IOSR Journal of Environmental Science, Toxicology and Food Technology (IOSR-JESTFT)
e-ISSN: 2319-2402,p- ISSN: 2319-2399.Volume 8, Issue 9 Ver. I (Sep. 2014), PP 20-27
www.iosrjournals.org

Impacts of Water logging on Biodiversity – Study on South-western Region of Bangladesh

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Abstract: *Water logging significantly affects existing biodiversity in South-western region, which has important implication for lives and livelihoods of the people. Collecting primary data through FGD, key informant interview and questionnaire survey from three water logged villages of two Unions of Dumuria and Keshabpur Upazila of South-western region, the study reaches to the conclusion that duration of water logging and peoples' response to that situation are two important factors that determine the effects of water logging in the study area. Impacts of water logging on biodiversity in the study area are visible in reduced number of birds, livestock, fisheries, as well as restrained growth of plants and vegetations. The study also finds that water logging affects peoples' well being by narrowing down the livelihood options of the people. Water logging squeezes the scope for maintaining household economy by reducing the number of livestock, fisheries, and restraining the growth of vegetation, fruit trees and timber trees.*
Keywords: *Biodiversity, Household economy, Livelihood options, Water logging, Well being.*

I. Introduction

Lives and livelihoods of the people in the South-western region of Bangladesh are greatly influenced by water. Water resources offer enormous potentiality in this region by providing income and employment opportunity for most of the people. Local economy in this region is predominantly a fishing economy, which integrates the region's economy into the national and international economy. Contrarily, water resources have particularly detrimental impacts on the peoples' lives and livelihoods, and on biodiversity and environment. In that sense, water is a blessing as well as a curse for the South-western region of Bangladesh. The rivers of South-western region in Bangladesh are characterized by active deposition of sediment causing significant reduction in their drainage capacity. Besides, construction of coastal polders that de-linked the flood plains from the rivers, and diminished upstream flow during the dry season deteriorated the sedimentation problem in the region. Consequently, the area has been experiencing severe drainage congestion and water logging since the early eighties. If we look at the history, we see that since 17th century, landlords or Zamindars constructed wooden sluice gates around the area to protect the arable land from flood. During rainy season, farmers exchanged saline water of their fields with river water when it becomes sweet. This traditional knowledge and practices of water management called Tidal River Management (TRM), which was effective enough to make a balance between sedimentation and subsidence in that area. But these local structures were weak and required continuous maintenance [1]. After abolition of the Zamindary system, the maintenance of these structures became disrupted. As a result, the land water management problems became serious and crop failure occurred frequently. In 1959, to solve this problem, a big program of construction and maintenance of permanent polders was undertaken by the then government. In Khulna and part of the Jessore districts, 39 polders (1,014,100 acres) were constructed [2]. Sedimentation in the tidal rivers of the South-western region of Bangladesh is the main reason behind water logging problem. These troublesome sediments have blocked the rivers and caused upstream drainage congestion and flooding [3].

Millions of people especially poor & landless farmers, sharecroppers, agricultural wage labors, petty traders and others lost their livelihood security due to water logging. Water logging also have detrimental impacts on biodiversity and environment in the South-western region. Water logging induced salinity has already killed off almost all types of vegetation in that region. Agricultural production has drastically reduced and even homesteads vegetation and cattle rearing become impossible. Most of the rivers have dried up. This situation caused immense suffering for the people in that region. Even the famine of 1941/42 was not so much disastrous for this area. The severity of water logging problem prevails in 274 villages of 17 unions under Khulna, Jessore and Satkhira districts. South-western region of Bangladesh has a long history of water logging, but all those phenomena were temporary in nature. Nearly one million people of eight Upazilas (sub-district) of South-western region namely Abhoyanagar, Monirampur, Keshobpur, Dumuria, Tala, Phultala and Daulatpur are the victims of water logging problem for the last 35 years [1].

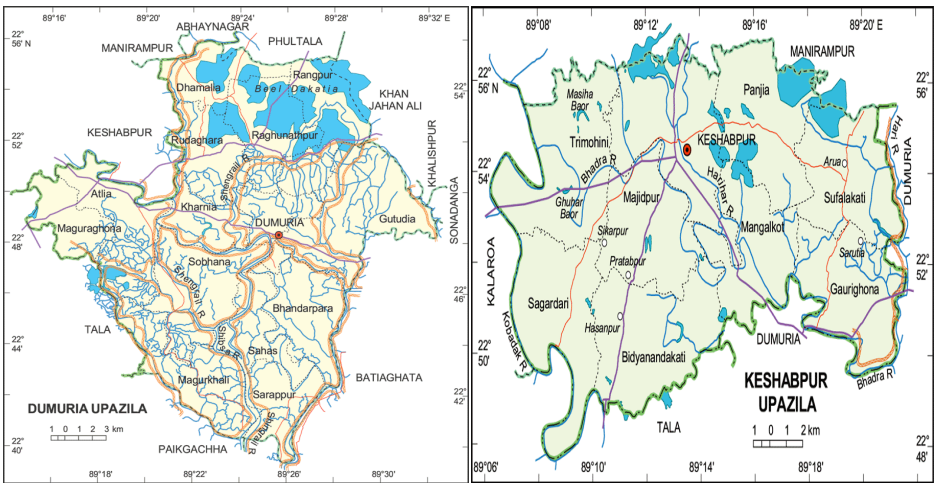
Available evidences provide supports in favor of destructive effects of water logging on cropping pattern and crop productivity. Houk et al. [4] found that water logging hampers production and profit loss in the agricultural sector and water logging induced salinity significantly impact farmers in the Arkansas River Basin of Colorado. Similar findings were made by Barrett- Lennard [5], who argued that interaction between water logging and salinity has major implication for saltland management, and for the selection and breeding of plants adapted to saltland. Likewise, water logging in the South-west region in Pakistan has been adversely affecting the cropping pattern and cropping productivity in irrigated areas. Cotton which comprised eighty percent of land coverage in that area, are now completely being replaced by paddy. Similarly, sugarcane, serson, and other crops have disappeared in the crop bundle of the farmers. Crop productivity of the most important crops like wheat and paddy have reduced almost fifty percent in water logged area [6]. Another study conducted by Towhid [7] captures the impact of rainfall induced water logging in the capital city of Bangladesh. In that study, he found that water logging creates adverse social, economic and environmental impacts resulting enormous sufferings for the inhabitants of Dhaka city.

Available literature focuses on the impacts of water logging on agricultural sector, particularly on crop productivity and cropping pattern in various parts of the world. But very few studies have undertaken capturing the impact of water logging on biodiversity in the South-western region of Bangladesh. As the people in this region have a close interaction between water resources and their lives and livelihood, any impact of water logging on biodiversity and environment significantly affect their wellbeing. Present study tries to discover the impacts of water logging on biodiversity in the South-western region of Bangladesh. It identified that water logging affects human settlement, habitation of birds, animals and fishes as well as growth of trees and plants in that region.

II. Materials and Methods

This study is descriptive in nature, which relies on both primary and secondary data sources. A comprehensive literature survey has done to investigate the causes of water logging problem in this region. The literature survey was also helpful to gain knowledge about human interventions undertaken to solve water logging problem in that region. The authors reviewed journals, books, newspapers, organizational reports and other published sources to perceive ideas on different issues of water logging.

Study area selection: The study purposively selects Dumuria and Keshabpur upazila of Khulna and Jessore district in South- western region of Bangladesh, as these areas have the long history of water logging. The study selects Latabonia and Dighalia villages under Shahos union of Dumuria upazila in Khulna district and Sagordari village under Sagordari union of Keshabpur upazilla in Jessore district.



Description of Dumuria Upazila: Total land area in Dumuria Upazila is 454.23 sq km, located in between 22°39´ and 22°56´ north latitudes and in between 89°15´ and 89°32´ east longitudes. It is bounded by Manirampur, Abhaynagar and Phultala upazilas on the north, Batiaghata and Paikgacha upazilas on the south, Khan Jahan Ali, Khalishpur and Sonadanga thanas and Batiaghata upazila on the east, Tala and Keshabpur upazilas on the west. Total population is 279862; male 144334, female 135528; Muslim 164126, Hindu 115245, Buddhist 264 and others 225. Main rivers are Shibsa and Singrail. Main sources of income are agriculture 65.43%, non-agricultural labourer 3.08%, commerce 14.05%, transport and communication 5.51%, service 5.54%, construction 0.88%, religious service 0.16%, rent and remittance 0.10% and others 5.25%. Main crops are paddy, jute, vegetables, and Main fruits are mango, jackfruit, coconut, betel nut [8].

Description of Keshabpur Upazila: Keshabpur upazila with an area of 258.53 sq km, is bounded by Manipampur upazila on the north, Tala and Dumuria upazilas on the south, Dumuria upazila on the east,

Kalaroa upazila on the west. Main rivers are Harthar and Chengral; and total number of Beels is 20. Agriculture accounts for 47.84% of people, agricultural labourer 26.52%, wage labourer 2.27%, commerce 9.43%, service 3.45%, industry 1.54%, transport 2.62% and others 6.33%. Total cultivable land is 20404.28 hectares; fallow land 297.86 hectares; single crop 28%, double crop 61% and treble crop 21%. Cultivable land under irrigation is 63%. Among the peasants 12% are landless, 64% small, 22% intermediate and 2% rich; cultivable land per head 0.12 hectare. Main crops are paddy, wheat, jute, potato, betel leaf, sugarcane, oil seed, chilli, turmeric, vegetables. And main fruits mango, jackfruit, black berry, betel nut and coconut [9].

Data Collection: The authors collect primary data during the period of September 2013 to December 2013. 20 semi-structured interviews were conducted for capturing the impact of water logging on plant growth, biodiversity and physical environment. The interviewees were mainly farmers and businessmen, who live in the study area for long time and thus would be able to capture the impact of water logging on biodiversity. In addition to this, five key informant interviews were conducted to get deep insight about changes in physical environment and changes in biodiversity and peoples' adaptation to those changes in the study area. Key informant interview incorporates local peoples' representative, local leader, local school teacher and one member of local water committee supported by one of the national NGOs Uttaran and another member from Water Development Forum formed by Bangladesh Water Development Board (BWDB). It was also necessary to collect data on the effect of water logging on plant growth, availability of birds, livestock, fish, fruit and timber trees etc. In order to gather data on these diversified issues, two FGD in Sagordari village and one FGD for each of Latabunia and Dighalia villages have done. After collection of all primary and secondary data, they were processed and analyzed to obtain the findings of the study.

III. Water logging Problem in the Study Area

The study area has been particularly suffering from water logging problem especially in the rainy season. Shahos union of Dumuria upazila, and Sagordari union of Keshabpur upazila are two major water logged areas in this region. Nature and severity of water logging problem differs in between these two regions. It is important to note that Latabunia and Dighalia villages are situated on the bank of the river Ghangrail, which have been waterlogged during rainy season in every year since 2008. Water logging problem stays there from one week to two weeks. The main reason behind water logging is the reduced capacity of Ghangrail river, which frequently over flowed during rainy season. Another reason is siltation of a canal named Hoglabunia, which was connected to the main river Ghangrail. This canal was three km of length and 50 feet of width, which was a natural canal of 100 years old. This canal passed through Latabunia and Dighalia villages, which served as a channel to discharge over flowed water during rainy season. But this canal had silted up eight years ago, due to manmade blockages for fish cultivation and by siltation carried out by Ghangrail river. Field survey shows that flood, making channel inside embankment of river for bringing salt water into the shrimp farm, weakness of embankment of river, stoppage of sluice gate, siltation of connecting canal of tidal river etc. are other reasons behind water logging problem in the study area. Water logging problem in the study area is temporary in nature, because Ghangrail river has sufficient flow during high tides and low tides, which discharges over flowed water in its normal sequence. This river carries at least 10 feet depth and 200 feet width of water during low tides; at best 30 feet depth and 300 feet width of water during high tides, which was sufficient enough to drain out over flowed water by one or two weeks from the locality. But siltation of the canal Hoglabunia creates drainage congestion problem in that area. This temporary nature of water logging affects 200 to 220 households in two villages combined. Like Ghangrail river, Kobadak river has been water logged during rainy season every year since 2001, which affects 800 households in Sagordari village. This area suffers severe water logging problem unlike Latabunia and Dighalia villages staying from eight months to ten months in a year. This permanent nature of water logging resulted from siltation of river beds of Kobadak river, decreased flow of Kobadak river and insufficient water holding capacity in the rainy season. This river has completely died off, which caused serious drainage congestion and water logging problem in the study area.

Available evidences show that water logging in the South-western region affects income, expenditure and occupation pattern of the households. Water logging creates livelihood displacement for the local poor through reducing access to the common property resources. This situation also squeezes their income earning opportunity from agricultural and non agricultural activities. It also restricts their access to the safe drinking water and sanitation system. Water logging destroys educational and religious institutions, housing conditions and reduces scope for other utility services. Again reduced land productivity, water pollution, deforestation and depletion of species are the direct consequences of water logging in the South-western region of Bangladesh [10]. It is important to note that water logging affects local biodiversity in that region, which subsequently changes the lives and livelihoods of the people of that area. Because there is a close interaction between peoples' welfare and the environment where they live. Field survey shows that the impact of water logging on biodiversity and environment differs to some extent due to nature, severity and coverage of water logged land in

the study area. It affects plant growth, availability of birds and livestock, fruit and timber trees and availability of fishes in this region. Present study is an attempt to make a detail investigation on this issue.

IV. Impacts of Water logging on Biodiversity in the Study Area

Biodiversity simply means the diversity, or variety of plants and animals and other living things in a particular area or region. Nature and extent of water logging significantly affects local biodiversity in the study area. Water logging reduces the availability of birds and fishes, restricts the opportunity to rear livestock. It restrains all sorts of plant growth, fruit trees and timber trees. Field survey shows that the scenario of whole physical environment has changed due to water logging.

Table 01: Impact of water logging on livestock

	Livestock_Latabunia			Livestock_Dighalia			Livestock_Sagordari		
Name	**Before (in %)**	**After (in %)**	**% change**	**Before (in %)**	**After (in %)**	**% change**	**Before (in %)**	**After (in %)**	**% change**
Cow (Bos primigenius Taurus)	80	60	(-)20	80	30	(-)50	80	30	(-)50
Goat (Capra hircus)	25	10	(-)15	10	10	0	80	30	(-)50
Duck (Anas platyrhyncha)	30	10	(-)20	85	60	(-)25	85	35	(-)50
Chicken (Gallus domesticus)	80	60	(-)20	65	35	(-)30	85	30	(-)55
Sheep (Ovis aries)	80	60	(-)20	60	30	(-)30			
Goose (family anatidae)	30	10	(-)20	10	5	(-)5	25	10	(-)15
Cat (Felis catus)	25	25	0	70	70	0	55	30	(-)25
Dog (Cannis familiaris)	10	10	0	10	10	0	50	30	(-)20
Squirrel (Rodentia sciurus)				50	60	(+)10			
Rat (Rattus norvegicus)	80	60	(-)20	70	80	(+)10			

N.B. The table above captures mean responses on availability of livestock of FGD participants in percentage form before and after water logging. The study categorizes four distinct types of responses on the basis of availability, which reports that (65-90)% means very commonly seen, (35-64)% means commonly seen, (15-34)% means rarely seen and (5-12)% means very rarely seen

Field survey shows that water logging restrains the opportunity of rearing livestock by the households. The table above compares the availability of livestock in three villages before and after water logging. FGD data shows that the number of cows, goats, ducks, chicken and goose have reduced significantly in three villages' altogether. It is important to note that number and availability of cows have reduced more in Dighalia and Sagordari rather than that of Latabunia village. In case of goat, significant change has occurred in Sagordari village, but the availability remains same in Dighalia village. Duck has reduced significantly in Sagordari village due to scarcity of fodder. Percentage of reduction in duck is less in Latabunia village than that of Dighalia village. Chicken has reduced more in Sagordari village than those of Latabunia and Dighalia village. Percentage change of Goose is more or less same in Latabunia and Sagordari villages. There are no changes in number of cats and dogs in Latabunia and Dighalia villages, but it has reduced in Sagordari village. Another finding is that the number of rats has increased in Dighalia village, while it has decreased in Latabunia village. The implication of this finding in Dighalia village is that rat has not increased in absolute number rather its appearance inside the human habitation has increased due to water logging in that area.

In case of livestock, Latabunia village has been experiencing comparatively little loss in rearing cows and sheep than other two villages even after water logging. The reason is that temporary nature of water logging in this locality does not affect the availability of fodder significantly and they have alternate source of fodder for cows other than grass. There is little availability of goats in Dighalia village even before water logging, which captures no change after water logging. This area has high preference to rearing sheep, which captures 30 percent reduction after the area being water logged. Number of duck supposed to be increased due to availability of water, but it captures 50 percent reduction in Sagordari village, this is 20 percent in Latabunia village and 25 percent in Dighalia village. Likewise reduction of chicken in these areas implies that water logging affects family food consumption level, a part of which were earlier being used as fodder for chicken and duck. Similar connotation may be applied for explaining the reduction of the number of cats and dogs in Sagordari village. Another finding is that due to water logging, appearance of squirrel and rats has increased in Dighalia village, meaning that water logging disrupts their habitation in open places. Finding no other way, they fix their places in surrounding areas along with human habitation.

Table 02: Impact of water logging on fish species

	Fish_Latabunia			Fish _Dighalia			Fish _Sagordari		
Name	**Before (in %)**	**After (in %)**	**% change**	**Before (in %)**	**After (in %)**	**% change**	**Before (in %)**	**After (in %)**	**% change**
Koi (Anabas testudineus)				10	10	0	60	20	(-)40
Taki (Channa punctata)				15	15	0	70	30	(-)40
Magur (Clarias batrachus)				12	12	0	50	15	(-)35
Singhi (Heteropneustes fossilis)				10	10	0	45	15	(-)30
Shoil (Channa striata)				10	10	0	60	10	(-)50
Maya Chela (Amblypharyngodon mola)				20	20	0	60	60	0
Tengra (Batasio batasio)	80	90	(+)10	40	50	(+)10	50	50	0
Punti (Puntius puntio).	60	25	(-) 35	35	20	(-)15	65	65	0
Bele (Glossogobius giuris)	60	60	0	20	20	0			
Baim (Mastacembelus armatus)				15			50	50	0
Telapia (Oreochromis mossambicus)				20			60	80	(+)20
Vetki (Lates calcarifer)	50	50	0	40	40	0	15	5	(-)10
Kholshe (Colisa fasciata)							30	10	(-)20
Gazar (Channa marulius)							10	10	0
Pangas (Pangasius pangasius)							15	15	0
Khorshula (Rhinomugil corsula)				15			12	4	(-)8
Ruhi (Labeo rohita)				30	15	(-)15	60	60	0
Katla (Catla catla)				30	15	(-)15	60	60	0
Silver carp (Hypophthalmichthys molitrix)				25	10	(-)15	50	50	0
Grass carp (Ctenopharyngodon idella)				25	10	(-)15	50	50	0
Mrigel (Cirrhinus cirrhosus)				30	15	(-)15	55	55	0
Nilontika (Oreochromis niloticus niloticus)	90	90	0	40	40	0			
Shrimp (Penaeus monodon)	90	90	0	80	80	0			
Parshe (Liza parsia)							10	10	0

N.B. the table above captures mean responses on availability of fishes of FGD participants in percentage form before and after water logging. The study categorizes four distinct types of responses on the basis of availability, which reports that (65-90)% means very commonly seen, (35-64)% means commonly seen, (15-34)% means rarely seen and (5-12)% means very rarely seen.

Field survey shows a mixed impact of water logging on fish species. The impact varies depending on the existence of fish availability in the study areas. In Dighalia village, there is no change in native fish species, like Koi, Magur, Taki, Singhi, Shoil etc., but water logging increases the availability of Tengra fish in that region. A significant reduction has occurred in the availability of Puti, khorshola, Ruhi, Katla, Silver carp, Grass carp and Mrigel. Unlike Dighalia village, Sagordari village has been experiencing a significant reduction of local fish varieties, for example Koi, Magur, Taki, Singhi, Shoil. But there is no change in Maya Chela, Tengra and Puti. Cultivation of tilapia has increased, but Kholshe, Vetki and Khorshula has decreased. No change has captured in case of Ruhi, Katla, Silver carp, Grass carp and Mrigel. In case of Latabunia village, Tengra cultivation has increased but Puti has decreased. Availability of Bele, Vetki, Nilontika and shrimp has remained unchanged.

It is important to note that Sagordari village seems to be rich in fish species, which is to be reflected by greater availability of different fish species than the other ones. It is important to note that water logging does not affect large scale culture fisheries, such as cultivation of Ruhi, Katla, Silver carp, Grass carp and Mrigel etc. in this locality. In that case, fish is cultivated in gher or pond on a commercial basis, where all of the sides of gher have made higher to protect water intrusion.

Significant reduction of local fish species like Koi, Magur, Taki, Singhi, Shoil, Maya Chela etc. reduces the accessibility of the local poor to open access fisheries, which has significant implication to livelihood security at community level and family protein consumption at family level in Sagordari village. Implication of no change of Ruhi, Katla, Silver carp, Grass carp and Mrigel is that these species are being cultivated at large scale in gher, which are pre cautiously managed from logged water.

Table 03: Impact of water logging on bird species

	Bird_Latabunia			Bird_Dighalia			Bird_Sagordari		
Name	**Before (in %)**	**After (in %)**	**% change**	**Before (in %)**	**After (in %)**	**% change**	**Before (in %)**	**After (in %)**	**% change**
Crow (Corvus splendens)	10	2	(-)8	10	8	(-)2	40	10	(-)30
House sparrow (Passer domesticus)	15	15	0	15	15	0	60	20	(-)40
Wood pecker (Melanerpes formicivorus)	10	8	(-)2						
Owl (Tyto alba))	8	2	(-)6	8	0	(-)8	8	1	(-)7
Pigeon (Columbia livia)	12	12	0	20	5	(-)15	30	30	0
Heron (Ardeola grayii)	50	20	(-)30						
Magpie Robin (Copsychus saularis)	30	30	0	30	20	(-10)	6	4	(-)2
King fisher (Halcyn smyrensis)	10	10	0	10	10	0	10	10	0
Tuntuni (Orthotomus sutorius)	10	10	0	10	6	(-)4	10	3	(-)7
Dove (Streptopelia chinesis)	10	10	0	15	5	(-)10			
Shalik (Acridotheres tristis)							15	5	(-)10

N.B. the table above captures mean responses on availability of birds of FGD participants in percentage form. The study categorizes four distinct types of responses on the basis of availability, which reports that (65-90)% means very commonly seen, (35-64)% means commonly seen, (15-34)% means rarely seen and (5-12)% means very rarely seen.

The table above captures the impact of water logging on availability of birds in the study area. Field survey shows that crow has reduced in all of the villages after water logging. A significant reduction has occurred in case of house sparrow in Sagordari village, but no change occurred in Latabunia and Dighalia village. Owl has almost disappeared from each of the villages due to water logging. 15 percent reduction has captured in case of Pigeon in Dighalia village. 10 percent of Magpie Robin has disappeared from Dighalia and 2 percent from Sagordari village. Tuntuni has reduced by 7 percent in Sagordari village, whereas it is 4 percent in case of Dighalia village. A significant reduction of dove has occurred in Dighalia village and Shalik in Sagordari village respectively.

If we look into the nature of birds disappeared from biodiversity in the study area, we find that the birds which depend on trees for their habitation are greatly reduced after water logging. For example, Owl, Wood pecker, Magpie Robin, and Shalik belong to this category. Then another significant reduction has occurred in case of Crow, which is dependent on human wastages like spoiled food, decomposed material etc. Water logging affects human well being by reducing consumption level and degrading living standard of the people, which restrains the scope for discarded material and spoiled food for the households.

Table 04: Impact of water logging on fruit plants

	Fruit_Latabunia			Fruit_Dighalia			Fruit_Sagordari		
Name	**Before (in %)**	**After (in %)**	**% change**	**Before (in %)**	**After (in %)**	**% change**	**Before (in %)**	**After (in %)**	**% change**
Blackberry (Syzygium cumini)				10	5	(-)10	70	10	(-)60
Jackfruit (Atrocarpus heterophyllus)							75	5	(-)70
Banana (Musa paradisiacal)	15	6	(-)9	12	4	(-)8	85	15	(-)70
Papaya (Carica papaya)	10	4	(-)6	12	3	(-)9	80	5	(-)75
Sofeda (Achras zapota)	50	50	0	10	10	0	70	60	(-)10
Coconut (Cocos mucifera)	30	10	(-)20	30	12	(-)18	80	30	(-)50
Boroi (Zizyphus mauritiana)	80	80	0	10	6	(-)4	55	12	(-)43
Mango (Mangifera indica)	10	4	(-)6	10	5	(-)5	50	30	(-)20
Litchi (Litchi chinensis)							25	10	(-)15
Palm (Borassus flabellifer)	10	10	0	10	10	0	60	10	(-)50
Guava (Psidium guajava)	30	12	(-)18	10	10	0	60	12	(-)48
Lemon (Citrus limon)							35	12	(-)23
Date (Phoenix sylvestris)							80	10	(-)70
Betel nut (Areca catechu)							85	10	(-)75

N.B. the table above captures mean responses on availability of fruit plants of FGD participants in percentage form. The study categorizes four distinct types of responses on the basis of availability, which reports that (65-90)% means very commonly seen, (35-64)% means commonly seen, (15-34)% means rarely seen and (5-12)% means very rarely seen.

The table above shows the impact of water logging on availability of fruit trees. Field survey shows that Sagordari village was rich in fruit plants before water logging, which is the most affected area after water logging. Water logging crumbles all sorts of fruit plants in Sagordari village. Water logging almost completely destroy blackberry, banana, jackfruit, papaya, coconut, Boroi, palm, guava and betel nut trees. Other species have also reduced significantly in Sagordari village. Temporary nature of water logging also affects fruit plants growth in Dighalia and Latabunia villages. In Latabunia village, greater loss has occurred in case of coconut and guava, which is 20 percent and 18 percent respectively. Again banana, papaya and mango trees capture 9 percent, 6 percent and 6 percent reduction respectively in Latabunia village. No change has captured in case of Sofeda, Boroi and palm fruits. In case of Dighalia village, significant reduction has occurred in coconut, blackberry, papaya, banana, mango and Boroi, but Sofeda, palm and guava have remained unchanged.

Table 05: Impact of water logging on timber trees

	Tree_Latabunia			Tree_Dighalia			Tree_Sagordari		
Name	**Before (in %)**	**After (in %)**	**% change**	**Before (in %)**	**After (in %)**	**% change**	**Before (in %)**	**After (in %)**	**% change**
Neem (Azadirachta indica)	60	60	0	10	10	0	30	20	(-)10
Shimul (Bombax ceiba)							10	8	(-)2
Kadom(Anthocephalus chinensis)				10	8	(-)2	10	7	(-)3
Gamari (gmelina arborea)							10	7	(-)3
Gaooa (Excoecaria agallocha),	80	90	(+)10	10	10	0			
Shegun (Tectona grandis)							30	20	(-)10
Mehaguni (Swietenia macrophylla)	10	10	0	10	8	(-)2	35	25	(-)10
Golpata (Nypa fruticans)	15	25	(+)10						
Baine (Avicennia officinalis)	10	10	0						
Shishu (Dalbergia sissoo)							25	25	0

N.B. the table above captures mean responses on availability of timber trees of FGD participants in percentage form. The study categorizes four distinct types of responses on the basis of availability, which reports that (65-90)% means very commonly seen, (35-64)% means commonly seen, (15-34)% means rarely seen and (5-12)% means very rarely seen.

The table above captures the impact of water logging on timber trees in three villages in the South-western part of Bangladesh. Permanent nature of water logging in Sagordari village reduces the availability of timber trees, such as Neem, Shimul, Kadom, Gamari, Shegun, Mehgani etc. Water logging induced salinity plays a major role behind this destruction. Unlike Sagordari village, Latabunia village has been experiencing increased number of salinity tolerate species, like Gaoa and Golpata. Neem, Mahegani and Baine has remained unchanged in that area. In case of Dighalia village, there is no change in the availability of Neem and Gaooa trees, but 2 percent reduction has occurred in Kadom and Mehegani trees respectively.

V. Socio-economic Implication of Biodiversity Loss in the Study Area

Field survey shows that severity and extent of water logging depends on condition of the adjacent river and existence and utilization of canals, which act as a connecting channel to discharge water from the locality. This study reveals that Sagordari village of Keshobpur Upazila is the utmost sufferer of water logging in terms of nature and severity of the problem. Kobadak river, which was full of tidal wave during 1970s and 1980s, gradually lost his power due to siltation of river beds and due to the flood during 2001-02. Now this river has completely died off, which causes a great suffering for the people of surrounding locality. These sufferings have been reflected in terms of biodiversity loss and resultant reduced well being.

If we compare among three villages studied, we find that Sagordari village was richer in biodiversity before water logging. Therefore, resultant biodiversity losses are greater when the area goes under water. In connection to this, it can be predicted that socio-economic vulnerability in this area should be more acute than other comparable villages. But observation in the field survey shows that socio-economic condition of the people in Sagordari village is better than other two villages although it suffers from eight to ten months duration of water logging. Key informant interview data discloses the fact that people of this village have been able to adapt the changed environmental setting and incorporate those changes into their livelihood dynamics. For example, water logging narrows down the scope for household economy, such as, squeezing options for rearing livestock and growing vegetables, fruits and timber trees, people adopt other diversified sources of income to compensate the losses. In relation to this, authors find that water logging reduces availability of native fish species in this village, but it does not have any major impact on large scale commercial fish cultivation. Again people adopt different nonfarm activities to reduce dependence on agricultural sector. Occupational diversification in this village ranges from day laboring, petty trading to large scale commercial fish cultivation, cropping, both government and non government service holding etc. People also tend to migrate both

temporarily and permanently to other adjacent places as a part of adaptation. All these strategies, apart from other positive factors, keep the living standard of the people in Sagordari village above minimum subsistence level in spite of long duration of water logging.

Unlike Sagordari village, Dighalia and Latabunia villages were comparatively poor in biodiversity. And average level of poverty in these two villages is higher than that of Sagordari village. These areas are salinity affected areas since before water logging. Therefore, water logging creates an extra pressure to the existing level of poverty in the region. Water logging reduces the scope for traditional fishing, kitchen gardening, livestock rearing and other household economies. As we see from the field survey that stock of native fish species has reduced due to water logging. Livestock rearing has reduced significantly. Growth of all sorts of trees except few salinity tolerate species have restrained due to water logging. Key informant interview data shows that occupational diversification in these two villages is less as a response to the problem. Therefore, water logging has a far reaching impact on the well being of the people in these villages.

VI. Conclusion

Foregoing analysis reveals that nature and severity of water logging problem affect the study areas in different ways. Duration of water logging and peoples' response to that problem are two important factors which determines the effect of water logging problem in the study area. Permanent nature of water logging in Sagordari village induces the people to adapt the consequences of water logging into their livelihood dynamics even amid severe biodiversity losses. On the contrary, temporary nature of water logging in Dighalia and Latabunia village does not compel the people to compensate the water logging induced welfare losses. But it is evident from the field survey that water logging has profound impacts on biodiversity loss and resulting reduced well being in terms of squeezed household economy and reduced access to open access fisheries.

Present study relies on recall data to capture the impact of water logging on biodiversity, which might have both upward and downward bias. Biodiversity losses in the study area have greater socio-economic implications, which have only partially addressed under this study. In addition to this, authors did not find any comparable study in the literature, findings of which might act as a yardstick to the present analysis.

In spite of these limitations, present study is important in terms of unveiling the livelihood implications of biodiversity loss in the study area. Present study lacks detail investigation on this particular issue, which requires further elaboration in the future research.

Analyzing the causes and impacts of water logging problem on biodiversity in the study area, present study suggest few recommendations to reach a long term solution towards this problem. These recommendations are extracted from the opinion of the respondents in the study area. People in Sagordari village opine that dredging of Kobadak river is the most important solution to allow regular tides of the river at first stage. Then it is also very important to prohibit active deposition of sediments inside the river beds. For this purpose local people suggest to adopt Tidal River Management (TRM) in severe water logged areas. In case of Dighalia and Latabunia village, people recommend excavation of existing canal named Hoglabunia to drain out logged water from the habitation. Local people in this area also suggest continuing TRM in the upstream rivers to increase drainage capacity of the Ghangrail river. But people in all of the study areas opine that whatever the measures adopted for solving water logging problem should incorporate local people and indigenous knowledge.

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