CHAPTER – VI

SUMMARY AND CONCLUSIONS

Diplai Beel is a natural freshwater body and an echo spot with rich biodiversity in the Kokrajhar District of Assam but in recent times due to direct and indirect anthropogenic activities its echo system and biodiversity have been threatened. To protect its ecology, water qualities, the impact of eutrophication and direct and indirect human interference should be stopped before it becomes ecologically destroyed forever.

The physico chemical characters of an aquatic body show influences directly on the aquatic flora and fauna grown in the water body. The fluctuations of the physico chemical characters in fresh water create an adverse environment for the living organisms limiting their growth and interfering into the physiological mechanisms. They reduce their ability to compete with other factors both physical and chemical in and outside the cell environment (Kedar and Patil, 2007).

As the first objective of my study is about diversity, density and abundance of macrophytes collected in Diplai Beel so I started with a standard questionnaire. A standard questionnaire of 20 questions was prepared for the villagers living around Diplai Beel to get their views regarding ecological and environmental changes they have witnessed in last 20 years. The analysis of questions has given lights to proceed in this research. The atmospheric temperature and rainfall as recorded have showed seasonal fluctuations during the study years from 2014-15 to 2016-17 which were slight significant in the ecosystem. The satellite images (1988, 1998, 2008 and 2016) of Diplai Beel physiomorphology of last thirty years have reflected how Diplai Beel has been changed its physiography by addition and emission of physical shape affecting in its area. The remote sensing photographs of Dipai Beel area vegetations and land use pattern were seen affected as because of deforestation in the area i.e. hillocks. It has been observed that the heavy siltation occurred due to the erosion in the surrounding area of Diplai Beel during study years. The macrophyte collections in Pre-Monsoon, Monsoon, Post-Monsoon and Winter seasons were noticeable because only a few plant species (47 species) were recorded from Diplai Beel water during the study years. The plants are divided into two main groups- Angiosperms and Ferns. Angiosperms are again divided into two- Dicotyledonous and Monocotyledonous. The dicotyledonous macrophytes classified to 9 families with 13 species such as Ceratophyllaceae-2, Lentibulariaceae-1, Convolvulaceae-2, Polygonaceae-3, Nymphaeaceae-2, Trapaceae-1, Amaranthaceae-1, Ceratophyllaceae-1, and Portulacaceae-1. The monocotyledon macrophytes are divided into 9 families

with 30 species. They are Pontederiaceae-3, Araceae-3, Lamnaceae-3, Hydrocharitaceae-3, Potamogetonaceae-1, Poaceae-9, Cyperaceae-5, *Alismataceae-2,* and Commelinaceae-1. The ferns are represented by three families and four species like Azollaceae-1, Salviniaceae-2 and Marseliaceae-1. The species are shown bellow (each species is represented by specific plant serial no. see Table no.11)

(1). Floating -8 sp such as *1. Eichhornia crassipes* (Mart.) Solms., 2. *Pistia stratiotes* L., 3. *Lemna perpusilla* Torry**,** 4. *Azolla pinnata* R.Br., 5. *Salvinia natans* (L) All., 6. *Salvinia cucullata*, 7. *Spirodela polyrrhiza* (L.) Schl., 8. *Wolffia globasa*,

(2). Submerged (anchored)-4 sp such as 9. *Hydrilla verticillata* (L.f.) Royle., *10. Potamogeton crispus*. L., *11. Valisneria spiralis* Linn., *12. Valisneria natans* (Lour) H.Hara

(3). Submerged (suspended)-2 sp such as 13. *Ceratophyllum demersum* L.14. *Utricu- laria exoleta* R.Br**.**

(4). Rooted Floating Shoot-2 sp such as 15. *Ipomoea aquatica* Forssk. 16. *Hygroryza aristata (*Retz.) Nees

(5). Rooted Floating Leaves-3 sp such as 17. *Nymphaea lotus* Linn., 18. *Nymphaea rubra* Roxb. Ex Salibs, 19. *Trapa natans* L. and

(6). Emergents- 28 sp. *20. Alternanthera philoxeroides* (Mart.) Grisep., 21. *Vetiveria zizanoides (* L.) Nass. *22. Cyperus bravifolius* (Rottb.) Hassk. , 23. *Cyperus iria, 24. Cyperus compressus* L. 25. *Cyperus corymbosus* Rottb., 26. *Hymenachne assamica* Hitch, 27. *Echinodorus angustifolius*, 28. *Ipomoea fistulosa* Mart**.**ex.Choisy., 29. *Scirpus eriophorum* L. *30. Marselia quadrifolia* L., 31. *Monochoria hastate* (L.) Solm., 32. *Monochoria* C. Presl., 33. *Polygonum barbatum* Linn., 34. *Polygonum hydropiper* Linn., 35. *Polygonum glabrum* Willd., 36. *Sagittaria trifolia* L., 37. *Cynodon dactylon (*L.) Pers.,38. *Digitaria ciliaris* (Retzius) Koeler. 39. *Portulaca quadrifida* L., 40. *Brachiaria mutica* (Forssk.) Stapf., 41. *Eragrostis unioloides*(Retzius) Nees., 42. *Hemarthria compressa* L., 43. *Pogonatherum crinitum* (T.) Kunth., 44. *Centella asiatica* L., 45. *Hydrocotyl sibthorpioides* Lmmk., 46. *Colocasia esculenta* (L.) Schott, 47. *Commelina benghalensis* L.

The different diversity indices of macrophytes distribution in Diplai Beel water revealed fluctuations in the study years. In 2014-15 the Shannon-Weaver index

of diversity is in Pre monsoon 2.96, in Monsoon 2.67, in Post monsoon 2.34 and in Winter 1.78 respectively. The Simpson index of dominance is also indicated by 0.04, 0.035, 0.057 and 0.075 respectively which are below the 1 in different seasons. It looks Species richness having very high value than others such as 23.21 in Pre monsoon, 21.07 in Monsoon, 17.86 in Post monsoon and 12.65 in Winter. The Evenness index shows its value below unity but more than Species richness. These are 0.765, 0.532, 0.476, and 0.389 in the seasons of the respective years respectively.

In 2015-16 the Shannon-Weaver index of diversity represents by 3.23, 2.98, 2.81, and 1.88 in the seasons respectfully. Simpson index is represented by 0.038, 0.041, 0.045, and 0.074 in Pre monsoon, Monsoon, Post monsoon and Winter accordingly. Species richness shows very high but fluctuation with the year 2014-15 in some seasons. The values of Species richness are 27.87, 22.34, 21.78 and 13.67. The Evenness index is also less than unity. In this year its values are 0.884, 0.792, 0.612 and 0.428 in the seasons respectively.

In the year 2016-17 Shannon-Weaver index of diversity of macrophytes are not above 3. They are 2.85 in Pre monsoon, 2.35 in Monsoon, 2.22 in Post monsoon and 1.54 in Winter. Almost no specific differentiation in Simpson index of dominance in Pre monsoon, Monsoon, Post monsoon and Winter of 2016-17. They bear the values under unity as observed in the graph. Their values are as 0.04, 0.056, 0.046 and 0.088. The Species richness is very high than other index values such as 20.75, 18.34, 16.84 and 11.88.

The study of the IVI ascending order of the collected macrophytes reflects that the floating macrophytes get affected more than the other types of macrophytes during study years (Table no 28 to 39)

The observed Density and Abundance of the collected macrophytes found to be reduced in different seasons of the study years. The species *Eichhornia crassipes* (Mart.) Solms. is found to be dominant over other macrophytes in different seasons of study years. Their IVI was also higher than the others.

The following species decreased their Density in **Pre Monsoon** in 2014 - 15, 2015-16 and 2016-17. (Table no.59) 4. *Azolla pinnata* R.Br., 9. *Hydrilla verticillata* (L.f.) Royle., 10. *Potamogeton crispus* L., 11. *Valisneria spiralis* Linn., 13. *Ceratophyllum demersum* L., 14. *Utricularia exoleta* R.Br**.,** 15. *Ipomoea aquatica* Forssk., 17. *Nymphaea lotus* Linn., 18. *Nymphaea rubra* Roxb. Ex Salibs, 20. *Alternanthera philoxeroides* (Mart.) Grisep., 26. *Hymenachne assamica* Hitch, 27.

Echinodorus angustifolius, 28. *Ipomoea fistulosa* Mart**.**ex.Choisy., 33. *Polygonum barbatum* Linn., 40. *Brachiaria mutica* (Forssk.) Stapf., 41. *Eragrostis unioloides*(Retzius) Nees., 43. *Pogonatherum crinitum* (T.) Kunth., 45. *Hydrocotyl sibthorpioides* Lmmk.

In **Monsoon** following species decreased in ***Density*** during 2014-15, 2015-16 and 2016-17. (Table no.59) 28. *Ipomoea fistulosa* Mart**.** ex.Choisy. *41. Eragrostis unioloides*(Retzius) Nees. *42. Hemarthria compressa* L.

In **Post Monsoon** following species decreased in ***Density*** during 2014-15, 2015-16 and 2016-17. (Table no.59). 16. *Hygroryza aristata (*Retz.) Nees. , 37. *Cynodon dactylon* (L.) Pers., 38. *Digitaria ciliaris* (Retzius) Koeler., 41. *Eragrostis unioloides* (Retzius) Nees. , 46. *Colocasia esculenta* (L.) Schott.

The following species decreased their ***Density*** in **winter** during 2014-15, 2015-16 and 2016-17. (Table no.59). 16. *Hygroryza aristata (*Retz.) Nees. 27. *Echinodorus angustifolius* 35. *Polygonum glabrum* Willd.

The following 7 species decreased in ***Abundance*** during **Pre Monsoon** of 2014-15, 2015-16 and 2016-17. (Table no.59). 2.*Pistia stratiotes* L.,15. *Ipomoea aquatica* Forssk., 24. *Cyperus compressus* L., 28. *Ipomoea fistulosa* Mart**.** ex. Choisy., 34. *Polygonum hydropiper* Linn., 38.*Digitaria ciliaris* (Retzius) Koeler.,43. *Pogonatherum crinitum* (T.) Kunth.

The 2 species decreased in ***Abundance*** during **Monsoon** in 2014-15, 2015-16 and 2016-17. (Table no.59). 1. *Eichhornia crassipes* (Mart.) Solms. 16. *Hygroryza aristata (*Retz.) Nees.5 Species decreased in ***Abundance*** during **Post Monsoon** during 2014-15, 2015-16 and 2016-17. (Table no.59). 6. *Salvinia cucullata,* 9. *Hydrilla verticillata* (L.f.) Royle*.,* 21. *Vetiveria zizanoides (*L.) Nass., 34. *Polygonum hydropiper* Linn*.,* 40. *Brachiaria mutica* (Forssk.) Stapf.6 Species decreased in ***Abundance*** during **Winter** in 2014-15, 2015-16 and 2016-17. (Table no.59). 22. *Cyperus bravifolius* (Rottb.) Hassk., 34. *Polygonum hydropiper* Linn., 38. *Digitaria ciliaris* (Retzius) Koeler., 35. *Polygonum glabrum* Willd., 36. *Sagittaria trifolia* L., 41. *Eragrostis unioloides* (Retzius) Nees.

The physico-chemical analysis of water parameters in the Diplai Beel clearly indicates that the most of the important water characters are found to be under the threshold permissible limits of the BIS guidelines.

The rise in water temperatures is found in May, July, October and January but

observed falls in November from 2014-15 to 2016-17. The atmospheric temperatures are observed high in March, August, February and it decreased in July and January of 2014-15 to 2016-17. These fluctuations in temperatures of Diplai Beel water show tremendous influence over macrophyte existence. (see Table no.60)

The colour (red tea) of Diplai Beel water is observed below permissible limit (5-15 *HU, IS 10500 of BIS) in the months of January, February, March and April during 2014-15 to 2016-17. The water odour is found to be totally disagreeable due to eutrophication, The TSS is observed higher than its normal limit in the Beel water. The TDS values of Diplai Beel water are found very low than the acceptable limit (500 mg/L)*. It is recorded lowering of TDS in May and January which fluctuates in different seasons. The Turbidity of Diplai Beel water increases only in April months during study years. It must remain in between 1 to 5 NTU*but it is found very high during study years in Diplai Beel water. High turbidity is always hampering the photosynthesis in plants due to insufficient light. The other monthly values of turbidity are found increasing in all months of 2014-15 year but it deceased in 2015-16 and again turbidity values increased in 2016-17. Transparency of light in Diplai Beel water is measured by Secchi Disc which indicates low during study years. The pH value is a sensitive parameter among all for water. The pH values in Diplai Beel are found to be in critical condition with ups and downs in the study years. pH must be in between 6.5 to 8.5* for good water which prefers healthy growth of water plants. It is seen that pH is decreased bellow 6.5 in July, December, January and February but found to be increased in September and October in the study years.

The electrical conductance observed lowering in the months of March to July and in December. The total alkalinity as $CaCO_3$ is recorded falling in March, April and June in study years. The BOD values dropped in March, May, August, November and February in 2014-15 to 2016-17. The BIS standard of BOD is 30 mg/L* for drinking water instead it is found very low and which is not good for aquatic organisms too. It is an indication of organic pollution of Diplai Beel water. The COD values are observed below BIS value of 250 mg/L*.

The DO values of Diplai Beel water is observed as very sensitive because it is found above 4 mg/L*. Healthy DO for fresh water and aquatic plants must be always bellow 4 mg/L throughout the study periods. The sulphate values are found very low. It is below 200 mg/L*, the standard of BIS. Nitrate's presence should be above 45 mg/L* according to BIS but the water analysis for nitrates of Diplai Beel shows very

low in August, September, October and November which come down consecutively. Nitrite values are also found very low. The ammonia nitrogen is observed almost normal as it must be above 0.5 mg/L*. The chloride values are found to be very low (limit 250-1000 mg/L)* which is not in threatened position. The phosphate values show under normal position. The increasing concentration of available phosphorus allows plants to assimilate more nitrogen before the phosphorus is depleted. Thus, if sufficient phosphorus is available, elevated concentrations of nitrates will lead to algal blooms. Although levels of 0.08 to 0.10 ppm phosphate may trigger periodic blooms, long-term eutrophication will usually be prevented if total phosphorus levels are below 0.5 ppm and 0.05 ppm, respectively. The natural levels of phosphate usually range from 0.005 to 0.05 mg/L. So the phosphorus is higher in Diplai Beel which is an indication of eutrophication in the Beel.

Sodium content in Diplai Beel water in the study period is found to be below the normal limit (>200 mg/L) according to WHO). The potassium value is also in a normal state. Calcium value increases in June from 1st to 3rd study years and decreases in July and December. The Ca analysis shows very low in content i.e.below 75 mg/L in water (limit 75-200 mg/L)*. The Mg is recorded below the limit (limit >30 mg/L)*. The Mg content in water decreases in the months of March, June, July, December, January and February during study period. Iron (Fe) analysis of Diplai Beel water indicates its inconvenient position which is below the permissible limit >0.30 mg/L*. Fe values decrease in March, May, June, November and January but rises in July September, October and February.

The heavy metals such as Cu. Zn and Pb analysis of Dalai Beel water indicate their normal presence in water. The limit of Pb (a toxic metal) in normal water must be >0.01 mg/L*and which is recorded in Diplai Beel water throughout the study period as normal and the water is out of danger. Pb increases in the month of February but goes down in March, April, May, July and December.

The Cu content in Dipal Beel water is recorded below its standard limit (0.05-1.50 mg/L)*. Cu values increase in March, April, June, September, November, December and February but decrease in August and October

The study of Zn analysis in Diplai Beel water reflects a poor occurrence according to standard limit (5-15 mg/L)* for aquatic macrophytes. Zn content in water collapses in April, May and November but it goes up in September, December,

January and February. [**Tolerance limits for Inland Surface waters, Class-A,B,C,D,E. BIS (IS: 2296-1982)*]

RECOMMENDATIONS:

The study on Diplai Beel water and its macroflora reveals that the all-round changes have been taken place in last two decades which is reflected through the studies of last three years. Time has come to work for preservation of this beautiful natural Beel situated in Kokrajhar district through the following few recommended measures.

1. Frequent Awareness Programmes should be organized among villagers on the importance and safety of wetlands.
2. Provision of awards and felicitation to NGOs, Eco-Clubs and other Social Organizations engaged in wetland preservation works should be introduced by government.
3. Diplai Beel should be converted to spectacular ecospot for tourists in BTC without disturbing its environment.
4. Issue immediate ban on fishing by nets, poisoning water and collection of precious aquatic flora and fauna to preserve its biodiversity.
5. Make rules for regular observation of water qualities and growth of flora and fauna by technical experts.
6. To hold available water by the Diplai Beel during winter the sluice gate on canal joined to mighty Brahmaputra should be risen up.
7. Formulation of scientific guidelines for the management of Diplai Beel by the authorities through leaflets and hoardings and to promote it into the 2nd largest Ramsar site in Assam.
8. Stop encroachment and issue strict ban on use of pesticides, herbicides, chemical fertilizers etc in the encroached cultivated lands.
9. The authority must discuss with International Experts for preservation of the Diplai Beel ecosystem etc.