CHAPTER 7: SUMMERY AND RECOMMENDATION

In Purulia and Bankura District the Fresh water areas are available in the form of rivers, canal, ponds and reservoirs etc. these fresh water areas are very important for fish production. Both the district has huge inland fishery resources in the form of pond, tank, and big water bodies mainly in the form of bandhs and reservoir. The district Purulia occupies maximum area under semiderilict water bodies. Most of these water bodies are good source of Aquaculture. The district Purulia having total 36 no's reservoir covering 5557.74 ha water area and spread over 19 blocks of the district. Pisciculture is an important factor of economic development of Bankura. The fish farmer of the district cultured wide variety of fish species in polyculture system.There are fourteen reservoirs in Bankura district. Among them Kangsabati is the largest reservoir in the state of West Bengal situated in Bankura district at KhatraRanibandh Block.

The present study entitled "*Studies on Status and Future Management Strategy of Fish Farming in the Rainfed Districts like Purulia and Bankura*" was under taken to assess the present status of the management aspects of aquaculture in primarily rain-fed districts of Bankura and Purulia, to evaluate the physico-chemical (Temperature, pH, dissolved oxygen, free carbon di-oxide, alkalinity, hardness, ortho-phosphate, NH_3-N, NO_3-N, organic-C) and biological conditions (plankton density and composition, macrophyte composition) of fish culture ponds towards formulating area specific management packages with respect to nutrition, and, water and soil quality parameters, to assess the present status of fisheries management of the reservoirs of these two districts and to evaluate the physico-chemical (pH, dissolved oxygen, free carbon di-oxide, alkalinity, hardness, ortho-phosphate, NH_3-N, NO_3-N,) and biological conditions (plankton density and composition, macrophyte composition) of the selective reservoirs towards identifying the limiting factors of production so as to recommend specific measures to augment production from the reservoirs.

In case of pond and reservoir for physiochemical parameter and biological parameter like plankton analysis sample were collected at regular interval (seasonally) for a period of two year February 2014 to January 2016. Identification of fish sample during the study period was made with the help of local fisherman and also from local fish market. Analysis of water and soil quality parameter and identification of the plankton and fishes were done by adopting standard method and keys. Analysis of Variance ANOVA was applied using standard statistical packages software. The variation was considered to be significant at two levels; $P < 0.05$ and $P < 0.01$. It was non significant if $P > 0.05$. The Correlation between the physic chemical parameter,

phytoplankton and zooplankton were analyzed. The species diversity indices like Shannon – Weiner diversity index was computed.

In case of Purulia District, ANOVA results shows that there is a significant variation between season for temperature, transparency, pH, D.O, hardness, NO_2 N and orthophosphate and non significant for alkalinity and NO_3N.

In case of Bankura DistrictANOVA results shows that there is a significant variation between season for temperature, transparency, pH, D.O, alkalinity, hardness, and NO_2 N and non significant for NO_3Nand orthophosphate.

In Purulia District the mean water temperature was high during Pre Monsoon Season i.e 28.06 ^{0}C and lowest during winter season i.e 17.19 ^{0}C. The pH of the pond water was high during Pre Monsoon month i.e 7.45 and lowest during winter month i.e 6.93. During the study period the transparency value was higher during post monsoon months i.e 34.51 cm and lower during monsoon season 22.95 cm. In the present investigation minimum D.O value was recorded in Premonsoon season i.e 3.8 mg/lt and maximum in Monsoon season i.e 4.5 mg/lt. Alkalinity value was highest during Pre Monsoon season i.e 65.36 mg/lt. and minimum value was observed during Monsoon month i.e 59.54 mg/lt. Higher value of hardness was observed during summer season i.e 103.47 mg /lt and lower value was observed during Post monsoon season i.e86.41 mg/lt. regarding nutrient parameter like and NO_2 N, NO_3N and Orthophosphate value was maximum in Monsoon season and lowest in winter season except NO_3N which is lower in Pre Monsoon season.

In Bankura District the mean water temperature was high during Pre Monsoon Season i.e 25.85 ^{0}C and lowest during winter season i.e 20.21 ^{0}C. The pH of the pond water was high during Pre Monsoon month i.e 7.73 and lowest during Monsoon month i.e 7.08. During the study period the transparency value was higher during Monsoon month's i.e 30.75 cm and lower during winter season 23.57 cm. In the present investigation minimum D.O value was recorded in Premonsoon season i.e 4.02 mg/lt and maximum in Monsoon season i.e 4.51 mg/lt. Alkalinity value was highest during Pre Monsoon season i.e 102.92 mg/lt. and minimum value was observed during Winter month i.e 77.42 mg/lt. Higher value of hardness was observed during summer season i.e 138.33 mg /lt and lower value was observed during monsoon season i.e 103.75 mg/lt. regarding

nutrient parameter maximum Nitrate nitrogen (NO_3N) concentration was found in Monsoon Season (0.02 mg/lt) and minimum value was found in winter season (0.01 mg/lt). Whilethe highest nitrite nitrogen concentration was found in Pre Monsoon Season (0.0045 mg/lt) and lowest concentration was found in Post monsoon Season (0.002 mg/lt). And another parameter like orthophosphate, the highest value of available phosphate was found during the Monsoon season (0.0022 mg/lt) and lowest value was found during winter season (0.0015 mg/lt).

The nutrient status of water and soil play the most important role in governing the production of plankton organisms or primary production in fish ponds. In the present investigation, in case of Purulia district, soil pH range varied from 6.15 to 6.31.In the present investigation the bottom soil pH was high in Winter Season and low in Monsoon Season.The highest value of organic carbon was observed during pre monsoon season (0.85 mg/100gm of soil) and lowest value (0.61 mg/100 gm of soil) was observed in post monsoon season.In the present study thelowest value ofavailable phosphoruswas observed during monsoon season (0.512 mg/100gm) and highest value (0.683 mg/100 gm) was observed during winter season.In the present investigation the available nitrogen content varied from 43.25 mg/100 gm of soil to 39.58 mg/100 gm of soil.

In the present investigation, in case .of Bankura district,the soil pH range varied from 6.12 to 6.83. The soil pH range was high in winter season and lowest in Pre monsoon season.In the present investigation thehighest value of organic carbon was observed during pre monsoon season (0.85 mg/100gm) and lowest value was observed in post monsoon season (0.61 mg/100 gm).In the present investigation the available P_2O_5 content was high during pre monsoon season (0.56 mg/100gm of soil) and low during post monsoon period (0.43 mg/100 gm of soil).The available nitrogen content was high (42.32 mg/100 gm) during pre monsoon period and low (38.33 mg/100 gm) during winter period.

Phytoplankton community serves as a bio-indicator for assessing the health of an aquatic ecosystem (Tiwari and Chauhan, 2006; Hoch *et al.*, 2008). Anitha Devi *et al.,* 2013 also described that phytoplankton are the primary producers of aquatic ecology and controls the dynamic of productivity.

During the study period in case of Purulia District, four groups of Phytoplankton consisting of 23 genera in order Cyanophyceae (6 genera), Chlorophyceae (8 genera), Bacillariophyceae (7

genera) and Euglenophyceae (2 genera).The phytoplankton identified were: *Anabaena sp*, *Lyngbyasp*, *Microcystissp*, *Oscillatoriasp*, *Nostocsp*, *Phormidiumsp* (Cyanophyceae); *Ankistrodesmussp*, *Chlorella sp*,*Closteriumsp*, *Mougeotiasp*, *Scenedesmussp*, *Spirogyra sp*,*Ulothixsp*, *Zygnemasp,* (Chlorophyceae),*Cyclotellasp*, *Diatomasp*, *Fragillariasp*, *Naviculasp*, *Nitzschiasp*, *Pinnulariasp*, *Synedrasp* (Bacillariophyceae), *Euglena sp*, *Phacussp*(Euglenophyceae). The maximum occurrence of group cyanophyceae was observed during Pre Monsoon month (38 no ind/lt) and minimum in Monsoon season (18 ind /lt). The maximum occurrence of Class Bacillariophyceae was observed during the Pre Monsoon season i.e 54 ind/lt and minimum during Monsoon season i.e 24 ind/lt. During the study period Chlorophyceae was most dominant in Pre Monsoon i.e Summer Months (47 ind /lt) and minimum in Monsoon Season (21 ind /lt). During the study period Euglenophyceae were most dominated in Pre Monsoon Season and minimum in Monsoon Season.

In the present study in case of Purulia District, the total no of species recorded were 386 org/lt, out of which Cyanophyceae are 104 org/lt (26.9 %), Cholorophyceae are 125 org/lt (32.4 %), Bacillariophyceae are 144 org/lt (37.3 %) and Euglenophyceae are 13 org/lt (3.4 %).

In ecological point of view, zooplankton influences all the functional aspects of an aquatic ecosystem such as food chains, food webs, energy flow and cycling of matter (Sinha and Islam, 2007). Zooplanktons are the smallest organisms present in almost all the water body. Zooplankton acts as main sources of food for many fishes and plays an important role in early detection and monitoring the pollution of water.

The zooplankton study in the selected ponds of Purulia District consists of five major groups like Rotifera (6 genera), Copepoda (10 genera), Protozoea (3 genera), Ostracoda (1 genera) and Cladocera (6 genera). The commonly occurring zooplankton species are*Brachionussp, Asplanchnasp, Keratellasp, Synchaetasp, Euchlanissp, Filiniasp, Nauplii, Diaptomussp, Pseudodiaptomussp, Cyclops, Mesocyclopssp, Paracyclopssp, Microcyclopssp, Eucyclops, Acanthocyclopssp, Heliodiaptomus, Amoeba, Paramecium, Arcella, Daphnia sp, Ceriodaphnia, Simocephalus, Bosmina, Moina, Diaphanosomasp*and*Cypris sp*.

In the present investigation the maximum no of Rotifera was found during summer season (44 ind /l) and minimum no (19 ind/l) was observed during monsoon season due to its preference for

warm waters. The highest concentration of Cladocerans was observed during Pre Monsoon months (80 ind /l) and minimum concentration was found during Monsoon (42 ind/l) months. Copepods showed higher population density in summer season (89 ind/l) and lower population density (34 ind/l) in monsoon period. In the present investigation highest concentration of Ostracoda found in 2 ind/lt and lowest in 1 no /lt. The population density of Ostracoda was higher in Pre Monsoon and Post Monsoon season and lower during Monsoon season. The population density of Protozoa was higher in post monsoon month and lower in monsoon month.

In the present study in case of Purulia District, the total no of zooplankton species recorded were 584 org/lt, out of which Rotifers are 118 org/lt (20.21 %), Cladocerans 221 org/lt (37.84 %), Copepods 234 org/lt (40.07%), Ostracods 6 org/lt (1.03 %), and Protozoa 5 org/lt (0.86 %).

In case of Bankura District, the phytoplanktonmembers comprised of 23 genera of which 6 genera belongs to Cyanophyceae group, 8 genera belongs to Chlorophyceae group, 7 genera belongs to Bacillariophyceae group, and 2 genera belongs to Euglenophyceae group. The commonly occurring phytoplankton species available in the ponds of Bankura District are *Anabaena sp.,Lyngbyasp,Microcystissp,Oscillatoriasp,Nostocsp,Phormidiumsp, Ankistrodesmussp,Chlorella sp,Closterium sp.,Mougeotiasp,Scenedesmussp,Spirogyra sp,Ulothixsp,Zygnemasp,Cyclotellasp,Diatomasp,Fragillariasp,Naviculasp,Nitzschiasp,Pinnularia sp,Synedra sp.*

The maximum occurrence of Cyanophyceae was observed during Pre Monsoon Season (50 org/lt) and minimum (22 org /lt) in Monsoon Season. The maximum seasonal density of chlorophyceae was in Pre Monsoon Season i.e (60 no's org/lt) and minimum in Monsoon Season i.e (26 no's org/lt).During the study period the maximum density of Bacillariophyceae was found during Pre Monsoon Season (73 org/lt) and minimum density was found during Monsoon months (33 org/lt).In the present study the maximum concentration of Euglenophyceae was found in Pre Monsoon month (7org/lt) and minimum density was found in Monsoon month (3 org/lt).

In the present study in case of Bankura District,the total no of species recorded were 516 org/lt, out of whichCyanophyceae are 136 org/lt (26.35%), Cholorophyceae are 165 org/lt (31.97 %), Bacillariophyceae are 196 org/lt (37.98 %) and Euglenophyceae are 19 org/lt (3.68 %).

A total 6 genus of Rotifera group (*Brachionussp*,*Asplanchnasp*,*Keratellasp*,*Synchaetasp*,*Euchlanissp*,*Filiniasp*) 10 genus of Copepoda (*Nauplii*,*Diaptomussp*, *Pseudodiaptomussp*,*Cyclops*, *Mesocyclopssp*,*Paracyclopssp*, *Microcyclopssp*,*Eucyclops*,*Acanthocyclopssp*,*Heliodiaptomus*), 3 genus of Protozoea (*Amoeba*,*Paramecium*,*Arcella*) 6 genus of Cladocerans (*Daphnia sp*,*Ceriodaphnia*,*Simocephalus*,*Bosmina*,*Moina*,*Diaphanosomasp*) and one genus of Ostracoda (*Cyprissp*) were identified from the ponds Bankura District.

The population density of rotifers was rich in summer season (81.92 org/lit) and less in Monsoon season (47.67 org/lit).The population densities of cladocerans were higher in summer season (27.17 org/lit) and lower in winter (10.5 org/lit.).Copepods showed higher population density in summer season (88.17 org/lit) and lower in winter (62.0 org/lit).The population density was higher in summer season (4.0 org/lit) and less in winter (1.17 org/lit).In the present study, 3 species of protozoa were recorded. The population densitywas higher in summer season (11.58 org/lit) and less in winter (4.83 org/lit).

The total no of species recorded were 665.83 org/lt, out of which Rotifers are 254.66 org/lt (38 %), Cladocerans 69.76 org/lt (10 %), Copepods 298.42 org/lt (45%), Ostracods 10 org/lt (2 %), and Protozoa 32.99 org/lt (5 %).

In case of water quality parameter of reservoir of Purulia District occurrence of highest temperature was observed in Pre Monsoon Season in Bandu Reservoir (29.2^0C) of Arsha Block and lowest temperature was observed in Winter Season in Patloi Reservoir of Purulia II Block. The average pH values of the reservoir water in the study area were varied from 8.5 ± 0.1 to 7.55 ± 0.15. Higher value of pH in summer season found in the Kumari reservoir of Balarampur Block The lower value of pH found in winter season in the Taragonia reservoir of Para Block.

During the study it was observed that the lowest value of alkalinity was observed during winter season i.e64.57 ± 4.18 mg /lt and highest value of alkalinity was observed during Pre Monsoon season i.e 92.5 ± 2.5 mg /lt. During the study period the hardness value of reservoirs of Purulia District varied from 113.06 ± 2.49 mg/lt to 183.175 ± 2.52 mg/lt. Higher value of hardness observed during Monsoon season and lowest value observed during winter season. The nitrite nitrogen value of reservoirs of Purulia district varied from 0.004 mg/lt to 0.5 mg/lt. and nitrogen value of reservoirs of Purulia district varied from 0.003 mg/lt to 0.1 mg/lt. The ortho phosphate value of reservoirs of Purulia district varied from 0.0025 mg/lt to 0.0055 mg/lt.

In case of water quality parameter of Kangsabati reservoir of Bankura District, Water temperature varies between maximum 28^0C (Pre Monsoon) to minimum 18^0C (winter). The ph range of the reservoir fluctuates in between 7.9 to 8.8. The higher value of transparency was observed during Monsoon season (35cm) and lower value of transparency was observed during winter season (26 cm). The dissolved oxygen value of the Kangsabati reservoir ranged from 7.3 mg/lt to 8.8 mg/lt. During the study it was observed that the lowest value of alkalinity was observed during winter season i.e 65 mg /lt and highest value of alkalinity was observed during Pre Monsoon season i.e 95 mg /lt. During the study period the hardness value of Kangsabati reservoir varied from 115 mg/lt to 140 mg/lt. The nitrite nitrogen value of Kangsabati reservoir varied from 0.004 mg/lt to 0.5 mg/lt. The nitrate nitrogen value of Kangsabati reservoir varied from 0.003 mg/lt to 0.1 mg/lt. The ortho phosphate value of Kangsabati reservoir varied from 0.0025 mg/lt to 0.0055 mg/lt.

A detailed study of plankton has been carried out in the study site.The population of phytoplankton in reservoirs of Purulia district composed of four major groups namelyCyanophyceae, Chlorophyceae, Bacillariophyceae and Euglenophyceae.All the dominant group ofphytoplankton was present throughout the study period. Diversity analysis showed thatCyanophyceae group represent 6 genera, Chlorophyceae group 8 genera, Bacillariophyceae group 7 genera and Euglenophyceae 2 genera. In case of Purulia district most of the phytoplanktonic group remain found in higher densities in Summer Season i.e Pre Monsoon Season and lower in Monsoon period.

A total number of 26 genera of zooplankton belonging to six groups namely Rotifera (6 genera), Copepoda (10 genera), Cladocera (6 genera), Protozoa (3 genera), Ostracoda (1 genera).

The total no of zooplanktonicspecies recorded were 1232 org/lt, out of which Rotifera are 317 org/lt (25.73 %), Cladocera 455 org/lt (36.95 %), Copepoda 400 org/lt (32.45%),Ostracoda 24 org/lt (1.99 %), and Protozoa 35 org/lt (2.88 %).

The population of phytoplankton in the Kangsabati Reservoir of Bankura District composed of four major groups namely Cyanophyceae, Chlorophyceae, Bacillariophyceae, and Euglenophyceae.During the study period the diversity analysis of phytoplankton showed that total 29 genera of phytoplankton belonging to four major groups. Among them Cyanophyceae consists of seven genera, Chlorophyceae consists of 12 genera, Bacilariophyceae consists of 8 genera and Euglenophyceae 2 genera.

Regarding the density the dominance of phytoplankton group are the following order Chlorophyceae>Bacillariophyceae>Cyanophyceae>Euglenophyceae

The data obtained from the study indicates that a total 36 genera of zooplankton were identified which is belonging to six groups namely Rotifera (10 genera), Copepoda (10 genera), Cladocera (9 genera), Protozoa (4 genera), Ostracoda (2 genera) and Amphipoda (1 genera).

The total no of species recorded were 1489 no's /lt, out of which Rotifera are 421 no's /lt (28.27 %), Cladocera 323 no's /lt (21.69 %), Copepoda 503 no's /lt (33.78%), Ostracoda 63 no's /lt (4.23 %), and Protozoa 171 no's /lt (11.48 %) and Amphipoda 8 no's /lt (.53%).

The Ichthyofaunal diversity study has been made for the reservoir of both the district which will be fruitful to the local and regional fisherman and useful data bank for the State Fisheries Department. During the entire study period total 37 species belonging to 7 orders, 15 families and 26 genera are reported in the reservoirs of Purulia Districts. In case of Bankura District, total 38 species belonging to 7 orders 15 families, 26 genera were found in the Kangsabati reservoir during the entire study period.

Total 15 genera of macrophytes are found in the study area of Purulia district and total 11 genera of macrophytes are found in the study area of Bankura district.