Chapter – VI

CONSERVATION OF WETLANDS

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6.1 Introduction:

Conservation is a socio-economic and ecological paradigm, which is entirely concerned with the sustainable utilization of natural resources – the rate, purpose and efficiency of use *(Tiwari, 2006)*. Conservation is generally acquired through improvement and protection of natural resources including wildlife, water, air, and earth deposits and human resources in a wise manner, securing derivation of their maximum economic as well as social benefits for a long term. Conservation of natural resources is one of the most significant indicators of a country's development. The conceptual basis of conservation initially has emerged as a balanced approach to the management and conservation of natural resources implying a realization of controlled use *(Caldwell, 1990)* and develops a concern against over exploitation of natural resources. Conservation includes the sustainable management of human use of diverse natural resources for current public benefits and sustainable social and economic utilization.

In the present world, various kinds of ongoing developmental process involve progressive transformation of economy and society. As a consequence, environmental degradation has become a frequent occurring phenomenon, which is closely associated with an existing large sized population as well as the application of resource depleting and polluting technology. Environmental degradation not only constitutes a major threat to the economic development, but endangers the very existence on earth's life *(Saha, 2006)*. Wetlands are not exceptions as everywhere, every day, being silently filled up and tend to be one of the most threatened natural ecosystems all over the world. Wetland degradation is chiefly attributed to the increasing human populace, changing land use pattern, over utilization of wetland resources causing negative impressions on wild life, water quality, hydrological cycle and other crucial ecological functions. Since the world convention on environment in 1972 at Stockholm, Sweden, the government and statesmen in different countries became aware of the horrific situation of deteriorating natural ecosystem worldwide, and particularly in the developed countries. Further, the Rio Earth Summit in 1992 drew attention to the crisis resulting with global warming and loss of biodiversity *(Saha, 2006)*. And resultantly, the idea of integration between development and environment considerations has received world-wide attention through the deliberations and resolutions of

the United Nations and other international organizations *(Stockholm Declaration, 1972, Bruntland, 1987, IUCN, UNEP & WWF, 1991)*. Therefore, a careful preservation and protection and a planned management of wetlands is awfully important, not even in terms of its intrinsic values and functions but because of numerous economic activities are based on this natural ecosystem.

6.2 Wetland conservation:

In order to preserve and conserve the wetland resource and realizing the importance of this crucial natural ecosystem, several steps have been commenced worldwide from the last few decades. Wetland conservation is aimed at protecting and preserving areas where water exists at or near the Earth's surface, such as swamps, marshes and bogs, which have become a focal issue for conservation due to the ecosystem services it provides. Wetland conservation and proper management aims to conserve the chief ecological services and restore the precious natural resources while fulfilling the socio-economic, and cultural needs of current and future generations. The environmentalists and conservationists have agreed on the view that development is inevitable to achieve a better future, but only when the changes take place in ways that are not wasteful and need not to provide any penalty.

6.2.1 International initiatives:

During the past few decades, numerous efforts have been made to prevent exploitation of wetlands and water bodies. *Ramsar Convention* and *Convention on Biological Diversity (CBD)* are the two land mark initiatives throughout the world towards the conservation of wetlands.

6.2.1.1 Ramsar Convention on Wetlands:

World Wetland Day, which is celebrated each year on 2 February, marks the date of the adoption of convention on wetlands, which was signed in Ramsar, Iran on 2 February, 1971, and came into force on 21 December, 1975. This is most popularly termed as Ramsar Convention, the oldest and first convention and the only global environment covenant/ treaty dealing with a particular natural ecosystem. Presently, this conservation comprises 154 Contracting Parties, and 1,634 wetland sites all over the world, totaling 145.73 million ha, is designated for inclusion in the Ramsar List of Wetlands of International Importance. Since its commencement, the convention has emphasized on the values and the functions of wetlands to be avowed, as well as their importance to the maintenance of biological diversity. Ramsar

provides a framework for national action and international co-operation for the conservation and wise use of wetlands and their resources. Further, the convention has broadened its scope to address all the aspects of wetland conservation and reflects the increasing acceptance and recognition of the importance of wetlands as ecosystems which contribute to both the biodiversity conservation and human well-being. In addition, *Montreux record* has been established under this convention by Recommendation 4.8 of the Conference of Contracting Parties, 1990. Montreux record is a register of wetlands under Ramsar list, which encounter immediate challenges from technological development and human interference. As an indication of achievement, in the year of 2015, World Wetlands Day has been celebrated in almost 59 countries. Through the world wetland day (2 February) celebration, Government agencies, non-government organizations and groups of citizens at all levels of the community have taken advantage of the opportunity to undertake actions, which are aimed at raising public awareness of wetland values and benefits in general and the Ramsar Convention in particular *(MoEF & CC, Govt. of India, 1985-86)*, which has made a considerable contribution to the conservation and wise use of biological diversity in wetlands. Ramsar convention works in close collaboration with other six International Organization Partners (IOPs) namely; International Union for Conservation of Nature and Natural Resource (IUCN), International Water Management Institute (IWMI), Wetlands International, International Wildfowl & Wetlands Trust (WWT), Birdlife International and World Wildlife Fund (WWF).

6.2.1.1.1 Concept of Wise use and Sustainable management of wetland:

In the present century, holistic planning for the conservation and preservation of wetland ecosystem is gaining momentum. And in this respect, another most indispensable concept, enunciated by Ramsar in association with wetland conservation is *sustainable development*. The concept of sustainable development has been contained in the *Stockholm Declaration* of 1972, which encounter the environmental debate more intensely in the mid 1970's, and has been popularized by the *Bruntland Report*, 1987 and further developed in the document *"Caring for the Earth"* by IUCN, UNEP, WWF, 1991. The concept of sustainable development had its origin to the renewable resource management from early twentieth century and afterwards, it was conceptualized as a fully mobilized approach to the conservation and holistic development by the world conservation strategy, which underlined the interdependence of conservation and sustainable development. Sustainable development has become the buzzword of the present century. It refers to creating a style of economic

development, which is sustainable within the context of the planet's ecosystem and human society *(Das et al., 2000)*. Sustainable development requires meeting of the basic needs of present without compromising the ability of future generations in order to meet their own needs and extending to all the opportunity to satisfy their aspirations for a better life *(Bruntland, 1987)*. The emergence of sustainable management is a tool for meeting the people's needs by utilizing the earth capital most judiciously and sustaining the global ecosystems. Water is a fundamental requirement for human life and well-being and wetlands are the cornerstone of sustainable cities, which yield the greatest successive benefits to the present generation, and concurrently fostering its potential to fulfill the needs and aspirations of future generations. Thus proper management of wetland is a means to improve the food production, productivity, as well as alleviating poverty. Being a critical component of sustainable development, sustainable water management is inherently related with the requirement of water resource for developmental purpose but without impairing the future supply. Sustainable water management involves allocating water between competing purposes and users *(Russo et al., 2014)*. Moreover, strategies of wetland use integrate three key principal of sustainability:

1. *Environmentally sustainable,* denotes facilitating a wetland management plan, which does not degrade the wetland and rather regulate and support the foreseeable future.
2. *Economically sustainable* facilitates the utilization of wetlands, which is economically beneficial in a sustainable manner. Further, the scientific knowledge will help in understanding the economic values, which in turn will help in sustainable management and development and
3. *Socially sustainable*, means facilitating the wetland management and strategies within the local community, which is developed by the local people and the stakeholders as well as based on their local knowledge. These approaches have been considered in the wetland discourse in progress the convergence of thinking towards a sustainable wetland management.

In modern times, the concept of *wise use* is at the center of Ramsar philosophy and very closely related with sustainable development. It has been defined first at the *Regina Conference* in 1987. Wise use uncovers the basic concept that, the conservation and sustainable management of wetlands and its resources is absolutely necessary for the benefits and furtherance of human kind, but in a way, compatible with the maintenance of the natural properties of ecosystem. Ramsar convention has made a considerable contribution to the conservation and wise use of wetland biodiversity, which has been defined by the secretariat

as "the maintenance of their ecological character, achieved through the implementation of ecosystem approaches, within the context of sustainable development" *(Ramsar Convention Secretariat, 2010)*. Furthermore, wise use of wetlands provides a range of collateral benefits for the local residents, who wholly depend on it for their ultimate survival and livelihood. The essential features of wise use include: a) assessment of wetland resources, b) development of national wetland policy, supported by legislative measures for regulation, c) inventory, d) capacity building, e) conservation of wetland sites and f) research *(Rao & Datye, 2003)*.

6.2.1.2 Convention on Biologial Diversity (CBD):

Ramsar convention responds to the *Convention on Biological Diversity*, which is a multilateral treaty, with the objective to develop the national strategy for the conservation and sustainable use of the entire biological diversity. This biodiversity convention is considered as the first comprehensive global agreement which addresses every aspects relating to biodiversity. The CBD has been enunciated in Rio Earth Summit, Brazil on 5 June, 1992 and entered into force on 29 December, 1993. CBD has universal membership of 193 countries as its parties and India becomes a party to CBD in May 1994. The three main goals of this convention include:

1. Conservation of biological diversity
2. The sustainable use of components of biological diversity and
3. Fair and equitable sharing of benefits arising out of the utilization of genetic resources.

CBD aims to encourage and enable all countries to conserve the biological diversity, to ensure its use, and to reconcile the national interests with maintenance of highest possible levels of global biodiversity *(Murthy et al., 2013)*. The 22 May is celebrated every year as the *International day for Biological Diversity* (IDB). This specific date has been proclaimed by the United Nations, in order to achieve prolong understanding and uplifting awareness towards the contribution of sustainable use of biodiversity, sustainable tourism, and economic development. This legally binding agreement (CBD) has done substantial work on the valuation of biodiversity in general, including wetlands as well as other ecosystems.

6.2.2 National initiatives:

6.2.2.1 National Conservation Strategy:

The Government of India aims to overcome the ever increasing threats to wetlands and maintain the values and functions of wetlands for a long term benefits in accordance with

specific strategies, which are set out in the *National Conservation Strategy* by Ministry of Environment and Forest, 1992. The management plan and strategies to be taken for the sustainable use of wetlands are:

1. Protection of the buffer zone near wetlands, to check agricultural encroachment and construction activities, only after thorough analysis of its impact.
2. Effective measures in order to ensure equitable access and responsibility for sustainable use of water resource.
3. Adoption of comprehensive approach for wetland conservation as well as ensure sustainable ecological and economic benefit.
4. Identification, classification and zoning of wetlands for maintaining the water quality as well as enhancing their capability to support various designated uses *(Parikh et al., 2003)*.

6.2.2.2 Ramsar Convention in India:

India is a signatory to Ramsar Convention and has absorbed as a contracting party to this convention in 1981. In last few decades, India has performed an efficient role in conservation and wise use of wetlands. At first, the Chilka lagoon in Orissa and Keoladeo National Park in Rajasthan were designated under the 'Ramsar list' of international importance. On the basis of the country's work in the field of wetland conservation, India has been nominated as a member of standing committee from 1993-1996 and from 1999-2002 *(MoEF, GoI, 2007)*. A total of twenty seven (27) wetlands of India have already been designated as Ramsar sites till date and four (4) are under process of designation. The Sundarban Mangrove in India has been accorded the status of 27th 'Wetland of International Importance' under the Ramsar Convention (Ramsar site no. 2,370) on 30 January, 2019. This site is located within the largest mangrove forest in world, within the delta of the River Ganga and Brahmaputra on the Bay of Bengal in India and Bangladesh as well as listed as an ecological marvel. India has received special acknowledgement at World Park Congress, held at Durban during 2003 for maximum number of sites being entitled in Ramsar list in the year of 2002. During the next triennium, it is proposed to include at least ten sites under the list which will include mosaic of habitats such as high altitude wetlands, corals, mangroves, creeks, and alpine wetlands in the list from India *(MoEF, GoI, 2007)*.

6.2.2.3 Nagoya Protocol under CBD:

India has taken up a unique and innovative biodiversity related activities. The *Nagoya Protocol* on Access and Benefit sharing (ABS) was adopted in 2010 as a supplementary agreement under the aegis of Convention on Biological Diversity (CBD). This protocol translates and gives practical effect to the equity provisions of the Convention on Biological Diversity. It has been signed by India on 11 May 2011 and has entered into force on 12 October 2014. India is successfully following the protocol objectives related with the fair and equitable sharing of benefits arising from the utilization of genetic resources. Moreover, India has hosted the eleventh meeting of the *Conference of Contracting Parties* (COP 11) to the United Nation Convention on Biological Diversity (UNCBD), held from 1-19 October 2012, in Hyderabad. The nation has hosted with an opportunity to fasten, scale-up and strengthen the world wide views on the biological diversity and showcases the leadership on biodiversity in the global arena.

6.2.2.4 National Wetland Conservation and Management Programme:

Acknowledging the importance of protecting the wetlands and water bodies, the Government of India has implemented the *National Wetlands Conservation and Management Programme (NWCMP)* in close collaboration with the concerned State/UT Governments since 1985-86. NWCMP aims at conserving wetlands in the country so as to prevent their further degradation as well as ensuring their wise use for the benefit of local communities and overall conservation of biodiversity *(MoEF, GoI, 2009)*. A total number of 115 wetlands have been identified under this programme till date by the Ministry which requires urgent conservation and management interventions. The identification of selected wetlands comprises several criteria such as location of wetland, topography, area, legal status, intimidations etc. Several steps have been undertaken to arrest further degradation and shrinkage of water bodies due to encroachment, siltation, weed infestation, catchment erosion, surface run-off, which carry pesticides and fertilizers from agricultural fields, and discharge of domestic sewage and effluents. Eventually, this polluted inlets results into deteriorating the water quality, prolific weed growth, decline in biodiversity and other associated problems *(MoEF, GoI, 2007)*. The National Committee on Wetlands, Mangroves and Coral Reefs, 1996 has emphasized the need for formulating national wetland policy in order to stop wetland alteration and degradation, to maintain wetland functions and biodiversity and to establish principles on sustainable resource utilization. In addition, rehabilitation of degraded wetland involving concerned agencies and local community and

application of Environmental Impact Assessment on all activities impacting wetlands *(Rao & Datye, 2003)*. In order to promote effective conservation plan to wetlands and lakes, Ministry of Environment & Forests and Climate Change have implemented two separate Centrally Sponsored Scheme (CSS) namely *National Wetland Conservation Programme (NWCP)* and *National Lake Conservation Plan (NLCP)*, which have further been merged in February, 2013 into a newly integrated scheme called the *National Plan for Conservation of Aquatic Eco-systems (NPCA)*. Further, in order to ensure better conservation and management of existing wetlands, MoEF and CC have notified the *Wetlands (Conservation and Management) Rules* in 2010. Later on, the *Draft Wetland Rules* has been brought in 2016, by the ministry as an amendment to the existing rules of 2010.

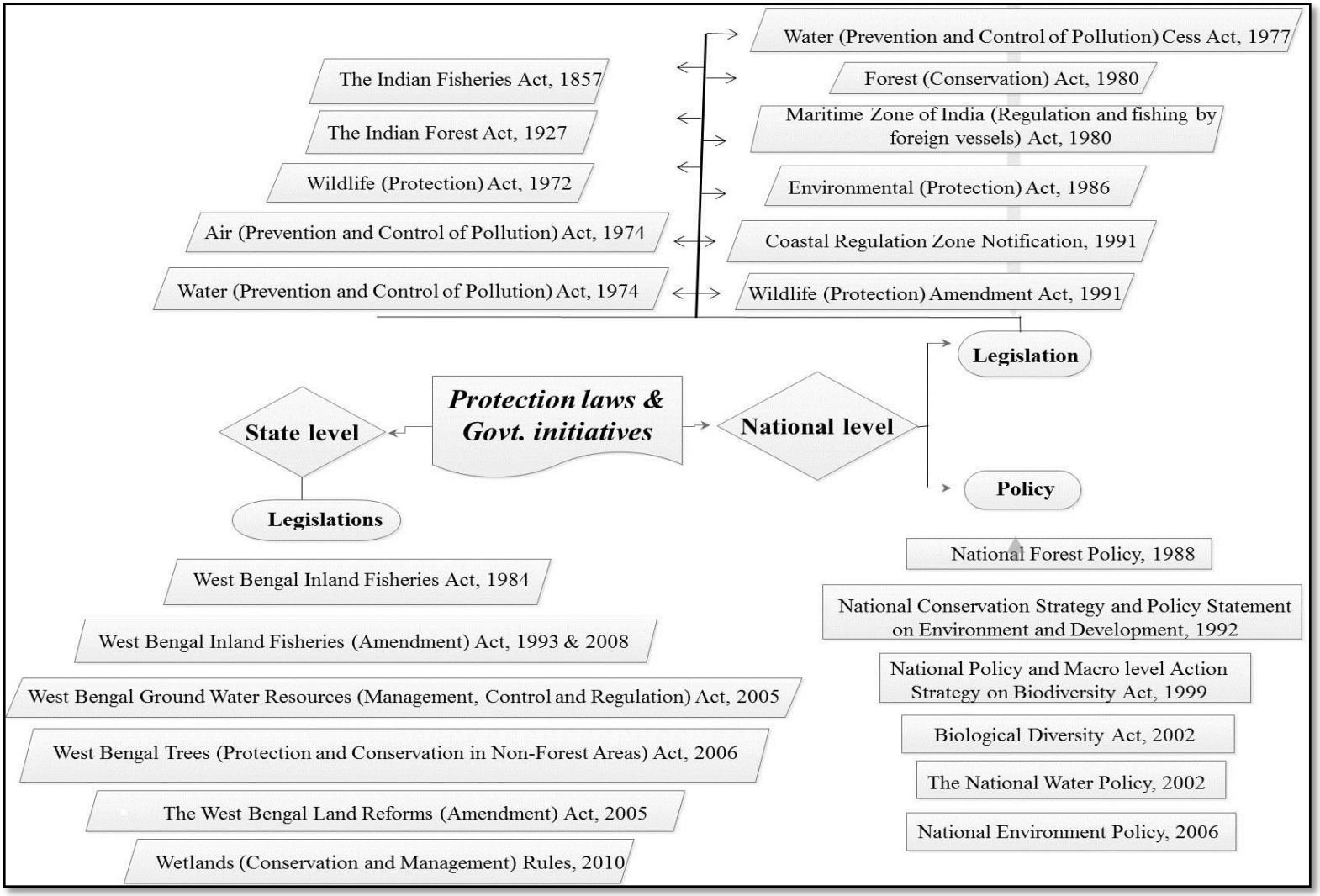
6.2.3 State initiative:

Wetlands in West Bengal are distributed in different geographical regions which range from marine, coastal to inland fresh water wetlands. However, the state is lacking in effective management mechanisms and proper appreciation of their true worth to conserve the wetlands. As a consequence, wetlands are being un-resisted to be downfallen through unsustainable activities, conversion and over exploitation of its resources. West Bengal comprises only two Ramsar sites of international importance namely, East Kolkata Wetland (2002) and Sundarban mangrove (2019). Sundarban (South 24 Parganas) has also been recognized as a *World Heritage Site* by United Nations Educational, Scientific and Cultural Organization (UNESCO) on 7 Dec, 1997 and is considered a biosphere reserve. Kulik Bird Sanctuary (North Dinajpur) is considered as momentous conservation site, which supports 164 bird species of residents and migrants. Further, Ahiron Beel in Murshidabad and the Rasik Beel in Koch Bihar have been designated as the wetlands of national importance under the *National Wetland Conservation Programme* (NWCP). In West Bengal, with the enactment of West Bengal Inland Fisheries Act (1984), the environmental concerns especially regarding wetlands and water bodies has received the acknowledgement as well as become a part of the policy. The state of West Bengal has its own set of laws concerning wetlands, which are given in figure 6.1. In accordance with the Wetland Conservation and Management Rules (2010), under Environment (Protection) Act (1986), the wetlands and water bodies are primarily classified for the purpose of conservation into two classes 1. *Class A* (Forested wetlands) and 2. *Class B* (Non-forested wetlands). Class B is further divided into public and private wetlands, each with another two sub-divisions i.e., natural and man-made *(Dept. of Environment, Govt. of West Bengal, 2012).* Apart from the mentioned legislations

(Figure 6.1), a policy named, *West Bengal Wetlands and Water Bodies Conservation Policy* has been notified in 2012. The policy has recommended that no wetlands and water bodies can be filled up, degraded, drained, converted or subjected to any kind of activity that is incompatible with the ecological integrity of the wetlands. Like all other states, West Bengal is advised to constitute Wetland Conservation Authority as an institutional framework, with the expertise on wetlands to oversee the effective execution of implemented programmes.

6.2.4 Institutional framework, legislations, policy and plan:

Along with formulating wetland protection act as a legislative vehicle, the effective management of wetlands requires a thorough appraisal of the existing laws, institutions and practices in order to restrict any inconvenience of wetlands, which eventually leads to loss of biodiversity as well as all degeneracy of the natural ecosystem. Some of the government initiatives in the form of protection laws and legal tools (legislations) which have already been passed in the Parliament and are directly and circuitously linked with wetlands are displayed in following *(Figure 6.1)*.

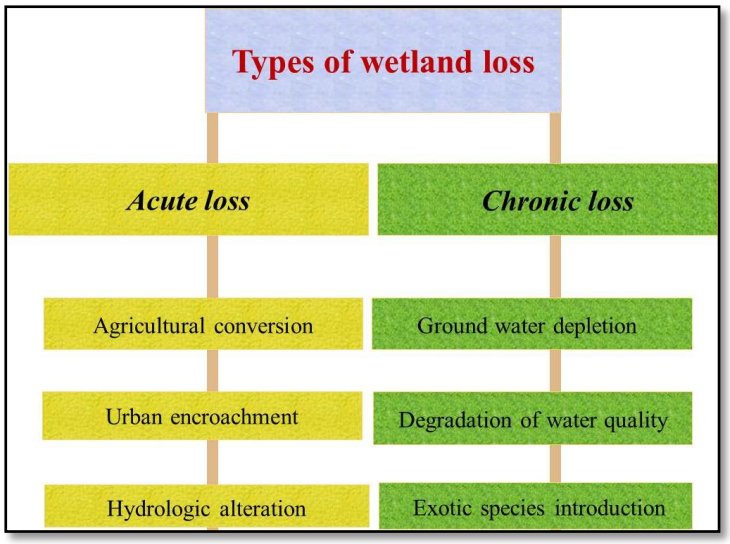


Source: *(Dept. of Environment, Govt. of West Bengal, 2012; Paul & Chanda, 2011; NWCP, 2009; Ramachandra & Ahalya, 2001)*

Figure 6.1 *Institutional framework, legislations, policy and plan*

6.3 Threats to ecological loss of wetlands in Malda:

Malda is significantly occupied by a fairly good portion of area under wetland coverage, which is exceptionally volatile, being particularly vulnerable to the diverse form of environmental changeability. It is well documented that wetlands, located under different physiography, have progressively been lost due to natural as well as anthropogenic activities for several number of years. Presently, a large number of wetlands have been under ongoing threat from environmental degradation in the form of fast expanding human population, land cover change and improper use of wetland resources. Among the threats, to be faced by most of the wetlands are area loss, which can be divided into two broad groups; presented in figure 6.2. The filling up of wet areas with soil and dumping materials constitutes the *acute loss*, whereas the gradual elimination of forest cover with subsequent erosion and sedimentation of the wetlands over many decades is considered as the *chronic loss (Prasad et al., 2002).*



Source: *Prasad et al., 2002*

Figure 6.2: *Types of wetland loss*

In the present study, most of the wetlands have absolutely involved a substantial degeneration of existing wetlands in the form of physical loss in its spatial extent and loss in the wetland functions. Wetland loss may be defined as "the loss of wetland area, due to conversion of wetland to non-wetland areas as a result of human activity" and wetland degradation is "the impairment of wetland functions as a result of human activity" *(Ramachandra et al., 2001).* The major environmental threats to the wetlands and its biodiversity have been observed during study period through diverse forms.

6.3.1 Acute loss

6.3.1.1 Agricultural conversion:

In the present study, the wetlands, located in different blocks are increasingly appalled by ever increasing population growth and resultant agriculture's growing demands for land and water. The wetlands are considered easy prey to encroachment because of poorly defined ownership and because the land underneath is necessary for further developmental activities *(Parikh, 2003)*. The wetlands under study are encircled by agricultural fields, which are considered one of the primary reasons for substantial wetland area loss. The principal threat is the continued expansion of agricultural activities along those wetlands, located at rural periphery *(Table 6.4) (Figure 6.4b)*. This agricultural area expansion leads to unauthorized conversion of wetland into non-wetland purpose as well as progressive direct loss of its spatial extent *(Plate 6.1 & 6.2)*. The trend of reclamation of wetland for the purpose of enhancing agricultural production in order to cope with the growing demand, turn out to be very expensive, both economically as well as ecologically. Although the crop output has definitely been ameliorated district wide, most of the wetlands confront with deadly shrinkage in its areal coverage.

Plate 6.1: *Siali wetland conversion into agricultural field*

Plate 6.2: *Chakla wetland conversion into agrcicultural field*

6.3.1.2 Urban encroachment:

Wetland area shrinkage due to urban construction work is considered another vulnerable cause for acute loss. To cope with the thriving population growth *(Table no. 6.1)*, wetlands are becoming the first onslaught whenever land is required for the expansion of numerous developmental activities such as excavation, filling, draining etc. The construction activity is considered major deleterious methods, resulting in the significant loss of spatial spread of those wetlands, located adjacent to urban centres of Malda district. One of the selected peri-urban wetland is Chatra, which is seriously threatened on account of huge scale

urban encroachment from north-east, east and south-east, which has been started since 1974 *(Plate 6.5) (Map 6.7 & 6.8)*. In order to accommodate the burgeoning population and ever increasing pressure, this peri-urban wetland has made way to the residential layouts, which eventually has contributed to vigorous urban encroachment *(Plate 6.4) (Figure 6.3)*.

Table 6.1 Population growth scenario in adjacent municipal wards around Chatra wetland

Ward No.	Population			Decadal growth (%)	
	1991	2001	2011	1991-2001	2001-2011
03	6735	9157	13097	35.96	43.03
23	8325	11375	14970	36.63	31.60
24	7116	10230	14838	43.7	45.04
25	-	9454	13491	-	42.70

Source: *Primary Census Abstract, Govt. of India 2001&2011; English Bazar Municipality ward based record of 1996 ;(Chattaraj & Sarkar, 2016)*

The construction of bandh road from NH 34, at the east of existing wetland in 1980-81 has encouraged huge encroachment in the form of three big localities of Malanchapalli, Krishnapalli and Buraburitala, which came up in between 1968 to 1980 *(Table 6.2) (Plate 6.3)*. As a consequence, a large portion of Chatra wetland has been wiped out and is being pirated for the settlement related construction, along with further developmental activities such as schools, markets, and roads etc. Ceaseless urban expansion at the cost of wetland area in Malda district continues to generate a range of negligible impacts on environment, which leave an almost indeterminate legacy.

Table 6.2 Chronology of urban encroachment around Chatra per-urban wetland

Locality	Encroachment started	Nature of encroachment
Malancha Pally (South-east of wetland)	1969-70	Lower middle class and middle class migrants from Bangladesh
Krishnapally (East)	1978-79	Lower middle class and middle class migrants from Bangladesh, service holder and workers of unorganized sectors
Buraburitala (North-east)	1982-83	Lower class immigrants, retrial traders and small traders, land developer and service holder.

Along Malda Govt. Teacher's Training College hostel (East-South)	2000-01	Lower class immigrants and workers of unorganized sectors
South of Noonbahi road (North)	2000-01	Lower class immigrants, middle class retailors, middle class whole sellers
Uttar Ramchandrapur & Uttar Jadupur (North-west & South-west)	2000-01	Agricultural encroachment for wheat cultivation and boro rice
Extension of Malanchapally & Krishnapally (towards north)	2010-11	Mainly lower class people from unorganized sectors and displaced people from Manikchak areas
Extension of Malanchapally & Krishnapally (towards south)	2015-16	Lower class people

Source: *English Bazar Municipality unpublished report, 2004; field study ;(Chattaraj & Sarkar, 2016)*

Plate 6.3: *Urban encroachment at Chatra wetland*

Plate 6.4: *Sold plot at Chatra wetland*

Plate 6.5: *Construction work at Chatra wetland*

Plate 6.12: *Brick kiln industry adjacent to Siali wetland*

6.3.1.3 Hydrological alteration:

Wetlands are very sensorial to any kind of hydrological alteration, which can change and hamper the functions, values as well as the entire appearance of wetlands. Most of the wetlands, under study are envisaged by hydrological alteration of water flowing in or change its level. In the case study of Siali wetland, a sluice gate has been built up at Fatehpur village in order to regulate the direct flow of Fulahar River as well as maintain the maximum flow towards Ganga. As a consequence, the surface flow of Siali wetland (located adjacent to River Fulahar) is not being allowed to be channelized some flow during the lean season (pre-monsoon), when the water level is much low and the surface flow within wetland gets disturbed. Resultantly, the inlet connection of this wetland is not at all functioning since 1999. Siali wetland receives only surface flow, coming from the surrounding low lands during monsoon, which ultimately drifts gradually through the outlet towards River Mahananda. Therefore, this wetland maintain relatively low water level throughout the year and especially during pre-monsoon, when the water availability is low.

In another case study of Naghoria wetland the surface flow of River Kalindri has started receding since 1980, due to the establishment of Nurpur Barrage, which has led this wetland to face devoid of water during the lean season (pre-monsoon). Furthermore, in the lower side of Naghoria, the Kalapahar sluice gate which generally regulates the post monsoon flow, is found non-functioning, and practically this wetland has not been receiving any flow from River Fulahar, is flowing directly to River Ganga in order to maintain an optimum level of water reserve at Farakka barrage throughout the year. Thus erroneous unplanned sluice gate formations conduct an imbalance between the proper inflow and outflow within these wetlands and related long term dearth of water resource. This eventually changes the water level and the volume of surface water flow, especially during lean season *(Chattaraj & Sarkar, 2018)*. As a consequence, the peripheral settlers especially of bed villages (Nagharia, Lakshmighat) encounter immense sufferings from the changing scenario of the traditional socio-economic condition. Further, most of the wetlands, under study experience another change in wetland hydrology in the form of over exploitation of water especially for irrigation and cultivation purpose throughout the year from the peripheral habitat and make differences in water level, goes down *(Plate 6.6 & 6.7).*

Plate 6.6: *Water extraction from Chatra wetland through pump*

Plate 6.7: *Water extraction from Naghoria wetland through Marshal*

6.3.2 Chronic loss

6.3.2.1 Ground water depletion:

Chronic losses include the impairment of wetland functions as a response of human interference. In the present study, the wetlands are considered an exigent part of the hydrological cycle for minimizing the malignance of flood, recharging the ground water as well as maintaining the overall balance of a substantial hydrological, ecological and biological role in the natural functioning of entire district. Several negative externalities in the form of wetland area encroachment and hydrological alterations result into loss of aquifer and resultantly, the ground water reservoir is getting decayed. There is the risk that the ecological characters of wetlands, adjacent to urban localities are being altered to the point where the essential regulating and supporting services *(Figure 5.1)* are lost. These disturbances reduce the benefit that society receives from wetland in controlling the frequent flood occurrence. Presently, the depletion of ground water in wetlands under study is fast and their restoration become very difficult, once these areas are put to mankind use. Furthermore, inestimable pressures on wetland in the form of groundwater extraction, as well as pollution have been documented as extending well beyond the municipal boundaries. Degradation and disappearance of wetlands and water bodies are directly responsible for lowering the ground water table, which is evident from early works in Bangalore city *(Ramachandra & Ahalya, 2001)*.

6.3.2.2 Degradation of water quality:

The deterioration of wetland water quality, through supremely infilling and inflow of polluted urban and agricultural waste water is considered another most visualized problem in the wetlands under study. The wetlands are the primary receptacles for agricultural discharge,

full of agro-chemicals, which has brought the crisis of non-point source pollution (pollutants come from widespread area and cannot be traced as a single point source) into forefront. Intensive agricultural activities in association with intensive aquaculture disturb the wetland ecosystem by adding the loads of pollutants such as pesticides, fertilizers, antibiotics, and disinfectants. Out of the selected wetlands, Chakla, Siali and Naghoria are subjected to inflow the ill effects of fertilizers and insecticides, which are used in adjoining agricultural fields as well as aggravate the pollution load *(Plate 6.9)*. A spurt in the volume of agricultural effluents entering the wetland has led to the problem of pollution, and toxic contamination by pesticides and organic compounds. Pollution from agricultural land run-off add materials to surface water and ground water which eventually upset the balance of wetland water chemistry in the form of water pH, conductivity and dissolved oxygen level as well as the biogeochemical cycle of materials in wetland ecosystems. In the present study, wetland siltation is coupled with anthropogenic activity (intensification of agriculture) and results into ever increasing rate of sedimentation, which eventually raise the wetland bed, decline the volume of surface flow, alter the biological composition as well as demote their present status. Moreover, deficiency in proper management of non-point source of pollution like agricultural run-off and unregulated land use management have misled people to consider these wetlands as waste lands that are afflicted by malaria and other vectors thereby, weakening the multiple benefits that they provide. In the context of peri-urban wetland, pollutants such as pesticides, sediments, domestic sewage discharge from different point-sources (also known as 'the end of pipe pollution' i.e., pollutants come from a specific source e.g., direct discharge of municipal sewage) and non-point sources (run off from agricultural fields) degrade this wetland functions and affect the entire wetland biodiversity *(Plate 6.8).* To make their situation worse, illegal dumping of solid waste at the close proximity of wetland edge, especially into Chatra wetland contribute to wetland loss and degradation *(Plate 6.10) (Figure 6.3).* Furthermore, rapid expansion of brick kiln industry *(Plate 6.12)*, surrounding the wetlands irrespective of urban and rural periphery, results into polluted water discharge into wetlands under study as well as degrade the water quality.

Plate 6.8: *Point source pollution into Chatra wetland from ward no. 25*

Plate 6.9: *Non-point source pollution into wetlands*

Plate 6.10: *Solid waste dumping at Chatra wetland*

Plate 6.11: *Brick kiln industry adjacent to Chatra wetland*

6.3.2.3 Introducing invasive species and resultant eutrophication:

Water pollution and resultant degradation of wetlands often enhance the accelerated growth of invasive species (one that rapidly spread and replace the native species), which threat wetland ecology and clog the water ways. Moreover, the introduction of invasive species within wetlands often leads to eutrophication (the process of water quality degradation, caused by excessive nutrients), which restricts the exchange of oxygen across the air/water interface within wetlands as well as hampers the process of photosynthesis. Further, extended eutrophication initially lead to algal bloom, which reduces the dissolved oxygen level and subsequently augment the mortality of various benthic organisms. The wetlands under study are encountered prominently by accidental and deliberate arrival of invasive species (*Eichhornia crassipes*, *Pistia stratiotes*) *(Plate 6.13; 6.14 & 6.15)* which eventually decimate the native species, significantly alter the aquatic food webs, and reduce the economic value of productive habitat. The wetlands, located adjacent to urban centers in Malda district, are sustained by inflow, beyond its assimilative capacity, which has further led

to eutrophication *(Plate 6.16)* and results into profuse growth and spread of water hyacinth as well as degrade the ecological integrity of wetland ecosystem.

Plate 6.13: *Eichhornia crassipes coverture in Chatra wetland*

Plate 6.14: *Eichhornia crassipes in Naghoria wetland*

Plate 6.15: *Pistia stratiotes in Chatra wetland*

Plate 6.16: *Eutrophication in Chatra wetland*

6.3.2.4 Biodiversity loss:

Wetland resources have been utilized at or beyond their sustainable limits, which cause significant threat to wetland biodiversity and resultant habitat loss. Contextually, the ever increasing demand for enhancing economic growth during last few decades with utter contempt for the long term ecological consequences has led to over exploitation of wetlands of Malda district. Moreover, poor equity of access to the benefits, derived from wetland ecosystem services and native poverty also result in over exploitation of wetland resources out of its economic necessity. In the selected case studies namely; Chakla, Siali and Naghoria wetland, the water quality and quantity deteriorations have contributed to substantial degeneration of biological diversity as well as productivity of wetland ecosystem. Furthermore, Naghoria wetland experiences immense downfall in number of fish fauna, because of over fishing and faulty fishing practices including net fishing, which upset the

balance and food web. In Chatra wetland, rapid urbanization swallows the wetland from the east ward side (north-east and south-east), which not only minimizes its spatial extent, but results into direct habitat loss and generates additional pressure on its existing biodiversity *(Figure 6.3)*. The unsustainable planning and subsequent use of water resources in order to support urban population have a significant impact on wetlands and the biodiversity, which support far beyond the peri-urban environment *(McInnes, 2013)*. During field observation and interviewing the local settlers, the detrimental impacts on the arrival of migratory birds along with other animal population have clearly been documented. Acute disturbance in habitat and food in the form of removal of aquatic vegetation and overfishing within wetlands of Malda district are assumed to have caused the disappearance of big migratory colony of Spot bills, Pochards and Pintails in last ten to fifteen years.

In the case study of peri-urban wetland (Chatra wetland), a household survey by random sampling (2% of household) with total number of 173 households, from the adjacent municipal wards (no. 3, 24 and 25) along the north-east, east and south-east boundary has been conducted in 2016-17 in order to know the perception on wetland environment *(Appendix-11) (Figure 6.3)*. The field study, field observation along with the household survey reveals that, Chatra wetland edge and open water experience the problem of solid waste dumping, as proposed by 63 households (36.42%) from the adjacent municipal wards. Moreover, being a peri-urban wetland, it encounters number of threats in which the majorly dominated one is wetland area encroachment as opined by 71 households (41.04%), followed by solid waste dumping with wetland (16.76%), water pollution (9.83%) from both point and non-point pollution sources. A small number of surveyed households (6.36%) have been found conscious regarding declining species diversity, whereas 45 no. of households (26.01%) have expressed their concern regarding this precious natural ecosystem with the respect to all the mentioned wetland degrading parameters *(Figure 6.3) (Appendix 11)*. Furthermore, the household survey reveals that, 42 numbers (24.28%) of households, residing in the contiguous municipal wards feel very serious and think the declining trend of wetland biodiversity, especially the aquatic fauna as vulnerable. The field study also reveals that, the abundance of migratory bird colony during winter months has been recorded relatively less, as compared with other case studies (*Figure 3.15*) in and around Chatra wetland.

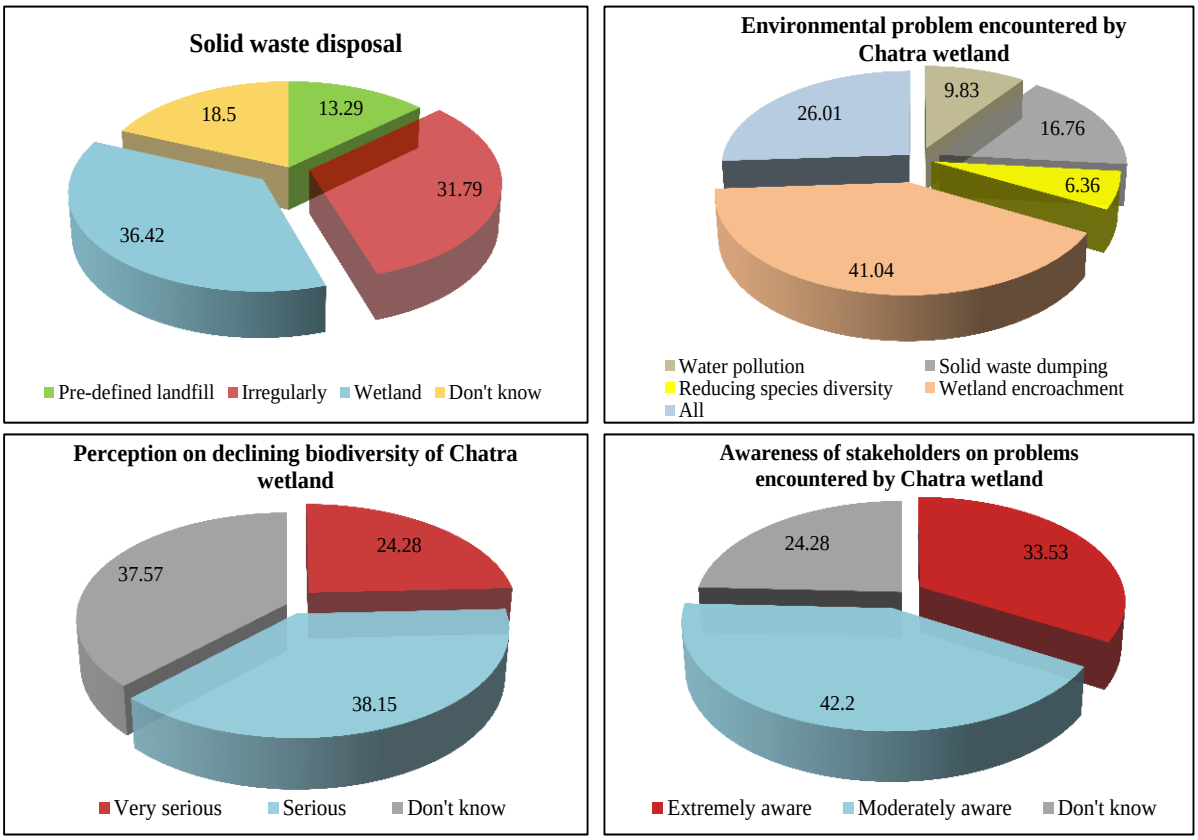


Figure 6.3: *Perception on wetland environment (Chatra) from English bazar municipal ward no. 3, 24 and 25*

The household survey to the adjacent municipal wards has been conducted in order to know, the level of awareness of the settlers as well as the stakeholders regarding these mentioned problems, encountered by Chatra wetland. A total of 58 households (33.53%) are extremely aware and some of those stakeholders have already been engaged with different NGOs and are being the members of Malda Vigyan Mancha and Jalabhumi Suraksha Samiti, whereas, 73 households (42.2%) are moderately aware regarding the problems, frequently encountered by Chatra wetland. The field study also reveals that, a total of 42 households (24.28%) still do not feel and even do not know, that what awareness is and why is it necessary in order to provide a sustainable future *(Appendix 11) (Figure 6.3)*.

The potential for preserving and promoting sustainable livelihood and so alleviating poverty and contributing to national development through wise use, management of wetland ecosystem has not yet been realized *(Friend, 2007)*. The lack of understanding and recognition to wetlands leads to ill-informed decision on wetland management, which eventually contributes to incessant degradation of this natural ecosystem. Instead of having

sound governmental commitment and necessary expertise there is unyielding sectoral approach with minimal inter sectorial planning and coordination. Therefore, it is time to plan for raising awareness on the importance of wetlands and for extending strategies of wetland restoration and conservation.

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6.4 Land use land cover (LULC) change around selected wetlands:

In order to assess the level of encroachment of wetland area as well as associated land use land cover changes, the mapping procedure has been done by comparing and analyzing satellite imagery data in the selected wetlands in Malda district.

6.4.1 *Siali wetland:*

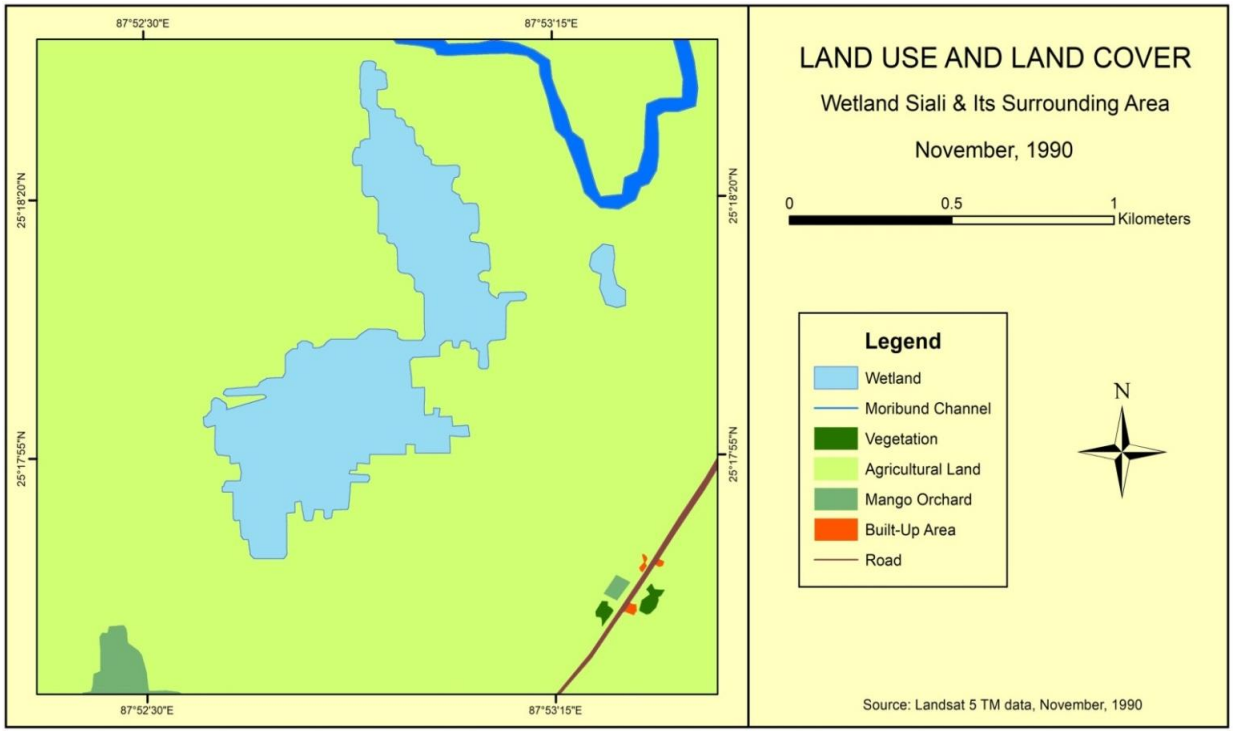
Siali wetland encounters immense challenges from reducing its spatial extent and losing its enormous growth potential for fishing, water fowls as well as the entire socio-economy of the peripheral settlers. As per satellite imagery (TM and OLI), the land use land cover dynamics has conspicuously been identified, where the area extension of wetland has been reduced from 47.49 ha to 18.74 ha with an absolute change of -28.85 ha (-60.63%) during the time frame 1990 to 2018. The commercial utilization of land use, surrounding Siali wetland is chiefly executed especially by mango orchard, which has increased from 3.50 ha to 24.93 ha and brick kiln industry (came into being after 1990) from 0 to 9.02 ha during 1990 to 2018. Moreover, built-up area has been increased negligible, whereas, the agricultural land has been reduced from 355.53 ha to 353.81 ha, as well as converted to mango orchards. Other land use land cover record almost no change around Siali wetland. Table 6.3, figure 6.4a, map 6.1 and 6.2 are self-explanatory.

Table 6.3 Land Use and Land Cover (LULC) change of Siali wetland and its surrounding area in between 1990 and 2018

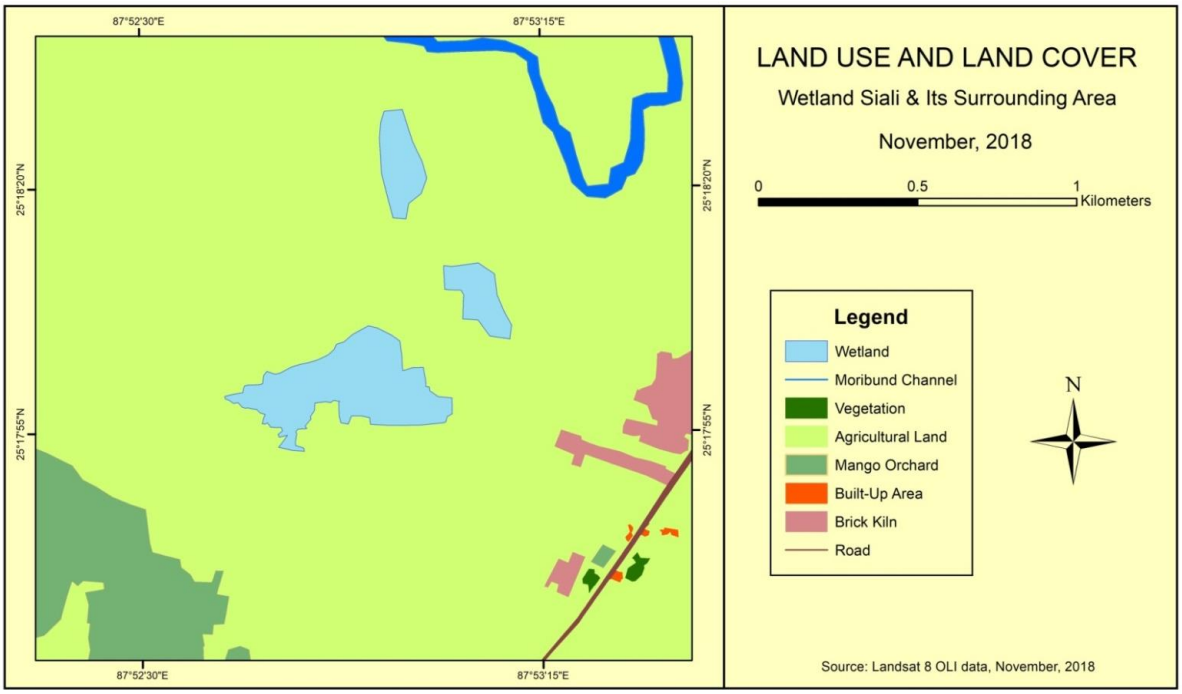
Class Name	Area (ha) 1990	% Area of LULC (1990)	Area (ha) 2018	% Area of LULC (2018)	Absolute change of LULC	% of change of LULC	Status
Agricultural Land	355.53	85.69	353.81	85.28	-1.71	-0.48	Almost No Change

Built-up Area	0.22	0.05	0.35	0.08	0.13	56.46	Increase
Moribund Channel	5.93	1.43	5.94	1.43	0.00	0.01	Almost No Change
Road	1.57	0.38	1.57	0.38	0.00	0.01	Almost No Change
Vegetation	0.55	0.13	0.55	0.13	0.00	-0.02	Almost No Change
Wetland	47.59	11.47	18.74	4.52	-28.85	-60.63	Decrease
Total Area	414.90	100.00	414.90	100.00			

Source: *Landsat 5 TM data (1990), Landsat 8 OLI data (2018), November*



Map 6.1: *Land Use and Land Cover change of Siali wetland and surrounding area in November, 1990*



Map 6.2: *Land Use and Land Cover change of Siali wetland and surrounding area in November, 2018*

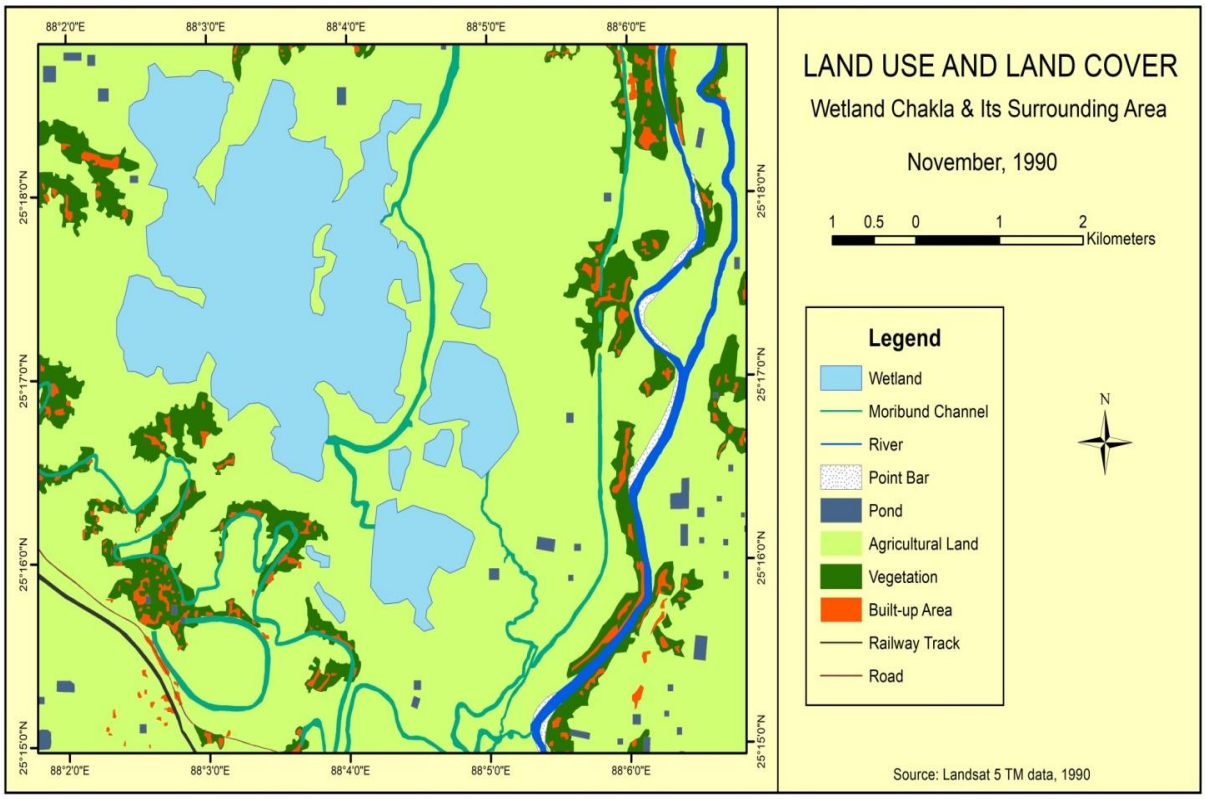
6.4.2 *Chakla wetland:*

The significance of Chakla wetland is restlessly threatened due to ever increasing pressures from unplanned land use activities *(Table 6.4) (Map 6.3 & 6.4)*. An immense livelihood dependency has mounted serious environmental pressures on this ecosystem and has affected them to such an extent that their benefits have declined significantly. The field observation and satellite imagery analysis reveals that the wetland area has been reduced from 1137.13 ha to 842.50 ha with an absolute change of -294.63 ha (-25.91%) during 1990 to 2018. The area under natural vegetation around this vast water body has been decreased by -77.52 ha (-15.62%), which has been converted into agricultural land. As a consequence, the area coverage under agricultural land has been increased from 4123.51 ha to 4411.98 ha, whereas the built-up area has also recorded an increasing trend by 82.59 ha (63.49%) from 1990 to 2018. Table 6.4, figure 6.4b, map 6.3 and 6.4 are self-explanatory.

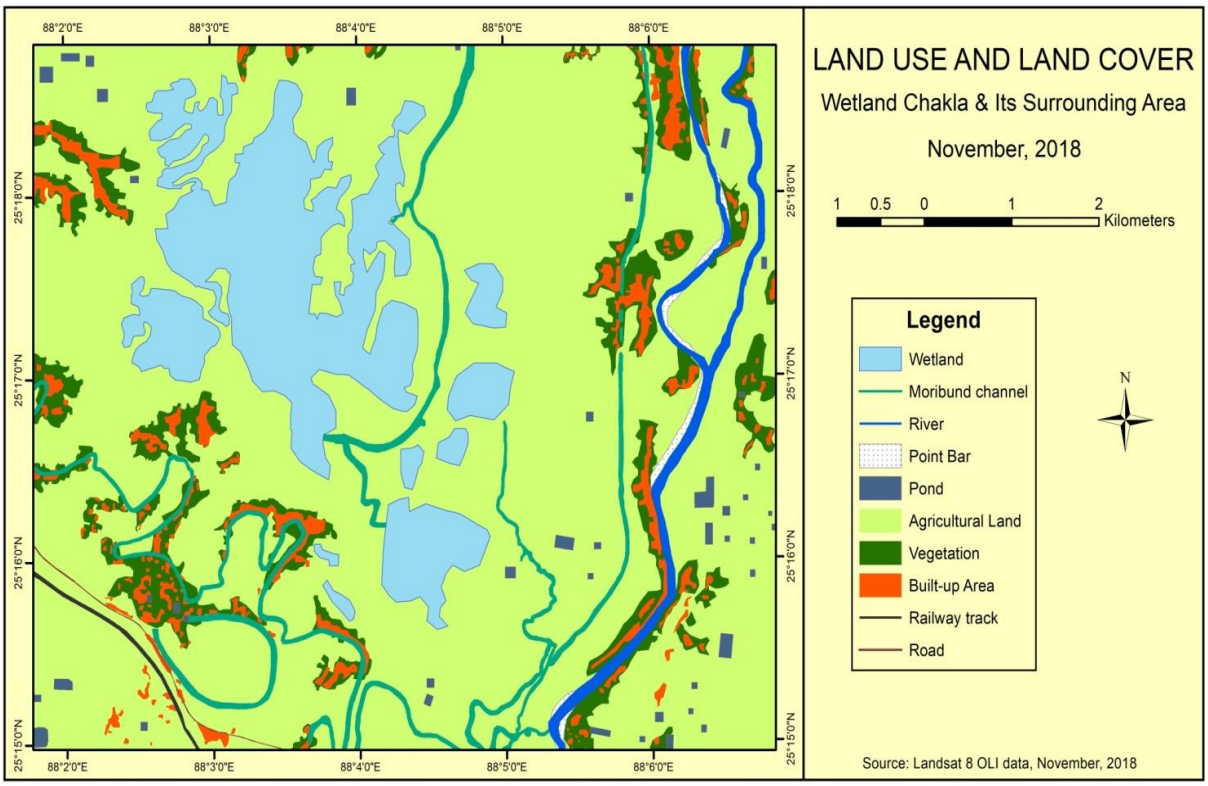
Table 6.4 Land Use and Land Cover (LULC) change of Chakla wetland and its surrounding area in between 1990 and 2018

Class Name	Area (ha) 1990	% Area of LULC (1990)	Area (ha) 2018	% Area of LULC (2018)	Absolute change of LULC	% of change of LULC	Status
Agricultural Land	4123.51	66.86	4411.98	71.54	288.47	7.00	Increase
Built-up Area	130.08	2.11	212.68	3.45	82.59	63.49	Increase
Moribund Channel	115.57	1.87	116.95	1.90	1.38	1.20	Almost No Change
Point Bar	24.07	0.39	24.08	0.39	0.01	0.04	Almost No Change
Pond	48.93	0.79	48.93	0.79	0.00	0.00	Almost No Change
Railway Track	11.60	0.19	11.60	0.19	0.00	0.01	Almost No Change
River	77.12	1.25	76.55	1.24	-0.57	-0.74	Almost No Change
Road	5.00	0.08	5.00	0.08	0.00	0.00	No Change
Vegetation	494.52	8.02	417.27	6.77	-77.25	-15.62	Decrease
Wetland	1137.13	18.44	842.50	13.66	-294.63	-25.91	Decrease
Total Area	6167.53	100.00	6167.53	100			

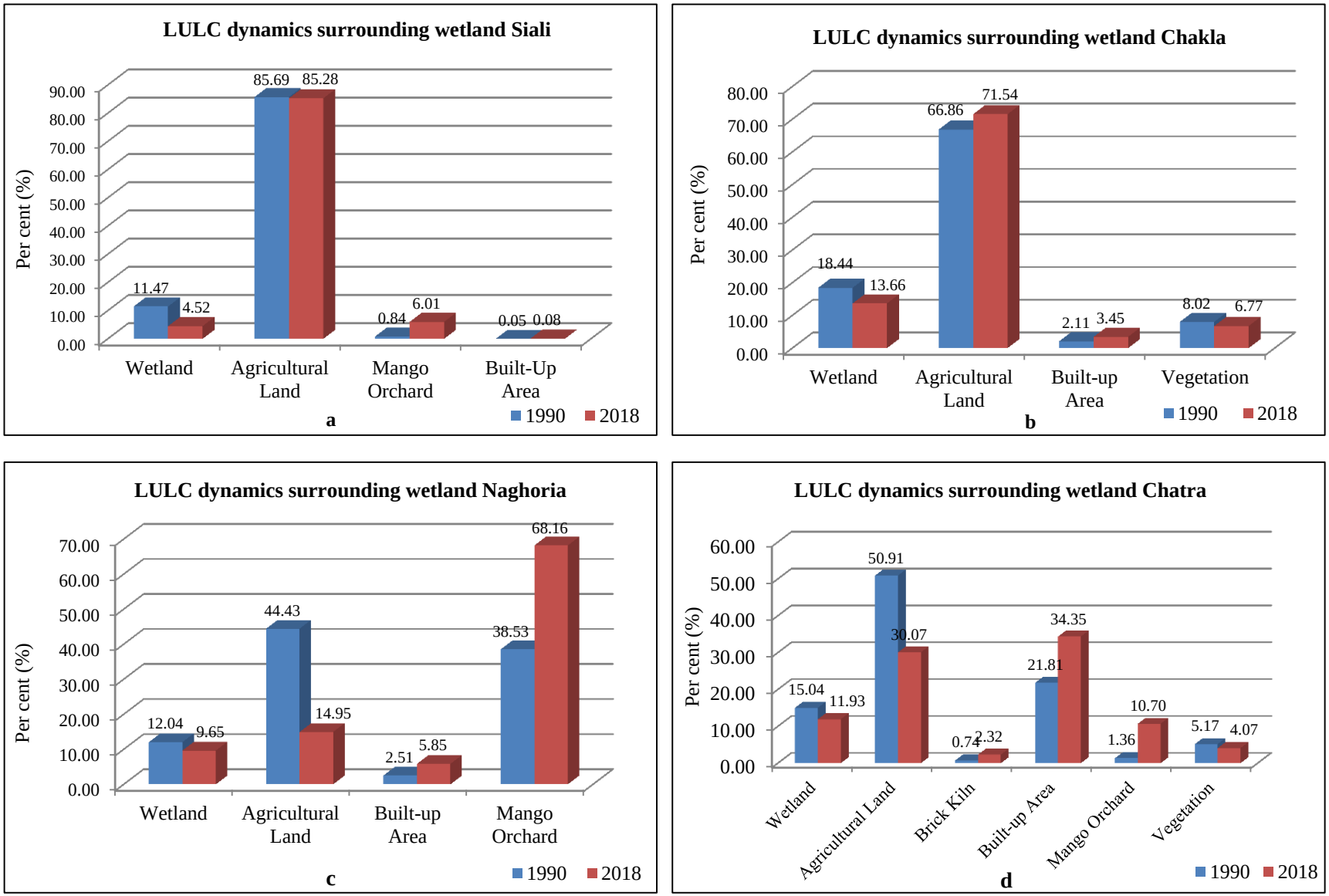
Source: *Landsat 5 TM data (1990), Landsat 8 OLI data (2018), November*



Map 6.3: *Land Use and Land Cover change of Chakla wetland and surrounding area in November, 1990*



Map 6.4: *Land Use and Land Cover change of Chakla wetland and surrounding area in November, 2018*



Source: *Landsat 5 TM data (1990), Landsat 8 OLI data (2018), November*

Figure 6.4: *Land Use Land Cover dynamics surrounding case studies between 1990 and 2018*

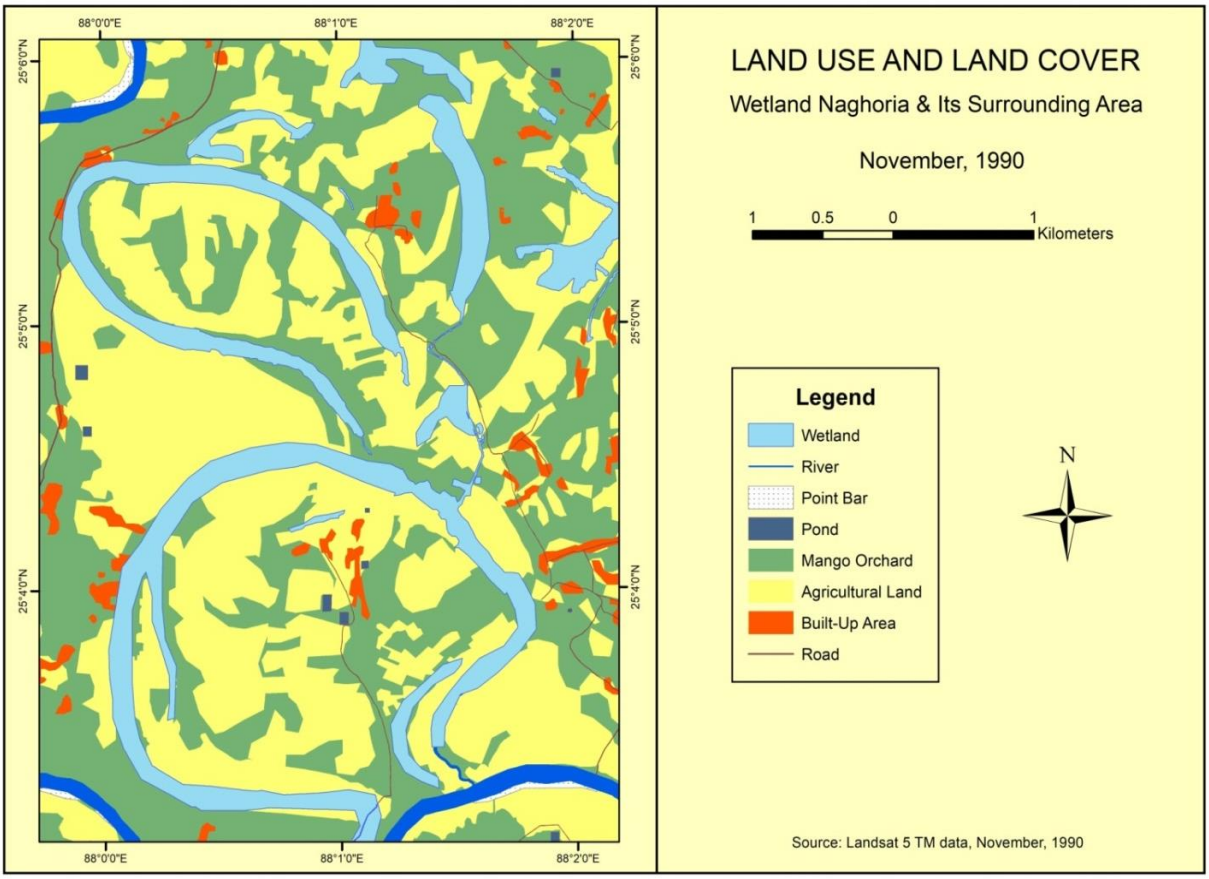
6.4.3 *Naghoria wetland:*

Naghoria wetland encounter immense challenges which results into direct loss and change the way it functions. The wise use of this cut off is lying neglected for long term. As per the field study and satellite imagery observation, the wetland area has been decreased from 284.62 ha to 228.13 ha with -56.49 ha of absolute change (-19.85%) from 1990 to 2018. The land use land cover dynamics has recorded massive change, where the agricultural land has been diminished by -697.09 ha (-66.36%), which has wholly been converted into mango orchards. The commercial utilization of land area adjacent to Naghoria wetland has chiefly been devoted to mango orchards, which increases from 911.07 ha to 1611.65 ha during 1990 to 2018. Moreover, built-up area has also been increased by 78.81 ha during last 30 years. Table 6.5, figure 6.4c, map 6.5 and 6.6 are self-explanatory.

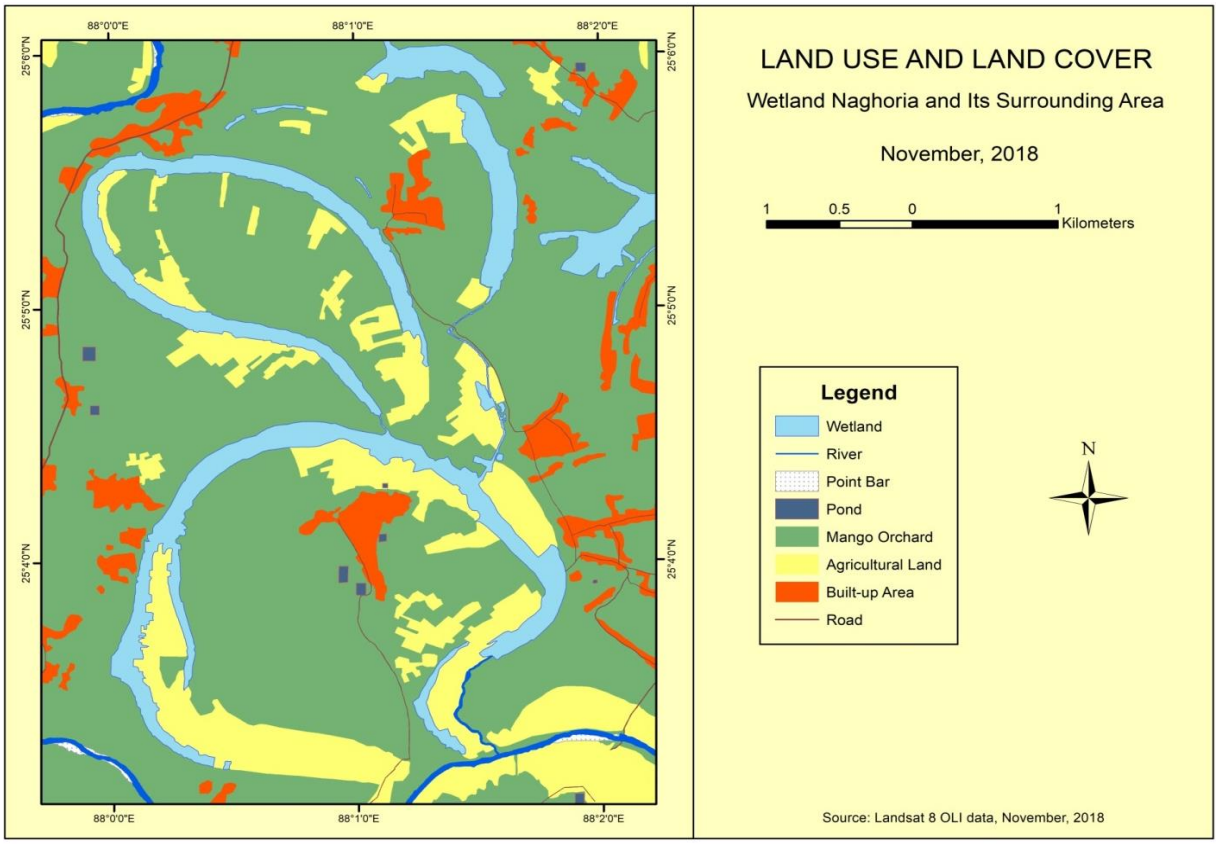
Table 6.5 Land Use and Land Cover (LULC) change of Naghoria wetland and its surrounding area in between 1990 and 2018

Class Name	Area (ha) 1990	% Area of LULC (1990)	Area (ha) 2018	% Area of LULC (2018)	Absolute change of LULC	% of change of LULC	Status
Agricultural Land	1050.52	44.43	353.43	14.95	-697.09	-66.36	Decrease
Built-up Area	59.41	2.51	138.22	5.85	78.81	132.65	Increase
Mango orchard	911.07	38.53	1611.65	68.16	700.58	76.90	Increase
Point bar	8.79	0.37	4.41	0.19	-4.38	-49.83	Decrease
Pond	4.07	0.17	4.07	0.17	0.00	0.04	Almost No Change
River	34.96	1.48	13.48	0.57	-21.48	-61.44	Decrease
Road	10.93	0.46	10.96	0.46	0.06	0.54	Almost No Change
Wetland	284.62	12.04	228.13	9.65	-56.49	-19.85	Decrease
Total Area	2364.38	100.00	2364.35	100.00			

Source: *Landsat 5 TM data (1990), Landsat 8 OLI data (2018), November*



Map 6.5: *Land Use and Land Cover change of Naghoria wetland and surrounding area in November, 1990*



Map 6.6: *Land Use and Land Cover change of Naghoria wetland and surrounding area in November, 2018*

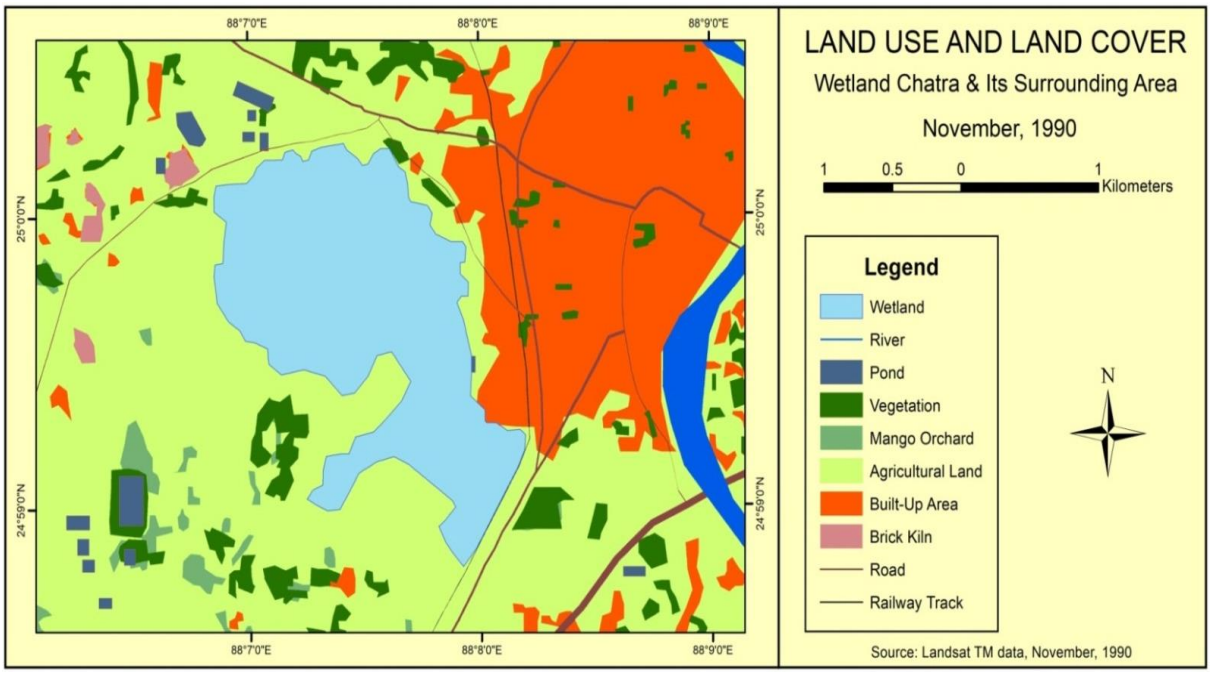
6.4.4 *Chatra wetland:*

Chatra wetland is the only peri-urban water body of Malda district, which is bounded in entire east (including north-east and south-east) by ward no. 3, 24 and 25 under English Bazar Municipality. Being neglected over the years by the municipality and district administration, this unique wetland confronts maximum amount of encroachment from the peripheral area in the form of human habitation and associated economic activities. These anthropogenic disturbances generate serious threats to the very existence of this precious ecosystem *(Map 6.7 & 6.8)*.

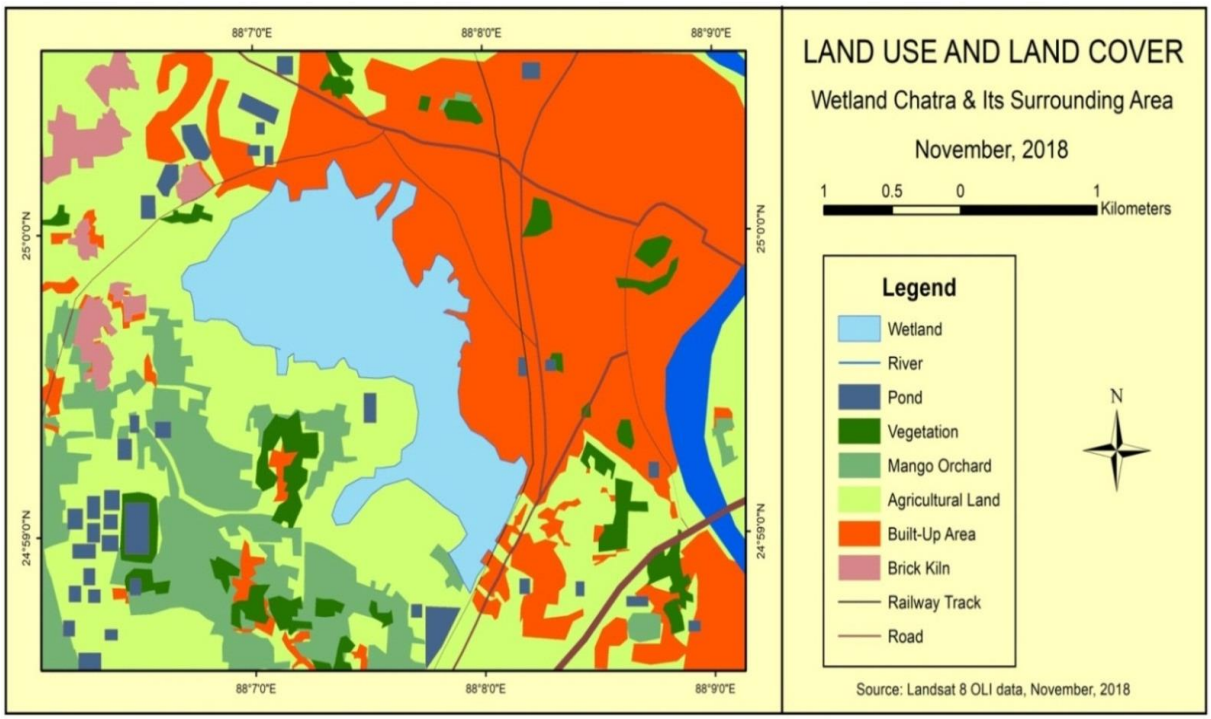
Table 6.6 Land Use and Land Cover (LULC) change of Chatra wetland and its surrounding area in between 1990 and 2018

Class Name	Area (ha) 1990	% Area of LULC (1990)	Area (ha) 2018	% Area of LULC (2018)	Absolute change of LULC	% of change of LULC	Status
Agricultural Land	1001.22	50.91	591.30	30.07	-409.92	-40.94	Decrease
Brick kiln	14.46	0.74	45.60	2.32	31.15	215.43	Increase
Built-up Area	428.95	21.81	675.59	34.35	246.64	57.50	Increase
Mango orchard	26.77	1.36	210.41	10.70	183.64	686.10	Increase
Pond	19.76	1.01	50.93	2.59	31.17	157.68	Increase
Railway Track	3.39	0.17	3.39	0.17	0.00	0.00	Almost No Change
River	42.64	2.17	41.82	2.13	-0.82	-1.93	Almost No Change
Road	31.94	1.62	32.90	1.67	0.96	3.01	Increase
Vegetation	101.72	5.17	80.09	4.07	-21.63	-21.26	Decrease
Wetland	295.73	15.04	234.54	11.93	-61.18	-20.69	Decrease
Total Area	1966.58	100.00	1966.57	100.00			

Source: *Landsat 5 TM data (1990), Landsat 8 OLI data (2018), November*



Map 6.7: *Land Use and Land Cover change of Chatra wetland and surrounding area in November, 1990*



Map 6.8: *Land Use and Land Cover change of Chatra wetland and surrounding area in November, 2018*

In the present study, after analyzing the satellite imagery, the wetland area has been recorded to be synchronizing from 295.73 ha to 234.54 ha during the time period 1990 to 2018, with an absolute change of -61.18 ha (-20.69%). The land use land cover dynamics has recorded massive change around Chatra wetland in the form of built-up area, which has increased by 246.64 ha (57.50%) and mango orchard, increased by 183.64 ha (686.10%) during 30 years interval (1990-2018). Furthermore, the land area, surrounding this peri-urban

wetland has increasingly been utilized for commercial purpose in the form of brick kiln industry, the area of which has increased by 31.15 ha during mentioned time period. Moreover, the area under natural vegetation has been reduced down by 21.63 ha, which has further been converted to built-up area, being the chief encroacher of Chatra wetland. Table 6.6, figure 6.4d, map 6.7 and 6.8 are self-explanatory.

6.5 Conservation of wetlands in Malda district:

The conservation and management strategies of wetlands under study keenly look at an integrated research work with precise understanding regarding wetland values and functions as an indispensible tool for constructing a long term conservation strategies. Conservation education is a tool, which can effectively be used for behavioural change by making people aware and by changing their attitudes towards wetlands and environment *(Mahajan, 2003)*.

6.5.1 Conservation strategies and recommendation of selected wetlands:

6.5.1.1 *Siali Wetland:*

In order to avoid further loss and degradation of this natural ecosystem and to maintain the values and functions of wetlands for the long-term benefit, appropriate management and restoration mechanisms need to be implemented. This entails:

1) The operation of already installed sluice gate is to be oriented in such manner to simplify the regular inflow and requisite outflow in order to maintain an adequate surface flow and water volume within wetland throughout the year. Moreover, the inflow and outflow channels, connected with Siali wetland are to be cleared every year with a regular interval especially before the arrival of monsoon (July – September).
2) Patrolling and regular surveillance at wetland site to resist further shrinkage of its spatial extent as well as conversion of wetland into agricultural land.
3) Wetland conservation and management strategy must be comprehensive in terms of addressing the myriad water quality problems, which persist from the non-point source of pollution. Hence, identification of non-point pollution sources (Agricultural runoff, domestic waste) along with the continuous monitoring on the quality of infiltrating water draining into Siali wetland is required.
4) Manual or mechanical de silting and dredging of Siali wetland is immediately to be implemented in order to keep the water volume intact within wetland throughout the year.

5) Makhana cultivation should be succeeded zone wise in this wetland through planned and regulated manner without backpedal the traditional fishing practices as well as keeping the villagers' economy unharmed. Further, frequent monitoring on the use of insecticides before sowing makhana seeds on wetland bed is to be practiced.
6) Over exploitation of wetland resource (over fishing, faulty fishing, and water extraction for irrigation) should strictly be prohibited in order to sustain heterogeneous assemblage of floral and faunal diversity.
7) Promoting awareness regarding the benefits of wetland through wide public awareness campaigns are to be formulated among the stakeholders.
8) Construction of partial embankment to connect Fatepur and adjoining villages surrounding Siali wetland with the main road (Bhaluka road and NH 81) for the purpose of planned eco-tourism development along with the setup of eateries and shops. So that, tourists may be encouraged to come here by cycle-rickshaw or auto-rickshaw from Harishchandrapur (nearest railway station).

6.5.1.2 *Chakla Wetland:*

Adequate management and restoration strategies are need to be redacted in order to rake up and conserve the physical and biological integrity of Chakla wetland. The actions suggested are as follows:

1) Sincere monitoring and productive engineering work are to be implemented in order to keep the surface flow intact within wetland throughout the year by increasing the inflow (through Nuna River in north and Bhoga River in the south) during post-monsoon and checking outflow during monsoon, thus simultaneously recharging the ground water.
2) De siltation and clearance of Mara Mahananda River (flowing south-west of wetland) in regular interval through conventional method in order to regulate the inflow within Chakla wetland complex including Khanpur, Singra and Chakla wetlands.
3) Formulation of stringent legal action against conversion of wetland complex area for non-wetland purposes (agricultural field). Moreover, identifying the non-point source pollution into wetland along with dynamic monitoring is awfully momentous on use of pesticides, land run-off from surrounding agricultural fields within wetland; at least twice a year.

4) Regular monitoring on the physico-chemical components of this wetland water before and after the monsoon season is required for maintaining an orderly scientific pisciculture. So that, it provides a technical support, which aid in formulating comprehensive wetland conservation, restoration and management programme.
5) The existing five fishing cooperative society under Malatipur Gram Panchayat should provide unique opportunity to devise mechanisms in order to promote commercial pisciculture and conserve this wetland complex in a better and coordinated way.
6) Fostering innovative strategy is essential to enhance the fishing activity in an organized way by practicing in already waterlogged agricultural fields for a long time period in a year. It will facilitate in boosting the adjoining rural economy for mass of fishermen.
7) Regulating the diversion and over extraction of water for irrigation and empowering local habitants to establish a participatory, equitable and accountable wetland water use.
8) The awareness and educational programme regarding once existing mega biodiversity in Chakla wetland should be formulated by the scientist and NGOs with the purpose of restoration and conservation of those species (resident and migratory birds, faunal species), which are at the brink of extinction.

6.5.1.3 *Naghoria wetland:*

In order to protect and conserve Naghoria wetland with keeping in view the tremendous potentialities in terms of ecological and economic viabilities and at the same time to maintain its wise use, some actions are suggested as follows:

1) In order to maintain a substantial water table throughout the year within this cut off, the inflow and out flow channels in the form of Nurpur barrage and Kalapahar sluice gate will have to be reoriented. A well-planned arrangement is required in order to increase the recharge potential of this water body as well as to improve the ground water table.
2) Restricting and preventing wetland area conversion to non-wetland purpose (agricultural land and mango orchard) and prohibiting resultant fragmentation in the catchment area. Immediate fencing from eastern (Lakshmighat village) and southern (Naghoria village) part is very urgent in order to arrest further encroachment and

conversion to active agricultural tract. And hoarding with caution notice should be fixed along with clearly drawn demarcation line between wetland area and surrounding agricultural fields.

3) The conservation and management strategies of Naghoria wetland must involve the protection of wetland by checking and regulating the impact of insecticides, fertilizers and effluents, draining into this cut-off from adjacent agricultural tracts. Appropriate and successful long term management of Naghoria wetland require, environmental awareness programme to correct non-point source pollution problem and make a buffer zone at the interface between the water body and adjacent land area, so as to limit anthropogenic activities around this wetland.
4) In association with the previous one, wetland conservation should include the protection of wetland by using water quality standards and safeguarding the biodiversity and productivity. Moreover, strict and continuous monitoring on net fishing and killing of young stocks within wetland and implementing organized fishing practice under the supervision of Uttar Lakshipur and Phulbaria Gram Panchayat is necessary.
5) Aquaculture should be encouraged, adjacent to the bed villages keeping in mind the sustainability and wise use of wetlands. In addition, the possibility of introducing prawn culture in wetland bed should be studied in detail, through which additional gainful employment opportunity can be achieved to the peripheral settlers.
6) Duck rearing within wetland can be served as an alternative economic support for the gainful self-employment. It should be practiced in more coherent and organized manner, avoiding scruffy environment as well.
7) Intense forestation is required, confining the wetland especially between Koklamari and Phulbaria village in order to check intense agricultural activity. Moreover, afforestation enhances aesthetic value of wetlands by increasing arrival of migratory creatures.

6.5.1.4 *Chatra wetland:*

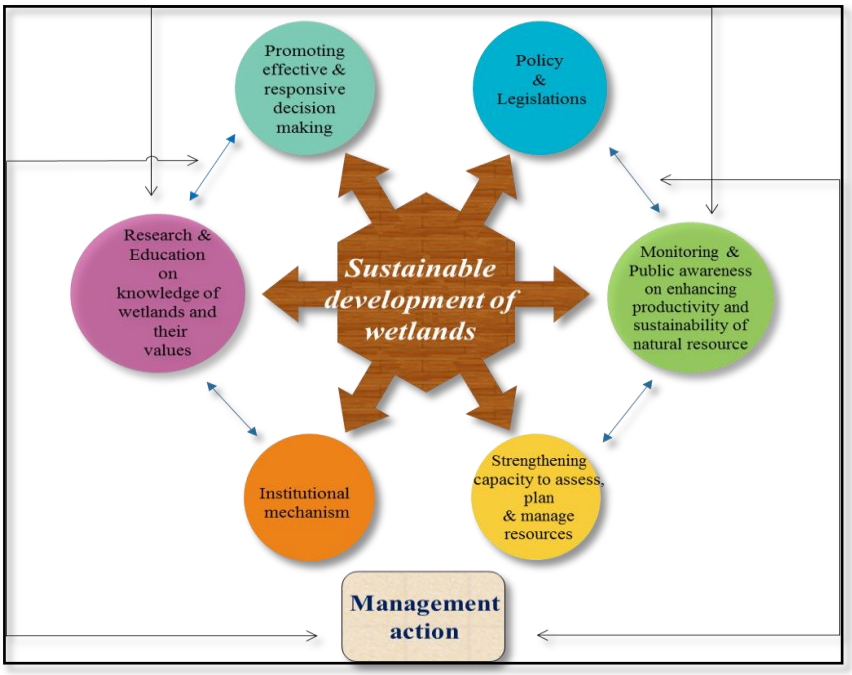
Immediate implementation of regulatory framework is necessary in order to originate a better comprehensive and sustainable conservation and management strategies of Chatra wetland (peri-urban) of Malda district:

1) Strong monitoring and strict measures should immediately be implemented by English Bazar Municipality and local government in order to restrict further alteration of wetlands to other land use categories (built-up area, agriculture and brick kiln).
2) The presently existing area of Chatra wetland will have to clearly be demarcated as well as fenced with the caution notices fixed at the different portions of fencing and must be maintained with successive sound monitoring.
3) Proper identification of point source pollution (municipal sewage) and prohibiting those activities (solid waste dumping, urban construction)) which are unsustainable on the basis of environmental substance. Implementation of integrated solid waste management as per the guidelines of the national Solid Waste Management (SWM) committee is needed *(Roy et al., 2011)*, in order to make the wetland garbage free and to keep them pollution free as well.
4) An appropriate sewage treatment facility is necessary with much emphasis on the re-cycle and re-use of waste water with assurance that does not contaminate the wetland water.
5) Keeping in view the East Kolkata Wetland, the wise use of Chatra wetland can be formulated by utilizing the city sewage for resource recovery practice on scientific basis. Organized waste recycling is to be constructed through basic conservation principal of sewage fed fishing and sewage fed aquaculture. Further, the garbage farms can be utilized for compost production, and applied in cultivation purpose.
6) Identification of non-point pollution sources and intense monitoring is needed for checking the impact of pesticides and fertilizers, and regulating the input, which is draining into this wetland. Conduct regular water quality monitoring, including the collection of surface water, biological samples, laboratory analysis and quality assurance *(Kiran & Ramachandra, 1999)*. Measuring water quality standards can be achieved by integrated efforts from efficient expertise under educational institutions, colleges and university.
7) De silting the wetland in order to enhance the storage capacity to retain and harness rain water in a feasible manner and so as to improve the ground water table by increasing the recharge potential. Moreover, a substantial water table round the year is essential in determining the frequent arrival of bird species.
8) A systematic and well organized areal distinction within wetland should be earmarked for both the makhana and fishing practice to make the pisciculture and its

associated economy uninterrupted. Furthermore, alternate gainful livelihood option can be provided to the surrounding rural community from profitable makhana cultivation via wise use of Chatra wetland.

9) Stringent law should be enforced for the violators against excessive utilization of wetland water and related resources (illegal poaching, trapping and hunting of icthyofauna and avifauna). 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.
10) Effective afforestation should be implemented at the adjoining areas of wetland (which already have cut down due to construction of railway tract and national highway) to check further encroachment, siltation and agricultural residues from farm chemicals and irrigation water.
11) Lastly, the conservation and management objective of this only peri-urban wetland seeks to harmonize planning at various levels involving concerned stakeholders to achieve the objectives of integrated wetland conservation and sustainable development.

Along with the case studies, the conservation strategies and recommendations for all the wetlands under study in Malda district require the proper implementation of those acts and rules *(Figure 6.1)*, which have yet not been executed, in a decentralized manner initially by the Government Agencies and subsequently by the stakeholders and community participation. So that, there will be stop of conversion of wetland into land for agriculture and other activities, as well as stop of encroachment of built up area to the natural boundary of wetland. Since the state government is the custodians of wetland resource, they must implement *National Wetland Conservation Programme (NWCP)* in order to ensure the wise use of wetlands. The administration is chiefly responsible for sustainable management of wetlands in the form of taking Management Action Plan (MAP) with short term and long term objectives to go in for remedial measures *(MoEF, GoI, 2009)*. Further, the protective and legal tools must directly be interlinked with the wetland conservation programmes in Malda district. It should get prioritized through proper planning and implementation as far as the wetlands under study are concerned *(Figure 6.5)*.



Source: *Acharya & Adak, 2009; Friend, 2007*

Figure 6.5 *Action Plan for Wetland Conservation*

Replacement of ongoing Green Revolution Technology (GRT) is highly essential, which is being widely practiced in the periphery of wetlands. Agricultural intensification with fertilizers, pesticides and other inputs often leads to washing away of soil by water flow and resultant siltation problem within wetlands and water bodies. Therefore, sustainable agriculture is recommended at wetland periphery without causing irreversible alteration to the wetland ecosystem character. As a consequence, siltation rate will also be controlled and wetland water will be pollution free as well.

Regular de siltation of wetlands is required along with use of this nutrient rich sediment in agricultural land which was once a well-known practice in order to make agricultural land more fertile. As a consequence, the water storage capacity and resultant infiltration rate of wetland bed will be increased, which will facilitate the ground water replenishment as well as result in restoration of river and other inland water bodies through the base flow.

Change in makhana cultivation technology especially in applying the toxic insecticides before makhana seed sowing in wetland water, is necessary in order to resist the eutrophication problem and to keep the biodiversity richness intact. Moreover, the Dept. of Fisheries in a close collaboration with Dept. of Agriculture, Govt. of West Bengal should undertake a detailed study in order to determine the possible detrimental effect by the introduction of Makhana practice within wetland. In addition, environmental awareness

campaign should frequently be launched for promoting sustainable agriculture and aquaculture along with the establishment of local conservation committee.

The sewage water need to properly be treated before releasing into those wetlands which are connected to urban sewage canal through which waste water is directed to wetlands. So that, there will be no more water pollution, no more eutrophication and wetland biodiversity of native species will be restored.

Restitution of wetlands under study through comprehensive approach needs to be adopted on sound ecological base in order to augment the biotic heritage. In addition, large scale forestation of fruit trees (mango, black berry, sabeda etc.) is required in the contiguity of wetlands with the purpose of nesting and roosting of migratory birds. Moreover, regulating centers are to be set up at wetland periphery in order to keep unremitting records of residents and migrant species and their movement round the year.

Proper efforts must be made to regulate the infestation of aquatic weed (thick mat of *Eichhornia crassiper*, *Pistia stratiotes*) by periodic clearing. Along with manual removal, utilization of available technology for rooting out extensive invasive weeds which can be recycled for energy regeneration through installation of community based biogas plants and compost production.

An appropriate economic valuation of wetland resources is highly essential, which plays an important role of putting a monetary value. Economic valuation catches the attention of decision makers as well as helps in financial resource mobilization and rational decision making *(Rao & Datye, 2003)*.

Formulation and implementation of planned wetland centric eco-tourism through multi-stakeholder partnerships involving public agencies, local communities and the investors for the sake of providing additional alternate income generation to the rural poor and promoting their economic growth.

Being an interface between policy and people, the institutions (rules, procedures, and norms of society) and organizations (government, private sector, and civil society) should encourage and assist the local government, local administration and Gram Panchayat in order to protect and conserve the wetlands of entire district through precise planning and execution.

Public awareness programme using traditional and modern communication media (group meeting, slide show, poster exhibition, workshops, eco-rallies, street theatres etc.) needs to be implemented with high priority, which states to educate the peripheral villagers regarding the substantial values and services provided by wetlands without any cost. All the stakeholder including institutions, government departments, non-governmental organizations

(NGOs), local governments and many others need to be better informed about the rationale, goals and methods of wetland ecosystem restoration. Local inhabitants have to be empowered to establish a participatory, equitable and accountable use of wetland resources in order to control their over exploitation.

6.6 Conclusion:

The human welfare in the form of economic improvement and ecological security of West Bengal depends largely upon the proper functioning of the natural resource systems, wherein wetlands are among the foremost which draw attention *(Dept. of Environment, Govt. of West Bengal, 2012)*. Thus, a paradigm shift in conservation ethic is also a strong need of an hour. This shift is necessary and perhaps mandatory due to the very nature of resource being conserved and 'protected' *(Prasad et al., 2002)*. The mentioned recommendations are essentially applicable to all the wetlands of Malda district which belong to unique individual characteristics. Therefore it is necessary to prepare separate management plans for individual wetlands. It is essential to develop a wetland authority at central government level which would coordinate with the authorities to be set up at the state government level. It would ensure the formulation and implementation of policies and action plans for conservation and wise use of wetlands *(Rao & Datye, 2003)*. Along with mentioned action suggestions; comprehensive laws, policies, regulation standards and guidelines should be adapted with assurance that to be enforced for effective wetland resource management. Moreover, wetland management require adapting multidisciplinary approach with increased coordination between different agencies (state departments concerned with environment, soil, agriculture, hydrology, fishery, forestry, urban planning and development, natural resource management) and policy makers. Effective wetland research is needed according to the regional priorities and initiatives for conservation of wetland biodiversity and their wise use. Preparing inventory and assessment of key macrophytes, icthyofauna and avifaunal species within individual wetland basins and periphery are to be prepared. Furthermore, a network of local administration, municipality, academicians, researchers and NGOs must coordinate grass root level implementation of policies and activities related to wetland conservation. The involvement of stakeholders with proper knowledge would entail the key functions and values of wetlands to gratify the critical resource needs to all the human population and sustainable management of wetlands in Malda district.

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