Chapter 07: Discussion

6. DISCUSSION

Diversity of freshwater fin fishes depend on hydrological factors (pH, temperature, TDS, turbidity, salinity, DO, OD, conductivity etc.) of the freshwater habitat and geological conditions (soil texture & type, water retention capacity, rainfall etc.). Various steps and projects have taken worldwide to conserve the biodiversity of freshwater through sustainable management practices. First and foremost task for conserving biodiversity is to assess the real time diversity of the available natural resources, identify the threatened one and thereby protection measures on priority basis (Krebs 1989).

Mapping of aquatic bodies using RS-GIS

Monitoring of the water resources is a prime requirement for water management and accessibility (Tóthmérész 1995). GIS demonstrate spatial distribution of these water bodies mapping (Groombridge and Jenkins 1998). Remote sensing made possible of analyzing and interpreting the landscape and aquatic bodies of inaccessible zones by the remotely sensed data.
GIS helps to recognize the conservation priority areas through analysis of various factors (Hossain, Chowdhury et al. 2009; Gamo, Shinoda et al. 2013) biological richness mapping (Menon and Bawa 1997), distribution (Kasturirangan, Aravamudan et al. 1996).GIS is a key tool, which has actually shifted the dimension of freshwater fishery research.

Distribution of water body and fin fish fauna

The water bodies of area more than 0.40 ha were extracted from Google image for Paschim Medinipur district. In this district about 23150 ha freshwater area recorded (approx. Water bodies 64022 no.). The reported water area may differ from the extracted area due to exclusion of embankment area. West Bengal is traditionally referred to as Nadimatrik i.e., land with many rivers with freshwater areas approximately 332379 ha. Total 76 species under 8 orders and 23 families have been recorded from this district. It shows a remarkable diversity of fin fishes in this region, but most unfortunate thing is the loss of wild fishes from this region due to various anthropogenic activities like habitat modification, urbanization, industrialization, use of pesticides, flow modification, overexploitation etc.

Analysis shows that high fish richness is found in community development blocks namely Daspur-I & II, Ghatal, Pingla and Sabang due to suitable hydrological parameters, soil texture, presence of large number of perennial freshwater bodies. Considerably large aquatic bodes near about 5 ha have high species richness in comparison to smaller water bodies. Mainly culture based fisheries exist in these areas but species evenness is not present because of selective species culture, culture of introduced fish species and negligence in propagating wild fish species. Total 45 fish species recorded belonging to 29 genera, 17 families and 8 orders from Kangsabati river in Paschim Medinipur District(Behera, Kushwaha et al. 2005).

Among the recorded fish species *Cyprinus carpio* is vulnerable and *Hypophthalmichthys molitrix*, *Chitala chitala*, *Oreochromis mossambicus*, *Parambassis lala*, *Ompok bimaculatus*, *Wallago attu, Ompok pabda* are under near threatened category (As per conservation status IUCN Ver. 3.1).

According to CAMP, 1998 of the recorded fish species in Paschim Medinipur district *Anabas cobojius,Anabas testudineus,Barilius vagra, Channa orientalis, Cirrhinus reba, Clarias batrachus, Gibelion catla, Heteropneustes fossilis, Mystus bleekeri, Mystus vittatus, Pethia conchonius, Puntius chola, Systomus sarana* are vulnerable, whereas *Chitala chitala, Eutropiichthys vacha, Ompok bimaculatus, Ompok pabda* are designated endangered and *Hyporhamphus affinis* and *Pangasius pangasius* are given critically endangered status.

On the basis of present conservation status, it is very obvious that some community development blocks should take immediate action in order to save the fish species from being extinct. This extensive survey will help the researcher and fish farmers acquainted with the conservation priority species and the areas.

Family wise fish distribution

23 families under 8 orders have been recorded among which Cyprinidae family shares the highest number (29) followed by Bagridae, Channidae, Ambassidae, Mastacembelidae, Osphronemidae and Siluridae. Single species found in family Aplochelidae, Badidae, Belonidae, Gobidae, Hemiramphidae, Heteropneustidae, Nandidae, Pangasidae, Serrasalmidae and Synbranchidae. Similar kind of result had also been obtained by earlier researcher (Kar, Bhattacharya et al. 2017).

Qualitative - quantitative distribution

Qualitatively among the 76 fish species recorded 48 species are highly commercial, 16 are minor commercial and 13 species are considered as game fish. As per IUCN ver. 3.1 out of these 76 species, 1 is vulnerable and 7 near threatened. Qualitatively and quantitatively Order Cypriniformes and family Cyprinidae is the most common and abundant followed by Perciformes, Siluriformes and Bagridae, Channidae.

The culture of fishes is mostly observed at Ghatal, Pingla, Sabang, Keshiary, Kharagpur community development blocks but many other blocks are dependent on paddy culture. This is due to inadequate knowledge and availability of reservoirs, ponds, tanks etc. Unwise use of pesticides to the agricultural field are damaging and destroying the habitat of fish and their natural diversity. Besides that, overexploitation, invasion of foreign fish species, selective culture made these species difficult to exist.

Conservation

Conservation is a great concern so far the species throughout the world is negatively affected by various anthropogenic and natural activities. The conservationists as well as nature enthusiasts are always engaged in formulating various policies in order to save the species as well as their ecosystem. Fish species can be conserved through *ex-situ, in-situ* method. But the responsibility goes to the local people for properly taking care of fish habitat and by restricting their exploitation in a particular season.

There are already evidences regarding the conservation of valuable as well as important natural resources either ethically or ritually. Conservation priority zones in the CDBs in Paschim Medinipur have been identified.

Low rainfall, less number of perennial aquatic bodies, construction of dam at different location of river limits the fish migration and availability of fishes. It has also been observed that, during rainy season the fish seeds getting intermingled between the river, nearby lowland region and ponds which enhances and brings the richness of the fishes. On the reverse, during drought most of the reservoirs are unsuitable and beyond the permissible hydrobiological parameters that may support the fish diversity and their abundance.

Proper plan for conservation and inhabitant people confidence is necessary to save the fishes from being extinct and also to enhance their population.

Modification of habitat is the prime cause so far the biodiversity loss is concern. Proper and regular survey, monitoring, documentation needed to make an overview related to the diversity of fishes in Paschim Medinipur district and carry a valid information that will identify the conservation priority zones and fish species of high risk. So, these areas are to be managed on urgent basis in order bring sustainability.

There are lots of thing to be carried out in order to save the degradation of fish habitat and of their diversity, which can be gained by the execution of better conservation policies.

RS-GIS technologies have greater impact in order to manage the fish diversity. It helps to visualize the zones of concern by generating maps using its gathered attribute data. Now days, it is mostly accepted and used for various data collection of reservoirs, habitat modifications and other conservation problems. GIS will therefore help definitely natural resources management.

Dam constructions had ruined the natural habitat for most of native finfish species by interfering their movements (Kremen, Razafimahatratra et al. 1999).

Farmers should stop to import the exotic fish seeds and on the contrary to enhance the native fish species by culture and their reproduction. Freshwater resources are needed to be conserved and maintain the stream flow by reducing the barriers.

The goal of this study can never be achieved until and unless the local people, fish farmers and the conservationists work together and motivate other normal people and young generations by various awareness campaign about the importance of threatened fish species and their habitat.

Physico-Chemical Parameters

Water quality of an aquatic system depends on physic0-chemical and biological properties in total which influences the beneficial use of water (Kar, Bhattacharya et al. 2017). There are various water quality variables that affect the aquatic life of pond, lake, river and other open reservoirs. All other things being equal, a pond with good water quality will produce more and healthier fish than a pond with poor water quality (Clavero, Blanco-Garrido et al. 2004). In this present research work parameters like temperature, pH, turbidity, TDS, salinity, conductivity, DO and OD have been considered. The living organisms have their own tolerable aquatic parameter range where they thrive effortlessly. Sharp drop or increase in desirable change adversely affect fish body functions (Boyd 1982). Water parameters will have to be monitored regularly and can never be neglected to maintain the fish food organisms and fish growth and

production(Boyd 1982). The aquatic parameters measured during this present study have been presented inTable No. 07.

Temperature:

This is important aquatic factors that have profound effect on chemical and biological processes (Kiran 2010). The chemical as well as biological reaction rate doubled in every 10°C temperature increase. Warm water fish grow the best at temperature range of 25°C to 32°C (Bhatnagar and Devi 2013). Monthly interval data showed that, temperature remain high during summer from the month May to September and it goes down after Autumn to Winter season from the month October to March of every year.

Water temperature found to be positively correlated with salinity (0.75637), turbidity (0.10409), TDS (0.2522), conductivity (0.16445) but negatively correlated with OD (-0.1621), DO (-0.1185) and species (-0.1967) as given in Table No. 08. Temperature affects pH but minimal in this case and not hampering too much to affect the fish and aquatic organisms.

The rocky lateritic zones like Jhargram and part of Midnapore sub-divisions receive higher temperature and less amount of rainfall. Also the perennial freshwater bodies are less in number in comparison to other parts in Paschim Medinipur district. Water temperature raises durig monsoon because of surface run off and addition of inorganic chemicals and minerals in these temperate zones. Standard temperature supports gonadal maturation and breeding. In this current study the temperature variation showing negative correlation with fish species diversity.

Optical Density

Optical density of water varies with the season and also during morning and day time. This variation is due to the accumulation of suspended solids, plankton population etc. Similar observations also reported by (Raghu Prasad 1956) High OD is observed during monsoon months due to surface runoff water and deposition of clay. High OD is also seen during morning time due to high plankton population in some reservoirs and low as the day progress. Low OD persists in the winter seasons and sunlight penetrates to the deeper water and helps the aquatic organisms to grow healthy have reported that during monsoon period, suspension of bottom deposits into water by wind action, accumulation of turbid water and high phytoplankton populations are responsible for decreasing the water transparency in lentic ecosystems. (Boyd

and Pillai 1985). The poor light penetration during rainy season was due to high density of suspended particles but cannot be attributed to the moderate density of phytoplankton.

Optical density was found to be positively correlated with pH (0.26069) but negatively correlated with water temperature (-0.1621), Sp. Cond. (-0.27923), TDS (-0.0348), turbidity (-0.09864) as per table no. 08. OD depends on the plankton population, total suspended solids and other water impurities. The areas like Kharagpur, Salbani have higher OD value than other areas due to population density and sewage disposal from household and industry. This affects fish population and diversity. The permissible OD value helps fish in migration, food searching, breeding within the microhabitat of aquatic bodies.

pH:

This is another factor affecting fish health. In case of freshwater fishes, ideal pH range is 6.5 - 9.0, but most of the marine animals cannot withstand wide pH range as freshwater animals, thus the optimum pH is usually between 7.5 and 8.5 (Salim and Ahmed 1985). Below pH 6.5 slow growth experiences by some species (Singh and Swarup 1979). The organisms slt balance is affected and reproduction stops at lower pH. Most of the fish species die at pH value 4.0 or less and pH 11 or more (Boyd and Zimmermann 2010). pH value is an indicator of the health of aquatic environment. It affects the biochemical reactions and controls the activities and distribution of flora and fauna (Lloyd 1992).

pH can be determined on the amount of free carbon dioxide and carbonates (Lawson 1995).The photosynthetic activity of the aquatic organisms consumes more oxygen and pH shifted towards alkaline.The measured pH data in Paschim Medinipur ranging from 6.1 to 8.5 which is closer to pH values prescribed by WHO (6.5 to 8.5).

Photosynthesis by phytoplankton increases the pH of the reservoirs by consuming carbon dioxide during day time and at night pH decreases due to respiration by releasing carbon dioxide. Such diurnal variation of pH affects the life of aquatic organisms. The low amount of pH release metals from sediments and rocks and affect fish metabolism. Low pH reduce carbon dioxide available to phytoplankton for photosynthesis. On the contrary, high pH levels produce the toxic ammonia rapidly precipitate the phosphate level of water (Sugunan 1995). Liberation of organic acids during decomposition lower the pH of water bodies (Jhingran 1991) have also observed the similar result.

pH was found to be positively correlated with transparency (0.26069), DO (0.07653) and fish species(0.07109) but negatively correlated with Sp. Cond. (-0.1651), TDS (-0.2337), turbidity (-0.0681) (Table no 08). A pH range of 7.2 to 8.5 is suitable for the plankton growth (Boyd 1990). Slight alkalinity of the aquatic body favours fish production (Bagde and Verma 1985).

Thus, the reservoirs with favourable pH range of the community development blocks have good number of fish diversity than the remaining blocks. The permissible range of pH acts as growth promoting factor, metabolic regulation and other developmental stages. Such phenomenon directly and indirectly supports fish diversity of this region.

Dissolved Oxygen (DO)

Dissolve oxygen is an important factor that affect the health of the aquatic organisms. Oxygen can enter into the aquatic system through two ways firstly by diffusion (mechanical aeration) and secondly due to photosynthesis (algae & plants).But excessive plants and algal populations results in decrease of DO. It is also decreased by the decomposition of the organic matters and respiration by the aquatic organisms. Low levels of dissolved oxygen results in fish death. There are some fishes (*Clarius batrachus, Amphipnous cuchia*, *Channa striatus* etc) those can withstand and adapted to the less DO of aquatic bodies. DO is affected by other hydrological parameters like temperature and salinity. DO is inversely proportional to the temperature and salinity as shown in table 8. It is really difficult to set a standard of DO as it is affected by various other hydrobiological factors. Still 5mg/L has been accepted by many workers.The community development blocks(Ghatal, Sabang, part of Garhbeta, Debra, Pingla, Daspur I & II) have DO value of about 4-5 ppm and exhibits higher fish diversity than the rest of the CDBs in Paschim Medinipur. This is due to awareness among the fishermen, controlled growth of plant species, non deposition of organic wastes, limited use of feeds and fertilizer and significant fish population. During survey, it has been found that, most of the large reservoirs have excessive algal growth which results in decreasing dissolved oxygen and the inhabitant fishes and aquatic organisms face hypoxia.

During Summer DO values of the freshwater bodies recorded low and maximum observed during Winter which has also been observed by (Mishra 2003) .The maximum DO in winter is

because of low atmospheric temperature and minimum DO in summer because of organisms high metabolic rate (Jhingran 1991).

DO was found to be positively correlated with pH (0.07653), OD (0.1037) but negatively correlated with water temperature (-0.1185), salinity (-0.2159), Turbidity (-0.2773), TDS (-0.0003), Cond. (-0.1378) as shown in table 08. The dissolve oxygen is showing positive correlation with the finfish diversity. Metabolic activity and physiological processes work well in this permissible range of DO.

The specific conductivity

Table 08 showed that, specific conductivity was positively correlated with water temperature (0.16445), salinity (0.05666), Turbidity (0.03296), TDS (0.78015) but negatively correlated with OD (-0.27923), DO (-0.1378) and pH (-0.1651). The conductivity is negatively correlated with the fish species (-0.0174) as the high conductivity affects fish movement and metabolism mainly during monsoon months.

TDS:

Freshwater TDS includes soluble salts. Maximum TDS had been observed in summer seasons because of evaporation and increased concentration whereas lowest amount found in rainy seasons due to dilution by the runoff water. Total dissolved solid is positively correlated with water temperature (0.2522), Salinity (0.08539), Turbidity (0.13773), Conductivity (0.78015) but negatively correlated with pH (-0.2337) and OD (-0.0348) and fish species (Table 08). The TDS slower the growth of fish and also affects fish diversity.

Salinity:

Salinity means the chloride content of water. The aquatic bodies of the study area has vary low and negligible amount of salinity. It has no effect on fish abundance or diversity at all. Still little amount has been found during summer month at the lateritic zones and rocky bottom of the aquatic bodies due to leaching and weathering. Salinity was found to be positively correlated with water temperature (0.75637), turbidity (0.13502), TDS (0.08539), Cond. (0.05666), but negatively correlated to DO (-0.2159) and fish species (-0.2036) as per table 08. Higher salinity

reduces oxygen availability resulting hypoxia to the aquatic organisms. It is therefore negatively related to the fish diversity.

Turbidity:

Turbidity of the water results from surface water runoff and addition of clay material to the nearby reservoirs. It may also arise due to feeding of the benthic fish species like catfish and other organisms. Turbidity of more than 20,000 ppm affects fish behavior. But normally no natural water body exceeds 2000 ppm of turbidity. Turbidity restricts penetration of light and affects photosynthetic activity. It also destroys beneficial bacteria of bottom dwelling organisms. Clay turbidity is reduced by adding hay and gypsum. Turbidity affects fish community by reducing the plankton populations. Turbidity raises water temperature that slower fish growth by affecting their metabolic activity.

Turbidity was found to be positively correlated with water temperature (0.10409), salinity (0.13502), TDS (0.13773), Cond. (0.03296) but negatively correlated to pH (-0.0681), DO (-0.2773) and fish species (-0.3933).Turbidity causes reduction of light penetration, limits photosynthesis and primary productivity. This in turn reduces the feed for finfish and other organisms residing in water.

The plots generated (Fig 09) based on relation among the aquatic parameters shows that water temperature is positively and highly correlated with the TDS, turbidity, conductivity and salinity. The DO and fin fish species are also positively correlated.

Fish and Fisheries:

Present investigation recorded 76 fish species from the entire Paschim Medinipur district. Some researchers reported 46 fish species from river Kangsabati in Paschim Medinipur (Sharma, Dixit et al. 2008). Some other reports also satisfy the present findings. Existing hydrological parameters, rainfall, soil texture supports the fish species diversity and richness of this district. All biological and physicochemical factors are responsible for the richness and diversity of the freshwater finfishes. So all are important and interrelated (Tara, Kour et al. 2011; Kar, Bhattacharya et al. 2017). So it is difficult to obtain the optimum diversity at any point of time. Family Cyprinidae is having the highest (29) fish species among the 76 fish species recorded in total as shown in table 6. The highest freshwater finfish diversity reported in order

Cypriniformes and Siluriformes (Welcomme and Bartley 1998). Most of the fishes are commercially important as food and as aquarium.

Fish biodiversity gradually decreasing due to various factors mainly anthropogenic. Some of the factors recorded during study are urbanization, domestic and industrial pollution, use of pesticides in agricultural field, non judicious exploitation of fish, catching of small size fish, no restriction in mesh size used, catching of fish during breeding season, proper knowledge regarding the threatened fish species. Restrictions in mesh size of the various nets, breeding season catch, harvesting in the protected zones will have to be strictly followed in order to enhance the fish availability and diversity and in bringing sustainable development. Permissible mesh size for gill nets is 30mm and above. Major carps of 15cm and above is permitted to harvest in rivers, ponds and reservoirs (Welcomme and Bartley 1998).

Fish diversity can be maintained and enhanced through proper policy formulation by the fisheries departments of Govt. of West Bengal and its implementation and monitoring regularly with the local people and through awareness campaign among the local people and the new generations.

Diversity indices:

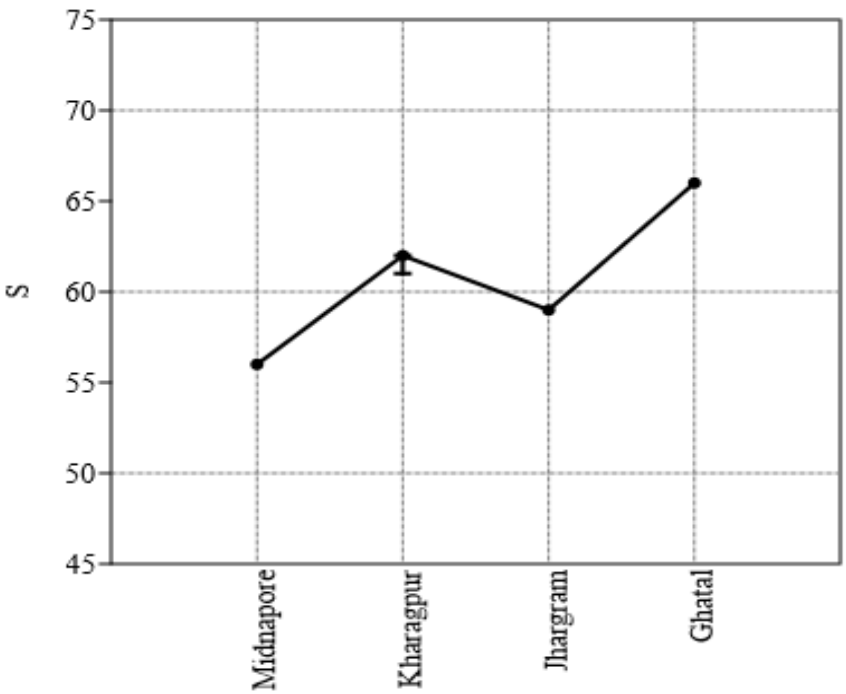

Fig 26: Species diversity index Sub-divisions wise at Paschim Medinipur

Figure 26 represents the number of taxa found in the four sub-divisions in Paschim Medinipur. Highest number of fish taxa found in Ghatal Sub-Division is 66 followed by Kharagpur, Jhargram and Midnapore with 62, 59 and 56 respectively.

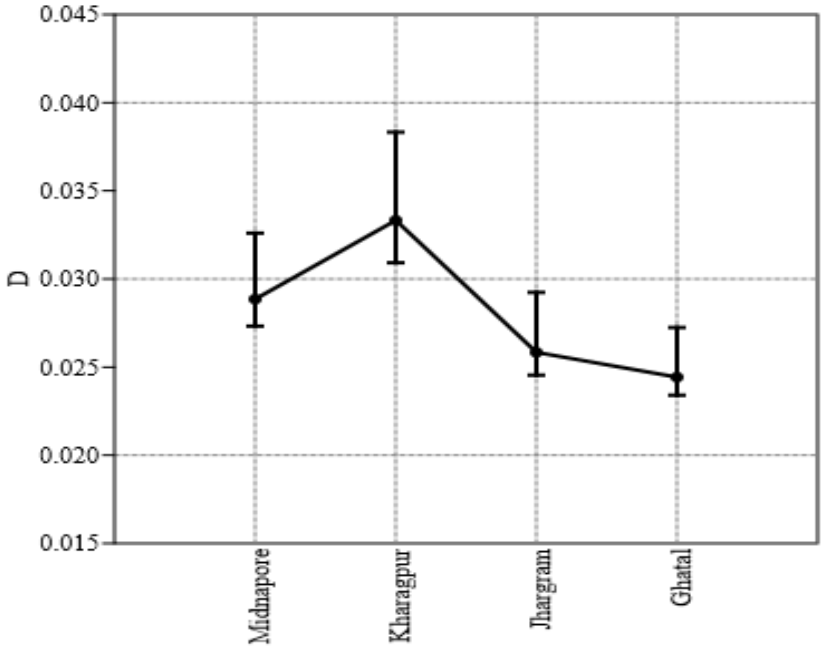

Fig 27: Dominance diversity index Sub-divisions wise at Paschim Medinipur

Figure 27 represents the dominance index that reflects abundance of species common to the studied areas. From this diagram it can be said that Kharagpur Sub-Division is having the highest dominance value (0.033) followed by Midnapore (0.028), Jhargram (0.025) and Ghatal (0.024). Conversely it can be said that, Kharagpur Sub-division is having the lowest fish species diversity and Ghatal is having the highest fish diversity.

A widely used dominance index is Simpson's diversity index. It considers simultaneously richness and evenness.

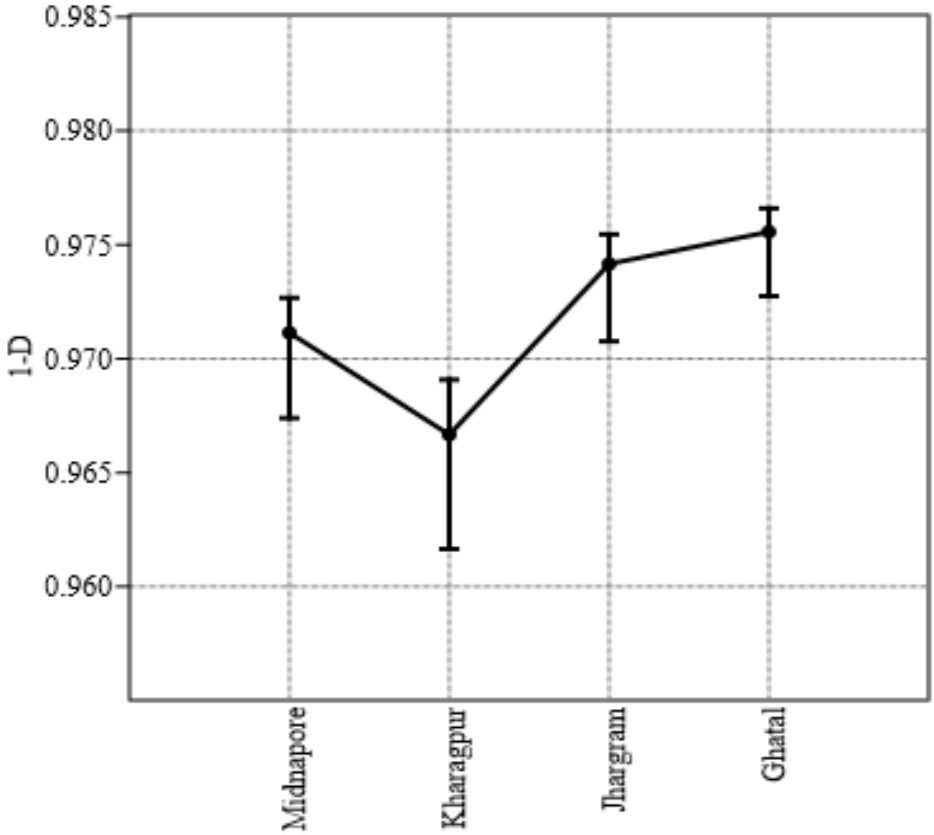

Fig 28: Simpson 1-D Index Sub-divisions wise at Paschim Medinipur

Figure 28 represents Simpson's diversity index in the four sub divisions in Paschim Medinipur. This showed the highest fish species diversity in Ghatal Sub-division (0.975) followed by Jhargram (0.974), Midnapore (0.971) and Kharagpur (0.966).

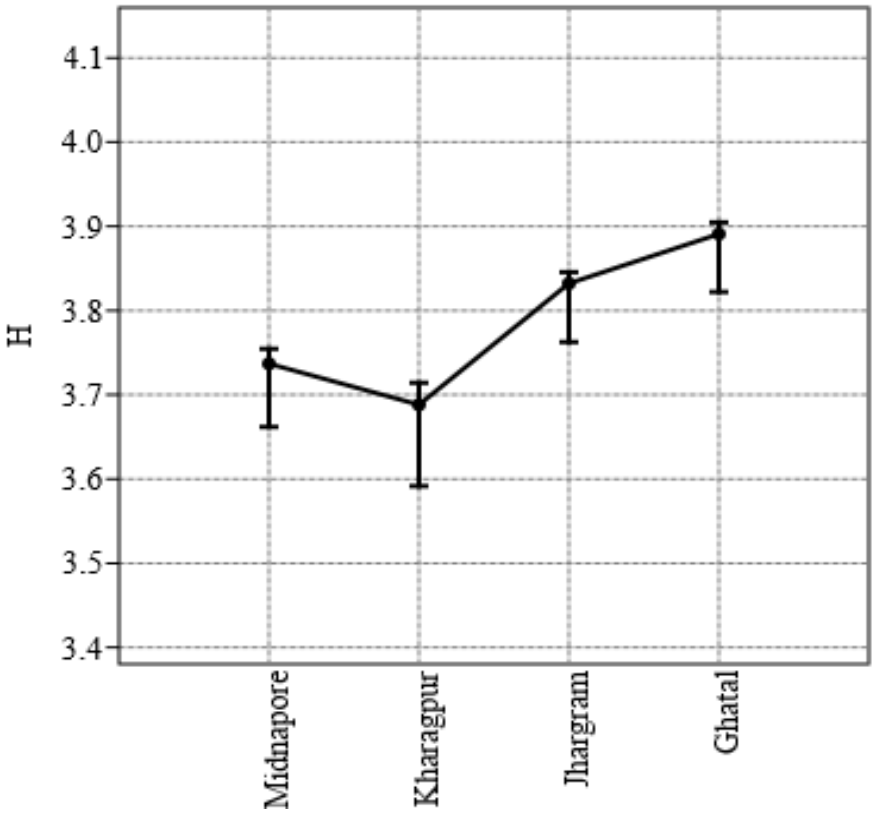

Fig 29: Shannon H Index Sub-Divisions wise at Paschim Medinipur

Figure 29 represents Shannon diversity index. It showed highest diversity in Ghatal (3.891) followed by Jhargram (3.832), Midnapore (3.737) and Kharagpur (3.688).

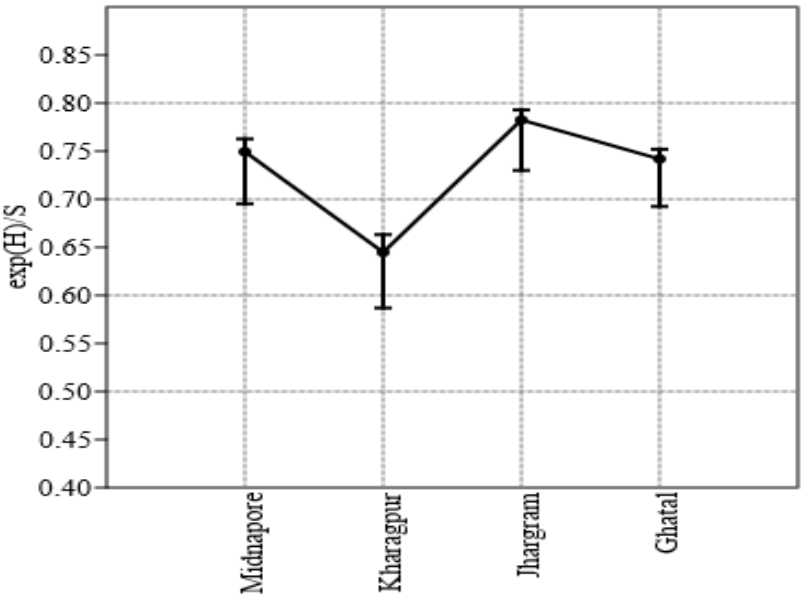

Fig 30: Evenness Index Sub-Divisions wise at Paschim Medinipur

Figure 30 represents species evenness. It tells us how the community is equally distributed numerically. This diagram exhibits lowest evenness (0.644) in Kharagpur Sub-division and highest evenness (0.782) in Jhargram. So the species are equally distributed in case of Jhargram sub division.

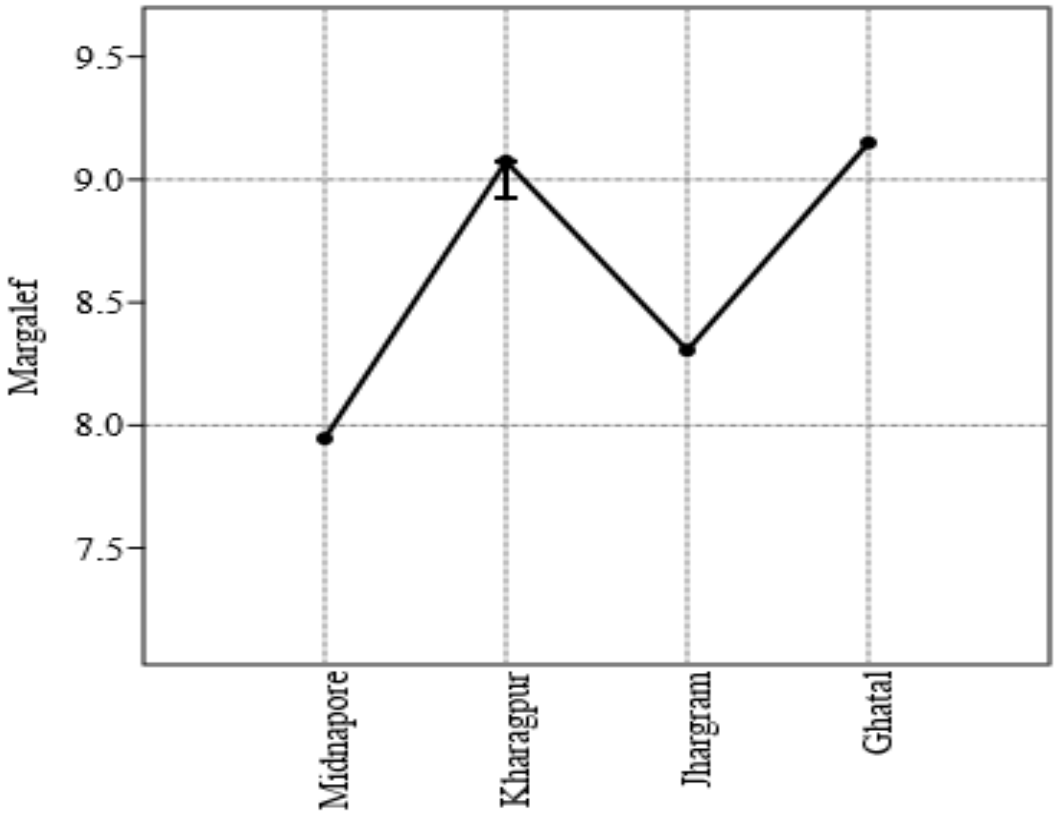

Fig 31: Margalef Index Sub-Divisions wise at Paschim Medinipur

Figure 31 represents Margalef's richness index. The diagram showing that Ghatal Sub-division (9.15) has highest species richness followed by Kharagpur (9.074), Jhargram (8.305) and Midnapore (7.946).

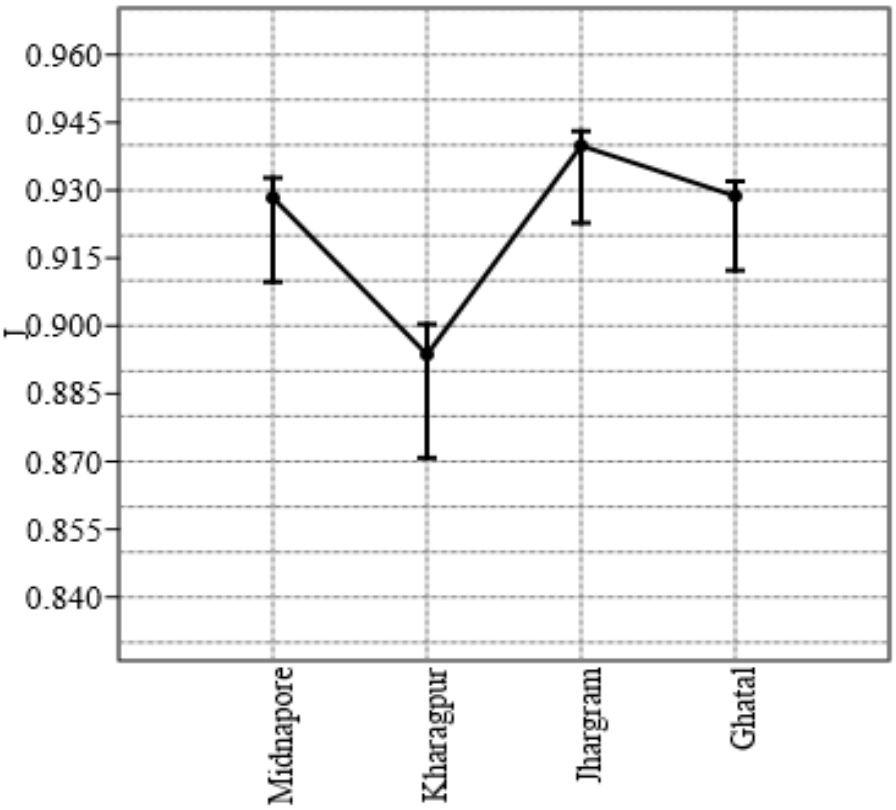

Fig 32: Equitability Index Sub-Divisions wise at Paschim Medinipur

Figure 32 represents Shannon's equitability index. So far the equitability index is concern, Kharagpur is having high evenness (0.8937) followed by Ghatal (0.9287), Midnapore (0.9283) and Jhargram (0.9399).

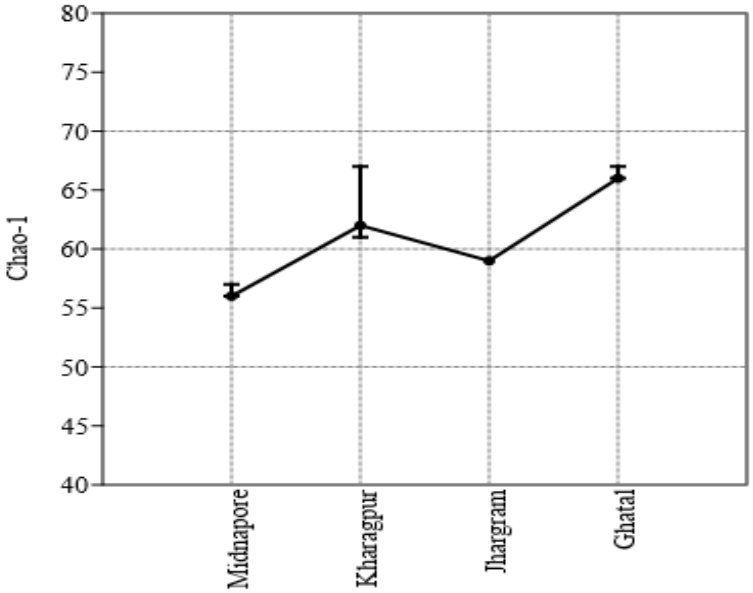

Fig 33: Chao -1 Index Sub-Divisions wise at Paschim Medinipur

Figure 33 represents chao-1 diversity index that determines total species richness. The diagram showed the highest Chao-1 value (66) at Ghatal Sub division among the four sub-divisions of Paschim Medinipur district. This highest value in Ghatal signifies highest species richness. The number of aquatic bodies, alluvial soil, inundated reservoirs or lowland enriches the planktonic or producers in the aquatic ecosystem and enhances the fish population and their diversity. But the remaining Sub-divisions are with low chao-1 value as well as low species richness due to presence of seasonal water bodies and other factors like low rainfall, lateritic soil etc.

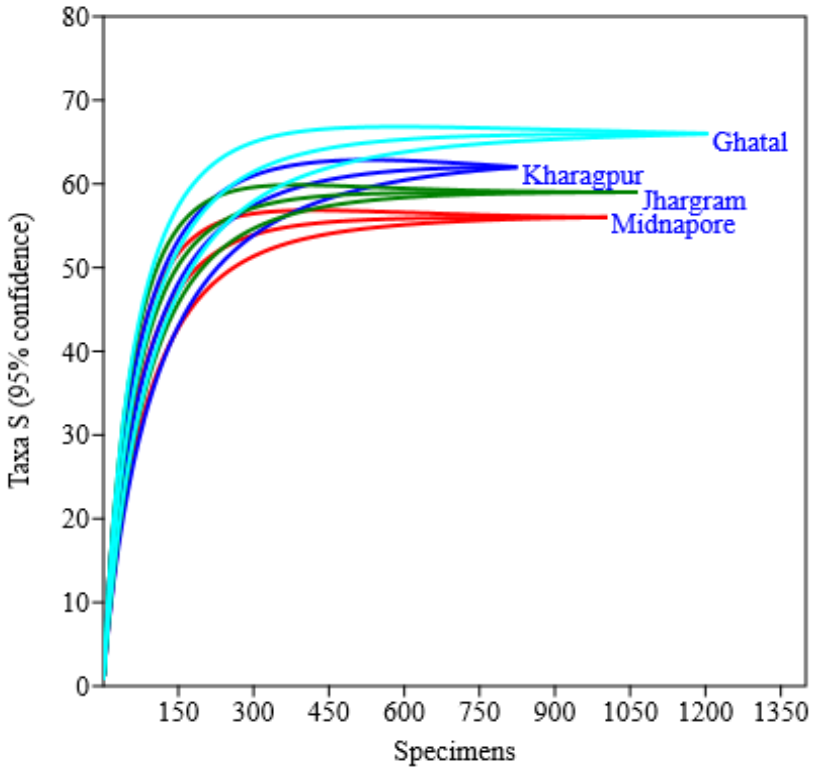

Fig 34: Individual rarefaction model Sub-Divisions wise at Paschim Medinipur

This model allows more than one abundance data for number of taxa and estimates the probable numbers of taxa to find in smaller individual size. Not only that, this rarefaction model also shows the similarity in taxa which are found in this work (at 95% confidence limit) (Fig 34). This also shows that around 45-49 species are common to the four sub divisions. The plateau determines the variety among the said zones.

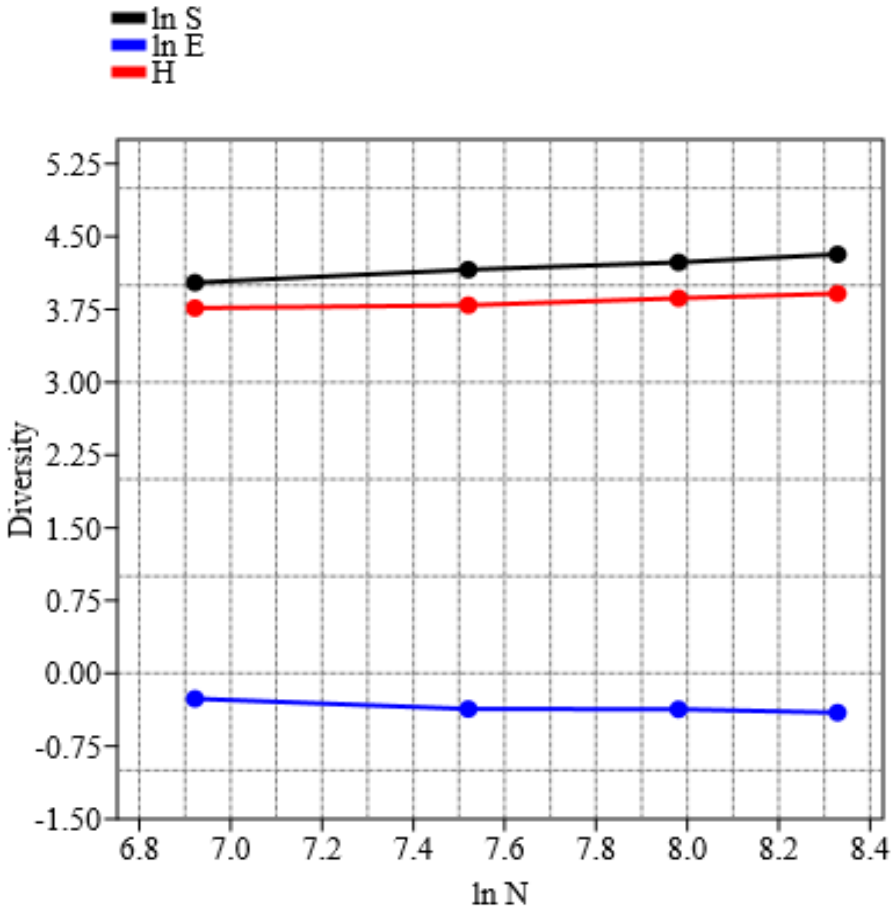

Fig 35: SHE analysis model Sub-Divisions wise at Paschim Medinipur

SHE analysis considers the species number and the equitability. It is useful for ecotone region. The log normal plot is showing that S and H value is gradually increasing but the E value is decreasing (Fig 35). The diagram shows that, the first site (from left) has less evenness than to the remaining three sites. The overall structure of the community can be deduced by this model. The favourable environment supports the fish diversity and evenness in the studied sites.

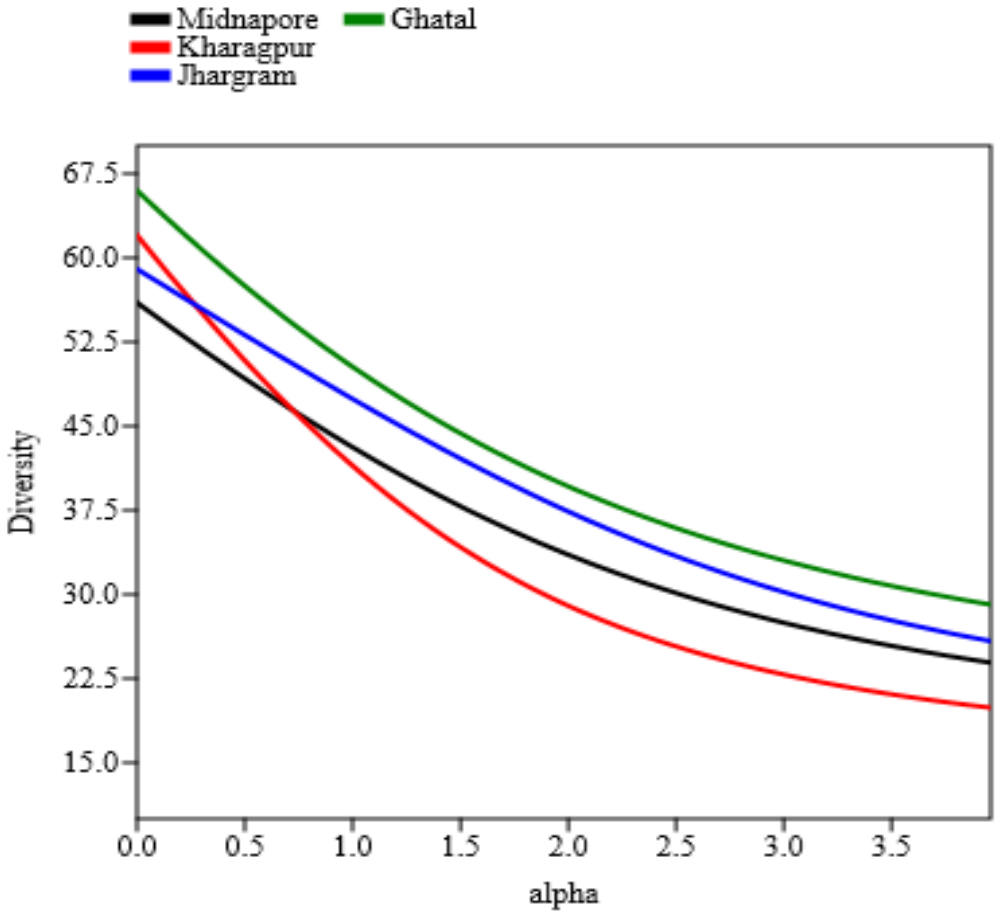

Fig 36: Alpha Diversity profiles Sub-Divisions wise at Paschim Medinipur

According to the data analysis diversity profiles shows that Ghatal, Midnapore and Jhargram Sub-division have the significant profiles but due to the anthropogenic activity, urbanization and other regulatory factors shows insignificant diversity profile (Fig 36) (because data on Kharagpur overlapped with other data).

Location of water bodies in Paschim Medinipur :

Survey report reveals that maximum number of water bodies are present in the community development blocks Daspur-I & II, Debra, Ghatal, Pingla, Sabang, moderate number found in Dantan I & II, Mohanpur, Chandrakona I & II, Keshiary, Kharagpur and less number is found in Binpur-I & II, Jhargram,Gopiballavpur-I & II blocks (Fig 10).This is due to the shifting of culture practices. Paddy farmers are getting shifted to the fish farming due to high economic

benefit. The rivers and its tributaries, ponds and other reservoirs are also maximum in those area and are perennial that is why they get benefitted and can harvest thrice in a year. But the blocks like Jhargram,Salbani, Midnapur Sadar Kharagpur are having less no. of aquatic bodies and are seasonal.That is why the fish diversity is also less in these community development blocks.

Block wise distribution of turbidity

This map shows the highest turbidity is present at Jhargram, Gopiballavpur,Sankrail, and part of Garhbeta due to siltation and having red lateritic soil (Fig 20). This stand maximum during monsoon season. But the blocks like Debra, Pingla, Sabang have less turbidity which supports fish growth and diversity.

Block wise fish species distribution

This map shows the how the fish species are distributed block wise. 57-66 number fin fish species are recorded from Daspur-I & II, Ghatal,Pingla and Sabang, 51-57 number fish species are recorded in blocks Chandrakona I & II, Keshpur, Debra, Kharagpur, Mohanpur, Narayangarh, Dantan-I, Keshiary, Gopiballavpur-I & II and Binpur-I, 46-51 number of fish species are found in blocks Jhargram, Jamboni, Sankrail, Midnapore, Kharagpur-I, Salbani, Nayagram, Garhbeta-I, II & III(Fig 07). The highest diversity recorded areas are having large amount of water bodies, rivers and tributaries, the reservoirs with high retention power and permissible range of hydrological parameters that enhance the fish diversity. The remaining blocks are with less number of aquatic bodies, mostly seasonal with less favorable hydrological parameters are the reasons behind the low diversity. The culture practice is also responsible to decrease the fish diversity. Fish farmers are welcoming the exotic species and are restricted to the few commercial one neglecting other indigenous fish species. Habitat modification, conversion of water bodies into concrete structures damaging the natural ecosystem of fish and there by losing diversity. Industrial blocks receiving water pollution have less fish diversity.

Block wise distribution of DO

This map shows that the community development blocks having the dissolve oxygen in good qualities (around 4-5 ppm) are Ghatal, Sabang, part of Garhbeta, Debra, Pingla, Daspur I & II, followed by Jhargram, Narayangarh, Keshiary, Keshpur having DO around 3 ppm and less amount (2 ppm) recorded from the blocks like Binpur-II, Midnapur sadar and Kharagpur-II. The

dissolve oxygen gradient (high to low) is seen from eastern part of this district to western part (Fig 23).The high temperature, low rainfall is the probable cause of less DO in those areas.

Block wise distribution of fish by order

Generated map displays that, 7-8 fish orders are found in blocks Chandrakona I & II, Pingla, Sabang, 6-7 orders recorded from Dantan I & II, Keshiary, Narayangarh, Mohanpur, Dapur, Ghatal, Keshpur, Garhbeta, 5-6 numbers of fish orders are recorded from Jhargram, Salboni, Sankrail, Nayagram, Midnapur and Kharagpur (Fig 05).

Block wise distribution of temperature

Temperature map on different community development blocks shows that, average temperature is high during summer season at Keshpur, Binpur I & II, Jamboni and Garhbeta due to presence of rocky lateritic soil. Such high temperature increases metabolic rate of fishes and slower the growth. High temperature decreases the DO, increases the salinity by leaching minerals, increasing conductivity and turbidity which collectively alters the permissible range of hydrological parameters of aquatic bodies. This is why fish diversity is less in these community development blocks. Less temperature recorded in blocks Daspur I & II, Ghatal, Pingla, Sabang and supports fish growth and diversity (Fig 17).

Block wise distribution of TDS

TDS map shows that, Jhargram, Keshiary, Dantan, Nayagram, Garhbeta have high average TDS due to salt deposition and algal growth which affects the fish biology. Low amount of TDS is observed in Ghatal, sabang, Dantan II, SAnkrail, Kharagpur, Binpur-II (Fig 19).

Block wise distribution of rainfall

Average rainfall data received from Indian Meteorological Department also showed that the community development blocks receiving high rainfall are Chandrakona I & II, Daspur, Ghatal, Mohanpur, Keshpur and less in Binpur, Khargapur, Jhargram which are drought prone too (Fig 13).

Block wise distribution of river

The rivers and their tributaries flows through the blocks like Ghatal, Daspur, Binpur-I , Gopiballavpur, Nayagram and enrich the fish diversity of the nearby reservoirs due to mixing of fish seeds during flood. The other development blocks have less diversity and or fish dominancy due to embankment and no connection with the rivers (Fig 12).

Block wise distribution of pH

pH map of the CDBs in Paschim Medinipur district shows that, Binpur-II, Keshpur, Dantan, Garhbeta have slightly alkaline pH values around 9 which is due to destructive human activities such as bathing, washing utensils etc. and algal bloom. The blocks Salbani, Jhargram, Sankrail, Garhbeta are having pH near neutral or slightly acidic due to leaching of rock and acid sulfate soils (Fig 16).

Block wise distribution of conductivity

Conductivity map shows that, Jhargram, Keshpur, Dantan, Kharagpur, Nayagram having conductivity 0.3 due to presence of salts in that soils though most of the survey areas recorded very minute amount of salts and minerals (Fig 21).