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Biodiversity Loss by Riverbank Erosion: A Study on the two Char Unions in Bangladesh

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Abstract

This study has explored the biodiversity loss of Lesraganj and Sutalari char unions through field survey, field observation technique and using BBS data. Bank erosion has destroyed the "habitat" of flora and fauna by disturbing the whole ecosystem chain of the study site. Many fruit varieties were available in mainland among which Jam, Amloki, Jalpai, Dalim, Chalta, Sharifa, and Latkan were not seen in the Charland. All types of homestead palm varieties have been lost while only banana is extensively practiced in the Charland. The mainland was rich in herbs and shrubs, but bank erosion has extinct them completely. The char dwellers are not capable to introduce any aesthetic varieties in the char homesteads and no aquatic vegetation could survive. The many mainland timbering yielding varieties are not found in the Charland except Eucalyptus and Babla while the mainland natural medicinal species cannot survive in the newly formed Charland. The mainland common mammalian fauna and birds are not found in the Charland due to the habitat damage. The mainland was rich in reptiles and amphibian species most of which have become very rare in the degraded char environment.

Keywords: Bank erosion; Biodiversity loss; Mainland; Charland; Habitat damage

Introduction

Natural hazards cause biodiversity loss and vice-versa. The various human activities and natural disruptions degrade ecosystem [1,2]. Bank erosion is a natural hazard, which destroys the existing biodiversity and/or ecosystem services of an area. Direct effects of biodiversity loss by bank erosion include an increased risk of sudden environmental changes- vulnerability to natural disasters (floods, droughts, and erosion), wildfires, disease, and access to clean water and raw materials, and food and energy security; decrease the regulation capability of regional or local climate [3,4]. In brief, the most adverse consequences of bank erosion are the "habitat loss" of flora and fauna by disturbing the whole ecosystem chain or safety net [5-7]. The bank erosion turns the healthy environment into a barren land or vacuum place with only a very few organisms or species [8].

This study has explored biodiversity loss of Lesraganj and Sutalari char unions of Harirampur Upazila on the Padma riverbed in Bangladesh (Figure 1). The study area (located between 23038/ and 23044/ north latitudes and between 89050/ and 90000/ east longitudes) is the isolated island. The island chars are very unstable because frequent erosion and regular sand carpeting changing the physical properties. The soils are seasonally flooded, have loamy to silty, and silty to silty textures and low organic matter contents [9-13]. The bank erosion has caused physical changes by eroding huge landmass, population displacement and damaging the natural environment and resources, therefore, the poor char community faces the challenges to meet their family needs including food, fuel and fodder. More importantly, the erosion has disturbed the whole ecosystem and spatially caused the habitat damage, which has exhausted the biological diversity. Before erosion, the study area was rich habitat where many species of flora and fauna co-exist but after erosion, the number of species, variety and variability of living organisms has been lost. This study has identified pre-existing biodiversity and biodiversity loss between the mainland and Charland considering the bank erosion as a root cause of the loss.

Figure 1: Biodiversity loss of Lesraganj and Sutalari char unions of Harirampur Upazila on the Padma riverbed in Bangladesh.

Materials and Methods

This study has conducted questionnaire survey among the char dwellers on the biodiversity loss issue. The two char unions consist of 25 mouzas. Five questionnaires were filled in each mouza that method provided 125 questionnaires for better coverage of nature. The respondents were selected by stratified sampling technique to pick up the real-world information. Two sessions of focus group discussion were held in the two char unions. Each session consisted of 15 char dwellers including all types of professional char people (Farmers, fisherman, boatman, day laborer's and teacher). Three expert officials of District Agriculture Extension Office (DAEO), District Animal Office (DAO) and Department of Environment (DoE) were employed to conduct a focus group discussion session significantly for achieving the real loss scenario. The Bangladesh Bureau of Statistics [14] provided the mainland fauna and flora list that were critically compared and examined in the char lands for identifying the lost varieties/species. The study has extensively performed field observation technique covering the whole year. The study team observed the Charland six times (two months interval) particularly in the dry season, spring and rainy (wet) season. Each time the survey team stayed ten or twelve days in hardship of the Charland. The seasonal observation technique has provided the information on the char physical environment and its associated flora and fauna varieties. The different char practitioners accompanied the survey team in performing the field observation technique.

Results and Discussion

Loss of fruit varieties

The common fruit varieties were available in the homesteads of the mainland. Among the mainland fruit varieties, Jam (*Syzygium cumini*), Amloki (*Phyllanthus emblica*), Jalpai (*Elacocarpus floribundus*), Dalim (*Punica granatum*), Chalta (*Dillenia indica*), Sharifa (*Annona squanaosa*) and Latkan (*Bixa orellana*) are completely absent in the char areas (Table 1).

English or Local Name	Scientific name	Pre-erosion	Post-erosion	Present Status of Species	
		Mainland	Charland	Lost	Introduced
Papaya	*Carica papaya*	Planted	Planted	-	-
Litchi	*Litchi chinensis*	Planted	Planted	-	-
Mango	*Mangifera indica*	Planted	Planted	-	-
Jackfruit	*Artocarpus heterophyllus*	Planted	Planted	-	-
Guava	*Psidium guajava*	Planted	Planted	-	-
Boroi	*Zizyphus mauritiana*	Planted	Planted	-	-
Bel	*Aegle marmelos*	Planted	Planted	-	-
Amra	*Spondias pinnata*	Planted	Practiced	-	-
Kamranga	*Averrhoa carambola*	Planted	Practiced	-	-
Jam	*Syzygium cumini*	Planted	Not Planted	Lost	-
Amloki	*Phyllanthus emblica*	Planted	Not Planted	Lost	-
Jalpai	*Elacocarpus floribundus*	Planted	Not Planted	Lost	-
Dalim	*Punica granatum*	Planted	Not Planted	Lost	-
Chalta	*Dillenia indica*	Planted	Not Planted	Lost	-
Sharifa	*Annona squanaosa*	Planted	Not Planted	Lost	-
Latkan	*Bixa orellana*	Planted	Not Planted	Lost	-

Table 1: Loss of fruit varieties in study area.

Loss of homestead plants

After erosion, all sorts of palm plants have lost identity to the char community (Table 2). Though Bamboo (*Bambusa bambos*) is the most useful material to build households dwellings unit and other homestead activities, the char community has not raised any bamboo thickets in the homestead which was very common in the mainland.

Local or English Name	Scientific name	Pre-erosion	Post-erosion	Present Status of Species	
		Mainland	Charland	Lost	Introduced
Bamboo	*Bambusa bambos*	Presence	Absence	Lost	-
Banana	*Musa paradisiaca*	Presence	Presence	-	-
Date palm	*Phoenix sylvestris*	Presence	Absence	Lost	-
Palmyra palm	*Borassus flabellifer*	Presence	Absence	Lost	-
Coconut	*Cocos nucifera*	Presence	Absence	Lost	-
Betelnut	*Areca catechu*	Presence	Absence	Lost	-
Gab	*Diospyros peregrina*	Presence	Absence	Lost	-
Dumur	*Ficus hispida*	Presence	Absence	Lost	-

Table 2: Loss of homestead plants in study area.

Banana (*Musa paradisiaca*) was usually grown both in the mainland and in the Charland [15]. The char community stated that a special variety of banana thickets close to the vicinity of the dwellings protects the dwelling units from erosion during the rainy season.

Loss of homesteads vegetation

The soil properties and relief, rainfall, temperature and humidity influence the diversity of vegetation cover in any locality [16]. The mainland was rich in herbs and shrubs (Table 3). But bank erosion has caused the loss of herbs and shrubs in the Charland radically [17]. Only the Hogla (*Typha angustata*) and Dhoincha (*Sesbania sesban*) have survived in the Charland.

Local Name	Scientific name	Pre-erosion	Post-erosion	Present Status of Species	
		Mainland	Charland	Lost	Introduced
Kata Mehndi	*Duranta repens*	Presence	Absence	Lost	-
Phani Mansa	*Opuntia dillenii*	Presence	Absence	Lost	-
Arhar	*Cajanas cajan*	Presence	Absence	Lost	-
Hogla	*Typha angustata*	Presence	Presence	-	Introduced
Dhoincha	*Sesbania sesban*	Presence	Presence	-	Introduced
Satamuli	*Asparagus racemosus*	Presence	Absence	Lost	-
Gulancha	*Tinospora cordifolia*	Presence	Absence	Lost	-
Kumarilata	*Smilax roxburghiana*	Presence	Absence	Lost	-
Jangla shim	*Canavalia gladiata*	Presence	Absence	Lost	-
Pui	*Azadirachta indica*	Presence	Absence	Lost	-
Orchid	*Dendrobium aphyllum*	Presence	Absence	Lost	-
Kochu	*Monochoria hastata*	Presence	Absence	Lost	-

Table 3: Loss of homesteads vegetation in study area.

Loss of aesthetic species

The char dwellers could not able to introduce such varieties of flowers plants in their homesteads (Table 4). Firstly, the geo-environmental conditions of the chars are not suitable for planting such types of varieties; secondly, the char community is at further risk of erosion which always makes them indifferent to planting the flower varieties for the beautification of their homesteads.

Loss of aquatic vegetation

The water-loving aquatic vegetation was found along the narrow water places of the mainland. The ten aquatic varieties were richness (Table 5) among which nine variety could not survive in the Charland. Only the Noll khagra (Phragmites karka) were seen scattered in the low land areas which lush only in the rainy season (Table 5). The cause of absence of varieties is any back swamp has not developed in the char areas and even artificial ponds have not been dug in the char area hence the floating macrophytes and ferns have not been able to grow in the non-aquatic environment.

Local Name	Scientific name	Pre-erosion	Post-erosion	Present Status of Species	
		Mainland	Charland	Lost	Introduced
Hasnahena	*Cestrum nocturnum*	Practiced	Not Practiced	Lost	-
Patabahar	*Codiaeum variegatum*	Practiced	Not Practiced	Lost	-
Gandhoraj	*Gardenia jasminoides*	Practiced	Not Practiced	Lost	-
Dolon Champa	*Hedychium coronarium*	Practiced	Not Practiced	Lost	-
Kamini	*Murraya paniculata*	Practiced	Not Practiced	Lost	-
Jaba	*Hibiscus rosa-sinensis*	Practiced	Not Practiced	Lost	-
Madhumalati	*Chilonias hybridus*	Practiced	Not Practiced	Lost	-
Togor	*Tabemaemontana divaricata*	Practiced	Not Practiced	Lost	-
Shefali	*Erythrina stricta*	Practiced	Not Practiced	Lost	-
Beli	*Jasminum sambac*	Practiced	Not Practiced	Lost	-
Aparajaya	*Clitoria ternatea*	Practiced	Not practiced	Lost	-
Sandhya malati	*Mirabilis jalapa*	Practiced	Not Practiced	Lost	-

Table 4: Loss of homestead aesthetic species in study area.

Loss of medicinal vegetation

The various natural medicinal species could grow in the mainland and they dominated in different habitats and microhabitats. But the Padma River has eroded the plain land of Harirampur Upazila, therefore, the important biological resources of the mainland have been lost and a few new varieties have grown in the emerged char areas (Table 6). There were many vegetation species in the mainland vitally important to humans because many cures for human diseases have been found in these vegetation species [18].

Local Name	Scientific Name	Pre-erosion	Post-erosion	Present Status of Species	
		Mainland	Charland	Lost	Survived
Kachuri pana	*Eichhornia crassipes*	Presence	Absence	Lost	-
Topa pana	*Pistia stratiotes*	Presence	Absence	Lost	-
Khudi pana	*Lemna perpusilla*	Presence	Absence	Lost	-
Paniphal	*Trapa bispissosa*	Presence	Absence	Lost	-
Panchuli	*Nymphoides*	Presence	Absence	Lost	-
Padma	*Nelumbo nucifera*	Presence	Absence	Lost	-
Shapla	*Nymphaea nouchali*	Presence	Absence	Lost	-
Kalmi	*Ipomoea aquatica*	Presence	Absence	Lost	-
Helencha	*Enhydra fluctuans*	Presence	Absence	Lost	-

Noll khagra	*Phragmites karka*	Presence	Presence	-	Survived

Table 5: Loss of aquatic vegetation in study area.

Local Name	Scientific Name	Pre-erosion	Post-erosion	Present Status of Species	
		Mainland	Charland	Lost	Survived
Bashak	*Adhatoda vasica*	Presence	Absence	Lost	-
Thunkuni	*Centella asiatica*	Presence	Absence	Lost	-
Datura	*Datura metel*	Presence	Absence	Lost	-
Kesaraj	*Eclipta alba*	Presence	Presence	-	Survived
Tulsi	*Ocimum sanctum*	Presence	Absence	Lost	-
Dando kolosh	*Leucas lavandulifolia*	Presence	Absence	Lost	-
Durba	*Cynodon dactylon*	Presence	Presence	-	Survived
Gandho bhadali	*Cyperus difformis*	Presence	Absence	Lost	-
Nisinda	*Vitex negundo*	Presence	Absence	Lost	-
Kata-khoria	*Amaranthus spinosus*	Presence	Presence	-	Survived
Shechi	*Dentella repens*	Presence	Absence	Lost	-
Goicha	*Eragrotis spp.*	Presence	Absence	Lost	-
Baita shak	*Chenopodium album*	Presence	Absence	Lost	-
Noll ghash	*Hamerthria protensa*	Absence	Presence	-	Survived
Son ghash	*Imperata cylindrica*	Absence	Presence	-	Survived
Kysha	*Phragmites karka*	Absence	Presence	-	Survived
Kash	*Saccharum spontaneum*	Absence	Presence	-	Survived

Table 6: Loss of medicinal vegetation.

Loss of timber yielding plants

The good number of timber yielding varieties was planted in the mainland (Table 7). The mainland timber varieties were not planted and even a few could not survive naturally in the Charland. The char dwellers planted only the Eucalyptus (*Eucalyptus globules*) and the Babla (*Acacia nilotica*) in the Charland (Table 7).

The char dwellers expressed the Eucalyptus and the Babla can easily and swiftly grow in the sandy soil where other species cannot do. The Eucalyptus might be adaptable to the aquatic environment especially in the high flooding conditions and must be protective of the char erosion The Babla can survive in dry hot summer in char areas because of its arid or semi-arid characteristics. Another reason of planting the Babla is that the thorny character protects it from damaging or destroying by the grazing of livestock in the char areas.

Loss of mammals

The Bengal fox (*Vulpex bengalensis*), Common mongoose (*Herpestes edwarsi*), the common Otter (*Lutra lutra*), five striped Palm Squirrel (*Funumbalus pennant*), Common house rat (*Rattus rattus*), House Mouse (*Mus musculus*) Rhesus Monkey (*Macaca mulata*), Bat (*Desmodus rotundus*), jungle Cat (*Felis chaus*), small Indian Civet (*Viverricula indica*), large Bandicoot (*Bandicota indica*) and Jackal (*Canis aureus*) were available in the mainland before erosion (Table 8) because the congenial environment favored them living and breeding. Among the thirteen mammals of the mainland only the four mammals' i. e., Cat (*Felis chaus*), small Indian Civet (*Viverricula indica*), large Bandicoot (*Bandicota indica*) and Jackal (*Canis aureus*) are now seen in the Charland. The river erosion degraded the local environment and caused the habitat damage which is the most influential drivers of mammals' loss in the Charland.

Local Name	Scientific Name	Pre-erosion	Post-erosion	Present Status of Species	
		Mainland	Charland	Lost	Introduced
Arjun	*Terminalia arjuna*	Practiced	Not Practiced	Lost	-
Chatim	*Alstonia scholarsis*	Practiced	Not Practiced	Lost	-
Pitraj	*Aphanamixis polystachya*	Practiced	Not Practiced	Lost	-
Hijol	*Barringtonia acutangula*	Practiced	Not Practiced	Lost	-
Simul	*Bombax ceiba*	Practiced	Not Practiced	Lost	-
Neem	*Azadiracta indica*	Practiced	Not Practiced	Lost	-
Tentul	*Tamarindus indica*	Practiced	Not Practiced	Lost	-
Sajna	*Moringa oliefera*	Practiced	Not Practiced	Lost	-
Jarul	*Lagerstroemia speciosa*	Practiced	Not Practiced	Lost	-
Mandar	*Erythrina fusca*	Practiced	Not Practiced	Lost	-
Kadam	*Anthocephalus chinensis*	Practiced	Not Practiced	Lost	-
Palash	*Butea monosperma*	Practiced	Not Practiced	Lost	-
Debdaru	*Polyalthia longifolia*	Practiced	Not Practiced	Lost	-
Krishnachura	*Delonix regia*	Practiced	Not Practiced	Lost	-
Akashmoni	*Acacia auriculiformis*	Practiced	Not Practiced	Lost	-
Mahagoni	*Swietenia mahagoni*	Practiced	Not Practiced	Lost	-

Sisso	*Dulbergia sissoo*	Practiced	Not Practiced	Lost	-
Silkoroi	*Albizia procera*	Practiced	Not Practiced	Lost	-
Randi Koroi	*Samanea saman*	Practiced	Not Practiced	Lost	-
Eucalyptus	*Eucalyptus globulus*	Practiced	Practiced	-	Introduced
Babla	*Acacia nilotica*	Practiced	Practiced	-	Introduced

Table 7: Loss of timber yielding plants in study area.

English Name	Scientific Name	Pre-erosion	Post-erosion	Present Status of Species	
		Mainland	Charland	Lost	Survived
Bengal Fox	*Vulpex bengalensis*	Presence	Presence	-	Survived
Common mongoose	*Herpestes edwarsi*	Presence	Presence	-	Survived
Palm Squirrel	*Funumbalus pennanti*	Presence	Absence	Lost	-
Common Otter	*Lutra lutra*	Presence	Absence	Lost	-
Common house rat	*Rattus rattus*	Presence	Presence	-	Survived
House Mouse	*Mus musculus*	Presence	Presence	-	Survived
Indian Parcupine	*Histrix indica*	Presence	Absence	Lost	-
Rhesus Monkey	*Macaca mulata*	Presence	Absence	Lost	-
Bat	*Desmodus rotundus*	Presence	Absence	Lost	-
Jungle Cat	*Felis chaus*	Presence	Absence	Lost	-
Small Indian Civet	*Viverricula indica*	Presence	Absence	Lost	-
Large Bandicoot	*Bandicota indica*	Presence	Absence	Lost	-
Jackal	*Canis aureus*	Presence	Absence	Lost	-

Table 8: Loss of mammals' types in study area.

Loss of birds

There are many common birds were found in the mainland (Table 9). Because all sorts of environmental advantages like safe habitat, food and breeding places were friendly present there. Among the bird varieties, only Brahminy Kite, common Kingfisher, spotted Dove, Pond Heron, and Pigeon have been seen in the char areas (Table 9). But these species are now vulnerable and will be newly endangered if the changing environment cannot recover the lost species.

English Name	Scientific Name	Pre-erosion	Post-erosion	Present Status of Species	
		Mainland	Charland	Lost	Survived
House Crow	*Corvus splendens*	Presence	Presence	-	-
House Sparrow	*Domesticus indicus*	Presence	Presence	-	-
Bhat Shalik	*Acridotheres tristis*	Presence	Presence	-	-
Black Drongo	*Dicrurus adsimilis*	Presence	Presence	-	-
Reduented Bulbul	*Pycnontus bengalensis*	Presence	Presence	-	-
Doel	*Copsychus saularis*	Presence	Absence	Lost	-
Common weaver bird	*Ploceus phillippinus*	Presence	Absence	Lost	-
Woodpecker	*Dinopium benghalense*	Presence	Absence	Lost	-
Little Cormorant	*Phalacrocrax niger*	Presence	Absence	Lost	-
Breasted water Hen	*Amauronis fiscus*	Presence	Absence	Lost	-
Hawk Cuckoo	*Cuculus varius*	Presence	Absence	Lost	-
Barn Owl	*Tyto alba*	Presence	Absence	Lost	-
Brahminy Kite	*Haliaster indus*	Presence	Presence	-	-
Common Kingfisher	*Alcedoathis bengalensis*	Presence	Presence	-	-
Spotted Dove	*Streptopelia chinensis*	Presence	Presence	-	-
Pond Heron	*Ardeola grajii*	Presence	Presence	-	-
Pigeon	*Columba livia*	Presence	Presence	-	-

Table 9: Loss of bird species in study area.

Loss of reptiles and amphibians

Amphibians and reptiles are particularly sensitive to changes in the environment [19]. The char land is subject to grazing, trampling, soil erosion and other biotic pressures [20]. Before erosion, the mainland was rich in reptiles and amphibian species. But after erosion, most of them have become very rare in the char environment (Table 10).

Local or English Name	Scientific Name	Pre-erosion	Post-erosion	Present Status of Species	
		Mainland	Charland	Lost	Survived
Geckoes or Tik-tiki	*Hemidactylus spp.*	Presence	Presence	-	-
Tokkay	*Gecko verticillatus*	Presence	Presence	-	-

Yellow Monitor	*Varanus bengalensis*	Presence	Absence	Lost	-
Grey land Monitor	*Testudo elongata*	Presence	Absence	Lost	-
Ghargini	*Lycodon jara*	Presence	Presence	-	-
Gokhra	*Naja naja*	Presence	Presence	-	-
Dhora Shap	*Cerberus rhynchops*	Presence	Absence	Lost	-
Paina Shap	*Enhydris enhydris*	Presence	Absence	Lost	-
Rat Snake	*Dtyas mucosus*	Presence	Absence	Lost	-
Bended Krait	*Bungarus fasciatus*	Presence	Absence	Lost	-
Pond Tortoise	*Chitra indica*	Presence	Absence	Lost	-
Common roof turtle	*Anthocephalus kadamba*	Presence	Presence	-	-
Kuno Bang	*Bufo melanostictus*	Presence	Presence	-	-
Bhawa Bang	*Rana tigrina*	Presence	Absence	Lost	-
Kotkoti Bang	*Rana cyanophlyctis*	Presence	Presence	-	-

Table 10: Loss of reptiles and amphibians.

Conclusion

The mainland was rich in different flora and fauna types, but bank erosion has acted as a driver to decrease the number or extinct of biodiversity because the mainland biomes could not survive in the degraded char environment. The biodiversity loss in the study area has been directly related to habitat destruction and/or damage of breeding and living places of flora and fauna species. Therefore, the biological resources of the mainland have not been able to adapt and creation of new generation making a colony in the degraded char environment. Bank erosion has caused radical changes of the zoo-geo-environmental habitat of the mainland which is the cause of the extinction of the biological diversity. This process could weaken the whole ecosystem, identified as mass extinction of the char ecosystem, and broken down the environmental stability. It is essential to reconstruct the degraded char environment by planting, harvesting and nursing the flora and fauna species so that the reconstructed ecosystem services may enrich the environment of the study area.

References

1. McNeely A, Gadgil M, Leveque C, Padoch C, Redford K (1995) Human influences on biodiversity, In: Heywood VH (ed.), Global Biodiversity Assessment, Cambridge University Press, Cambridge, UK, pp. 711-812.
2. Stedman-Edwards P (1998) Root causes of biodiversity loss. An analytical approach, World Wide Fund for Nature, Washington DC.
3. Novacek MJ (editor) (2001) The Biodiversity Crisis: Losing What Counts. New York: American Museum of Natural History Books.
4. Fisher B, Turner RK, Morling P (2009) Defining and classifying ecosystem services for decision making. Ecological Economics, 68: 643-653.
5. Chambers N, Simmons C, Wackemagel M (2000) Sharing Nature Interest. Ecological footprints as an Indicator for Sustainability, Earthscan Publications Ltd., London, UK.
6. Sinclair ARE (2000) The loss of biodiversity, the six-great extinction. In: Van Kooten GC, Bulte EH, Sinclair ARE (editors), Conserving nature's diversity, Ashgate, Vermont, pp. 9-15.
7. Reveret JP, Weber A (2002) Economics and Biodiversity Management. In: Le Prestre PG (ed.), Governing Global Diversity, Ashgate, Hampshire, UK, pp. 233-246.
8. ISPAN (1993) The dynamic physical environment of riverine char lands: Padma, Irrigation Support Project for Asia and the Near East, Prepared for Flood Plan Coordination Organization, Dhaka, Bangladesh.
9. Ahmed N (1968) Geography of East Pakistan, O.U.P. Dhaka.
10. Rashid H (1991) Geography of Bangladesh. The University Press Limited. Dhaka, Bangladesh.
11. Brammer H (1995) Geography of soils of Bangladesh, The University Press Limited, Dhaka, Bangladesh.
12. BBS (2011) Population Census, 2011, Dhaka: Bangladesh Bureau of Statistics, Statistics Division, Ministry of Planning, Government of the People's Republic of Bangladesh.
13. Rahman MM, Islam MM, Islam MM (2016) Integrated approach of remote sensing and field survey data in assessment of bank erosion intensity of the Padma river in Bangladesh. International Journal of Geomatics and Geosciences 7: 285-297.
14. BBS (2015) Agriculture Sample Survey of Bangladesh-2005, District Series Manikganj, Planning Division, Ministry of Planning, Government of the People's Republic of Bangladesh, Dhaka, Bangladesh
15. BBS (2009) Year book of Agricultural Statistics of Bangladesh, Bangladesh Bureau of Statistics, Statistics Division, Ministry of Planning, Government of the People's Republic of Bangladesh.
16. Evans LT (1963) Environmental Control of Plant Growth, Academic Press Ltd. New York.
17. BARC (2007) Application of Agro-ecological Zones Database in Drought Management and Water Availability Assessment, Report, prepared by Environment and GIS Support Project for Water Sector Planning, Ministry of Water Resources, Government of Bangladesh, Dhaka.
18. Hasan MA (2015) Ucchay Maddhaymik Gibbiggan, first and second paper, Hasan Book House, Dhaka.
19. McCallum ML (2007) Amphibian Decline or Extinction? Current Declines Dwarf Background Extinction Rate. Journal of Herpetology 41: 483-491.
20. Quadir K (1996) Vegetation Diversity in Flood Plains: A Biogeographical Approach, M. Sc. Thesis, Department of Geography, Jahangirnagar University, Savar, Dhak.