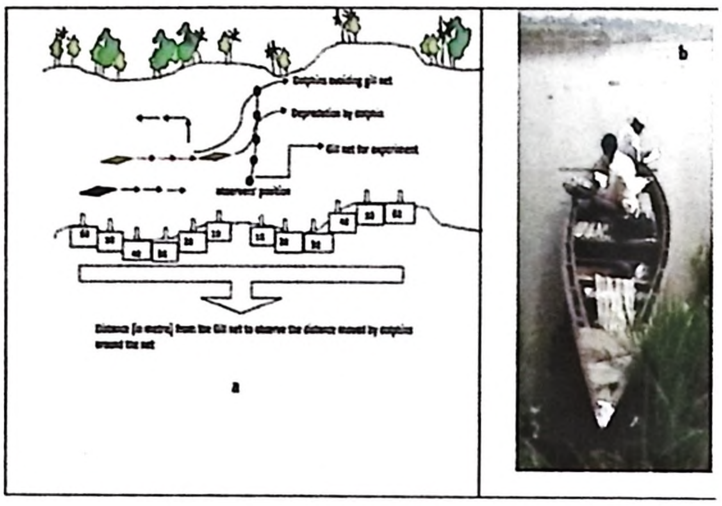

Fig. 3. Field set-up for Pinger experiment (a. showing the gill net and observers' position to record the sighting distance frequencies of dolphins, b. observers' recording data).

The frequency of sighting distances from the fishing gear was estimated to compare the proximity of Ganges dolphins to the control of fishing gear set up with rest of the three experimental set upss. The mean distance of the Ganges dolphin from different experimental set up was estimated. A Chi-square test was made to compare the frequency of distance observed between control and different experimental set upss. Data were analysed by using MS Excel and R software.

The upstream (towards the net) and downstream (away from the net) and the turning point from the net was estimated for all the four experimental set upss.

RESULTS

The dolphin behaviour around the control and experimental set ups was observed for 375 hrs (Table 1). The sighting rates declined at a minimum range of 1-2m and at a maximum range of 80-85m onwards from the net (Fig 2- 4). The sighting intensity declined near the net because of the presence of fishing net itself, whereas on the other hand, as the animal moved away, the sighting intensity declined again because of the observers' limitation. Hence the distance recorded beyond 30m was discarded.

Table.1. Total duration of observation around different experimental set-ups

Experimental Set up	Total observation time (hh:mm:ss)
Control net	69:54:00
With reflectors	59:34:00
With Porpoise Pingers	36:36:00
With Dolphin Pingers	21:43:00

The nearest proximity of dolphin was recorded minimum (<1m) for Control net with a sighting rate of 0.01 sightings/hr, and highest was for experimental set up with active Dolphin Pingers (4-5m) with a sighting rate of 0.02 sightings/hr (Fig. 4- 7). The probable reason behind this was that the reflectors used for the experiment were locally used by the fishermen on the nets as floats or attractant for the fishes (plastic bottles, the bark of banana plant) which could probably act as an attractant for dolphins too. Chi-square test has shown a significant difference between the distance frequencies obtained in control and three experiments (Table 2).

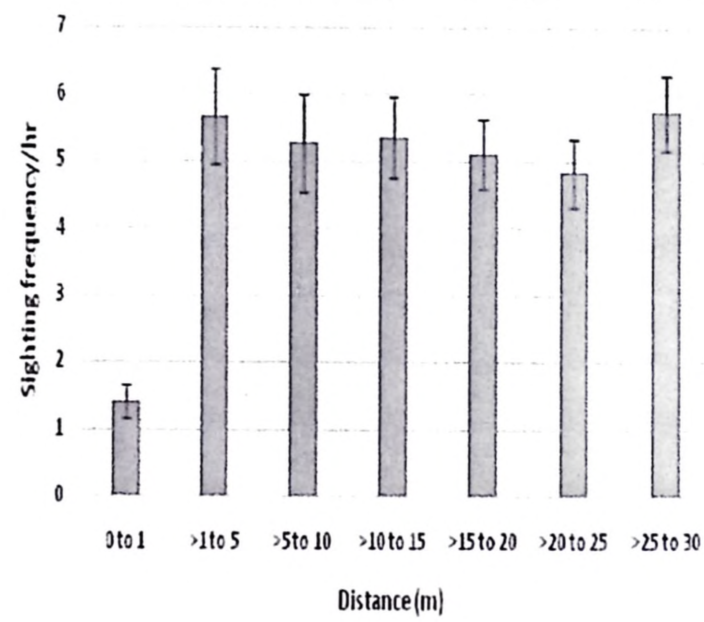

Fig.4. The frequency of dolphin sightings in different distance ranges with control Gear set ups (without Pingers and reflectors)

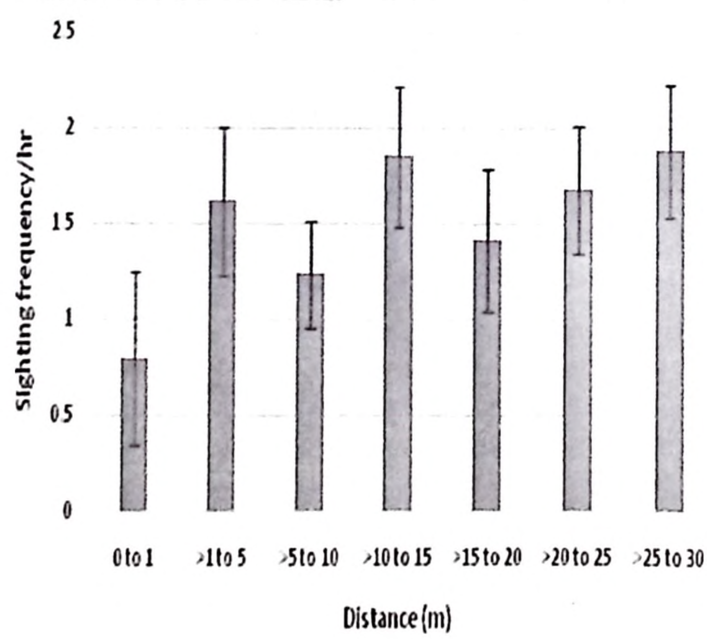

Fig.5. The frequency of dolphin sightings in different distance ranges with Gear set upss loaded with reflectors (bark of the banana plant, plastic bottles)

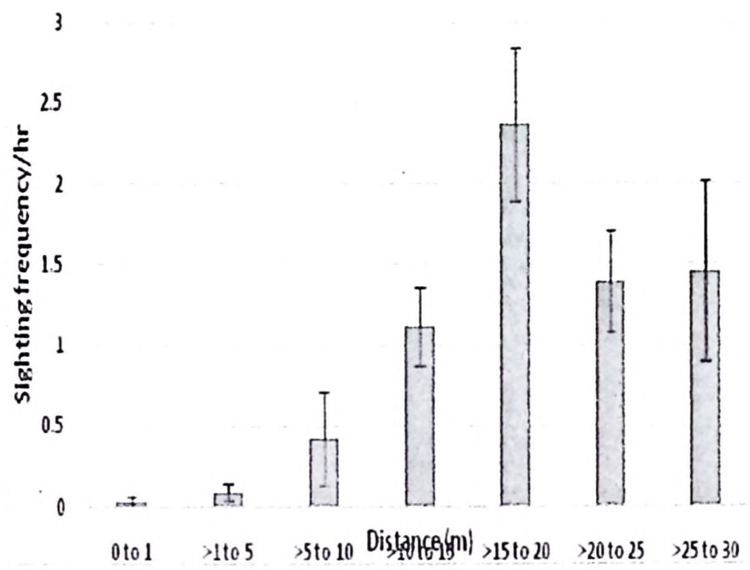

Fig.6. The frequency of dolphin sightings in different distance ranges with Gear set ups loaded with Porpoise Pingers (10kHz)

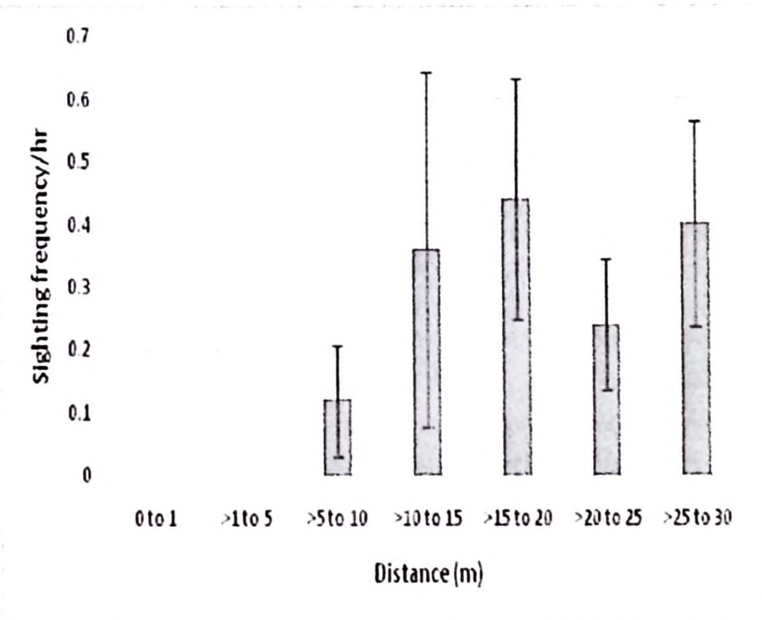

Fig.7. The frequency of dolphin sightings in different distance ranges with Gear set upss loaded with Dolphin Pingers (70kHz)

Table.2. Comparison of sighting distance frequency between different experimental set-ups

Comparisons	Chi-square	df	p- value
Control- Reflector	14.72	6	0.02
Control- Porpoise Pinger	48.12	6	0.001
Control- Dolphin Pinger	13.26	6	0.04
Reflector-Porpoise Pinger	35.47	6	0.001
Reflector-Dolphin Pinger	8.08	6	0.23
Porpoise Pinger- Dolphin Pinger	7.59	6	0.27

The frequency of sighting distance of Ganges dolphins and different patterns of movement around the experimental set upss for Pinger experiment

The dolphins were seen turning back and swimming away from the net during the trial, which could be considered as their range of detecting the net while approaching. The minimum distance recorded from where the dolphins turned back was <1m while using the controlled net. However, this detectability range increased to 6- 7 m when Pinger loaded net was introduced.

Age structure wise behaviour around the nets set ups

The distance for new-born and calves near the control net was recorded from 1 m and above from the net whereas adults were recorded <1m from the net. In the net with reflectors, a similar pattern of movement among the three age structures of dolphins was recorded, i.e., about a 1m distance from the net. In net with Porpoise Pingers, the nearest proximity of the new-born was at a range of 8 to 9 m from the net; calves were recorded at a distance of 4 to 5 from the net and adults were recorded at about 1m distance from the net. In the net with active Dolphin Pingers, the nearest proximity of the new-born was 9 to 10 m from the net, calves were recorded at 4 to 5 m from the net, and the adults were recorded 6 to 7m from the net. The average frequency estimation for new-born and calf was found more in different distance ranges with the active dolphin Pingers (Fig. 8).

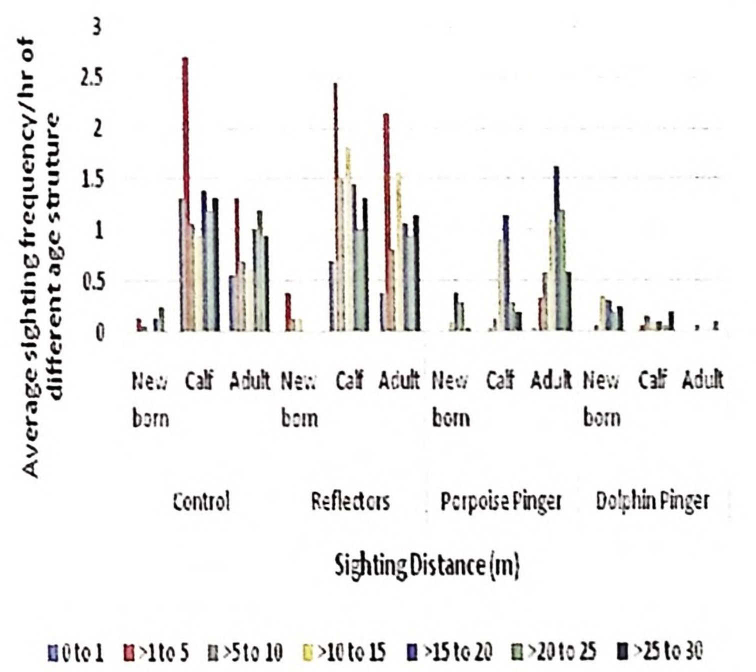

Fig.8. Average sighting frequency (per hour) of different age classes of dolphin in different experimental set ups.

DISCUSSION

Significant results (70% reduction in bycatch) were also observed in the controlled experiments addressing bycatch in Argentina (Bordino*et al.*, 2002), off California (Barlow and Cameron, 2003) and off Peru (AlferoShighuetu, 2010) with Netmark 1000 Pingers. However, consistent results were not seen for another two Pinger types (Aquamark 200 and Femunda10kHz) (Imbert*et al.*, 2007). The probable reasons cited were sparingly loaded nets and not in correct spacing (than the one instructed from the company), depleted batteries and sometimes fatal attraction of the animals than displacement (Dawson *et al.*, 2013). Hence, it is vital to properly space the Pingers on the net since a bigger gap in signals in between can mislead the dolphins, which can give them an impression of narrow escape and can lead to entanglement or increase in bycatch rate (Palka *et al.*, 2008; Carretta and Barlow, 2011). Also a low level of battery will lead to decreased sound pressure level and frequency which ultimately will not displace the dolphins.

In our study, in all the experimental set ups, it was observed that the dolphins turned back from the nearest proximity of the gear without getting entangled. The probable reason behind it could be related to the time of the experiment, which was done during winter or low water season. The low water depth also allows to increase their detectability ranges, as we had seen that the maximum casualties always happened during Monsoons or high water season when the water volume and velocities were on its peak. This might be due to high water velocity which could make dolphins deaf and make them near impossible to echolocate the fine monofilaments of Gill net.

Though our study has shown some impact of Pingers on Ganges dolphins, the experiment was of short duration. Hence carrying forward the Pinger experiment on fresh water dolphins to the next level is necessary. Specific questions such as effect in CPUE of the fish in active gears, behavioural responses of Ganges dolphins towards Pinger, either they would habituate or entirely avoid their critical habitats in the long run; the seasonal efficacy of Pingers; how readily would the fisher community accept it, etc., needed to be addressed in the future. However, questions such as CPUE of fish in active nets in marine habitat did not show significant differences (Barlow and Cameron, 2003). But on the other hand, it has been reported that there is always an issue of compliance in the fisheries, and hence proper implementation is difficult even for the most sophisticated fisheries of developed countries (Dawson *et al.*, 2013). Many insignificant studies on Pinger were the results of such inconvenience (Trippleet *al.*, 1999; Dawson and Slooten, 2005; Orphanides, 2012). However, proper channelization of education and outreach programmes for the communities and enforcement, whenever required, would be some critical points for effective implementations (Dawson *et al.*, 2013). It is always suggested that employing Pingers along with other mitigation approaches such as time-area closure and gear modification could lead to successful implementation (Dawson *et al.*, 2013). The state's fishery department has to play a vital role for handling such a crucial issue of Ganges dolphin conservation which will be a holistic approach towards saving the entire freshwater habitats.

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Concluding, I profess my gratitude to my inspiration ...... Kulsi River, whose alluvial land, soft sand, never ending meanders and simple lifestyle which can never be forgotten.....

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EXECUTIVE SUMMARY

Gangetic River dolphin (Platanista gangetica gangetica Roxburg 1801), an endangered fresh water mammal belonging to the order Cetacean is the only blind freshwater dolphin and navigate and feed with the help of echolocation is found in the riverine system of Ganges and Brahmaputra in the whole South Asia. In nineteenth century its population worldwide was plentiful (Sinha & Sharma 2003) but in the last 100 years the population has drastically declined (Reeves & Leatherwood 1995). Now its total population has been estimated to be about 3000 individuals worldwide. IUCN has updated its threatened status from Vulnerable (Klinowska 1991) to Endangered (1997). The basic factors behind the declining population of Gangetic River Dolphins are the extensive fishing practices, discharge of industrial pollutants, agricultural fertilizers and pesticides, progressing hydro- power projects, net entanglement and deliberate killing of dolphins in the major habitats of dolphins.

My study took place in a tributary of river Brahmaputra named Kulsi which originates from the Meghalaya enters Assam at Umkiam where it is known as Kulsi and finally discharges at Brahmaputra at Nagarbera, Assam. It is a highly populated riverscape. According to 2011 census data, the riverscape has 55972.88 hectares of cultivable land which is solely dependent for irrigation on natural sources (Rainfall and Rivers). Also, the river is divided into 7 River fishery under Revenue department of Assam. About 2500 commercial fishermen are registered under the fisheries of Kulsi River and 1,29,095 cultivators. Apart from this fine quality sand is a boon to the people of Kulsi floodplain. More than 5000 families were dependent on this business. The recent increase in construction business in Guwahati metropolitan and the nearby blooming towns is raising the earning bar of the people of Kulsi River.

My study aimed at the following objectives:

1. Estimating the abundance & patterns of dolphin distribution across Kulsi River.
2. Estimating the effects of different human activities which can possibly affect the habitat and distribution pattern of dolphins in Kulsi River (special preferences to existing commercial fisheries, sand mining, & irrigation).
3. Socio- economic status of fishermen community, sand mining community and farmers and their attitudes towards dolphin and wider ecosystem conservation.
4. Examine suitable measures to minimize/prevent the harmfulness of these fishing gears and practices in the commercial fisheries of Kulsi.

Individual capture-recapture method with both tandem vessels and single vessel with double observer platform was performed for the visual surveys to address the perception bias (observer bias) in visual survey methods of cetacean surveys. In addition to this underwater transect was done with pair of acoustic hydrophones to correct for the unavailability due the animal behaviour in visual survey. Correction factor was calculated using the acoustic tag data. Seasonal encounter rates of dolphins and anthropogenic activities were estimated from the visual survey data. An average encounter rate including the total survey efforts was 0.27 dolphin/km (SE=0.04). A higher encounter rate of Ganges dolphin for winter season survey in 2012-13 was estimated (0.45 dolphin/km, SE=0.02) followed by Monsoon survey (0.37 dolphin/km, SE=0.04). Chapman corrected Lincoln-Petersons estimate and Huggins estimator was used to estimate the seasonal abundance of Ganges dolphins in Kulsi River. Covariates such as sighting distance, channel types and cluster sizes were considered to correct the detection probability in visual surveys estimates. The estimates with higher AIC value of different models were considered. Population estimation was higher for Monsoon season (49 dolphins, SE=7). This is due to the migrating behaviour of Ganges dolphins from the main channel to the smaller tributaries during high water season. Percentage seasonal distribution of Ganges dolphins and different channel types was estimated. Test of significance was done to estimate the habitat preferences of Ganges dolphins. Kulsi River was seen mostly narrow and meandered throughout the seasons except during Monsoons when the river becomes flooded. Dolphins were seen mostly distributed in the meanders and confluences, narrow channels during low water season and wide channels during high water seasons. We found a significant difference in the seasonal occurrence pattern of dolphins in different channel types ($\chi2$=49.53, df=4, p-value=0.001). Channel depth mostly ranges between <1m during low water seasons to >10m which mostly represents the deep pools. Dolphins were seen preferred depth ranging from > 2m and above. During low water seasons dolphins were also encountered in stretches below 2m however not less than 1m depth. Encounter rates of different anthropogenic factors was estimated. Fishing activities were encountered throughout all the seasonal surveys. Mosquito net fishing was seen throughout the season despite is banned status according to Assam Fishery rules (1953). Dolphins were observed significantly higher in low fishing zones ($\chi2$=58.27, df=3, p-value=0.001). Sand mining activities were encountered throughout all the seasonal surveys with highest activity during low water seasons. Use of sand mining pumps was seen only from 2016 pre-monsoon survey onwards. Dolphins were observed significantly higher in low sand mining areas ($\chi2$=97.74, df=3, p-value=0.001).

To understand the resource availability and co-predators (viz., Ganges dolphin and human) competition; a fish sampling during pre-monsoon season, seasonal catch calendar, seasonal fish landing sites survey and fishermen questionnaires survey enquiring the changes in seasonal trends of fishing was done. Fish sampling was done with a cast net (4m radius length and 1cm mesh size) and a Gill net (50m length and 2.5cm mesh size) lying the fishing gears diagonally across the cross section and in every kilometre of the river. Catch per unit effort (CPUE) was estimated for both the gears separately and was found that the CPUE of cast net was higher (1.73 no. of fish caught/hr, SE=0.4) than Gill net (0.19 no. of fish caught/hr, SE=0.03). The species diversity with cast net was also higher than Gill net. The seasonal catch calendar was prepared with the help of local commercial fishermen. Highest CPUE was recorded for Monsoon season (4.6 no. of fish/hr, SE=1.7) followed by Post-monsoon season (3.1 no. of fish/hr, SE=1.3). Lowest CPUE was recorded for winter season (0.20 no. of fish/hr, SE=0.09). In Pre-monsoon and Monsoon seasons CPUE was higher for lower mesh size fishing gears (<1mm), however in Post-monsoon (11cm mesh size) and winter seasons (4cm mesh size) CPUE was higher with big mesh size fishing gears. Although with Mosquito net fishing, CPUE was always higher irrespective of different seasons. Fish landing sites were surveyed to compare the total resource extracted to the total economic value of the catch. The overall amount of harvest was comparatively less in pre-monsoon season (500.2kg/month, SE=19.1), however in the rest three seasons it was almost equal. The highest harvest was in winter season (2205.1 kg/month, SE=109.6) followed by monsoon season (2008.3kg/month, SE=82.4). The total average price/kg on the other hand was more in pre-monsoon season (304.4 INR/kg, SE=35.1) compared to rest of the three seasons, which was again of similar ranges. The lowest ranges go for winter season (191.4 INR/kg, SE=22.9). The availability of fish species (Mastacembelus arnatus arnatus, Prawn spp., Mystus spp.) of size classes 1-30cm, preferred by Ganges dolphin (Sinha et al. 1993) was found throughout the seasons with higher demand in markets (ranging from 200-300/kg). According to the fishermen questionnaire report fishing took place throughout all seasons with a higher amount of harvesting during post-monsoon season. In monsoon season small mesh sized gear were used as smaller fish were more abundant during this time. The species diversity is more during monsoon and post-monsoon season. Cast net of smaller mesh size (<1cm) were preferred most by the fishermen community of Kulsi River followed smaller mesh size gill net (1-2cm). The prey-source available in Kulsi is basically small sized fishes, viz., Mastacembelus arnatus arnatus, Channa punctatus, Anabus testudineus, Colisa fasciata, Labeo bata, Punctius spp., Mystus spp. etc. Large size species like

Aorichthys spp., Wallago attu, Labeo rohita and carps were caught in moderation from Monsoon to Winters.

To understand the extant and impact of sand mining activities in Kulsi river, sand miners questionnaire survey (n=64) was done. It was estimated that in an average 1.1cubic metre (SE=0.2) of sand was dug manually and 2.5 cubic metre (SE=0.6) of sand was dug with water pumps in an hour. The primary productivity of Kulsi was estimated to be very low (mining area=43×10^3 phyto-planktons/lt and unmined=50×10^3 phyto-planktons/lt, no significant difference was observed) compared to Subansiri river () which is an unmined tributary of Brahmaputra and has a resident population of Ganges dolphin (pers. comm.). Considering water quality of Kulsi River, the DO level was found less compared to the normal requirement of DO level for freshwater biodiversity.

Irrigation from Kulsi River is extensive during dry season crop (Irri cultivation) leaving the river bed exposed. With the help of secondary information, it was estimated that an average of 686 lt. of water/bigha/day (SE=69) is pumped out from Kulsi River for irrigation. During this condition, the abiotic factors, such as Dissolved Oxygen levels, water temperature, suspended and bed load sediment size distributions and streambed stability get altered (Ward and Stanford, 1983; Sparks, 1992; Nestler et al., 1994; Allan, 1995; Richter et al., 1996). The DO level of Kulsi river was found to be less (2-6 mg/l) compared to the normal requirement for most of the freshwater fishes (8-14mg/l) such as Carps, Trouts etc.

The socio-economics of the three stake holders considered in the study reveals almost similar story. Among the three communities the economic conditions of the fishermen community were vulnerable with a highest average income generated during post-monsoon season (INR 200/- day). They reported that the number of fishermen has significantly declined over past 10 years as the fish quantity is also declining drastically. Whereas on the other hand the number of sand-miners has increased in last 10 years where most of them have identified themselves as fishermen who have shifted their occupation due to resource depletion.

The literacy rate was estimated to be less than 50% and of which maximum belongs to only primary education level for all the three community stakeholders. The higher age group interviewees were with low education qualification and vice versa. Also, a higher education qualification is not contributing towards more income generation in any of the occupation. The level of education shows significant correlation with the awareness level regarding Ganges dolphin conservation among fishermen communities.

The growing need for fish extraction for livelihood is resulting in the by-catch mortality and injury of the aquatic mammals through fishing net entanglement. It is one of the most significant issues of conservation of Ganges Dolphin. The inability of Ganges dolphins to identify the presence of monofilament gill nets results in entanglement and death due to suffocation. In this study, we have studied the interactions of Ganges dolphin with fishing gear (Gill net) by attaching Pingers. It was assumed that the proximity zone around the fishing gear is the risk zone for the Ganges dolphin. A visual observation was made in an experimental set up of: Control Net (Without reflectors or Pingers), Net with reflectors (used locally to attract fish), "Porpoise pingers" with frequency and source level lower than what is used by Ganges dolphins (10 KHz and 132 decibel) and "Dolphin pingers" with Ganges Dolphin frequency (70 KHz and 145 decibel). We have estimated a significant difference in mean sighting distance of Ganges dolphins from different experimental setups. Nearest proximity in control net was <1m with a sighting rate of 1.41 sightings/hr whereas for Dolphin Pingers it was 5 to 10m with a sighting rate of 0.12 sightings/hr. Dolphins seem to avoid fishing gear with active Pingers and hence the experiment should be carried forward to the next level of estimating if there is any attraction or change in catch per unit effort (CPUE) of fish or habituation of dolphin. Popularising the efficiency of Pingers among management stakeholders and introducing it to the fisher communities can be the next significant step to conserve the species.

CHAPTER 1: INTRODUCTION

1.1. Evolutionary History

Cetacea (/sɪˈteɪʃə/) (from the Latin cetus, meaning "whale" and Greek ketos, meaning "huge fish") is the mammalian order to which dolphins belong, along with whales and porpoises. They are taxonomically the most diverse clade of aquatic mammal. Their fossil record goes back at least to the Middle Eocene (52 millions of years before the present) (Fordyce and Barnes, 1994; Fig. 1.1). In 1891, Flower noted a close resemblance between the larynx, stomach, liver, reproductive organs and foetal membrane of the aquatic Cetacea and the superficially very different terrestrial Artiodactyla (Gregory, 1910). However, a very recent description of two archaic whales reveals a clear morphological homology between cetaceans and artiodactyls (Gingerich et al., 2001; Thewissen et al., 2001).

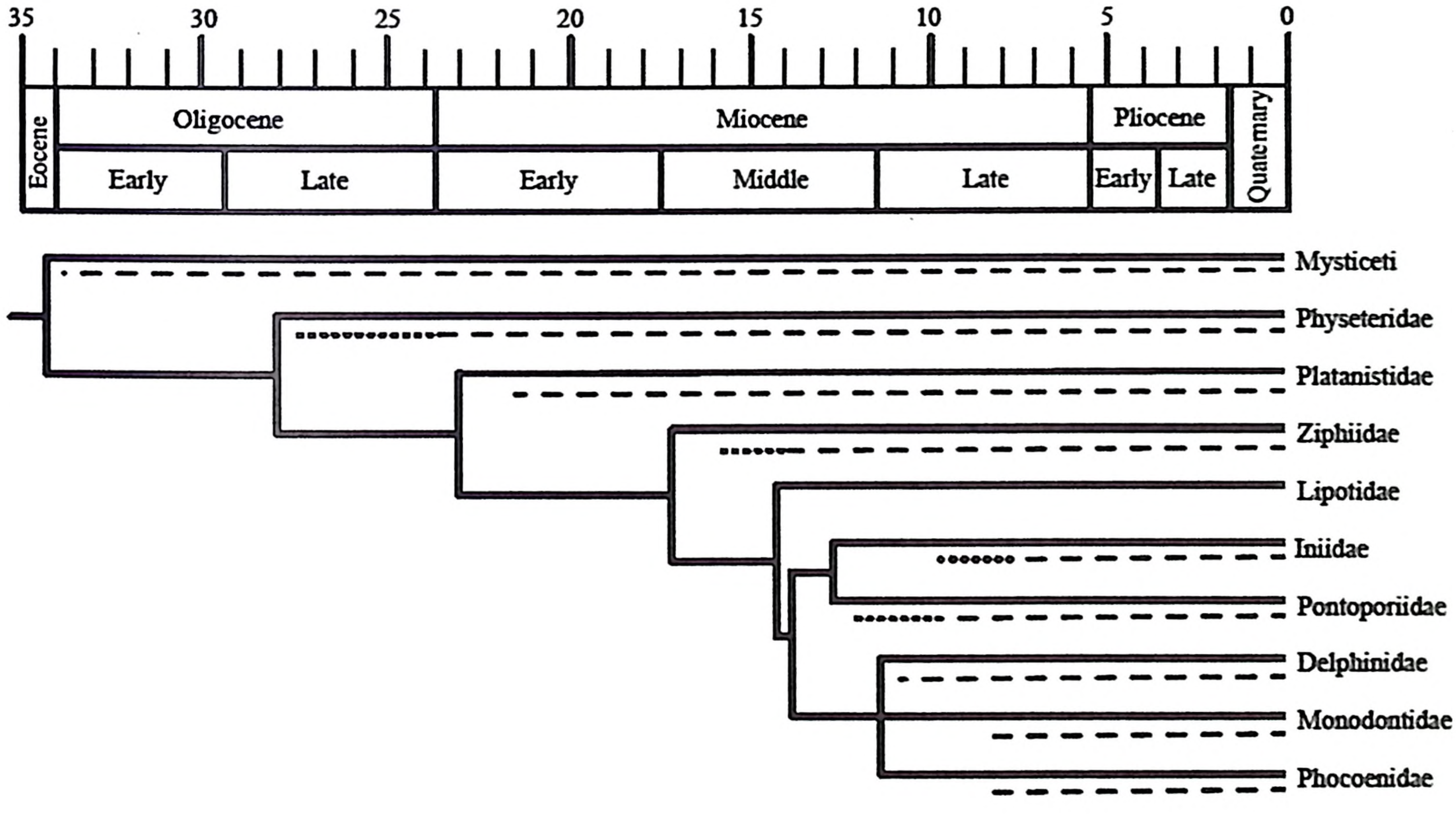


Figure 1.2-1 General correspondence between the hypothesized and fossil record of the sub-order Odontoceti (Source: Hamilton et al. 2001).

Dolphins belong to the sub-order Odontoceti. They are also ecologically the most diverse group of animals because their habitats ranges from coastal to oceanic and from tropical to polar waters. There are 40 extant species of dolphin, and these belong to the families

Delphinidae, Platanistidae, Iniidae and Pontoporiidae. Several of these species live exclusively in marine waters or in fresh water. Among these are the river dolphins, of the genera Inia, Pontoporia, Lipotes and Platanista, which evolved in four disjunct habitats, viz. The Amazon, Parana, Yangtze and Indo-Ganges river basins, during the Late Neogene (Hamilton et al., 2001). These form a little studied and endangered group that has sometimes been assumed to be monophyletic (Simpson, 1945; Kasuya, 1973; Zhou, 1982). This is because of the typical elongated rostrum and mandibular symphysis of these animals, which are the primitive characters of odontocetes. Hence they were grouped into the same family, the Platanistidae. However, their monophyletic evolution was questioned because of their highly modified autapomorphic characters, which are more useful than the shared characters for determining their affiliations (Gray, 1863; Hyening, 1989; Messenger, 1994; Fordyce and Barnes, 1994; Fordyce, 1994; Messenger et al., 1998).

Many theories have been proposed to explain the highly evolved characters of the river dolphins and the survival of their lineage (Cassens et al., 2000; Hamilton et al., 2001). The theory of Messenger and others (1998), that the evolution of river dolphins is polyphyletic, was confirmed by phylogenetic analysis of the nucleotide sequences of mitochondrial and nuclear DNA (Cassens et al., 2000). It has been suggested that the evolution of the river dolphins is related to the three significant marine transgressive–regressive cycles (high sea levels) that occurred during the Middle Miocene (Haq et al., 1987). These cycles resulted in large-scale marine transgressions into the low-lying, shallow epi-continental sea in the Indo-Gangetic plain, of the Indian sub-continent, in the Amazon and Parana river basins, of South America, and in the Yangtze River, of China. The transgressions led to increased tolerance of the aquatic mammals to the osmotic differences between the fresh water and salt water. They also provided the aquatic mammals with diverse food resources because of the mixing of riverine and marine waters (Hamilton et al., 2001). And after the sea-water level dropped during the Late Miocene regression (Hallam, 1992), these archaic odontocetes survived in the river systems, while their marine relatives were superseded by the radiations of delphinoids (Cassens et al., 2000; Hamilton et al., 2001).

Platanista gangetica is distinguished from the other three species of river dolphin by its modifications, the greatest known in any cetacean. These modifications include its side swimming behaviour and lack of vision (Miller, 1923). Although no fossils have been recovered from the broad, flat Indo-Gangetic foreland basin, other fossil relatives of the family Platanistidae such as members of the families Dalpianzinidae (Muizon, 1994) and Waipatidae (Fordyce, 1994), are known to have inhabited Miocene epi-continental seas in

North America (Morgan, 1994; Gottfried et al., 1994). These records suggest that Platanista gangetica is the only surviving descendant of an archaic odontocete that ventured into the epi-continental seas of the Indo-Gangetic basin. The lineage remained there through the transition of this basin to an extensive freshwater ecosystem during the regression of the sea during the late Neogene (Hamilton et al., 2001). Yang and Zhou (1999) described two sister river dolphins that belong to the family Platanistidae, i.e., Platanista gangetica gangetica (Ganges Dolphin), distributed in India, Nepal and Bangladesh, and Platanista gangetica minor (Indus Dolphins), found in the Indus River, of Pakistan.

1.2. Morphology

The Ganges Dolphin is grey or brown in colour, with the venter being lighter. The animal has a distinctively elongated beak, the length of which may be 15–27 percent of the body length (Sinha and Kannan, 2014). The teeth are distinct, and they get worn and flattened with age (Anderson, 1879; Sinha and Kannan, 2014).

The Ganges Dolphin have a very highly developed sonar system (Purves & Pilleri, 1973-74; Pilleri et al., 1976). Since the animal is blind, it emits pulses of sounds continuously to navigate and to search for prey. The sound has a frequency of 40 kHz. The skull of the animal is highly developed, with the pneumatized maxillary crest arching over the face and acting as an acoustic reflector for echolocation (Nikaido et al., 2001). The air-filled, bony maxillary crest reduces the centroid frequency of the clicks and provides a more directional sound beam compared with what would be expected from the size of the head. This might help the dolphin catch swift prey items in shallow and murky waters (Jensen et al., 2013).

The Ganges Dolphin swims almost constantly and often exhibits a peculiar behaviour of side swimming, with the pectoral fins repeatedly touching the river bed. This may be a situational behaviour that is an adaptation to movement in shallow water (Pilleri, 1970). Since the animal breathes, it surfaces according to a rhythm. This rhythm is dependent on various factors, such as the environmental factors, age-class and time of the day. The dive time of the Ganges Dolphin as observed in different rivers is nearly 2 minutes (Wakid et al., 2009; Sinha et al., 2010).

Ganges Dolphins are mostly solitary in nature; groups may have three to 10 individuals, but such congregations are seldom seen (Sinha and Kannan, 2014). Calves stay with their mothers until they are weaned (Sinha, 1999).

The species exhibits sexual dimorphism: the adult female is larger than the male. Adult females have long and slightly upward curved rostra. It has been estimated that both males and females attain sexual maturity by the time they are 10 years old (Kasuya, 1972). Sexual intercourse is preceded by vigorous movements and splashing of water, with four to five adult males chasing one adult female. One male finally succeeds, and this may be inferred from synchronized surfacing of a male and the female and rubbing of their ventral sides (Sinha and Kannan, 2014). The gestational period is reported to be 8–9 months (Anderson, 1879), at the end of which a single offspring is borne. It has been reported from Bangladesh that calves are born during October–March, with a peak in December (Kasuya, 1972). Not much has been reported on the lifespan of the Ganges Dolphin, but observations made on carcases suggest (Kasuya, 1972) that it may be more than 30 years.

1.3. Abundance and Distribution

The distributional range of the Ganges Dolphin currently lies in the Ganges–Brahmaputra-Meghna river system, in India, Nepal and Bangladesh, and the Karnaphuli–Sangu river system, in Bangladesh (Anderson, 1879; Kasuya and Haque, 1972; Haque, 1976; Jones, 1982; Mohan, 1989; Shrestha, 1989; Reeves and Brownell, 1989; Reeves and others, 1993) (Fig. 1.2). In the 19th century, it was plentiful (Sinha and Sharma, 2003), but in the last 100 years the population has declined drastically (Reeves and Leatherwood, 1994) (Fig. 1.2). Along the Ganges, population estimation surveys have been carried out in different regions separately by different biologists. Detailed population estimates made using the best count method for various stretches are available in the IUCN Red List of Threatened Species (Smith et al., 2012). Estimates made from the early 2000s till more recently across the range show that there are approximately 3500 dolphins in the entire range (Sinha and Kannan, 2014; Table 1). However, many tributaries of the Ganges and the entire Barak river system are yet to be surveyed.

Table 1.1.3 Estimates of Ganges Dolphin populations made from the early 2000s till more recently (Sinha and Kannan, 2014)

River stretch	Estimate	Source
Ganges River—main stem and tributaries	2381	Sinha (1997), Sinha et al. (2000, 2010a,b), Sinha (1999), Sinha and Sharma (2003 a,b)

Brahmaputra and tributaries	635	Wakid, A. (pers.comm., 2014)
Ganges River system and Bangladesh Sunderbans	460	Smith et al. (2006, 2009), Alam and Sarker (2012)
Karnali River and tributaries, Mohana River; and Koshi River in Nepal	>50	Smith et al. (1994)
Total	>3500	

1.4. Threats

There was a massive decline in the numbers of the species during the 1990s because of the following:

i. Construction of major dams on the main stem and on the tributaries. The stretches below such dams end up with higher sedimentation (Smith et al., 1998) and altered assemblages of fish and invertebrate species (Smith, 2012; Sinha et al. 2000).

ii. Building embankments causes sediments to be deposited on the river bed itself instead of on the floodplain, which reduces the eddy currents where dolphins were found (Smith e al., 1998) and restricts the critical habitat available for the reproduction and growth of riverine fishes (Boyce, 1990). It has been reported that dolphins were eliminated from the 35 km stretch of the Punpun, a tributary of the Ganges, after the construction of embankments in 1975 (Sinha et al. 2000).

iii. Dredging activities (Smith et al. 1998), removal of stones (Shrestha, 1989), mining of sand from river beds (Mohan et al., 1998) and large-scale lift irrigation during the dry season reduces the depth and flow drastically.

iv. The concentrations of toxic substances such as organochlorines and butylin in tissue samples have been observed to be very high (Kannan et al. 1993, 1994, 1997; Senthilkumar et al., 1999). Increasing industrial activity and disposal of waste in the river is increasing the pollutant load in the river. Large agricultural fields on riverbanks added chemical fertilizers and pesticides into the water through runoff.

v. There is competition among co-predators always. In the case of the Ganges Dolphins and fishers, the competition has become conflict. Mortality due to incidental by-catches in gill nets is growing severe throughout the range of the dolphin (Sinha, 2002).

vi. Ganges Dolphins were killed intentionally in the Ganges in India and Bangladesh and in the lower parts of the Brahmaputra to extract oil from their blubber for use as fish bait and as a cure for rheumatism (Smith and Reeves, 2000; Sinha, 2002; Smith et al., 1998; Mohan et al., 1997). Tribal communities living along the upper stretches of the Brahmaputra also kill the dolphin for its meat (Mohan et al., 1997). "Assisted incidental capture" of dolphins is a case where fishing nets were set strategically in areas used by dolphins to trap them (Sinha, 2002).

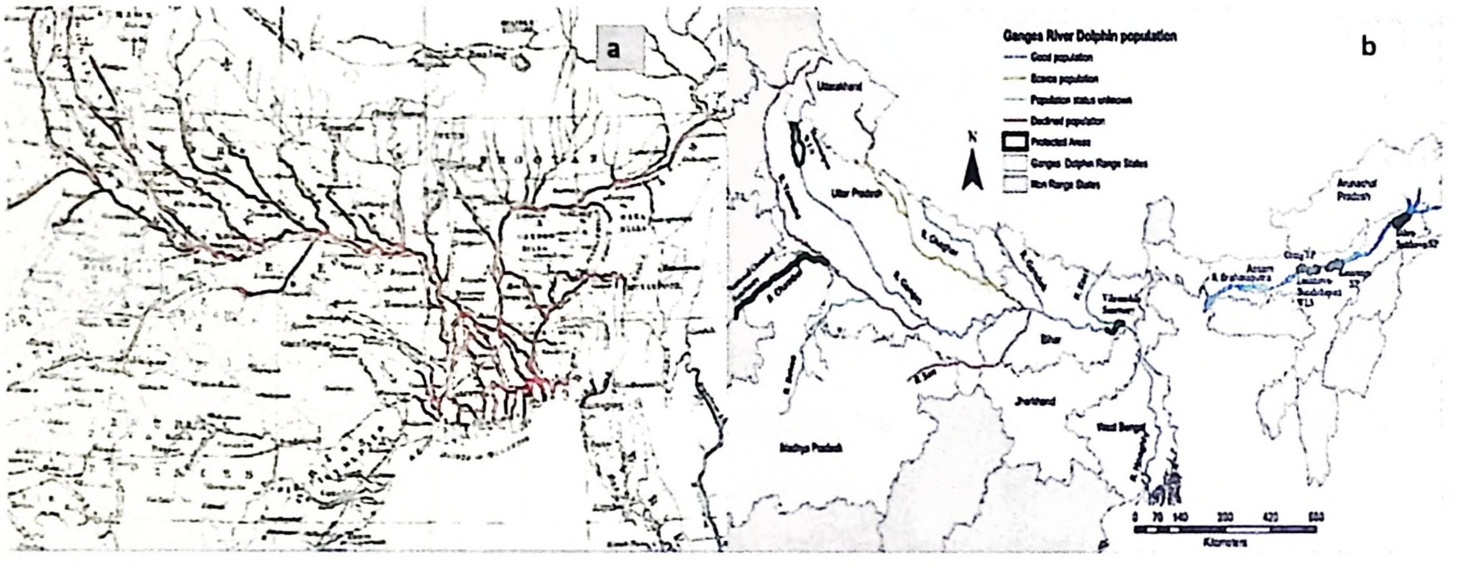


Figure 1.2-2(a) Historical (Anderson, 1879) and (b) present distribution ranges of the Ganges Dolphin (Source: Sinha and Kannan, 2014.

1.5. Conservation Status

The IUCN moved the Ganges Dolphin from Vulnerable (1991) to Endangered in 1996, following the sudden collapse of the species of the 1990s. As a result, it has also received the highest category of protection, i.e. it is listed in Schedule I of to the Wildlife Protection Act, 1972. The animal was recognized as the National Aquatic Animal of India in 2009 at the first meeting of the National Ganga River Basin Authority (NGRBA). It had also been declared the state aquatic animal of Assam in 2008. It has been declared the first City Animal of Guwahati, Assam (2016).

In 1991, a 60 km stretch of the Ganga River (Sultanganj to Kahalgaon) in Bhagalpur District was declared the first protected area of the Gangetic Dolphin (Vikramshila Gangetic Dolphin Sanctuary). In Uttar Pradesh, a 95 km stretch of the Ganges traverses through Hastinapur Wildlife Sanctuary, where the Ganges Dolphin has been recorded. A 425 km stretch of the Chambal River had been designated the National Chambal Sanctuary in 1979 in an attempt to revive the Gharial population. The Chambal also has a significant population of Ganges Dolphins. In Assam, the Brahmaputra passes through some protected areas: a 45 km stretch through Dibru-Saikhuwa National Park, a 52 km stretch through Kaziranga National Park, a 35 km through Laokhowa-Burachapori Wildlife Sanctuary and a 17 km stretch through

Orang National Park. These stretches hold most of the population of the Ganges Dolphin of the Brahmaputra River in Assam (WII, 2018).

1.6. Justification of the Study

The freshwater river dolphins as a group have been the least studied animals, and their ecology has not been studied much. The Ganges Dolphin is one of the oldest evolved animals in the world and has undergone complicated transformations to adapt to the freshwater environment. With time, the riverscape has been dominated by humans and their activities. These factors have converted the entire habitat into a more complicated one and thus made the study of the animal more difficult. The sudden decrease in the population in the past 50 years has drawn the attention of many biologists and conservationists across the world. The species is distributed within vast floodplains that are surrounded by a mosaic of human settlements, both rural and urban, and the interactions are also becoming complicated. Hence, the conservation measures that are required are becoming critical too.

Today we have detailed information on most of the distributional range; however, we have only limited knowledge about the population ecology of the Ganges Dolphin. Due to the behaviour and habitat of the animal, the methods used for population estimation have never been free of biases.

Tributaries, on the other hand, have played an important role in the evolutionary traits of the Ganges Dolphin. The Kulsi river is a small tributary of the Brahmaputra that has a resident dolphin population. Human activity along the Kulsi is intense. During the monsoon, as the river floods and the main channel of Brahmaputra river swell up, the dolphins tend to migrate from the Brahmaputra to its tributaries (Kasuya and Haque, 1972). The Kulsi, itself has four tributaries, and dolphins probably move from the Kulsi towards its tributaries and vice versa during the monsoon. The high intensity of anthropogenic activities along the Kulsi river potentially acts as a barrier to this local migration. The present study aims to identify the relevant anthropogenic activities and the level of intensity. The project also aims to identify how the distribution of the dolphin population across the Kulsi river has been affected by these human activities. The study was carried out in an average of 64km of the stretch from the year 2012 to16 to complete the following aims and objectives.

1.7. Aims and Objectives

1.1.1. Estimating the abundance of dolphins and pattern of dolphin distribution across the Kulsi river

a. What are the seasonal variations in the abundance and distribution pattern of the river dolphins?

b. What are the factors affecting the abundance and distribution pattern of the river dolphins in the Kulsi (habitat and anthropogenic factors)?

1.1.2. Estimating the effects of different human activities that can possibly affect the habitat and distribution pattern of dolphins in the Kulsi river

a. What are the encounter rates of river dolphins in the existing commercial fisheries and at the sand mining sites along the Kulsi river?

b. What is the extent of prey overlap between fishers and river dolphins?

c. What are the types of fishing gear posing a threat to the dolphins of the Kulsi river? To what extent are they are being used?

d. What are the extent and impact of sand mining?

e. What is the impact of irrigation on the water flow in the Kulsi river and on the dolphin distribution along the Kulsi river?

1.1.3. The socioeconomic status of the fisher community, the sand mining community and the farmers and their attitudes towards the dolphin and conservation of the wider ecosystem

a. What is the socioeconomic structure of the fisher community and the sand miners of the Kulsi river and the farmers residing along the banks of the Kulsi?

b. What are the attitudes of the fishers, sand miners and farmers towards dolphin conservation and the wider ecosystem?

1.1.4. Examining suitable measures to minimize/prevent the harmfulness of the fishing gear and practices of the commercial fisheries of the Kulsi

a. What is the rate of interaction of river dolphins with the fishing gear (gill nets) set-up—controlled and experimented?

1.8. Organisation of the Thesis

This thesis is organized in seven chapters. The first two chapters are introductory and about the study area. Chapters 3 to 6 are based on the four broad objectives of the present study. Each chapter has a brief introduction, followed by the methodology, results, discussions of the results and, wherever possible, conclusions. Chapter 7 is a synthesis of the results and the discussions of the previous chapters. Chapter 1 starts with the evolutionary history of the animal, which is followed by a literature review based on the objectives. It also describes the major aims and objectives and the duration of the present work. Chapter 2 deals with the study area, physical features, drainage patterns, climate and rainfall, vegetation types, flora and fauna and the people of the Kulsi floodplain. Chapter 3 deals with the abundance and pattern of distribution of the Ganges Dolphin in the Kulsi river. Chapter 4 deals with the effects of fishing, sand mining and irrigation pressures on the Ganges Dolphin. Chapter 5 deals with the socioeconomics of the community stakeholders (fisherfolk, sand miners and cultivators) of the Kulsi floodplain and their perspectives of the conservation of the Ganges Dolphin and its habitat as a whole. Chapter 6 deals with experiments with pingers and the behaviour of Ganges Dolphins around gill nets. These experiments were performed to test a mitigation measure for entanglement of Ganges Dolphins in gill nets. In Chapter 7, the results and discussions are synthesized. Recommendations are made for the conservation of the animal and its habitat in the near future on the basis of the results and discussions.

CHAPTER 2: STUDY AREA

2.1. Introduction

Kulsi river flows through the lower Kulsi basin (extends latitudinally from 25°45'N along the Northern foothills of the Meghalaya Plateau to 26°10'N along the southern bank of Brahmaputra and longitudinally from 90°55'E to 91°35'E) in the western part of Kamrup (Rural) district in Assam (Fig. 2.1.). The river originates on the West Khasi Hills ranges of Meghalaya (25° 38' N and 91° 38' E) at an elevation of about 1500m from the sea level and flows down to finally discharge into the Brahmaputra at Nagerbera. The length of the river is about 120 km in Meghalaya, and about 135km in Assam (Kalita, 1991). In Meghalaya, the river comprised of three important streams, viz., the Khri, the Krishniya and the Umsiri which originates from the same hill ranges. These three streams again joined with several hilly rills, streams, and rivulets and meet at Umkiam beel (25° 38' N and 91° 38' E) and are known as Kulsi from this point (Fig.2.1.).

2.2. Physical features

Kulsi floodplain is surrounded by the mighty Brahmaputra in the north, foothills of Meghalaya plateau in the south, Kalbog River in the east and the Deosila River (a tributary of Kulsi river) in the west. According to the administrative boundaries, Barpeta and Nalbari districts lie in the North, West Khasi Hills District of Meghalaya in the south, Goalpara district in the west and no political or administrative boundary in the east (Fig. 2.2.). Physiographically, the region is divided into three distinct broad divisions (Kalita, 1995):

i. The alluvial floodplain in the north,

j. ii. The built-up zone in the middle and

k. iii. The foothills zone in the south.

The floodplain area is a result of continued alluvial deposition by the hydrological activity of Brahmaputra resulting into formation of small islands (or sand bars), marshes, swamps, and wetlands; which are about 29 percent of the total area (GSI, 1976). The built-up zone is composed comparatively of fine alluvial deposits over the northward sloping pre-cambrium rock basement by the rivers and comprises of about 25 percent of the total area (GSI, 1976). The foothills zone is basically a part of the northern Meghalaya Plateau, which has some steep valleys cut by the hilly torrents and streams and occupies about 46 percent of the regions total area (GSI, 1976).

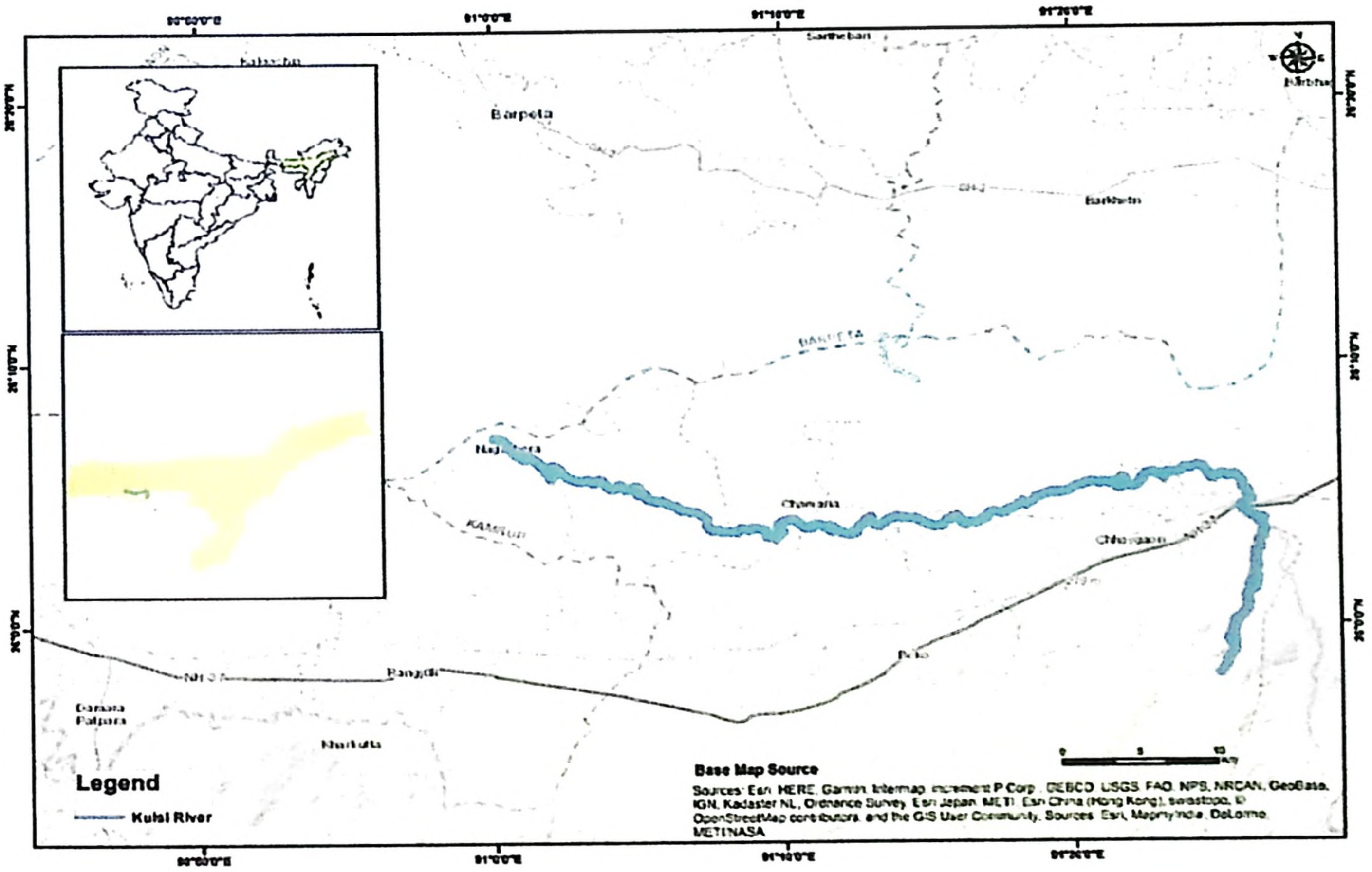


Figure 2.3-1 Kulsi river (76 km stretch from Kulsi Town to Nagarbera).

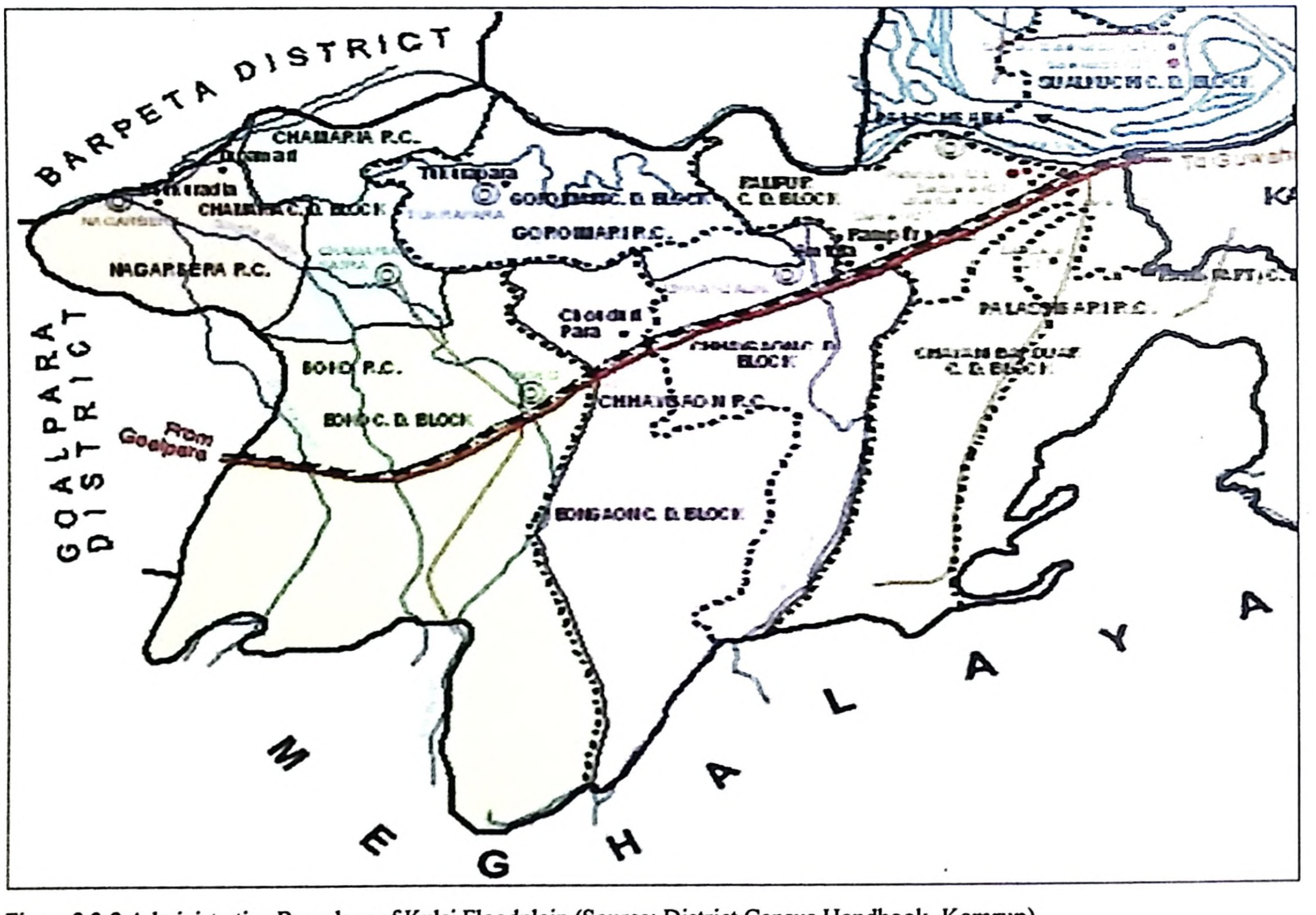


Figure 2.3-2 Administrative Boundary of Kulsi Floodplain (Source: District Census Handbook, Kamrup).

According to 2011 census, the floodplain has 116289.5 hectares of land and 7,80,502 population distributed among 6 sub-districts with 627 villages of Kamrup (Rural) District. The Kulsi river basin has a total catchment area of 1896sq. km along with its Boko and Singra tributaries in Assam and is characterised by numerous wetlands (beels), swamps and marshes both in the foothills margin and floodplain zone. The average width of the Kulsi river is between 35-40 m in up-stream to 60-100m in downstream during low water season and is characterised by the meanders and confluences. The basin is characterised by alluvial floodplain in the north near the river Brahmaputra, the built-up plains in the middle and the hills and foothills in the south.

Land use and land cover for the 2 km buffer on either side of Kulsi river (Fig.2.3.) was used to calculate the percentage area which revealed the highest percentage of cultivated land followed by settlement area (Table 2.1.).

Table 2.1 Percentage of Land use/cover type around 2km buffer of Kulsi river.

Sl.no.	**Land Cover/Use**	**Percentage of Area**
1	Agriculture	63.45
2	Grassland	0.18
3	Moderately Dense Forest	0.99
4	Open Forest	2.82
5	Plantation	2.66
6	River (Dry)	0.15
7	River (Perennial)	2.27
8	River Dry	0.23
9	River Sand	1.81
10	River Scrub	0.72
11	Scrub	0.35
12	Settlement	22.98
13	Wasteland	0.06
14	Waterbody	0.32
15	Wetland	1.03

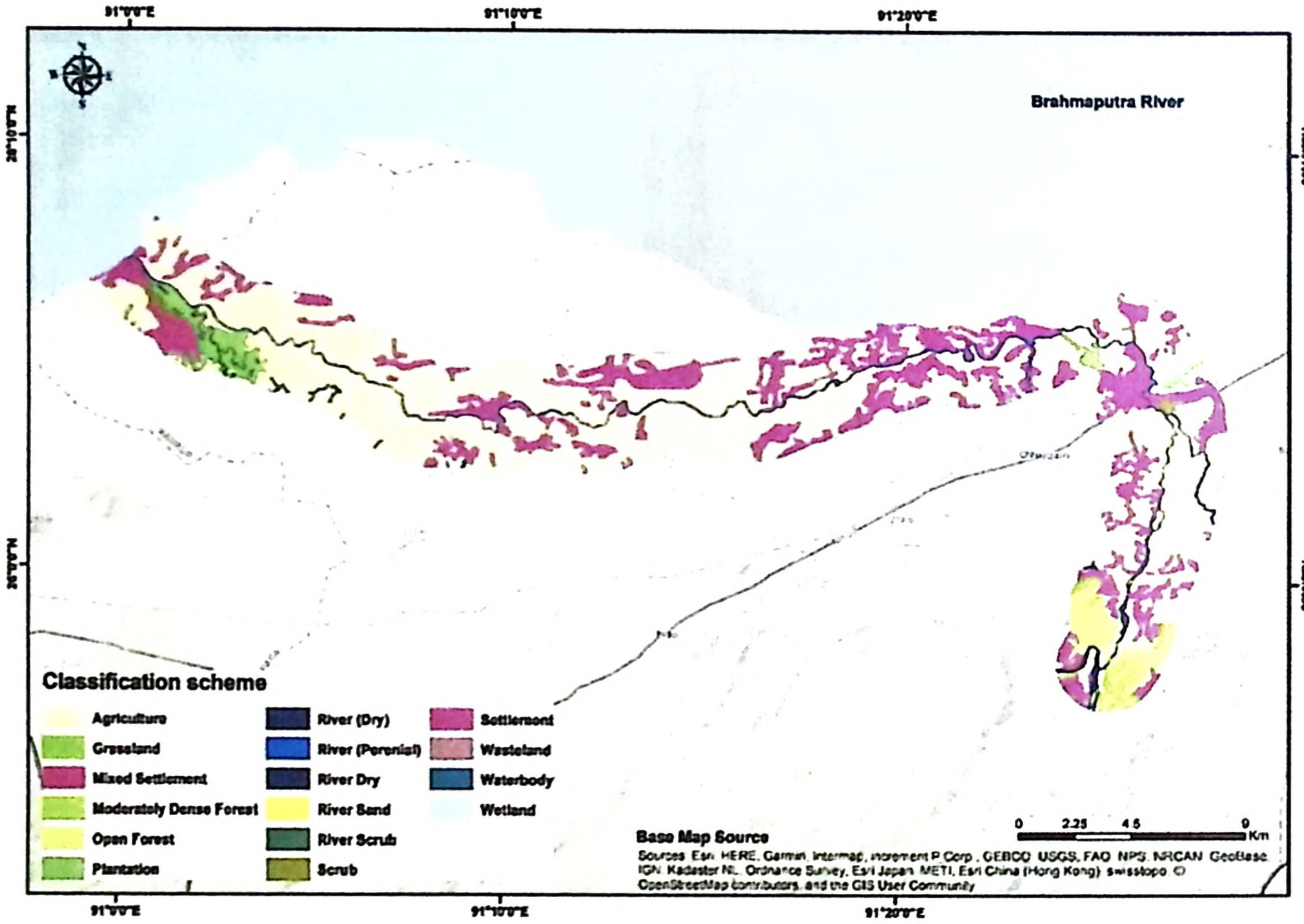


Figure 2.3 Land use and cover map in a 2km buffer on both sides of Kulsi river.

2.3. Drainage pattern and Waterbodies

Kulsi river after traversing for 20 kms from Ukium beel bifurcates into two branches near the Kulsi Village. The western branch again splits into two arms near Hatigarh village. The left arm is known as Khorkhori and the right arm as Kulsi. The eastern branch is joined by two other important tributaries, Batha and Ranigodam. All these branches are joined in the lower course at different points. The river finally confluences with the Brahmaputra where it is known as Joljoli. The other tributaries originating from Meghalaya Plateau; Boko, Singra, Singua, and Deosila, joins Kulsi at different points (Fig 2.4.a.). Thus the Kulsi basin is formed with a total catchment area of 3491km^2 of which 1595 km is in Meghalaya and 1896 km is in Assam.

The floodplain is also characterised by numerous wetlands, swamps, and marshlands both in the foothill margins and floodplain zone. The Chandubi and Ukiam wetlands are on the foothills (Fig.2.4.), Salsala, Kukurmara, and Dora wetlands on the built-up zone and Palpara, Deudara, Hatishila, Panikhaiti, Kalapani, Palasbari and Hekra wetlands in the floodplain zone. Since 1991, the number of associated wetlands and streams of Kulsi have reduced with increasing human population.

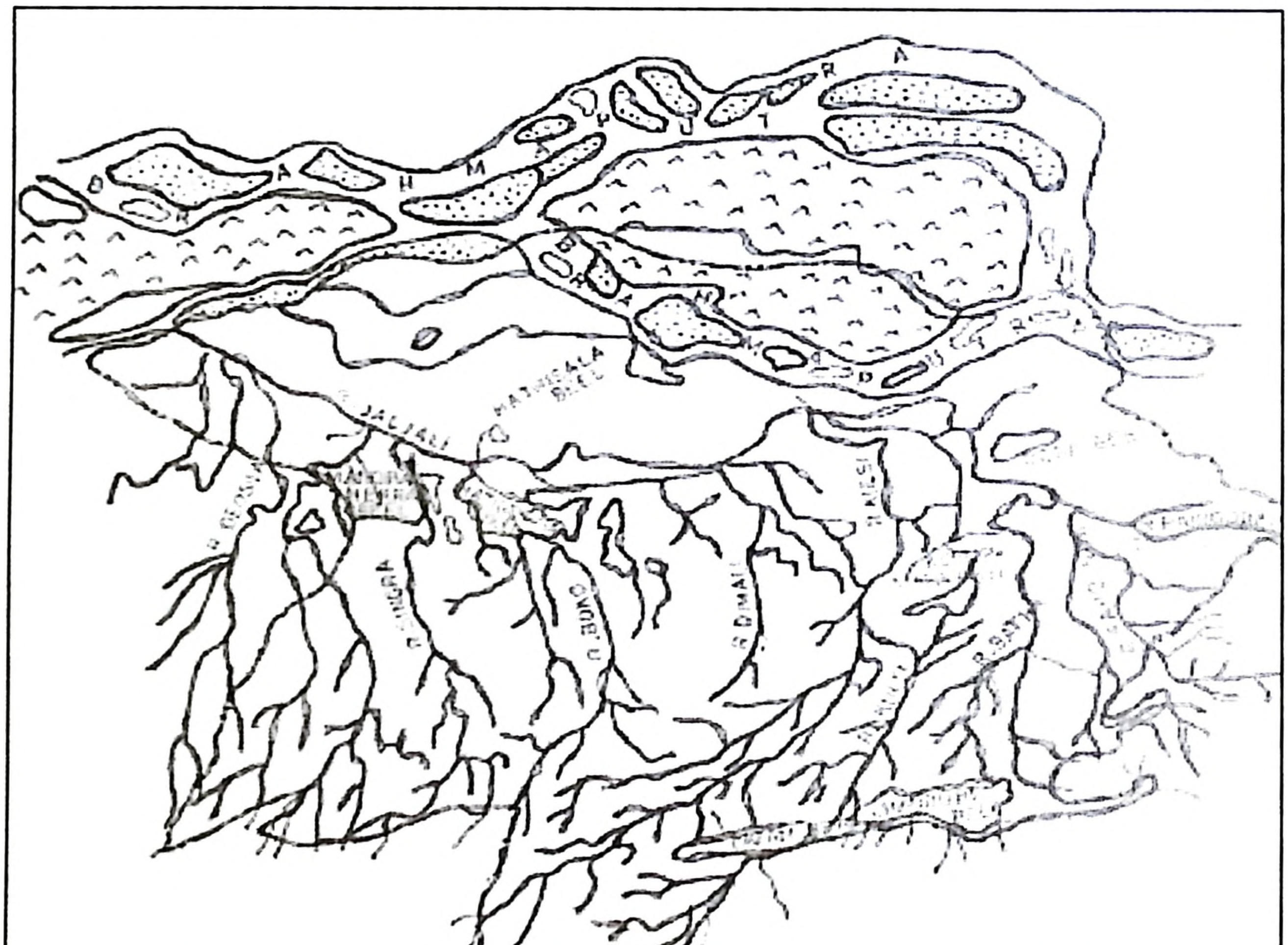


Figure 2.4 Drainage basin of Kulsi during 1991 (Source: Kalita, 1995).

2.4. Rainfall and Climatic condition

In study area mean annual maximum temperature ranges between 30° to 33° C during July-August and the minimum temperature ranges from 6° to 12° C during December to January. The average rainfall in the area according to 2016 meteorological data was 458mm which was reported to be 2060 mm in 1991 (Fig 2.5). This data shows that 50% of the total rainfall had occurred in the pre-monsoon season and 47% of the rainfall had occurred during monsoon season. During winter and post-monsoon seasons, rainfall was negligible. Humidity remains high, at about 80% for most of the year. It comes down to about 65 to 70% during the months of January and April (Gopalkrishnan, 2000).

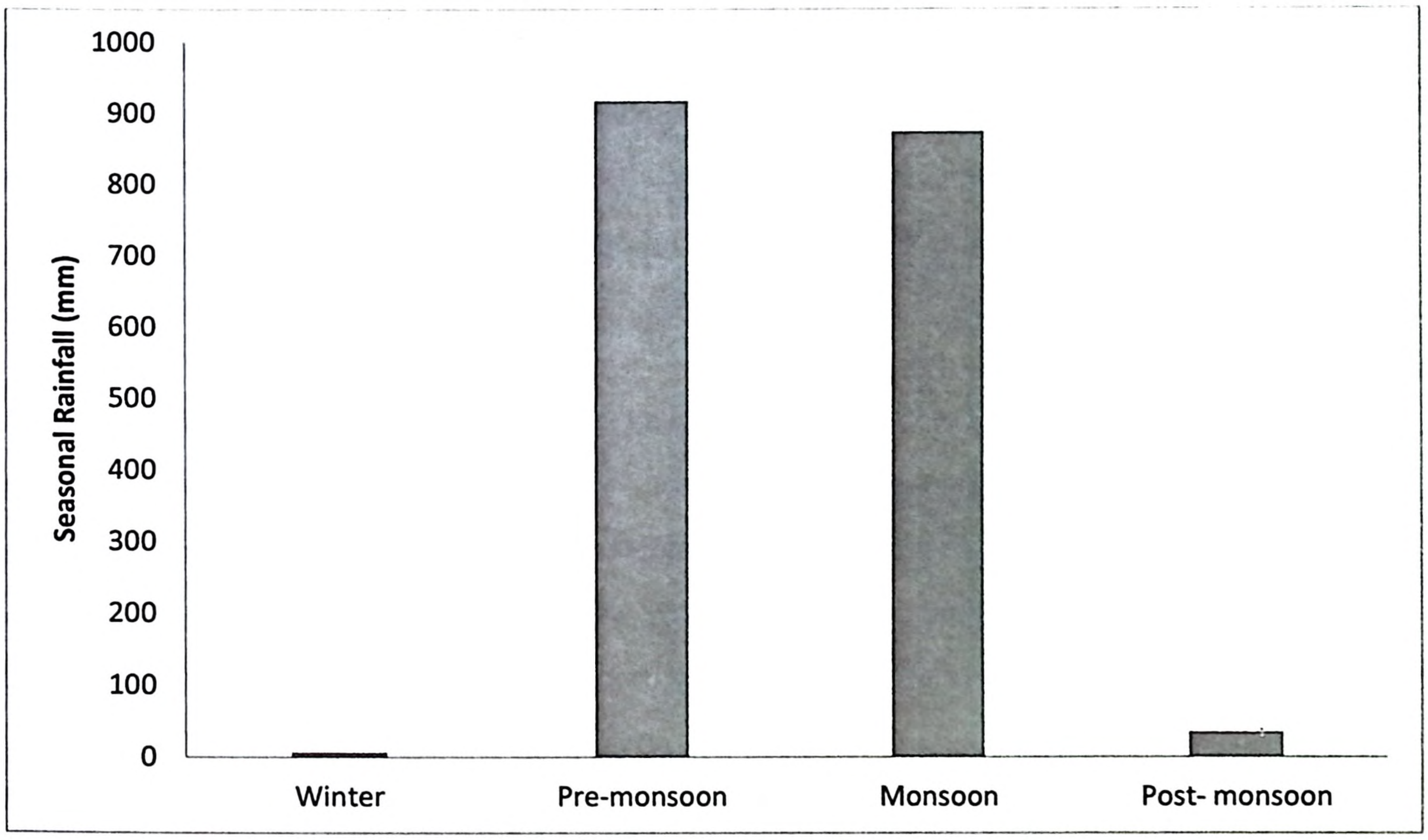


Figure 2.5 Seasonal Rainfall data of Kamrup rural district, 2016 (Source: Report no. ESSO/IMD/HS/R.F. Report/01(2017)/23).

2.5. Flora and Fauna

The area has four storeys of vegetation, the first and the second storey comprises of both deciduous and evergreen species (teak and sal) goes up to a height of 30m and 25m respectively, with shrubs and bushes as the third storey and grasses as the forth. Riverine tracts were composed of grasses, bamboos, intermediate shrubs and trees like Bombax ceiba, Anthecephelus chenesis, Toona ciliate etc. However, with increasing human settlements along the river bank, this vegetation is reduced and getting cleared for cultivation. The 2km buffer around the Kulsi river shows only 3.70% of open forest, 1.30% of moderately dense forest and 0.24% of grassland cover (Table 2.1.).

The Kulsi floodplain holds an assemblage of faunal diversity. However, the faunal diversity of Kulsi floodplain is sparsely studied and least addressed in the scientific media. Apart from the Ganges dolphins, the floodplain is rich in ichthyofaunal diversity with few exotic and mostly indigenous species (Goswami and Ali, 2012). More than 60 fish species were recorded from Kulsi belonging to 8 orders of which Cyprinidae was the most common (Goswami and Ali, 2012). The tectonic lakes, viz., Chandubi, Solbeel, and Beeldora were the eminent sources. Twenty species of Amphibia were reported from the entire district (Chowdhury et al. 2001), however, the study has more scope for elaboration. The floodplain also attracts many avian flocks like adjutants, cormorants, darters, egrets, herons, green shank etc. and raptors like brahminy kites, serpent eagle, vultures etc. Different species of turtles were also seen on the study site, however, were not reported on scientific media.

2.6. People and Culture

Kulsi floodplain is comprised of different communities of people representing different cultures. In the northern region of the floodplain, majority population belonged to Muslim community followed by the Hindu- Assamese and few pockets of Hindu-Bengali community (Namasudras). The built-up zone has a majority of non-tribal Assamese community and Assamese fisher community (Koibatras) near river banks. The foothill zone is represented by different tribal communities.

Except for the Namasudras and the Koibatras, all communities were mainly farmers. The influx of people from flood-affected areas of Brahmaputra char and chapori (Islands) has added to the population and occupied open cultivable areas. Erosion has been playing critical role in pushing people from the banks and leaving them landless to become more dependent on the resources of the Kulsi floodplain, including fishes and minerals such as sand. Also as the fishing pressure in the rivers is increasing, more people were getting converted into sand miners. Due to limited options for livelihood support, people have been taking sand mining as an alternate way of generating income.

The resource extraction from the river takes place irrespective of any community. The intensity of using fishing gears which are harmful to the ecosystem (e.g. mosquito nets, lift nets) or fishing gears which can directly harm the dolphins (e.g. gill nets, hooks) has increased. According to the Assam fishery Rules, 1953, mosquito nets are banned throughout the year and there is "fish banned" seasons from 1st May to 15th July. Despite of these rules and regulations, people are continuing illegal fishing practices. Another threat to Kulsi ecosystem is heavy sand mining operations. It was observed during the surveys that lots of illegal sand mining operations were taking place throughout the stretch. A number of unregistered sand mining landing sites are coming up. The practice of sand mining with sand mining motors was seen which can affect the ecosystem more than the traditional one. People have converted riparian habitats into agricultural fields and to irrigate those cropfields during dry season they use water pumps. The frequency of using such water pumps towards the lower part of the river is more as compared to the upper part and the trend is observed to be increasing compared to last few years. It is an important factor from ecosystem conservation point of view to have the minimum water level in the riverine system for its sustenance. Irrigation as well as mechanised sand mining can pose a serious threat to the ecosystem when the water level is low during dry season.

CHAPTER 3: ABUNDANCE AND DISTRIBUTION PATTERN OF GANGES DOLPHIN IN KULSI RIVER

3.1. Introduction

The distribution range of the Ganges dolphins is spread over Ganges-Brahmaputra- Meghna and Karnaphuli-Sangu rivers of India, Bangladesh and Nepal respectively. However, dolphins doesn't occur in all the states through which the river flows. The distribution range of the species has declined drastically than what was mapped by Anderson (1879). In Ganga, the historical range such as the 100km stretch between the Madhya Ganga Barrage at Bijnor and the Bhimgoda barrage near Haridwar, the dolphin population has completely been wiped out (Sinha et al., 2000). Similarly, dolphin population got vanished from 400km stretch of Yamuna river from the Chambal confluence to upstream till Delhi (Sinha et al. 2000) and the Kaptai river of the Karnaphuli- Sangu river system (Smith et al., 2001).

The historical distribution of Ganges dolphins in Brahmaputra river system was observed in its entire stretch and all of its tributaries. However, since then the range has drastically reduced to only the 900 km stretch of the main stem of Brahmaputra (from Assam-Arunachal border to India-Bangladesh border). Subansiri and Kulsi were the only tributaries which left with the few viable populations of dolphins in it (Wakid, 2005; Mohan et al., 1998). The recent survey in the Brahmaputra has estimated 583 (SE=18) dolphins in Brahmaputra main channel and 35 (SE=4) dolphins in Subansiri and 17 (SE=2) dolphins Kulsi river (Pers. comm.).

This species is under continuous threats like Gillnet entanglement and mortality (Reeves and Leatherwood, 1994; Mansur et al., 2008), prey resource overlap (Kelkar et al., 2010), construction of dams (Reeves and Leatherwood, 1994; Smith et al., 1994), mining (Nairn et al.,2004, Hobbs, 2003), direct poaching (Mohan, 1989; Mohan, 1992; Mohan et al., 1997 in Assam), pollution (Smith et al., 1998), constructions of barrages and embankments (Mohan, 1992; Reeves et al., 2000)etc. worldwide which only affected its distribution pattern. Apart from that the species also have affinities for specific habitat such as they were generally more concentrated in confluences, deep pools and meanders (Kasuya and Haque 1972, Smith 1993, Simth et al., 1998).

There are not many studies to find regarding the seasonal distribution pattern of Ganges dolphin. Available studies have revealed almost similar story. It has been reported from Pakistan and Nepal (Kasuya and Hoque, 1972) that Ganges dolphin shows some seasonal changes in the distribution pattern. They have seen migrated to lower regions of larger streams during low water season and get extended to smaller tributaries during high water season. This can be seen with the movement of fish from the areas that becomes entirely dry in low water season which in turn indicates the change in dissolved oxygen and water level changes (Martin and da Silva, 2004).

This will also be quite difficult to draw the actual population estimate of the species because the surveys were carried out in different areas in the different time frame and even with different methods. However, a rough estimate accounts for a total of about 1200-1800 animals in its entire distribution range (Smith et al., 2015).

The surveys carried out by different workers in Brahmaputra river system in different times (Mohan et al., 1997; Wakid 2009; Wakid & Braulik 2009; Biswas & Boruah 2000; Hazarika et al 2010; Baruah et al 2012) employed single observer team-based "direct counts" and obtained "best estimates" (minimum count) and encounter rates. Gangetic dolphin surveys were also done by Smith et al. (1994, 1998), Behera (1995), Mohan (1997), Sinha et al. (2000) and Sinha et al. (2003) in rivers of India-Nepal and Bangladesh. There were always issues in designing correct survey methodology for river dolphin abundance estimation due to complicated river geomorphology, water current, boat navigation, animal distribution, etc. (Dawson et al., 2008; Hibby and Krishna 2001; Braulik 2006). The two main biases occurred in river dolphin surveys were namely, Perception bias and Sighting or Availability bias. Perception bias is an observer bias which arises due to differential ability of observer and observer fatigue. However, availability bias is due to the animal behaviour or habitat typeas the dive time of river dolphin is dependent on the activity of the animal in that particular time of survey (feeding, playing, resting, etc.). There is a high chance of missing or double counting the animal, which will lead to a biased estimate. Keeping in mind the challenges mentioned above, biologists have designed different methods for river dolphin population estimation. Direct count method was initially followed to count the river dolphins (Reeves and Brownell, 1989; Sinha et al., 1997a; Shrestha, 1989; Mohan et al., 1997; Smith et al., 2001; Wakid, 2009; Wakid & Braulik, 2009), but this method of survey does not take into account the main biases which lead to underestimation of river dolphin population size (Smith et al., 2006; Dawson et al., 2008).

In Amazon, Yangtze and Ganga, biologists have carried out modelling for population estimation of Amazon River dolphin and porpoises respectively (Vidal et al., 1997; Zhao et al., 2008, Bashir, et al., 2010). However, without modelling underwater area in a stream, the assumption that the animal is log-normally distributed (Buckland et al., 2001) will be violated. In two independent observer team method either on a doubled platform boat (Laake and Borchers 2004, Smith et al. 2006, Kelkar et al. 2010) or two separate boats moving in tandem (Braulik 2012) were used. In this method, the capture-recapture occasions by the two independent teams were matched (recapture) either using time (Kelkar et al. 2010) or the GPS location (Braulik 2012) to estimate the portions missed by either of the observer team. The data were either analyzed with Lincoln-Petersens Chapman's biased- corrected model (Smith et al. 2006, Kelkar, et al. 2010) or with Huggins model in MARK software (Smith et al. 2006, Braulik 2012; Wakid et al., 2013). Braulik (2012) incorporated covariates (sighting conditions and group size) into "Huggins" model to correct the detection probability of population estimate and hence reduced the perception bias to a significant level.

This method is also applicable for narrow width river of certain geomorphology like Kulsi with slight modifications by incorporating under water acoustic surveys (Akamatsu et al., 2008).

3.2. Methods

3.2.1. Visual Observation

The Kulsi river was surveyed using a modified method due to its narrow and shallow channel structure. The channel width ranged from 23m in the upstream region to 130 m in the downstream region and a depth range of 0.3m to 8m in the dry season (winter and pre-monsoon). In low water season, two independent teams travelling in tandem (Braulik, 2012) were used for the survey. The second boat travelled 1km behind the first boat which was sufficient to ensure sighting independence between the two observers (Braulik et al., 2012). The two boats moved downstream at an average speed of 4.7km/hr (SD= 0.64). In high water season, a single boat with double observer platform was used. Observer teams were consisted of one observer and one data recorder in each boat. First boat was considered as primary observer team and second boat as the secondary team. While using a single boat, lower platform was considered as primary observer and the raised platform as secondary observer. A single observer was sufficient to cover the entire viewing angle of the Kulsi river due to its narrow width.

As soon as a dolphin was sighted by the observer, data recorder recorded the time, GPS location, number of dolphins, age structure, radial angle and angular distance.

Along with dolphin sightings, habitat and visibility factors were recorded as covariates to improve the abundance estimates (Table 3.1. and 3.2.). Data from the primary and secondary observer teams were verified during each interval break. Data correction, data entry and basic GIS display were carried out at the end of each day to resolve any problems.

It was assumed that the probability of double counting of an animal from surveyed to the un-surveyed area is balanced by the probability of missing the equal number of the animal due to their movement in opposite direction overnight (Braulik, 2006, Wakid and Braulik, 2009).

Table 3.1 Channel types recorded during the surveys.

Channel Type*	**Characteristics**
Channel type 1	Narrow/ Wide Confluence (Channel width <60m and >60m respectively)
Channel type 2	Narrow/ Wide Meanders (Channel width <60m and >60m respectively)
Channel type 3	Narrow/ Wide Downstream mid-channel island (Channel width <60m and >60m respectively)
Channel type 4	Narrow straight channel (channel width <60)
Channel type 5 (*Channel Width was estimated from the distances to the left and right banks of the river from the boa)	Wide straight channel (channel width >60)

Table 3.2 Visibility conditions recorded during the surveys.

Visibility Conditions	**Scales**
Rain/Fog	0= No rain/fog, 1=fog/rain obscuring no more than 10% of the field of view or slight fog/rain partially obscuring no more than 50% of the field of view, 2 = Severe fog/rain obscuring more than 10% of the field of view or slight fog/rain partially obscuring more than 50% of the field of view
Wind condition	0 = water surface is glassy or had only small

	ripples, 1 = small waves but no white caps, 2 = larger waves with whitecaps
Glare	0 = No glare, 1 = when glare is very severe (view completely obscured) but covering <10% of the field or when glare is slight (view only partially obscured) and covers less than 50% of the field view, 2 = severe glare covering more than 10% of the field of view or slight glare covering more than 50% of the field of view

3.2.2. Underwater Acoustic observation

An underwater acoustic survey with two pairs of hydrophones was also conducted in Kulsi to correct for the unavailability of the animal in the visual survey due to its diving behaviour. It acts as a third observer in capture-recapture modelling.

The first acoustic sensor was positioned on a rope at 8m from the rear end of the boat to avoid noise contamination from the propeller. A float was also placed at 1m distance in front of the sensor to avoid dragging of the sensors on the river bed. The second acoustic sensor was positioned at 18m distance from the rear end of the boat with two floats at 1m each in front and back of the hydrophone (Fig.3.1.). The threshold level was kept constant at 35 count and maximum baseline as short. "Threshold level" is the variable detection threshold of A- tag (Pascal= 0.0771Xcount) whereas maximum baseline depends on the distance between two hydrophones of the A- tag (in our case Baseline= <208 which requires setup= Short, time difference interval =+/-271ns and Sound Pulse Limit (SPL) interval=500us, Akamatsu et al., 2008).

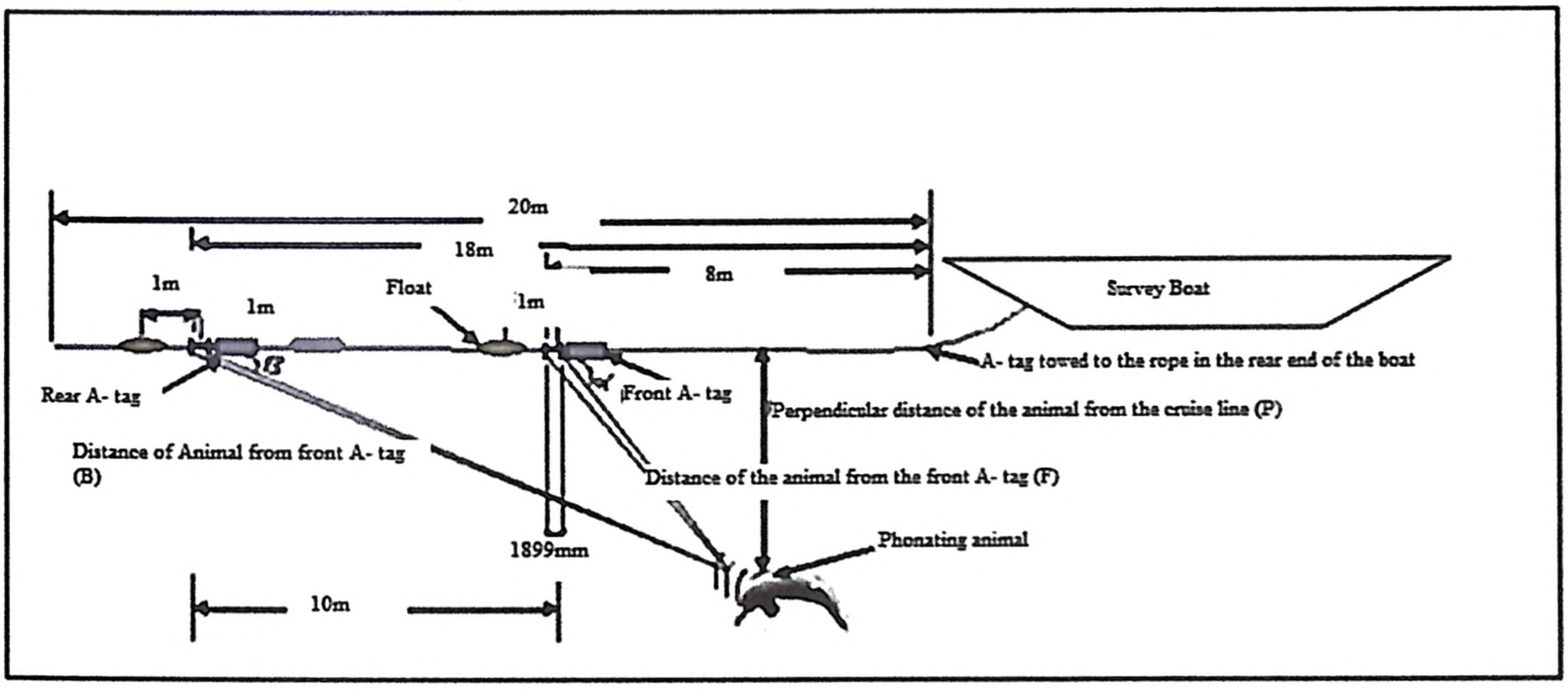


Figure 3.1 A- tag set up for Kulsi river survey.

A-tag was equipped with an analog-to-digital converter, A CPU (PIC18F6620; Microchip, USA) for system control and data processing, a 128-MB flash memory module for data storage, a miniature high-frequency pulse recorder and a battery cell containing one CR2 alkaline batteries in a waterproof tube (Dong et al., 2011, Li et al., 2009).

The acoustic data from the sensor were downloaded at the end of each survey session, converted into plain text (.csv) format using the Logger Tools (MMT Inc) and visualized in ".pxp" format using IGOR pro visualization software (Wavemetrics, AZ, USA) (Fig. 12) to detect any equipment operational problems. The sonar clicks were identified by a continuous click train from positive to negative and at the point "0", where it cuts across, known as the time of detection or the time difference. The click trains were considered as one individual dolphin and the time of its detection was obtained from the graph.

3.2.3. Analysis

a. Using Direct Count method by averaging Primary and Secondary observer team's data of dolphin counts, the encounter rate of dolphin per kilometer was estimated.
b. A two-sample capture-recapture method using Chapman's unbiased estimator.

The double-platform independent observer surveys, where sighting data from each platform represents an independent capture occasion, were used in a two-sample capture-recapture framework for estimation of population abundance along with estimates of capture probabilities and precision. All sighted dolphins were considered to be 'captured' and were then classified as 'recaptured' if seen by both observer teams or unique if missed by either observer group. GPS locations of every sightings recorded by both observer teams were overlaid on Arc GIS to confirm the matching (Braulik et al., 2012). We used Chapman's unbiased estimator (Chapman, 1951; Marsh and Sinclair, 1989) to obtain an estimate of the number of dolphins.

$$\widehat{N} = \left(\frac{(n_p + 1) \times (n_s + 1)}{m_{ps} + 1}\right) - 1$$

Where,

$\widehat{N_c}$= population size estimate

n_p = number of animals sighted by the primary observer team

n_s = number of animals sighted by the secondary observer team

m_{ps} = number of animals sighted by both teams (matches or recaptures)

The probability of detection is estimated as m_{ps}/n_p, m_{ps}/n_s

The associated variance V_c is given by (Seber 1970):

$$V_c = \frac{(n_p + 1) \times (n_s + 1) \times (n_p - m_{ps}) \times (n_s - m_{ps})}{(m_{ps} + 1)^2 \times (m_{ps} + 2)}$$

The upper and lower ranges of the 95% confidence interval were calculated as

$$95\%\ \mathrm{CI} = \widehat{N_c} \pm (1.96 \times \sqrt{V_c})$$

c. Two sample capture-recapture method using Huggins conditional likelihood model.

The capture-recapture analyses assume homogeneity of capture (sighting) probabilities. This assumption may have been violated by extraneous variations such as individual dolphin diving behaviour, and the combined effects of covariates such as sighting condition and habitat types. We also conducted the analyses where capture probabilities were modelled as a function of sighting covariates according to Huggins (1989).

$$\mathrm{logit}(p_{ik}) = \mathrm{In}\left(\frac{p_{ik}}{1 - p_{ik}}\right) = \beta_0 + \sum_j \beta_j x_{jk}$$

Where logit= type of link function, i= {p, s} primary or secondary observer team, k= dolphin sighting, β_0= intercept, β_j= the slope parameter for the covariate value x_j.

A type of Horvitz-Thompson estimator (Horvitz-Thompson, 1952) was used to estimate the abundance $\widehat{N}$ and the associated variance using program MARK 7.1.

$$\widehat{N} = \Sigma_k \frac{1}{1-(1-\hat{p}_{pk})(1-\hat{p}_{sk})},$$

$$\mathrm{var}\widehat{N} = \sum_k \frac{1}{1 - (1 - \hat{p}_{pk})(1 - \hat{p}_{sk})}(1 - \hat{p}_i)$$

MARK 7.1 software was used for conducting the analysis. Channel type and radial distance to dolphin were included as covariates. The effect of the covariates was scaled on the basis of Akaike's Information Criterion (AIC) (Akaike, 1973) and the best-fit model was selected based on the minimum AIC value. We also considered the models whose AIC values differ from the best fit model by less than 2 following the rules of thumb by Burnham and

Anderson (2002) which means that these models have approximately equal weight in the data.

d. Habitat and Anthropogenic factors.

   i. Encounter rates of dolphin presence in different channel type and depth ranges across the seasons was estimated.

   ii. Percentage counts of different habitat type were calculated.

   iii. Encounter rates of various anthropogenic activities were estimated.

   iv. Chi-square test was done to estimate the difference in dolphin occurrence in different habitat types.

   v. Chi-square test was done to estimate the difference in dolphin occurrence in the presence of various intensity of anthropogenic activities.

3.3. Results (Seasonal Distribution and Abundance)

3.3.1. Seasonal Total Transect Effort

The transect effort for all the seasons were about 64km on average. Seasonal rough currents in high water season and very low depth in low water season make the river inaccessible due to which transect effort could not be evenly distributed. However, the major distributional ranges of the animal in the river had been covered in all the seasons (Table 3.3., Fig. 3.3-3.5).

Table 3.3 Showing seasonal transect effort in Kulsi river survey.

Seasons	**Month of Survey**	**Effort (km)**	**Effort (hrs)**
Pre-monsoon, 2012	April	63.5	13:04
Monsoon, 2012	July	63.2	11:33
Post-monsoon, 2012	November	65	13:47
Winter, 2013	Jan-Feb	60.2	12:10
Pre-monsoon, 2014	June	69	14:27
Pre-monsoon, 2016	May	63	15:02
Monsoon, 2016	July	62	06:19
Post-monsoon, 2016	November	65	09:44

3.3.2. Seasonal Encounter rates

The overall average encounter rate of Ganges dolphins (including the total survey efforts) is about 0.27 dolphins/km (SE= 0.04). However, we estimated a higher encounter rate during post-monsoon seasonal survey in 2012 followed by monsoon survey in 2012 (Table 3.4). On the other hand, population estimation surveys carried out during 2016 had low but nearly constant encounter rates (Table 3.4). However, the difference was not significant across all seasons (p-value>0.5).

Table 3.34 Showing seasonal linear encounter rates of Ganges dolphins in Kulsi river.

Seasons	Encounter rate (dolphins/linear km)	SE
Pre- monsoon, 2012	0.17	0.02
Monsoon, 2012	0.37	0.04
Post-monsoon, 2012	0.34	0.02
Winter, 2013	0.45	0.02
Pre-monsoon, 2014	0.23	0.01
Pre-monsoon, 2016	0.20	0.01
Monsoon, 2016	0.23	0.01
Post-monsoon, 2016	0.18	0.07

Calve population was encountered less than non-calve population in all seasons (t=-2.99, p=0.01) (Fig.3.2.).

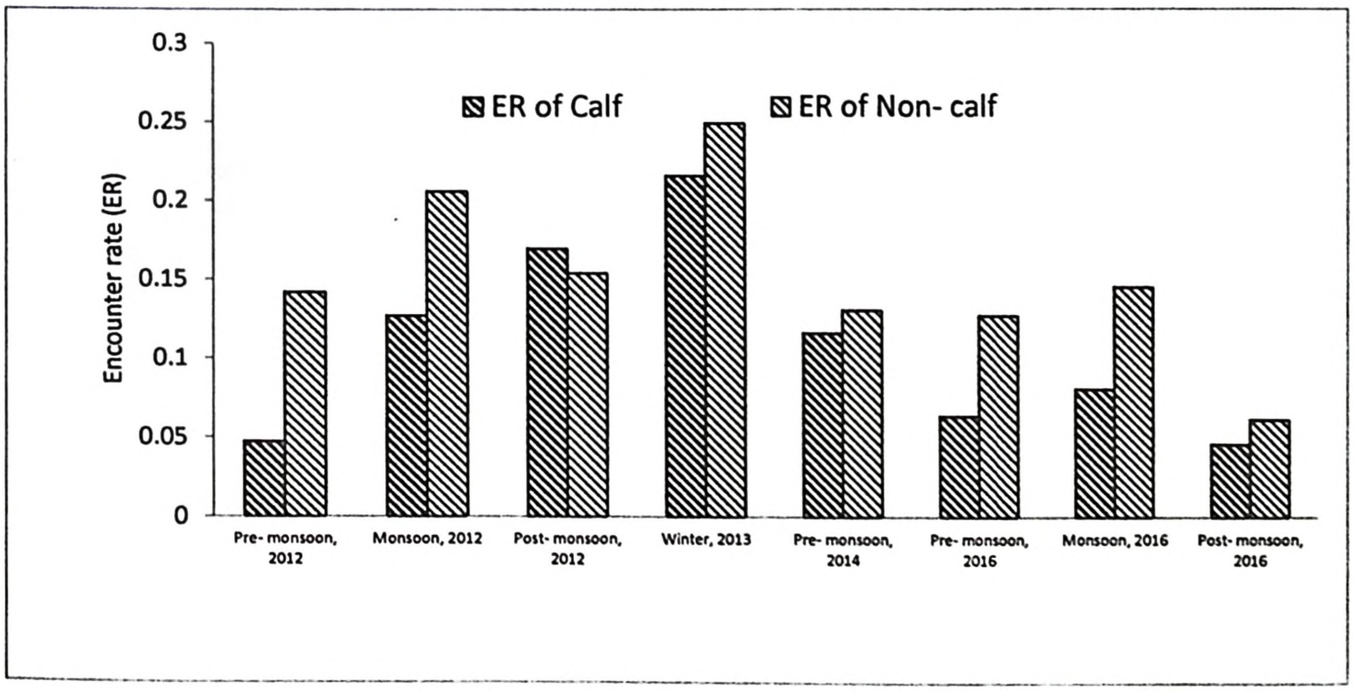


Figure 3.2 Graphical representation of seasonal encounter rates of calves and non- calves population of Ganges dolphins during Kulsi river population estimation surveys.

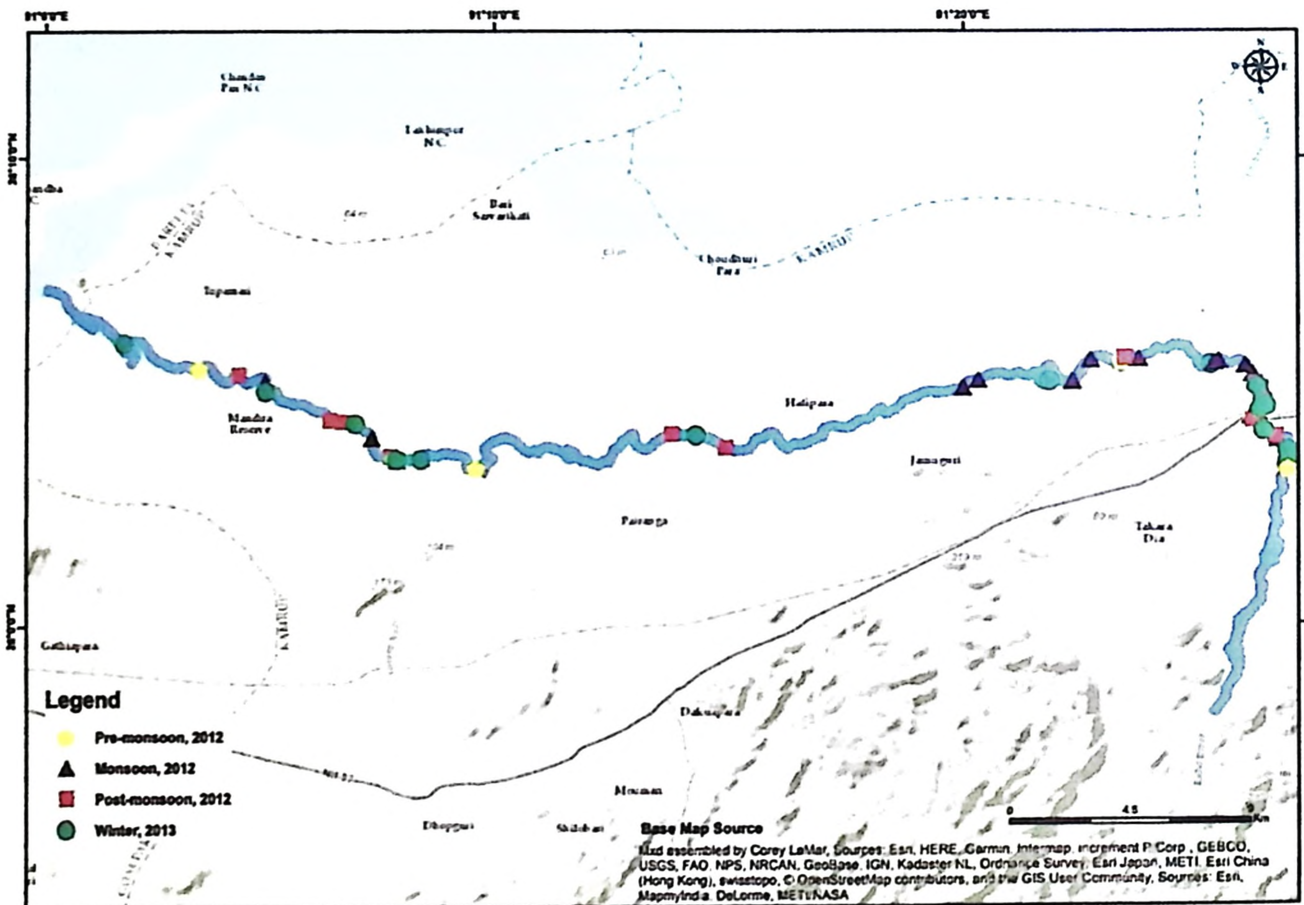


Figure3.3 Dolphin sightings during 2012 seasonal surveys.

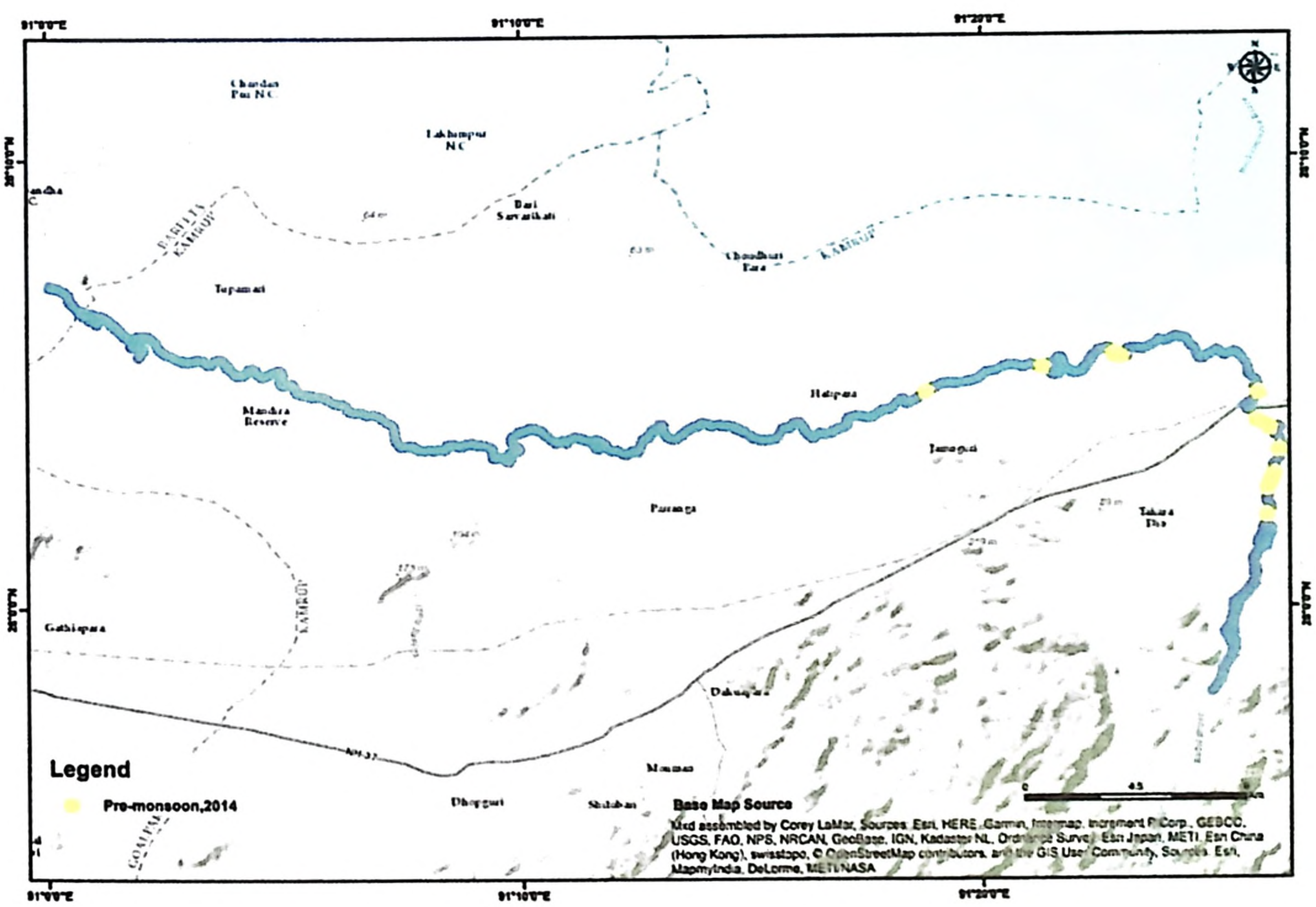


Figure 3.4 Dolphin sightings in 2014 post-monsoon survey.

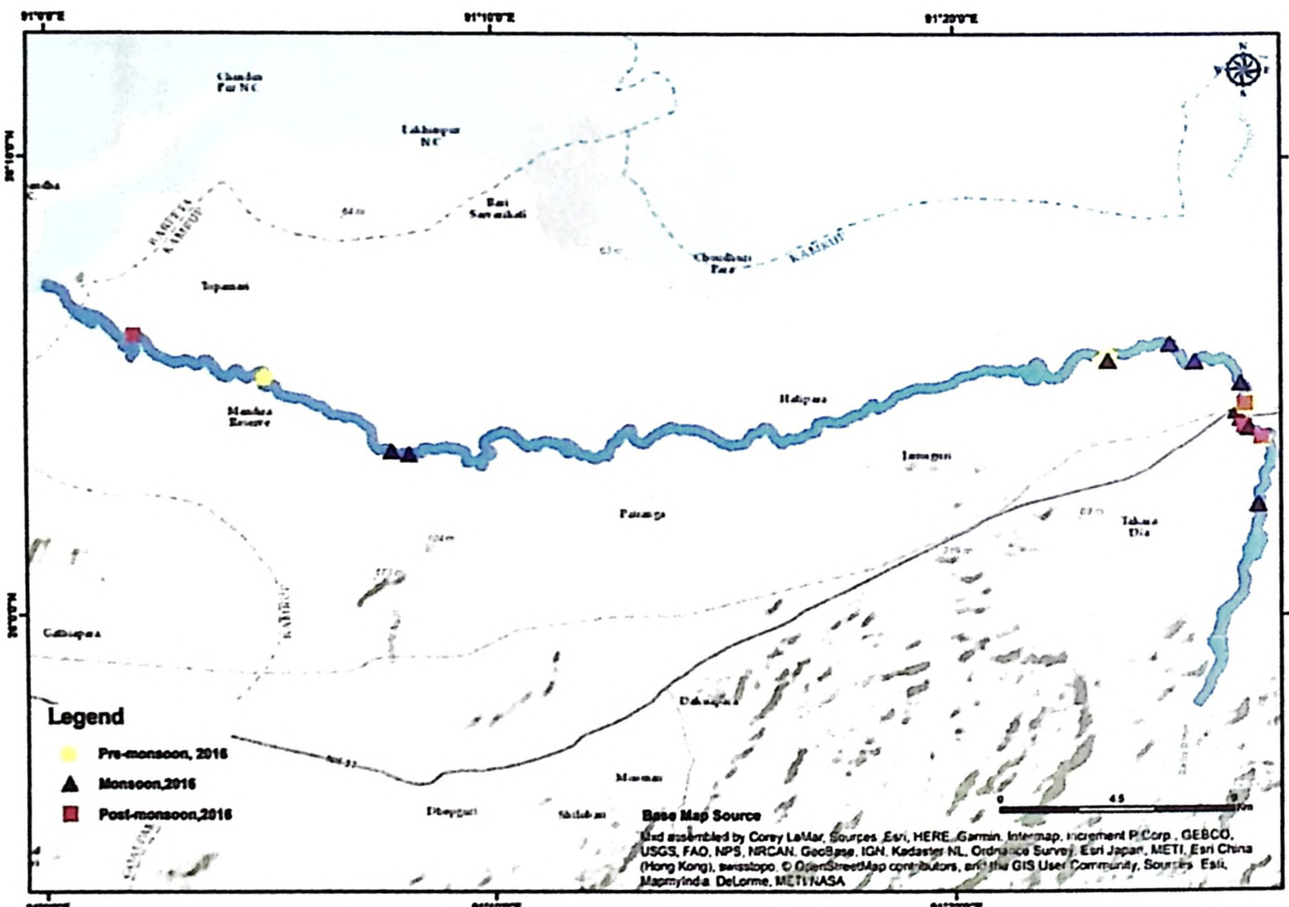


Figure3.5 Dolphins Sightings during 2016 seasonal surveys

3.3.3. Seasonal Abundance estimate with Null and Huggins

Although null estimate gave lower AIC values for few of the surveys, the model in others gets improved with the inclusion of covariates (radial distance, channel type, and depth) using Huggins estimator (Appendix 1). The estimates of pre-monsoon seasonal surveys in 2012 and 2016 were almost similar. However, the population estimates in 2016 shows lower estimates comparatively than 2012-13 and 14 surveys (Table 3.5.). Estimates of population varied with seasons in Kulsi river (χ^2=38.59, df=7, p-value=0.001).

Table 3.35 Showing population estimates of Ganges dolphins in Kulsi river with Lincoln-Petersen and Huggins estimator.

Year	Season	Estimate	SE	LCI	UCI	p-value	SE
2012	Pre-monsoon	14	1	14	19	0.83	0.08
2012	Monsoon	49	7	40	72	0.47	0.08
2012	Post-monsoon	35	3	32	46	0.64	0.08
2013	Winter	38	4	34	51	0.57	0.07
2014	Pre-monsoon	25	3	21	36	0.57	0.09
2016	Pre-monsoon	16	1	15	21	0.81	0.09
2016	Monsoon	19	1	18	25	0.76	0.09
2016	Post-monsoon	22	4	18	36	0.52	0.11

3.3.4. Acoustic survey results

Due to logistical issues in acoustic tags, only three season data could be utilised for population estimation. Highest estimation was in monsoon season followed by winter season (Table 3.6.)

Table 3.36 Population estimation with Acoustic survey.

Year	Season	Estimate	SE	LCI	UCI	p-value	SE
2012	Monsoon	60	4	55	73	0.48	0.05
2012	Post-monsoon	36	1	35	40	0.72	0.05
2013	Winter	39	1	38	44	0.72	0.06

The correction factor for each season was estimated by using the A-tag estimate with Huggins. The average estimate of the correction factor for monsoon season was more than post-monsoon and winter seasons (Table 3.7.).

Table 3.37 The unseen part due to availability bias during the visual survey in different seasons.

Year	Season	Average Estimate	SE
2012	Monsoon	1.27	0.07
2012	Post-monsoon	1.05	0.02
2013	Winter	1.05	0.12

3.3.5. Habitat analysis

a. Percentage coverage of Channel types

The percentage of change in the occurrence pattern of different channel types of Kulsi river was observed (Fig.3.6.). There was a significant difference in the seasonal changes of channel types in Kulsi river (F=4.59, df=3, p=0.009). The occurrence pattern on Ganges dolphins in different channel types was significantly higher in meanders (F=3.34, df= 3, p=0.03, Fig. 3.7.). To further understand the usage of different channel types, Ivlev's Index was used to quantify the availability of the channel type and its usage (Ivlev, 1961). It indicates that the meanders and confluences were used more (χ^2= 2.601E-185, df= 3, p=0.0001, Fig. 3.8). During 2016 surveys, the use of confluence gradually decreases and during 2016 post-monsoon survey no dolphins were recorded in the confluence (Fig. 3.8.).

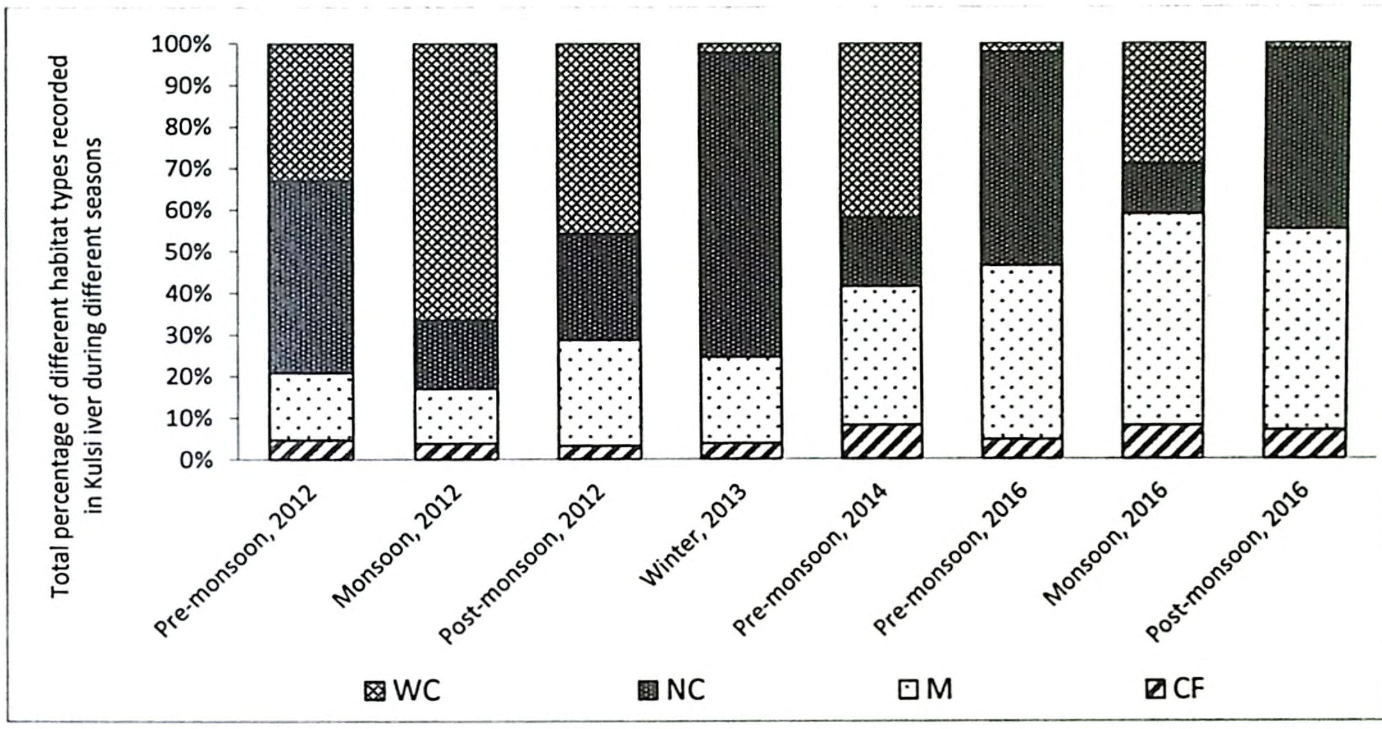


Figure 3.6 Percentage occurrence of different channel types in different seasons in Kulsi river (WC= wide channel, NC= Narrow channel, M= Meander, CF= Confluence).

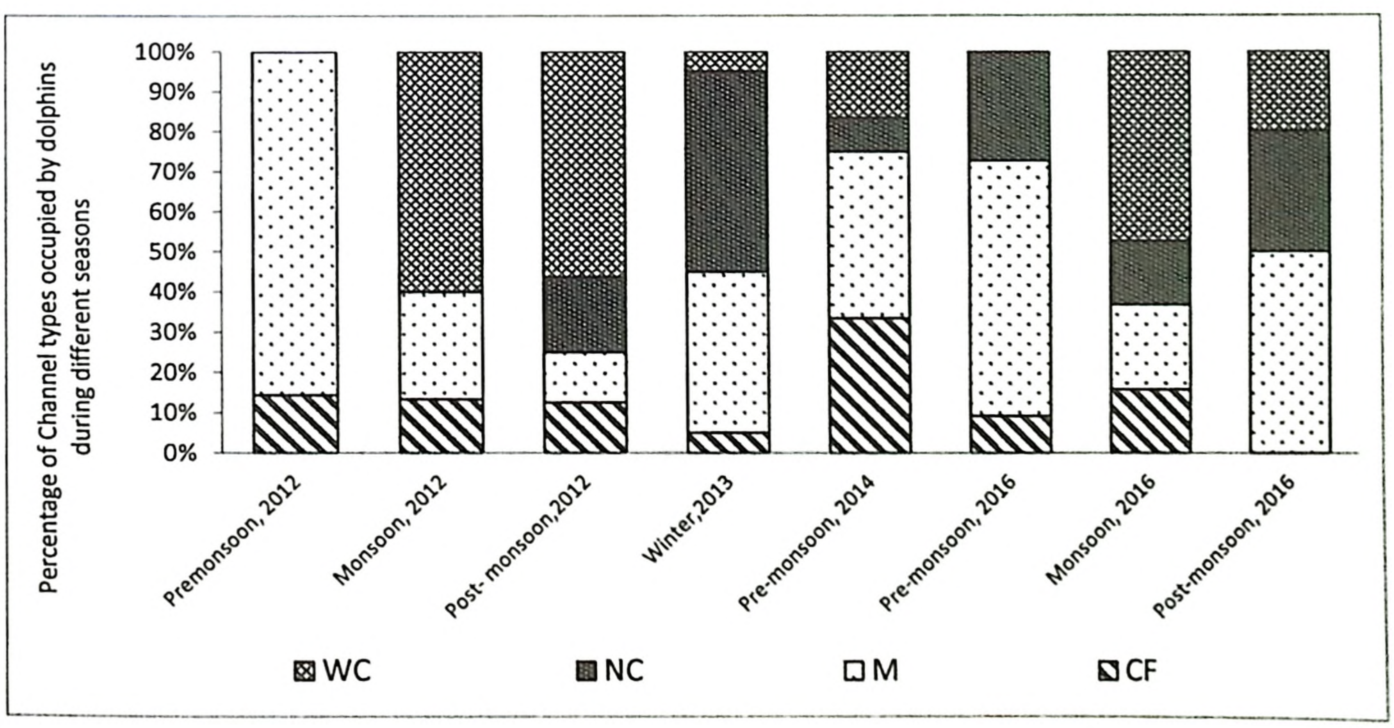


Figure 3.7 Percentage observation of Ganges dolphins in different channel types during different seasons in Kulsi river (WC= wide channel, NC= Narrow channel, M= Meander, CF= Confluence).

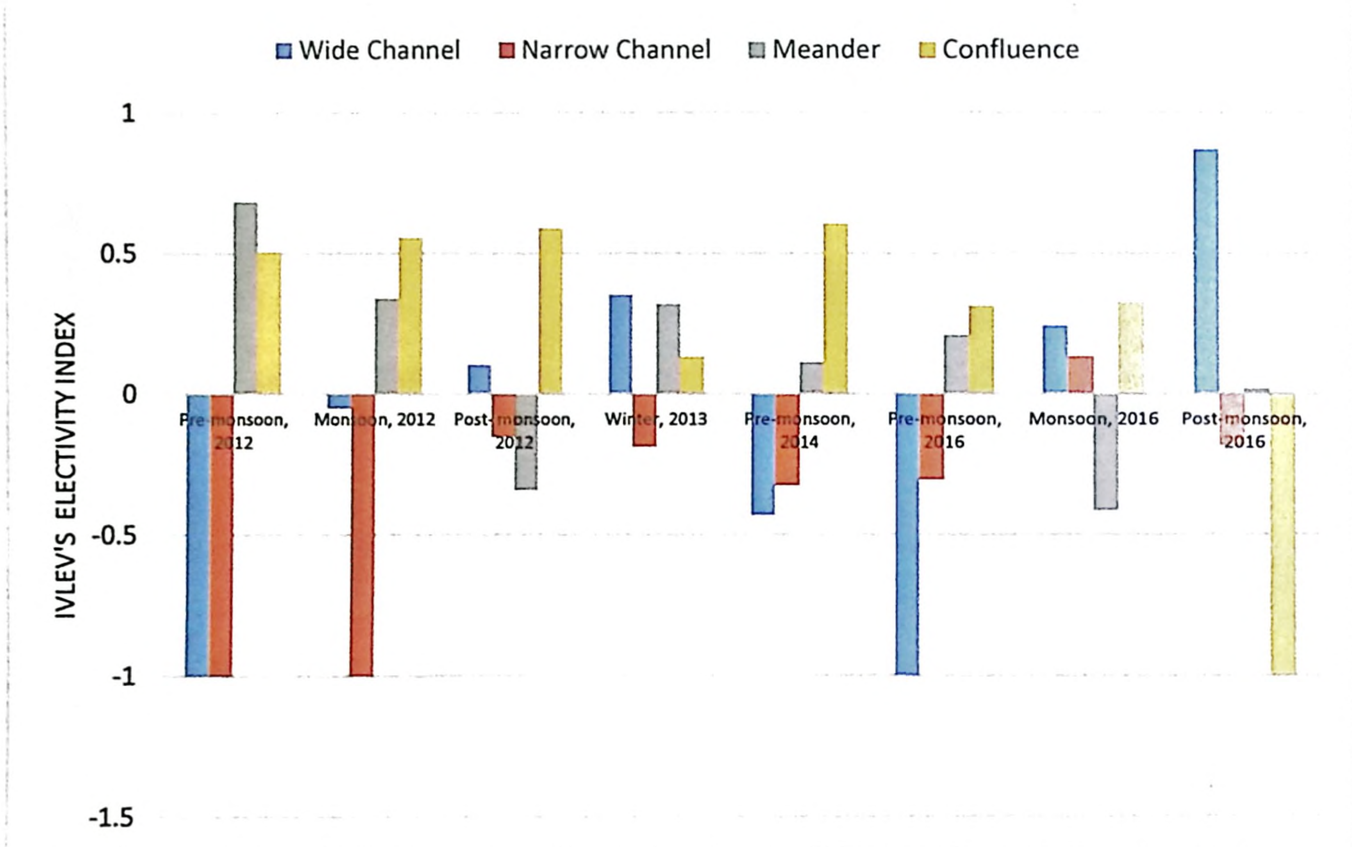


Figure 3.8 Ivlev's electivity index for habitat preference by Ganges dolphin in Kulsi river.

b. Percentage coverage of Seasonal Depth ranges:

The depth of the Kulsi river changes a lot during different seasons. It ranges from as shallow as 1m in Pre-monsoon season to more than 9m in Monsoon season (Fig.3.9.). However, the deep pools (>8m) were always present throughout the seasons.

Dolphins were recorded at a minimum depth of 1m only during pre-monsoon seasons (Fig.3.10.). In all other seasons, they were recorded above 2m depth. Chi-square test has shown a significant difference of occurrence pattern of Ganges dolphin in different channel depths (Table 3.11).

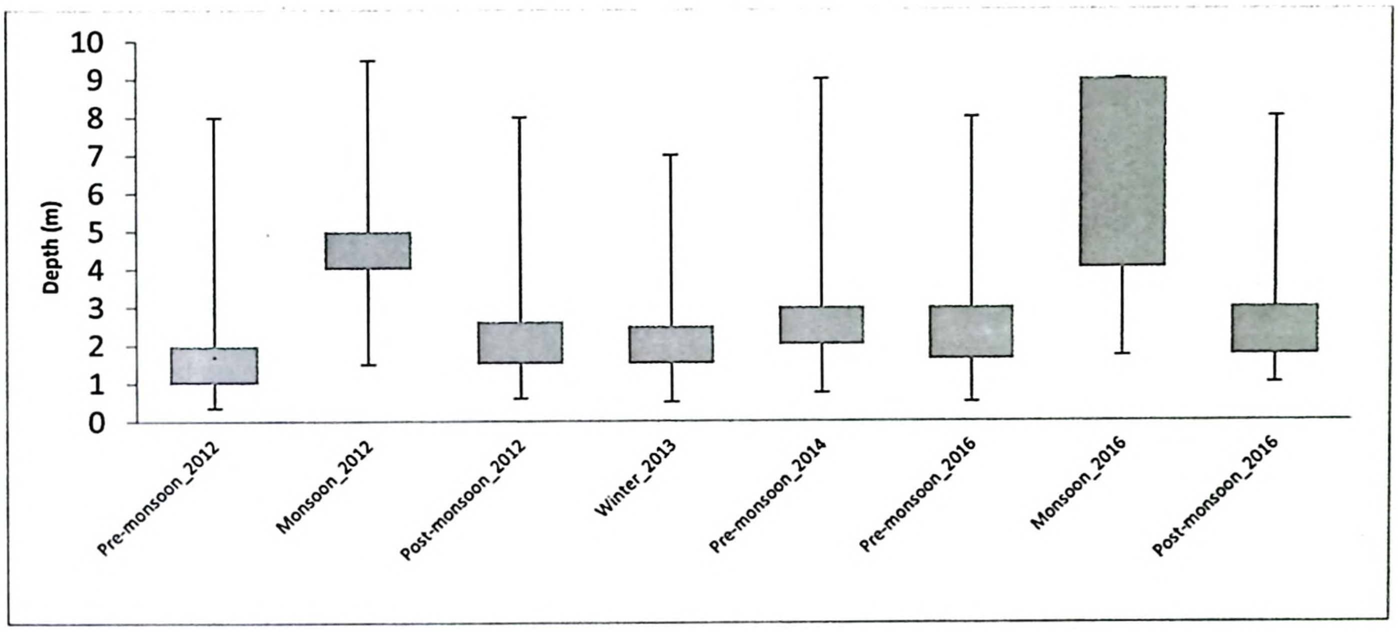


Figure 3.9 Seasonal Depth ranges in Kulsi river.

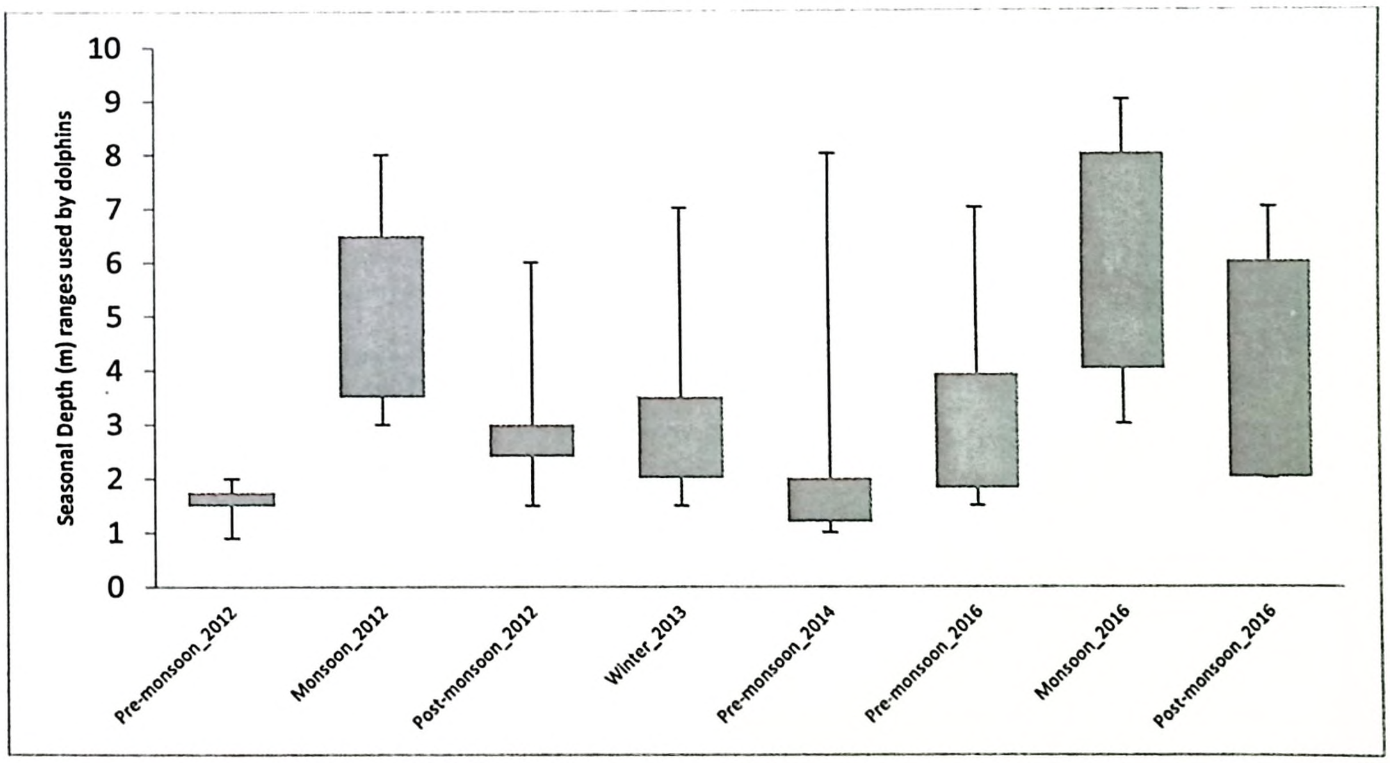


Figure 3.10 Depth preferences of Ganges dolphin in different seasons in Kulsi river.

3.3.6. Anthropogenic activities

i. Fishing Activities encounter rates:

Encounter rates of gill nets was higher in post-monsoon seasons. Mosquito net was encountered moderately throughout all the seasons, hook fishing was encountered most in low water seasons from post to pre-monsoon seasons, overall cast net fishing encounter rate was lower in comparison to other fishing activities although encountered minimally throughout all seasons. Lift net fishing was higher during monsoon season followed by post-monsoon season and Jeng (enclosure) fishing was higher during the low water seasons from post- to pre-monsoon seasons (Table 3.11.).

Table 3.8 Encounter rates of fishing activities (per km) recorded during the Ganges dolphin population surveys in Kulsi river.

Season	Fishing Boat	Gill Net fishing	Mosquito Net fishing	Hook fishing	Cast Net fishing	Lift-Net fishing	Jeng (Enclosure) Fishing
Pre-monsoon, 2012	2.33	0.33	0.46	0.46	0.35	0.31	1.24
Monsoon, 2012	0.92	0.05	0.22	0.05	0.46	4.79	0
Post-monsoon, 2012	1.72	0.69	0.29	3.4	0.28	2.86	2.06
Winter, 2013	1.64	0.38	0.27	0.56	0.2	1.1	3.02
Pre-monsoon, 2014	0.90	0.12	0.22	0.28	0.33	2.20	0.29
Pre-monsoon, 2016	0.46	0.06	0.14	1.25	0.35	1.13	0.86
Monsoon, 2016	0.35	0.18	0.02	0.00	0.00	2.60	0.00
Post-monsoon, 2016	2.03	0.42	0.18	4.43	0.49	1.80	2.78

Chi-square results show a significantly higher dolphin occurrence in low fishing pressure areas (Table 3.11).

ii. Sand mining activities encounter rates:

The encounter rate of sand mining activities such as recording sand mining boats and sand stocking areas (Ghats) remain constant in all seasons. The use of sand mining pumps has increased only after 2014 (Table 3.9). The stocking areas have also increased along the bank of Kulsi river in the preceding surveys (Table 3.9).

Table 3.3 Showing encounter rates of sand mining activities (per km) recorded during the Ganges dolphin population survey in Kulsi river.

Season	**Sand Mining Boat**	**Sand Mining Ghat**	**Sand Mining Pump**
Pre-monsoon, 2012	8.92	0.14	0
Monsoon, 2012	4.81	0.22	0
Post- monsoon, 2012	5.82	0.43	0
Pre-monsoon, 2014	2.32	0.33	0
Pre-monsoon, 2016	2.98	0.52	0.46
Monsoon, 2016	1.15	0.03	0.05
Post-monsoon, 2016	3.14	0.43	0.69

Chi-square results show a significantly higher dolphin occurrence in low sand mining areas (Table 3.11).

iii. Encounter rates of other anthropogenic activities:

The use of irrigation pumps has been recorded in all the seasons however the use was seen more during the post-monsoon season (Table 3.10.). Human bath ghat was always encountered in higher rates in Kulsi river and the Ferry crossing is a chance record which hence cannot be shown as seasonal comparison of occurrence.

Higher dolphin occurrence was observed in areas without ferry crossing, irrigation pumps and with less human bathing during the surveys (Table 3.11).

Table 3.310 Showing encounter rates of other human activities (per km) recorded during the population survey of Ganges dolphins in Kulsi river.

Season	Ferry Crossing	Human Bath	Irrigation pumps
Pre-monsoon, 2012	1.35	7.81	2.64
Monsoon, 2012	1.25	5.09	0.26
Post- monsoon, 2012	0.30	3.33	0.90
Winter, 2013	0.82	0.95	0.02
Pre-monsoon, 2014	0.27	0.19	0.02
Pre-monsoon, 2016	1.06	6	0.32
Monsoon, 2016	0.11	6.23	0.15
Post-monsoon, 2016	1.15	6.6	1.11

Table 3.3 Chi-square test results for dolphin occurrence with various covariates.

Habitat Types/ Anthropogenic activities	χ^2	df	p-value
Depth	91.91	28	0.001
Cultivated land presence	0.97	1	0.76
Fishing Activities	58.27	3	0.001
Sand mining activities	94.74	3	0.001
Human habitation	53.8	3	0.001
Human Bath	391.4	6	0.001
Irrigation	240.5	3	0.001

3.4. Discussion

The independent double observer capture-recapture method in Kulsi partially solved the major sources of error in cetacean surveys. Detection probability increases by correcting perception bias (or observer bias occurred due to observer fatigue) in two independent observer method. Further, the model gets corrected with the inclusion of various covariates viz., radial distance to the animal, depth and channel types during different seasons as the detection probability gets affected by these factors. Similar results were also observed for

Ganges dolphin population estimation in Bangladesh Sunderbans (Smith, 2006) and in Indus (Braulik et al., 2012).

The method for Kulsi river becomes robust with the introduction of Acoustic hydrophones along with visual method (Akamatsu et al., 2008, Richman et al., 2014). The second type of bias i.e., availability of the animal during the passing mode survey method has been addressed with the help of underwater transect done with acoustic tags. The Huggin's model was further improvised with the capture history recorded by acoustic tags. Although the part missed by visual observers in Kulsi river was small which can be confirmed by the correction factor calculated using Acoustic data.

The seasonal surveys lead us to the changing population structure of Ganges dolphins along with the seasonal changes in hydrological factors of Kulsi river. The observed significant seasonal fluctuation in the population reveals that there could be movements of the population between Kulsi, its tributaries and main stem of the Brahmaputra River. Among the three sets of pre-monsoon surveys, the 2012 survey was done in the leanest period (in April) compared to the other two surveys (June 2014 and May 2016) when the first shower begins in Assam. According to the meteorological department of India reports, monsoon and post-monsoon rainfall in Kamrup district were less in 2016 compared to previous year's rainfall (Fig.3.11.). This can be one of the reasons for comparatively fewer encounter rates of Dolphins during this period compared to the previous year surveys of the same seasons.

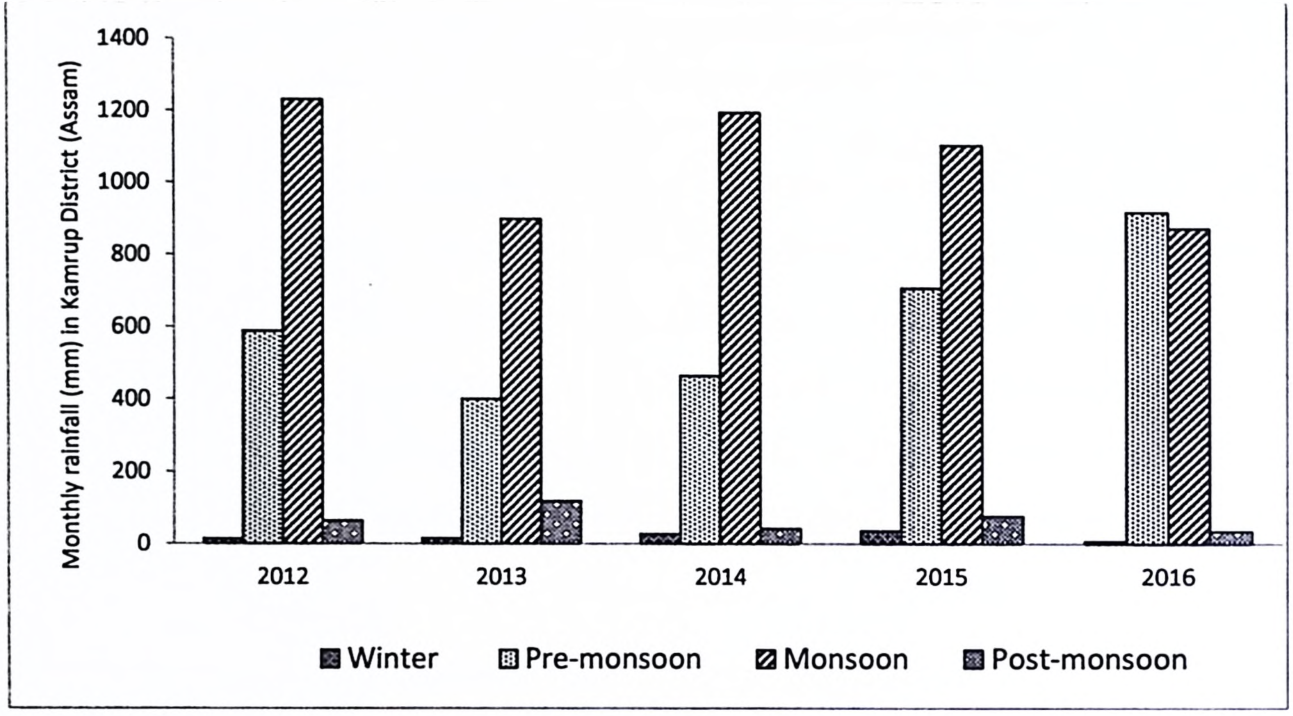


Figure 3.11 Seasonal rainfall data (mm) in Kamrup District, Assam (Source: Report no. ESSO/IMD/HS/R.F. Report/02(2013)/16, Report no. ESSO/IMD/HS/R.F. Report/02(2014)/18, Report no. ESSO/IMD/HS/R.F. Report/01(2016)/19, Report no. ESSO/IMD/HS/R.F. Report/04(2016)/22, Report no. ESSO/IMD/HS/R.F. Report/01(2017)/23).

On the other hand, monsoon (49 dolphins) and winter (38 dolphins) seasons show higher estimates during 2012 surveys. In monsoon, water level in the Brahmaputra main stem rises due to flood and facilitates dolphin to move towards Kulsi. Similarly, in winter, movement of dolphins from the tributaries towards main stem Kulsi could be a reason behind more sightings. This shows the migrating behaviour of Ganges dolphins (Kasuya and Haque, 1972). In pre-monsoon and post-monsoon seasons, maximum sightings were in meanders. This behaviour is also suggested by other studies (Kasuya and Haque, 1972; Smith 1993). The eddy currents in meanders increase the flow of micronutrients. This facilitates growth in plankton population in meanders and attracts fishes. This is turn attracts the dolphins towards these multispecies fish pools (Cummings et al. 1984, Sedell et al. 1984). In Brahmaputra and Sunderbans of Bangladesh also, a high correlation was established between dolphin presence and confluences (Biswas and Baruah, 2000 and Smith et al., 2009). The depth of the Kulsi river ranges from less than 1m in low water seasons (winter to pre-monsoon) to more than 9 m in high water season (monsoons). However, the dolphins irrespective of the changes in the river morphology prefer depth ranges from 2 m to 8-9 m. In Kulsi, during lean water seasons few observations were made in stretches with less than 2 m depth but not less than 1m depth. This might be because of the inaccessibility to higher depth range during low water season. In Indus dolphins, it was observed that during low water season they prefer significantly greater mean depth, maximum depth, cross-sectional area and hydraulic radius and significantly narrower river width and a low degree of braiding areas (Braulik et al., 2012). In the case of Irrawaddy dolphins, they seem to prefer low-velocity deep pools during dry seasons (Baird and Beasley, 2005; Beasley, 2007).

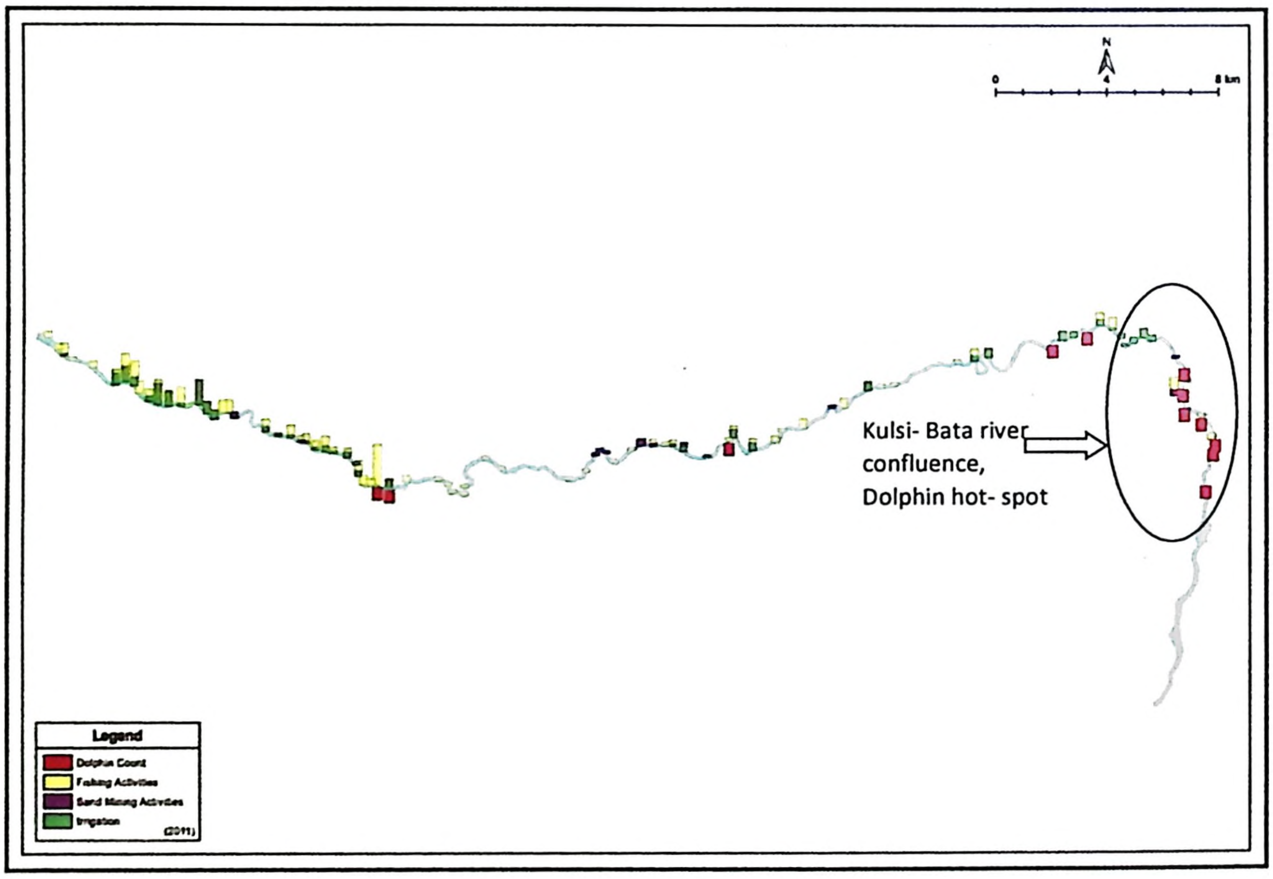


Figure 3.12 Distribution of Ganges dolphin vs Anthropogenic activities in 2011 (Red columns: Dolphin sightings, Yellow columns: Fishing activities, Purple columns: Sand mining activities, Green columns: Irrigations pumps)

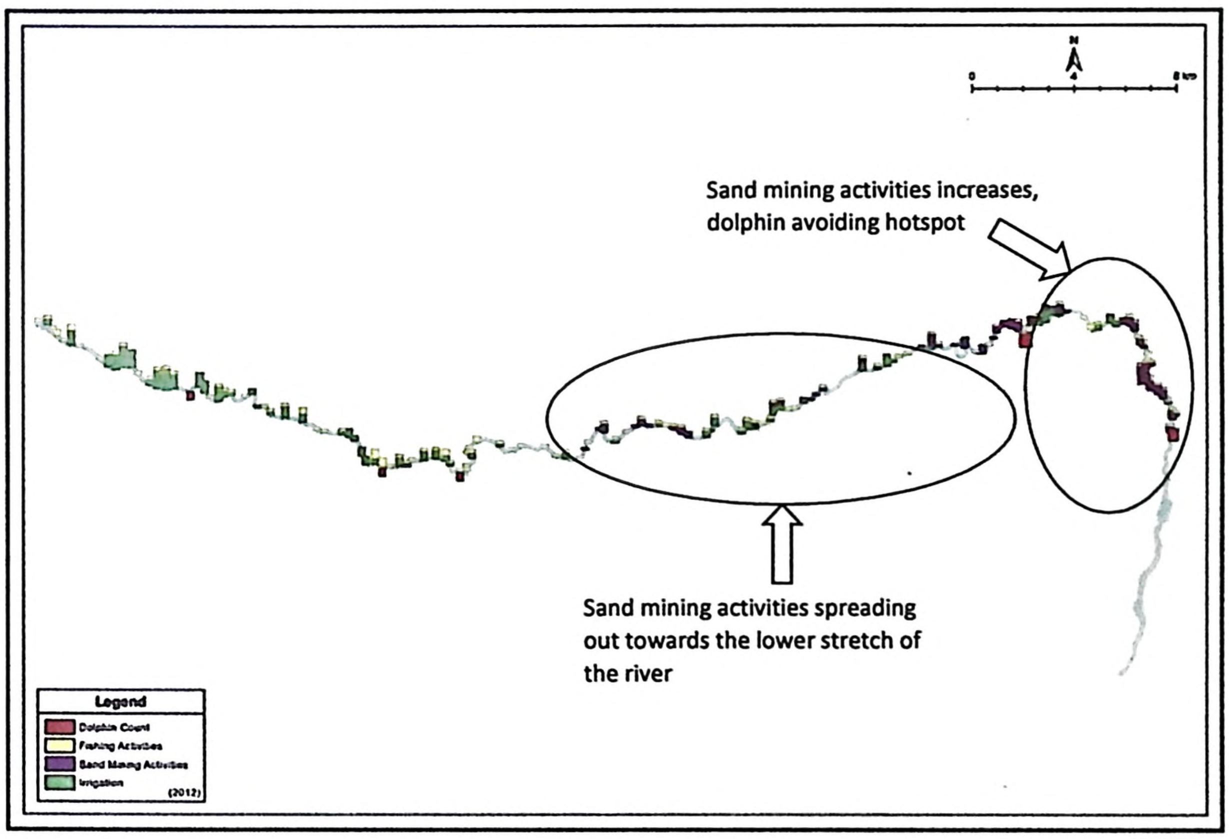


Figure 3.13 Distribution of Ganges dolphin vs Anthropogenic activities in 2012 (Red columns: Dolphin sightings, Yellow columns: Fishing activities, Purple columns: Sand mining activities, Green columns: Irrigations pumps).

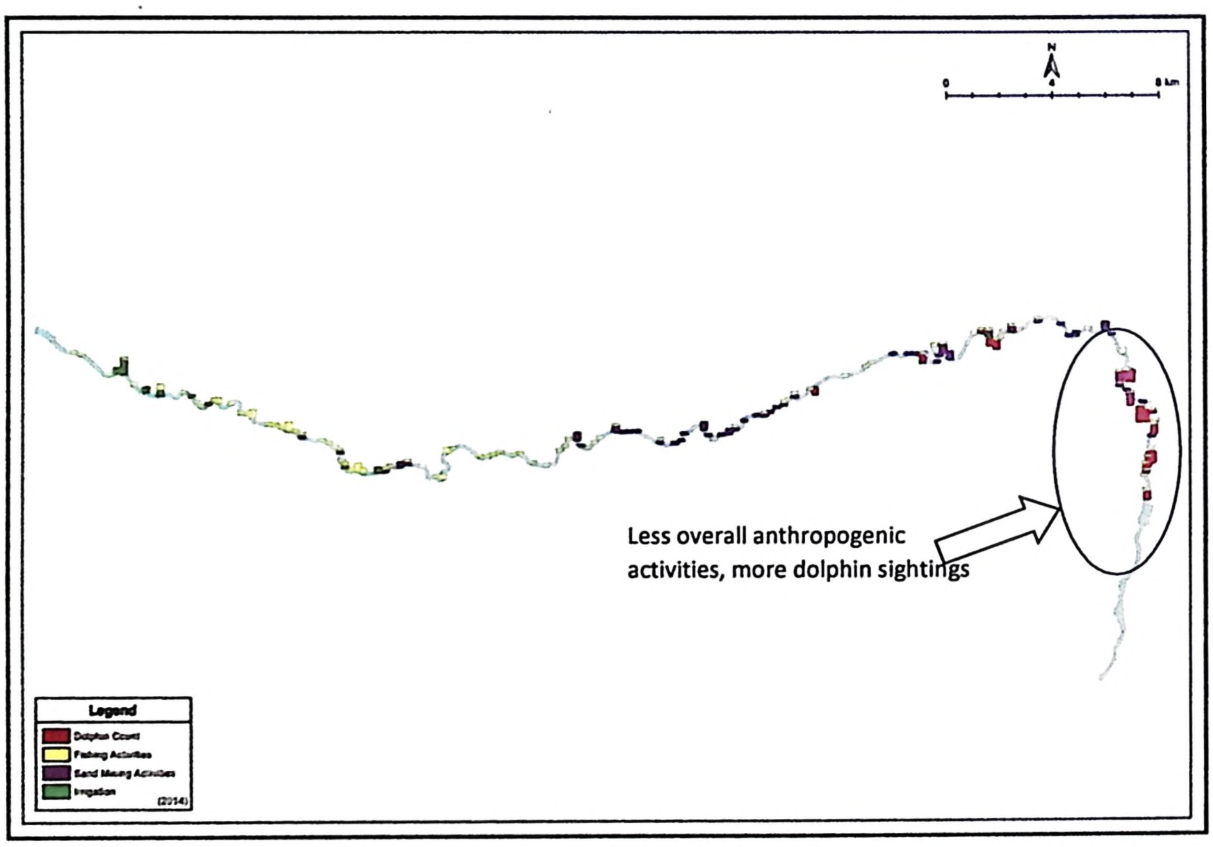


Figure 3.14 Distribution of Ganges dolphin vs Anthropogenic activities in 2014 (Red columns: Dolphin sightings, Yellow columns: Fishing activities, Purple columns: Sand mining activities, Green columns: Irrigations pumps).

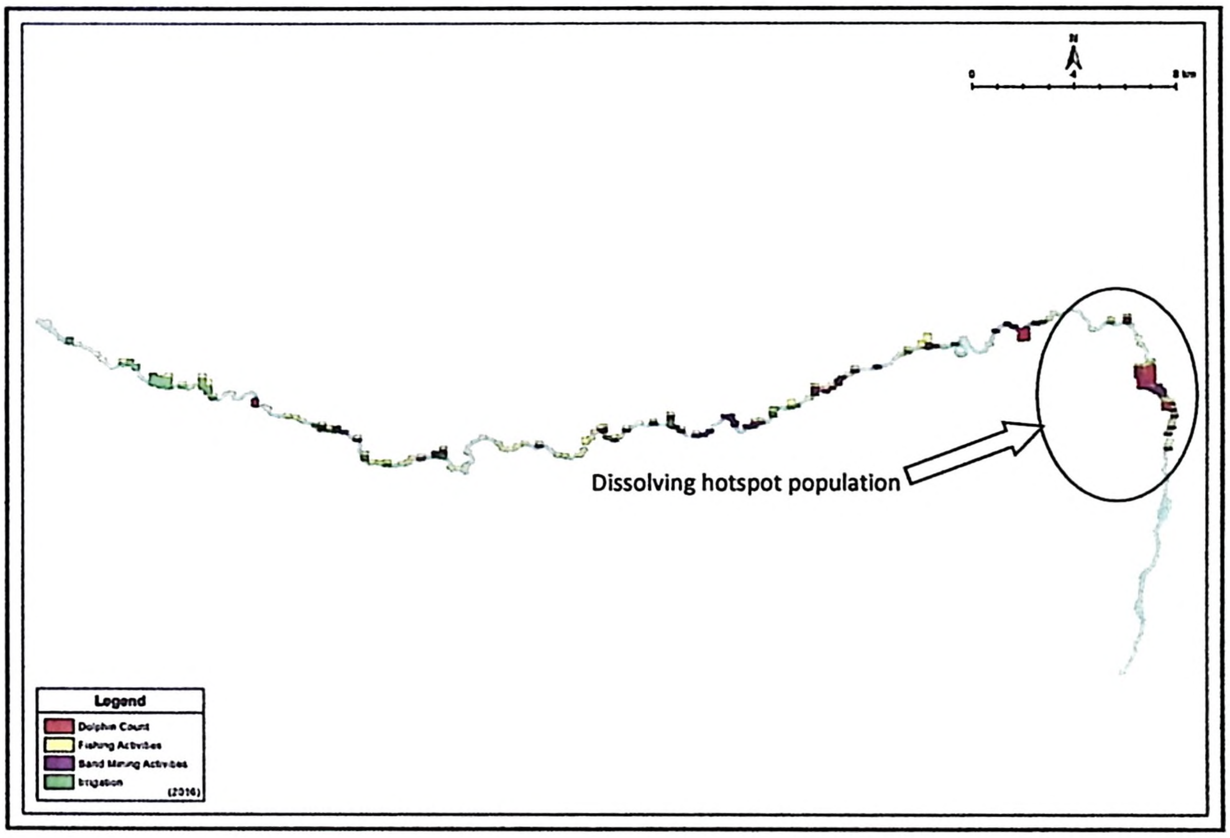


Figure 3.15 Distribution of Ganges dolphin vs Anthropogenic activities in 2016 (Red columns: Dolphin sightings, Yellow columns: Fishing activities, Purple columns: Sand mining activities, Green columns: Irrigations pumps).

The identified hot-spot of dolphin presence from the study is the Kulsi and Batha River confluence (Fig. 3.12). In 2011, during pre-monsoon survey, the hot-spot area had very few anthropogenic activities and the dolphins were observed to be present from hot-spot area to further upstream (Deori et al., 2011, Fig.3.12). The anthropogenic activities in the hot- spot started to increase from 2012 onwards. The dolphin distribution permanently got fragmented as observed in the consecutive surveys (Fig.3.13) that no dolphins were sighted between hot-spot and upstream stretch of Kulsi river. In 2014, during pre-monsoon survey, also the anthropogenic activities were observed to be reduced than in 2012 and an increase in dolphin sightings was observed (Fig.3.13-14) as well. The dolphin population estimate was 25 during pre-monsoon survey of 2014, which was more than the estimates of pre-monsoon survey in 2012 (14 dolphins). Till 2014, uniform usage pattern of confluence was seen throughout the seasons was observed in Kulsi. In 2016 surveys, it was observed that the use of confluence declined gradually and in post- monsoon surveys no dolphins were recorded in the confluence of Kulsi. Apparently in 2016, the anthropogenic activities were observed to be intensive than all the previous surveys (Fig.3.15). It is to be mentioned that the mechanised sand mining was observed for the first time in the upstream of hot-spot area. The mechanised way of sand mining contributed more towards the overall intensity of anthropogenic disturbances in 2016. Although such fluctuations in dolphin sightings are hard to explain, but at the same time we cannot deny the fact that dolphins tend to avoid areas with more intensive disturbances. The lowest number of sightings (19) during monsoon survey in 2016 could be argued as dolphins tend to move towards the tributaries of Kulsi but overall reduction in dolphin sighting in all the seasonal surveys in 2016 could be a co-incidence triggered by the anthropogenic activities. Calves were seen in all seasons. However, the frequency was higher in low water seasons, from post-monsoon to winter season. Similar results were also seen in Amazon River Dolphins(Inia geoffrensis) (Aliaga-Rossel, 2002). A study on the reproductive behaviour of Amazon River Dolphins (Inia geoffrensis) throughout Amazon and Orinoco River basin revealed that reproduction in Inia often occurs year-round, with seasonal peaks varying according to geographic locations (Mcguire et al., 2007).

Seasonal changes in riparian types were also observed in Kulsi riverbank. The reason behind this is the annual flood which mostly affects the downstream areas of Kulsi. Majority of area is covered with cultivated land whose main source of irrigation is Kulsi river during lean water seasons. Higher number of irrigation pumps was also recorded during post-monsoon to pre-monsoon seasons for paddy cultivation (Irri). Since Kulsi is a rain-fed river, pumping out of water for irrigation during the lean period is an additional cause for low water level in Kulsi river. Apart from this, over-irrigation can lead to degradation of freshwater ecosystems and fisheries (Petr and Mitrofanov 1998, Dudgeon 2000).

Fishing activities occur irrespective of fish ban season according to Assam fishery rules (1953). Fishing activities were encountered in all the seasonal surveys in Kulsi river. Dolphins in Kulsi river were sighted in areas with low to medium fishing pressure (low= zero to one; medium= more than one to five, High= More than five fishing activities) during the surveys. Similar results were also found in Vikramshila sanctuary where the dolphins were seeming to be avoiding fishing zones with higher fishing activities (Kelkar et al., 2010). The mosquito net fishing was encountered in all the seasonal surveys in Kulsi river which is totally banned according to Assam fishery rules. This type of fishing nets collects all size classes of fish species including the spawns and thus affecting the fish recruiting process. In Vikramshila sanctuary, a high correlation was found between the presence of fish catches and dolphin gut content, showing a higher degree of resource overlap between them (Kelkar et al., 2010).

Kulsi is also used as a major source of transportation. Congregation of motor boats (Ferry) occurs during the weekly markets viz., Champupara bazaar, Chamariya bazaar and Nagarbera bazaar along the Kulsi bank. The impact of motor boats on the distribution of Ganges dolphin was beyond the scope of these surveys as these were chance records, however new studies have revealed that ship noises can affect the echolocating Ganges dolphins and can increase the metabolic stress (Dey et al. 2019). The study of impact of ship noise on Ganges dolphin in a narrow river like Kulsi can be considered as further area for research.

CHAPTER 4: EFFECTS OF DIFFERENT HUMAN ACTIVITIES WHICH CAN POSSIBLY AFFECT THE HABITAT AND DISTRIBUTION PATTERN OF DOLPHINS IN KULSI RIVER

4.1. Introduction

Kulsi river is one of the smallest tributaries of the Brahmaputra River but the riverscape is highly populated. The riverscape of Kulsi can be classified into mosaics of land patterns such as forest land, shrublands, grasslands, cultivated lands, islands etc., which are used as resources by different communities of people residing. As we move down the river starting from Ukiam to Nagarbera, we can feel the changes in culture, perceptions, standard of living and their dependency on Kulsi. We can see the old villages which were mainly on the upstream of Kulsi river. Some new settlements could also be seen which are formed as a result of alternative livelihood generation and as refuge for emigrated people from flood affected areas of the Brahmaputra.

The people of this area have two main occupations, namely fishing and cultivation which they have been traditionally practicing. The Kaibatras and the Namashudras were originally fishers. The Bodo tribes were plain tribes and were originally farmers. The Bengali Muslim community were basically floodplain dwellers and also originally very expert cultivators of Assam. However, with increasing population, these communities were facing land and resource shortage which resulted in extensive resource exploitation along the Kulsi river.

This is how another source of income generation such as sand mining has evolved in Kulsi river. Some 50 years back the communities of Kulsi river discovered the fine sand particles that Kulsi river carries with it from the Khasi hills. Today the construction business is flourishing with the sand of Kulsi river in nearby towns and city.

In the course of time, we see a fistful of people were earning handsome amount of money using various dreadful techniques to extract maximum of resources and directly hampering the balance of nature. We have observed among fishing communities the use of small mesh size fishing gears like mosquito net to reduce the fishing effort and money investment and increase the catch rate. This becomes more dreadful when the operations happened during fish spawning time which actually sieves out the entire new recruitment, i.e., juveniles or fingerlings (Darkey and Turatsinze, 2014; Butunyi and Oloo, 2008; Kelkar, 2014). This could largely decline the productivity of fish in Kulsi river.

The increasing recruitment of sand miners is a serious concern as majority of recruits are fishers and the landless farmers. The demand for sand is increasing with growing construction industry and hence the techniques of mining have been improvised from the traditional manual digging of sand to sand mining pumps. More sands were dug out in less time and labour with pumps. Such non-regulated extraction of sand is actually destroying the entire benthic structure along with the water quality, hence further reducing the primary as well as secondary productivity of the aquatic ecosystem (Nairn R et al., 2004; Asraf et al., 2011; Borges et al., 2002; Dubois and Towle, 1985).

The riparian biodiversity of Kulsi river has been decreasing with time. Most of the shrublands, grasslands, and sandbanks were converted into agricultural lands. Although in monsoon and post- monsoon seasons most of these lands were not accessible due to flood but in dry seasons paddy cultivation (Irri) alongwith cash crops like jute, mustard, coriander, chillies were cultivated. The only source of irrigation is Kulsi river during dry season. In winters hundreds of water pumps were kept running for 10 to 12 hrs a day for three to four months daily to irrigate fields. In places, the Kulsi river turned to a drain exposing the river bed. The greatest water problem of our time is the inability to link environmental security, water security and food security at the management level (Falkenmark, 2001). Many scientific models were generated in last two decades to estimate how much water is required for a river to sustain (Spark et al., 1990; Richter et al., 1997; Smakhtin, 2002). Due to little exposure to such methods and little or no use of those in policy making, developing countries like us is ending up in severe degradation of the aquatic ecosystem (Smakhtin, 2002). The alteration in flow in peak dry season leads to increased stress level in all aquatic organisms especially the stress will be higher in fish and invertebrates (Smakhtin, 2002).

In this chapter quantification of resources extracted from Kulsi river was done. Three major resources, viz. fish, sand and water for irrigation was quantified. The results were compared with other such studies. No direct evidence of impact was recorded for dolphins during the study, however support of secondary information and available relevant literatures were taken into account to draw conclusions.

4.2. Methods

4.2.1. Catch Calendar

A seasonal catch calendar was prepared with the help of local commercial fishermen in 2016. The number of fishermen targeted in each season was dependent on the suitability of fishing conditions and willingness of fishermen to participate in the activity. The fishermen were asked to fish like any normal day without changing their technique of fishing.

Time of every cast was recorded. With every catch, species were identified, measurements for length and breadth was taken and was weighed.

Average species-wise weight per month in different season was estimated. Catch per unit effort for every fishing gear was estimated.

4.2.2. Fish sampling

Fish were sampled with the help of a Cast net (with dimensions 4-metre diameter and 1cm mesh size) and a Gill net (with dimensions 50m length and 2.5cm mesh size). These dimensions were considered for the sampling as these were the average net size used by the fishermen community of Kulsi river. The cast net sampling was done as shown in the Fig.4.1. With three sampling points, (two near the banks of the river and one on the centre to cover the possible microhabitats of the fishes) the nets were laid horizontally to the flow of the river. Whereas the gill net was placed once, covering the river cross-section in each point. Samples were collected in every one kilometre. The cast time for cast net was set to 1minute/cast and for Gillnet 10minute/cast.

Catch per unit effort for both the gears were estimated.

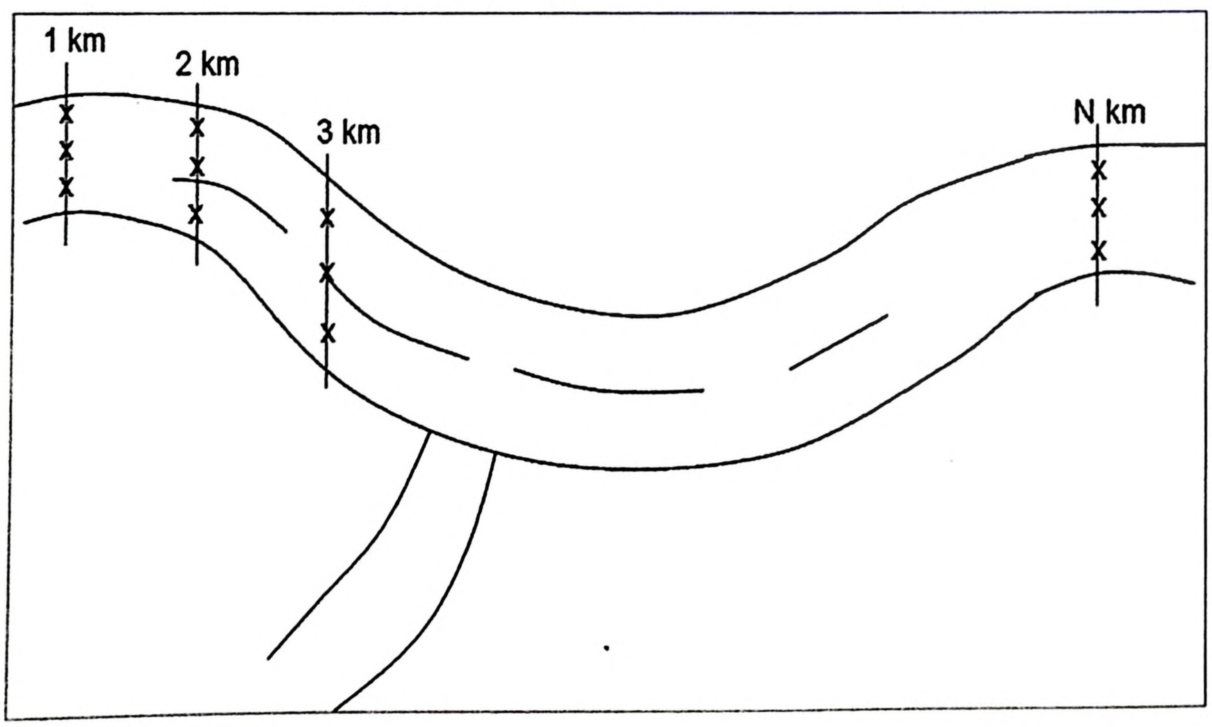


Figure 4.1 Fish sampling method used in Kulsi river.

4.2.3. Fish Landing site survey

Seasonal fish landing site data was collected from three landing sites of Kulsi river, viz., Kukurmara fish landing site, Chammariya fish landing site and Nisilamari Fish landing site. Among them, Nisilamari was the bigger fish landing site followed by Kukurmara and then Chammariya fish landing sites.

From the landing sites, data on fish species composition, weight and fishing gear used to catch them were collected. Price per kilogram for each species was recorded.

Species-wise weight harvested per month in each season was estimated. The total income generated per month and average species-wise price in each season were estimated.

4.2.4. Fishermen questionnaire

A closed-end questionnaire was done to estimate the trend of fishing and the amount of resource extracted seasonally by the fishermen community of Kulsi river (Refer Chapter 5 for detailed methodology). Percentage use of different fishing gears, fish targeted with them and amount of fish caught in Kulsi river was estimated for four seasons separately.

Spearmen rank correlation was done to estimate the correlation between seasonal differences of fishing activities and catches.

4.2.5. Sand mining Questionnaire Survey

A closed-end questionnaire survey was done among the sand miners of Kulsi river to collect information regarding the seasonal trend of mining which includes total time and amount extracted (Refer Chapter 5 for detailed methodology). The amount of sand dug per hour manually and with the help of sand mining pumps in different seasons was estimated.

4.2.6. Plankton Survey

To understand the impact of sand mining on the lower trophic level of Kulsi ecosystem, plankton sampling survey was conducted. Plankton net of dimensions of 60-micron mesh size and 1X0.4 (length X mouth diameter) was used for sampling. Twenty five litres of water was filtered from every location in the morning hours. A stratified random sampling was done for sand mined, un-mined and previously mined areas in Kulsi river.

The analysis was done to estimate the density of planktons/lt of water in different locations of Kulsi river with sand mining activities ongoing, sand mining activities stopped since 5 or more years back and no sand mining areas. The counting of planktons was done in a drop of the sample (per drop= 40 microlitre in this case) using Sedwick-grafter slide under a 40X magnification microscope. Ten drops of water were counted from each sample.

4.2.7. Water quality in sand mining areas

To compare the changes in water quality parameters in sites with sand mining activities, samples were taken in five different categories of sample areas, viz., a) areas where sand mining stopped since 5 or more years back, b) sand mining areas with pumps, c) downstream of sand pumped areas, d) manual sand mining areas, and e) downstream of manually mined areas. The parameters selected for the comparison were: a) water temperature, b) salinity, c) pH, d) dissolved oxygen (DO) and e) turbidity. YSI multi-parameter probe was used to measure water temperature, salinity, pH and DO. Turbidity was measured in the YSI turbidity meter (calibrated Nephelometer).

Chi-square test was done to compare each parameter among the different sampling sites.

4.2.8. Riverbank Farmers Interview

A closed-end questionnaire survey was done with the farmers on the bank of Kulsi river whose only source of irrigation during dry season is Kulsi river water (Refer Chapter 5 for detailed methodology).

The amount of water pumped out to irrigate one Bigha of cultivated land was estimated with the percent response of the interviewee.

4.3. Results

4.3.1. Catch Calendar Results

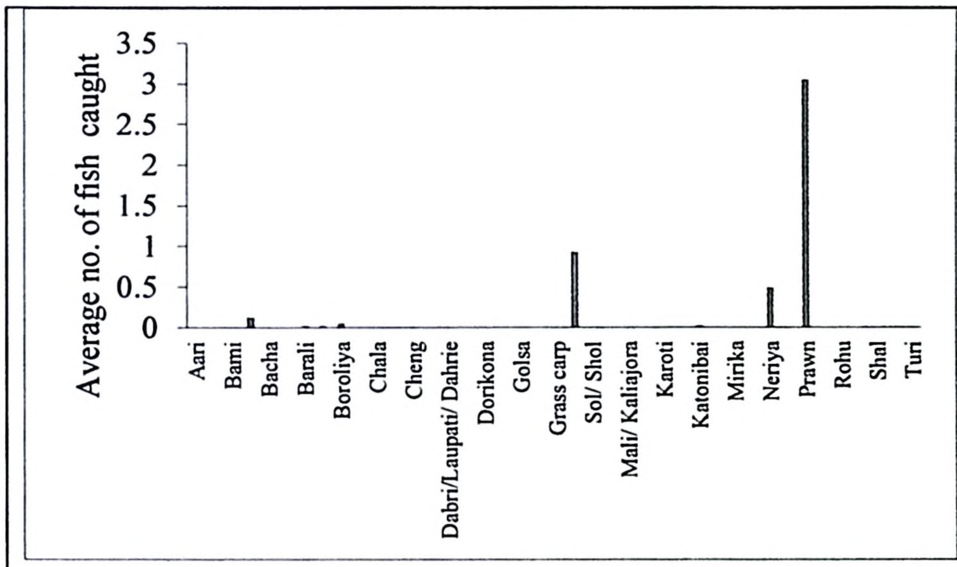
a. Pre-monsoon season

The catch calendar of pre-monsoon season was comprised of three lift nets of different length and mesh sizes. The time spent for each net is mentioned in Table 4.1. The catch per unit effort (CPUE) for the net with lowest mesh size (1cm) was highest (0.19kg/hr) among the three and the lowest (0.003kg/hr) with shorter length (8m) and larger mesh size (2cm).

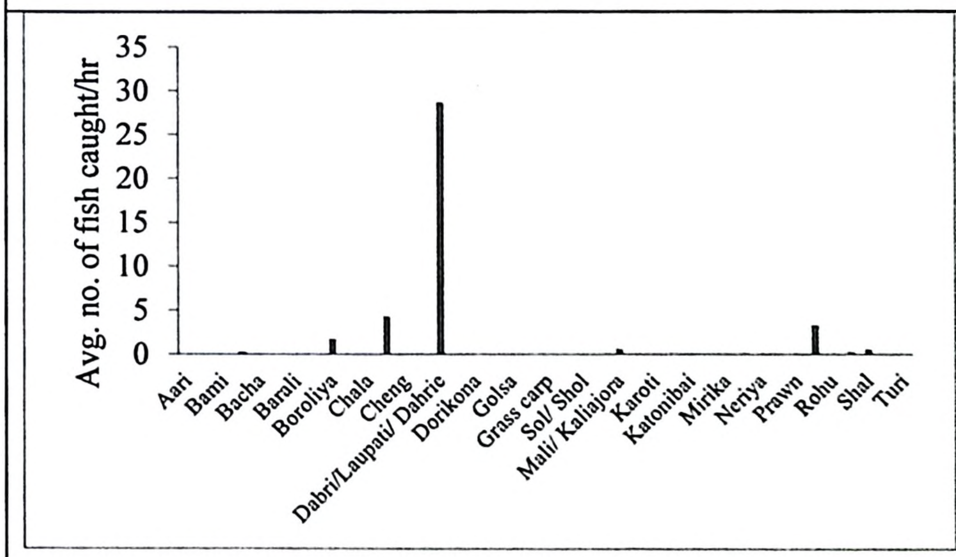
Table 4.1 Pre-monsoon season: Catch calendar CPUE for each gear type.

Sl. No.	Gear Type	Gear Dimension		Total time spent (hrs)	CPUE (kg/hr)
		Length	Mesh size		
1.	Lift net	13m	1cm	50.35	0.19
2.	Lift net	14m	2cm	4.73	0.14
3.	Lift net	8m	2cm	6.90	0.003

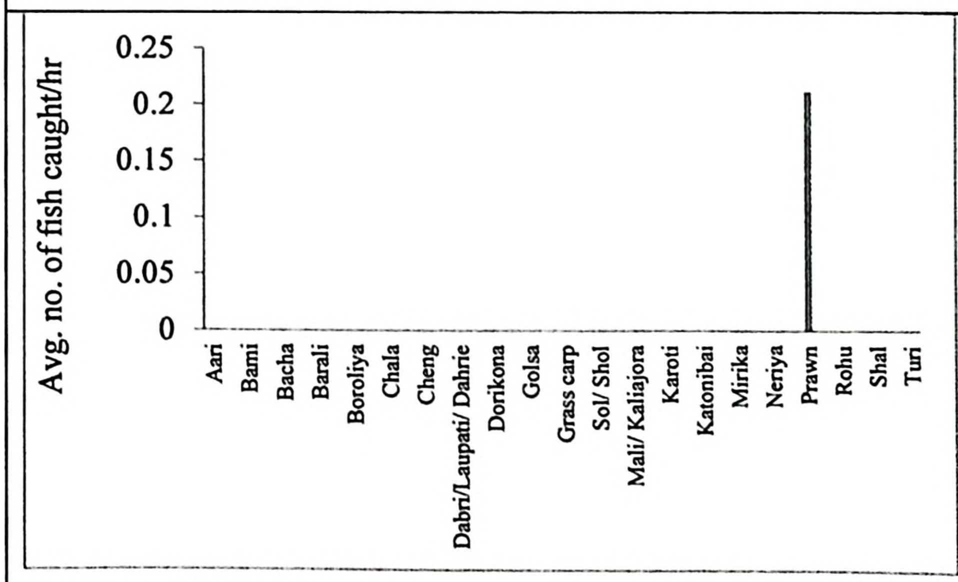
In this season the fishermen use gear size with 1-2 cm mesh size and target the fish size accordingly which includes Punctius spp., Prawns, Chanda nama, etc (Fig.4.2: a-c). Another spp. of immature sizes such as Labeo calbasu, Xenentodon cancila, Channa stewarti etc. also caught but in smaller quantity. Migratory species Hilsa ilisa is also targeted in this season. However, the overall average catch/hr is very low in this season (0.37 no. of fish caught/hr, SE=0.23).



a. Catch rate (No. of fish caught/hr) of Lift net with dimensions 13m length and 1cm mesh size during pre-monsoon season



b. Catch rate (No. of fish caught/hr) of Lift net with dimensions 14m length and 2cm mesh size during pre-monsoon season



c. Catch rate (No. of fish caught/hr) of Lift net with dimensions 8m length and 2cm mesh size during pre-monsoon season

Figure 4.2 No. of fish caught/species during pre-monsoon catch calendar survey with different fishing gears (Scientific names provided in Appendix 2).

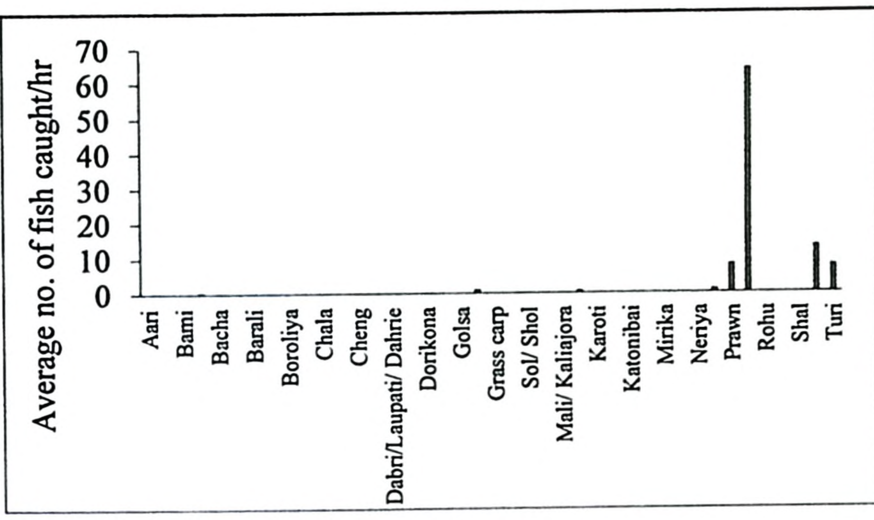
b. Monsoon season

The catch calendar of monsoon season was comprised of eight different fishing gears of different length and mesh sizes. The time spent for each net is mentioned in Table 4.2. The CPUE for mosquito net was highest (6.47kg/hr) among them followed by lift net with smaller mesh size (1cm, 2.01kg/hr). The lowest with Gillnet (0.09kg/hr) with mesh size 1.3cm.

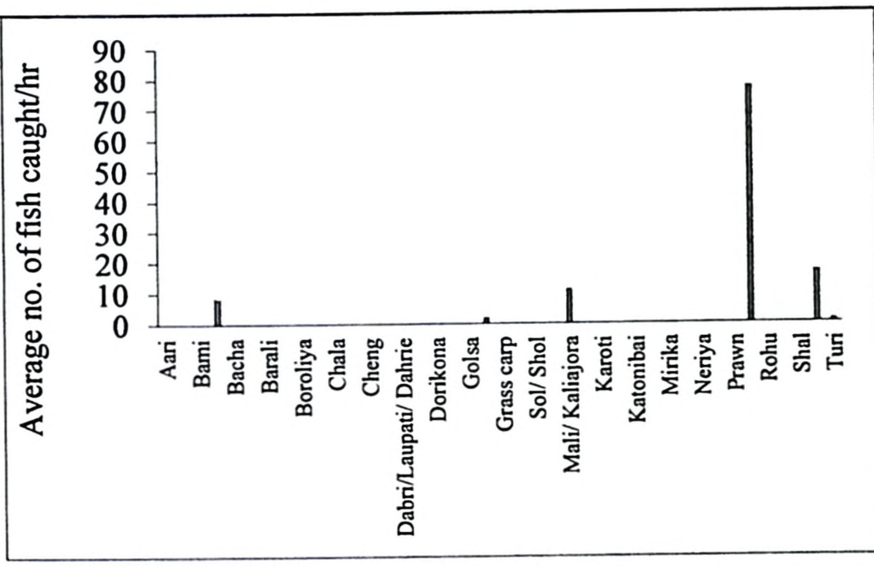
Table 4.2 Monsoon season: Catch calendar CPUE for each gear type

Sl. No.	Gear Type	Gear Dimension		Total time spent (hrs)	CPUE (kg/hr)
		Length	Mesh size		
1.	Cast net	4.1m	1cm	3.72	0.69
2.	Gillnet	457m	1cm	7.53	0.59
3.	Gillnet	305m	1cm	13.34	0.21
4.	Gillnet	98m	0.8cm	13.34	0.25
5.	Gillnet	55m	1.3cm	13.34	0.09
6.	Lift net	13m	1cm	11.04	0.27
7.	Lift net	15m	2cm	11.89	2.01
8.	Mosquito net	229m	<1mm	4.53	6.47

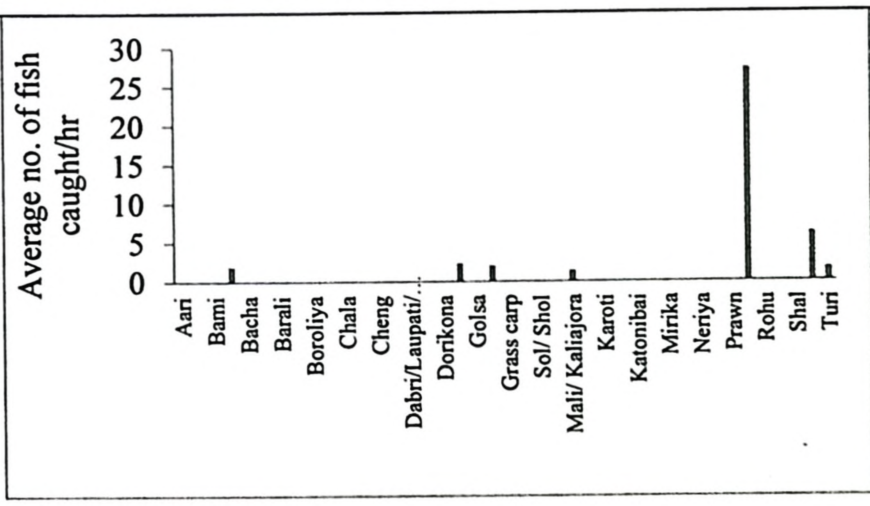
The diversity of fishing gear used increases in monsoon season compared to pre-monsoon season. The mesh sizes of fishing gears range from <1cm (in mosquito nets) to 2cm. The most common species caught in all types of gear during monsoon season were Puntius spp., Mystus spp., Macrognatus aral, Nandus nandus, Channa punctatus, Labeo calbasu and Labeo bata. In gears with mesh size >1cm had also some other additional species in the catch list which are Eutropiichthys spp., Ctenopharyngodon idella, Cirrhinus mrigala, Clupisoma garuwa, Labeo rohita etc. in a lower amount (Fig. 4.3. a-h). Overall average catch/hr is 4.6 no. of fish/hr (SE=1.7).



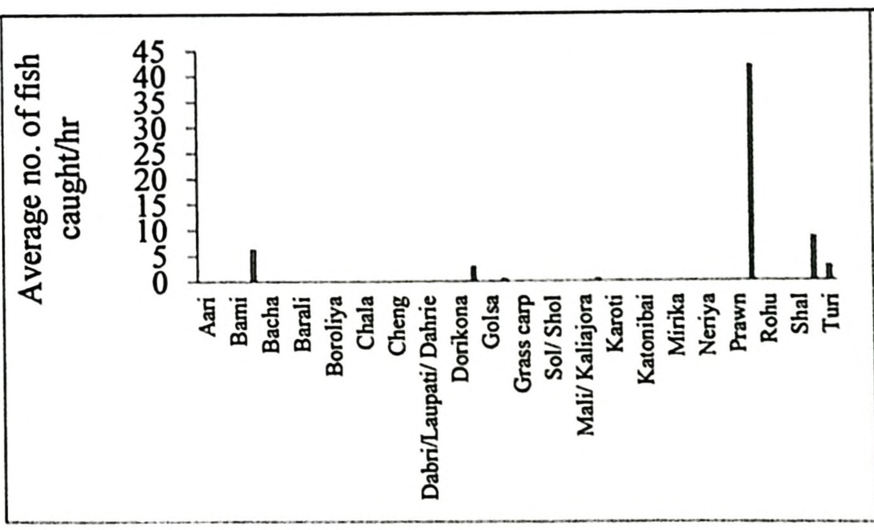
a. Catch rate (No. of fish caught/hr) of Cast net with dimensions 4.11m length and 1cm mesh size during Monsoon season



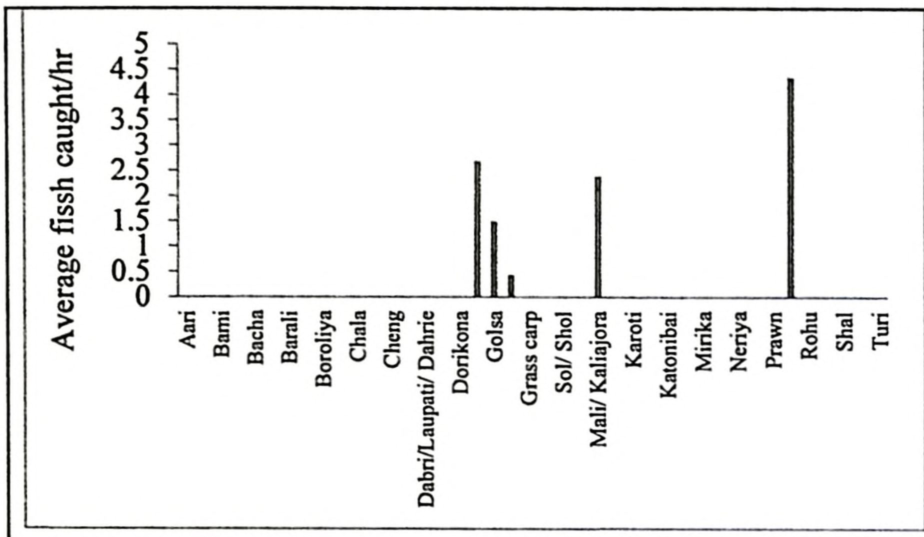
b. Catch rate (No. of fish caught/hr) of Gill net with dimensions 475m length and 1cm mesh size during Monsoon season



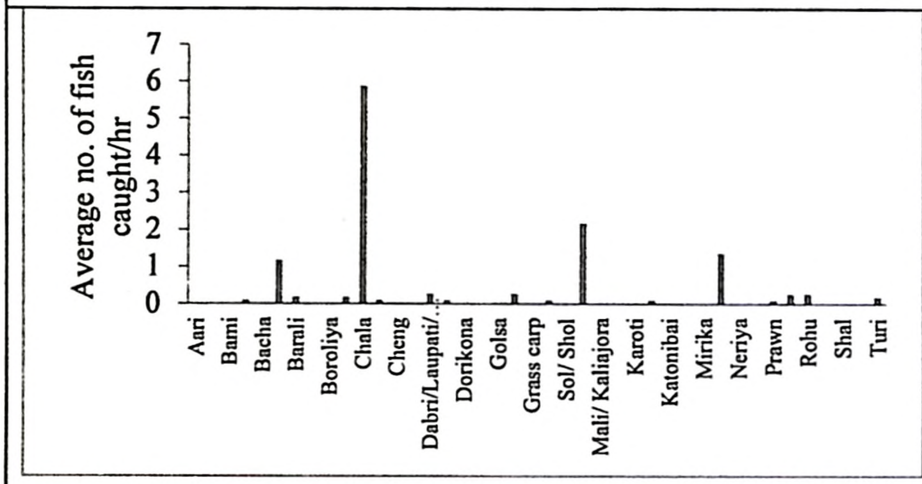
c. Catch rate (No. of fish caught/hr) of Gill net with dimensions 305m length and 1cm mesh size during Monsoon season



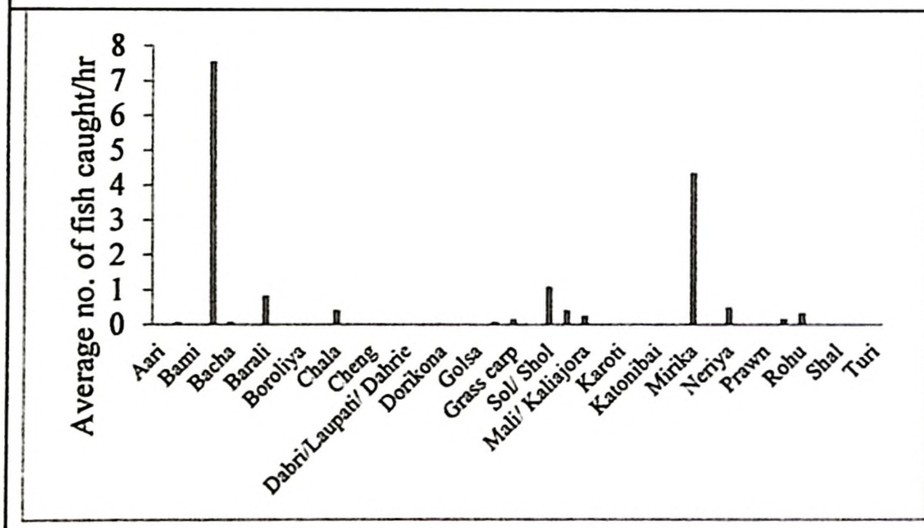
d. Catch rate (No. of fish caught/hr) of Gill net with dimensions 98m length and 0.8cm mesh size during Monsoon season



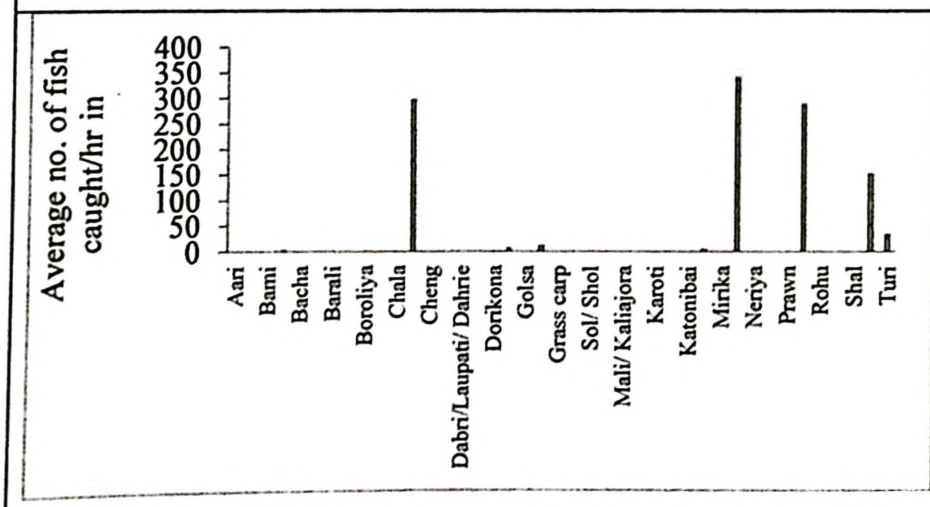
e. Catch rate (No. of fish caught/hr) of Gill net with dimensions 55m length and 1.3cm mesh size during Monsoon season



f. Catch rate (No. of fish caught/hr) of Lift net with dimensions 13m length and 1cm mesh size during Monsoon season



g. Catch rate (No. of fish caught/hr) of Lift net with dimensions 15m length and 2cm mesh size during Monsoon season



h. Catch rate (No. of fish caught/hr) of Mosquito net with dimensions 229m length and <1mm mesh size during Monsoon season

Figure 4.3 No. of fish caught/species during Monsoon catch calendar survey with different fishing gears (Scientific names provided in Appendix 2).

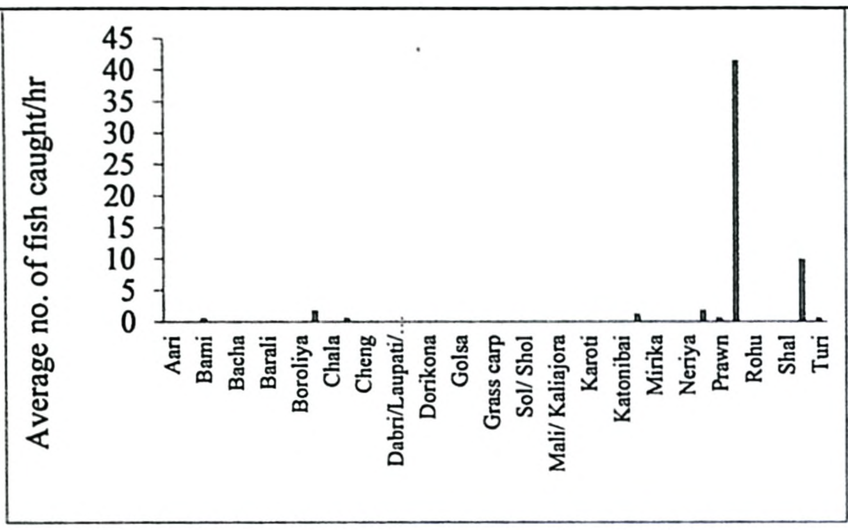
c. Post- monsoon

The catch calendar of the post-monsoon season was comprised of seven different fishing gears of different length and mesh sizes and time spent for each net is mentioned in Table 4.3. The CPUE for Gillnet with mesh size 11cm and mosquito net was almost similar (4.38 and 4.37kg/hr respectively). The lowest was also with Gillnet (0.10kg/hr) with mesh size 11cm but lesser length (50m).

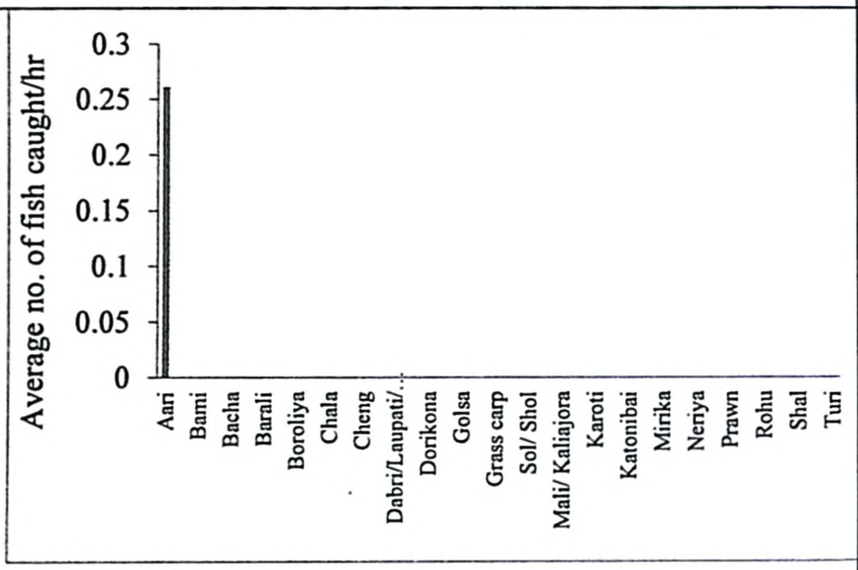
Table 4.3Post- monsoon season: Catch calendar CPUE for each gear type

Sl. No.	Gear Type	Gear Dimension		Total time spent (hrs)	CPUE (kg/hr)
		Length	Mesh size		
1.	Cast net	4m	1cm	1.62	0.34
2.	Gillnet	50m	11cm	4.05	0.10
3.	Gillnet	63m	11cm	2.28	4.38
4.	Hook	1.5cm		9.61	0.17
5.	Hook	4cm		4.78	0.33
6.	Lift net	13m	1cm	10.91	0.25
7.	Mosquito net	145m	<1mm	5.33	4.37

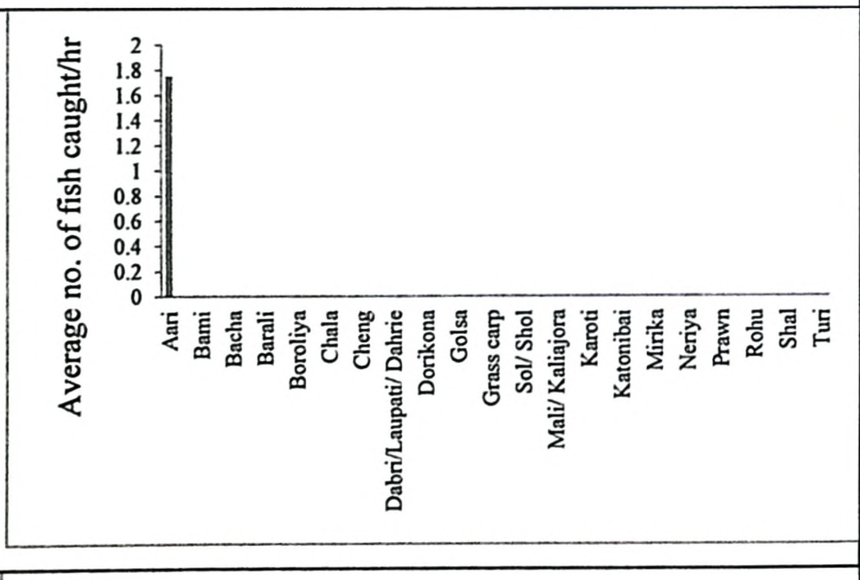
The preferred gear type during post-monsoon season were bigger hooks (4cm length), and nets with bigger mesh size (11cm) targeting more specific species like matured Aorichthys spp. and Wallago attu. However, simultaneously smaller hooks and nets with smaller mesh size (ranging from <1cm to 1cm mesh sizes) were also used targeting the similar species as of Monsoon season. The commonly caught species were Mastacembelus arnatus arnatus, Chanda nama, Gagata spp., Glossogobius giuris, Prawn, Puntius spp., Mystus spp., Macrognathus aral etc. (Fig. 4.4. a-g). The overall no. of fish caught/hr in the post-monsoon season was 3.1 (SE=1.3).



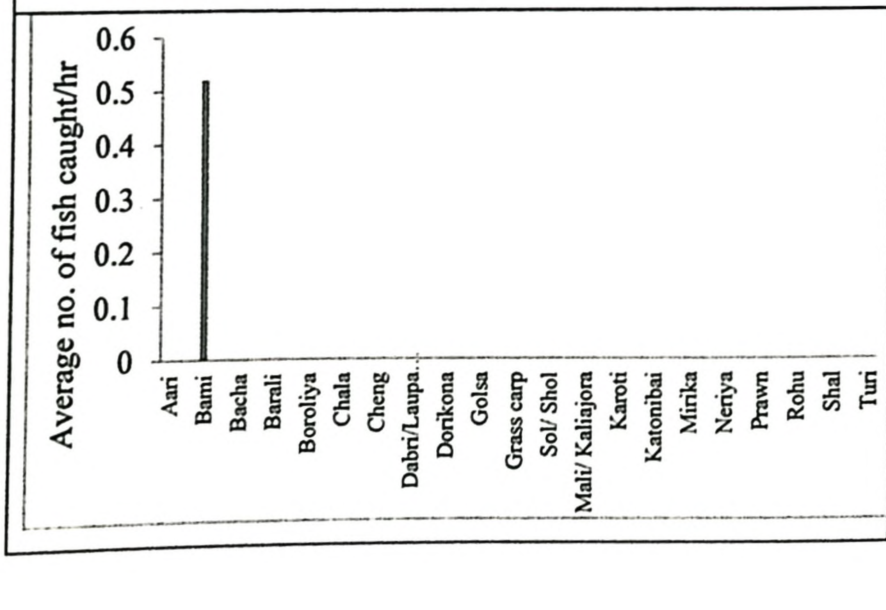
a. Catch rate (No. of fish caught/hr) of Cast net with dimensions 4m length and 1cm mesh size during Post-monsoon season



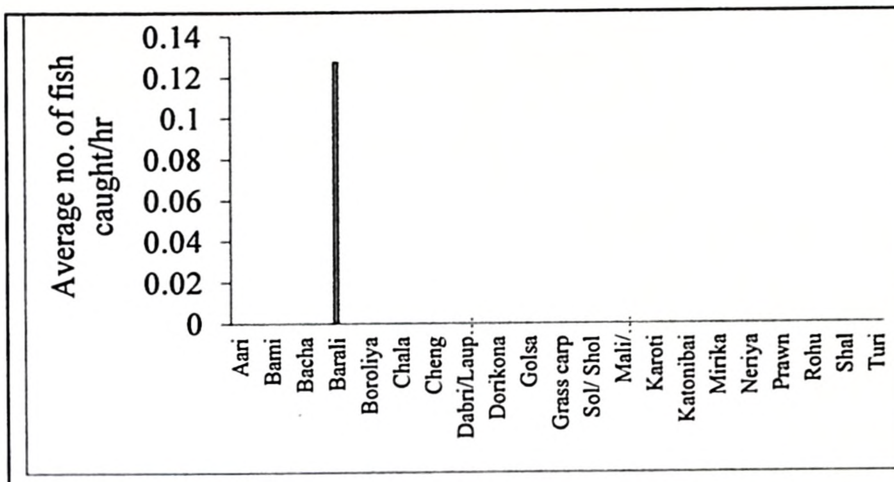
b. Catch rate (No. of fish caught/hr) of Gill net with dimensions 50m length and 11cm mesh size during Post-monsoon season



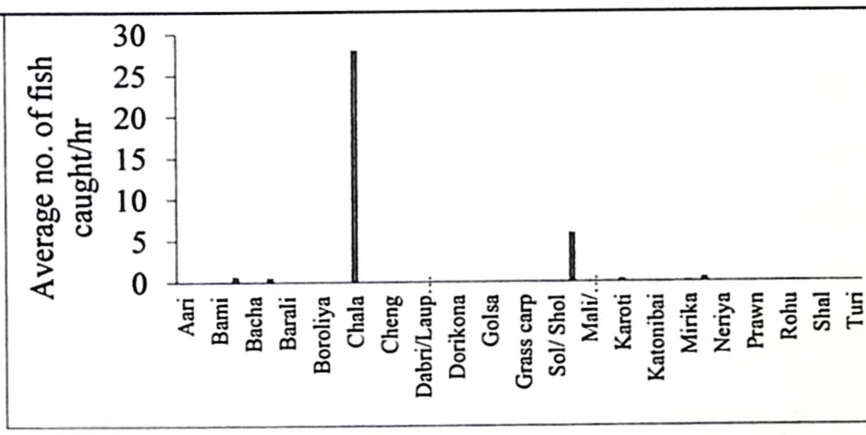
c. Catch rate (No. of fish caught/hr) of Gill net with dimensions 63m length and 11cm mesh size during Post-monsoon season



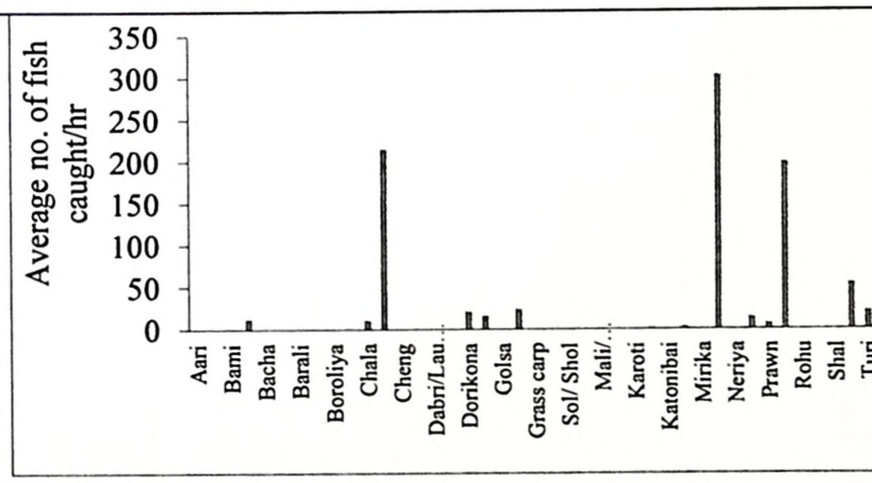
d. Catch rate (No. of fish caught/hr) of Hook with dimensions 1.5cm length during Post- monsoon season



e. Catch rate (No. of fish caught/hr) of Hook with dimensions 4cm during Post-monsoon season



f. Catch rate (No. of fish caught/hr) of Lift net with dimensions 13m length and 1cm mesh size during Post-monsoon season



g. Catch rate (No. of fish caught/hr) of Mosquito net with dimensions 145m length and <1mm mesh size during Post-monsoon season

Figure 4.4 No. of fish caught/species during Post-monsoon catch calendar survey with different fishing gears (Scientific names provided in Appendix 2).

d. Winter

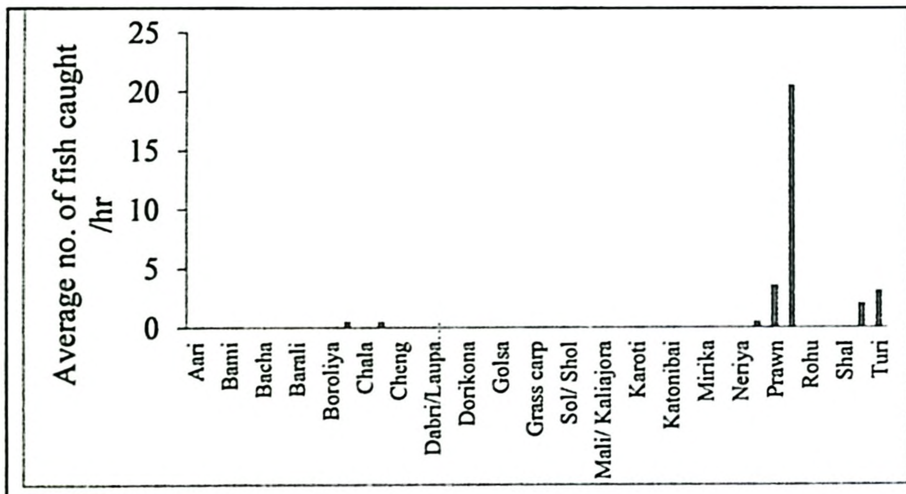
The catch calendar of the winter season was comprised of six different nets of different length and mesh sizes and time spent for each net is mentioned in Table 4.4. The CPUE for Gillnet with mesh size 4cm was highest amongst all (0.34kg/hr respectively). CPUE was zero for Hook fishing (4cm).

Table 4.4Winter season: Catch calendar CPUE for each gear type.

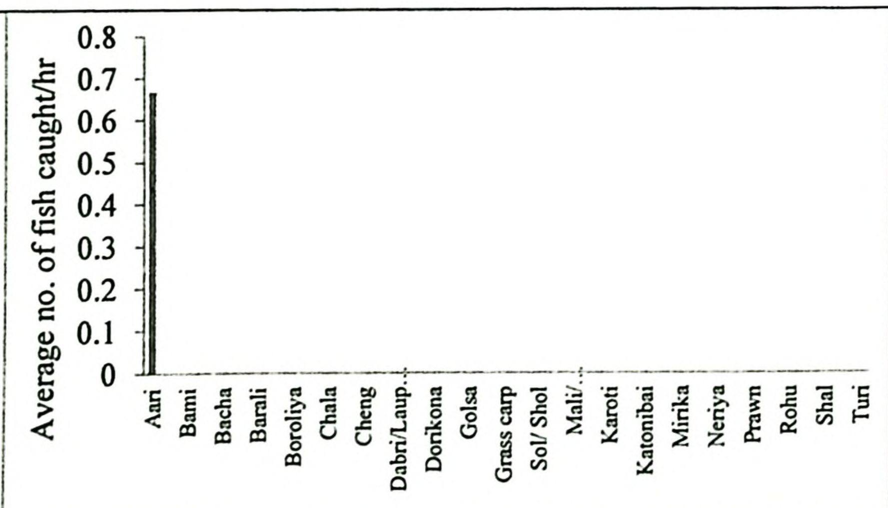
Sl. No.	Gear Type	Gear Dimension		Total time spent (hrs)	CPUE (kg/hr)
		Length	Mesh size		
1.	Cast net	4m	1cm	1.94	0.14

2.	Gillnet	82m	4cm	8.99	0.34
3.	Hook	1.5cm		7.37	0.16
4.	Hook	4cm		8.04	0
5.	Enclosure fishing	46m	<1mm	360	0.03
6.	Enclosure fishing	91m	<1mm	360	0.05

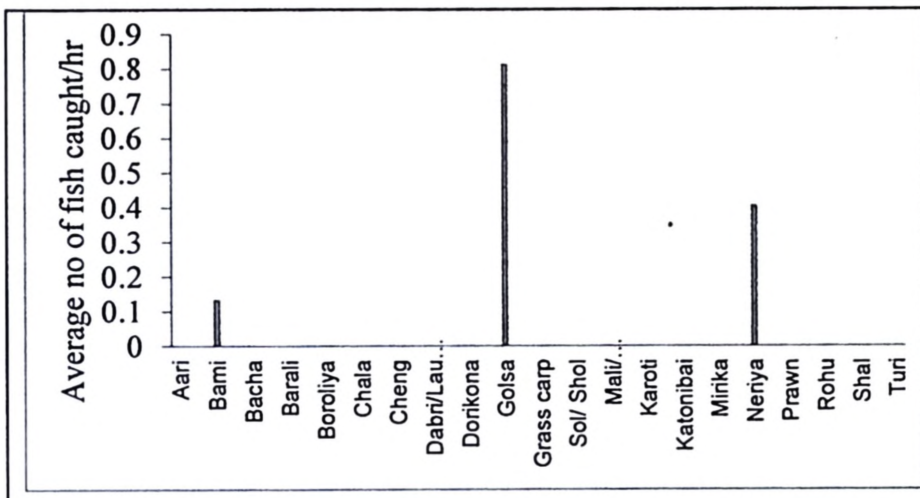
The fishers target for matured species with bigger mesh size gear (4cm) and hooks (4cm). Another comparatively less laborious technique of fishing by enclosing an area with a net which was covered with water hyacinth or Ipomia for certain duration (in my case 15days) and also putting some bait (mustard seed husk) into it to attract fish, locally known as Jeng fishing, is also practiced in this season. However, the catch is comparatively lower in winter season with limited species such as Mastacembelus arnatus arnatus, Chanda nama, Botia dario, Glossogobius giuris, Prawn, Puntius spp., Mystus spp., Macrognathus aral etc (Fig. 4.5. a-e). The overall no. of fish caught/hr is 0.20 (SE=0.09).



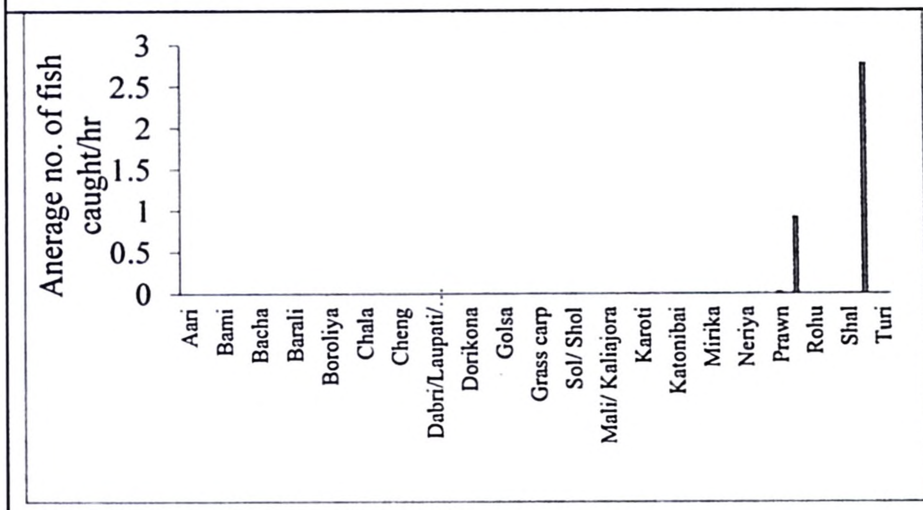
a. Catch rate (No. of fish caught/hr) of Cast net with dimensions 4m length and 1cm mesh size during Winter season



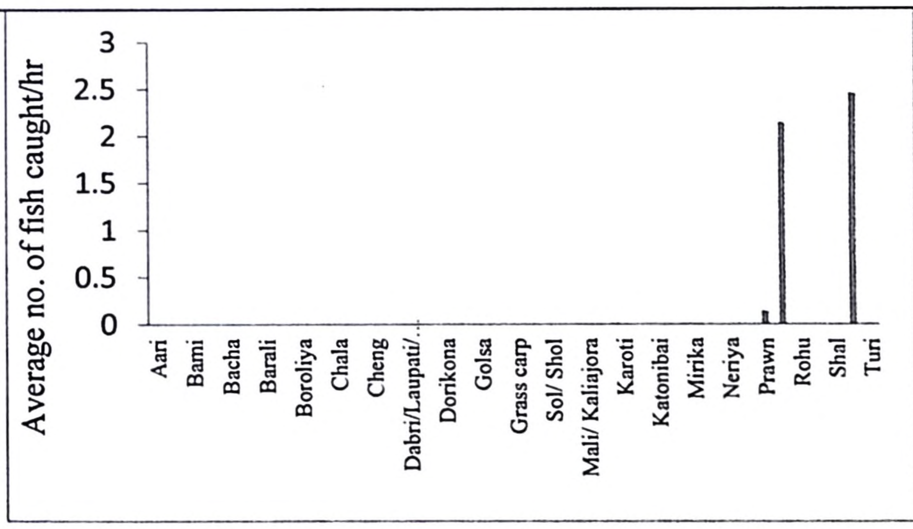
b. Catch rate (No. of fish caught/hr) of Gill net with dimensions 82m length and 4cm mesh size during Winter season



c. Catch rate (No. of fish caught/hr) of Hook with dimensions 1.5cm length during Winter season



d. Catch rate (No. of fish caught/hr) of Enclosure fishing with dimensions 46m length and <1mm mesh size during Winter season



e. Catch rate (No. of fish caught/hr) of Enclosure fishing with dimensions 91m length and <1mm mesh size during Winter season

Figure 4.5 No. of fish caught/species during Post-monsoon catch calendar survey with different fishing gears (Scientific names provided in Appendix 2).

e. Variation in average length of fishes caught during catch calendar survey

The fish length varies from average 0.65cm to 5.26cm during pre- monsoon to 2.79cm to 12.75cm during winter with a lowest limit of 0.5cm during pre- monsoon to a highest limit of 43.02cm in winter seasons (Fig. 4.6). We can also see an increase in average length from pre-monsoon to monsoon season with a drop in length during post-monsoon season and again witha rise in winter season with maximum length.

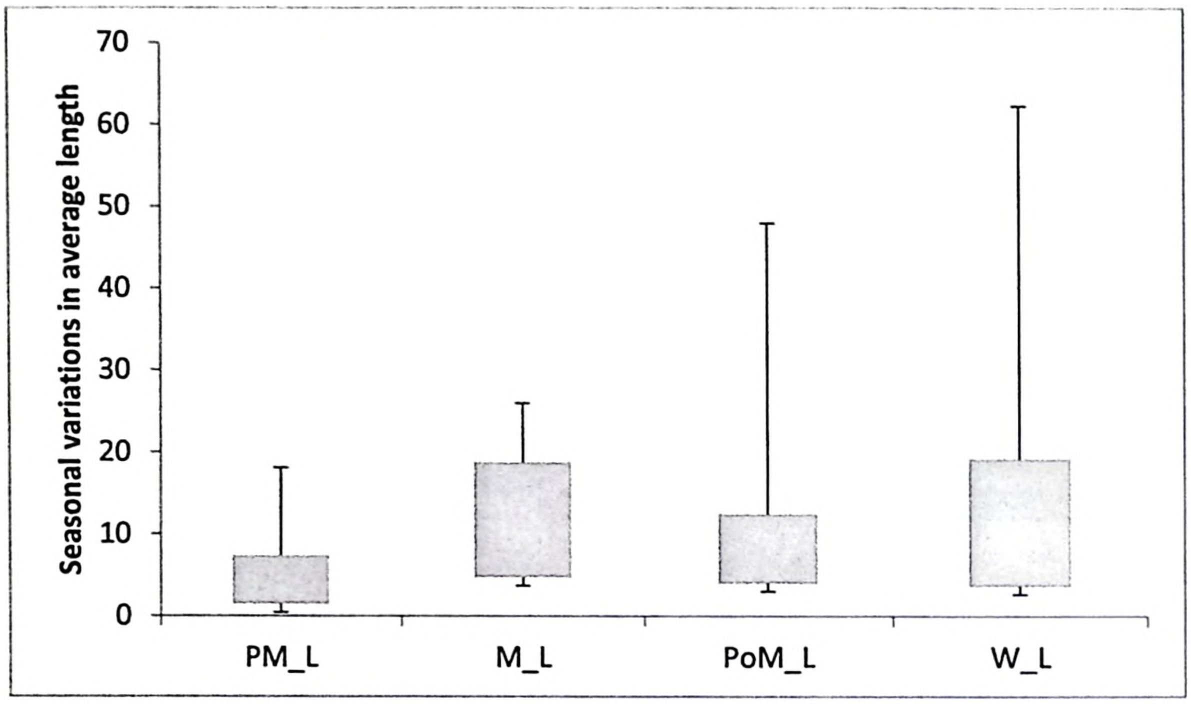


Figure 4.6 Average seasonal fish length caught during catch calendar survey in Kulsi (PM_L= Average fish length during Pre- monsoon season, M_L= Average fish length during Monsoon season, PoM_L= Average fish length during Post- monsoon season and W_L= Average fish length during Winter season).

f. Percent composition of CPUE of preferred and other species with different fishing gears

Here "preferred species" is refer to the species identified during gut content analysis (Sinha et al., 1993, Appendix 3) which were also recorded in catch calendar survey in Kulsi River and rest of the species were categorised as others. There was difference between the seasonal CPUE of preferred and other prey species with different fishing gears (χ^2=46.92, p-value=0.0001). It was observed that in lift net (LN) and Hook (H) the CPUE of the preferred species was less during all seasons and in Cast net during Winter season was less (Fig. 4.7). In rest of the fishing gears the percentage of CPUE for preferred prey species was always high in all the seasons compared to other species (Fig. 4.7). The *Separata seenghala* was found to be targeted with monofilament gill nets during Post- monsoon and winter seasons during the catch calendar survey in Kulsi river commercial fisheries.

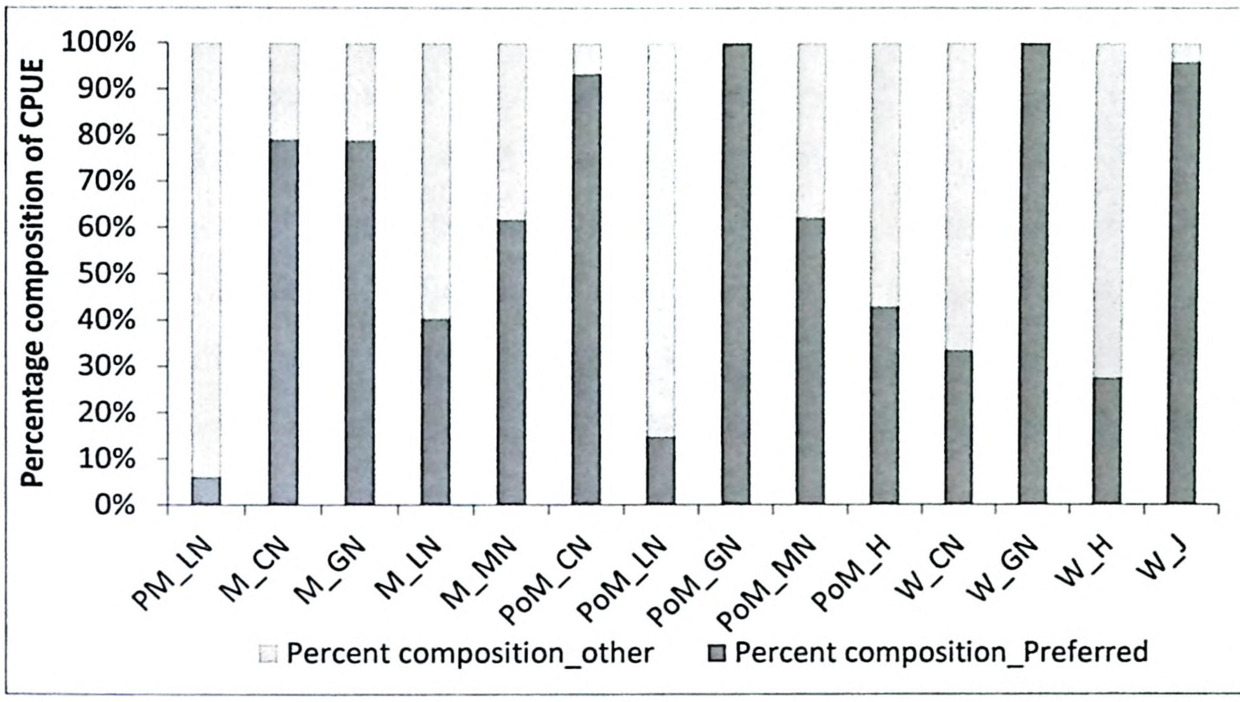
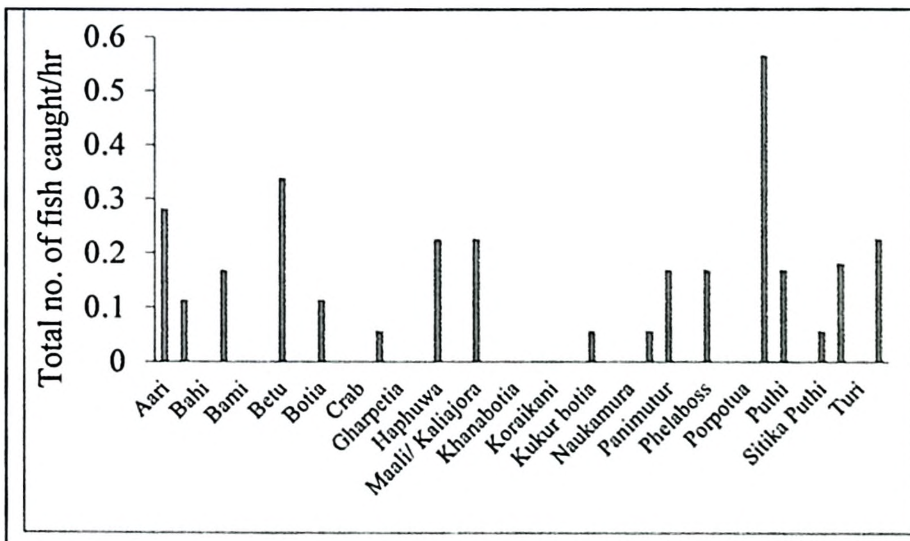


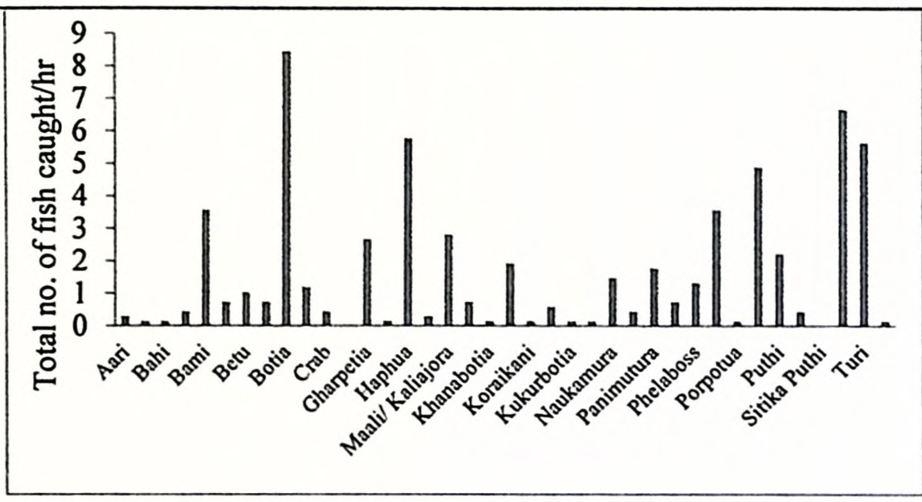
Figure 4.7 Percent composition of CPUE of Preferred and other prey species of Ganges dolphin with different fishing gears during Catch calendar survey in Kulsi River (PM= Pre-monsoon, M= Monsoon, PoM= Post-monsoon, W= Winter, LN= Lift net, CN= Cast net, GN= Gill Net, LN= Lift net, MN= Mosquito net, H= Hook, J= Jeng or enclosure fishing.

4.3.2. Fish Sampling

Average no. of fish caught with the cast net (1.73 no. of fish caught/hr, SE=0.4) was more compared to the Gillnet (0.19 no. of fish caught/hr, SE=0.03) during fish sampling survey. Species composition observed in cast net (Fig.4.8.a) fishing was more in comparison to Gillnet fishing (Fig.4.8.b).



a. Species-wise number of fish caught/hr with Gillnet (50m length and 2.5cm mesh size) during fish sampling in Kulsi river



d. Species-wise number of fish caught/hr with Cast net (4m radius length and 1cm mesh size) during fish sampling in Kulsi river

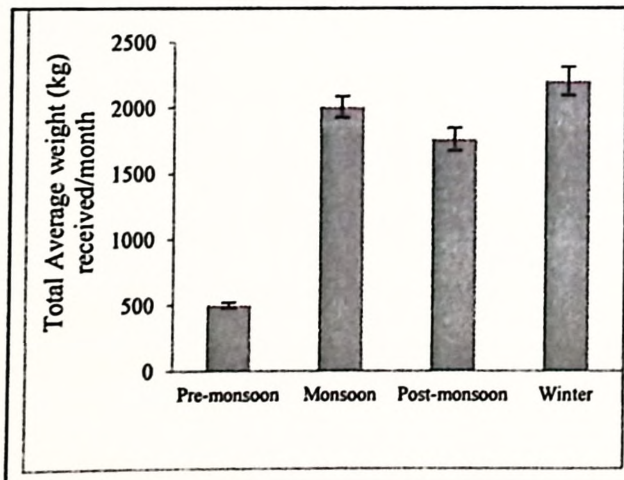
Figure 4.8 Total number of fish caught/species during fish sampling survey (Scientific names provided in Appendix 2).

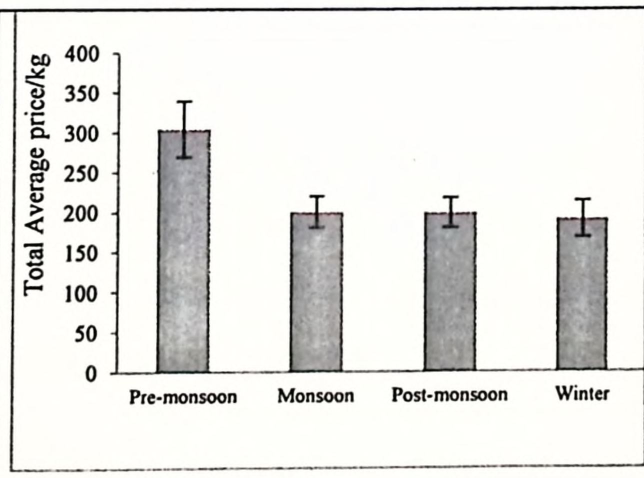
4.3.3. Fish Landing site survey

a. Average total weight and price in different seasons at fish landing sites of Kulsi river

The overall amount of harvest was comparatively less in pre-monsoon season (500.2kg/month, SE=19.1), however, in the rest three seasons, it was almost equal (Fig.4.9.a). The highest harvest was in the winter season (2205.1 kg/month, SE=109.6) followed by the monsoon season (2008.3kg/month, SE=82.4).

The total average price/kg, on the other hand, was more in pre-monsoon season (304.4 INR/kg, SE=35.1) compared to rest of the three seasons, which was again of similar ranges (Fig.4.9.b.). The lowest ranges observed in the winter season (191.4 INR/kg, SE=22.9).





a. Total average weight (kg) of fish landed at different landing sites of Kulsi river during different seasons.	b. Average price/kg of fish at fish landing sites of Kulsi river during different seasons.

Figure 4.9 Total seasonal average weight and price/kg at fish landing sites.

b. Seasonal average weight received per month and price/kg for each species of fish.

i. Pre-monsoon season

Matured size large species such as Aorichthys spp. and Wallago attu were received in moderation (Fig.4.10.a) with elevated prices in the landing sites (Fig.4.11.a). In addition, smaller species such as Mastacembelus arnatus arnatus, Aspidoparia spp., Botia dario, Channa punctatus, Prawn, Punctius spp. and Mystus spp. were received in moderation (Fig.4.10.a) but with higher price value/kg compared to other seasons (Fig.4.11.a). High market value species Notopterus notopterus and Ompok spp. in very smaller amount were also received in landing sites during this season (Fig.4.10.a).

ii. Monsoon season

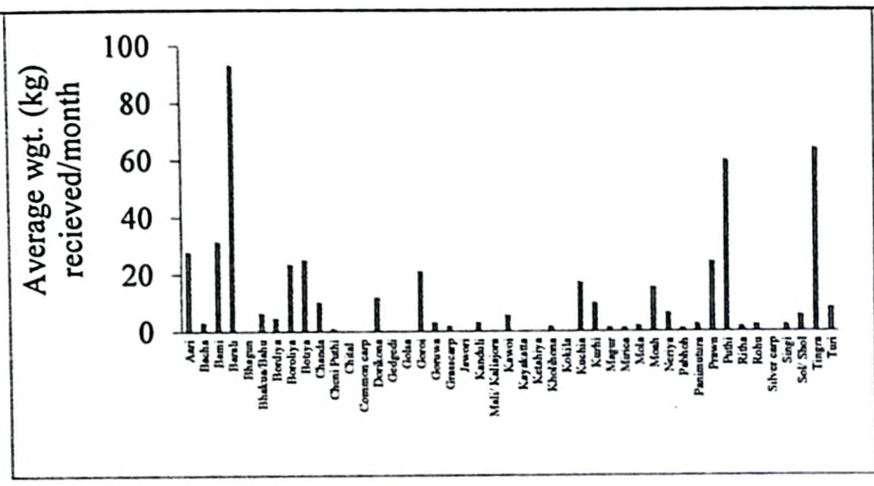
The small-sized fish species such as Labeo bata, Chanda nama, Nandus nandus, Channa punctatus, Anabus testudineus, Amphipnuous cuchia, Amblypharyngodon mola, Aspidoparia jaya, Prawn, Punctius spp. and Mystus spp. etc were received in higher amount (Fig.4.10.b) during this season although comparatively in a lower price than pre-monsoon season (Fig.4.11.b). Carps were also started appearing from this season onwards although in moderation (Fig.4.10.b) but at comparatively higher price than to rest of the seasons (Fig.4.11.b).

iii. Post-monsoon season

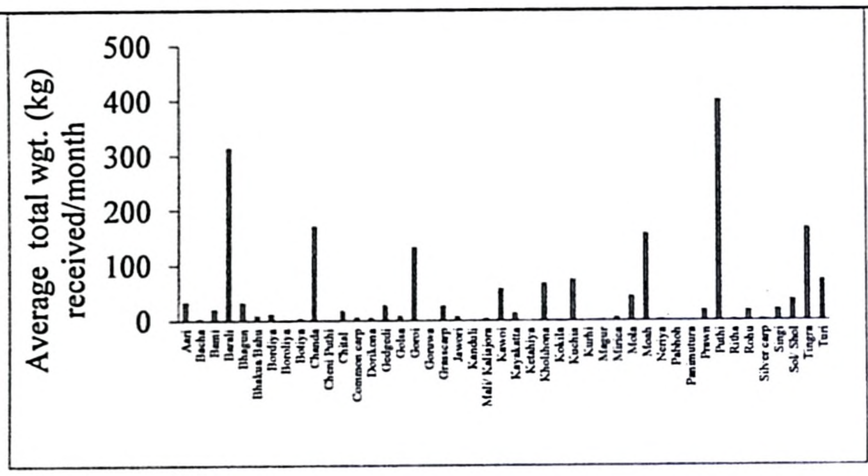
Matured size large species were received in higher amount (Fig.4.10.c) in the fish landing sites of Kulsi river during this season; however, the price is comparatively less compared to other seasons (Fig.4.11.c). Other smaller species were received in moderation except for Channa punctatus, Punctius spp. and Mystus spp. which were received in a higher amount (Fig.4.10.c).

iv. Winter Season

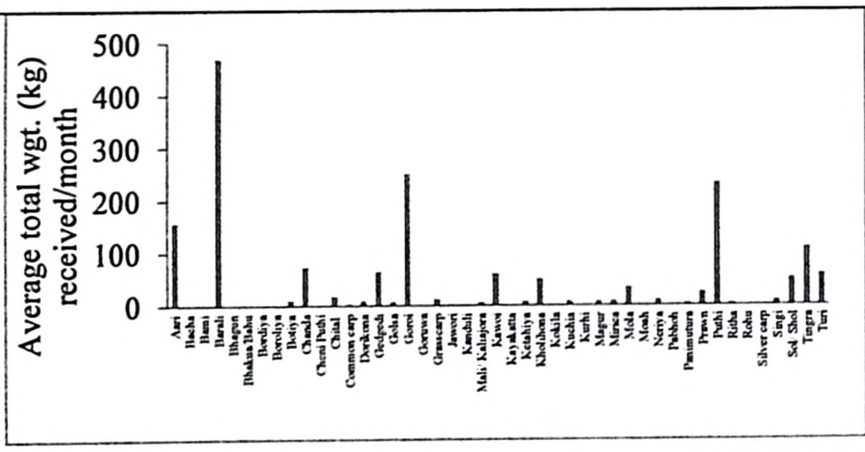
The fish diversity in the landing sites decreases in this season. However, the fish quantity of smaller size species received during the season is comparatively higher than all the seasons (Fig.4.9.d). The matured large size fish were received in moderation (Fig.4.10.d). The species-wise price also doesn't fluctuate much from the post-monsoon season (Fig.4.11.d).



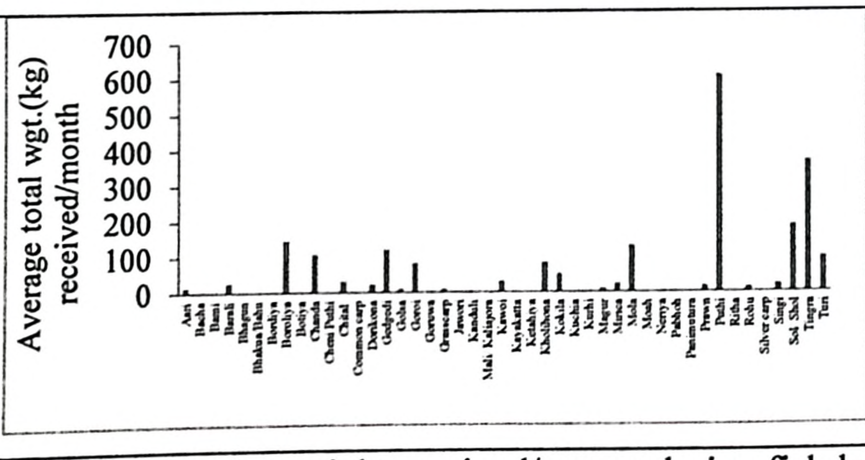
a. Average species-wise weight received at the fish landing sites of Kulsi river during Pre-monsoon season



b. Average species-wise weight received at the fish landing sites of Kulsi river during Monsoon season

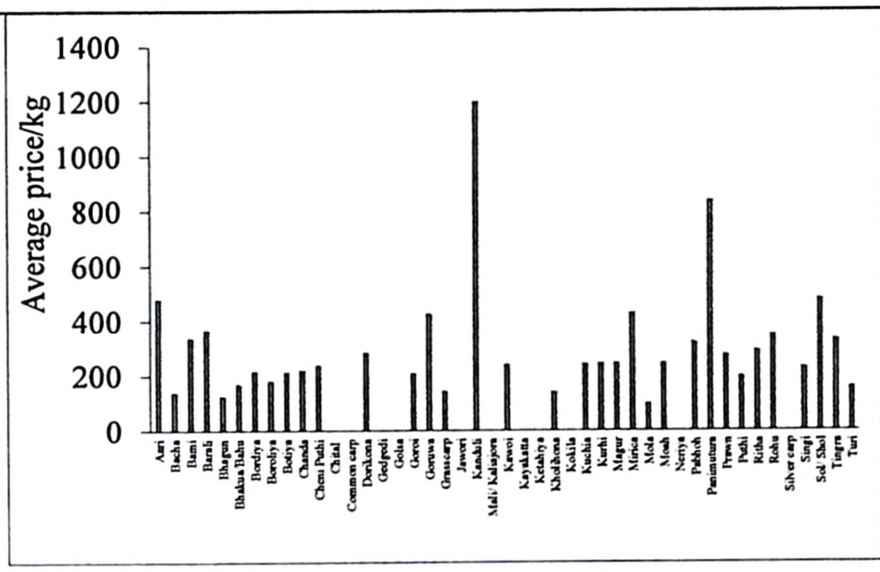


c. Average species-wise weight received at the fish landing sites of Kulsi river during Post-monsoon season

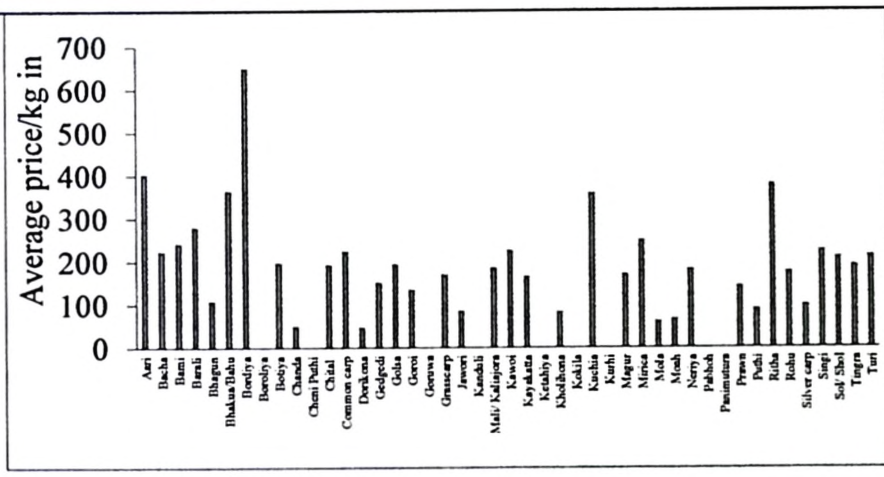


d. Average species-wise weight received at the fish landing sites of Kulsi river during Winter season

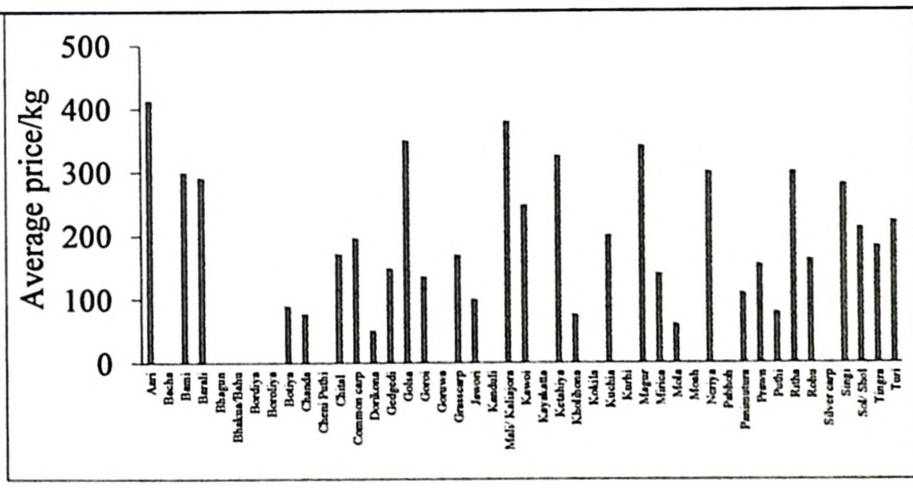
Figure 4.10 Species-wise weight received/season during fish landing site survey (Spp. scientific name list is mentioned in Appendix 2).



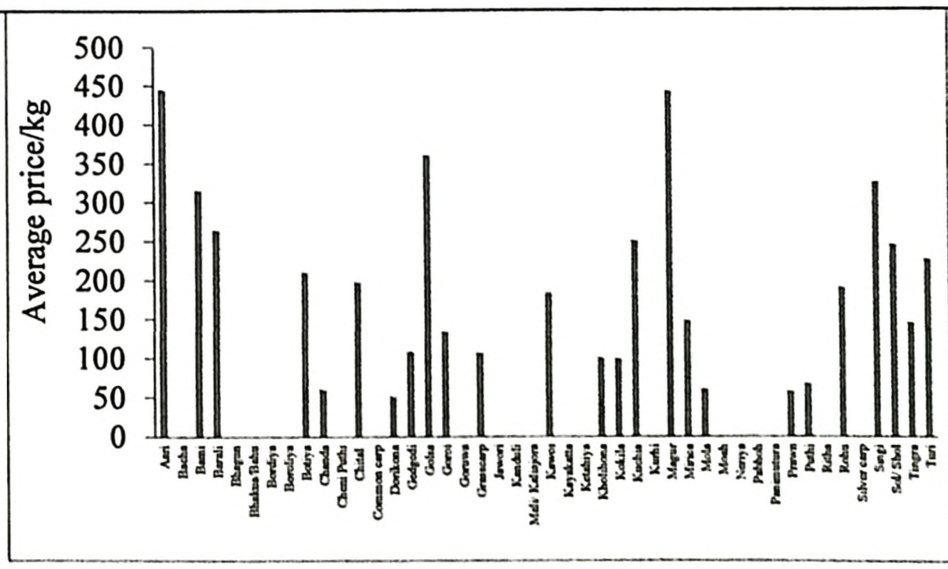
a. Average species-wise price/kg at the fish landing sites of Kulsi river during Pre-monsoon season



b. Average species-wise price/kg at the fish landing sites of Kulsi river during Monsoon season



c. Average species-wise price/kg at the fish landing sites of Kulsi river during Post-monsoon season



d. Average species-wise price/kg at the fish landing sites of Kulsi river during Winter season

Figure 4.11Seasonal species-wise price/kg at the fish landing sites (Spp. scientific name list is mentioned in Appendix 2).

c. Percentage of commercially used fishing gears throughout different seasons

Broadly nine types of fishing techniques were practiced commercially by the fishermen of Kulsi river and supply fish at the fish landing sites of Kulsi river. Use of **Cast net** was seen highest in pre-monsoon season which abruptly decreases during monsoon and post-monsoon seasons and rises slightly towards the winter season (Fig.4.12). Use of **Gill net** was less in pre-monsoon season which increases during monsoon and post-monsoon seasons and again decreases towards winter season (Fig.4.12). Use of **Mosquito net** gradually increases from pre-monsoon season and reaches peak in the winter season (Fig. 4.12). **Lift nets** increases gradually from the pre-monsoon season towards post- monsoon but decreases in the winter season (Fig.4.12). Use of **Hooks** or **hook line** abruptly increases in the monsoon season and then gradually decreases (Fig.4.12). **Spears** or **harpooning** is done mostly in monsoon season and very sparsely in rest of the seasons (Fig.4.12). Use of **Enclosure** locally known as Jeng fishing increases gradually from pre-monsoon season and practiced highest in the winter season (Fig.4.12). **Fish traps** were mostly used in post- monsoon season and least in the winter season (Fig.4.12). **Dragnets** were also mostly used during post-monsoon season and least during winters whereas not used in pre-monsoon season (Fig.4.12).

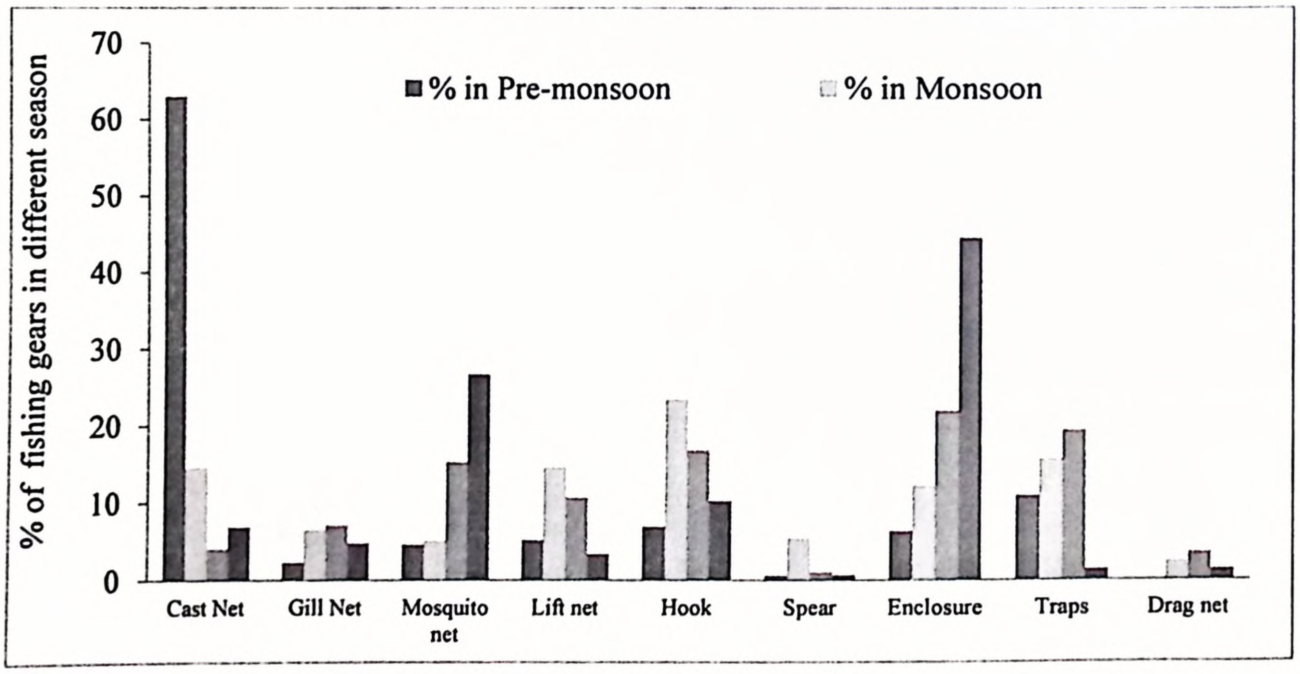


Figure 4.12 Percentage of different commercially used fishing gears supplying fish at the fish landing sites of Kulsi river in different seasons.

d. Average total Seasonal Catch

Total average catch (kg)/ month in winter season are highest in the fish landing sites of Kulsi river followed by monsoon season and lowest in pre-monsoon season (Fig.4.13).

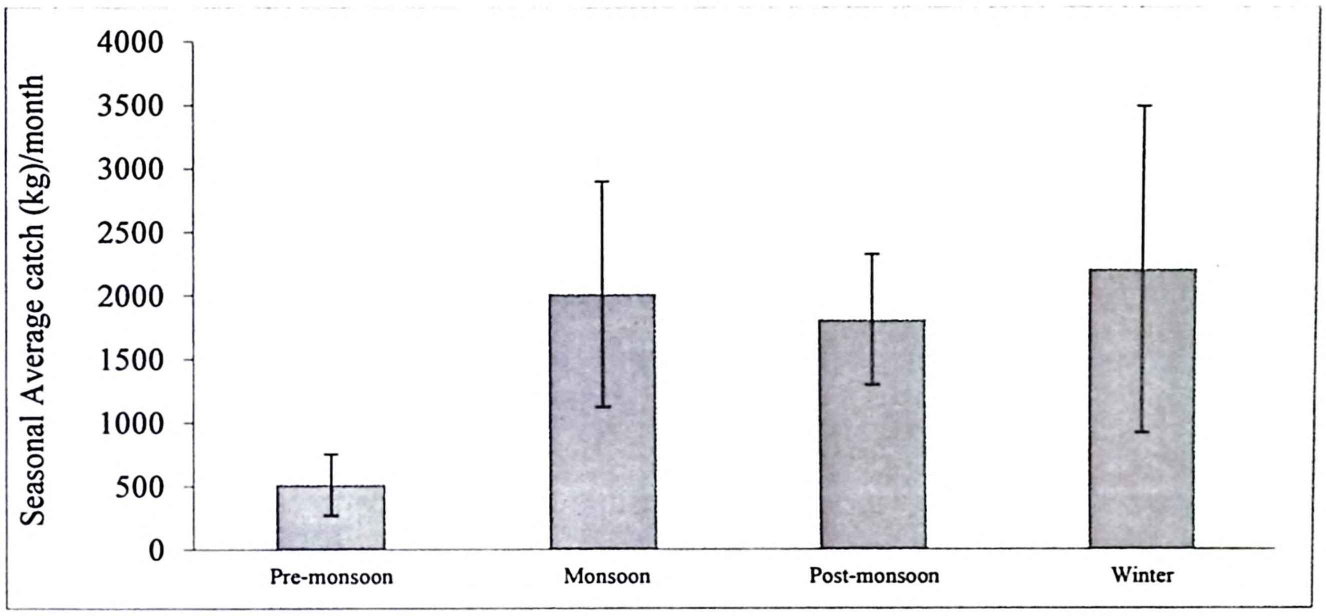


Figure 4.13 Average fish quantity (kg) received per month in different seasons at fish landing sites from Kulsi river

e. Average total money generated at fish landing sites of Kulsi river

Average total money is generated highest during post-monsoon season followed by monsoon Season and lowest in pre-monsoon season (Fig.4.14).

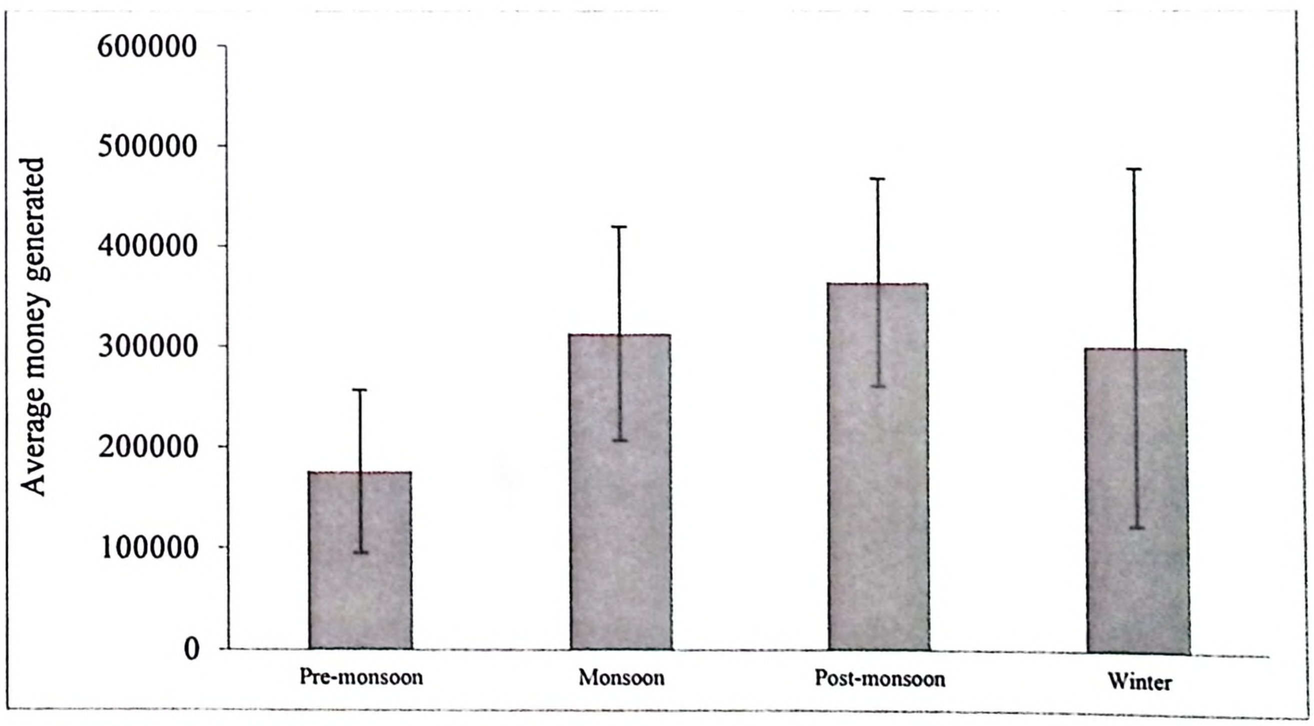


Figure 4.14 Average money generated per month from three fish landing sites in Kulsi river in different seasons.

f. Comparing composition of preferred and other species in fish landing sites

The composition of preferred species in terms of total weight recieved in fish landing sites was significantly not different from the amount of the other species received in those seasons (Fig. 4.15, χ^2=4.84, p-value= 0.18). However, the seasonal percentage composition varies from 40-60% (Fig. 4.17).

In terms of money, a significantly higher composition of other species was observed in comparison to preferred species (Fig. 4.16, χ^2=18.20, p-value= 0.0004). However, it will be also important to notice that the percent composition of total amount recived from the preferred species comprise of more than 40% for all the seasons (Fig. 4.17).

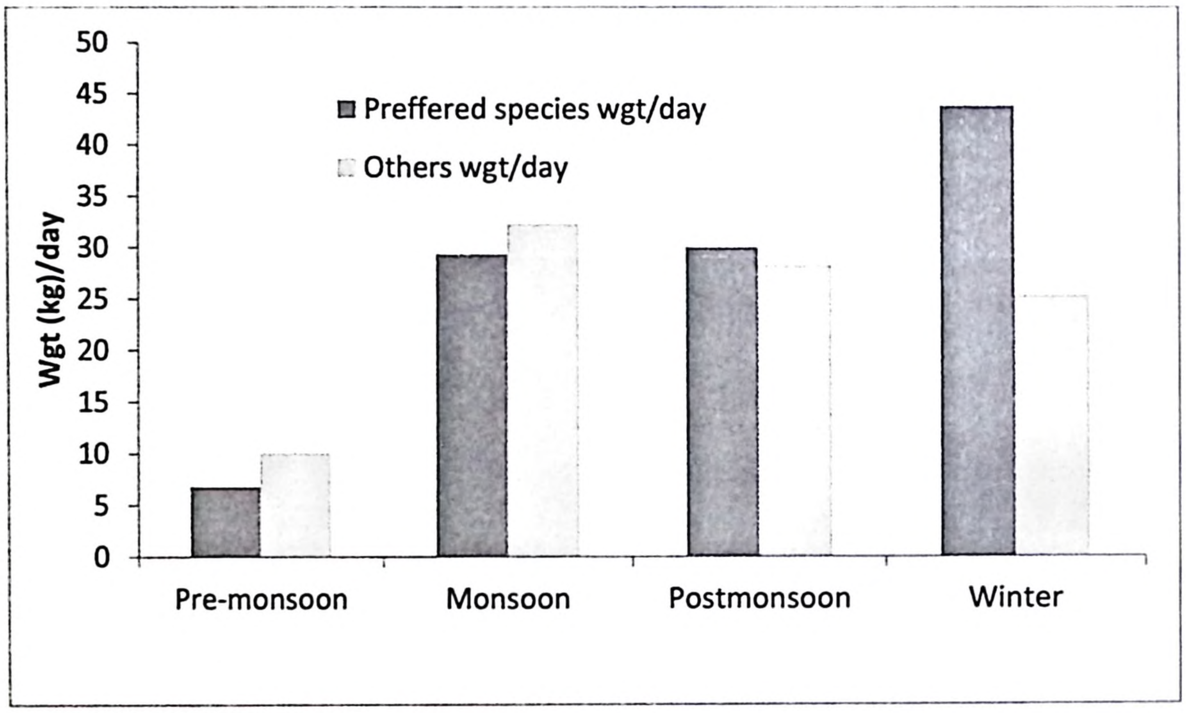


Figure 4.15 Seasonal vaiations in amount (kg/day) of preferred and other prey received in fish landing sites.

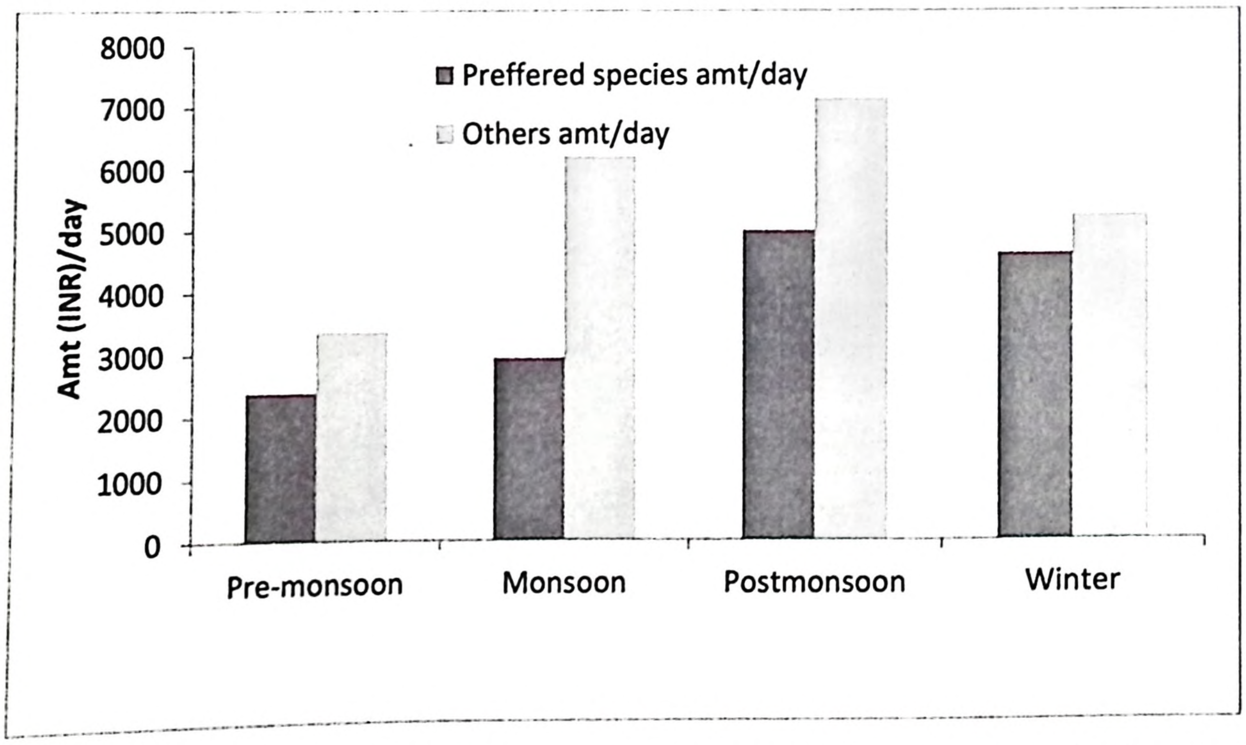


Figure 4.16 Seasonal vaiations in amount (INR/day) of preferred and other prey received in fish landing sites.

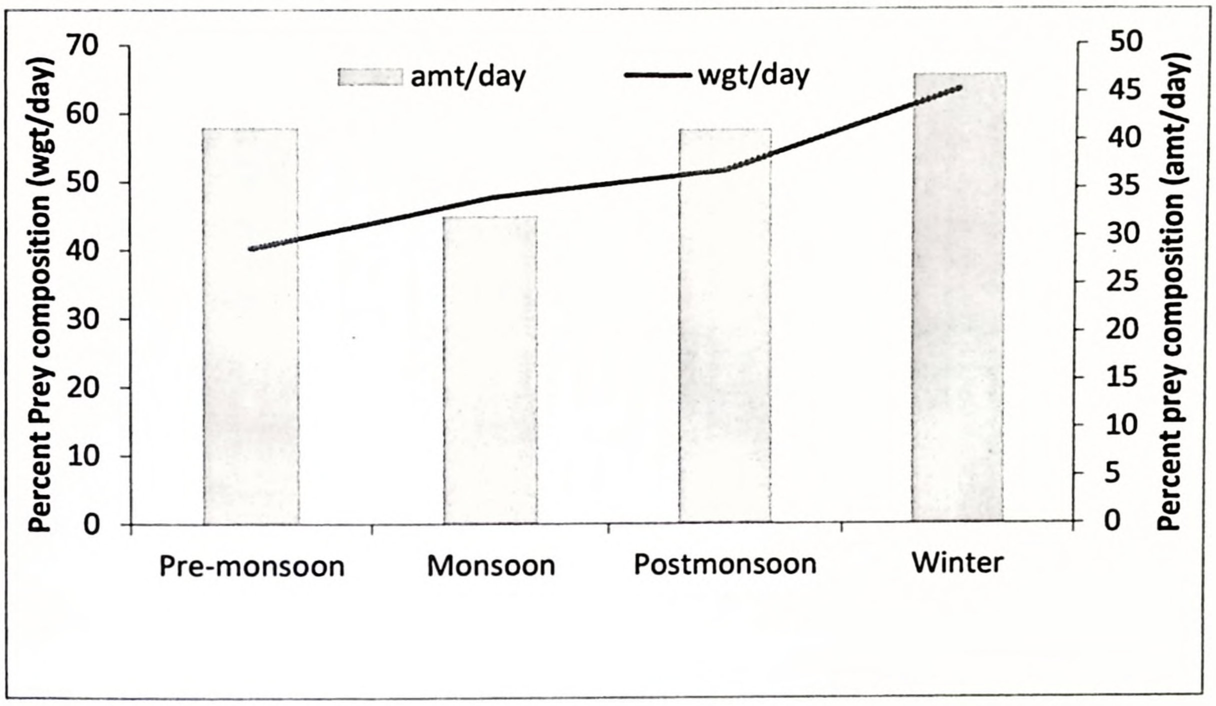


Figure 4.17 Percentage seasonal composition of preferred prey (wgt and INR/day) in the fish landing sites of Kulsi River.

4.3.4. Fishermen Interview results to track the fishing trends in the Commercial fishery of Kulsi river (N=122)

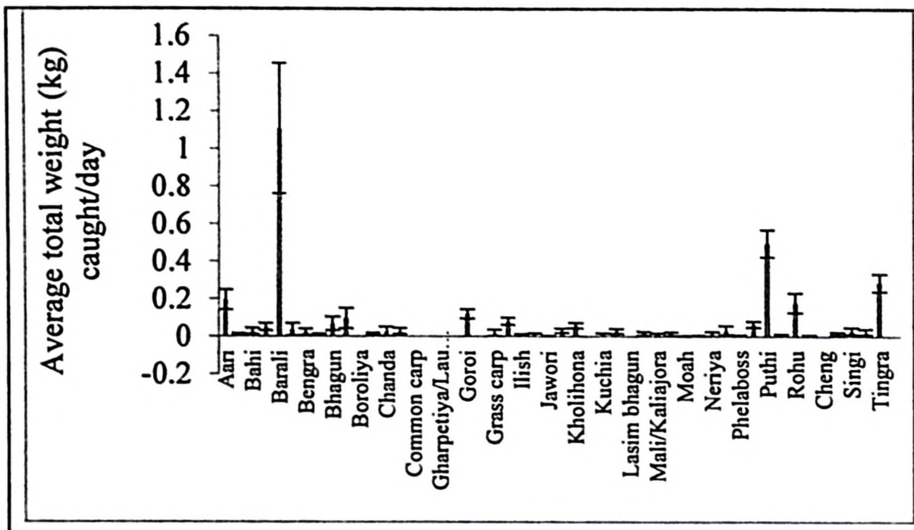
a. Seasonal catch (per day): General View of Fishermen communities of Kulsi river

General view of fishermen communities of Kulsi river is that during pre-monsoon season fish caught per day (kg/day) for most of the species is below 0.5kg/day (Fig.4.18.a) except for matured size Wallago attu which ranges from 0.8 to 1.5kg/day and Punctius spp. which were caught in an amount of 0.5-0.6kg/day (Fig.4.18.a).

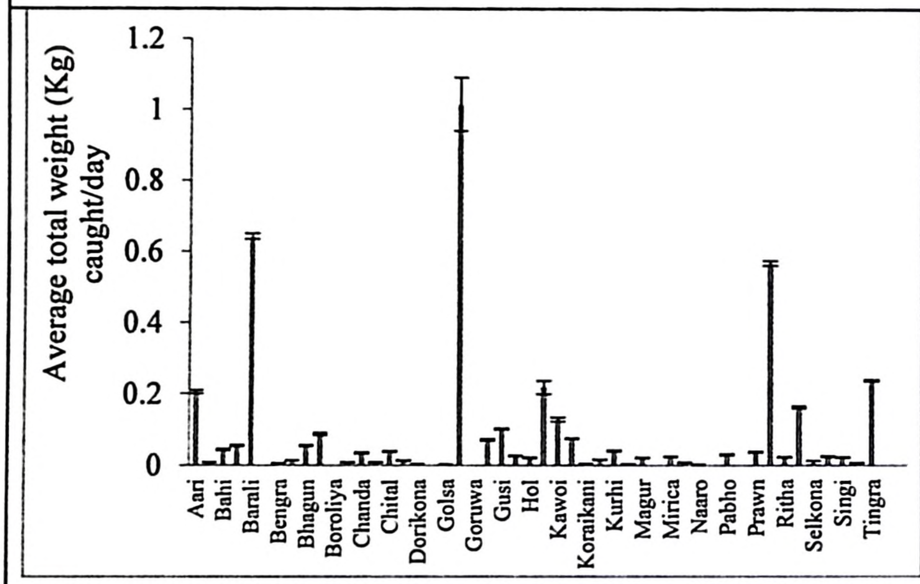
In Monsoon season small-sized species were harvested more Mastacembelus arnatus arnatus, Channa punctatus, Anabus testudineus, Colisa fasciata, Labeo bata, Punctius spp., Mystus spp. etc. (Fig.4.18.b). Large size species like Aorichthys spp., Wallago attu, Labeo rohita were caught in moderation (Fig. 4.18.b). Carps were also available in minimal during this season (Fig. 4.18.b).

In the post- monsoon the fish sizes increases and hence harvested amount also increases comparatively for all the species (Fig.4.18.c). Carps were caught in moderation during this season (Fig.4.18.c).

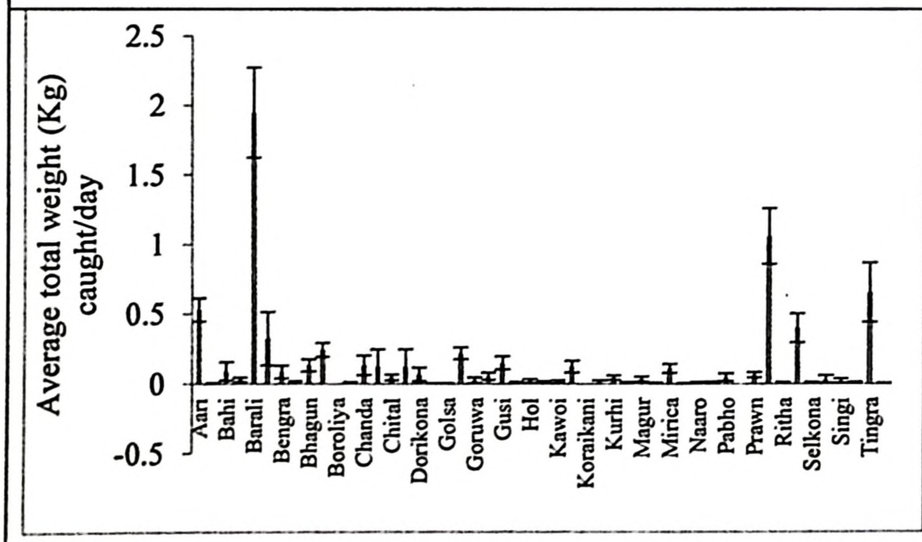
In winter season the overall species diversity decreases but the quantity of fish harvested of those particular species such as Aorichthys spp., Wallago attu,Punctius spp., Mystus spp.were similar to the quantity harvested in post- monsoon season (Fig.4.18.d). Carps decreases during this season (Fig.4.18.d).



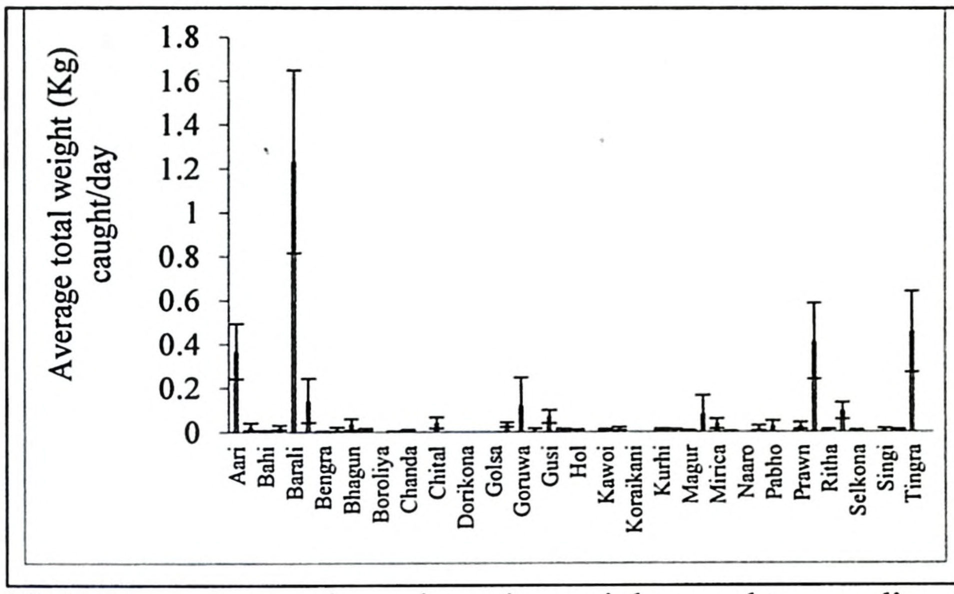
a. A general overview of total weight (Kg) of fish caught per day during Pre-monsoon season from Kulsi river according to the fishers



b. A general overview of total weight (Kg) of fish caught per day during Monsoon season from Kulsi river according to the fishers



c. A general overview of total weight (Kg) of fish caught per day during Post-monsoon season from Kulsi river according to the fishers



d. A general overview of total weight (Kg) of fish caught per day during Winter season from Kulsi river according to the fishers

Figure 4.18 Average seasonal species-wise weight caught according to fishers' interview (Spp. scientific name list is mentioned in Appendix 2).

b. Most preferred season for fishing (N=122)

The most preferred season for fishing is post- monsoon season followed by Monsoon season (Fig. 4.19). Fisher also gives high fishing effort (more than 5 days a week for fishing) in Post-monsoon season (64% of respondents), however in monsoon season they give medium effort (3-4 days a week). Winter season in the least preferred season for fishing. 57% of the respondents have said they give no effort during this season.

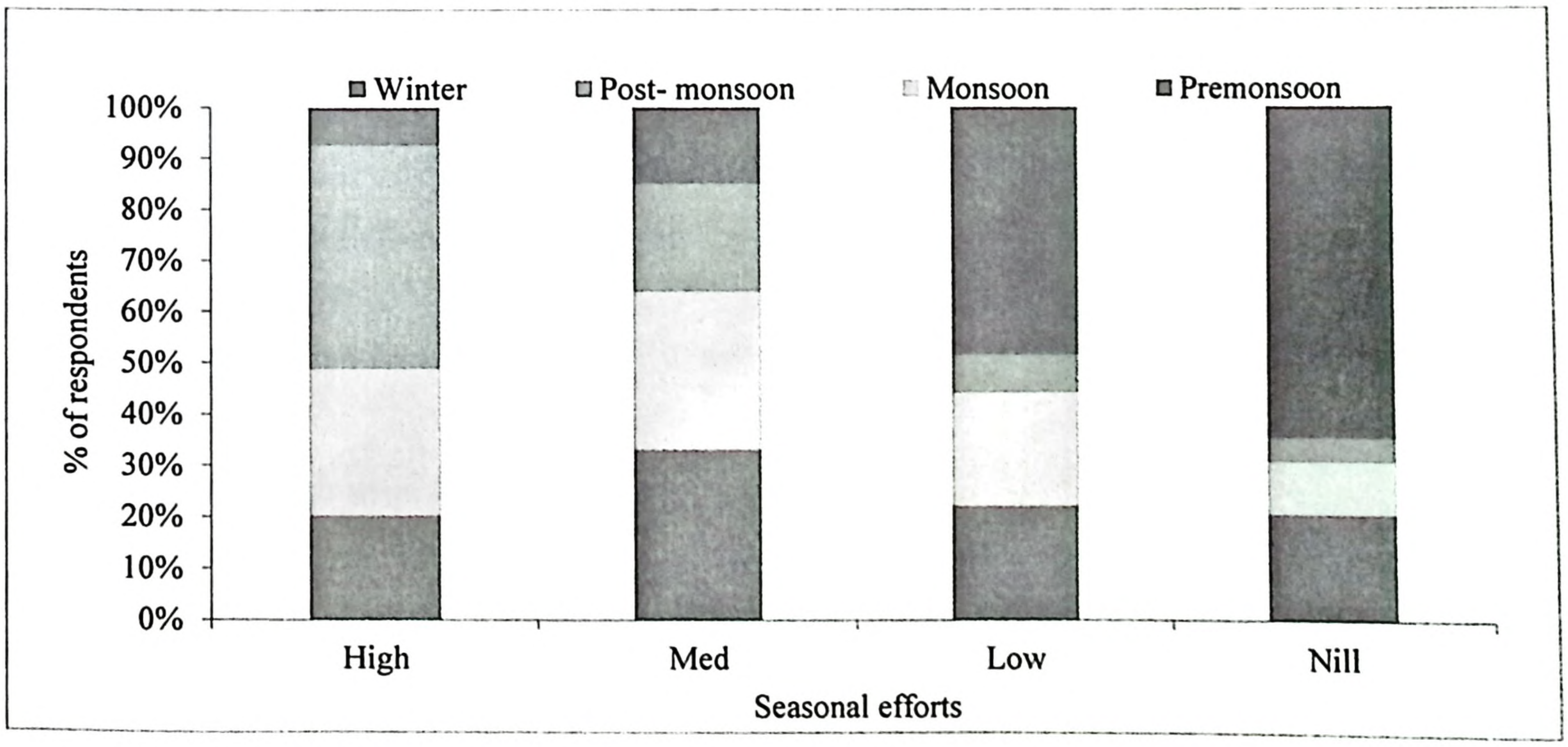


Figure 4.19 Seasonal efforts for fishing

c. Seasonal fishing gear preferences according to the fishermen interviewed (N=122)

First, most preferred gear type of Kulsi river fishermen throughout all the seasons was recorded to be Cast net followed by Gill net and lift net (Fig.4.20). However, no correlation (Spearmen's rho correlation coefficient=-0.02) was observed between the use of different fishing gears in different seasons.

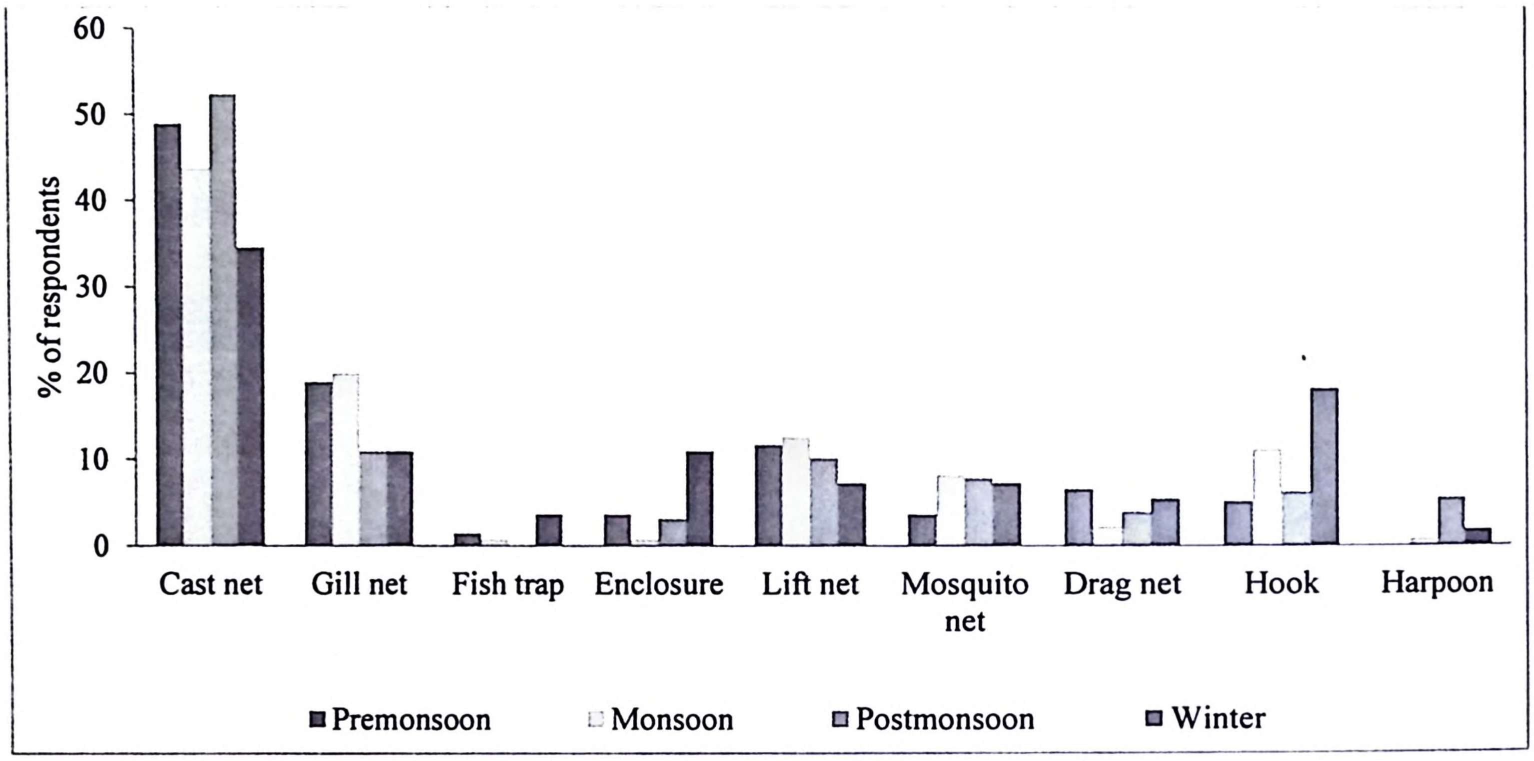


Figure 4.20 Most preferred gear type of Kulsi river fishermen for different seasons.

d. Seasonal differences in mesh sizes of Fishing gears of Kulsi Fishermen

It was observed that mesh sizes of ranges less than 1 cm to 2cm were used more frequently in Kulsi river irrespective of any seasons (Fig.4.21). 2cm to 4cm mesh sizes were used moderately throughout all the seasons (Fig.4.21.). Above 4cm mesh sizes were used seldom and mostly during winters (Fig.4.21). However, there was no correlation (Spearmen's rank correlation coefficient=-0.016) between uses of different mesh sizes in different seasons.

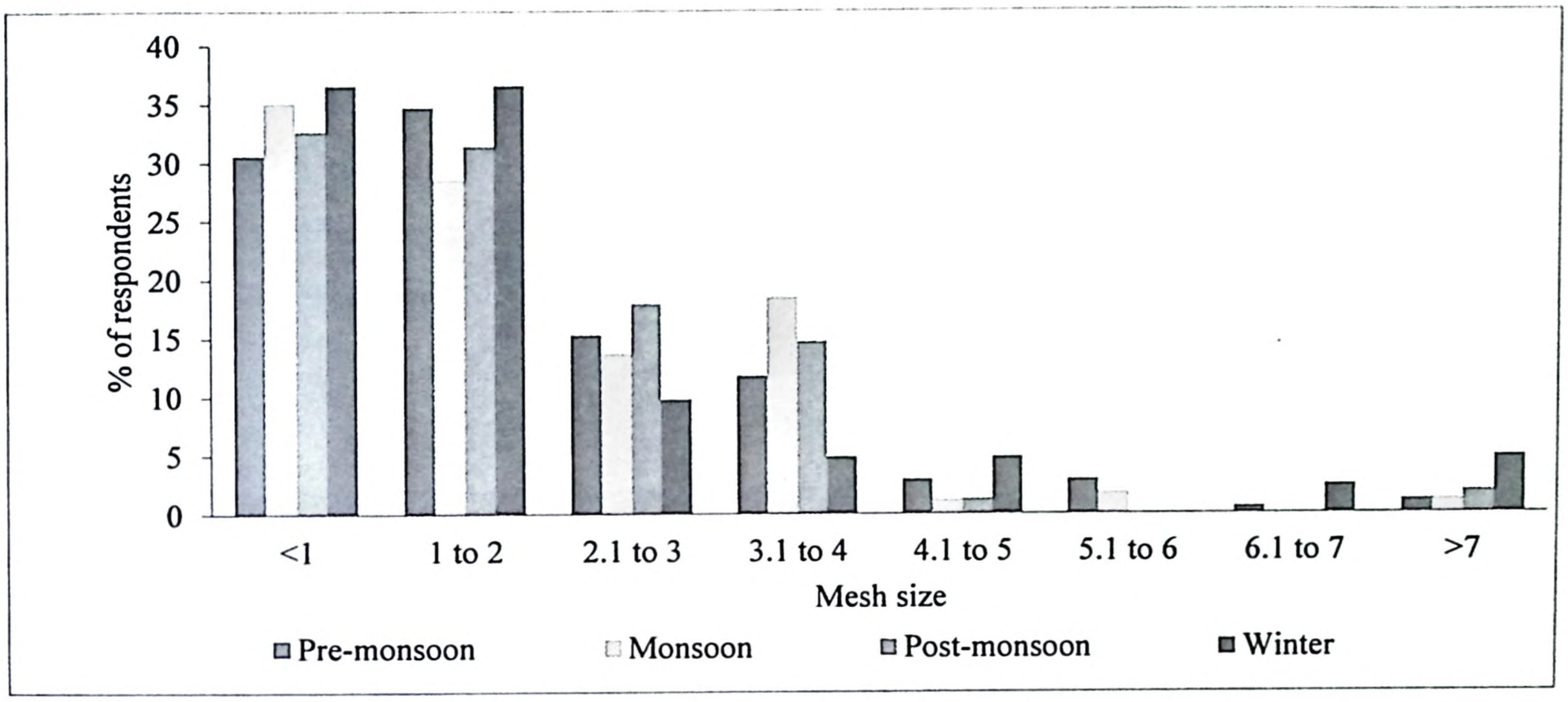


Figure 4.21 Seasonal mesh sizes (cm) of fishing gears.

4.3.5. Sand mining trends (N=64)

a. Hours spent/ day for sand mining in Kulsi river and the amount of sand mined

A maximum number of sand miners spent 4 to 6 hrs a day in mining activity which includes reaching to the mining spot, loading the boat with sand, coming back to the depositories and unloading the boat (Fig.4.22.a). Beyond 8hrs the numbers of respondents decrease. However, miners digging with pumps dig for 10 to 12hrs a day.

Average sand dug manually by one person (with the help of buckets) in one hour time 1.10 cubic metre (SE=0.20). On the other hand sand duh with a pump of 5hp in one hour is 2.50 cubic metre (SE=0.60).

b. Sand mining activities in last 10 years

According to the miners, the percentage of sand mining is increasing for the last 10 years (Fig.4.22.b).

c. River stretch used for sand mining

Sand miners mostly (17%) use 2-3km of stretch around the depositories for digging sand from the river bed. 8 to 6% uses 4 to 6kms of stretch around the depositories to extract sand. 1 to 3% of miners go beyond 7kms to dig sand around the depositories (Fig.4.22.c).

d. Season preferred most for sand mining

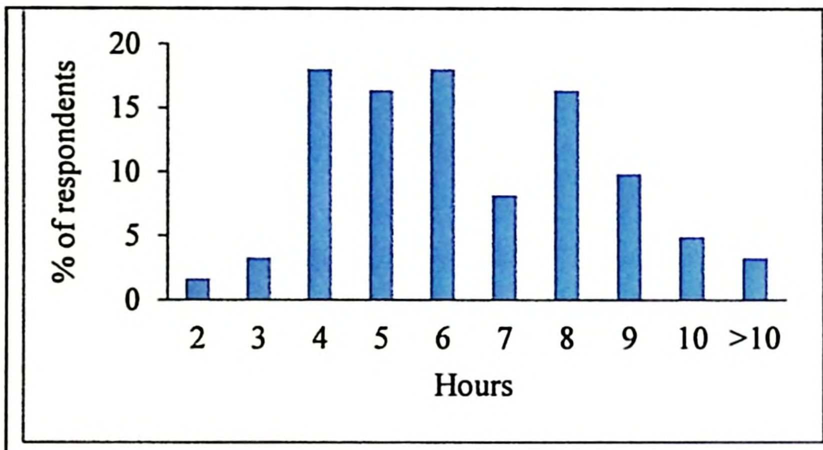
According to 12% of the respondents, they mined throughout all the seasons, however, 43% responded that they prefer monsoon season most for mining followed by pre-monsoon season (19%) (Fig.4.22.d).

e. Seasonal demands for sand

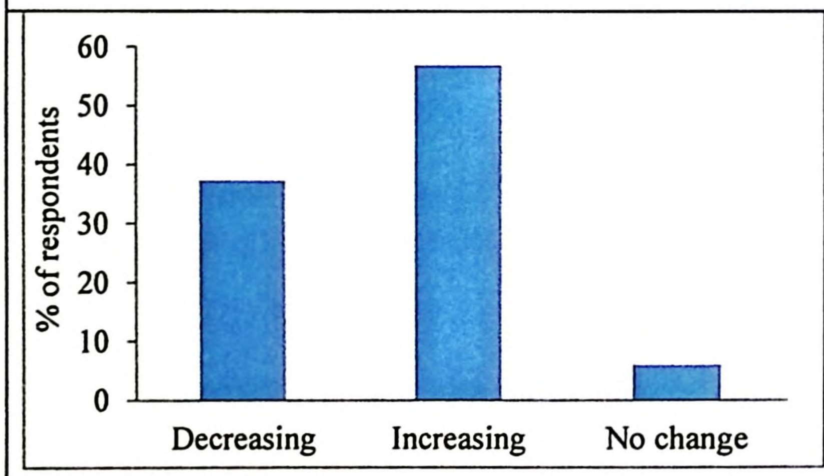
Although 40% have responded that there is never low demand of sand from Kulsi river throughout the seasons, however, 43% have responded that during winter season there is a comparatively lesser demand of sand (Fig.4.22.e). The sand price per cubic metre during winter or low water season ranges from INR 140-150 and during monsoon or high water season the price per cubic metre goes up to INR 200- 250.

f. The quantity of sand in the river

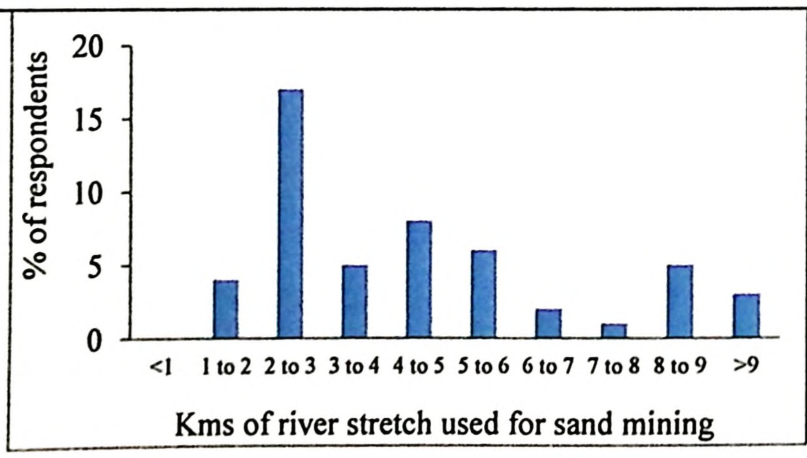
The response towards overall sand quantity in the river comes up to be decreasing in the last 10 years (Fig.4.22.f).



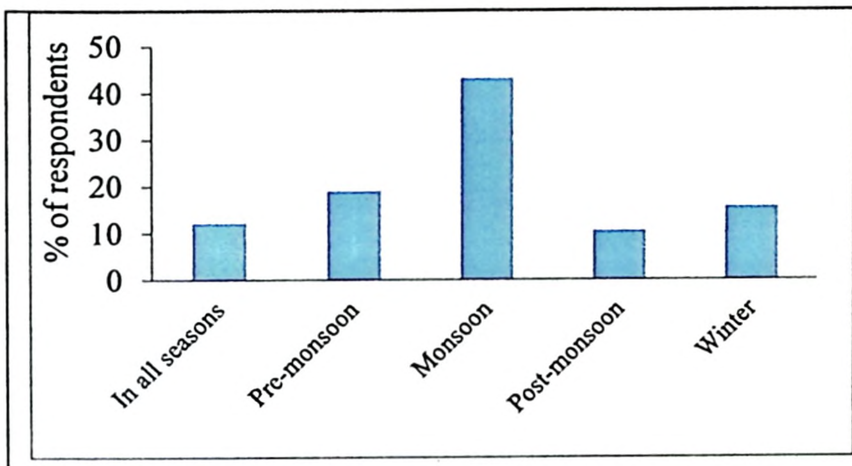
a. Percentage of respondents regarding the duration of hours invested in sand mining activities



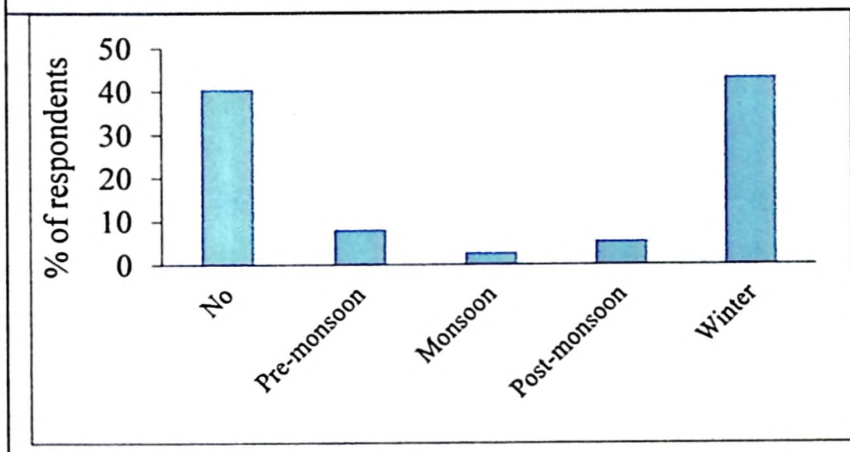
b. Percentage of respondents regarding their views on the intensity of sand mining activities in past 10 years



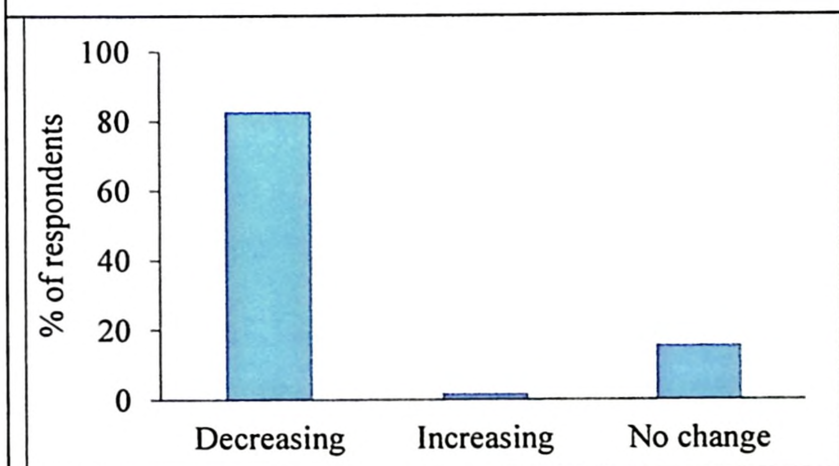
c. Percentage of respondents regarding total stretch (in km) of the river used for sand mining.



d. Percentage of respondents regarding their views on seasonal preferences for sand mining



e. Percentage of respondents regarding their views on seasonal low sand demand



f. Percentage of respondents regarding their views on the quantity of sand in the river in comparison to last 10 years

Figure 4.22 Percentage respondents of the sand-miners interview (N=64).

4.3.6. Plankton Survey

Total 12 locations where sand mining is actively happening till today, five locations without any occurrence of sand mining activity happened previously and five sites where mining stopped five or more years back from where the sample was collected for analysis. The density estimate of phytoplankton was higher compared to zooplanktons throughout all the sites (Table 4.5). However, no significant difference was observed across different sites (F_{phyto}=0.79, p-value=0.46, df=2; F_{zoo}=0.03, p-value=0.98, df=2).

Table 4.5 Density estimates of Phytoplankton and Zooplankton during Pre- monsoon season (2016) in Kulsi river.

Mining status	Phytoplankton, n/L	Zooplankton,	Phytoplankton, n/L	Zooplankton, n/L

	(SE) (collected from (mid of stream)	n/L (collected from mid of stream)	(collected from bankside)	(collected from bankside)
Mined	34.36 (±5.14)	1.37 (±0.35)	34.37 (±3.72)	1.6 (±0.36)
Previously mined	24.4 (±12.01)	0.4 (±0.59)	38.48 (±2.75)	1.76 (±0.57)
No mining	16.4 (±9.07)	1.33 (±0.48)	37.04 (±6.73)	1.44 (0.47)

4.3.7. Water Quality in Sand mining areas

It was observed that the temperature of the downstream area with sand mining pumps has a higher value compared to the rest of the categories followed by areas with sand mining pumps (Table 4.6). pH was less in downstream areas of sand mining pumps followed by areas with sand mining pumps (Table 4.6). DO was less in areas with sand mining pumps followed by downstream channel with sand mining (Table 4.6). Turbidity was higher in an area where mining took place 5 or more years back followed by areas with a downstream channel with sand mining (Table 4.6).

However, the values of each water quality parameter in all the different sites do not vary significantly from one another ($p>0.05$).

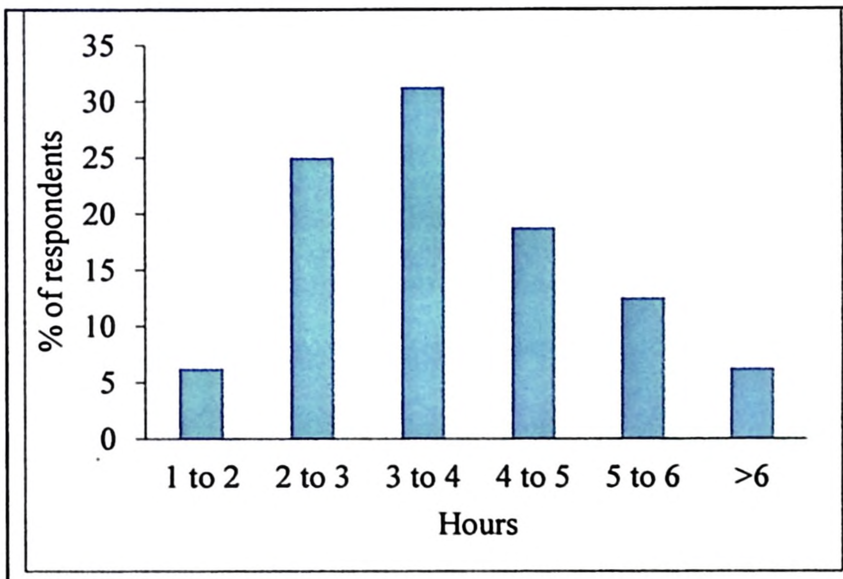
Table 4.6 Average of water quality parameters on different sites with various intensity of sand mining.

Sites (Total no.)	Temperature (SE)	Salinity (ppt) (SE)	pH (SE)	DO (mg/l) (SE)	TDS (mg/l) (SE)	Conductivity (us/cm) (SE)	Turbidity (NTU) (SE)
Unmined (2)	29.84 (0.64))	0.03 (0.01)	8.13 (0.09)	5.93 (0.63)	40.84 (8.82)	69.03 (15.61)	47.06 (14.74)
Mined once (>5yrs back) (3)	29.47 (0.55)	0.02 (0.001)	8.25 (0.20)	6.30 (0.21)	30.33 (0.57)	51.60 (1.00)	55.87 (13.31)
Mined manually (4)	29.92 (0.47)	0.024 (0.004)	8.27 (0.14)	5.98 (0.37)	36.18 (5.20)	60.08 (8.11)	49.66 (7.91)
Mined with pumps (3)	31.28 (0.25)	0.04 (0.001)	7.92 (0.08)	2.70 (0.38)	53.19 (0.53)	91.16 (1.38)	45.18 (1.22)
Downstream of mining sites (2)	32.46 (0.40)	0.03 (0.001)	7.80 (0.18)	2.70 (0.90)	50.25 (0.85)	87.77 (0.01)	50.94 (0.68)

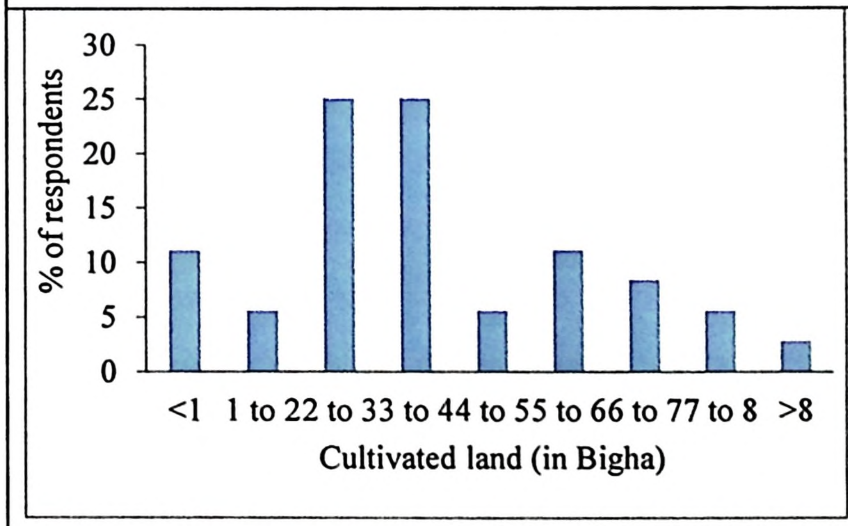
4.3.8. Farmers irrigating field directly from Kulsi river (N=36)

All the farmers interviewed use Kulsi river as the only source of irrigation for their cultivated lands during low water season or during winter to pre-monsoon season. Mostly all the cultivated lands reside the bank of Kulsi river especially in the alluvial floodplain zone of Kulsi river. Their cultivation comprises extensively rice (Irri cultivation). However, some other crops include Jute, mustard, and chilies. In monsoon and Post- monsoon seasons most of these areas remain flooded, due to which cultivation is not possible.

A questionnaire survey responds gave an estimate of the average requirement of 3.3 hrs a day to irrigate one bigha (0.16 Ha) of land using a 5hp water pump (Fig.4.23.a.). With the help of this information, it was estimated that an average of 686 lt. of water/bigha/day (SE=69) is pumped out from Kulsi river for irrigation.



a. Average hours spent in a day to irrigate one bigha (0.16 Ha) cultivated land with a 5hp motor pump.



b. Percentage of respondents regarding their total cultivated land along the bank of Kulsi river.

Figure 4.23 Percentage respondents of farmer on resource utilization (N=36).

The winter season crop is of 4 months which required 3 months of irrigation. Almost 50% of the respondents have 2 to 4 bighas of cultivated land along the bank of Kulsi river which required irrigation almost on daily basis (Fig.4.23.b.).

The average volume of water flown per sec (cubec or cubic mt/sec) was estimated; with the flow data of low water season (m/s), depth and channel width; to be 27.57 cubec (SE=1.05) during low water season.

4.4. Discussion

Shifting in fishing targets from large sized fishes towards small size fishes was observed in all the surveys carried out to estimate the prey abundance of Ganges dolphin. The most used mesh size throughout all the seasons was <1cm. The bigger mesh sizes (6- >7cm) were least used. A higher catch per unit effort was estimated for smaller mesh size fishing gears during Catch calendar surveys in all the seasons. The most abundant species recorded from fish landing site survey was comprised mainly of crustaceans, Puntius spp., minor carps such as reba of Cyprinidae family, Mastacembelus armatus of Mastacembalidae family and Mystus spp. of Bagridae family of class sizes from >1-20cm. These are also the preferred fish species of Ganges dolphin (Sinha et al. 1993, Tawquir et al. 2010), Market value of those species in fish landing sites of Kulsi was found to be consistent throught out the seasons (250-300/- kg) which also indicates their continuous demand.

The market survey results revealed that big size species like Wallago attu and Aorichthys spp. reaches on an average of 1-2 kg in size only during the time of harvesting. Major Carps were received at minimal rate in the fish landing sites. This trend shows that the availability of big size fish in the entire habitat of Kulsi river is declining. And on the other hand abundant small size fish and decrease in the abundance of commercial species from the ecosystem indicates overexploitation (Kelkar et al., 2010; Murawski, 2000). The distribution of fishing activities over the years shows a decline, which may also indicate the declining fish population resulting into shift in occupation by traditional fishers to other profitable occupation such as sand mining.

Studies on gut content of Ganges dolphins done in Ganga (Sinha et al., 1993) and site preferences of Ganges dolphins in Vikramshila Ganges dolphin sanctuary (Kelkar et al., 2010) concludes that the prey resource of Ganges dolphins is predominantly occupied with small-sized fish. On the other hand, the abundance of small size fish can critically decline following the evolving fishing trend of the fisher. The fish harvest continues during fish spawning period i.e. during monsoon season. According to the Assam fishery Rules 1953, 1st May to 15th July is recognised as fish banned period and throughout the seasons mesh size below 1-2 cm is not allowed. However, the rule does not prevail among the fisher community which we can observe from the questionnaire surveys. During the peak season of spawning, the newly recruited fish to the ecosystem is harvested with the aid of harmful gears like mosquito nets. Small mesh sized fishing gears were used irrespective of the seasonal changes. According to Uttar Pradesh state fishery rule below 40mm mesh size for fishing is illegal, but their study shows that due to non- regulation of the rules almost 75% of fishers fish illegally (Kelkar et al., 2010).

Apart from this, depletion in the lower trophic level, i.e. planktons, which comprises the major food source of the small-sized fishes, has also been observed in Kulsi river. No significant difference was observed among different sites of Kulsi river. This can probably because of the growing numbers of mining sites and the impact from mined to unmined sites is becoming homogeneous. On the other hand, the abundance of plankton in Kulsi river is very much lower than that of Subansiri (Pers. comm.). Subansiri is also one of the major tributaries of Brahmaputra and holds a resident population of Ganges dolphin. The mining activities is negligible compared to Kulsi river. A seasonal fluctuation in plankton numbers was seen in Subansiri (higher during winter season and low during monsoon season), however the density (n/L) is much higher compared to Kulsi river (Fig. 4.24.).

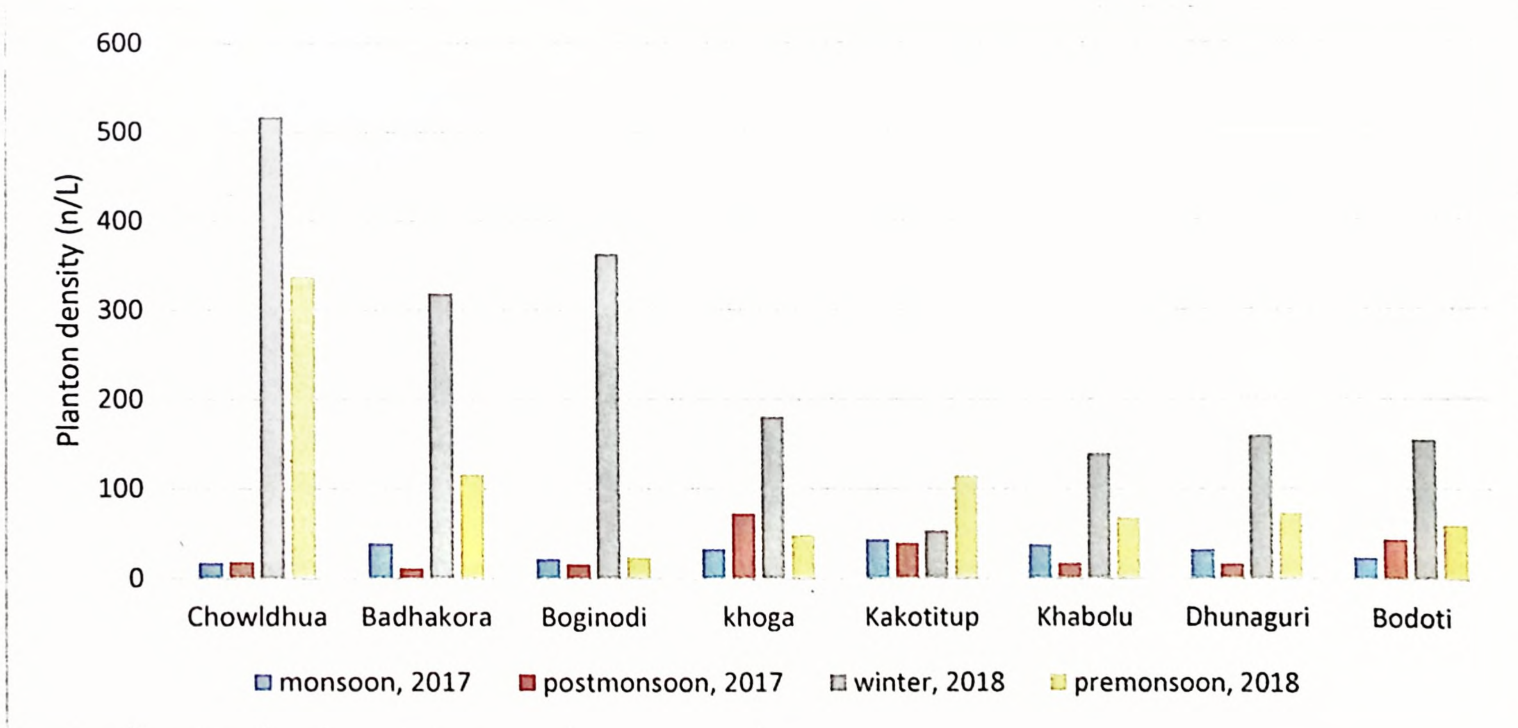


Figure 4.24 Seasonal variations of plankton abundance in different sites across Subansiri river (Pers. comm.)

The distribution of sand mining activities in Kulsi river has increased since 2011. Earlier the manual sand mining was focussed in the upper stretch of Kulsi river. In 2016 the manual digging of sand from the river bed is gradually shifted to pump mining to reduce the manual effort. This could potentially disturb the benthic substrate and reduce suitability of habitat in benthos (Nairn et al., 2004; Asraf et al., 2011). The smothering effect of increased turbidity in the water column reduces the primary productivity in the water and increases the biological oxygen demand of the ecosystem due to introduction of unwanted organic materials and nutrients (Borges et al., 2002; Asraf et al., 2011). The dissolved oxygen level in Kulsi river in various sand mining sites was not significantly different from each other; however, the overall DO level was less compared to the normal requirement of DO level for freshwater biodiversity (Fig.4.25). Mining activities uncover the toxic substances and reintroduce them to the ecosystem (Dubois and Towle, 1985, Borges et al., 2002, Asraf et al., 2011). It was observed that the minimum DO required for the carps and trouts is from 7mg/l and above. On the other hand, in Kulsi the DO level fluctuates between 2.7-6.3 mg/l. Although from the data, detrimental effect of sand mining on the benthic community is not visible or significant, in the near future the anthropogenic activity like mechanised sand mining could impart significant effect by further reducing the DO level and hence the primary productivity. With prompt intervention by regulating illegal and intensive sand mining activities, we could restore the habitat and ensure sustenance to the dolphin population.

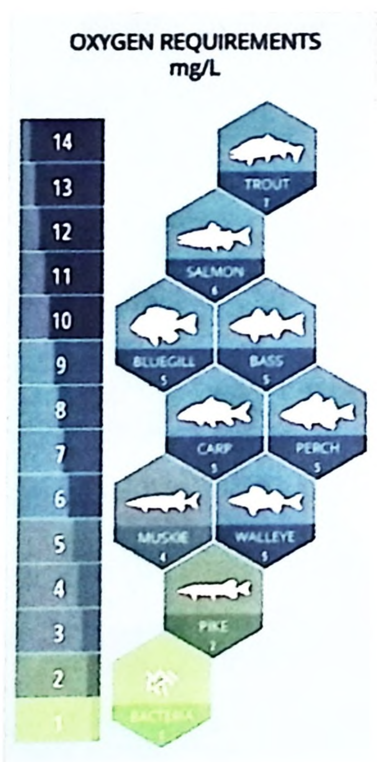


Figure 4.25 Minimum Dissolved oxygen requirements of different freshwater species to survive (Source: Fundamentals of Environmental measurements, fondriest.com).

Bank erosion due to sand mining with pumps.has been reported by the sand miners in Kulsi river during questionnaire surveys and formations of rapids in Kulsi river on the downstream of mining areas was spotted everywhere. A case study in Selangor River of Malaysia (Asraf et al. 2011) where unregulated sand mining is the major problem has come up with the conclusion that the heavy sand mining is resulting into the two primary processes of channel degradation, viz., Head cutting which occurs due to the excavation of mining pit in the active channel creating a nick point (Fig.4.26.a.) and resulting into downstream bed degradation due to increased energy flow (Fig.4.26.b.). Secondly, the pit excavation increases the water table-dependent woody vegetation in the riparian areas and decreases wetted periods in riparian wetlands finally resulting in bank erosion (Fig.4.27.a-b). The decreasing depth of streambed, braided flow or subsurface inter gravel flow in riffle areas, hinders movement of fishes between pools (Borges et al. 2000, Asraf et al. 2011).

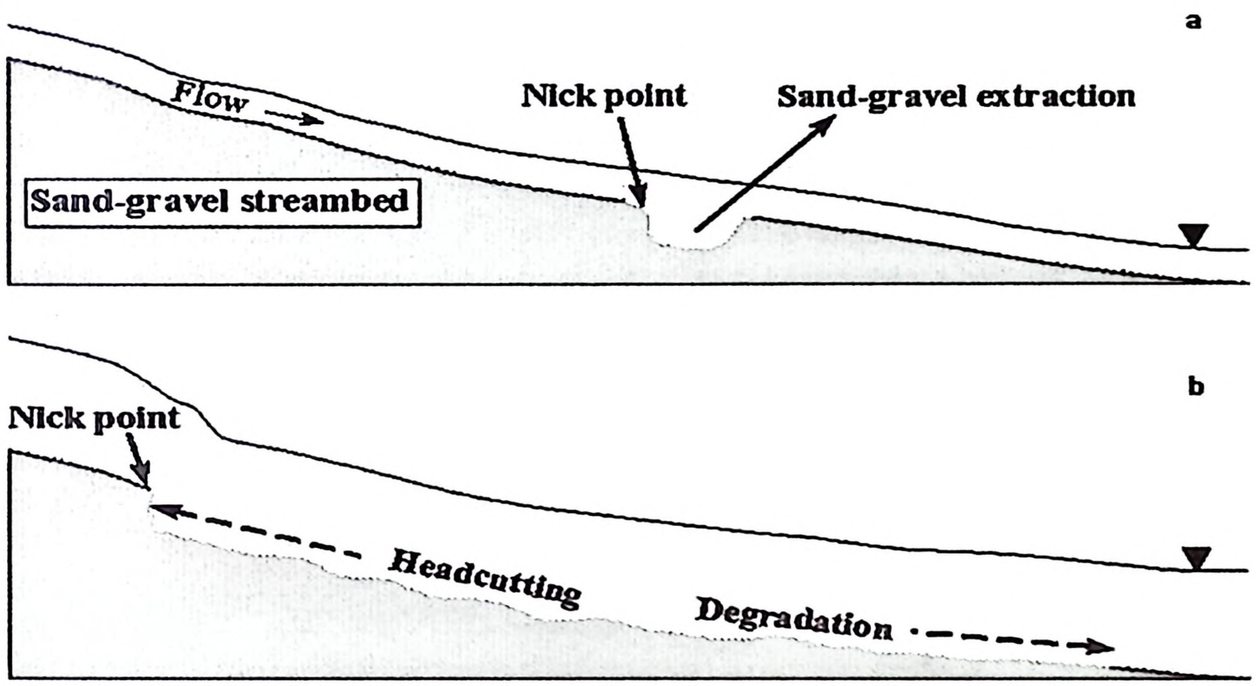


Figure 4.26a. Shows the formation of nick point that develops with a pit excavation during the stream bed mining process. b. The upstream head cutting and downstream bed degradation that develop during high flows (Source: The Ojos Negros Research Group).

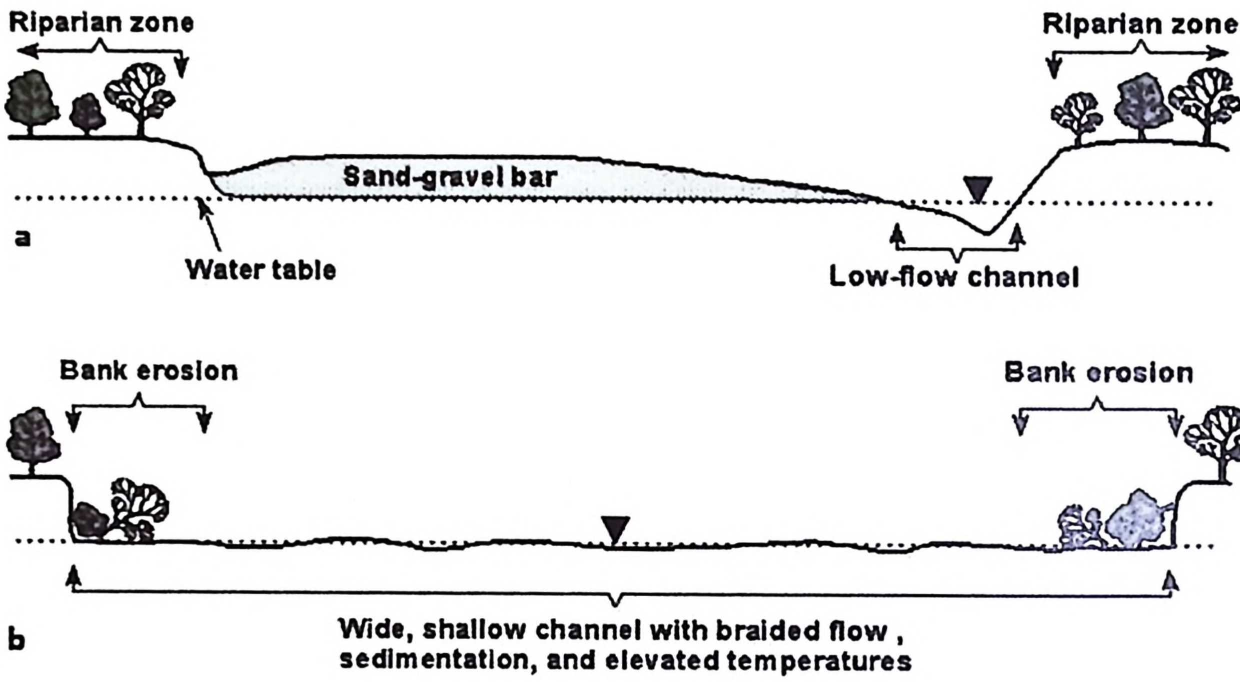


Figure 4.27 ***a:*** *Cross section of a typical sand- gravel bar in relation to the low- flow channel, riparian zone, and water table.* ***b.*** *Cross section of the wide shallow channel that results from unrestricted mining resulting in bank erosion, braided flow, sedimentation and increased water temperature (Source: The Ojos Negros Research Group).*

More than double the quantity of sand extraction was done with pump (2.56cum/hr, SE=0.56) as compared to manual digging (1.07cum/hr, SE=0.20) in Kulsi river. According to fishers, since the fish sources are declining, they were heading towards sand mining.

The lack of alternative irrigation facility among the farmers is further adding restrictions to the natural flow regime of Kulsi river water. During dry season, lifting Kulsi water for irrigation using motor pumps exposes the river bed. This is a condition when many abiotic factors, including Dissolved Oxygen levels, water temperature, suspended and bed load sediment size distributions and streambed stability could alter (Ward and Stanford, 1983; Sparks, 1992; Nestler et al., 1994; Allan, 1995; Richter et al., 1996). Since the environment is pushed outside the range of its natural variability, it is reducing the potentiality of survival of the native species and natural communities (Resh et al., 1988; Swanson et al., 1993).

In addition to habitat alteration due to mechanised way of sand mining and irrigation, it also creates a loud noise in the river and shoreline. This could disturb the animal and compel it to avoid its primary habitat (Smith, 1993). It is also evident from the questionnaire survey where the farmers have confessed that dolphins were seemed to move away from the place when the pumps were started.

CHAPTER 5: SOCIOECONOMIC STATUSES OF THE COMMUNITY STAKEHOLDERS AND THEIR PERCEPTION TOWARDS HABITAT CONSERVATION OF GANGES DOLPHINS

5.1. Introduction

The Brahmaputra basin of North- Eastern India is one of the water-rich basins in the world. The basin has socio-economic importance and influences the livelihoods of people in five countries, viz., Tibet, Nepal, Bhutan, India, and Bangladesh. It has the highest surface water potential of all the river basins in India. It possesses 31.33% annual available water resource of national potential (Pandit et al. 2015). It has 33 major tributaries (Sharma, 1993) with a per capita water availability of 16,589 cubic m per year (Pandit et al. 2015). The river ecosystem provides many tangible services to the communities residing on the floodplains with fish, irrigation, sand and other minerals, etc. along with numerous intangible services.

According to the Census of India 2011, Assam, the floodplain has total 1,16,289.5 hectares of land and 7,80,502 population distributed among six sub-districts with 627 villages of Kamrup (Rural) District. The 2011 census data says that Kulsi floodplain has 55,972.88 hectares of cultivable land belonging to 1,29,095 cultivators who solely dependent for irrigation on natural sources (Rainfall and Rivers). The Kulsi river basin has a total catchment area of 1896sq km along with its Boko and Singra tributaries in Assam and is characterized by numerous wetlands (beels), swamps and marshes both in the foothills margin and floodplain zone.

The river is divided into 7 River fishery units under Revenue department of Assam, and about 2500 commercial fishermen are registered under the fisheries of Kulsi river.

Fine quality sand is a boon to the people of Kulsi floodplain. More than 5000 families were dependent on this business. The recent increase in the construction business in Guwahati metropolitan and the nearby towns is reflecting in the increasing involvement of people in sand mining in Kulsi river.

However, the increasing population in the landscape is generating tremendous pressure on the resources available and the entire aquatic ecosystem. In this chapter the socioeconomics of the communities, viz., fishers, cultivators, and sand miners of Kulsi floodplain was estimated. Since these communities were directly or indirectly benefitted by the resources of Kulsi ecosystem, hence their perception towards the conservation of the ecosystem was studied. Ganges dolphin is the major attraction of Kulsi river. Thus the awareness among the communities regarding the species was investigated.

5.2. Methods

A snowball sampling method was followed for all the questionnaire surveys (Goodman, 1961). Few informants were identified initially and the subsequent sample was taken by asking for key recommendations such as village names, from these informants. Non-probability qualitative sampling continues till data saturation, that is, until it was recognized that no new data were forthcoming. The interviews were conducted following the ethical norms of socio- economic surveys (Silverman, 2005). Only the interested interviewees were interviewed in a deal not to disclose the interviewees' identity. Audio recorders were used with due prior permission from the participants. All informants were interviewed in a one-to-one basis in relaxed informal settings by a local Assamese speaker (with Kamrupia dialect) and a Bengali speaker (Char community dialect) to deal with different communities. In- depth interviews were conducted with structured (Punch, 2005) to semi- structured (Dunn, 2000) type of questions. The interviewers remained neutral during the surveys and avoid using leading questions, so that the informants do not get influenced (Turvey et al. 2013). All the interviews were completed within 15- 20 minutes' time.

The questions in the questionnaire was all factual and was developed to gather information about certain conditions or practices, of which recipient is presumed to have knowledge (Denzin and Lincoln, 1998; Appendix 5). It was divided into three parts, the first part was related to their occupation and ways involvement. The results and discussion of this part is done in the previous chapter. The second part was comprised of questions related to their socio- economic aspects and the third part was regarding their perception towards the conservation of Ganges dolphin and its wider ecosystem.

5.2.1. Fishers questionnaire survey

Interviews were conducted in about 22 fisher villages covering the entire stretch of Kulsi river. The informants belonged to three major fishing communities, viz., the Kaibatra community (original fishing community of Assam); the Namasudra community (Bengali Hindu fishing community) and the Muslim community. A few were also from Rabha tribal community of Assam. A total of 122 fishers were interviewed during the questionnaire survey. They followed a questionnaire with three sections. First with questions dealing with the trend of fishing they use to follow, secondly with questions related to their socio-economic status and thirdly their perception towards Ganges dolphin and wider ecosystem conservation. The results of the first part of the questionnaire were discussed in the previous chapter.

5.2.2. Sand miners' questionnaire survey

A total of 64 sand-miners were interviewed during the questionnaire survey. The questionnaire was again divided into three parts similar to the previous questionnaire: i. questions related to methods and quantification of sand mining, ii. Socio- economics and iii. Regarding Ganges dolphin and their perception towards conservation. The first part of questionnaire is presented in the previous chapter.

5.2.3. Crop cultivators' questionnaire survey

A total of 36 such cultivators were interviewed during the questionnaire survey. Similar to the previous questionnaires, this one was also divided into three parts, ways and quantification and perception towards Ganges dolphin conservation.

5.2.4. Analysis

A percentage response for each question was estimated for the three set of the questionnaire survey. Average seasonal incomes were estimated for fishers and sand-miners were estimated. Total average investments in crops and overall crop yields were evaluated for the cultivators.

Pearson's Chi- square test was used to estimating the correlations between the various aspect of socio-economic structure and perception towards dolphin conservation of the communities residing in Kulsi floodplain.

5.3. Results

5.3.1. Fishermen Community

a. Age Group

Among the fishermen interviewed during the session, major age groups belong to 40 to 50years followed by 51 to 60years and 20 to 30years of age group (Fig.5.1.a.).

b. Educational Qualification

Most of the fishermen were illiterate (58%) among the fishermen community of Kulsi river. The highest education level (28%) among the community was found to be primary education (Fig.5.1.b.).

c. The total lifetime spent in fishing Profession

Fishers with 21 to 30years of fishing experience were encountered most (38%) during the interviews (Fig.5.1.c.). Few percent of the fishermen were with fishing experience more than 50 years (Fig.5.1.c.).

d. Season-wise monthly Income through fishing activities

Highest average seasonal monthly income was earned during the Post-monsoon season by the fishermen community (INR 5252/-month) of Kulsi river followed by Monsoon season (INR 3548/-month) (Fig.5.1.d.).

e. Percentage of Respondents fishing throughout the year

Out of the total fishermen interviewed 66% of them go for fishing throughout all seasons. Only 34% of them go for other alternative sources of livelihood during unfavourable seasons (Fig.5.1.e.).

f. Season-wise monthly Income through other alternative sources of income

Out of that 34 % of fishers (Fig.5.1.e.) who goes for an alternative source of income during unfavourable seasons, average monthly income was seen highest during monsoon season (INR 7600/- monthly) followed by pre-monsoon season (INR 6900/-month) (Fig.5.1.f.).

g. Percentage of respondents changing fishing gears types and techniques in last ten years

Fishers with above ten years of fishing experience were asked for whether any changes in fishing gear types and techniques were made during last ten years of which only 7% have agreed (Fig.5.1.g). The respondents have explained that due to a shift in fishing targets from large sized fishes to smaller sized fishes, they made these changes. Apart from this, it was also mentioned that few fishing gears need high maintenance cost, which they cannot bear from their earnings and hence changed their technique.

h. Respondents views regarding the change in fisher number in their locality in the last ten years

Most of the fishermen (82%) have notified a decrease in fishermen number in the last ten years in their region (Fig.5.1.h). The apparent reason behind it was mentioned to be decreasing fish population in Kulsi river with time.

i. Respondents view regarding their knowledge about fish banned season declared by Assam Fishery rules (1953)

Total 62% of respondents were aware of the three fishing banned months of the year as per mentioned on Assam fishery rules (Fig.5.1.i). Although the rest 38% knows about the fish spawning time in the year, however, they don't know about the restrictions on fishing ordered by Assam fishery department.

j. Respondents view regarding Ganges dolphin behaviour towards them while fishing

Regarding observation of Ganges dolphins towards the fishers, while they were fishing, most of the fishermen (90%) have informed that dolphins do not disturb them while they are fishing (Fig.5.1.j). However, rest 10% have explained that dolphins do disturb them while fishing either by depredating their catches from their fishing gears (0.9%) or by chasing the fish away from their fishing gears (9.09%) (Fig.5.1.j).

k. Respondents view regarding seeing dolphin entanglement in fishing gears

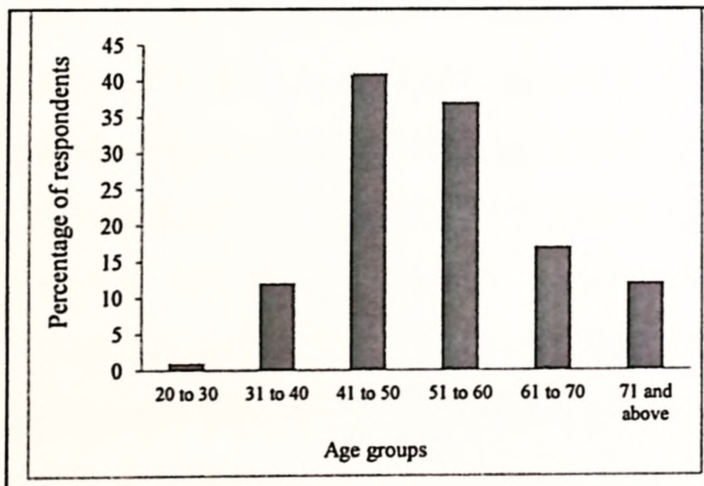
Total 91% of the fishermen have said they never saw or heard about dolphin entanglement in fishing gears (Fig.5.1.k). However, 9% have reported that they have seen or heard dolphin entanglement in various fishing gears in their locality (Fig.5.1.k). Highest entanglement was observed in gillnets followed by lift nets and drag nets in Kulsi river by the fishermen (Fig.5.1.k).

l. Percentage of respondents using dolphin parts (meat/oil/others)

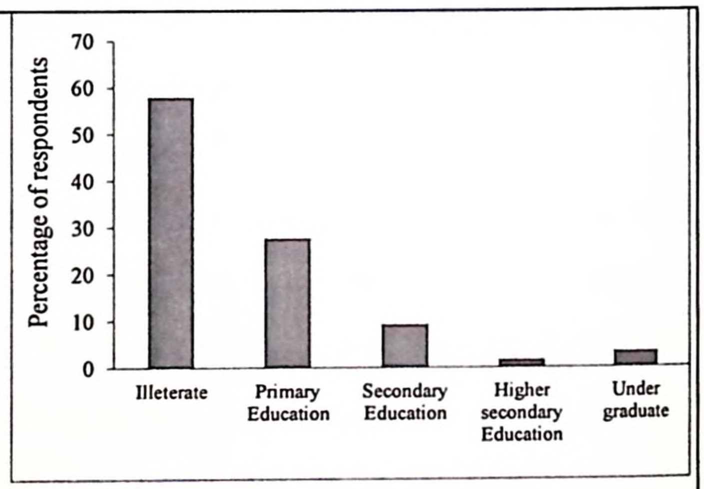
Total 98% of respondents have said that they have never used the dolphin part for any purpose (Fig.5.m). However, 2% have agreed that they have used dolphin oils extracted from its blubber either for fishing (67%) or for treating rheumatoid arthritis (33%) (Fig.5.1.l).

m. Awareness about the population status of Ganges dolphin, its title as a National and Assam aquatic animal, Protection level according to Wildlife Protection Act (1972) and the legal penalties declared for killing Ganges dolphin

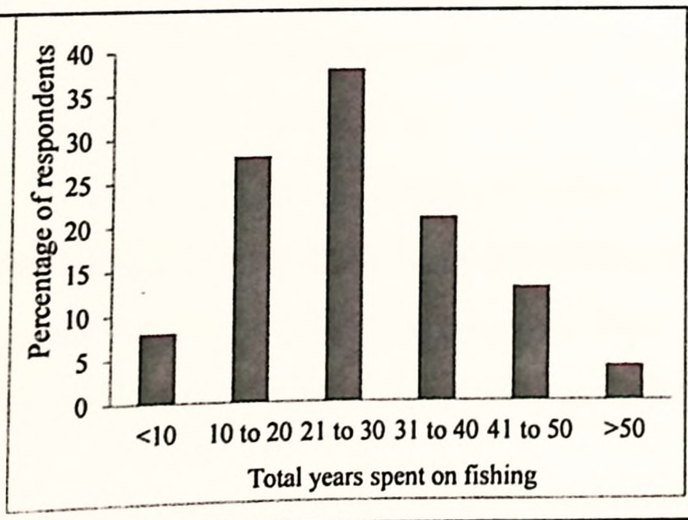
The fishers' community of Kulsi has agreed that the population of Ganges dolphin has decreased in the last ten years (Fig.5.1.o). About the recent fact that Ganges dolphin has been declared as the state aquatic animal of Assam, only 27% of the respondents were aware of the fact (Fig.5.1.p). About its title as National Aquatic animal, only 11% were aware of the fact (Fig.5.1.q). Regarding the killing of the Ganges dolphin as a punishable offense according to the Wildlife Protection Act (1972), maximum percentage (77%) of respondents was aware of the fact (Fig.5.1.r). However, regarding the penalties associated with the crime of killing Ganges dolphins, only 2% responded (Fig.5.1.s).



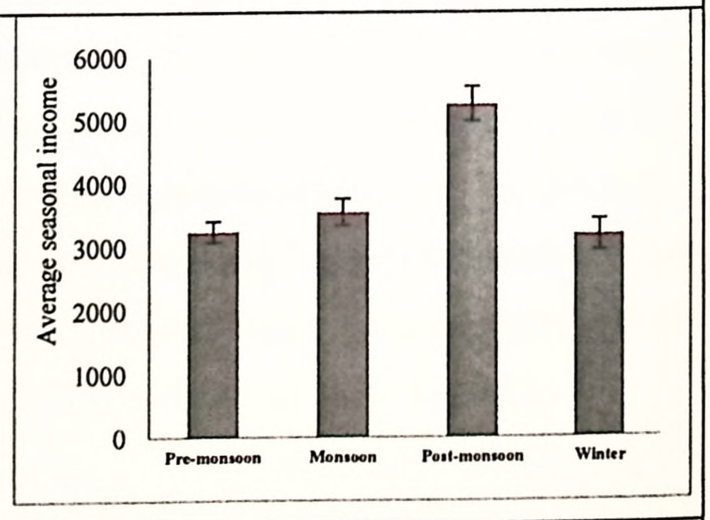
a). Percentage of respondents of different age groups.



b). Percentage of respondents of different level of educational qualification among the fishers.



c). Percentage of respondents regarding



d). Seasonal average monthly income

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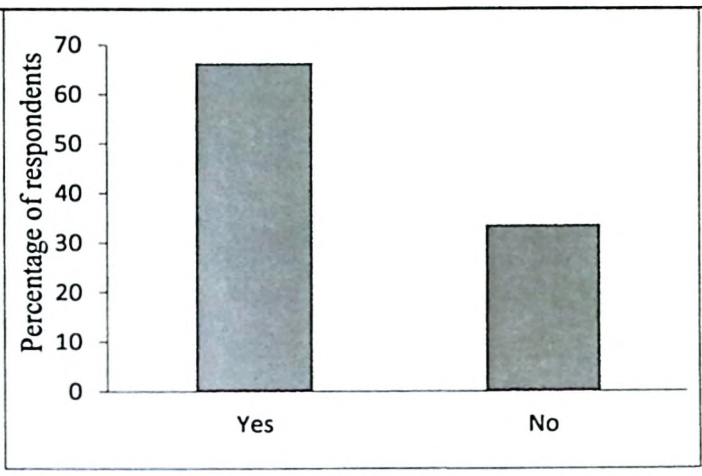
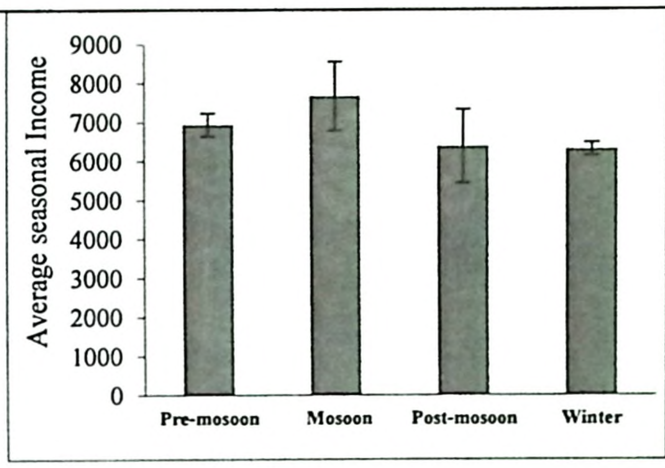
<tr><td>their total lifetime spent in fishing occupation.</td><td>from fishing activities.</td></tr>
<tr><td>
</td><td>
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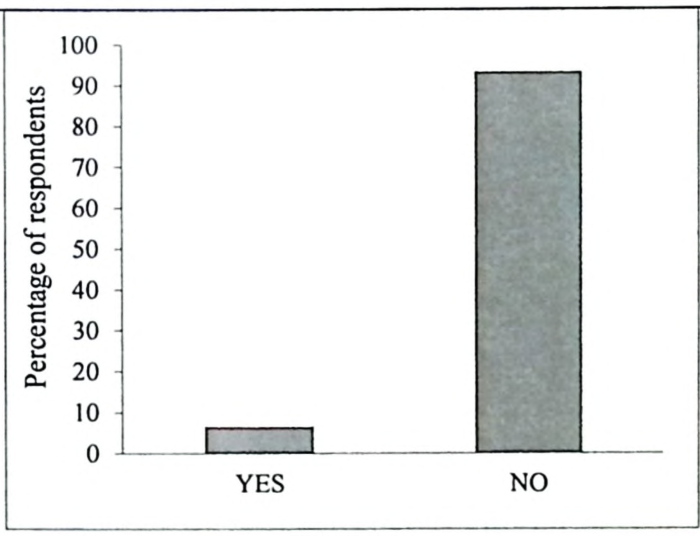
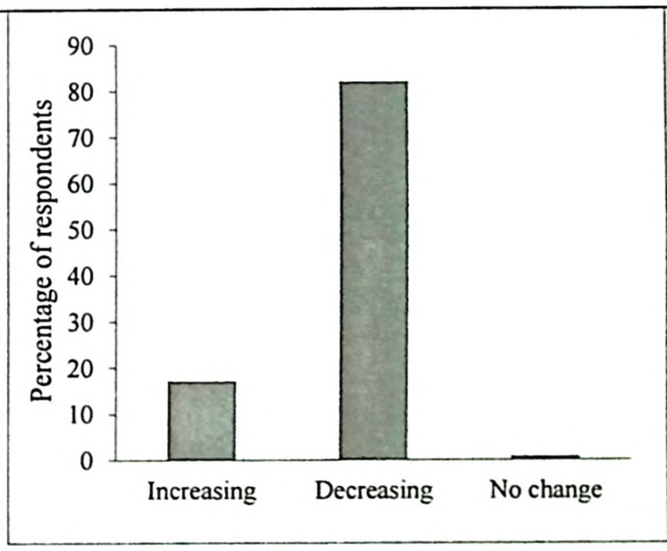
<tr><td>e). Percentage of fishers fishing throughout the year in the Kulsi river</td><td>f). Seasonal average monthly income from an alternative source of livelihood.</td></tr>
<tr><td>
</td><td>
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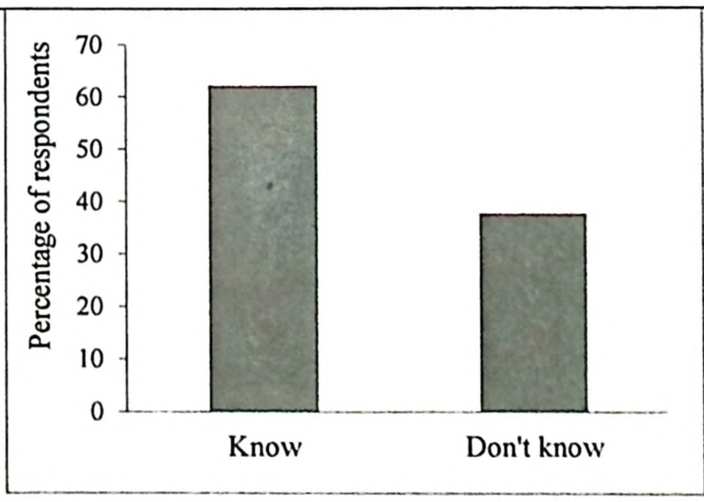
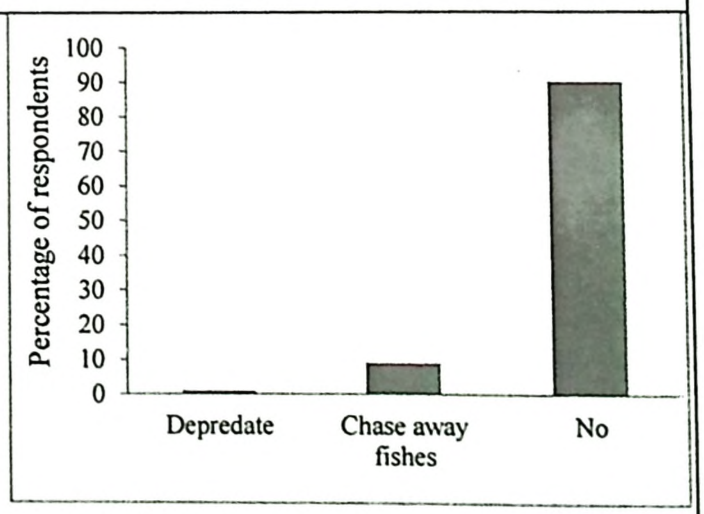
<tr><td>g). Percentage of respondents changing fishing gears types and techniques in last 10years.</td><td>h). Respondents view regarding the change in fisher number in Kulsi river in the previous ten years.</td></tr>
<tr><td>
</td><td>
</td></tr>
<tr><td>i). Percentage of respondents regarding their awareness about the fish banned season declared by Assam fishery rules</td><td>j). Percentage respondents towards Ganges dolphin behaviour while fishing.</td></tr>
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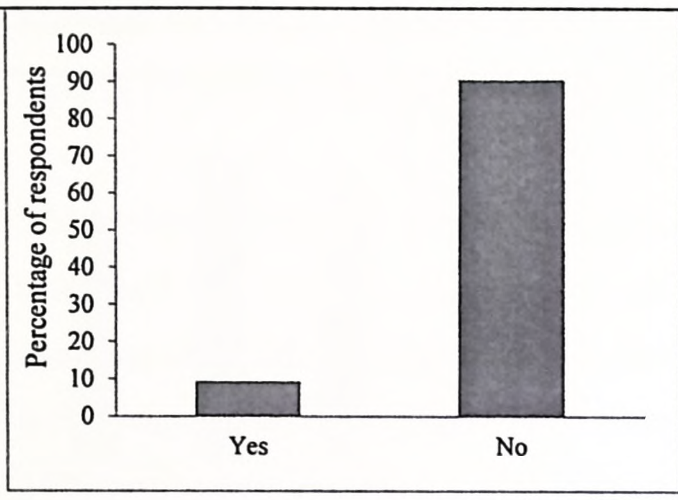
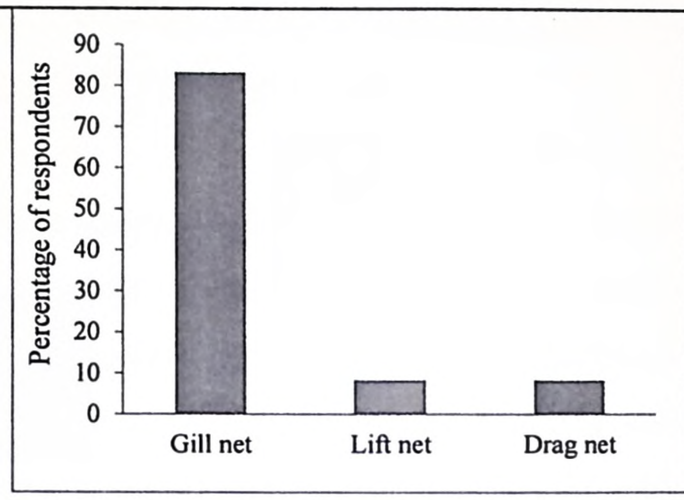
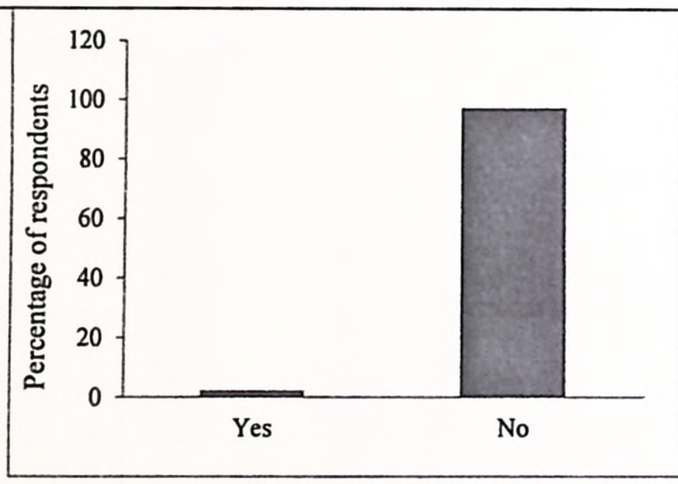
(1953).



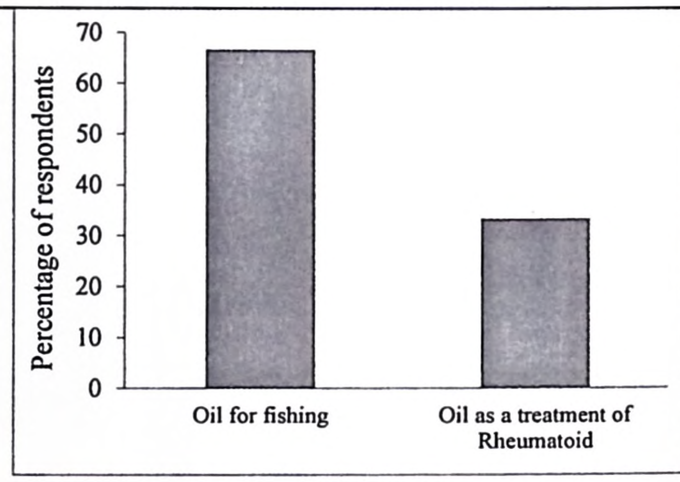
k). Percentage of respondents view regarding seeing dolphins getting entangled in fishing gears.



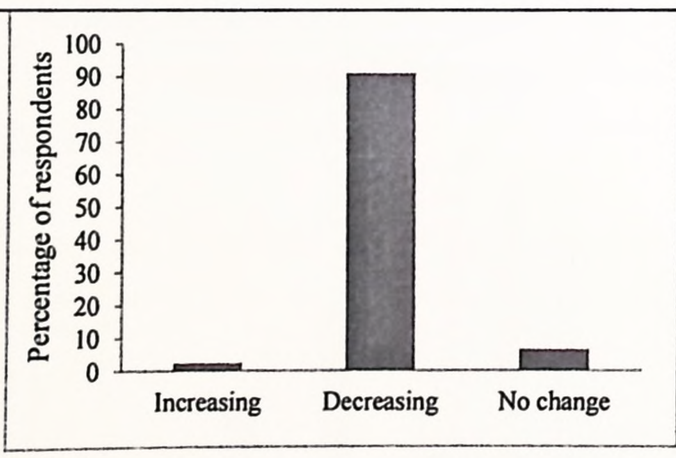
l). Percentage of respondents regarding different types of fishing gears responsible for dolphin entanglement.



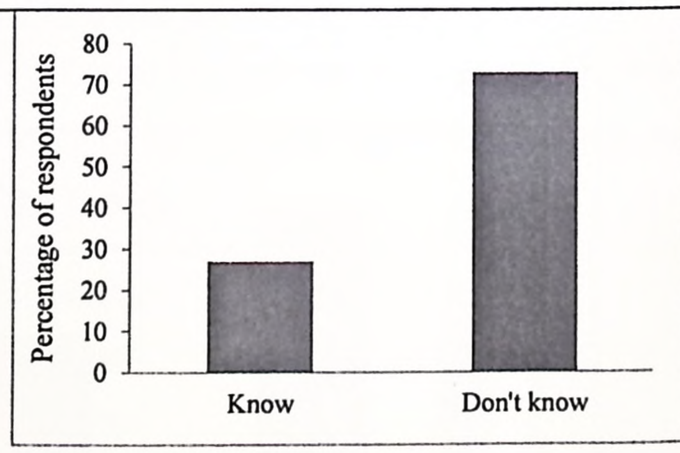
m). Percentage of Respondents using dolphin part throughout Kulsi river.



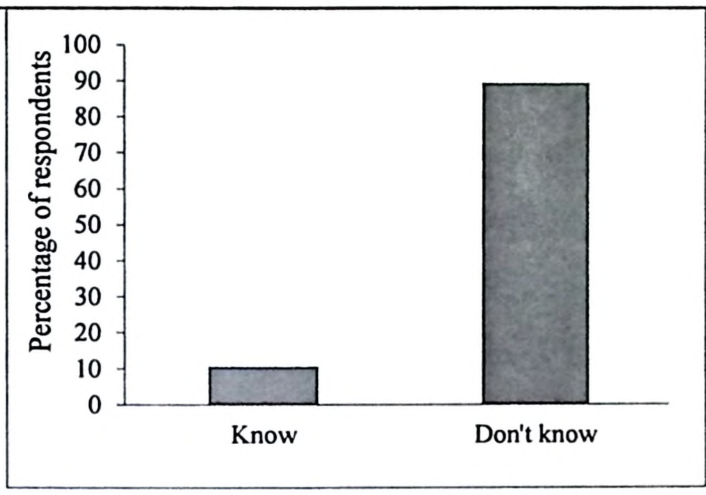
n). Percentage of respondents using dolphin oil for different purposes.



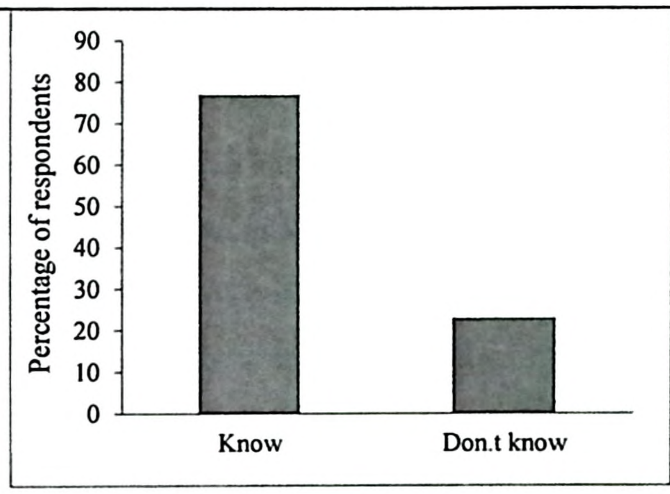
o). Percentage of respondents views regarding the change in Ganges dolphin population in the past ten years in Kulsi river.



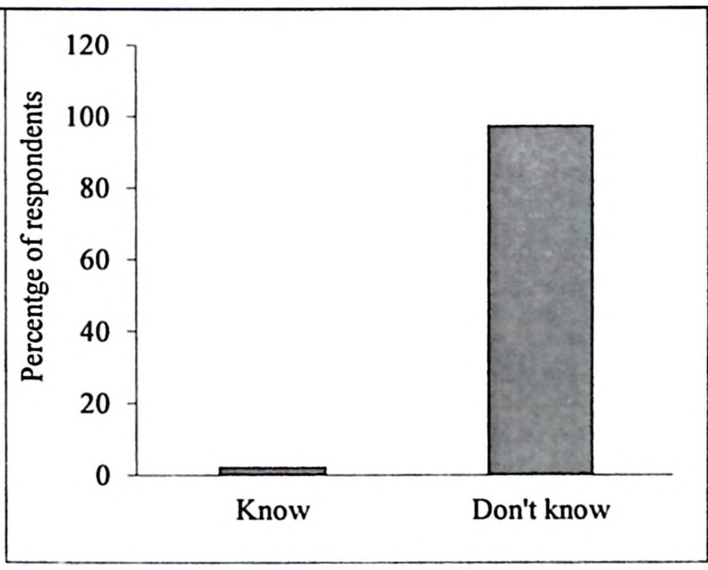
p). Percentage of respondents' awareness regarding the title of Ganges dolphins as a State aquatic animal of Assam.



q). Percentage of respondents' awareness regarding the title of Ganges dolphins as a National aquatic animal of Assam.



r). Percentage of respondents' awareness regarding Ganges dolphin killing as a punishable offense according to Wildlife Protection Act (1972).



s). Percentage of respondents' awareness regarding penalties associated with Ganges dolphin killing.

Figure 5.1 Percentage of respondents of fishers of different age groups (N=122).

n. Correlations between different aspects of socio-economic and perception of fisher community towards dolphin conservation

Significant differences were observed between education qualifications and level of awareness in fisher community regarding Ganges dolphin conservation (Table 5.1). It was observed that fishers with higher educational qualification were more aware about the wildlife regulations and fishery rules compared to the less educated or illiterate fishers. Significant differences were also observed in the responses of fishers who fish throughout the season and those who don't regarding awareness about fish banned season, information on net entanglement of dolphins and information on use of various organs of Ganges dolphin for different purposes (Table 5.1). It was observed that fishers who fish throughout all seasons were less aware about fish banned seasons, have more information of dolphin gear entanglement and were more prone to use various dolphin organs compared to the rest of the fishers. We have also found significant differences in the response of fishers complaining about the disturbances created by Ganges dolphin while they were fishing to the rest, regarding dolphin gear entanglement and use of dolphin parts for various purposes (Table 5.1). No significant difference was observed in respondents of different earning categories on their knowledge regarding fish banned seasons and on total life time spent on fishing (table 5.1).

Table 5.1: Chi-square results for different aspects of socio-economic and perception of fisher community towards dolphin conservation.

Sl. No.	Correlations	Chi- square value	df	p- value
1.	Educational qualification and awareness about the status of Ganges dolphin as a State aquatic animal of the respondents	1.38E+02	10	0.001
2.	Educational qualification and awareness about the status of Ganges dolphin as a National aquatic animal of the respondents	1.29E+02	10	0.001
3.	Educational qualification and awareness about the status of dolphin population in last 10 years of the respondents	1.24E+02	10	0.001
4.	Educational qualification and awareness about the fish banned season announced by the Assam Fishery rules of the respondents	1.32E+02	10	0.001
5.	Respondents views on disturbances created by dolphin while fishing vs their knowledge about dolphin entanglement incidences	1.34E+02	4	0.001
6.	Respondents views on disturbances created by dolphin while fishing vs use of various parts of dolphins by fisher	1.35E+02	4	0.001
7.	Respondents views on fishing throughout all season vs fish banned season	1.27E+02	4	0.001
8.	Respondents views on fishing throughout all seasons vs information on fishing gear entanglement of dolphins	1.22E+02	4	0.001
9.	Respondents views on fishing throughout all seasons vs use of various parts of dolphins by fisher	1.23E+02	4	0.001
10.	Annual income vs fish banned season	9.821	6	0.13
11.	Annual income vs total life time spent on fishing	10.67	6	0.1

5.3.2. Sand Miners

a. Age Group

Minimum age group involved in sand mining activities was found to range between 15 to 20 years of age. The highest percentages of respondents were from 25-30 years of age group. Respondents older than 50 years of age were also present among the interviewees (Fig.5.2 a).

b. Education

About 51% of the total respondents were illiterate, and 35% had the primary education (Class 1 to 5). The highest level of educational qualification was under graduation and comprised of about 2% of the total respondents (Fig.5.2 b).

c. Number of family members per household

The household of the sand-miners was mostly comprised of 4 to 5 family members (45% of respondents). Respondents' household with more than ten family members were also present among the interviewees (5.3%) (Fig.5.2 c).

d. Monthly Income generation from sand mining

About 25% of respondents have declared that their monthly earning from sand mining was INR 8000- 9000/-. The highest amount of income earned per month doing sand mining (13% of respondents) was reported to be more than INR11000/- (Fig.5.2 d).

e. Years spent as a sand miner and percentage of respondents who have to change their livelihood source to the sand mining business

Maximum percentage (35%) of sand-miners had spent 1 to 5 years in sand mining activities. Highest time spent on sand mining activities was found to be more than 20 years (3.2%) among the respondents (5.2 e).

About 70% of the respondents have agreed that they have shifted towards the sand mining business leaving other livelihood sources (Fig.5.2 f).

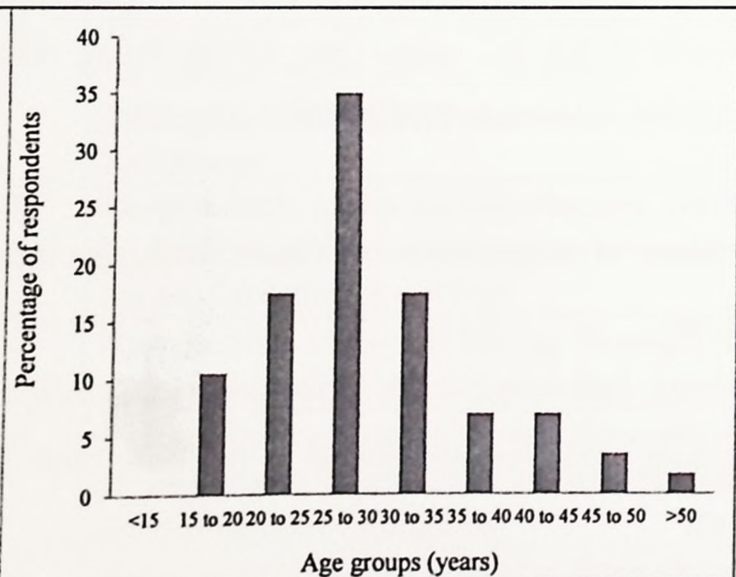
f. Motivation towards sand mining and carrying forward the trend to their next generation

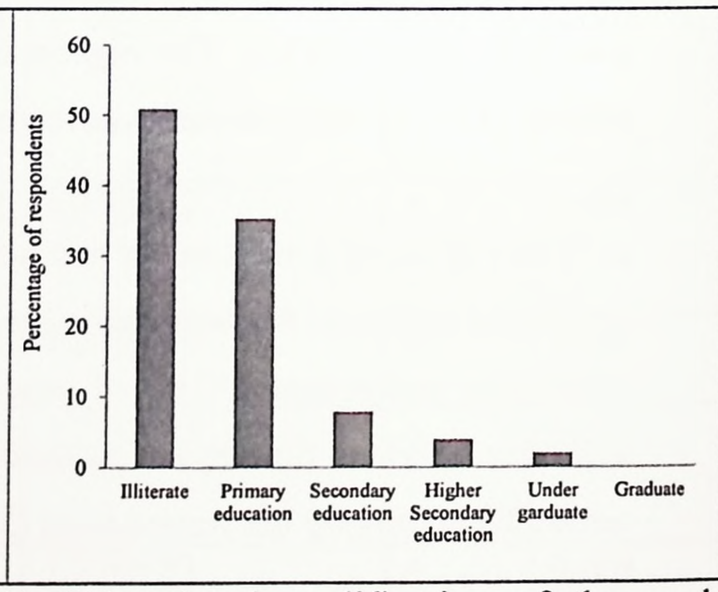
60% of sand miners have replied that they don't want to continue sand mining if they get any other equivalent or better source of livelihood as sand mining costs more hardship than they earn. However, 20% of the respondents have said that they want to continue sand mining because they don't have any other source of livelihood whereas another 20% of the respondents intend to continue sand mining because they were earning more with sand mining compared to other available livelihood sources (Fig.5.2 g).

About 98% of the sand miners don't want their children to carry on their trend of the sand mining business. However, 2% of the respondents think that they will allow their children to get into sand mining business as it has profits (Fig.5.2 h).

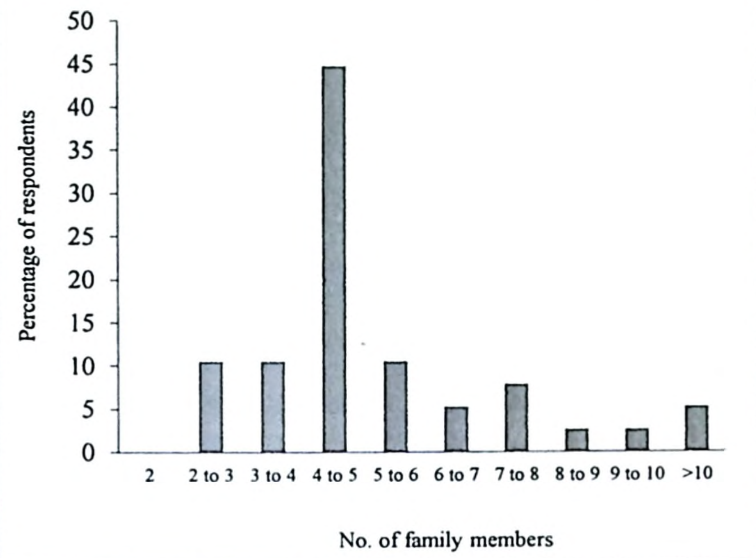
g. Knowledge regarding the status of Ganges dolphin population in last 10years in their locality and killing Ganges dolphins as a punishable offense according to Wildlife Protection Act (1972)

Most of the sand miners (78%) have respondent that the number of Ganges dolphins in Kulsi river has decreased since the last ten years (Fig.5.2 i). About 77% of the respondents know that killing Ganges dolphin is a punishable offense according to law (Fig.5.2 j).

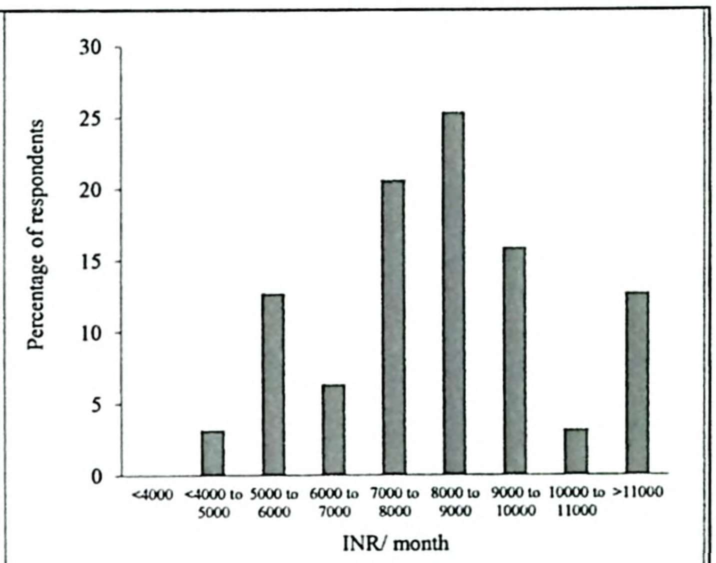




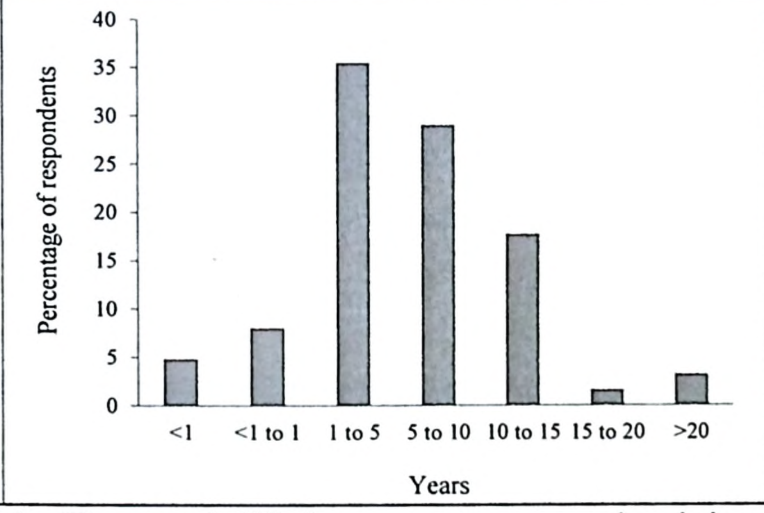
a). Percentage of respondents of sand-miners of Kulsi river of different age groups.	b). Educational qualification of the sand miner interviewees.



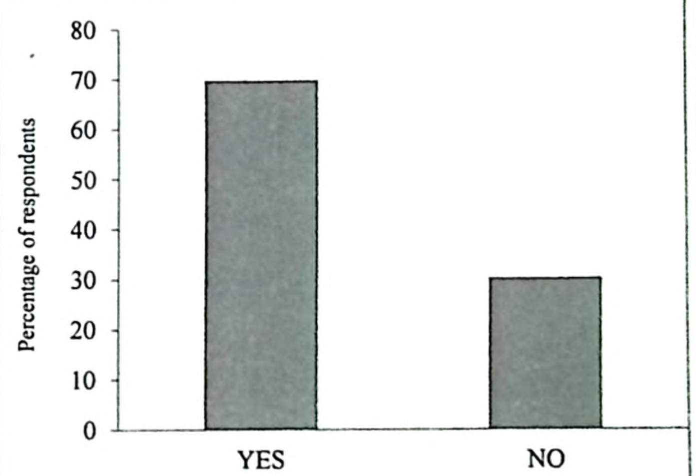
c). Percentage of respondents regarding the total number of family members in their households.



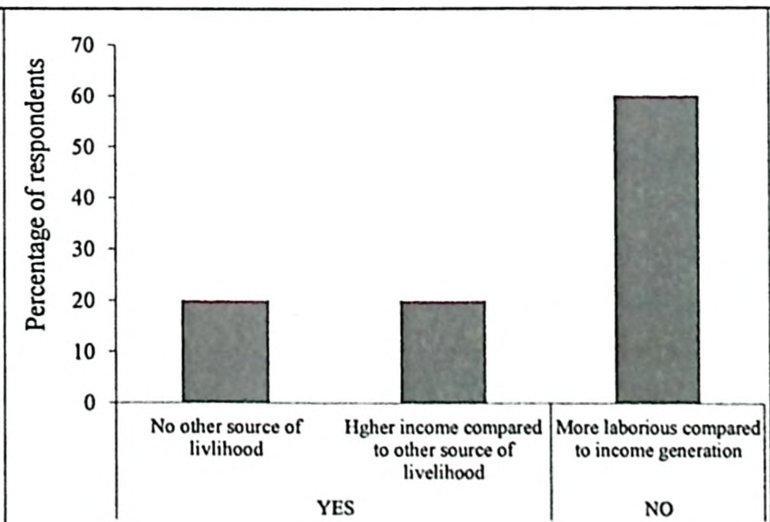
d). Percentage of respondents on monthly income generated by sand mining.



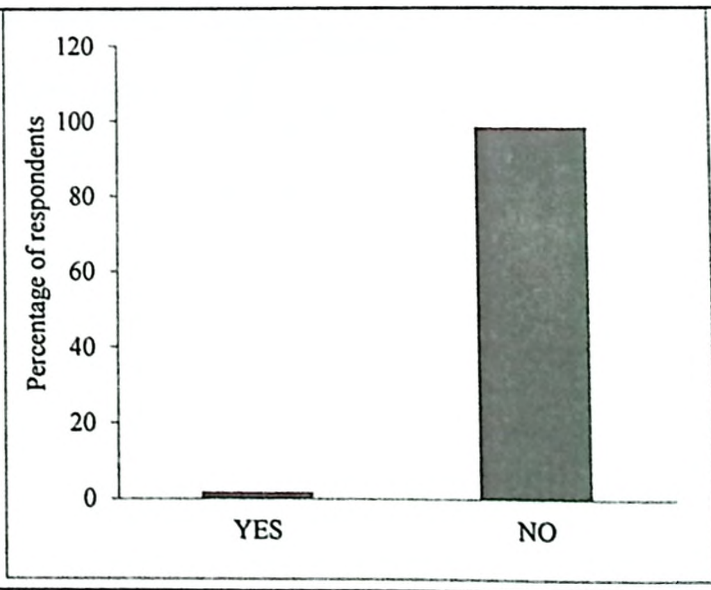
e). The total lifetime spent on sand mining activities among the interviewees.



f). Percentage of respondents regarding their opinion of shifting their livelihood source to sand mining.



g). Percentage of choice for sand mining business as a livelihood source among the



h). Percentage of respondents' views regarding carrying forward the sand mining

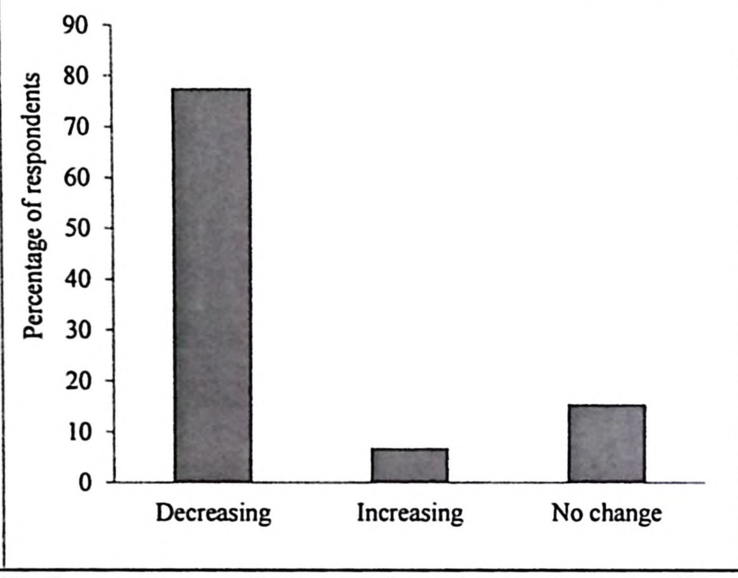
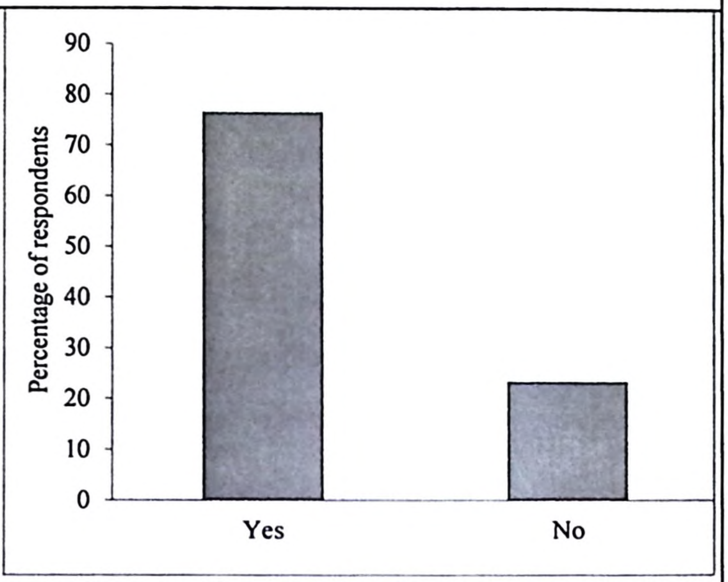
interviewees.	activity to their next generation.
	
i). Percentage of respondents' views regarding the change in Ganges dolphins population in Kulsi river in last ten years	j). Percentage of respondents' awareness regarding the killing of Ganges dolphins as a punishable offense under Wildlife Protection Act (1972).

Figure 5.2 Percentage of respondents among sand-miners of Kulsi river (N=65).

h. Correlations between different aspects of socio-economic and perception of sand miners of Kulsi river towards dolphin conservation

Significant difference was observed between the responses of sand-miners of different educational qualification regarding increase or decrease in intensity of sand mining in last 10 years and their willingness to carry on sand mining as their future source of livelihood (Table 5.2). It was observed that with higher educational qualification, the sand miners get more opportunistic towards alternative source of livelihood. Significant differences were observed for total time spent in river for sand mining and total income generated (Table 5.2). In case of sand-miners, the educational qualification was not significantly related to the awareness and perception level (Table 5.2).

Table 5.2 Chi- square test results for different aspects of socio-economic and perception of sand miners of Kulsi river towards dolphin conservation

Sl. No.	Correlations	Chi- square value	df	p- value
1.	Education qualification and observation of respondents regarding increase or decrease in intensity of sand mining in last 10 years	13.67	4	0.01
2.	Education qualification and willingness of respondents to carry on sand mining in future as source of income	15.6	4	0.004

3.	Education qualification and willingness of respondents to introduce sand mining as a source of income to their children's	0.67	4	0.96
4.	Education qualification and awareness about the status of dolphin population in last 10 years of the respondents	7.4	8	0.49
5.	Education qualification and awareness about dolphin killing as illegal	3.81	4	0.43
6.	Education qualification and observation of respondents regarding increase or decrease in number sand-miners in the river	6.2	8	0.62
7.	Education qualification and observation of respondents regarding increase or decrease in quantity of sand in the river	4.11	8	0.85
8.	Monthly income generation and total hours spent in sand mining in a day	54.4	18	0.001
9.	Total years spent in mining and willingness to carry on sand mining in future as source of income	7.13	3	0.07
10.	Total years spent in mining and observation of respondents regarding increase or decrease in quantity of sand in the river	9.82	6	0.13

5.3.3. Farmers

a. Percentage of respondents from different age groups

The majority of respondents' age group ranges between 20 to 50 years. The respondents belonging to the lowest age group were 15 to 20 years, and the highest age group were above 60 years (Fig.5.3 a).

b. Educational qualification of respondents

Higher percentages of respondents were illiterate (64%). The highest level of educational qualification recorded among the respondents was under graduation (3% of respondents) (Fig.5.3 b).

c. Average Investment vs. Average Income from Different Crop

Dry season crop in Kulsi river bank starts with mustard cultivation at the beginning of Winter followed by Paddy cultivation along with a small quantity of vegetables (Chillies, Coriander, etc.) and Jute which again depends on the favourability of the land (as high land is required for vegetables and Jute cultivation). The investment in Mustard cultivation is less (viz. Land rent, labor charge, fertilizers and irrigation in minimal) which ranges from 0 to a little more than 2000 INR/bigha of land in Kulsi riverbank. It was recorded that 100% of the crop yield was used for selling. The average gross profit earned from mustard cultivation/bigha with zero investment was estimated higher (>INR 3500/ bigha) compared to when investment increases (Fig.5.3 c). Whereas the investment in dry season Paddy cultivation (viz. Land rent, labor charges, fertilizers and irrigation in maximum) ranges from INR 1000 to > INR 6000/ bigha of land. Total 64% of the respondents cultivate paddy for their consumption, and 36% do it to sell. The average gross profit was estimated highest (>INR1800/ bigha) with an average investment of INR 4000- 6000/ bigha of land in Kulsi bank (Fig.5.3 d).

d. Crop Yield

The average crop yield for mustard was estimated to be 73kg/bigha, and for Paddy, it was estimated to be 831kg/bigha in the bank of Kulsi river (Fig.5.3 e).

e. Respondents owing water pumps for Irrigation

55% of respondents said that they have their water pumps for irrigation of which 44% have one pump each and 11% have two water pumps fitted to Kulsi river for irrigation. Total 44% of respondents didn't own a water pump. They take it on rent for irrigation (Fig.5.3 f).

f. Respondents view regarding changes in Kulsi river morphology over last ten years

Over 82% of respondents have said that the depth of Kulsi river has decreased significantly over the past ten years. About 3% have also added that the width of the channel has also increased in the last ten years. Total 7% of respondents have brought into notice that in places where heavy sand mining activities are going on, the depth has increased abnormally. However, 7% of respondents couldn't convey their views regarding Kulsi morphology (Fig.5.3 g).

g. Dolphin distribution when water pumps are running

Total 64% of respondents have said that when the water pump is on they don't see dolphins nearby. Whereas 36% have observed dolphins while water pumps were on (Fig.5.3 h)

h. Respondents views on seeing Ganges dolphin carcass in their locality

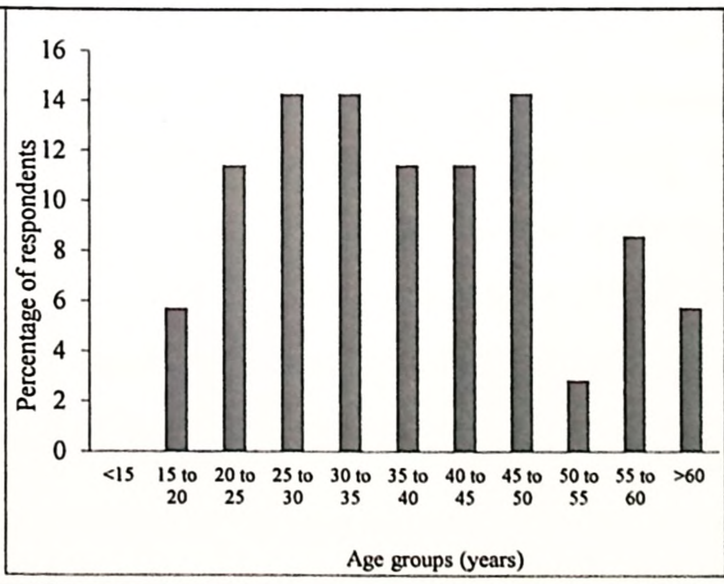
About 31% of respondents have agreed that they have witnessed Ganges dolphin carcass in their region (Fig.5.3 i). Out of that 75% have seen dolphin carcass died due to Gill net entanglement and 25% have seen dolphins entrapped in the Mosquito net.

i. Views of respondents regarding Ganges dolphin population status in Kulsi river in last ten years

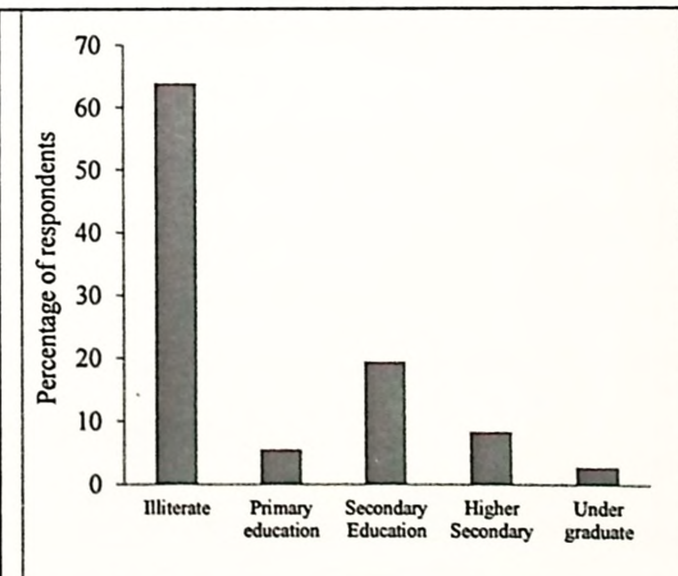
Total 75% of respondents have replied that the population of Ganges dolphins has significantly declined compared to last ten years and about 11% of respondents' view was population had increased in last ten years. However, 11% have also said that they didn't notice any change in population in the last ten years. About 4% couldn't express their view regarding this matter (Fig.5.3 j).

j. Respondents awareness towards the killing of Ganges dolphins as a punishable offense under Wildlife Protection Act (1972)

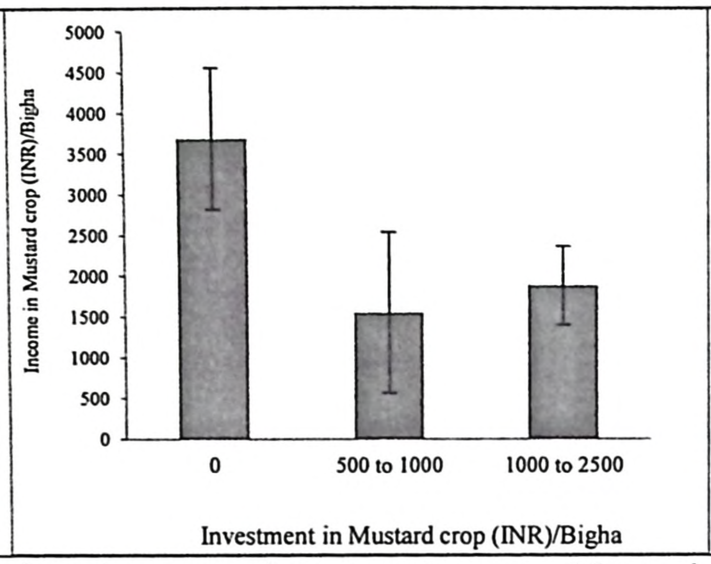
A higher percentage of respondents (53%) don't know about the banned on Ganges dolphin killing and punishment awarded under Wildlife Protection Act (1972) for such action. However, 47% of the respondents have said that they know about the banned but don't know how much penalty is awarded for the crime under the act (Fig.5.3 k).



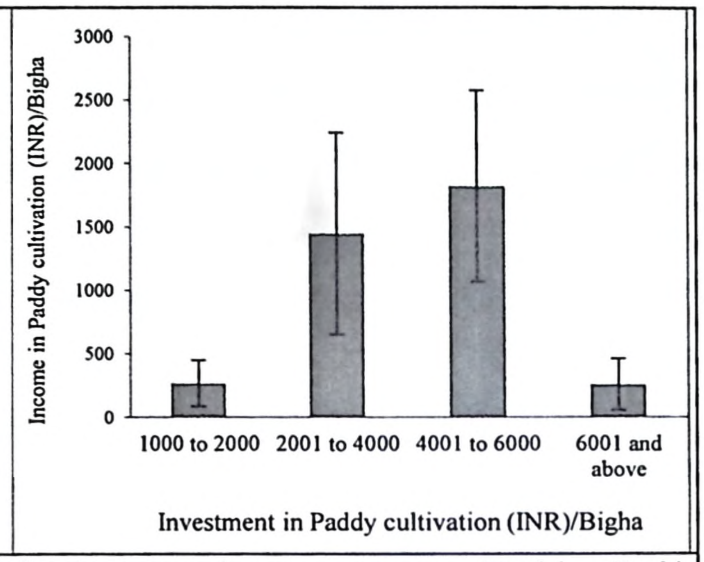
a). Percentage of Respondents of different age groups



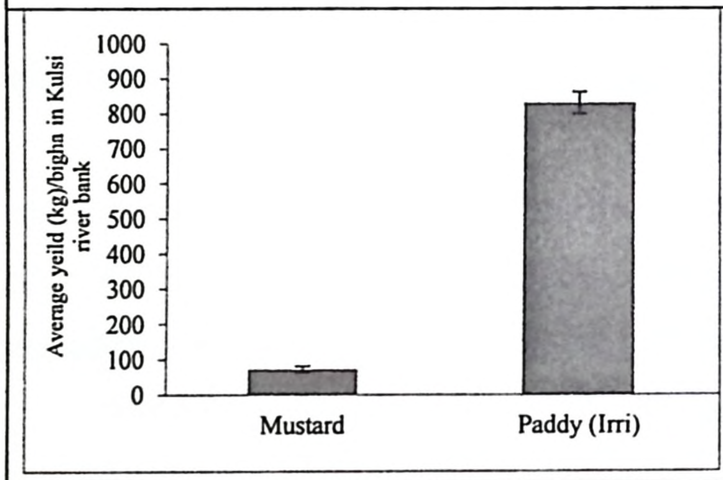
b). Percentage of educational qualification among the respondents



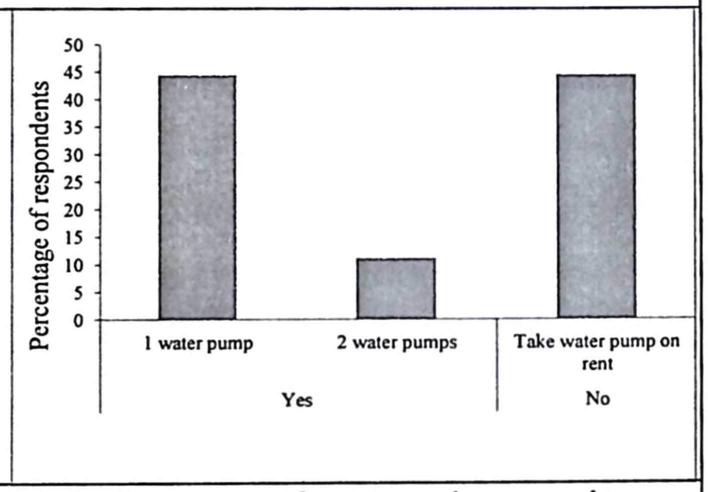
c). Average investment per Mustard crop/bigha vs. Average Gross Income per Mustard crop/bigha



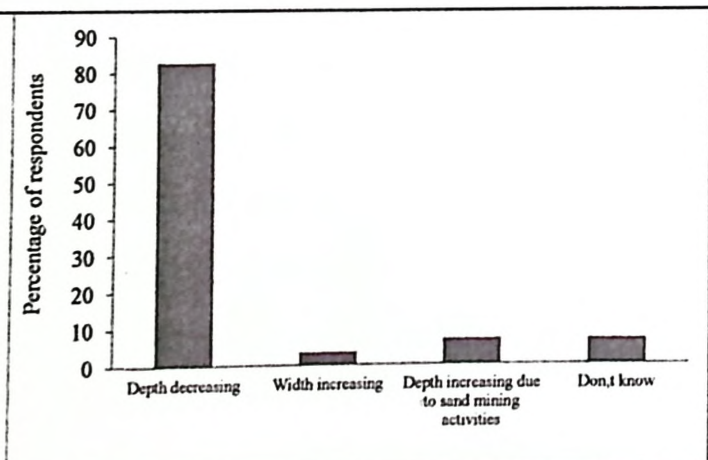
d). Average investment per Paddy (Irri/ Boro) crop/bigha vs. Average Gross Income per Paddy (Irri/ Boro) crop/bigha



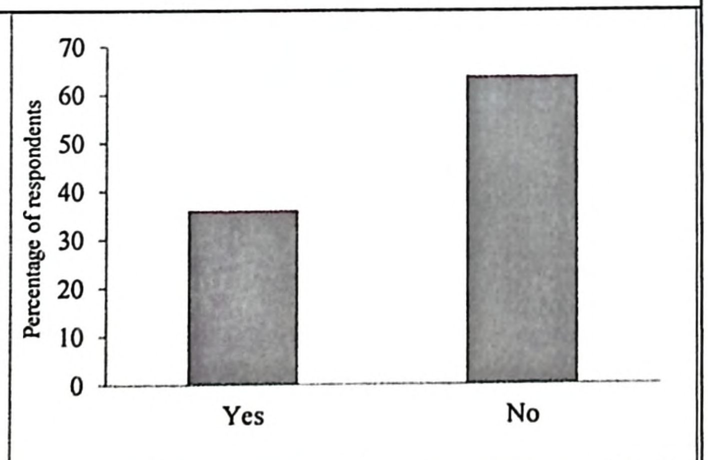
e). The average yield of Mustard and Paddy (Irri/Boro) (kg/ bigha) of land in Kulsi riverbank



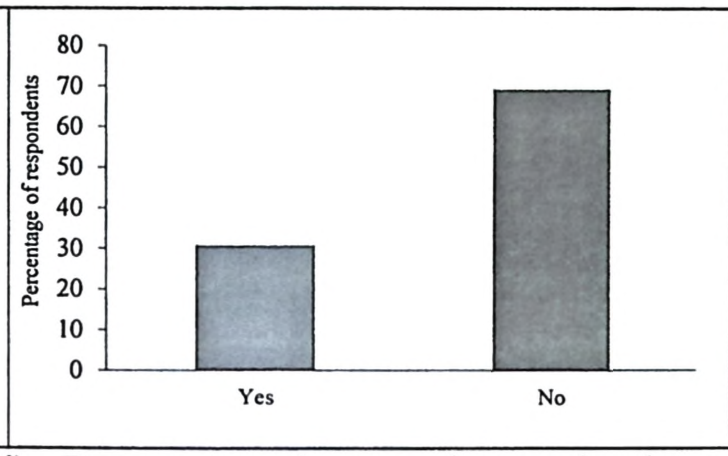
f). Percentage of respondent owing a water pump for irrigating cultivated lands from Kulsi river.



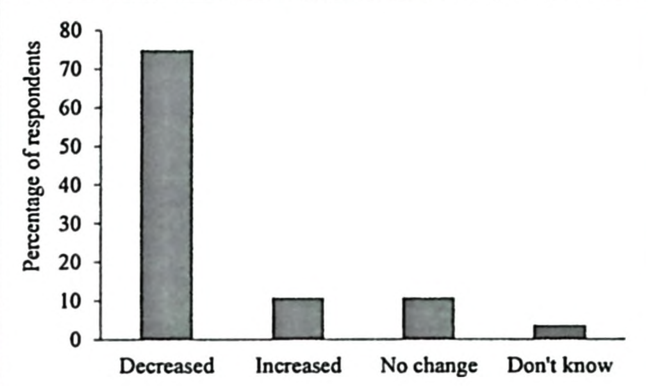
g). Respondents views on changing the morphology of Kulsi river over last 10 years



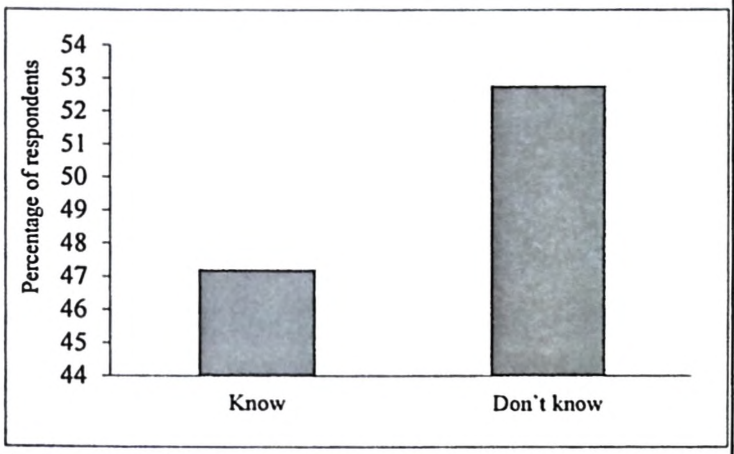
h). Percentage of respondents regarding dolphin distribution when water pumps are running



i). Percentage of respondents who have observed Ganges dolphin carcass in their locality



j). Percentage of views of respondents regarding the change in population status of Ganges dolphins in Kulsi river over last 10years



k). Percentage awareness among respondents regarding the killing of Ganges dolphin as a punishable offense under Wildlife Protection Act, 1972

Figure 5.3 Percentage of respondents of farmers of Kulsi river (N=36).

k. Correlations between different aspects of socio-economic and perception of sand miners of Kulsi river towards dolphin conservation

We didn't observe any significant difference between respondents with different educational qualification and their level of awareness regarding status of dolphin population or its conservation (Table 5.3). A significant difference was observed for the relation between educational qualification and their observation regarding the presence of dolphin in an area with active irrigational pump (Table 5.3).

Table 5.3Chi- square test results between different aspects of socio-economic and perception of sand miners of Kulsi river towards dolphin conservation

Sl. No.	Correlations	Chi- square value	df	p- value
1.	Education qualification and awareness about the status of dolphin population in last 10 years of the respondents	4.77	8	0.78
2.	Education qualification and awareness about dolphin killing as illegal	7.14	4	0.13

3.	Education qualification and observation made by the respondents regarding presence of dolphin in the area when water pump is active	9.615	4	0.05
4.	Total profit per crop and observation made by the respondents regarding presence of dolphin in the area when water pump is active	4.23	3	0.24
5.	Total investment per crop and observation made by the respondents regarding presence of dolphin in the area when water pump is active	1.45	5	0.92

5.4. Discussion

5.4.1. Socio-economic conditions and perception towards Ganges dolphin and habitat conservation of commercial fisher communities of Kulsi river

Out of 75 km of Kulsi river in Assam, about 52 km stretch is registered as Government fishery under Revenue department, and the rest is under private management or open access. The fisher of Kulsi pay 25% of the catch amount to the leaseholder on the contrary to the fisher of the Brahmaputra who pay 40% (Pandit et al. 2015). The fisheries of Brahmaputra River and wetlands in associated floodplain in Assam were categorized on the basis of ownership in two different categories: Government Fisheries and Private fisheries and the transfer of fishing rights are determined through either tendering methods or direct transfer based on the criteria of different departments of government (Table 5.4, Chandra and Bhattacharyya, 2016).

Table 5.4 Formation of the ownership and control rights in Fisheries of Brahmaputra River and associated floodplain wetlands (Source: Chandra and Bhattacharyya, 2016).

Controlling agencies	Purpose	System of transfer or license		Criteria for selection
Department of Revenue	Collection of revenue: Utilizations by fishing populations	Open tender system price fixed on the basis of produce in one year till January 31st	7 years	Highest bidder or to Fisherman Cooperative if within 7.5% range of highest bid
Dept. of Fisheries	Collection of revenue; Utilization by fishing populations	tender to highest bidder to fishermen community or fishermen Cooperative	7 Years	-do-
Assam Fisheries Development Cooperation	Development of fisheries; Better utilization by fishing populations	leasing by tenders to fishermen community or fishermen Cooperative	7 years	-do-
Dept of Environment & Forest	Conservation of the resource, Protection of wild life	wetlands are not given on lease and fishing is only restricted for locals for sustenance	No license	
Village Panchayat	Betterment of the fishing populations; Revenue collection	Direct transfer or limited tenders to the villagers or individuals	7 years	Local fisher cooperative or beel development committee

The management of River fisheries in Assam was done by access and allocation of rights for river fisheries either by Private management (individuals and Groups) or by the Primary fisher's cooperative society (PFCS) and open access (Fig.5.4.) (Chandra and Bhattacharyya, 2016). On the basis of a leasing system where the management rights of registered fisheries were handed over to the highest bidders on conditions such as the bidder should be a fisherman (a person belonging to Schedule castes in Assam) and defined and engaged themselves in fishing by themselves, or undertake fish trades or member of fishermen cooperative societies (Chandra, 2011).

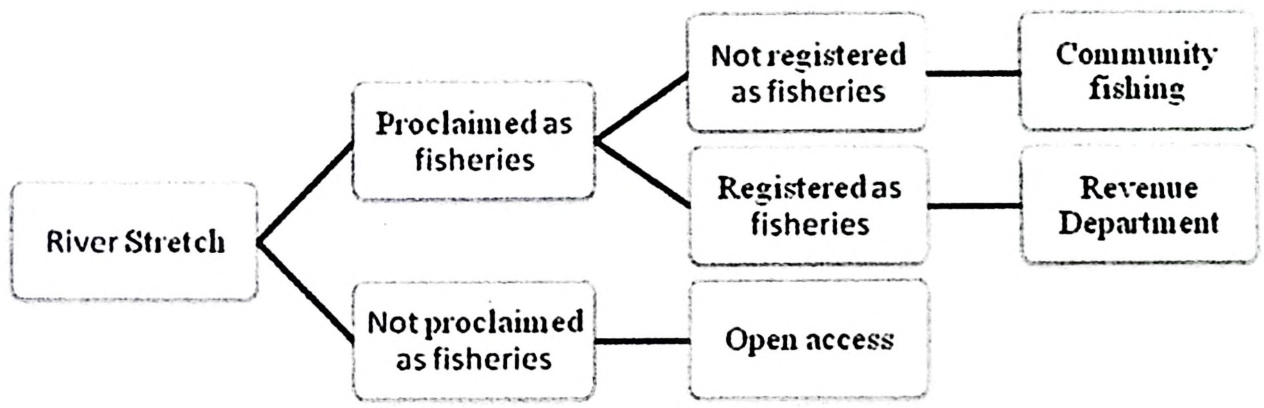
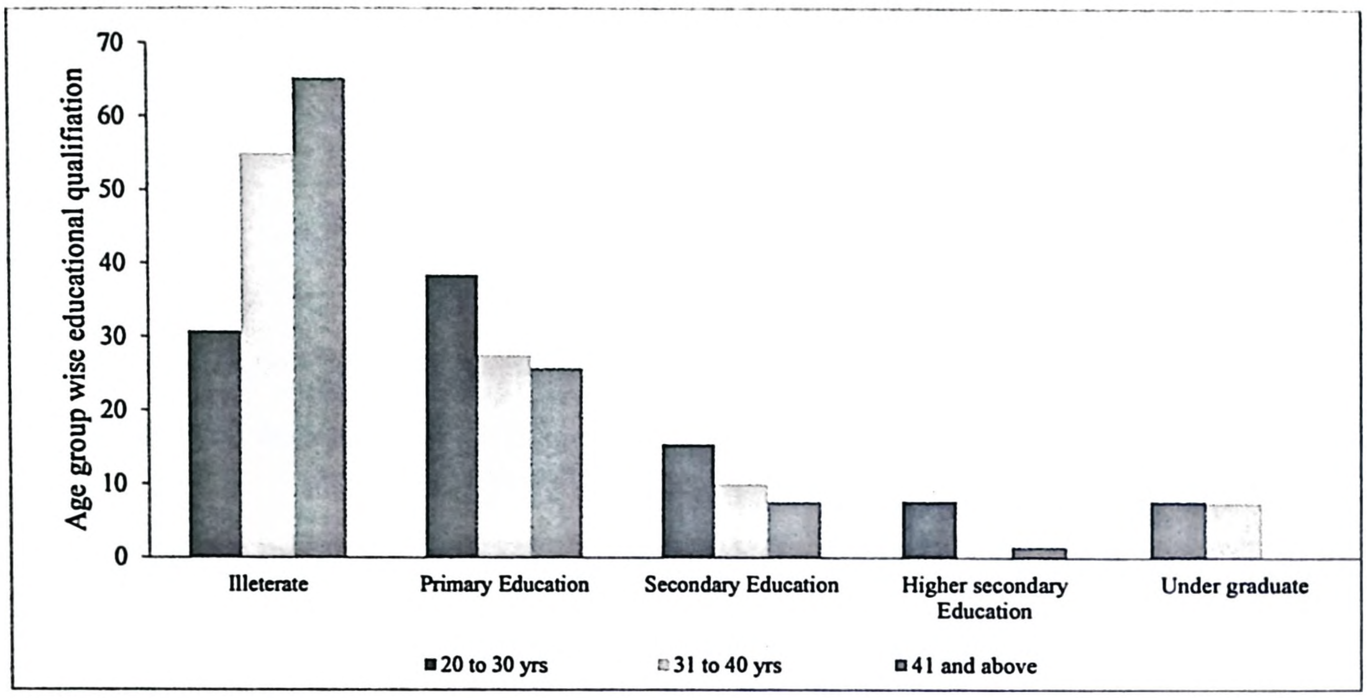


Figure 5.4 River fishery management System in Assam (Source: Chandra and Bhattacharyya, 2016).

It was observed that the commercial fishermen mostly belong to 30years of age group and above however as early as 20years onwards they start their carrier as a commercial fisher among the fisher communities of Kulsi river which is also similar to the entire state scenario of the fisher communities (Chandra and Bhattacharyya, 2016).

Regarding academic educational qualification of the fisher communities, most of them were illiterate in Kulsi river which is contradictory to the literacy rate of Assam which is estimated about 75% for fishers (Chandra and Bhattacharyya, 2016). Similar conditions were also observed in other fisher communities of Assam (Sheikh and Goswami, 2013; Bordoloi et al., 2012; Bhattacharyya and Dutta, 2012; Goswami et al., 1994). It was also observed that respondents of the age group of 20 to 30 years were more educated than the rest of the age groups (Fig.5.5.). From this, we can conclude that the new generation of people give more importance towards academic education. However, this trend also decreases after primary education level, and very few could continue until Higher secondary or under graduation level. The low socio-economic conditions of the families couldn't encourage their children for higher education (Bashir et al., 2010).



*F*igure 5.5 Percentage of education level among different Age groups of fishermen communities of Kulsi river.

The total lifetime spent in commercial fishing activities will go with the flow of age of fishers; i.e., more the age of the fishermen, more lifetime spent in fishing activities; which we can observe for the fishers' community of Kulsi river. However, about the fishers who have newly started their carrier as a fisherman and were above 30 years, the probable reason behind this can be running out of other sources of livelihood and deplorable economic condition which are compelling them to choose the easiest option. Although the fisher community of Kulsi river has accepted that the number of fishers over past ten years has declined significantly due to declining fish source in Kulsi river.

A small percentage of respondents have also agreed that they have changed their fishing gears and techniques in the last ten years as the fish targets are changing from previously available big size fishes to smaller fishes. This percentage of respondents belongs to the older generation (above 40years). However, it is quite evident that the newer generation fishermen have already entered the commercial fishing business with more advanced fishing techniques to increase their catch with small mesh size gears or harmful mosquito net. This is also resulting into higher resource level competition and interaction (depredation or chasing away fishes by the dolphins or entanglement in fishing gears or intentional killing of dolphins by the fishermen) among the fishermen and Ganges dolphins. In the Brahmaputra, it was reported that mortality of altogether 21 dolphins in 2008 and 2009, out of which 20 were the victims of fisheries net entanglement (Wakid, 2010). In the Upper Ganges, an interrelation has been established between excessive fishing and River dolphin deaths (Bashir et al., 2010). Work on Vikramshila Gangetic Dolphin sanctuary estimated 75% prey- resource overlap between fisheries and River dolphins (Kelkar et al., 2010).

All kind of awareness level regarding conservation of aquatic habitat, be it the regulations in the use of harmful fishing gears (small mesh size gill nets, traps etc., mosquito nets) or the fish banned season during fish spawning time mentioned in Assam Fishery Rules (1953); or killing and use of parts of Scheduled 1 Endangered Ganges dolphin as a punishable offence under the Wildlife Protection Act (1972), significant positive correlations were found between educational qualification level of fishers' and their awareness level. Although it was difficult to extract facts about the illegal use of dolphin parts, still a small percent of the interviewee has agreed to use dolphin oils for fishing and curing rheumatoid. However, that small percentage also belongs to the group of fishermen with low awareness level regarding Ganges dolphin conservation.

The initiative to aware the communities regarding the rules and regulations and compensation schemes by Government institutions also remain limited to accessible areas only. Hence a significant portion of the communities remains uninformed. "One- time benefit programme" for the registered commercial fisher was dissolved. Other schemes like "Matsya- Jagaran: Ghare ghare pukhuri, ghare gahre maach" and "Seed bank programmes" under Rural Infrastructure Developing Fund (RIDF) are meant for inland fisheries. "Matsya mitra" is an another initiative by the GOI where the local village youths were encouraged to participate in gathering vital information (pH, carbon content in pond and surrounding soil) required for aquaculture. These schemes have been successfully implemented by Jharkhand governments with a significant positive impact on the fisheries sector development in the state (Mallick and Dash, 2019). However, proper implementation is still needed in Assam by way of generating awareness. Although the riverine fisheries of Assam comprise the maximum area (205,000 Ha) compared to all other fishery resources, the productivity is comparatively low (only 190kg/Ha, Gogoi et al. 2015) despite its potential.

5.4.2. Socio-economic conditions and perception of Sand- miners of Kulsi river towards Ganges dolphin and its habitat conservation.

Although the major age group involved in sand mining activities was from 25 to 30 years. Age group starting from 15 to 20 years to as late as more than 50 years of people are involved in sand mining activities. The only probable reason behind large section of people getting influenced towards sand mining in Kulsi river is because of higher income level. The sand miners have higher income per month compared to fishers of Kulsi river. They also don't have any regulations like the banned period for sand mining. However, we have also observed that as the age group increases the percentage of involvement is decreasing. This is because the manual sand mining is very laborious. Respondents have mentioned that the absence of other alternative source of income and good profit in Sand mining were the reasons for their involvement in the business. The educated sand miners were not interested in continuing mining in future and were ready to shift to other occupation if provided. We have also observed that sand mining activities were very laborious and can't correlate with total time spent during the day and money earned as the sand is not distributed equally in the entire stretch of Kulsi river. In some stretches, miners move many kilometers up- or downstream in search of sand which requires the investment of time and energy. The excellent quality sand is mostly available in the upstream of Kulsi river, which has a higher price compared to the quality found in further downstream. The sand miners who dug sand manually move upstream to collect the fine sand which requires more time and labour, whereas, on the other hand, the pump miners compromise with the price of sand as they can dig more sand in less time. Hence, we can observe that people are also shifting to pump mining to reduce the effort and to dig more sand in less time and earn more.

It has been said by local people that sand mining started in Kulsi river about 50 years back. But our interview data shows that respondents were getting involved from more than 20years only. Most of the sand miners have recently engaged in the sand mining business (1 to 5 years only) and have shifted from other livelihood sources such as fishing and farm labour in the absence of employment. However, they don't want to carry forward this business to their next generation.

Maximum sand mining labours were illiterate and as the age group increases, the literacy rate decreases. A similar pattern of education level like the fishermen communities was also observed among the sand miners. The level of education goes down after Primary level of education, and the reason can be no different from the fishermen. However, they have noticed the changes in the Kulsi river morphology over the past years. They have agreed that the water level in Kulsi river has significantly gone down over the past ten years and the population of Ganges dolphin is also decreasing.

5.4.3. Socio-economic conditions and perception of Cultivators of Kulsi riverbank towards Ganges dolphin and its habitat conservation.

The age group among the cultivators of Kulsi floodplain also ranges from 15years to more than 60 years. The similar pattern of educational qualification like fishers and sand miners was also observed among the respondents of cultivator group of Kulsi river. Also, the educational qualification level among the older generation was less compared to the newer generation. The investment in crop cultivation included land rent, labour charges, fuel and rent for irrigation with water pumps, fertilizers and pesticides. However, with only paddy cultivation, the total investment and profit show no correlation as the results say that most of the cultivators cultivate paddy for own consumption rather than to sell in market. However, mustard cultivation brings significantly higher profit with investment.

The Dry season crop starts with mustard cultivation on the bank of Kulsi river with the onset of winter. This crop is a kind of investment for the next crop. Since mustard cultivation requires minimal investment which includes the labour charge and fertilizers basically and helps the farmers to prepare themselves for the next crop. It was observed that the gross return from mustard cultivation was 73kg/bigha which were estimated to be higher than the national average, i.e., 65kg/bigha. The dry season paddy cultivation, locally known as Irri/ Bodo crop, needs more investment which includes higher labour, Irrigation and fertilizer charges. Although the bodo crop yield has increased with more modified varieties; viz. Jaya, Joybangla, Biplab, China, etc.; which are commonly used by the cultivators of land with Irrigated flood free ecosystem. However, in Kulsi bank, the average yield was estimated to be slightly lower (831kg/bigha) compared to the state average yield of Irri (911kg/ bigha). The Irrigation sector of Assam as a whole is, however, lagging behind in creating the irrigation potential from the available resources due to environmental, technical and economic constraints compared to rest of the states of our country (Goyari, 2008; Sharma and Sharma, 2015). The productivity of rice was estimated to be 1475kg/h in 2004-05 which was low to the average production of India (1980kg/ha), and insufficient irrigation system was one of the leading factor (Sharma and Sharma, 2015). This is like the Scarcity in the Midst of Plenty (Goyari, 2008).

The respondents have agreed that the water level of Kulsi river goes down significantly during dry season because of hundreds of active irrigation pumps throughout and also due to sand mining pumps. They have also agreed that due to this the channel width has drastically increased in the last ten years which is a negative sign for the dwellers of Kulsi floodplain.

This is could be a potential threat to the population of once abundant Ganges dolphin in Kulsi river. They have agreed that the noise produced by the water pumps during irrigation disturbed the dolphins and compelled them to avoid the area.

CHAPTER 6: PINGERS: CAN BE THE EYES OF BLIND GANGES DOLPHINS?

6.1. Introduction

Interaction of aquatic mammals and commercial fisheries is an age-old history (Reeves et al., 2001). However, increasing demand for fish in the market with growing human population caused depleting fish population for aquatic mammals as well as for humans. The increasing fishing pressure results in the by-catch mortality and injury of the aquatic mammals and becoming the most significant issue of conservation of these animals (Mitchell, 1975; Woodley and Lavigne, 1991; Perin et al., 1994; Broadhurst, 1998; Secchi and Vaske, 1998; Read et al., 1998; Donoghue et al., 2002; Noke and Odell, 2002; Cox et al., 2004; Lauriano et al., 2004; Read et al., 2006; Brotons et al., 2008; Read, 2005; Sigler et al., 2008; Read, 2008). Hall (1996) defined it in a more negative connotation for the fishers or environmentalists, says 'it is that part of the capture that is discarded in the water, dead (or injured to the extent that death is the result).' The incidences came to notice when millions of dolphins got killed in tropical eastern Pacific (NRC, 1992) with the growing commercial fishing industries and the evolved purse seines fishing of the pelagic fishes (IWC, 1980).

Since then various experiments were carried out with passive and active methods to reduce the fishery interactions in marine fisheries (reviewed in Jefferson and Curry, 1996). The passive methods include net modification (Barham et al., 1977; Leatherwood et al., 1977; Norris, 1978; Pryor and Norris, 1978, Coe et al., 1985) and some add-on-reflectors (Au and Jones, 1991; Au, 1994) which make them detectable to dolphins. Although few experiments showed some behavioural responses of small cetaceans towards passive reflectors (Goodson et al., 1994; Silber et al., 1994), however, the sample sizes and absence of controlled experiments to compare with the reality, made studies inconclusive (Hasegawa et al., 1987). Most of the trials didn't end up with any significant differences (Snow et al., 1988; Jones, 1990; Goodson and Datta, 1992; Dawson, 1994; Goodson et al., 1994; Hatakeyama et al., 1994) or work only other way round (Hembree and Harwood, 1987; Goodson, 1990) or too expensive to continue (Peddemors et al., 1991).

The active methods don't rely on animal echolocation behaviour but produce sounds which are audible to the animal to deter them from the gears. People have tested Gunshots to keep Australian Fur seals (Pemberton and Shaughnessy, 1993), dolphins in the Mediterranean (Ravel, 1963), Killer whales of Alaskan waters (Matkin, 1986; Dahlheim, 1988) at bay from the fish farms or explosives such as "seal bombs, Thunderflash, Beluga firecrackers, Cracker shells" etc. were manufactured commercially (Mate and Miller, 1983; Awbrey and Thomas, 1987) to deter seals or pinnipeds. These techniques however never worked out and were found that the animals get habituated to them with time (Shaughnessy, 1981; Mate and Miller, 1983; Matkin, 1986; Matkin et al., 1987; Awbrey and Thomas, 1987; Scholl and Hanan, 1987; Steiner, 1987; Dahlheim, 1988). Eventually, by 1990s, these methods have been banned from US waters on the basis that it can cause serious harms to the animals (Myrick et al., 1990; Myrick et al., 1990).

Other active methods were more mechanical like playing biological sounds (Cummings et al., 1971; Fish and Vania, 1971; Anderson and Hawkins, 1978; Shaughnessy et al., 1981) or placing mechanical sound generators like non- electronic clangers, rattles, bell bouys and bang pipes (Kasuya, 1985; Peddemors et al., 1991; Nasaka, 1979) underwater. They showed the minimum or no- response and were considered outdated (Fish and Vania, 1971; Anderson and Hawkins, 1978; Shaughnessy et al., 1981; Coe et al., 1985; Matkin et al., 1987; Dahlheim, 1988).

The recent development in the technology is the production of electronic active sound generators which was previously categorized under two sets, viz. acoustic deterrent devices (ADDs) to address the problem of bycatch and acoustic harassment devices (AHDs) to mitigate depredation (as reviewed by Dawson, 2013). These devices are more abrasive emitters and hence were used initially in commercial fisheries to deter pinnipeds (Johnston and Woodley, 1998; Quick et al., 2004) or harbor seals (Mate and Greenlaw, 1987). The effectiveness of the technology has experimented and the significant reduction in depredation and bycatches were observed later (Kraus et al., 1997; Tripple et al., 1999; Barlow and Cameron, 2003; Leeney, 2007; Carretta et al., 2008; Gazo et al., 2008; Buscaino et al., 2009; Carretta and Barlow, 2011). With the increasing concerns about bycatch and depredation (Read, 2008), its use has become mandatory in some of those commercial fisheries (Anderson et al., 1996; Bordino et al., 2002). However, 100% efficacy of Pingers on Commercial fisheries is still questioned (as reviewed by Dawson et al., 1998; Dawson et al., 2013). There are also incidents which suggest no complete elimination of by-catch or depredation interactions (Brontons et al., 2008b; Wapples et al., 2013) and two other incidences when entanglement happened in nets loaded (Northridge et al., 2003; Read and Wapples, 2010) with active Pingers.

In this paper, we have experimented with the efficacy of Pingers on freshwater Ganges dolphins for the first time. Since the animal is almost blind (Herald et al., 1969) and relies continuously on sonar clicks for echolocation, get entangled very often in fishing gears (Sinha, 2002; Mansur et al., 2008) which were made of materials acoustically transparent, in this case, monofilament gillnets. Although, the intensity of getting entangled is not comparable to the marine odontocetes, however, we also have to consider the entire remaining population of Ganges dolphins which is about 3000 individuals (Sinha and Kannan, 2014). In 2008, out of 21 dolphin mortality reported from Brahmaputra, 20 were the victims of gillnet entanglement (Wakid, 2010). Hence, gillnet entanglement can be considered as a serious concern for the conservation of the species. In a developing country like India, with growing competition for resource extraction, where the socio-economic condition and awareness levels among fisher community are so low, that logistical loss of gear damage due to dolphin entanglement, is given priority to dolphin life. Hence it is essential to work out to reduce the interactions of fisheries and dolphins for the conservation of the species, and this is an attempt towards that goal.

6.2. Method

6.2.1. Study area

The experiment was carried out with a group of 4-5 dolphins at Kulsi river in a 3.95km stretch of Kulsi river near Malibari village (from N 26°3'36.22'' and E 91°7'46.7'' to N 26°3'19.04'' and E 91°9'40.43''). The stretch is also frequently used by the fishers of the area (Fig. 6.1).

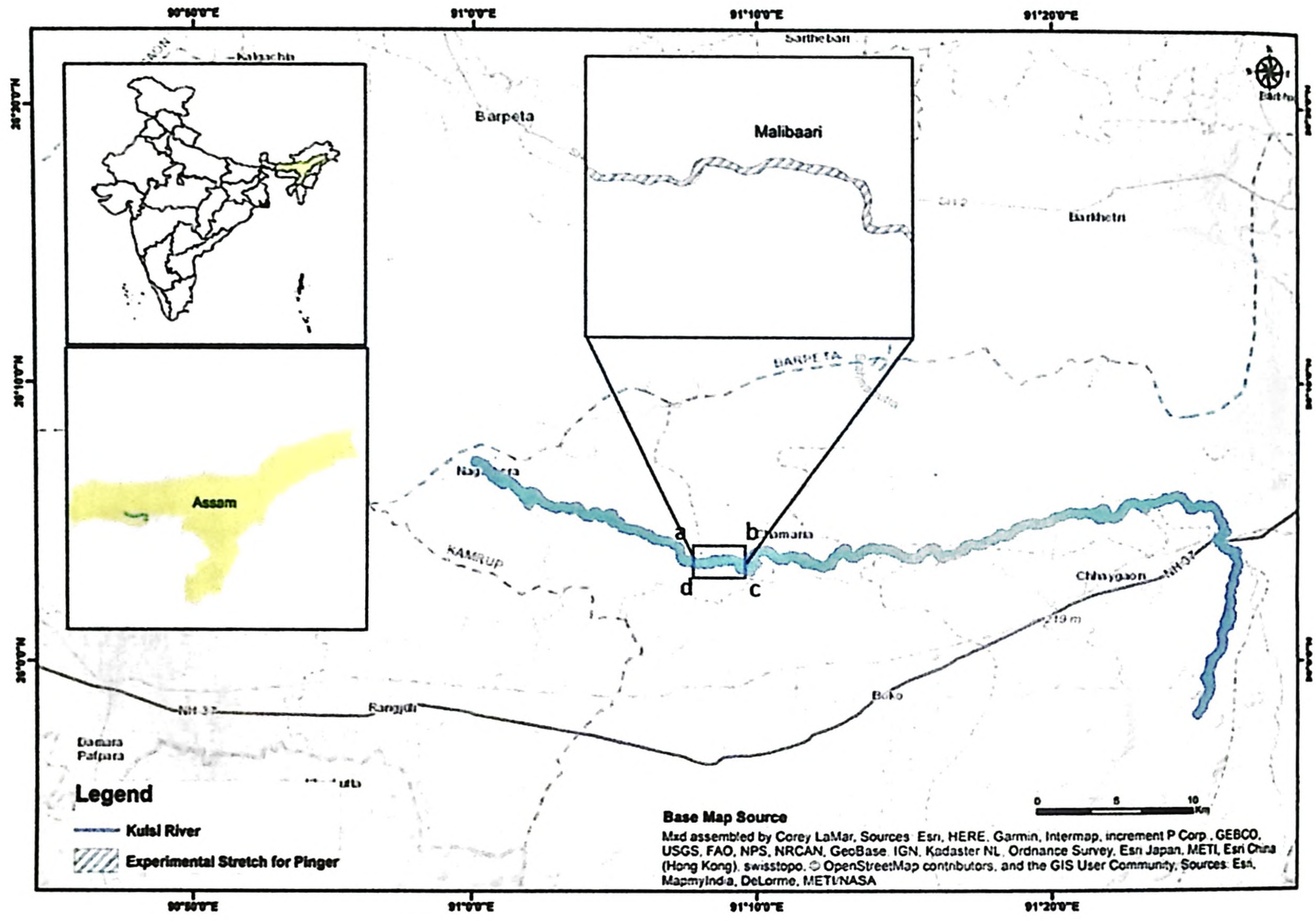


Figure 6.1 Kulsi river and study area (Box).

6.2.2. Field Methods and Data Analyses

A monofilament gill net of 150m length and 4cm mesh size was used for the experiment which is also a commonly used dimension of gillnet by the fishers' community of Kulsi river. The study was carried out from January- March 2017. Four fishing gear set up was made to test the interaction of Ganges dolphin:

1. Gill net without any reflectors or Pingers loaded on it (Control).

2. Gill net loaded with different reflectors used locally by the fishermen, which can make noise in water (thermocol pieces/ empty plastic bottles/ banana plant bark).

3. Gill net loaded with active Pingers with frequency and sound source level (10kHz, 132 decibels) lower than used by Ganges dolphins (70kHz, 145 decibels).

4. Gill net loaded with active Pingers with frequency and sound source level similar to Ganges dolphins.

The Pingers were developed by the group of Future Oceans Pingers (www.futureoceans.com). The power supply to the Pinger was a 3.6volts, 8500mAh lithium-ion non- rechargeable battery. Pingers turn on automatically when submerged in water and within 60 seconds of start-up delay. In each 100m of the net one Pinger was loaded to maintain the covering range of the Pinger (100m radius). The Pinger emits the signal in every 4 seconds.

The gill net in each set up was fixed in a position, and the dolphin movement was observed with the help of two experienced observers on both upstream and downstream of the net (Fig. 6.2). Since in case of Ganges dolphin, the entanglement rate is lower to that of Marine cetaceans, the proximity of the dolphins to the fishing gear was considered as the line of threat in this study. With every dolphin sighting the observer recorded the time of the sighting, the distance of the individual from the net, age structure of the individual (new-born/calf/non- calf), surfacing patterns (away/towards/along the line) (Dawson and Lusseau, 2005). The surfacing pattern of Ganges dolphin was recorded to understand the movement of the dolphin towards or away from the net, or turning away from or towards the net. The direction of the appearance of the rostrum of the dolphin confirms the position of the dolphin around the net. Along with these other anthropogenic activities occurring in the area were also recorded with each sighting.

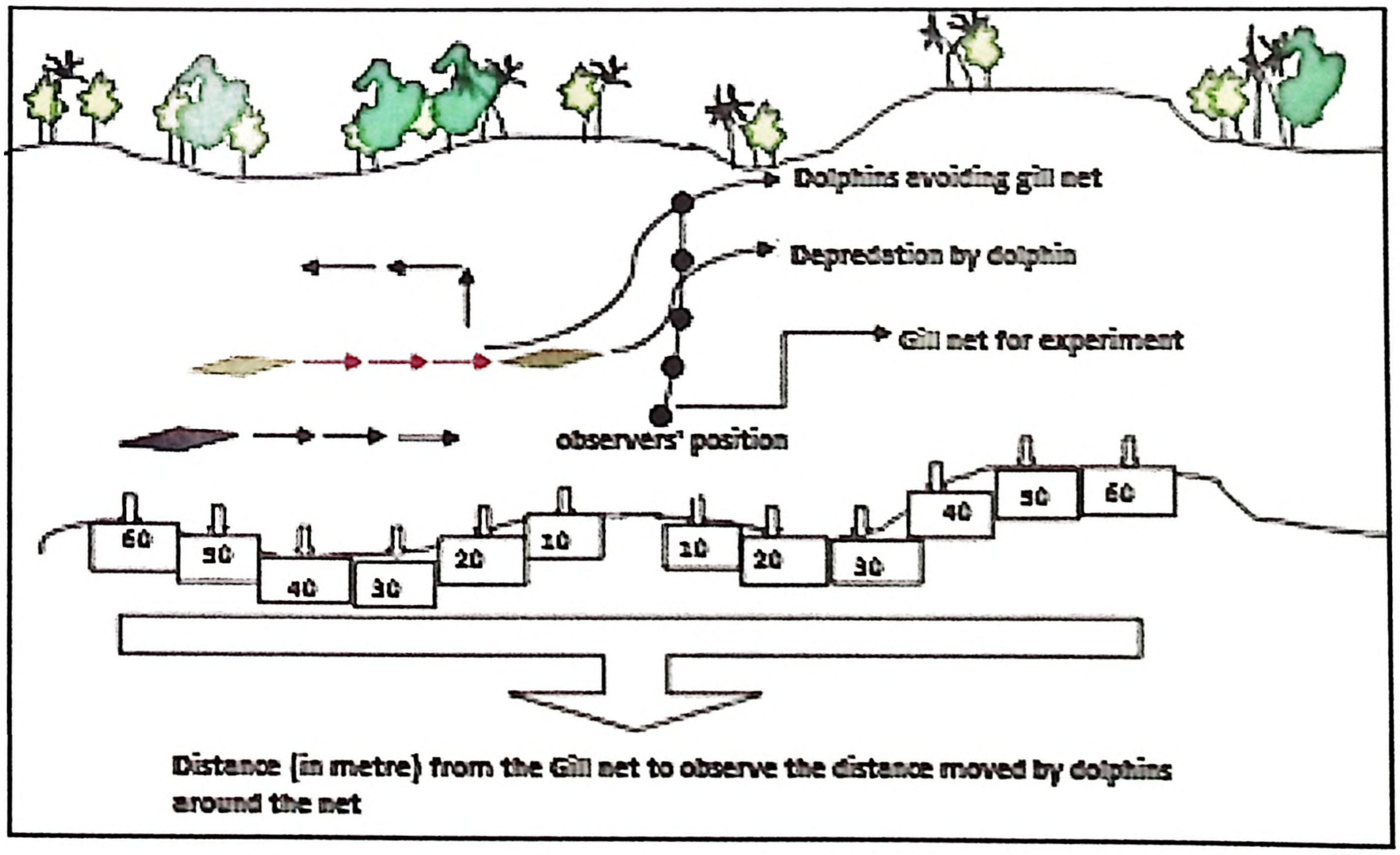


Figure 6.2 Field set-up for Pinger experiment (showing the gill net and observers' position to record the sighting distance frequencies of dolphins).

The frequency of sighting distances from the fishing gear was estimated to compare the proximity of Ganges dolphins to the control of fishing gear set up with rest of the three experimental setups. The mean distance of the Ganges dolphin from different experimental set up was estimated. A chi-square test was done to compare the frequency of distance observed between control and different experimental setup. Data were analysed in MS Excel and R software.

The upstream (towards the net) and downstream (away from the net) and the turning point from the net was estimated for all the four experimental set.

6.3. Results

6.3.1. Total effort

The dolphin behaviour around the control and experimental set up was observed for 375 hrs (Table 6.1). The sighting rates decline at a minimum range of 1-2m and at a maximum range of 80-85m onwards from the net (Fig 6.3- 6.6). In our study, the sighting intensity declines near the net because of the presence of fishing net itself, whereas on the other hand, as the animal moved away, the sighting intensity declines again because of the observers' limitation. Hence the distance recorded beyond 30m were discarded.

Table 6.1 Total duration of observation around different experimental set-ups.

Experimental Set up	**Total observation time (hh:mm:ss)**
Control net	69:54:00
With reflectors	59:34:00
With Porpoise Pingers	36:36:00
With Dolphin Pingers	21:43:00

6.3.2. Sighting frequency

The nearest proximity of dolphin was recorded minimum (<1m) for Control net with a sighting rate of 0.01 sightings/hr, and highest was for experimental set up with active Dolphin Pingers (4-5m) with a sighting rate of 0.02 sightings/hr (Fig. 6.3- 6.6). The probable reason behind this was that the reflectors used for the experiment were locally used by the fishermen on the nets as floats or attractant for the fishes (plastic bottles, the bark of banana plant) which can probably act as an attractant for dolphins too. Chi-square test has shown a significant difference between the distance frequencies obtained in control and three experiments (Table 6.2).

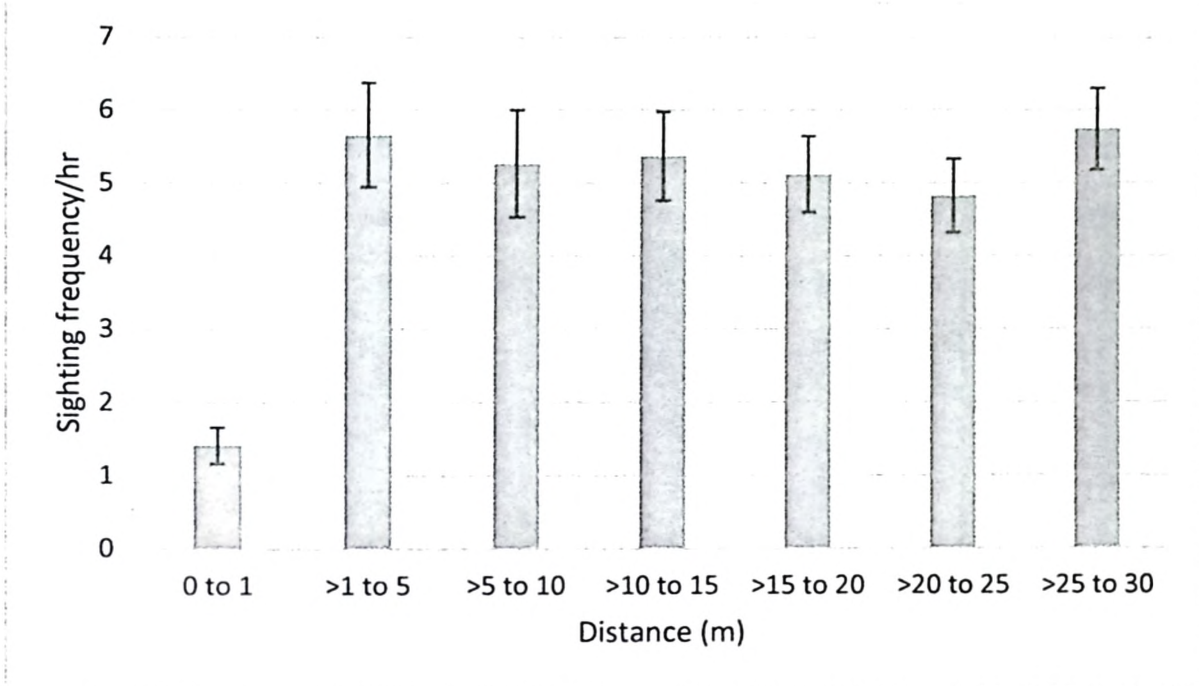


Figure 6.3 The frequency of dolphin sightings in different distance ranges with control Gear set up (without Pingers and reflectors).

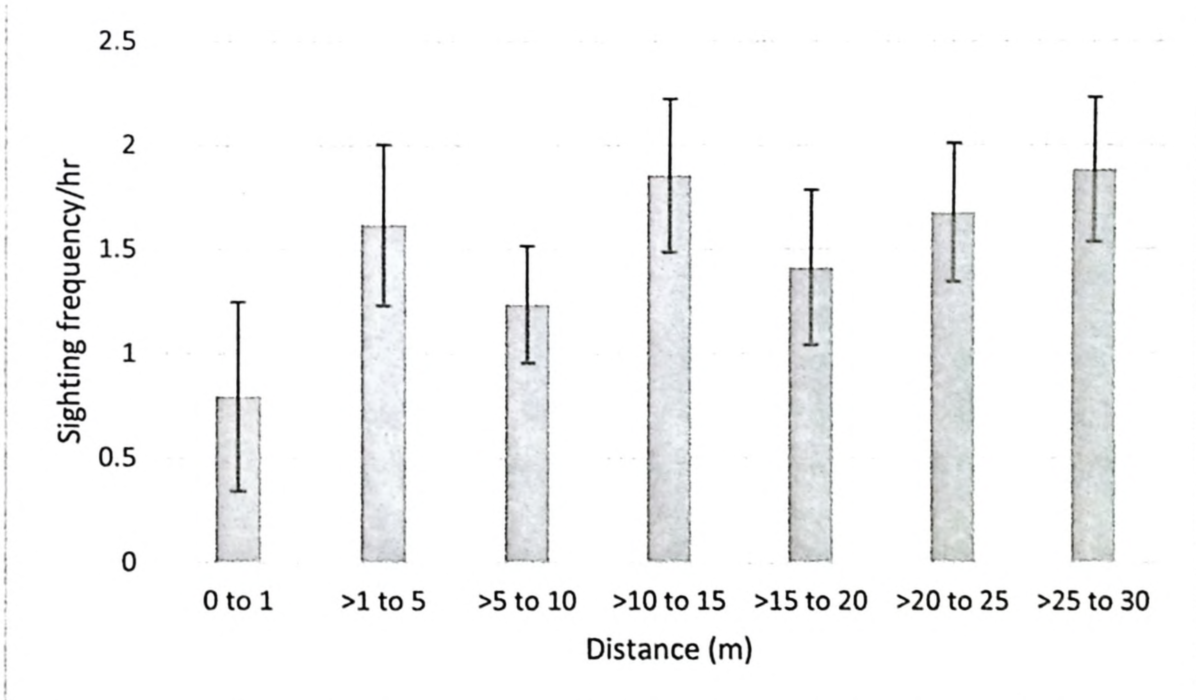


Figure 6.4 The frequency of dolphin sightings in different distance ranges with Gear setup loaded with reflectors (bark of the banana plant, plastic bottles).

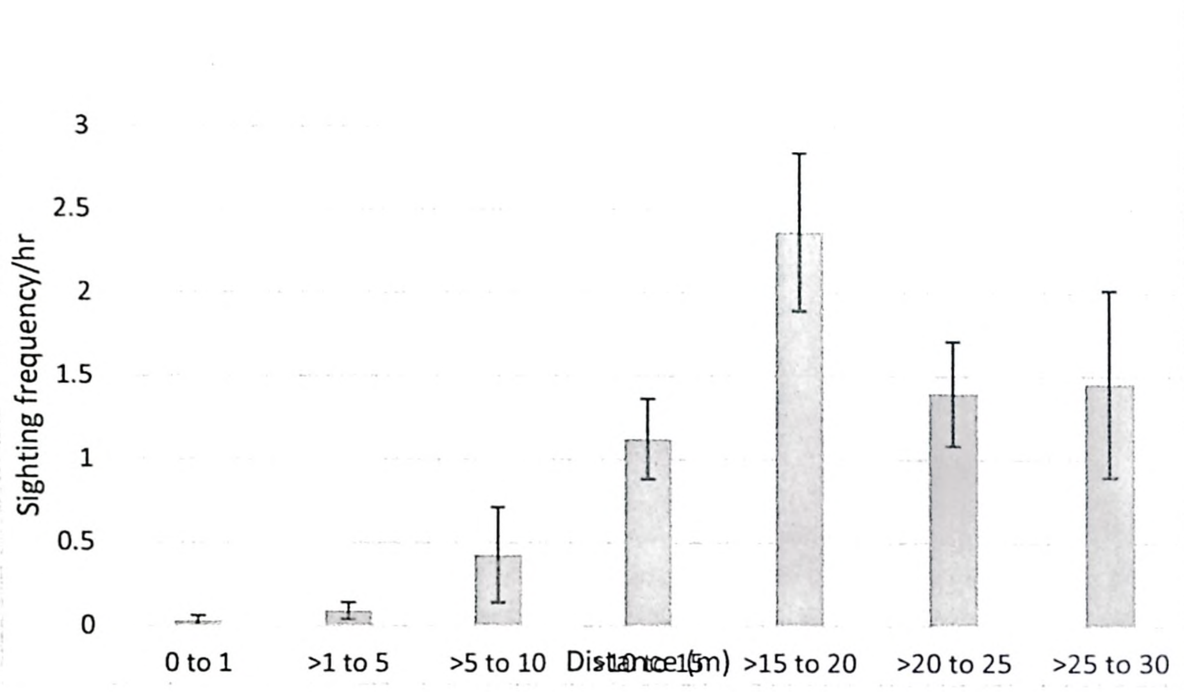


Figure 6.5 The frequency of dolphin sightings in different distance ranges with Gear setup loaded with Porpoise Pingers (10kHz).

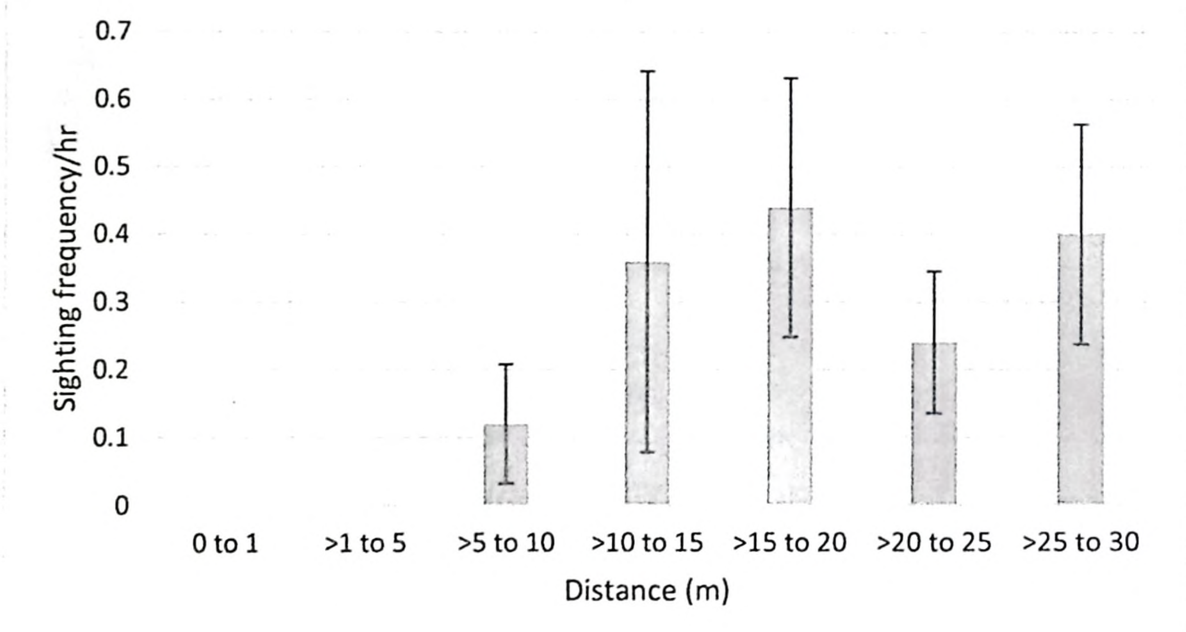


Figure 6.6 The frequency of dolphin sightings in different distance ranges with Gear setup loaded with Dolphin Pingers (70kHz).

Table 6.2 Comparison of sighting distance frequency between different experimental set-ups

Comparisons	Chi-square	df	p- value
Control- Reflector	14.72	6	0.02
Control- Porpoise Pinger	48.12	6	0.001
Control- Dolphin Pinger	13.26	6	0.04
Reflector-Porpoise Pinger	35.47	6	0.001
Reflector-Dolphin Pinger	8.08	6	0.23
Porpoise Pinger- Dolphin Pinger	7.59	6	0.27

6.3.3. Movement pattern

The dolphins were seen turning back and swimming away from the net during the trial, which can be considered as their range of detecting the net while approaching. The minimum distance recorded from where the dolphins turned back was <1m while using the controlled net. However, this detectability range has increased to 6- 7 m when Pinger loaded net was introduced.

6.3.4. Age structure wise behaviour around the nets setup

The distance for new-born and calves near the control net was recorded from 1 m and above from the net whereas adults were recorded <1m from the net. In the net with reflectors, a similar pattern of movement among the three age structures of dolphins was recorded, i.e., about a 1m distance from the net. In net with Porpoise Pingers, the nearest proximity of the new-born was at a range of 8 to 9 m from the net; calves were recorded at a distance of 4 to 5 from the net and adults were recorded at about 1m distance from the net. In the net with active Dolphin Pingers, the nearest proximity of the new-born was 9 to 10 m from the net, calves were recorded at 4 to 5 m from the net, and the adults were recorded 6 to 7m from the net. The average frequency estimation for new-born and calf was found more in different distance ranges with the active dolphin Pingers (Fig. 6.7).

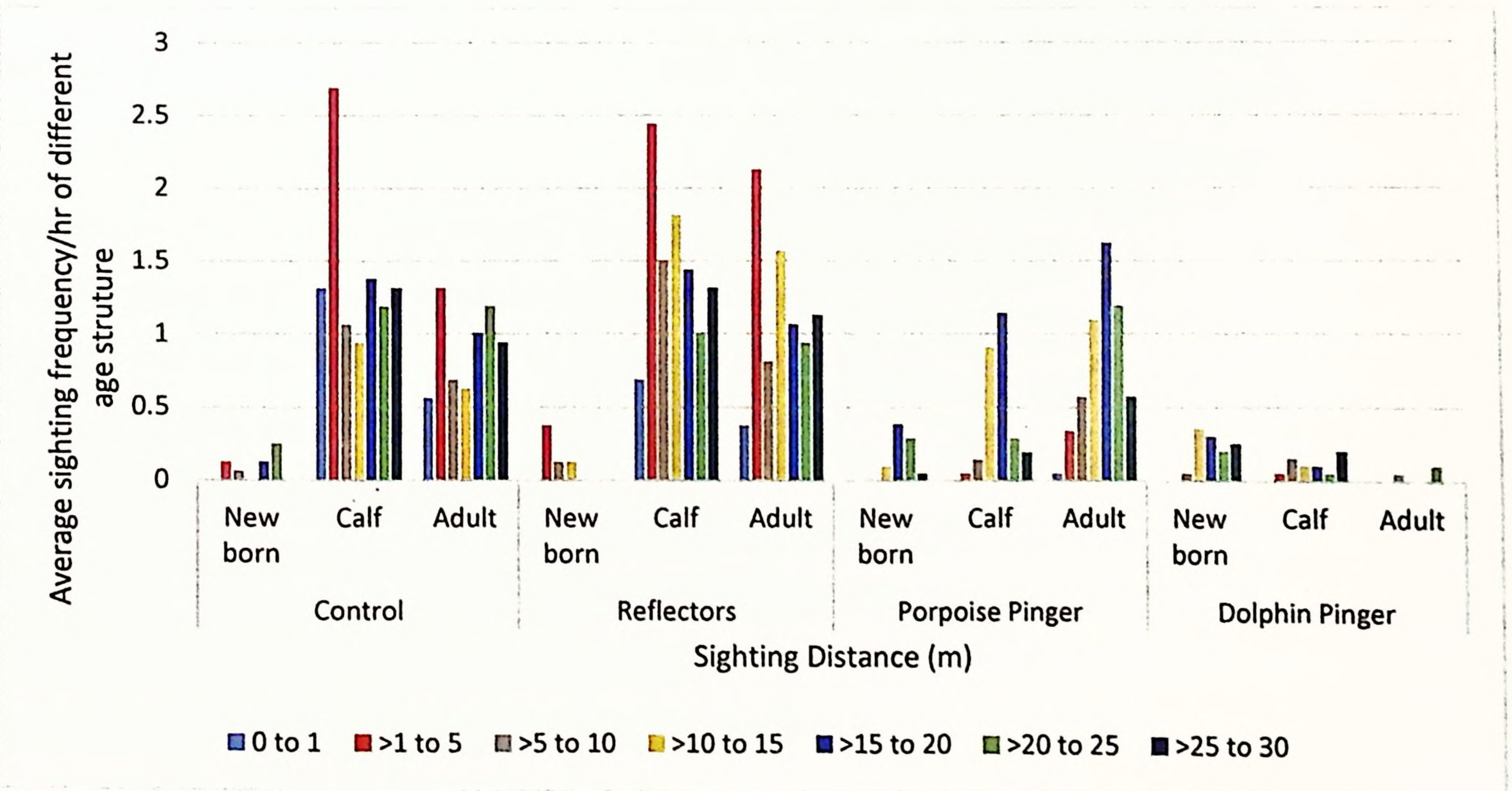


Figure 6.7 Average sighting frequency (per hour) of different age classes of dolphin in different experimental setup.

6.4. Discussion

Significant results (70% reduction in bycatch) were also observed in the controlled experiments addressing bycatch in Argentina (Bordino et al., 2002), off California (Barlow and Cameron, 2003) and off Peru (Alfero Shighuetu, 2010) with Netmark 1000 Pingers. However, consistent results were not seen for another two Pinger types (Aquamark 200 and Femunda 10kHz) (Imbert et al., 2007). The probable reasons cited were sparingly loaded nets and not in correct spacing (than the one instructed from the company), depleted batteries and sometimes fatal attraction of the animals than displacement (Dawson et al., 2013). Hence, it is vital to properly space the Pingers on the net since a bigger gap in signals in between can mislead the dolphins, which can give them an impression of narrow escape and can lead to entanglement or increase in bycatch rate (Palka et al., 2008; Carretta and Barlow, 2011). Also a low in the battery will lead to decreased sound pressure level and frequency which ultimately will not displace the dolphins.

In our study, in all the experimental setups, it was observed that the dolphins turned back from the nearest proximity of the gear without getting entangled. The probable reason behind it may be related to the time of the experiment, which was done during winter or low water season. The low water depth also allows to increases their detectability ranges, as we had seen that the maximum casualties always happened during Monsoons or high water season when the water volume and velocities were on its peak. This might be due to high water velocity which can make dolphins deaf and make them near impossible to echolocate the fine monofilaments of Gill net.

Though our study has shown some impact of Pingers on Ganges dolphins, but the experiment was of short duration. Hence carrying forward the Pinger experiment on freshwater dolphins to the next level is necessary. Specific questions such as effect in CPUE of the fish in active gears, behavioural responses of Ganges dolphins towards Pinger, either they will habituate or entirely avoid their critical habitats in the long run; the seasonal efficacy of Pingers; how readily will the fisher community accept it, etc. needed to be addressed in future. However, questions such as CPUE of fish in active nets in marine habitat has found no significant differences (Barlow and Cameron, 2003). But on the other hand, it has been reported that there is always an issue of compliance in the fisheries, and hence proper implementation is difficult even for the most sophisticated fisheries of developed countries (Dawson et al., 2013). Many insignificant studies on Pinger were the results of such inconvenience (Tripple et al., 1999; Dawson and Slooten, 2005; Orphanides, 2012). However, proper channelization of education and outreach programmes for the communities and enforcement, whenever required, will be some critical points for effective implementations (Dawson et al., 2013). It is always suggested that employing Pingers along with other mitigation approaches such as time-area closure and gear modification will lead to successful implementation (Dawson et al., 2013). The state's fishery department will have to play a very significant role for handling such a crucial issue of Ganges dolphin conservation which will be a holistic approach towards saving the entire freshwater habitats.

CHAPTER 7: RELATIONSHIP OF THE GANGES DOLPHIN POPULATION WITH ITS HABITAT AND THE ANTHROPOGENIC STRESSORS IN A NARROW AND SHALLOW RIVER: A SYNTHESIS

7.1. Introduction

The endangered Ganges dolphin is distributed in one of the most threatened habitats of the world, i.e., the freshwater ecosystem (Meybeck 1996). Although its population worldwide was plentiful in the nineteenth century (Sinha and Sharma, 2003), it has seen a drastic decline over the last hundred years (Reeves and Leatherwood, 1994).The distributional range of Ganges dolphin is currently spread through the Ganges- Brahmaputra- Meghna River systems in India, Nepal and Bangladesh (Anderson, 1879; Kasuya and Haque, 1972; Haque, 1976; Jones, 1982; Mohan, 1989; Shreshtha, 1989; Reeves and Brownell, 1989; Reeves and other, 1993; Wakid, 2006). In the Brahmaputra river, the distribution of dolphin was evident in all of its major tributaries. Presently, only the Kulsi and the Subansiri tributaries hold dolphin population. Apart from these, no recent document on dolphin presence is available for the other perennial tributaries. The dynamics of socio-cultural plurality of the region and resource utilization exerts pressure on the fresh water ecosystem of Kulsi river, where the anthropogenic activities are much higher in comparison to that of Subansiri river. This study reveals the impact of anthropogenic activities on dolphin distribution.

7.2. Status of the Ganges dolphins in Brahmaputra and its tributaries

The earlier studies in Assam were all based on direct count method using a single observer team giving the least count of the animal (Mohan et al. 1997, Mohan et al. 1998, Wakid 2006, Wakid 2009, Biswas and Boruah, 2000, Hazarika et al. 2010, Baruah et al. 2012). However, the recent estimates made using the standardised independent double observer method revealed 877 dolphins (±19) in the main channel of Brahmaputra (Qureshi et al., 2018). The river stretch under the protected area (Kaziranga National park) shows higher estimates than the disturbed areas (Goalpara).

In Subansiri also, the recent estimate was made using the independent double observer method (48±6 dolphins, Qureshi et al. 2018). In Kulsi, the population fluctuates between 15-25 dolphins during pre- monsoon seasons of different years (Fig. 7.1). This suggests that there is a movement of dolphins in and out of the river to the main channel of Brahmaputra from Kulsi.

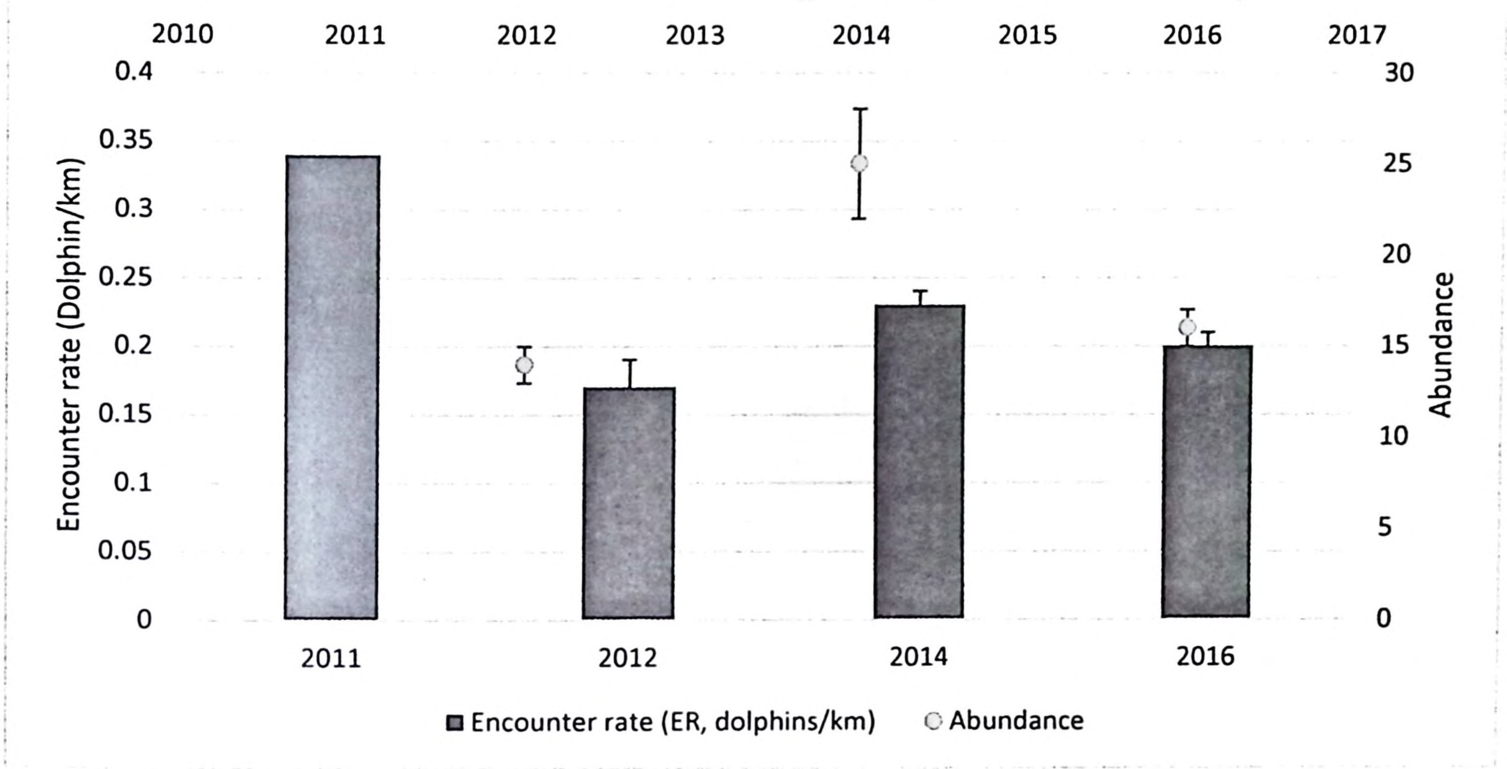


Figure 7.1 Encounter rates and abundance estimates of Ganges dolphin during pre- monsoon seasons in Kulsi river from 2011-16 (estimates during Mar- Mid of Jun).

7.3. Population estimation with independent double observers and underwater acoustic hydrophones

The earlier studies did not take into account the major source of bias in population estimation, i.e., the observer bias which is dependent on sighting conditions such as channel types or fatigues; and the unavailability bias which depends on the diving pattern of the animal (Smith et al. 2006). During this study, two independent visual observer teams (Smith et al. 2006, Braulik et al. 2012) were used for mark-resight type method. Analysis was done using the Lincoln- Petersen, and Huggins estimator to estimate the abundance.

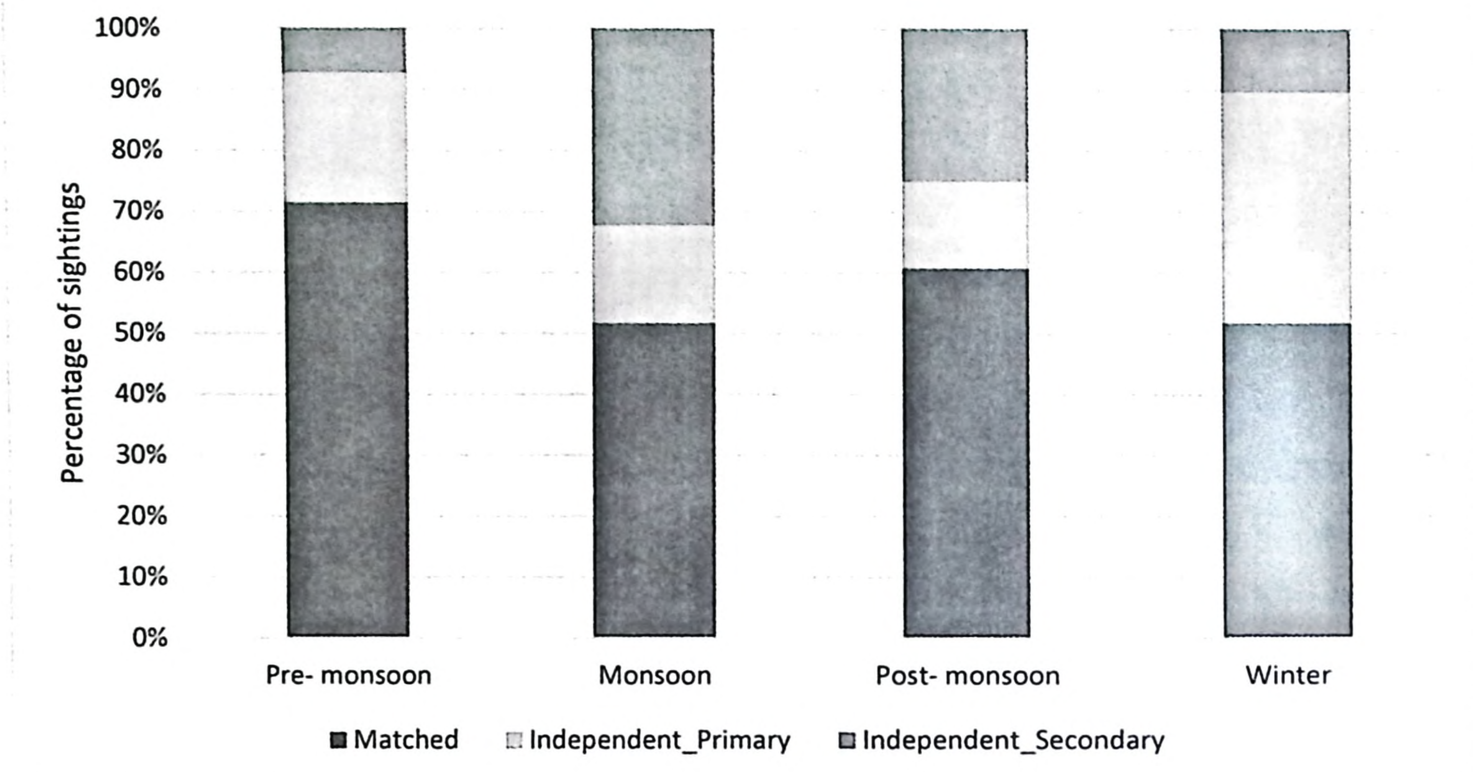


Figure 7.2 Percentage of matched and independent sightings made by each observer in different seasonal surveys (2012-13).

The condition of homogeneity in capture probabilities was diluted by incorporating covariates (individual dolphin diving behaviour, habitat types, and sighting conditions) to the models. Unsuitable visibility conditions were always avoided during the surveys, i.e. surveys were done only when there was no rain or fog, glare and wind (0 or 1 condition was considered, Chapter 3). During low water seasons, detecting surfacing dolphin in a narrow river like Kulsi is not problematic. On the other hand, as the channel is at its widest during the monsoons, the ability to detect dolphin surfacing becomes difficult. Using the Huggins model corrected the detection probabilities by incorporating channel types as one of the sighting conditions and made the estimate more robust (Fig. 7.3.).

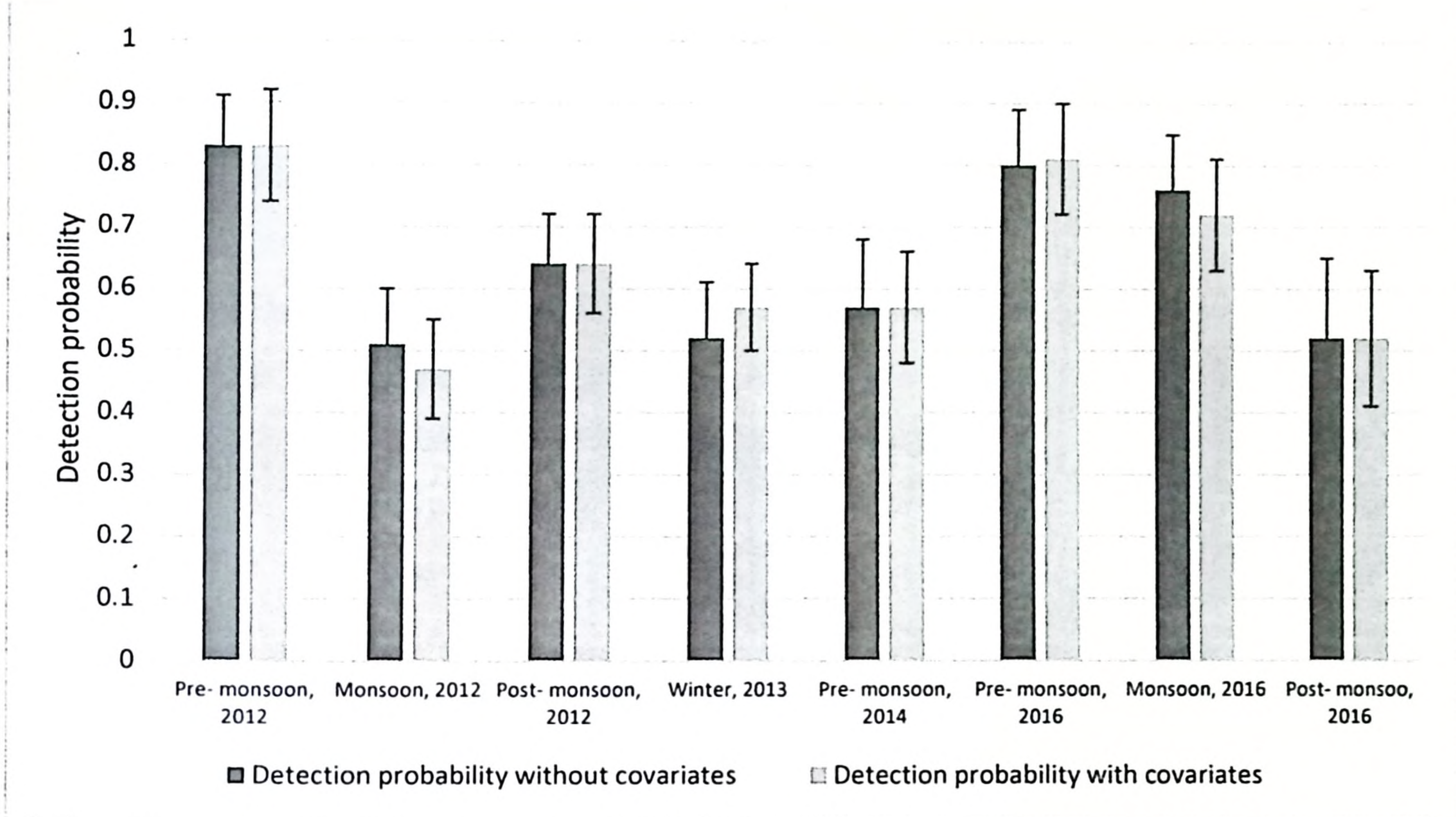


Figure 7.3 Detection probabilities for models with and without covariates across different seasonal surveys in Kulsi river.

Underwater acoustics tags on the other hand were used to tackle the unavailability bias (Akamatsu et al. 2008), i.e. the unseen dolphins which remain underwater when the boat with visual observer passed by. As the Ganges dolphins release continuous trains of high frequency echolocation clicks (Herals et al. 1969, Pilleri et al. 1970, 1976), the active acoustic hydrophones record the signals. The estimates recorded using combined methods of visual and acoustic were always higher (Fig. 7.4.). The correction factor was also higher during high water season (1.27 unseen dolphins by visual observer) as compared to receding season (1.05 unseen dolphins by visual observer). Although, this combination of visual and acoustic survey may work out for narrower channels, the same may not hold true for wide channels of Brahmaputra and Ganges as the sound pressure level will decrease from a distant source (dolphin) and may be missed by the acoustic tags or go unrecorded.

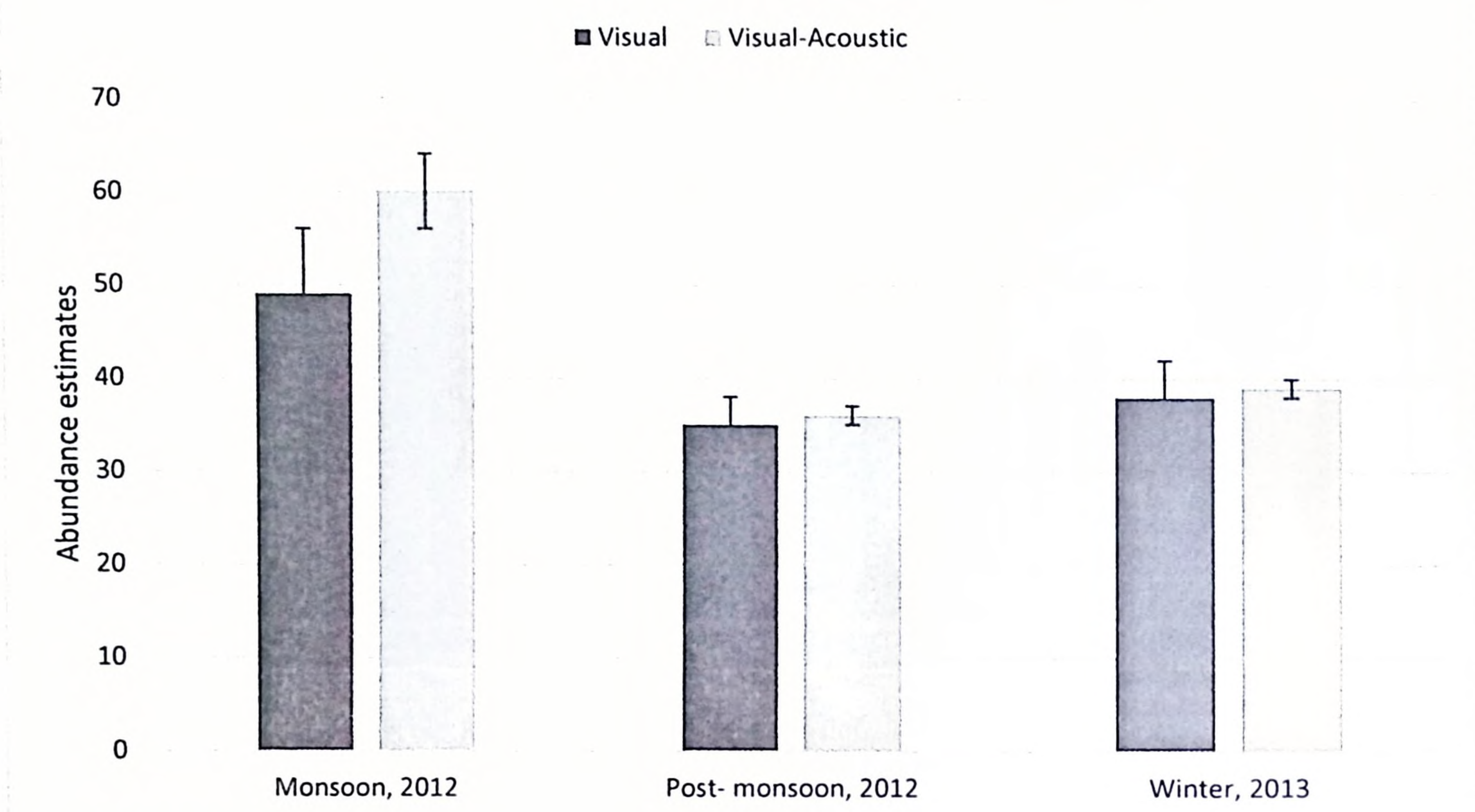


Figure 7.4 Comparing visual observer estimates with combined visual- underwater acoustic methods in different seasons.

7.4. Importance of Tributaries

The tributaries play an important role in facilitating dolphin movements from the main channels during the flood season. The difference in dolphin sightings during different seasons suggests that dolphins move into the main channel, Brahmaputra, during the low water seasons, and move towards the tributaries during the high waters in monsoon season. This local migratory behaviour of dolphin is crucial for its survival and hence it becomes necessary to conserve the tributaries. It has been evident that the tributaries are susceptible to disturbances caused by anthropogenic pressure from the human settlements on the banks of the tributaries. The tributaries are narrow in width and the anthropogenic pressure is greater in areas where both the banks are populated. In Kulsi river, the different communities exercise different livelihood activities such as fishing, sand mining and farming. This study was conducted over 75 km stretch of Kulsi river to understand the relationship between the Ganges dolphin's abundance and distribution with anthropogenic pressures.

7.5. Anthropogenic pressure as potential threat to dolphin population

In Kulsi, the level of anthropogenic activities is high and only increasing. A wide range of anthropogenic activities are undertaken in Kulsi, such as harmful fishing practices (mosquito net fishing), sand mining activities, irrigation with pumps to irrigate fields, and sand boat traffic (Mohan et al. 2007, Jayachandran et al. 2007). It was observed (Chapter 3) that the hotspots (Kulsi- Batha confluence) of dolphins shifted to other areas owing to the increase in anthropogenic activities such as fishing and sand-mining.

Monsoon and winter seasons were found to be crucial for Kulsi river. The monsoon season (0.37dolphins/km, S.E. 0.04 in 2012 and 0.23 dolphins/km, S.E. 0.01 in 2016) serves as a refuge to the migrating population of dolphins from the main channels of Brahmaputra as the water level rises. However, higher peaks of dolphin encounter rates were also observed in winter season (0.45 dolphins/km, S.E. 0.02 in 2013) because of the migration of Dolphins from the tributaries of Kulsi towards Kulsi. Another probable reason can be due to low anthropogenic activities as fishers and sand miners do not prefer to work during this season (secondary data results, Chapter 5). More dolphin calves were also encountered during this season, indicating a vital time for spawning (Kasuya, 1972). Ganges dolphins use meanders and confluences more than other habitats (Smith 1993). Dolphins in Kulsi are mostly distributed in all the confluences; Kulsi- Batha river confluence being the hotspot which also has connectivity with the surrounding wetlands. This is directly related to the fish pools which are mostly restricted to those habitats (Cummings et al. 1984, Sedell et al. 1984). The catch calendar and the market surveys have revealed the abundance of the preferred fish species of Ganges dolphins (Shrestha 1989, Sinha et al. 1993, Choudhary et al. 2006, Bashir et al. 2010) which is mostly comprised of fish sizes of 1-20 cm length and 0.5 - 200 gm of weight. The plankton abundance in Kulsi was also found to be much lower compared to Brahmaputra and Subansiri, which indicates a low primary productivity in Kulsi river (Chapter 4). Considering the water quality of Kulsi river, the DO level was found to be less compared to the normal requirement of DO level for freshwater biodiversity (Chapter 4).

It was observed that dolphins avoided places with high fishing pressure (Kelkar et al. 2010) or places with increased underwater noise due to boat traffic or dredging activities (Pirotta et al. 2013, Pirotta et al., 2015) as it resulted to increased metabolic cost for animals who are dependent on sound for navigation and hunting (Dey et al. 2019) and thereby start avoiding potential habitats (Bejdar et al. 2006, Rako et al. 2013). The irrigation pumps used to pump out water for dry season crop (Irri cultivation), further affect the primary habitats of dolphins as the water level drops in these areas. The farmers also reported that dolphins start avoiding the areas where the irrigation pumps generated heavy noise on the shoreline. Similar conditions also prevailed where sand mining was done by the pumps on the river. These operations mainly occur during the post- monsoon and the pre- monsoon seasons.

The socio- economic culture of the communities residing in Kulsi riverscape has been changing. The interviews with the community indicate that the fish production has declined significantly in the past ten years and the traditional livelihood culture of fishing (traditional fishers, Chapter 5) has been shifting towards sand mining. Selection of sand mining as the alternative to fishing has become a trend in Kulsi. Since sand mining is a more promising occupation, the mining activities have increased in the past ten years. People have also upgraded from the original way of digging sand manually from the river bed to pump mining.

Furthermore, the habitats used by dolphins were also preferred by the fishermen for fishing. In Kulsi, it was observed that dolphins usually avoid places with high fishing pressure. It can also be concluded from the catch calendar and fish market survey that there is always a competition for prey resource between Ganges dolphin and fishermen community in Kulsi. More than 40 percent of the revenue from the fish landing site is comprised of fishes preferred by Ganges dolphins (refer to Chapter 4). On top of that, the use of harmful fishing gears such as monofilament gillnet (major source of death due to entanglement) and mosquito nets (ease resource depletion, Mohan et al. 1997) has worsened the situation. Despite the fishing regulations (Assam Fishery Rules, 1953), there is a lack of awareness and owing to the absence of an alternate source of income, fishers are compelled to break the rules.

7.6. Communities and conservation

To conserve Ganges dolphin and its habitat we must understand the issues of the communities. In this study, three main stakeholders were identified, viz., the fishers, the sand miners and the farmers. The activities of the three identified stakeholders directly depend on the tributary for their livelihood.

Due to poor socio- economic conditions, it was observed among all the communities that the people start working at a very early age. The majority of the population have acquired primary education only. More than 50% of the interviewers among all the three stakeholders were illiterate. The primary education on the other hand does not help them in gaining awareness towards conservation values of the area. About 32% of the fishers interviewed, do not have awareness regarding fishery rules. They are also unaware of the various government schemes implemented for commercial fishers and have no knowledge about whom to approach. The sand miners, without knowing the future impact of the mechanised way of mining on the river, are involved in pump mining. Among the three communities, it was observed that the farmers had the least knowledge regarding the surviving population of the Ganges dolphins in Kulsi river (about 6% of the interviewers believed in increasing population of the Ganges dolphins in Kulsi during last ten years). Among the respondents, 18% of the fishers, 23% of the sand miners and 52% of the farmers did not know that dolphin killing is a punishable offence according to the Wildlife Protection Act, 1972. Also, about 0.6% of the fishers use dolphin oil as medicinal remedy (as a cure for Rheumatoid) and 1.3% as fish bait.

During the surveys, it was obvious that the communities were looking forward to other alternative sources of livelihood. The fishers, for instance, have a general awareness about the spawning season of fish and the adverse impact of fishing using mosquito net but they practise it due to the absence of other livelihood options. They also opt for sand mining as the next suitable source of livelihood. The population of the landless farmers who turn to fishing and sand mining as periodic sources of livelihood is also high. The quality of life for the communities has not changed positively. Rather they stay poor with the increase in the cost of living.

7.7. Pingers: Technology to aid Ganges dolphin with detectability

Casualties of Ganges dolphins due to their entanglement in monofilament gillnet is one of the major concerns for the conservation of the species. Acoustic deterrent devices (Pingers) have shown the avoidance by dolphins (emitting 70 KHz frequency). However, the study was of a short duration compared to other studies on marine cetaceans (Kraus et al. 1997, Tripple et al. 1999, Barlow and Cameron 2003, Leeney 2007, Carretta et al. 2008, Gazoet al. 2008, Buscaino et al. 2009, Carretta and Barlow 2011) and need further investigation.

We were unaware of the fact that whether Pinger would act as "dinner bell" or rather act as deterring device in long run. It was seen in few studies done in marine habitats that after prolonged use of such devices, the mammals started to recognise the noise made by the acoustic deterrent device. In marine studies, the species start considering it as a source for depredation rather than avoiding it (Kraus 1999, Carreta et al., 2011). Also, we do not have the information on the change in the catch per unit effort of fish with and without active acoustic deterrent device, which could otherwise have been the main convincing point for the fisher community to accept the device. The duration of study in Kulsi is not enough to draw the conclusion on whether the dolphin's response to the device could save them from net entanglement. This study could consequently propose doing a long term study to look into all the possible consequences in different seasons. It would also be interesting to experiment its effectiveness in wider channels of Brahmaputra and Ganges. Since the use of Pinger has happened for the first time in fresh water ecosystem, long term data on dolphin behaviour could give us the actual information on the future use of Pinger.

7.8. Contribution of the thesis/ Recommendations

An unbiased monitoring mechanism can be implemented to estimate the Ganges dolphins' population. A robust method to do this would be a combination of two independent observer teams with a pair of underwater acoustics and an analysis using the Huggins estimator. The seasonal movement of resident dolphin population would be information of utmost importance for the managers in preparing a conservation management plan for the dolphins.

In Kulsi, illegal fishing (fishing during banned seasons and fishing with banned fishing gears) has to stop in order to restore the original fish stock of the river. The Revenue and the Fishery departments should act hand in hand to ban the use of harmful gears such as small mesh size gillnets and mosquito nets (Bishwas and Baruah, 2000). This could restore the original fish-size structure to reduce competition (Dungeon, 2005; Link, 2005). However, along with bringing regulations, alternative solutions must be brought forward. The socio-economic conditions of the fishers of Kulsi river is below poverty line and the absence of alternative livelihood sources only aggravates this condition thereby making the implementations ineffective. The "one-time benefit" scheme implemented as a compensation scheme during the fish banned seasons for the commercial fishers have been dissolved. Other schemes like "Matsya- Jagaran: Ghare ghare pukhuri, ghare gahre maach" and "Seed bank programmes" are meant for inland fisheries. "Matsyamitra" is indeed a good initiative by the GOI to educate village youths and involve them in gathering vital information (pH, carbon content in pond and surrounding soil) required for aquaculture. However, proper implementation is still needed in Assam by way of generating awareness. Although the riverine fisheries of Assam comprise the maximum area (205,000 Ha) compared to all other fishery resources, the productivity is comparatively low (only 190kg/Ha, Gogoi et al. 2015) despite its potential.

The extraction of sand from Kulsi river is also widespread. It is time for the Revenue and Forest departments to work together towards totally banning the use of sand mining pumps in Kulsi river and to regulate mining activities. Although on paper, there are in total six sand mining depositories on two developmental blocks of the district- three in Rampur block and three in Chaygaon block, numerous illegal mining depositories, have come up in recent time.

A detailed study of environmental flow is an urgent necessity. A proper review of restoration models for floodplains should also be done and experimental set ups should be placed on smaller scales. Finally, long-term monitoring programmes to keep a track on the restoration procedures and an effective dolphin conservation programme, with the elaborate involvement and participation of the communities, should be undertaken in order to revitalise the Kulsi river and ensure the survival of the species.

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Appendix 1.1Data sheet for Dolphin abundance estimation

Data sheet no.	Date:	Observer: (Primary/ Secondary)	Data recorder:	Start location	End Location	Start time:	End time:	Total time:	Avg. boat Speed
				N	N				
				E	E				

Sl. No.	Sighting time	GPS location		Group structure				Distance data			Visibility condition			Channel type	Anthropogenic activities	Comments
		N	E	NB	C	A	CS	RD	RA	DNB	Windy (0/1/2)	Glare (0/1/2)	Rain/ fog (0/1/2)			

Group structure: NB: New born, **C:** Calf, **A:** Adult, **CS:** Cluster size

Distance data:RD: Radial distance, **RA:** Radial angle, **DNB:** Distance of animal from nearest bank

Visibility condition:Wind:code 0= no wind, **code 1**= wind forming small waves in the water without forming white crest, **code 2**= wind forming white crested waves in the water

Glare: code 0= no glare, **code 1**= severe glare (view completely obscured) covering 10% of the field view or slight glare (view only partially obscured) covering less than 50% of the field view, **code 2**= severe glare covering more than 10% of the field view or slight glare covering more than 50% of the field view

Rain/ fog:code 0= no fog/ rain, **code1**= fog or rain obscuring no more than 10% of the field of view or partially obscuring no more than 50% of the field of view, **code 2**= fog or rain obscuring more than 10% of the field of view or partially obscuring more than 50% of the field of view.

Appendix 1.2Data sheet for Habitat mapping and anthropogenic activities

Data sheet no.:	Date:	Data recorder:	Start time:	End time:	Start location	N	E
					End location	N	E

Recording time	GPS pt. (WP)	Channel width		Riparian type		Depth	CT	Anthropogenic activities												
		LB	RB	LB	RB			FB	CN	GN	MN	HF	LN	JF	FC	SMb	SMg	Ir	FCr	INd

Water quality																
Press. (mmHg)	Temp.	TDS (mg/l)	Cond.	Turbidity (NTU)	DO		Ph	Sal.	Nitrite		Nitrate		Ammonia		Phosphate	Comments
					%	mg/l			mg/l	mg/l N	mg/l NO_3	mg/l N	mg/l N	mg/l NH_4	mg/l	mg/l P

									NO_2						PO_4		

GPS pt. (WP) : Way point, **LB:** Left bank, **RB:** Right bank, **CT:** Channel type.

Anthropogenic activities: FB: Fishing boat, **CN:** Cast Net, **GN:** Gill net, **MN:** Mosquito net, **HF:** Hook fishing, **LN:** Lift net, **JF:** Jeng fishing, **FC:** Fishing camp, **SMb:** Sand mining boat, **SMg:** Sand mining ghat, **Irr:** Irrigation, **FCr:** Ferry crossing, **INd:** Industry.

Water quality:Press.: Pressure, **Temp.:** temperature, **TDS:** total dissolved solid, **Cond.:** Conductivity, **DO:** Dissolved oxygen, **Sal.:** Salinity.

Riparian type: MF: Matured forest, **SB:** Shrub land, **GL:** Grass land, **SB:** Sand bank, **CL:** Cultivated land, **HH:** Human habitation, **MM:** Major markets.

Habitat type: CF: Confluence, **M:** Meander, **DMCI:** Downstream mid- channel island, **NSC:** Narrow straight channel, **WSC:** Wide straight channel.

Appendix 1.3 Target Group: Lease Holder

Data Sheet No.	Date:	Data Recorder:				
Start time:	End time:	Location:				
Villages under the fishery:						
Name of Informant (lease holder):		Age:		Gender:		
1. What is the name of the fishery?						
2. What is the size of the fishery (area/boundary): Map to show the boundaries	Area	Boundary				
3. What is the duration of your lease?						
4. How much did your lease cost?						
5. How many fishermen are involved in **your** fishery:						
6. Do you have share holders? (YES/ NO) How many? At what cost do you sell the lease to the share holders?						
7. To which fish landing sites do you supply?	a.	b.	c.	d.	e.	f.
8. Types of gear used	**Time of gear used (Season based)**					**No. of gear used**
a.	Pre- monsoon Monsoon Post Monsoon Winter					
b.	Pre- monsoon Monsoon Post Monsoon Winter					
c.	Pre- monsoon Monsoon Post Monsoon Winter					
9. Do you support your fishermen during fishing close season? (YES/NO) If Yes, how?						
10. Do you know anything about river dolphins of Kulsi? (in detail)						

Appendix 1.4 Fish landing Sites

Data Recorder:							
Data Sheet No.		Date:		Start Time:		End Time:	
Landing Site		N:					
		E:					
Name of Informant:	(Have to go for particular person who will be most suitable)	Age:					
Amount (in kgs. to know the biomass extracted) of fish landed from Kulsi fishery each Season/ Monthly basis:							
Month	Amt. of Small fish (Kg)	Economic exchange	Amt. of medium fish (Kg)	Economic exchange	Amt. of large fish (Kg)	Economic exchange	
Jan							
Feb							
Mar							
Apr							
May							
Jun							
Jul							
Aug							
Sept							
Oct							
Nov							
Dec							

Appendix 1.5 TARGET GROUP: Fishermen (Questionnaire for fishermen's socio-economic status, fishing trend and Attitude towards Conservation of dolphin)

General Information					
Data-sheet no.:		Interview starting time:	Interview ending time:		
Interview date:		Location:			
1	Fishermen information:	Name:			
		M/F:			
		Age:			
		Community:			
		Education:			

		Fishery lease name:				
2	Are you a permanent resident of this village? (YES/ NO)					
	If YES– how long have your family been living in this area?					
	A). If No, since when you are living in this village?					
	B). Why did you move to this village?					
3	How long have you been fishing?					
4	a. Do you own a boat? (Yes/ No)					
	b. If not, how do you hire the boat? (own money/ money from loan)					
	c. If loan, from where?					
5	What is your income from fishing?					
	Pre-monsoon	Monsoon	Post-monsoon	Winter		
	(Apr-Jun) (Jan – Mar)	(Jul-Sept)	(Oct – Dec)	(Jan – Mar)		
6	What is your income from other sources?					
	Pre-monsoon	Monsoon	Post-monsoon	Winter		
About fishing trends						
1	Where do you usually fish other than Kulsi River?					
	Wetland	Other	Where			
2	How far do you go fishing in the River?					
a	Upstream?					
b	Downstream?					
3	Which season do you catch the most fish? Rank the seasons in descending order.		Time spent fishing during the different seasons			
	Pre-monsoon season		Low	Medium	High	Don't fish
	Monsoon season		Low	Medium	High	Don't fish
	Post-monsoon season		Low	Medium	High	Don't fish
	Winter season		Low	Medium	High	Don't fish
4	**Which fishing gear type do you use most?**		**In which season do you**	**Which species do you**	**Where on the river do you use this type of**	

			use them?	catch with this fishing gear?	fishing gear?
	Gear length?	Mesh size?			
			Pre- monsoon		Confluence
			Monsoon		Mid channel Island
			Post- monsoon		Deep pools
			Winter		Meanders
					Any other

PREPARE PHOTO CARDS

5.	**Which is your second most commonly used gear type?**		**In which season do you use them?**	**Which species do you catch with this fishing gear?**	**Where on the river do you use this type of fishing gear?**
	Gear length	Mesh size	Pre-monsoon		Confluence
			Monsoon		Mid channel Island
			Post-monsoon		Deep pools
			Winter		Meanders Any other
6.	**Which is your second most commonly used gear type?**		**In which season do you use them?**	**Which species do you catch with this fishing gear?**	**Where on the river do you use this type of fishing gear?**
	Gear length	Mesh size			Confluence

			Pre-monsoon			
					Mid channel Island	
			Monsoon			
					Deep pools	
			Post-monsoon			
					Meanders	
			Winter		Any other	
7.	Have you used the same types of fishing gear for the last 10 years you have been fishing? (circle an answer)					
	Yes No					
	A). If No, what types of other gear have you used?					
	B).When did you stop using these gears and why?					
8.	Within the last 10 years, has the number of fishermen at this site……….					
	Increased	decreased	no change	Don't Know		
9.	Within the last 10 years, has the amount of fishes in this site……………….					
	Increased	decreased	remained constant?			
	Why?					
10.	Do you know about the fisheries regulations issued by Department/Ministry of Fishery					
	Yes	No				
11.	If yes, do you think they are important? Yes / No					
	If No, why?					
12.	What job do you do during the fishing ban season?					
13.	If answer to "26" is "fishing", why don't you go for an alternative livelihood?					
14.	Do other fishermen at the site follow the regulations?					
	Yes	No				
	What jobs do the other fishermen at your site do during the fish-ban season					
15.	Does your community have its own fishing rules?					
	Yes	No				
	If yes, what?					
About Dolphins						
1	Show them a photograph of the River Dolphin. Ask them what the animal is.					
	If they can't identify dolphin, finish survey					
2	When did you last see a dolphin?					
3	In which seasons do you see them?					

4	Pre-monsoon	Monsoon	Post-monsoon	Winter	Don't Know		
5	In which season do you see them most?						
	Pre-monsoon	Monsoon	Post-monsoon	Winter	Don't Know		
6	What does the river dolphin feed on?						
7	Do dolphins create problems to your fishing? (Yes/ No/ Don't know) If YES, how?						
	a) By taking fishes away from your fishing gears						
	b) By destroying fishing nets						
	c) Others (Specify)						
8	Has a dolphin ever got entangled in your fishing gear? Yes/No						
	If yes then in which gear?						
9	Have you ever seen dolphin got entangled in net of other fishermen of your site?						
	If yes then in which gear?						
10	Do you ever use any part of a dead dolphin?	Yes/No					
	a). For direct use:	Oil : YES/ NO					
	b). if YES	for fish bait	medicine				
	c). Meat:	YES/NO					
	d). From where do you get them?						
	e). Do other people in your site use dolphins ? Yes/No/Maybe/Don't Know						
	If Yes/Maybe for what purposes?____________________						
11	Is the no. of dolphins increasing or decreasing in the last 10 years?						
12	What is the state aquatic animal?						
13	What is the national Aquatic animal?						
14	Are you aware about the punishments and penalties for killing a Dolphin?						

Appendix 1.6 TARGET GROUP: Sand miners (Questionnaire for Sand miners' Socio-economic status, Sand mining trends and attitude towards dolphin conservation)

Questionnaire number:			**Interview date:**	
Interview start time:	Interview end time:			
1. Interviewee information:				
1.2 Informant's name:				
1.3 Informant's age:				

1.4 Contact details:					
1.10 Gender:	M	F			
1.9 Name of the lease holder society:					
1.11 Level of education:					
1.12 Place of residence:					
1.13 Residence:	Temporary	Permanent			
1.14 How long have you lived in this area? (Years):	0 to 5 years	5 to 10 years		>10years	
1.15 Number of people in household (including respondent)?					
2. Livelihood details:					
2.1 For how many years are you doing sand mining?					
2.2 How many members of your family are into sand mining?					
2.3 What is the monthly income from sand mining?					
2.4 What is the per head monthly income if more than one family members does sand mining?					
2.5 No. of hours spent in the river per day for sand mining:					
3. About Sand Mining: History and Trend					
3.1 When did sand mining start in Kulsi river?					
3.2 Within the last 10 years, has the sand mining increased, decreased or remained constant?					
3.3 Is there a closed season for sand mining?					
3.4 If yes, what do you do for livelihood in that season?					
3.5 What is the upstream and downstream limit of sand mining? (distance in kms.)					
3.6 Which season do you the most sand mining? Rank the seasons in descending order.	Time spent fishing during the different seasons				
Pre- monsoon	**High** (1 to 2 days a week)	Pre-monsoon	Monsoon	Post-monsoon	Winter
Monsoon	**Medium** (3 to 4 days a week)	Pre-monsoon	Monsoon	Post-monsoon	Winter
Post- monsoon					
Winter	**Low** (5 to 7 days a week)	Pre-monsoon	Monsoon	Post-monsoon	Winter
3.7 Do you own a boat for sand mining?					
3.8 Is there any Govt. Rules or regulation for sand mining? If yes, what is it?					
3.9 Is there a season when there is low demand of sand?					
3.10 Has sand mining increased significantly at the cost of fishing or other occupations?					
3.11 Do you think there has been an increase/decrease in the amount of sand in the river					

bed in Kulsi river? Give reasons for your answer?
3.12 Would you continue doing sand mining in future and why?
3.13 Would you like your children to take on the same occupation?
4. Dolphin Awareness and Conservation Details:
4.1 Is there any record of dolphin mortality with the sand mining boat?
4.2 According to you has there been a increase/decrease in dolphin number within last 10 years in Kulsi river?
4.3 In which area dolphins are more frequently sighted in Kulsi river?
4.4 Do you think dolphin killing is banned?
4.5 Have you ever seen/heard any NGO/forest/fishery officer talking about dolphin protection?
4.6 Any other information that you would like to share?

Appendix 1.7 TARGET GROUP: Farmers residing bank of Kulsi River (Questionnaire for farmers' socio- economic status, irrigation trend and Attitude towards Conservation of dolphin).

Questionnaire number: Interview date:
Interview start time: Interview end time:
1. Interviewee information:
1.2 Informant's name:
1.3 Informant's age:
1.4 Contact details:
1.10 Gender: M F
1.9 Village Panchayat:
1.11 Level of education:
1.12 Place of residence:
1.13. Are you a permanent resident of this village? (YES/NO)
If YES, then since when you are in this village?
If NO, then when did you came to this village?
1.14 How long have you lived in this area? (Years): 0-5 5-10 >10
1.15 Number of people in household (including respondent)?
2. LIVELIHOOD DETAILS
2.2. In how much land do you cultivate?
2.3. Since when you are doing cultivation?
2.4. What do you cultivate?
2.5. What is your annual yield of each cultivation?
2.6. What is your annual income generation from each cultivation?
2.7. Do you 1). invest labour to you field (YES/NO)
If YES, how much do you spend annually for labour investment?
2). or you do by yourself and with the help of your family members? (YES/NO)
2.8. Do you have some other source of income generation? (YES/NO)
If YES, what is annual income generation of the source?
3. IRRIGATION RELATED

3.1. Is Kulsi River water is only source of water for irrigating your field? (YES/NO)
3.1.a. If YES, how many water pumps is required to irrigate your fields?
3.1.b. If NO, what is the other source of irrigation?
3.2. When did you started using a water pump for your field?
3.3. Before that what was your source of irrigation?
3.4. For how many days do you irrigate your field for every cultivation?
3.5.For how many time (hrs.) do you pump out water from the river in a day?
3.6.Do you run the pump for same duration in both dry and wet season? (YES/NO)
If NO, then how many hrs. in Dry season?______________ and Wet season?______________
4. REGARDING ATTITUDES OF FARMERS TOWARDS DOLPHIN CONSERVATION
a. Have you ever seen a dolphin in the area of your water pump when you put your water pump on?
b. Do you think irrigation from river only can lower the water volume of your river? (YES/NO)
c. Is there any record of dolphin mortality in your area? (YES/NO) If YES, then how? (Natural mortality(During Dry/ Wet Season)/Fishing gear entanglement/Sand mining accident)
4.2. According to you has there been a increase/decrease in dolphin number within last 10 years in Kulsi river?
4.3. In which area dolphins are more frequently sighted in Kulsi river?
4.4. Do you think dolphin killing is banned?
4.5. Any other information that you would like to share? 262:280

Appendix 1.8 Data Sheet for Catch Calendar

1). Date: 2). Location: (N) (E)

3). Start Time: 4). End Time:

Sl. No.	Weather: (S- 0, 1, 2 / W- 0, 1, 2 / R- 0, 1, 2)*	Habitat type: (C/ M/ SWC/ MCI/ DP) **	Gear Type	Duration of the effort	Fish type	Fish Size	No. of fishes collected	Wgt. of fishes

*S= Sunny day, W= Windy day, R= Rainy day (codes for the categories were similar to Appendix 1.1)

** C= confluence, M= meander, SWC= straight wide channel, MCI= mid channel island, DP= deep pool

Appendix 1.9 Data Sheet for recording Dolphin Interaction with fishing with and without by- catch mitigation tools.

Experiment to test the Interaction of dolphins with different fishing gears													
Data sheet no.	Date:	Start Time:		GPS location of the gear (Start point- End Point)									
		End Time:		Lat		Lon		Lat		Lon			
Length of the gear:			Height of the gear:			Mesh size:			Twine size:				
Water Temperature	Weather Condition								Visibility*				
	Sunny			Cloudy			Rainy		1		2		3
GPS Points of the "distance points" from the gear													
Left	50m	100m	150m	200m	250m	Right	300m	50m	100m	150m	200m	250m	300m
Lat						Lat							
Lon						Lon							
Depth						Depth							
Dolphin Interaction with Gear													
Age Class	Adult				Sub-adult				Calf				
No. of Dolphins													
Heading													
Depredation													
Avoiding													
Fish depredated													

Appendix 2 Fish species identified during fish sampling, catch calendar, fish landing sites and fishermen questionnaire surveys in Kulsi River

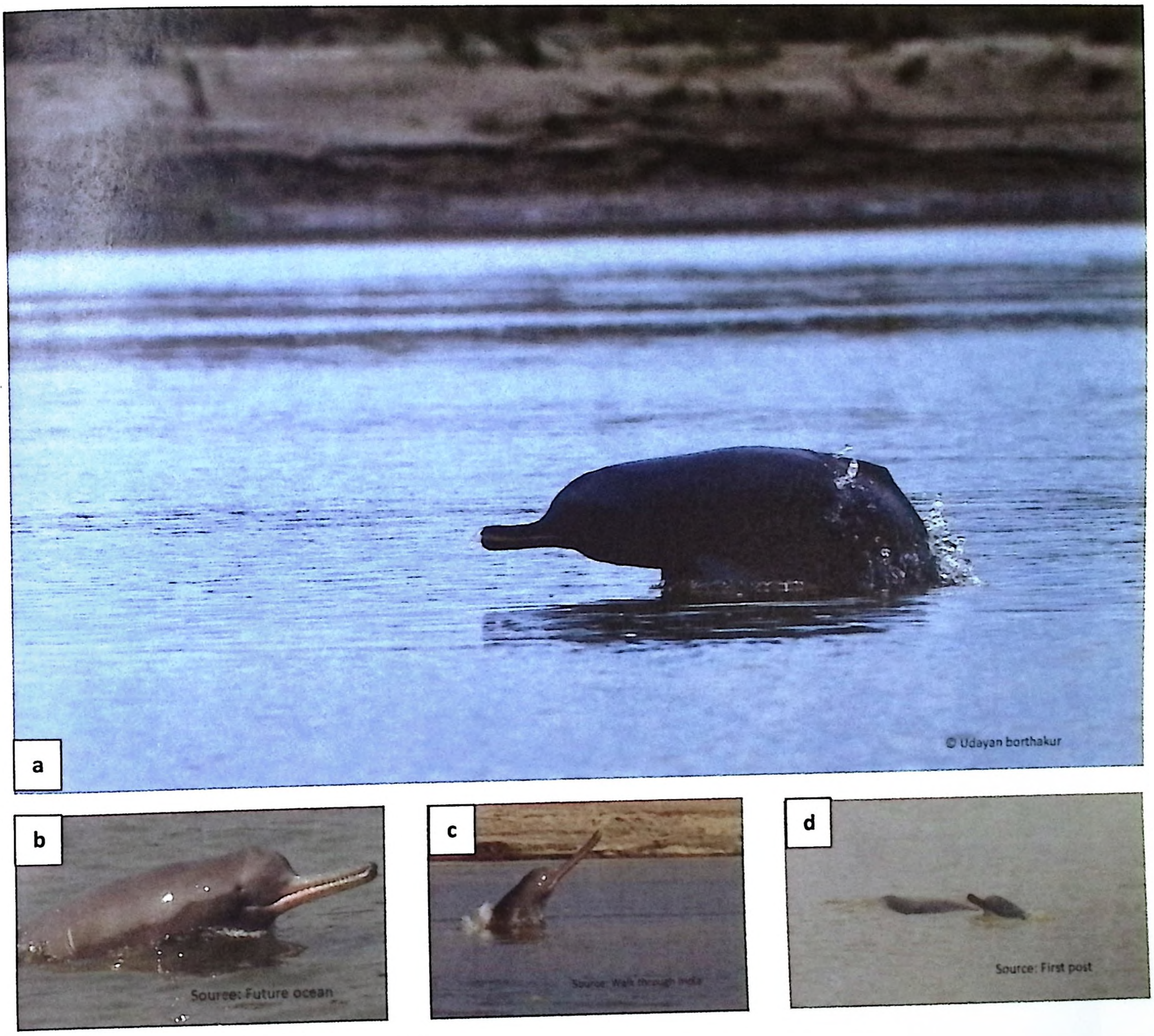
Sl. No.	Local name	Scientific name	Family
1	Aari	Aorichthys spp	Bagridae
2	Baitkia	-	
3	Bami	Mastacembelus arnatus arnatus	Mastacembalidae
4	Bhagun	Labeo bata	Cyprinidae
5	Bacha	Eutropiichthys spp.	
6	Batorosi	-	
7	Barali	Wallago attu	Siluridae
8	Bhakua/Bahu	Catla catla	Cyprinidae
9	Boroliya	Aspidoparia spp.	
10	Botia	Botia dario	Cobitidae
11	Chala	-	
12	Chanda	Chanda nama	Ambassidae
13	Cheng	Channa barca	Channidae
14	Common carp	Cyprinus carpo	Cyprinidae
15	Dabri/Laupati/ Dahrie	Danio davario	
16	Dushi	-	
17	Dorikona	Esomus danricus	Cyprinidae
18	Gedgedi	Nandus nandus	Nandidae
19	Golsa	-	
20	Goroi	Channa punctatus	Channidae
21	Grass carp	Ctenopharyngodon idella	Cyprinidae
22	Ilish	Hilsa ilisha	Clupidae
23	Sol/ Shol	Channa striatus	
24	Jawori	-	
25	Mali/ Kaliajora	Labeo calbasu	Cyprinidae
26	Kholihona	Colisa fasciata	Belontiidae

27	Karoti	Gudusia spp	
28	Kokila	Xenentodon cancila	Belonidae
29	Katonibai	-	
30	Kayakatta	Gagata spp.	
31	Mirika	Cirrhinus mrigala	Cyprinidae
32	Mola	-	
33	Neriya	Clupisoma garua	Schilbeidae
34	Panimutura	Glossogobius giuris	Gobiidae
35	Prawn	Prawn	
36	Puthi	Puntius spp.	Cyprinidae
37	Rohu	Labeo rohita	Cyprinidae
38	Chengeli	Channa stewarti	
39	Shal	Channa marulius	Channidae
40	Tingra	Mystus spp.	Bagridae
41	Turi	Macrognathus aral	Mastacembalidae

Appendix 3 Fish species identified during the Gut content analysis of Ganges dolphins (Sinha et al. 1993)

Scientific name	**Local name (Assamese)**
Osteobrama cotio	Chanda
Crosochelius latius	Mirica
Mystus cavasius	Tingra
Heteropneustus fossilis	Hingi
Parambasis ranga	Chanda
Seperata seenghala	Aari
Chela laubuca	bhagun
Colisa fasciatus	Kholihona
Glossogobius girrius	Panimutura
Mastacembelus pancalus	bami
Channa punctata	Goroi
Puntius sophore	puthi

Plate no. 1: Ganges dolphin (*Platanista gangetica gangetica*)



Picture a. Ganges dolphin sub- adult

Picture b. An adult male (Rostrum length: shorter than female)

Picture c. An adult female (Rostrum length: longer and slightly curved upwards)

Picture d. Mother- calf association

*Sex identification during continuous survey is not possible.

Plate no. 2: Threats to Ganges dolphin in general

Plate no. 3: Population monitoring surveys in Kulsi river

Seasonal surveys in Kulsi river

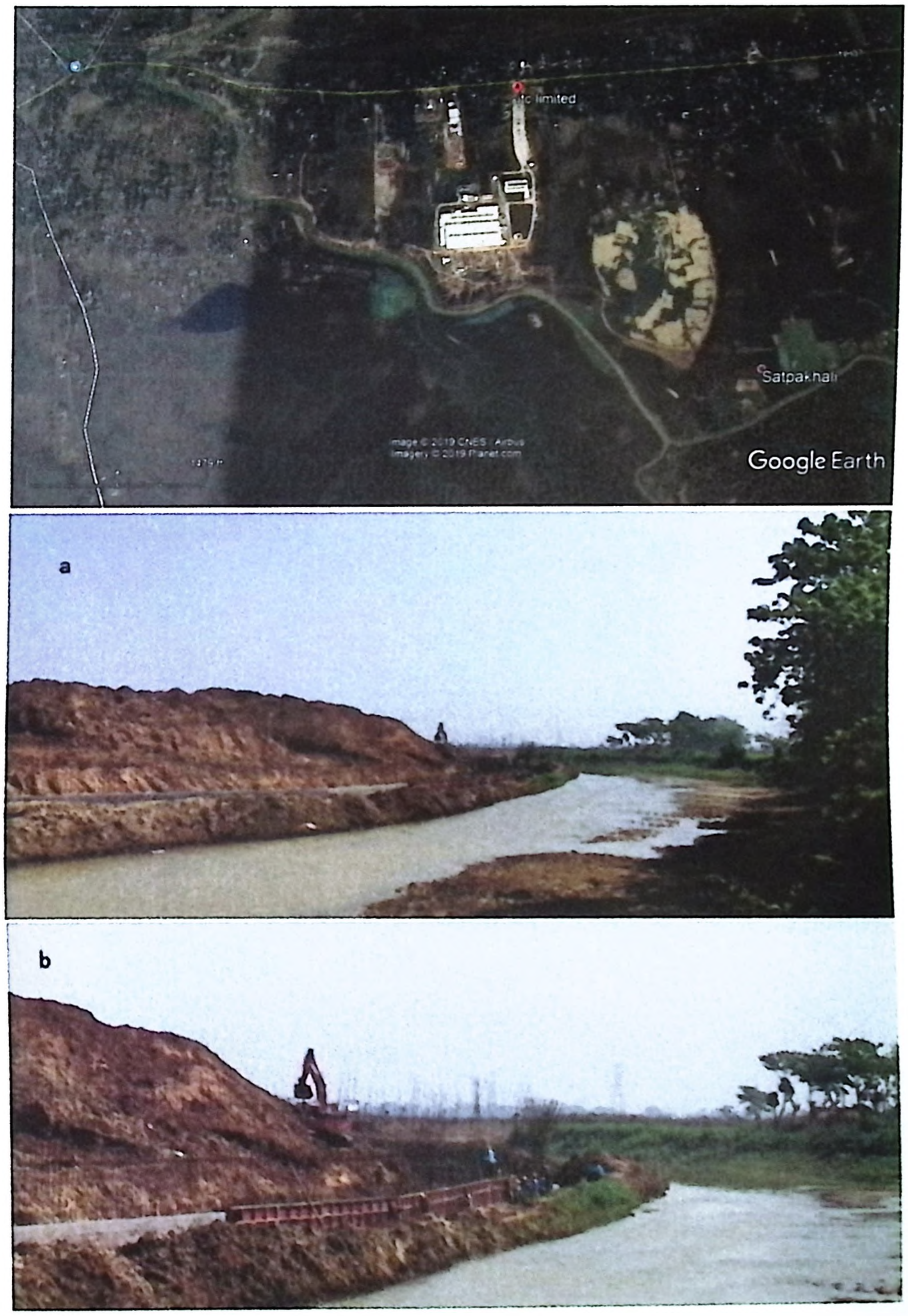
Acoustic Tag (hydrophone) deployment

Kulsi Ganges dolphin monitoring team

Plate no. 4 Anthropogenic activities in Kulsi river

Picture 1: Lift net fishing (barricade the river with bamboos to facilitate the fish movement towards the net)
Picture 2: Mosquito net fishing
Picture 3: Cast net fishing from river bank
Picture 4: Manual sand mining
Picture 5: Sand mining using pumps
Picture 6: Irrigation during dry season

Plate no. 5: Boundary wall constructed on the major Ganges dolphin hot- spot of Kulsi river



Construction of Boundary wall of a ITC company on Kulsi- Batha (Jagaliya) Confluence (Ganges dolphin hot- spot of Kulsi river) in 2019. Dolphins started avoiding the area (seen in most recent surveys conducted in Kulsi during 2019).

Plate no. 6: Fishes of Kulsi River

Plate no. 7: Catch calendar, Market Survey and some of the fishing gears used by fishers

Plate no. 8: Plankton survey in Kulsi River

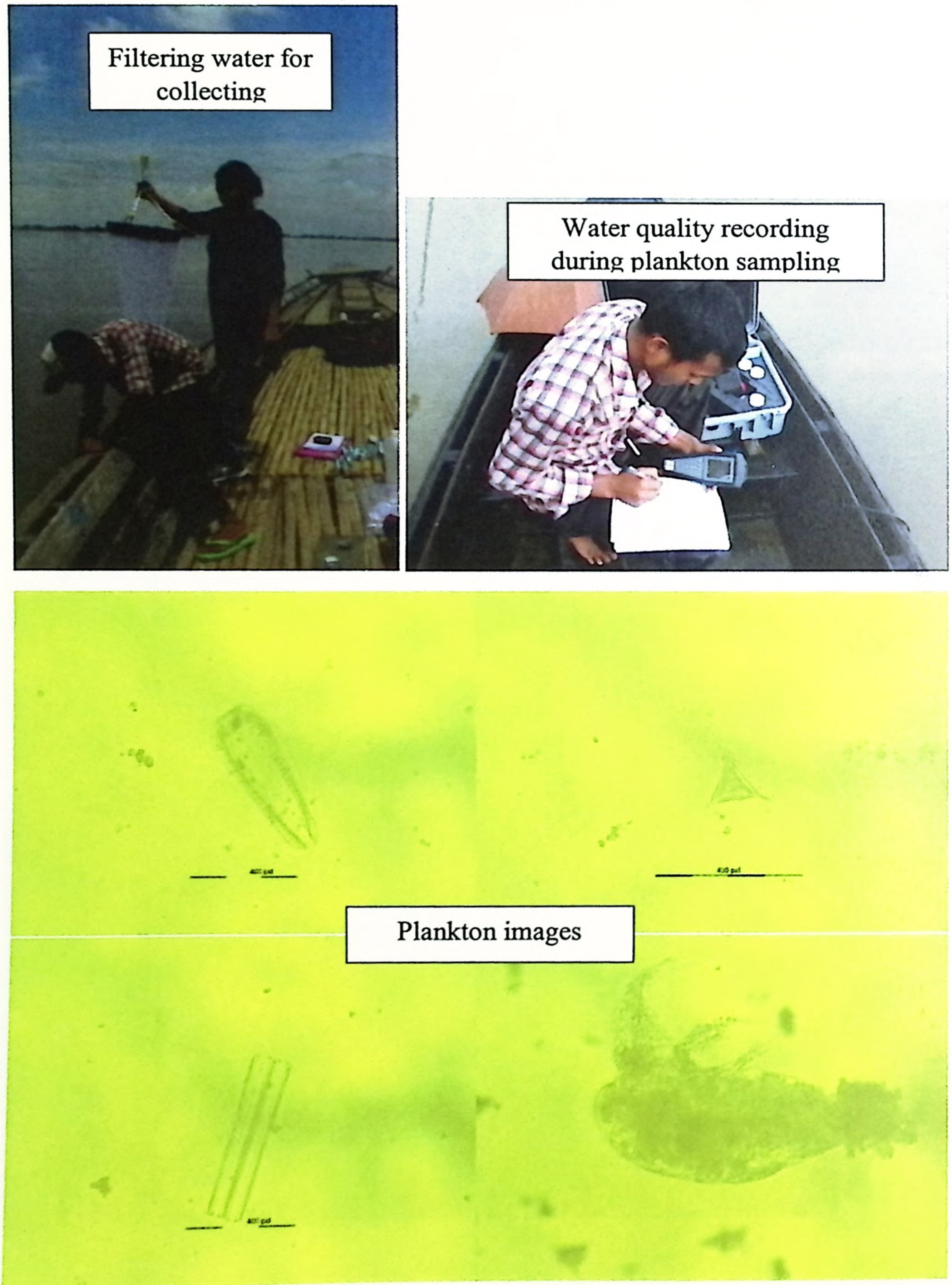


Plate no. 9: Social surveys among fishers, sand miners and cultivators

Fisher's Interview

Sand miner's Interview

Kulsi river bank cultivator's Interview

Plate no. 10: Pinger experiment in Kulsi river