

Chapter **7**

GENERAL DISCUSSION

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7.1. Materials

Wetland plants of the Terai and Duars region of West Bengal have been surveyed during the period 2010 to 2014. The bulks of specimens collected were processed into mounted Herbarium sheets, identified using standard literature and matched at NBU and CAL Herbaria. After the completion of the work, first set of specimens will be deposited at NBU and the second set at CAL. Ethnobotanical specimens and photographs will be stored in the Taxonomy and Environmental Biology Laboratory of the Department of Botany, University of North Bengal for further references and use.

7.2. Flora

From the field survey in the study area a good number of 455 species of vascular plants have been recorded representing 244 genera and 84 families (Table 7.1). Among the Pteridophytes, the highest number of species have recorded from Salviniaceae (4 species) followed by Pteridaceae (3 species) and Dryopteridaceae (3 species). 192 species from only 22 Monocotyledonous families have been recorded. Poaceae with 64 species and Cyperaceae (45) are the largest families and are followed by Commelinaceae (13) and Araceae (13).

Table 7.1. Numerical representation of different major taxa in the flora

Taxa		Family	Genera	Species
Angiosperms	Dicotyledons	49	135	241
	Monocotyledons	22	92	192
Pteridophytes		13	17	22
Total		84	244	455

Hydrocharitaceae, Aponogetonaceae, Potamogetonaceae and Alismataceae show the significant number of species. Recorded 49 dicotyledonous families comprise of 135 genera and 241 species. Among these, Asteraceae is the dominating family contains 34 species followed by Polygonaceae (16), Fabaceae (14), Linderniaceae (13). Acanthaceae (12), Amaranthaceae (11), Lythraceae (10), Nympaceae (4).

7.2.1. Habit groups:

Among 433 species of angiosperms, 244 no. of species chosen for detailed phonological study, of these 132 species (54.10 %) are annuals. They complete their life cycle within a span of one year, from appearance to death. These are followed by 67 species (27.46 %) of emerged or marshy species, 10 species of rooted with floating leaf hydrophytes, 09 species of submerged hydrophytes, 09 species of perennial herbs, 06 species of suspended hydrophytes, 04 species of under shrubs, and 04 species of free floating hydrophytes. In addition, there are 03 species of aquatic trailer hydrophytes.

7.2.2. New Records: During the present survey, a good number of wetland species has been recorded as ‘new reports’ for the state, country, or even at the continent levels (Table 7.3).

Table 7.2. New records of vascular plants from the Terai-Duars region of West Bengal

Name	Family	New report for	Publication
<i>Adenostemma suffruticosum</i>	Asteraceae	Asia [for entire N. Hemisphere]	Pleione 7(2): 589 – 593. 2013.
<i>Potamogeton gramineus</i>	Potamogetonaceae	India	Intrn. J. Curr. Res. 7(2): 12362 – 12364
<i>Polygonum hastatogagittatum</i>	Polygonaceae	India	As. J. Biol. & Life Sci. 4(1): 38 – 40
<i>Ludwigia peruviana</i>	Onagraceae	West Bengal	Pleione 7(1): 286 – 289. 2013.
<i>Hygrophila erecta</i>	Acanthaceae	West Bengal	Pleione 8(1): 207 - 209. 2014.
<i>Soliva anthemifolia</i>	Asteraceae	Eastern India	Pleione 5(2): 352 – 356.2011.

- i. ***Adenostemma suffruticosum*** Gardner (Asteraceae), basically endemic to Brazil, previously known to grow only in few locations in Brazil. Its present report of occurrence from the Terai and Duars of West Bengal shows a transcontinental migration from a country in the Southern Hemisphere to a location in the Northern Hemisphere. Probably migratory birds are the carriers of its propagules.
- ii. ***Potamogeton gramineus*** Linnaeus (Potamogetonaceae), a new record of the pondweed from the sub-Himalayan wetland of West Bengal, India. This record extends the known geographical distribution of this species from Europe, North America, Russia, SW Asia (Iran), Japan, Mongolia, Pakistan, Kazakhstan, Turkmenistan, Uzbekistan and China, to sub- Himalayan region of West Bengal.
- iii. ***Polygonum hastatogagittatum*** Makino (Polygonaceae), has been collected from the natural water bodies in Duars of Himalayan Biodiversity Hotspot regions of West Bengal, India. This species is first time recorded from the territory of India. This species is now growing and reproducing nicely in the study area. It is not recorded from any other adjoining areas of this region and its distribution is still restricted. This piece of work is adding one more species in the flora of India.
- iv. ***Ludwigia peruviana*** (Linnaeus) H. Hara (Onagraceae), is a robust bushy wetland plant that has been collected first time from Mahananda river bed at Naukaghat near Siliguri and from the campus of North Bengal University of the Darjeeling district of West Bengal. These collections represent the first set of specimens of this species collected from the state of West Bengal and the local floras did not record it earlier from the state territory.
- v. ***Hygrophila erecta*** (N.L. Burman) Hochreutiner (Acanthaceae), an erect wetland plant have been collected first time for the main land of India from the margins of the roadside ephemeral water bodies at Dash-Dargaon and Pani-kouri of Jalpaiguri district of West Bengal. Previous record from Pakistan, India [Andaman & Nicobar Islands, Manipur and now from West Bengal.
- vi. ***Soliva anthemifolia*** (A. Jussieu) R. Brown (Asteraceae), is first time collected from Duars and Maldah district in turn for the entire Eastern India. This is also the addition at the generic level for the flora of this region.

7.2.3. Endemic Plants:

Few endemic plant species of Indian sub-continent have also been recorded growing in good condition in this area. In Indian more than 100 wetland species have been recorded as endemic and some more are extending their distribution only to the neighboring countries like Nepal, Bhutan or Bangladesh having similar physiographic conditions (Cook, 1996).

Few endemic plants like *Aponogeton crispus*, *Hygrophila difformis* and *Myriophyllum indicum* are widely grown over here.

7.2.4. Exotic Plants

In the wetland flora of Terai and Duars there are a good number of exotic species. The species are: *Parthenium hysterophorus*, *Alternanthera paronychioides*, *Argemone mexicana*, *Eclipta prostrata*, *Gnaphalium purpureum*, *Ipomoea carnea*, *Oxalis corniculata*, *Scoparia dulcis*, *Xanthium indicum*, *Evolvulus nummularius*, *Mikania micrantha*, *Nicotiana plumbaginifolia*, *Physalis minima*, *Croton bonplandianus*, *Eichhornia crassipes*, *Stellaria wallichiana*, *Persicaria hydropiper*, *Ottelia alismoides* etc.

7.3. Rare, Endangered and Threatened (RET) wetland plants

Among the collected specimens, several species have been recognized under the RET (Rare, Endemic and Threatened) categories. Some interesting wild plants like *Oryza latifolia*, *Oryza rufipogon* are still available in these areas but the population structures of these plants drastically decreasing due to several anthropogenic reasons. Plants like *Dopatrium junceum*, *Coix aquatica* and *Rotala mexicana* are quite rare in the study area.

Few threatened species of Indian sub-continent have also been recorded in very good condition from this area. In Indian more than 120 wetland species have been recorded as endemic and identified few extending neighbouring country (Cook, 1996).

Few endemic plants like *Aponogeton appendiculatus*, *Butomopsis latifolia* and *Potamogeton alpinus* are *Adenostemma suffruticosum* widely grown over here.

7.4. Phenology of Wetland plants

7.4. 1. Life forms

Life forms study of wetland plants of Terai and Duars have been recorded for 5 years (2010 – 2014). The observation shows *Therophytes* are the most dominating group with 111 species (50.68 %). They are followed by *Cryptophytes* with 64 species (29.23 %), 27 species of *Chamaephytes*, 13 species of *Hemicryptophytes* and 5 species of *Phanerophytes*. As the study was restricted to the wetland habitat, so the *Cryptophytes* were studied in details and result shows that there are 34 *Hydrophytes* and 30 *Helophytes*. The vegetation in Terai and Duars wetlands are mainly dominating with *Therophytes* and *Cryptophytes*.

7.4.2. Pollination

All the three major pollination types i.e. *Anemophily*, *Zoophily* (mostly *Entomophilous*) and *Hydrophily* are common for wetland plants. From the direct on-field observation of 244 angiosperms, it has been recorded that around 109 (49.77 %) species are *Entomophilous* followed by *Anemophilous* (75 species) and *Hydrophilous* (9 species). Some species utilize two or more ways for to ensure their effective pollination. So, there are 21 *anemo-entomophilous*, 4 *entomo-epihydrophilous* and only 2 *anemo-epihydrophilous* plants. Among the 9 *hydrophilous* plants, 4 species (*Najas indica*, *N.*

graminea, *Nechamandra alternifolia* and *Ceratophyllum demersum*) are hypohydrophilous (pollination takes place under water) and rests 5 species (*Hydrilla verticillata*, *Blyxa octandra*, *Nechamandra alternifolia*, *Vallisneria spiralis* var. *denseserrulata* and *Potamogeton crispus*) are epihydrophilous (pollination takes place on the water surface).

7.5. Wetland Degradation

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” (Chowdhury, 2009); (Chatrath, 1992) and wetland degradation is “the impairment of wetland functions as a result of human activity”. It is one of the most destructive causes that are destroying the ecological balance. About 50 % of the world’s wetlands have been lost in the last century, primarily through drainage for agriculture, urban development and water system regulations. It has been estimated that nearly one hectare of the world’s wetlands are getting degraded at the tick of every minute of the clock (Chatrath, 1992).

Dense human population in the catchments, urbanization, and various other anthropogenic activities has resulted in over exploitation of wetland resources, leading to degradation in their quality and quantity. Now, there is increasing concern to conserve and restore perishing wetlands and endangered habitats to achieve ecological sustainability. Some of the major threats to wetlands are:

7.5.1. Anthropogenic Causes:

- A. Over population & urbanization:** In modern world civilization is not possible without urbanization. The overpopulation in most part of the world is responsible for increasing developmental pressure for residential, industrial and commercial facilities. Large numbers of new villages are concentrated around or on catchments areas of wetlands, which greatly affects the existence wetland areas (i.e. habitat fragmentation). The wetlands like the river bed of *Mahananda*, *Balason*, *Karala*, *Jarda Teesta Domohani beel*, *Kathambari beel* etc. are modifying very fast for such invasive human activities.
- B. Agricultural activities & loss of ecosystem:** Excessive agricultural activities is one of the most destructive phenomenon of wetland degradation i.e. conversion of wetlands for paddy fields; construction of a large number of reservoirs, canals and dams; diversion of streams and rivers to provide water for irrigation. Farmers wipe out wild plants, before completing their life cycles; they prepare the soil mostly for Paddy, Jute, Jal-singara and Makhana cultivation. In this way the natural diversity of wetlands are being affected visibly.
- C. Deforestation:** Alternative land-uses for farming and fisheries production have replaced many forest areas and continued to facade threats to the forests. The loss of wetland forests reduces the ability of wetlands by slowing down flowing-speed of water and trapping the suspended particles as sediments at the bottom. The removal of vegetation in the catchments is also leading to rapid soil erosion and siltation in the down-stream.
- D. Pollution:** Pollution is one of the major causes of wetland degradation such as- unrestricted dumping of sewage, solid wastes and toxic chemicals from industries, agricultural fields and households. The primary pollutants causing degradation are sediments, nutrients, pesticides, salinity, heavy metals, weeds, low dissolved oxygen, pH and selenium concentration.
- E. Salinization:** Over withdrawal of groundwater has led to salinization and result of wetland degradation. It degrades the water quality and destroys the wetland plant diversity, both planktonic and macrophytic.
- F. Degradation of water and soil quality:** For the growing greedy and comfort-loving human population agriculture is the most common financial source of this village dominated country. For

the maximum amount of crop production and to avoid the loss from diseases and pests, various types of dangerously poisonous synthetic chemical substances are used in the crop fields. These chemicals gradually pollute and poison the water and soil of wetlands.

- G. *Creation of new Ponds for Aquaculture and Roads:*** Aquaculture, mainly Pisciculture is one of the most important and lucrative occupation of the inhabitants of Terai and Duars. Many families directly or indirectly attached to this occupation. For this occupation, they normally create artificial ponds and lakes by fragmenting the natural wetlands. These practices are destroying the natural wetlands-ecosystem. From two – three years observation it is understood that, this random practice gradually converts the natural wetlands into artificial small ponds, which creates pressure on natural habitat and biodiversity. To maintain the short-rout communication between two villages, the villagers creates new road by separating the wetlands with mud-bunds which also causes similar habitat fragmentation.
- H. *Selective fish culture & over harvesting:*** One of the most important threats to wetlands is regular cultivation of very few selected species of fishes and over fishing. In post monsoon period wetlands are treated as the houses of several wild fishes, snails, snakes, toads, and insects, which are good food for migratory and native birds and for some other local animals. During rainy season, people go for fishing in such wetlands using traditional fishing equipments. Such uncontrolled over fishing practice creates much pressure on wetland ecosystem and makes its biodiversity vulnerable.
- I. *Creation of brick field:*** This is the age of concrete, steel and plastic (Das, 2012). So, to fulfill the demand of growing greedy populations a number of brick factories are established outside the town areas, which are mostly found nearest to or directly on wetland areas. For the manufacture of bricks soil and water is taken from the wetlands. The temperature and humidity of the surrounding areas increases due to regular burning of bricks. The increasing temperature and humidity directly affects the wetland biodiversity of those areas.
- J. *Poaching and extinction of wildlife:*** Poaching is one of the major causes of wildlife extinction. From field and local market survey it is observed that a number of waterfowl or many migratory birds have been brutally killed, consumed and marketed by the neighboring people. As a result, the number of different species of waterfowl or of migratory birds is decreasing considerably during the last few years. The local villagers commonly catch or hunt different migratory birds specially *Bali Hans*, *Peeing Hans*, *Sharal*, *Jal-Pipi*, *Madantak*, *Samukh-Khol*, *Brahmni-Duc* etc. which are with good market demand.
- K. *Burial place and dumping ground:*** Being civilized, we are always destroying our land and environment where we live. If any kind of animal is found then we threw it in wetland without any sort of hesitation. Beside this, huge bulk of our domestic or other type of garbage is also thrown in to wetland because most of us think that wetlands are dirty land and we can use those as we like! As a result, water and soil quality has been enormously degraded affecting the habitat conditions and the biodiversity.
- L. *Deposition of degraded plant parts:*** Most of the wetlands of Terai & Duars are continuously losing their depth. One of the major causes is the accumulation of huge biomass of aquatic weeds. The degraded part of aquatic weed (*Eichhornia cressipes*, *Monochoria hastata*, *Nymphaea sp* etc) and cultivated plants such as *Euryale ferox*, *Trapa bispinosa*, *Nelumbo nucifera* and the after processing rejected parts of *Ananas coamosus* (Linnaeus) Merrill are deposited at the bottom and are affecting in the similar manner. Basically roadside ditches are under such threat because these are generally present beside the stretches of cultivated lands.

- M. Replacing native species by aggressive exotics:** Tropical wetlands in India are largely threatened by a few exotic species of which *Eichhornia crassipes* is the most aggressive. Other such plants include *Salvinia cuculata*, *S. natans* and *Pistia stratiotes*. These plants cover large areas of water surface and create innumerable disturbances. All these four species are free floating and can spread very fast. Their growth rate is also extremely fast and ecological amplitude is very broad. As habitat conditions are changed, the native weaker plants fail to survive there. When wetlands lose native species of animals and plants, they are thought to be of lower value making it tougher to justify their continuation and conservation.
- N. Climate changing:** Wetlands both contribute to and suffer from changes in climatic conditions. They are the single largest source of methane; a gas that is a major contributor to the atmospheric trapping of heat which leads to global warming. Unlike most regions of the world, the population of India has been high enough to cause change in the landscape. Continued degradation of water and wetland resources means that extensive regions will be marginalized or rendered less habitable by people and domestic animals if a warming and drying cycle of change affects India's climate.
- O. Uncontrolled dredging:** It is one of the destructive causes of wetland degradation. Wetland vegetation is also destroyed through this which greatly affects the successional changes in wetlands.

7.5.2. Natural stresses:

Additional pressures on wetlands from natural stresses like subsidence, drought, erosion, Excessive growth of weeds etc. are also destroying the biodiversity in our wetland.

- A. Subsidence:** Different parts of Duars are proving to recurring and devastating floods. Teesta, Jaldhaka, Shankosh, Dayna, Murti etc. are the main rivers passing through the Duars. All these rivers originated from Himalayan hills, flowing from North-east to South-West and, are rain fed, except Teesta which has its origin from the glaciers in North Sikkim. Flood is quite common and regular in these areas. Most of the blocks and towns are severely affected. During flood all the garbage's, different types of inorganic chemicals, plastics, non-degradable products, and burnt machine-oil come out with the water from the urban areas and deposited in wetlands and it destroy the wetland ecology.
- B. Soil runoff:** Huge amount of soil is carried to the wetlands from upland areas by streams and run-away water which is deposited as sediment at the bottom especially during rainy season. This is the major cause behind the loss of depth for different wetlands. The rain water also carries different non-degradable products from the urban and populated areas. This polluted water directly affects the biodiversity of wetland ecosystem.
- C. Drought:** Drought is one of the natural calamities of wetland destruction. If the wetland is fall in under prolonged drought conditions then it lost its phytodiversity and animal diversity.
- D. Erosion:** Soil erosion is one of the major causes of wetland destructions. The eroded soils from the surrounding areas are deposited in wetlands resulting the decrease of depth.
- E. Excessive growth of weeds:** Excessive growth of weeds in wetlands is another natural stress. It creates a devastating problem in wetland biodiversity. This natural hazard also reduces the water current and disturbed the wetland ecological balance. Too much of dense growth arrest the movement of water, reduce the oxygen content, lower strata of water become darker, produce more half-decomposed biomass to settle at the bottom, etc. are some of the disadvantages.

7.6. Need for Wetland Conservation

Understanding the multifarious services of wetlands for the biosphere as a whole, it is now well convinced that destruction of wetland means the invitation to early extinction of biological elements.



PLATE 7.1. Figs. 1 – 6. Stress on wetland vegetation: 1. Wetland used as burial ground; 2-4. Polluted by household garbage; 5-6. Excessive agricultural activities in non-private wetland areas



PLATE 7.2. Figs. 7 – 12. Floristic elements: 7. A house is built on wetland; **8.** Destruction of flora during fishing activities; **9 & 10.** Clearing wetland plants for agriculture and other use; **11.** A truck terminus on wetland; **12.** Plastic factory established on wetland



PLATE 7.3. Figs. 13 – 17. Floristic elements: 13. Killing of fishes by poisoning river water; **14.** Wetland used as washing and bathing places for man and domestic animals; **15.** Jute retting, **16.** Excessive agricultural activities, **17.** Poaching & dumping site, **18.** Polluted by end products of festival

Modern world knows, the development means urbanization through fragmentation of wetlands. It is found that wetlands are always treated as obnoxious and unproductive systems throughout the world. But, surprisingly, in 1971, at an International Convention that was held at Ramsar in Iran and organized by IUCN to draw attention for the wetland conservation for its great economics and ecological importance.

It was then expressed that wetlands are the most productive ecosystems among the living worlds. They are the cradles of biological diversity, providing the water and its primary products upon which innumerable species of plants and animals depend for their survival. They provide the shelter for birds, mammals, reptiles, amphibians, fishes and innumerable invertebrate species. Wetlands are also significant storehouses of plant genetic resources.

In addition, wetlands are important, and sometimes indispensable, for the health, welfare and safety of people and wildlife that live in or near such areas. But in recent years it has been increasingly understood the multiple roles of wetland ecosystems and their value to humanity.

To fulfil the demand of growing greedy populations of India wetlands are drastically fragmented and are converted into non-wetland areas. Like in the most other countries of the world, India has been drastically losing its wetland biodiversity

This scenario is not exceptional for West Bengal. So many wetlands have already been destroyed for urbanization, extensive agricultural activities, industrialization and over exploitation. One of the first six Ramsar sites recognized from India, the *East Calcutta Wetland* has already lost its vast area due to over population and industrial growth.

In Terai and Duars, wetland degradation has been occurring in each and every moment. Many wetlands are gradually losing their areas as well as their depth due to various reasons like urbanization, excessive agricultural activities, establishment of various kinds of industries and many other so-called developmental programs. Among these areas Duars basically over flooded in rainy season due to the increasing loss of depth of the wetlands. Some special and sustainable utility reasons for wetland conservation are discussed below:

7.6.1. Shoreline stabilization: Wetlands function like big sponges. Vegetated wetlands along the edges of streams help control erosion caused by stream currents and flood. They also protect lake shores from wind generated waves. For shoreline stabilization conservation of wetlands is very much essential.

7.6.2. Food and habitat of fishes and other wildlife:

- A. Fish:** Wetlands serve three major functions for fish communities. They provide breeding grounds, sources of food and provide cover from predators. Most species of freshwater fishes are dependent on wetlands for one or more of these functions.
- B. Wildlife:** Many varieties of waterfowl and non-game birds depend on wetlands for their feedings and resting areas. Other wildlife, such as a variety of reptiles, amphibians and mammalians depend on insect-based food webs and on water to drink. And wetlands also treated as a house of turtles, snakes, frogs and toads etc.
- C. Habitat for RET Species:** Wetlands are the life-land for the survival of various plants and animals, including threatened and endangered species. Approximately 30% of Michigan's threatened and endangered plants and 60% of the threatened and endangered animals are wetland species so the conservation of wetland is crucial.
- D. Flood control:** Being like a sponge they absorb large volumes of water and protect cities, towns and villages from flooding. To save ourselves from flood-damages wetland conservation is to be the first essential step.

- E. Recreation and aesthetics:** Wetlands are home to an ample diversity of animals, but also to human beings with diverse hobbies. Hikers, photographers, bird watchers, hunters and those with the gratitude of nature feel affection to visit wetlands.
- F. Scientific and educational value:** Wetland provides a unique outdoor ecological laboratory for the researchers. And, act as an outdoor nature-study classroom related to nature for the students.
- G. Source of natural products:** A variety of wetland products are consummated by us. Various types of food products include wildlife; fish, shellfish, wild rice, wild vegetables, medicinal plants, etc. are getting from wetlands. Wetlands also provide firewood, fencing materials, materials for the making of decorative items dried animal pelts used in clothing, etc.
- H. Groundwater recharge:** Wetland is the kidney for the living world. These areas are often connected to a groundwater system and may provide a site for water infiltration into the soil and recharge an underlying aquifer. This can be a very important function for individuals or drinking water systems of living organism.

7.7. Sustainable utilization: For sustainable utilization of bio-resources conservation of wetland is the basic and mandatory. Such sustainable utilizations include:

- i. Agriculture:** The depth of wetlands are not equal everywhere. So, during summer, when the water level recedes major part of marshy areas are exposed or with less than 1m deep water. Such land can be used for the cultivation of different crops. These lowlands are largely used for growing paddy. *Oryza sativa*, *Aeschynomene aspera* and *Corchorus capsularis* are cultivated in pre-monsoon season on dried or exposed land. during post-monsoon when water bodies again gradually dried up at that time shallow water bodies are being chosen for the cultivation of Makhana (*Euryale ferox*) and Paniphal or water-chestnut (*Trapa natans*). Upland areas are used for the cultivation of mustard and few other seasonal vegetables.
- ii. Irrigation:** In summer these area has been suffered from water crisis and that has been created due to excessive agricultural activities. The irrigation in this area is almost completely dependent on the wetlands. Wetlands store huge amount of water during rainy season or the water is stored in groundwater aquifers in those areas. Local people use this water for their post-monsoon crops, until and unless the wetlands are dried up.
- iii. Fisheries:** The wetlands of this area are the good habitat for different species of wild and cultured fishes. Most of these are coming from the nearby rivers and ponds during flood. Several marshes or lakes, which are permanent deep water bodies are also have been used for fish culture. Government provides many wetlands to the interested people on lease for this purpose. Wetlands like *Gajoldoba*, *Doumohani Beel*, *Mahananda Barrage*, *Rajbari dighi* etc. are used for pisciculture. The fishes like *Rahu*, *Katla*, *Mrigel*, *Bata* and some other varieties are cultured in these wetlands. But, some wetlands where fishes coming with flood water are used for fishing throughout the year by the local poor fishermen.
- iv. Ground water recharge and flood control:** Considerable amount of water moves down into the underground aquifer that is referred to as groundwater recharge. Such underground water is drawn up through deep tube wells, for human consumption including dry-season cultivation. The presence of numerous wetlands in Terai & Duars always save these areas from devastating flood because huge amount of flood water took place in the low-land areas. During rainy season all the water bodies (rivers, ponds, lakes and ephemeral water bodies) forming a single body. In 1968, Jalpaiguri town was affected by devastating flood and the life of at least 216 persons and 1370 cattle were lost (Sarkar *et al.*, 2001). Proper scientific management programs through the government agencies to maintain these wetlands can help the people of Terai & Duars to save much of their properties during flood.

- v. **Rural economy:** The local poor including tribal communities living near the wetland areas collect a good number of plant species for their daily use. They use numerous plants parts as food, fodder, medicine, building materials, decorative, etc. They also put several edible and medicinal plants for sale in the rural and urban markets. Many species of grasses and sedges are also sold as fodder in urban markets. Some tall grasses (*Saccharum arundinaceum*, *S. spontaneum*, *Vetiveria zizanioides* etc.) used as broom and building materials by the poor villagers. Poor villagers including children are generally catch good amount of fishes during post monsoon season in all the seasonal flooded wetlands of the study area. They drain out the water from wetlands areas and catch fishes like *Chana punctata*, *Clarias batrachus*, *Heteropneustes fossilis*, *Oreochromis mossambicus* (Telapia), *Trichogastes fasciatus*, *Puntius sarana*, *Channa striatus*, *Burbus tinto* (Titputi), *Puntius ticto*, *Anabas testudineus*, *Collisa fasclata* (Khalisa) etc. The *Daumohani Beel*, *Gajoldoba*, *Mahananda Barrage* produce huge amount of fishes and the economy of local fisherman are almost completely dependent on the extent of fishing. During the survey, it is roughly estimated that more than 250 families are depending on these wetlands for their survival through fishing.
- vi. **Jute retting:** Jute is another important crop of these areas. The presence of wide areas of wetlands encourage the farmers for jute cultivation during early monsoon. Jute retting is a common practice in these areas in different water bodies. Mainly the roadside ditches are largely used for jute retting during monsoon.
- vii. **Green manure:** It was found that farmers of these areas are using wetland weeds for the production of green manure to use in their cultivated lands for improving the soil fertility. A good number of plants like *Azolla pinnata*, *Salvinia cucullata*, *Eichhornia crassipes*, *Monochoria vaginalis*, *Monochoria hastate*, jute-leaves etc. are use by the farmers as green manure in different ways. In this manner, these people not only save good amount of money from purchasing chemical fertilizer, the practice is also desirable for the improvement of soil and maintaining the land culturable for a long period.

7.8. Conservation Strategies for the Prevention of Wetland Destruction:

In India, wetland conservation is indirectly influenced by an array of several policy and legislative measures (Parikh & Parikh, 1999). Apart from the government regulation, establishment of better monitoring methods are needed to increase the knowledge of the physical and biological characteristics of wetlands and their resources, and to gain, from this knowledge, a better understanding of wetland dynamics and their controlling processes (Prasad *et al.*, 2002). India being one of the mega biodiversity countries of the world should strive to conserve the ecological characters of these ecosystems along with their flora and fauna (MOEF, 2009). Understanding the status of wetlands can help to frame proper conservation strategies, which can be as follows:

i. Increasing the depth of wetlands

Most of the wetlands in these areas are very old so their depth has been decreased considerably due to siltation by rainwater, runoff and deposition of degraded plant biomass. To generate the wetlands healthy and productive good amount of silt may be removed by digging during dry season. By this way water holding capacity of these wetlands will increase so that they can perform as better buffer during floods.

ii. Periodical weed removal

Most of the wetlands are suffering from the invasion of few noxious aquatic weeds. The exotic weed *Eichhornia crassipes* is the most troublesome species in this region. Most of the wetlands

of these areas are dominating by this plant. The huge amount of biomass produce and contribute by this plant can reduce the depth of the wetlands quickly. Periodical removal of this weed [and converting those to green manure] can keep the wetlands healthy. It is very interesting and quite common practice in these areas is that the people of rural areas collect and use the *Eichhornia crassipes* biomass directly or after burning as agricultural manures. Such kind of practices should be encouraged by the government for the production of non-toxic crop through proper awareness programs. The plant body of *Makhana* and *Jal-singara* also decomposed quickly and reduces the depth of wetlands. So after fruiting season is over, the old plant bodies should be removed as soon as possible from the wetlands.

iii. Building public awareness

In these areas most of the people think that wetland is a wasteland and is a dirty place. In their everyday life they got several facilities from those wetlands but never try to understand its importance. The main cause is that the villagers of this region are not properly educated. For achieving any sustainable success in the protection of these wetlands, awareness among the general public, educational and corporate institutions must be created to help them to realize the future if the wetlands are missing from these region and some suggestions are:

- Launching various environmental awareness campaigns
- Organizing various programmes, workshops, folk dances, street theatre for creating awareness regarding wetlands
- Using both formal and non-formal education tools for awareness generation.
- Creation of environmental awareness through brochures, training programmes, padayatras, and hoardings
- Developing various publicity materials on wetlands
- Declaring awards for better maintenance of areas wetlands; etc.

iv. Creation of more bird sanctuaries

Department of Forest, govt. of West Bengal has already initiated plantation around or on the upland areas of different wetlands in the study area. The wetland areas are very important habitat and breeding sites for several important resident, resident migratory and migratory water birds. Among the various water birds many have been enlisted by the IUCN as endangered. But, some important wetlands hosting large flocks of visiting waterfowls like *Mahananda barrage*, *Gajoldoba*, *Doumohani beel* required immediate plantation with properly selected species of plants those are preferred by birds for nesting and for food. Forest department also takes care to the waterfowls for food supply and medicine. The local government should restrict much public infestation [including picnics and eco-tourism activities] into the dense and bushy wetland areas because several water birds mainly ducks, jacanas are nesting for breeding within those bushes during the post-monsoon period.

v. Protection and Monitoring

Today's primary necessity is to protect the existing wetlands. Patrolling and surveillance, setting up of watch-towers, socio-economic development through community participation, etc. can be of much help. Formation of advisory committees for regular mid-term reviews mainly by experts from universities and organizations working for conservation is very important. Of the many wetlands in Terai & Duars only one wetland is protected [Gossaihat, Khuttimar Beel under Moraghat Reserve forest]. But there are several wetlands which are biologically and economically significant but have no legal status for their protection and conservation.

vi. Control of over-fishing

The ichthiofaunal diversity of Terai & Duars of West Bengal is very rich and that proves the suitability of these water bodies as good habitat for fishes. Many species of fishes prefer many aquatic weed as their shelter and breeding ground. The fishes like *Channa marulius*, *Channa punctatus*, *Oreochromis mossambica*, *Heteropneustes fossilis*, etc. use the degraded plant parts as food. The fishes are coming to the wetlands from local rivers and fish-cultured ponds. Several hundred families survive through fishing in these wetlands. These fishes are also sources of food for resident and migrated waterfowls. Excessive fishing in these wetlands affects the food scarcity for waterfowls. This food scarcity, in turn, gradually leads to the reduction of waterfowl population structure in these areas. So, severe control over fishing in those areas should be limited. On the other hand, many fish species are now gradually become rarer or even extinct. Over fishing always disturb the biodiversity and a stable ecosystem.

vii. Control of excessive agricultural activities

We understand the value and/or importance of agriculture. Simultaneously, we have to understand the importance of the conservation of healthy and good ecosystems not only for the conservation of Biodiversity but also for human welfare. Excessive agricultural activities are destroying regularly the biodiversity of these wetlands. So, the ecosystems of these wetlands became unstable. The paddy, mustard and jute cultivation alter the natural vegetation in leading to the removal of the numerous local species of plants and animals. Not only that, maximum application of toxic chemicals as fertilizer, herbicide, pesticide, etc. for the production of higher amount of crop, polluting the wetland habitat, which is directly affecting the biodiversity killing and modifying numerous wild species. So, excessive agricultural activity should be controlled or need to be done scientifically to maintain the beauty and biology of natural ecosystem of the entire area.

On the other hand, the farmers should be trained to use more organic manure than synthetic fertilizer. They can produce more manure using some wetland plants like *Azolla pinnata*, *Eichhornia crassipes*, *Salvinia cucullata* etc.

viii. Control of monoculture

The wetlands of the study area have been used for Lotus (*Nelumbo nucifera*) and Chestnut (*Trapa natans*) cultivation since long. But, for the last 4 – 5 years, Makhna (*Euryale ferox*), a profitable crop, is widely cultivated in the wetlands of Shovabari Beel, Doumahoni Beel, etc. of the study area. The area of its cultivation is increasing very fast in this zone. This kind of monoculture is also seriously destroying the wetland ecosystem. For Makhna cultivation, seedling is planted only after the killing of all the fishes using poison because they eat its seedlings. This type of monoculture should be controlled in favour of the conservation of biodiversity.

ix. Control of bird poaching

Bird poaching is rampant and is increases during post-monsoon period when migratory birds visit these wetlands from different part of the world for food and for breeding. Present study revealed that the waterfowl count is reducing day by day in different wetlands. Many local people catch birds using fishing nets and fire guns for food and are quite often sold in village markets. The local administration fails to control it. Wetlands conservation in India is indirectly influenced by an array of policy and legislative measures (Parikh & Parikh 1999). Several acts on wetland, water, wildlife, biodiversity have created by Indian government in different years to protect the environment and ecosystem of such habitat. But, unless the implementing authority becomes serious in the implementation of such rules, it will become a menace leading to the destruction of local natural wealth.

x. Stop releasing urban and industrial influx or sewages in wetlands

Some wetlands of Terai & Duars are suffering from the release of huge quantity of urban sewages. The drains are directly or indirectly connected with the wetlands and local rivers. The *Mahananda Barrage*, *Gajoldoba* etc. that are composed of many smaller wetlands become highly polluted as most of the drains of main town is connected with its different part by a number of channels. It is used as the main sewage release and garbage deposition site of the nearby towns. Very soon, the developmental activities will increase like anything along with the establishment of a new regulated market and 2 or 3 new townships. All these activities will, no doubt, highly degrade the environmental status of these wetlands. There are several small and large industries in the study area. The influxes are releases into the nature directly from these factories without any proper pre-treatment. These poisonous chemicals first mix with ephemeral water bodies then, during flood, spreading to the other nearby important wetlands and river system and pollute those regularly. Immediate steps need to be taken by appropriate authorities strictly; otherwise wetlands in those areas become unhealthy and will suffer from critical eutrophication which will destroy the stable ecosystem of these wetlands.

xi. Research and Monitoring

The wetland and other water bodies of this area are very important in various aspects. But, the knowledge related to the resource, biodiversity, encroachment, injection of pollutants, etc. are not known to the authorities in detail. For such knowledge generation and to protect the wetlands detailed research works are required in the field of biodiversity, soil & water chemistry, soil, mapping, socio-economics, etc. need to be taken up immediately. The wetlands and river systems of Terai & Duars is also very rich in their faunal diversity. But, a good proportion of these, especially the fishes, reptiles, amphibians, waterfowls etc. are not recorded or poorly recorded from this region. It is very important for various stakeholders along with the local community and corporate sector to come together for an effective management plan to save our biological diversity in wetlands. So, the necessity for research in wetlands in the formulation of national strategy to realize the dynamics of these ecosystems and ultimately will help the planners to formulate the strategies for the mitigation of pollution. The local government authorities, mainly land reforms and forest department should monitor those wetlands properly with well developed management strategies and machineries. The proper wetland mapping of the different wetlands should be done using remote sensing to understand diversity and its present nature including biodiversity. The remote sensing data can help also to monitor the condition of these wetlands.

xii. Legislation

Although several laws are there to protect wetlands, but there is no special legislation pertaining specially to the wetland ecosystems. Environment Impact Assessment is needed for major development projects highlighting threats to wetland and its diversity need to be formulated with much more stricter parameters.

xiii. Comprehensive inventory

There has been no comprehensive inventory of all the Indian wetlands despite the efforts by the Ministry of Environment and Forests, Asian Wetland Bureau and World Wide Fund for Nature. The inventory should involve the flora, fauna, and biodiversity along with their values and different other useful academic and exploitable values.

xiv. Coordinated approach

Since the wetlands are common property with multi-purpose utility, their protection and management also need to be a common responsibility. An appropriate forum for resolving the conflict on

wetland issues has to be set up. It is important for the administration to allocate sufficient funds towards the conservation of wetland ecosystems.

Maintaining the proper health of wetlands is intimately related to the well-being and survival of survival of human societies. Man need to realize that “. . . commercial exploitation is only for today’s survival but conservation is for the long term survival”, otherwise our activities will invite the final disaster for the biosphere on this planet (Das 2012).