Chapter – VII

CONCLUSION

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Malda district is centrally located in West Bengal. Being a flat terrain, the district is crisscrossed with numerous rivers and is made of alluvial formation. The district is endowed with three physiographic regions namely, *Tal* (north and north-west), *Barind* (east) and *Diara* (south and south-west) with small altitudinal variations. The general slope is gentle which is proved by the meandering river courses, flowing from north to south. The district exhibits strong evidences of complex hydrological activities which comprise recurring shifting of river channels, massive bank erosion along with frequent dereliction of rivers. This typical hydro-geomorphic set-up promotes various number and categories of wetlands in the form of natural inland water bodies like seasonal waterlogged areas, cut-off meanders, lakes, marsh etc. The wetlands, referred as lowlands, are covered with shallow and some time temporary or intermittent waters.

Malda district is occupied by freshwater inland water bodies (lakes, marshes and swamps), containing two sub-classes 1. Natural and 2. Man-made. In order to classify different types of wetlands along with estimating their geographical extent (objective no. 2), two classifications have been followed in present study. The first systematic approach regarding wetland mapping and classification has been initiated by Institute of Wetland Management and Ecological Design (IWMED) established by Govt. of West Bengal, Kolkata (2000) with manifold application of remote sensing technologies. They incorporate 562 wetlands (≥ 2.25 ha) with a total area of 294.16 sq. km, out of which, waterlogged seasonal (inland) wetlands are largest in number with an area coverage 209.56 sq. km. The second approach has been conducted by Space Application Centre (SAC) ISRO, Ahmedabad (2010) in collaboration with Institute of Environmental studies and Wetland Management (IESWM), who incorporates a total number of 502 wetlands (≥ 2.25 ha) with an area cover of 20,725 ha. The district is occupied by a considerable number of inland natural wetlands including ox-bow lake formations. Under the man-made classes, tanks occupy a significant number rather than reservoirs and water logged cover. Mapping of the entire wetland resource (objective no. 1) of Malda district has been done in order to monitor their behavior as well as suggest conservation measures for sustainable development of wetland resources. In order to analyse the present status of wetlands of the entire district, a total of four case studies have been

selected as representative wetlands for further detail analysis namely, *Siali wetland* under block Harishchandrapur 2, *Chakla wetland* under block Chanchal 2 and Ratua 2 in *tal* physiographic division; *Naghoria* wetland under block Ratua 2 and English Bazar and *Chatra wetland,* under block English Bazar in *Diara* physiographic division *(Appendix-4)*. Selection criteria have been considered for the case studies are; different categories of wetlands (i.e. riverine, waterlogged, ox-bow lakes etc.), degree of human interferences and resultant encroachment of wetland area (depending on location of wetlands at rural and urban periphery) and finally the agro-economic and biological potentials (in order to sustain the socio-economy of peripheral settlers) of wetlands of Malda district. All the wetlands, under study are directly or indirectly linked with the major rivers viz., Ganga, Mahananda, Kalindri, Fulahar along with their tributaries. Out of the case studies, Siali wetland is relatively small sized natural wetland (18.74 ha) with less than 2 to 3.5 m water level throughout the year and appears to be definite irregular shape. The geological composition of the area comprises wide alluvial plain where the gradient is perceptibly gentle. The area is formed by the excessive silting of the Kalindri and Mahananda River of recent origin. The wetland is connected with two inlets, Kankhor and Kali kosi, the tributaries of River Baramasia, which meets with River Kalindri, flowing from north-west to south. Two outlets, through which the excess water drains out, are Kokra Bridge and Elangi canal, connected with this water body, and play significant role in maintaining the hydrology of the entire wetland. Chakla wetland is considered the largest one with 842.50 ha area coverage and 2 to 3.5 m water depth throughout year. The slope is gradual, as is proved by the meandering course of Mara Mahananda (flowing through south-west) and Mahananda River (flowing through east). The entire area of the Chakla wetland complex is covered by typically dark, loosely compacted recent alluvium, with a high water and organic material content. The Nuna and Bhoga River, two tributaries of Mahananda, with southward flow, control the inflow of water during the pre-monsoon season and check the outflow during the monsoon period. The river water from Nuna along with surface discharge is the principal sources of Chakla wetland water. In diara region, extreme bend of River Kalindri has cut-off from main stream and rejected channel forms oxbow lakes. Naghoria wetland is an ox-bow lake with area coverage of 228.13 ha and an average water depth of 2 to 3 m round the year. The general slope of the wetland region is towards east and south-east and is perceptibly gentle. The maximum portion of the region is a part of active flood plain which is formed by immature dark, loosely compacted newer alluvium with higher moisture content. The main support of its drainage is mainly rain water, along with the river water, where surface run-off from the vast catchment area enters into

Naghoria wetland during the monsoon and post monsoon period from Kalindri and through Nurpur barrage from mighty River Ganga. These mentioned three wetlands are characterized with a rural set up, whereas the fourth one namely Chatra wetland is surrounded by both the rural (North-west, west, south-west) and urban (North-east, east, south-east) set up, and located adjacent to English Bazar Municipality, Malda district. Chatra wetland is formed on the flat area and shallow slope, in association with alluvial tract, which is created mainly by the combined actions of erosion and deposition by River Mahananda and River Ganga. This wetland is considered peri-urban with a definite irregular shape. Its area extension is 234.54 ha with less than 2 to more than 3.5 m water level throughout the year. Regular supply of Malda Municipal sewage flow as well as the surface discharge in the form of rain water is the permanent source of water intake of this peri-urban wetland.

The present study analyses the biological diversity of wetlands through field study and interviewing the local people. The diverse species of macrophytes and icthyofauna have been collected as well as identified and avifaunal species are sighted and identified for preparing the inventory as well as estimate the biodiversity potential of these wetlands (objective no. 4). A general survey on the macrophytes, reveals a heterogeneous assemblage of growth forms, namely; emergent, rooted floating leaved, free floating, semi-emergent, submerged rooted, and emergent grass to be present in and around the wetlands under study. A total of 21 species of macrophytes, belonging to 21 genera and 17 families have been collected and identified from present study, which are found in two habitats namely open water and wetland water edge. The dominant families are *Asteraceae*, *Nymphaeaceae* and *Salviniaceae*, represented by 2 species each. The wetlands under case study display a regular growth of macrophytes such as *Centella asiatica, Colcasia esculenta, Enydra fluctuans, Eclipta alba hassk, Heliotropium indicum, Polycarpon prostratum* etc. in wetland water edge. Similarly a large number of aquatic flora such as, *Aeschynomene aspera, Trapa natans, Nelumbo nucifera, Euryale ferox, Nymphaea nouchali* etc. are identified in the vast open water. Moreover, the wetlands act as the store house of known medicinal properties e.g. *Centella asiatica, Hygrophilia auriculata, Enydra fluctuans* etc. which are observed to play substantial role in the local socio-economy of the entire district. Furthermore, the wetland bed harbor a thick assemblage of *Euryale ferox* cultivation, which is full of nutritional value and is considered a commercially viable potential aquatic cash crop. The present study depicts that the wetlands of Malda district are the places of intense biological activity including the breeding of many species of fishes and aquatic organisms. A total number of 24 species,

belonging to 21 genera and 14 families of fish fauna have been identified from the case study. The wetlands which have organized fish cultivation through cooperative societies are endowed with rich faunal diversity in association with *Labeo catla, Clarias batrachus, Labeo rohita, Cirrhinus cirrhosis, Arius arius, Cirrhinus cirrhosis, Arius arius, Labeo calbasu, Labeo bata* etc. *Cyprinidae* is found most dominant and diversified family with 11 species. Apart from, diverse species of aquatic flora and icthyofauna, wetlands of Malda district are considered significant natural ecosystem which facilitates diverse ornithological composition. The wetland open water and water edge are characterized by a wide range of feeding and breeding migratory and residential species. A total of 32 bird species, belonging to 27 genera and 17 families are sighted and identified by applying point count method, out of which 23 are residents and 9 are migrant species. The avifaunal family of *Anatidae containing 9 species and Ardeidae with 7 species is considered most dominant*. Various residents namely *Phalacrocorax fuscicollis, Anas paltyrhynchos, Ardea alba, Ardea cinerea, Ardeola grayii, Spilopelia chinensis, Pycnonotus cafer* etc. have commonly been sighted in and around wetlands. Furthermore, large assemblage of migrant bird colonies ranging from Leh, Ladakh and other parts of Himalayas, to Siberia namely; *Anas acuta, Anas clypeata, Anas poecilorhyncha, Aythya nyroca, Aythya fuligula* etc. have been sighted. Migratory birds appear in the wetlands and its periphery during the annual migrations in winter months, from November and stay up to February. The present study has attempted to determine the avifaunal species diversity and species evenness by applying Shannon-Weaver diversity index. Out of the case studies, Naghoria is recorded with maximum species diversity, followed by Chakla, Chatra and Siali wetland. Species evenness index reveals similar picture of highest evenness in Naghoria and relatively lower in Chatra and Siali wetland. The lower species diversity and evenness in peri-urban wetland, compared with other case studies is attributed to increasing water pollution (recorded from water quality testing), wetland area shrinkage and associated problems. The case studies reflect the presence of topographic and biological diversity of all the wetlands in Malda district, which maintain the density and diversity of aquatic floral and faunal species. Being a historical heritage most of architectural structures and ruins in the form of mosques, tombs, and gateways have been formed by the rulers alongside wetlands, in several centuries back. The wetlands with intact biotic diversity (aquatic flora and fauna) in association with historical structures are potential enough in order to promote the eco-tourism activity by constructing proper infrastructure (afforestation, road networks, bird watching tower and other amenities) as well as enhance the aesthetic importance and economic development of the entire district. These evidences along with the

inventory of biotic components *(Appendix-5,6,7)* in the wetlands of Malda are sufficient to prove the hypothesis no. 3 i.e., rich biodiversity of wetlands has the potentiality for wildlife vis-à-vis aesthetic and recreational uses i.e., eco-tourism activities. Moreover, the wetlands with heterogeneous biotic assemblage (as proved by field observation and diversity indices) are sufficient to prove hypothesis no. 1 that, wetlands are potential in order to provide biodiversity conservation in Malda district.

Malda district and its environs has been suffering from flood hazard, caused by the River Fulahar, Kalindri, Tangan and Mahananda, overflowing its banks almost annually and cause damage and tremendous stress on the fabric of entire district. The existing wetlands, as interlinked with the major mentioned rivers, are potential in order to protect the district from the fury of occasional flooding. In the present study, the database, which has been generated as the outcome of present research is capable to prove hypothesis no. 1, that the wetlands of Malda district are potential in order to mitigate flood hazard in the adjacent terrestrial ecosystem, by storing large volume of water, ranging from 554,358 m^3 to 42,314,620 m^3 during monsoon period and eventually replenish the ground water. Moreover, the water quality measure is considered an ideal tool for establishing base line data to assess the pollution status within wetlands, which are attributed to various anthropogenic activities and resultant wetland degradation (objective no. 6). In this regard, a general survey on the physical (water temperature, turbidity), chemical (pH, total dissolved solids, conductivity, total hardness, dissolved oxygen, chloride, fluoride, iron content etc.) and bacteriological (total and faecal coliform) water quality parameters have been made. The water samples have been collected from case studies during study period (2015-2018) covering three different seasons (pre-monsoon, monsoon, and post-monsoon) *(Appendix-8)*. Collected water sample are tested in laboratory for further analysis, which reveals the following findings: Water temperature as a physical parameter records an average temperature ranging 27 to 29°C in the wetlands. The average water turbidity is recorded 3 to 6 NTU within the wetlands, with maximum concentration during monsoon, followed by post-monsoon and pre-monsoon. Out of chemical parameters, an average wetland pH is recorded 7.2 to 7.7 with maximum concentration during pre-monsoon. The peri-urban wetland records high pH content which is slightly alkaline and substantiates an excessive algal growth in wetland water. Average conductivity is recorded fluctuating throughout year and ranges from 115µ.s. to 450µ.s. with maximum concentration in wetland, adjacent to urban periphery which may be caused due to large ionic concentration and pollution status especially from point-source pollution. The

peri-urban wetland records an average total dissolved solid concentration of 241 ppm, which is attributed to point (municipal sewage) and non-point (agricultural run-off) sources of pollution. Other case studies record an average tds of 55 to 75 ppm. The average total hardness is recorded 75 to 212 mg/L with maximum concentration in peri-urban wetland. The wetlands exhibit high concentration of total hardness, turbidity and conductivity which are found to exceed the desirable limit *(BIS, 2012; APHA, 2017)*. The high content of mentioned chemical parameters is resulted from the agricultural run-off, which is full of toxic chemicals, in association with sewage inflow from the peripheral settlements. The measure of amount of oxygen, available in water for biochemical activity is considered as dissolved oxygen, which is recorded 5 to 9 mg/L with maximum record during post-monsoon. Other chemical components (chloride, fluoride, iron, arsenic etc.) are recorded in low concentration throughout the year. The bacteriological parameters, total and fecal coliform counts are recorded maximum during post-monsoon with an average count 4 to 10 MPN/100 ml and 0 to 4 MPN/100 ml of water respectively. The peri-urban water body receives a large volume of sewer inflow due to favourable slope condition from the adjacent municipality wards (no. 3, 23, 24 and 25) along the north-east and south-west boundary. The water sample test records *(Appendix-8)* that most of the water quality parameters are restricted within permissible range, as recommended by BIS (2012) and APHA (2017), which is attributed to the filtering effect of this peri-urban wetland and the presence of aquatic macrophytes. Some of the chemical parameters (except water pH, dissolved solid, conductivity and water hardness) are recorded a bit higher than the recommended range. Therefore, the present output of water quality test proves the hypothesis no. 1, that the peri-urban wetland is potential to treat waste water inflow from 22 numbers of sewerages, under ward no. 3 and 25 along the south-west boundary of adjacent English Bazar municipality.

Moreover, the variation of different physical, chemical and bacteriological parameters between the wetlands and between the seasons has been computed by one way Anova. The statistical analysis reveals that water parameters record both the significant (p value $< \alpha$ value) and non-significant (p value $> \alpha$ value) results between the wetlands and between the seasons. Water turbidity under physical parameter; conductivity, total dissolved solid, dissolved oxygen, total hardness, iron, chloride, fluoride, arsenic under chemical parameter and faecal coliform under bacteriological parameters have recorded significant variation between the wetlands (case studies) at 0.05 levels in two-tailed test at 95% confidence level. Whereas, the water temperature, turbidity under physical parameters; water pH, hardness, dissolved oxygen, iron, arsenic under chemical parameters; total and faecal coliform under

bacteriological parameters record significant variation between the seasons (pre-monsoon, monsoon and post-monsoon) at 0.05 levels in two-tailed test at 95% confidence level.

Furthermore, the observations on the water quality parameters of selected wetlands are further analyzed with the Pearson's product moment correlation coefficient. The correlation coefficient results into highly significant ($p<0.01$) positive correlation between water temperature, pH and water hardness; between pH, total dissolved solid and conductivity; and between total and faecal coliform counts. Highly significant ($p<0.01$) negative correlation is found in water temperature and pH, both with total and faecal coliform. Significant ($p<0.05$) positive correlation is recorded between water temperature, conductivity and tds and negative correlation is found between water temperature and dissolved oxygen. The low content of dissolved oxygen is found during pre-monsoon period, which indicates poor status of aquatic life within wetlands. Therefore, water sample testing and analyzing the water quality parameters of selected wetlands provide a base line data in order to know the ecological status of entire wetland resource of Malda district. The study reveals that, the wetland resource encounter immense challenges from anthropogenic activities either in the form of land run-off from adjacent agricultural field, or is being contaminated by municipal and domestic effluents along with solid waste dumping as well as eventually results into further degradation. Therefore, the hypothesis no. 5 i.e., the current piecemeal and consumption-oriented approaches affecting adversely the wetland resources of malda district, which is proved by water sample test and the different sources of water pollution has also been documented by applying one way Anova test .

The wetlands of Malda district directly and indirectly support large number of population in providing services such as food, fiber and clean water supply. The habitats (villages) surrounding the case studies are classified into two categories *Bed village* (at immediate vicinity of wetland and entirely wetland dependent) and *Belt villages* (a bit far-off and depend on wetlands only for commercial purpose). A household survey (5% of universe) has been conducted randomly from bed and belt villages in order to analyse the utilization of wetlands *(Appendix-9,10)* (objective no. 3). The study reveals that bed villagers are entirely dependent on wetlands through different occupations like irrigation, cultivation, fishing, gathering wetland products (macrophytes and aquatic fauna etc.). However, in the present study, all the case studies experience a good portion of its area coverage along with its ample water resource to be contributed for cultivation, which provides critical economic support to the rural households. Wetland bed along with its edge is utilized for the major crops like

paddy (Aush, Aman, Boro), legumes, wheat, mustard and pulses (Kalai, Moong) and mixed vegetables etc. especially by the settlers, residing at the periphery (Bed village). Boro paddy, which is considered much remunerative, is cultivated during November to February in the water spread area, immediately after monsoon. Aush and aman paddy are cultivated at wetland edge with the help of wetland water as zaid and kharif crop respectively. Jute is considered another dominant kharif crop as well as commonly cultivated at the wetland edge. Additional crops such as Corn (March to July) and Bajra (August to November), are cultivated at wetland periphery with the help of wetland water. Siali wetland is characterized with a good association of cereals (Motor, Chola, Kalai) as well as several vegetables (Brinjal, Cauliflower, Radish) etc. along with betel leaf, which is considered an important cash crop of high economic value. These wetlands are also used as a source of irrigation by tapping through indigenous system (shallow pumps or shallow bore wells) for the adjacent farm lands. Therefore, the farmers around the wetlands get initial benefit in the form of less cost of irrigating their farm lands and subsequently, they divert the deposited money in order to buy other agronomical inputs. Along with the support to agricultural production, wetlands facilitate better opportunities for the inhabitants in the form of fishing practice, which has immense socio-economic values, attached to it. The fishing practice is mainly done by the cooperative societies under Gram Panchayats on lease basis in Siali and Chakla wetland. The entire fishing practice is controlled by the Bhaluka Fishing Cooperative Society in Siali wetland (on lease for 3 to 4 years). Fish cultivation is done in Chakla wetland under five cooperative societies (Rampur Fishing Cooperative, Ojitpur cooperative, Goalpara cooperative, Boalia cooperative and Dhanga cooperative society). Diverse varieties of carps are produced in Chakla and Siali wetland along with Rohu, Ar, Shingi, Mangur, Bata, Mrigel and Catla as dominant fish species. Chatra and Naghoria wetland do not have any fishing cooperative and fish cultivation, except fish catch by the local fishermen. Dominant fish species which are usually caught in these wetlands and sold to the local and main market include Bata, Kalbaush, Catla, Koi, Mangur, Prawn, Rohu, Tangra etc. Moreover, a large section of peripheral settlers are dependent for their livelihood on these wetlands both for cultivation and fishing. In the present study, wetlands are utilized for several product gathering in the form of aquatic flora (Kalmi, hingcha, kulekhara) as food which also possess important medicinal ingredients and fauna (oysters/mollusks and gugli). These wetland products are sold at local market, as well as supplement the household economy for the people residing in the vicinity of the wetlands. The aquatic macrophytes are also used by local habitants directly for the food, fiber and fuel. The thick cover of water hyacinth, which

is present in all the wetlands, under case study is collected as fodder, which is considered a cheap source for feeding the cattle population. The economic valuation of the case studies have been done, which encompasses the true costs of utilizing the wetland products, utilized by the stakeholders. In the present study, apart from utilizing wetland water as a source of irrigation to cultivate agricultural field, the total benefit from makhana cultivation from the case studies range from Rs. 3,50,625.00 to Rs. 51,97,500.00 per annum. Wetland fishing is found much more remunerative than food crop cultivation and ranges from Rs. 4,62,500.00 to 14,47,500.00 per annum. Wetland product gathering records relatively less profitable (Rs. 21,600.00 to Rs. 76,500.00 per annum) than cultivation and fishing. Therefore, the total estimated benefit, found from the case studies range from Rs. 8,75,000.00 to Rs. 57,36,500.00 per annum. The case studies act as the representative wetlands in order to analyse the dependency on wetland ecosystem, utilization of wetland water and other resources and their economic valuation, which depict a vivid picture of the entire wetland resource utilization in Malda district. Therefore, the sample survey in bed and belt villages is sufficient in order to know the utilization of wetlands by surrounding households as well as to prove the hypothesis no. 2 i.e., wetlands of Malda district are currently utilized for agriculture, aquaculture, and coir rotting, gathering fruits and fiber etc., and also satisfying various socio-economic needs. Although the present study reveals that the coir rotting is practiced negligible in the wetlands of Malda district.

In the present study, the wetlands are found to flourish a number of valuable aquatic cultivation which can be harvested on a sustainable basis in order to provide an alternate economic support to village livelihood (objective no. 5). Wetland cultivation promotes immense potentiality in the form of *Euryale ferox* (makhana) cultivation, which is considered an important cash crop with high nutritional value. The cultivation of *Euryale ferox* has already been introduced as well as expanded on mass scale especially in the wetlands of *Tal* and *Diara* region. A significant number of households, irrespective of bed and belt villages are engaged in makhana cultivation on lease basis under fishing cooperatives and gram panchayats. Being immense potential to provide considerable amount of cushion to counteract the impact of poverty, efforts are being made to spread this distinguished aquatic crop to other wetland areas. Apart from makhana, another important crop with high economic valuation is betel leaf (dishi/ indigenous) on which a good number of households are dependent. The judicious use of wetland water for betel leaf cultivation is considered economically potential enough for sustaining the habitants' livelihood. Trapa natans, locally called as paniphal, is a traditional aquatic crop and is cultivated in open water. Paniphal can

commercially be cultivated as edible fruits in wetlands under study with immense potential to provide alternate economic return on a sustainable basis to the rural mass of Malda district. Apart from wetland cultivation, duck rearing within wetlands is also considered economically significant and an important source of highly demanding duck eggs in market. Moreover, *Aeschynomene aspera* (Sola) is cultivated in small number of wetlands under Malda district, which contains significant potentialities in providing nitrogen input in soil in order to enhance the agricultural productivity and act as green manure. Further, sola cultivation within wetlands is found highly potential as well as remunerative in order to provide indigenous handicrafts and to save the traditional heritage. The present study reveals that, there is ample scope to utilize wetland resources in Malda district (cover a good portion of area under wetland cover) in the form of cultivating commercial crops along with other activities which facilitate the income generation of rural mass, thus prove the hypothesis no. 4 that, wetlands have the potentiality to provide alternative economic support to rural people through generation of gainful self-employment.

In view of the ecological, biological and socio-economic importance of the wetlands, under study, the present work has attempted to analyze a paradigm shift in conservation ethic to this natural ecosystem with special reference on its wise use and sustainable management. The Ramsar Convention (2 February, 1971) and Convention on Biological Diversity (5 June, 1992), two international initiatives have been conceptualized as mobilized approach to the conservation and holistic development of wetland ecosystem. Both the initiatives have made considerable contribution to the wise use of wetland resources, including its biodiversity by the world conservation strategies which underline the interdependence of conservation and sustainable development. A total of twenty seven (27) wetlands of India have already been designated as Ramsar sites of international importance till date. Ministry of environment and Forest, Government of India has conducted strategic and science-based approach, namely National Wetlands Conservation and Management Programmes (1985-86), National Conservation Strategy (1992), with the aim of conserving wetlands in the country so as to prevent their further degradation and ensuring their wise use for the benefit of local communities. Furthermore, a number of protection laws and legislative tools (The Indian Forest Act, 1927; The Indian Fisheries Act, 1857; Wildlife (Protection) Act, 1972; Water (Prevention and Control of Pollution) Act, 1974; Forest (Conservation) Act, 1980; Environmental (Protection) Act, 1986; Wildlife (Protection) Amendment Act, 1991 etc.), policies (National Forest Policy, 1988; National Conservation Strategy and Policy Statement on Environment and Development, 1992; The National Water Policy, 2002; National

Environment Policy, 2006 etc.) *(Figure 6.1)* have been initiated by national and state government in order to restrict any inconvenience of wetlands, which eventually leads to further loss of biodiversity as well as all degeneracy of the natural ecosystem. In spite of being occupied by fairly good number of wetlands, Malda district encounter several vulnerabilities and resultant environmental changeability. In the present study, the satellite imagery (TM and OLI) revel conspicuous land use land cover change surrounding the wetlands between the time periods 1990 to 2018 *(Table 6.3 to 6.6) (Figure 6.4) (Map 6.1 to 6.8)*. All the wetlands record its area alteration to non-wetland commercial purposes especially in the form of mango orchard, agricultural field, brick kiln industry and built-up area. In this regard, a perception study has been made through household survey by random sampling (2% of universe) in the municipal wards (ward no. 3, 24 and 25), which are at the immediate vicinity of the only peri-urban wetland of Malda district (case study- Chatra wetland). The perception study reveals that, the open water and wetland edge encounter rapid area encroachment through continuous expansion of built-up area, solid waste dumping, water quality degradation and biodiversity reduction. Moreover, a small no. of households as well as stakeholders, adjacent to this peri-urban wetland are aware regarding the mentioned problems, whereas a large no. of population in spite of being a part of the ecological problem of wetland, still show a lot of negligence and even do not know the necessity of wetlands, in order to provide a sustainable future *(Appendix-11)*. Therefore, the present study has recommended the outlines of conservation strategies in order to restrict the remarkable changes, already happened to the overall land use conversion and other associated degradation of these wetlands (objective no. 7). Strict measures and continuous monitoring are suggested to be taken immediately by the appropriate authority in order to restrict further wetland alteration (urban encroachment) especially in the peri-urban wetland. Proper legal action is required to check wetland conversion to non-wetland purpose (agricultural land encroachment). Integrated planning is to be taken in order to maintain adequate surface flow within wetlands, throughout the year. Wetland conservation and management strategy must be comprehensive in addressing the degrading water quality which persists from agricultural run-off and sewage inflow. Preparing inventory of aquatic flora and fauna on sound ecological base along with promoting eco-tourism are considered highly essential to augment the aesthetic heritage of wetlands. Moreover, formulating stringent legal actions are required to be taken against the over exploitation of wetland resources. The judicious utilization of this wetland is largely important for enabling the socio-economic development and simultaneously promotes the social cohesion along with economic stability. Public awareness

and outreach programmes regarding wetland values and functions are to be decentralized as well as conveyed to the adjoining community. All the stakeholder including institutions, government departments, non-governmental organizations (NGOs), local governments and many others need to stand together and be better informed about the rationale, goals and methods of wetland ecosystem restoration. Furthermore, a network of local administration, municipality, academicians, researchers and NGOs must coordinate grass root level implementation of policies and activities related to wise use of wetlands of Malda district and its conservation for sustainable management. Therefore, already implemented legislations, policies and plans along with conservation strategies and recommendations are sufficient to prove the last hypothesis no. 6, that the economic and environmental functions of wetland can be maintained sustainably if appropriate conservation methods and management technologies are adopted.

The present work concludes with further research scope in strengthening the ability to document, measure and value the linkages between wetland ecosystem and human population in entire Malda district. There is a scope for further research regarding land use land cover change at wetland periphery over the years and increasing metallic pollution within wetland water especially from the accelerated growth of high demanding brick kiln industry. This research can be possible with future satellites, aided with precise and accurate spatial and spectral resolution. However, wetland management as an applied side of wetland science requires a detail understanding of the scientific aspects of wetlands of Malda district. Moreover, this understanding must be balanced with an awareness of legal, institutional and socio-economic realities and incorporating the newly developed space technologies in order to ensure protection of this valuable ecosystem *(Roy & Behera, 2003)*.