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Analysis of the Wetland Degradation around the Vicinity of Dhaka City in Bangladesh

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Abstract: Degradation of wetland creates adverse impact on natural environment, ecosystem and on drainage congestion. The situation is more alarming in case of urban areas especially Dhaka and its adjacent areas. The objectives of the study are to determine the status of wetland reduction around Dhaka city in terms of extent of area and causes responsible for degradation. Satellite images of 1967, 1977, 1989, 1999, 2009 and 2010 have been used for preparing permanent wetland maps while satellite images of 1996 and 2009 have been used for preparing seasonal wetland status. Analysis showed that extends of permanent wetlands have been reduced in all the study areas during 1996-2009. Wetland degradation was found to be worse in eastern Dhaka followed by western Dhaka and Dhaka-Narayanganj-Demra (DND) areas. In case of Seasonal Wetlands, western Dhaka showed almost two-time more degradation than that of eastern Dhaka in case of areal extension, when the same period of 1996-2009 is considered. Extensive increase of population and commercially productive use of land within the city are mainly responsible for this degradation. Demand driven urban growth that has profound adverse effects on the water resources and the wetland system in Dhaka have caused adverse impacts on the drainage systems. Unplanned urbanization has hampered the natural state of drainage, and hence caused sudden inundation and water-logging. Another major reason for seasonal wetland degradation is loss of the connectivity of floodplains within the study area.

Key words: Wetland, images, degradation, drainage.

Introduction

With time, the adjacent area of Dhaka city is changing its infrastructure rapidly and expanding its area very fast. This is why; Dhaka City has been facing tremendous problems including flooding, water logging and other related concerns. In the past the city was regarded as the Venice of the East or the City of Channels (Dani, 1962). A few decades ago there were numerous lowlands, *khals* and channels within and around Dhaka that would drain the city efficiently (JICA, 1991). However, western Dhaka, eastern Dhaka and Dhaka-Narayanganj-Demra (DND) area are considered in this study to assess the degradation rate of wetland in terms of areal extension and find out the probable causes of it. The DND area has been protected by big dike during 1962-68, pursuant to the national objective of attaining self-reliance in food grain production by providing comprehensive flood control, drainage and irrigation (FCDI) facilities in the area. Western Dhaka is also flood protected while eastern Dhaka in not flood protected. Land-use pattern of the study area has progressively been changed from the originally planned one and most of the agricultural land has been transformed into residential or industrial plots and roads with the rapid urbanization process associated with the establishment of Dhaka as the capital city of Bangladesh. About 6.7 percent of Bangladesh is always under water, 21 percent is deeply flooded (more that 90 cm) and 35 percent experiences shallow inundation (FAO, 1988). Bangladesh is estimated to have seven to eight million hectares of wetlands in the form of permanent rivers and streams (480,000 hectares); estuarine and mangrove

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swamps (610,000 hectares); shallow lakes and marshes (120,000-290,000 ha); large reservoirs (90,000 ha); small ponds and tanks (150,000-180,000 ha); shrimp ponds (90,000-115,000 ha); and seasonally flooded floodplains (5,770,000 hectares) (Nishat et al., 1993).

Climate change is recognized as a major threat to the survival of species and integrity of ecosystems worldwide (Hulme, 2005). Pressures on wetlands are likely to be mediated through changes in hydrology, direct and indirect effects of changes in temperature, as well as land-use change (Ferrati et al., 2005). Under currently predicted future climate scenarios, the spread of exotics will probably be enhanced, which could increase pressure on watersheds and ecosystems (Root et al., 2003). Moreover, climate change will make future efforts to restore and manage wetlands more complex.

Wetlands cover 6% of the world's land surface and contain about 12% of the global carbon pool, playing an important role in the global carbon cycle (IPCC, 1996, 1998; Ferrati et al., 2005). In a world of global climate change, wetlands are considered one of the unknowns of the near-future regarding element dynamics and matter fluxes (IPCC, 2001; Paul et al., 2006). The expansions of agriculture and subsequent conversion for settlement and infrastructure development along with the rising population have put immense pressure on wetlands and shrinking it alarmingly.

In Dhaka city as well as in the surrounding areas, development of infrastructure is taking place in an unplanned manner without considering the drainage systems as well as the conservation needs of the wetlands. The rapid urbanization and population pressure of the vicinity of Dhaka city has degraded many of the wetlands since 1960 and the process is ongoing. However, the environment and the ecosystem of particular areas are directly interlinked with its natural wetland system and its sustainability. Wetlands have been facing immense degradation and wetland biodiversity is disappearing rapidly Therefore, it is essential to assess the extent of wetland degradation and causes responsible for it. Thus the study attempted to assess the wetland degradation with the objectives: (i) to quantify the extent and rate of wetland degradation that is occurring in the vicinity of Dhaka city; and (ii) to identify the causes responsible for wetland degradation.

Methodology

Description of the Study Area

The DND area covers 56.79 sq.km. and located in Demra and Shampur thanas (administrative unit) of Dhaka district and Fatullah, Siddirganj and Sadar thanas of Narayanganj district of Bangladesh. The Lakhya River lies on the east and the Buriganga on the west of the study area. The flood protected western Dhaka is around 143 sq. km extending from the Tongi Khal in the north to DND area in the south and Turag-Buriganga river in the west to the railway line Pragati Sarani-Atish Dipankar Road in the east. The eastern Dhaka which is not flood protected is around 116 sq. km extending from the Tongi Khal in the north to DND area in the south and Balu in the east to the railway line Pragati Sarani-Atish Dipankar Road in the west. The study area is shown in Figure 1. Gradually the vicinity of Dhaka city is changing its land use, and most of its agriculture land, wetland and fallow land are occupying for residence and industrial purpose. The surface water area of Dhaka city is about 10-15% of total land area (DOE, BCAS and UNEP 2006). The Buruganga, Turag, Tongi *Khal* and Balu River are the main streams that surround the Dhaka city and its extension area where the development activities are going on and many of the connectives canal flow to these rivers. However the surrounding rivers, the lakes, canals and low-lying areas have been considered as wetlands and wetlands are divided into two categories; permanent wetlands and seasonal wetlands to serve the purposes of the study.

Images Collection

Multi-dated satellite images that are available (Table 1) were used in this study. As permanent wetlands can only be identified in the dry season, images between January to March were used to identify permanent wetlands, In order to identify seasonal wetlands, images between July to October were considered. During this period the rivers of Bangladesh become over flowed and in the same period heavy shower occur which cause slightly low-lying area seem to be wetlands. In order to avoid cloud hazard RADARSAT ScanSAR narrow beam satellite image has been used in this study. This type of image is very much useful in identifying extent of seasonal wetlands during monsoon. An optical image which is cloud-free was also collected. Four frames of Corona Arial photographs were acquired to cover the study area. Arc GIS 9.2 and EDRAS 9.1 have been used as analysis tools in this study.

Geo-referencing and Co-registration

During this study, satellite images have been processed at different levels to identify the extent of permanent wetlands, seasonal wetlands, settlement and urban development areas, and agricultural land/vegetation/ fallow/bare land. All images have been corrected

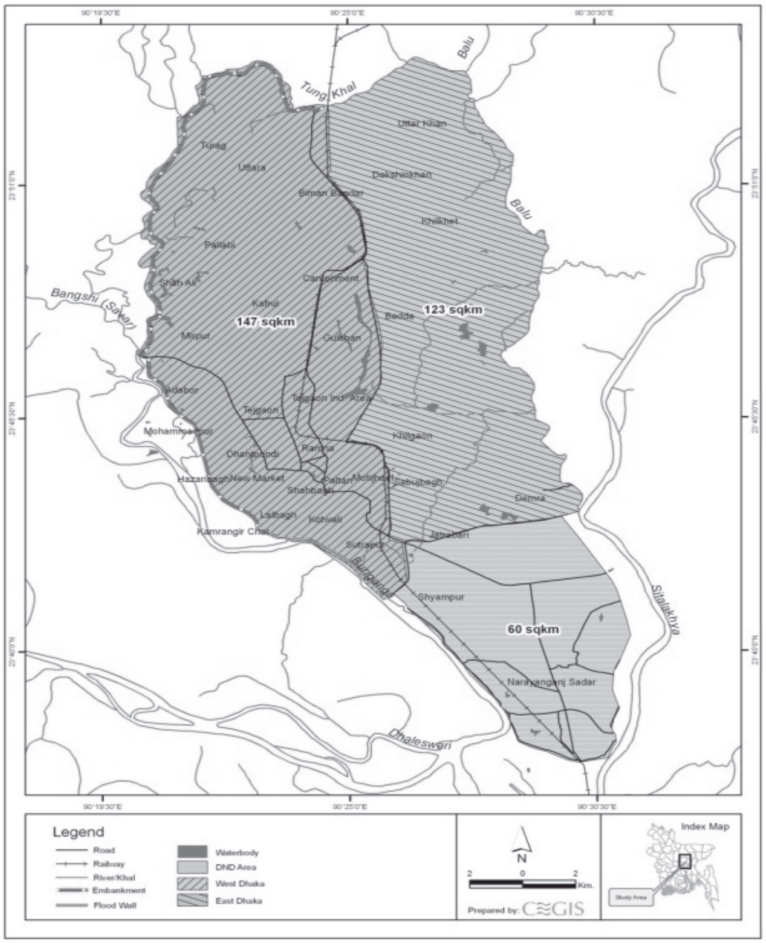

Figure 1: Location map of the study area.

Table 1: Satellite images used for wetland mapping

Sl No.	*Sensor*	*Date*	*Resolution*
1	Corona Space photo	01 March 1967	12 m
2	Landsat2 MSS	03 January 1977	80 m
3	Landsat4 TM	12 January 1989	30 m
4	Landsat5 TM	01 February, 21 March 1999	30 m
5	Landsat5 TM	30 January 2010	30 m
6	RADARSAT Scan SAR Narrow	03 September 1996	50 m
7	Landsat5 TM	26 October 2009	30 m

geometrically with the reference of IRS Panchromatic images of 2003 which had been geometrically corrected previously using DGPS and projected to the Bangladesh Transverse Mercator Projection system. The maximum acceptable error of geo-referenced images was one pixel. However, after geometric correction, all the images were co-registered with each other to match properly.

Digital Classification

The Iterative Self–Organizing Data Analysis (ISODATA) clustering algorithm was used to derive extents of seasonal and permanent wetlands and other land uses using the satellite images. These three classes helped in delineating how much permanent or seasonal wetland have been changed or degraded due to rapid development of settlement and urban areas. To identify the permanent wetlands, Corona Arial photographs of 1967 were classified initially into 50 classes. Similar spectral classes were grouped together to generate the permanent wetlands map. Same approach has been used in different studies to determine the land use of Dhaka city (Islam et al., 2010). After the initial classification, similar spectral classes were grouped together to generate permanent wetlands maps of 1977, 1989, 1999 and 2010. The same procedure was followed to identify seasonal wetlands, settlements and urban areas, and agricultural areas from the images.

Review of Relevant Reports

Satellite images of study area were taken to know how fast the wetland, agricultural land and fallow land are shrinking and converted into housing and industrial area in and around Dhaka city. Actually, there are many factors behind it to degrade the wetland i.e. land graving, wetland filling and unplanned urbanization and many more. To fulfill the objectives of the study different types of reports focussing on causes of wetland degradation were reviewed to find out the initiatives that mostly consequences the wetland degradation around Dhaka city.

Result and Discussion

Permanent Wetland Mapping and Analysis

Different maps (Figure 2) have been derived from multi-dated satellite images to assess the wetland degradation of the study area. Extracted data from different images were arranged in tabular form and the changes in different land-use types were analyzed.

It is found from the analysis of data (Table 2) that the domain area of DND was almost 6054 ha of which permanent wetland occupied 4.15% (251 ha) in 1967. Except in 1977, a descending trend in the extents of wetlands was noticed and an alarming reduction to 1.16% (70 ha) was recorded in 2010. It also disclosed a moderate reduction in agricultural lands/vegetation/fallow and bare lands during 1967 to 1989 which occupied 49.92% and 47.56%, respectively. Interestingly, within the same period, a gradual growing tendency was reported in settlements and urban developments viz. 45.93% and 47.13%. In the following years, a rapid increase in settlements and urban development's took place reaching 4157 ha (68.67%) in 2010. However, the analysis revealed that increasing of settlement and urban development is prominent cause of wetland and agricultural land reduction.

Total land area of eastern Dhaka was all but 73,700 ha as calibrated from images (Table 2). It was found from the analysis that permanent wetland decreased all of the estimated years i.e. 14.44% (10,655 ha) in 1967 and mildly decreased to 14.28% in 1977. In addition, as found in 1989, it was alarming (9.96% land occupied by wetland) which became the worst in 2010 and wetland coverage declined to 3.37% (2486 ha). In the case of agriculture/vegetation/fallow/bare land extended area from 1967 to 2010, it was in increasing trend in 1967, 1989 and 1999 which was 46.16% (34,052 ha), 49.41% and 53.14% accordingly but only exception found in 1977 that possessed 45.54% of total land. On the contrary, in 2010 it decreased dramatically and takes it to the lowest at 37.35% (27,547 ha). Regarding settlement and urban development, moderate increases were found in 1967 to 1999 and around 41% land was used under this purpose. However, it sharply increased to 59.28% (43,730 ha) in the year 2010. Lastly, it may be concluded that up to 1999 both agricultural and settlement and urban expansion simultaneously caused wetland reduction. However, in 2010, settlement and urban developments were solely responsible for wetland and agricultural land deduction. The wetlands of the urban fringe of eastern areas are in the process of rapid transformation. The rate of permanent wetlands transformation appears to be drastic and this type of wetlands is converted to built-up area (Segufta et al., 2010).

Permanent wetland in western part of Dhaka was also found degraded in terms of areal extension (Table 2). During the years 1967-1977 it was almost same comparing the subsequent years and demonstrated about 14% as it occupied. Since 1989 it started to lose its area drastically and in 2010 it reached 4.3% (3034 ha) which was 10,031 ha in 1967. The highest settlement and urban development occurred in 2010 followed by in 1999 that showed 48.03% and 40.85% of land occupant respectively. Regarding area coverage, during 1967 to 1989 there was no significant change in this respect. However, fluctuated phenomena were observed in agriculture/vegetation/fallow land coverage which demonstrated highest value 53.87% in 1999. The lowest rate 47.66% was calculated in 2010 due to massive invasion of settlement and urban development for the same year which also caused the lowest area coverage of wetland. Both categories (water bodies and lowlands) of wetlands of Dhaka city have decreased sharply by 32.57% of the water bodies and 52.58% of lowlands from 1960 to 2008. It also showed that shape of lowlands is being changed mainly because of land filling activities of the area. In 1960 lowlands covered most of the eastern part and western edge of the Dhaka city but in 1988, the lowlands of north-eastern part were reduced (Islam et al., 2010).

Seasonal Wetland Mapping and Analysis

Two different images i.e. RADARSAT and Landsat TM satellite dated 3 September 1996 and 26 October 2009 were used accordingly to identify the Seasonal wetlands, Settlement and urban developing area; and Agriculture land/vegetation/fallow/bare land. However, Landsat5 TM satellite image of 2009 is a multi-spectral image (Figure 3). So its multi-spectral characteristics help to delineate easily Seasonal wetlands and Settlement and

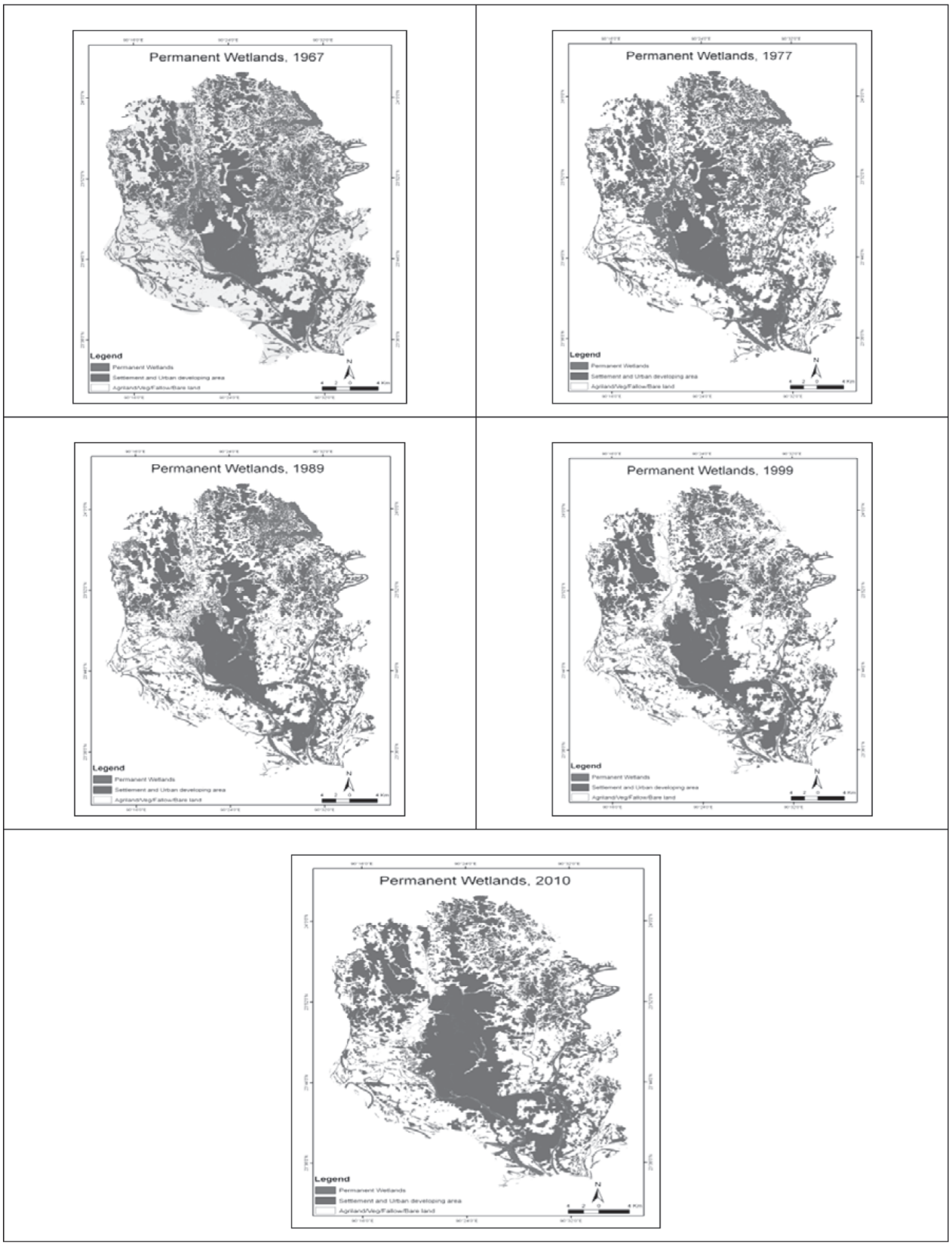

Figure 2: Permanent wetlands derived from different satellite images.

Table 2: Comparison of different land-use types under the permanent wetlands in the study area

Year	*Area*	*Permanent wetlands*		*Settlements and urban development areas*		*Agricultural lands/vegetation/ fallow/bare land*	
		(ha)	*(%)*	*(ha)*	*(%)*	*(ha)*	*(%)*
1967	DND	251	4.15	2780	45.93	3022	49.92
1977		541	8.94	2772	45.79	2741	45.28
1989		322	5.32	2853	47.13	2879	47.56
1999		232	3.83	3904	64.49	1918	31.68
2010		70	1.16	4157	68.67	1827	30.19
1967	Eastern Dhaka	10,655	14.44	29,052	39.39	34,052	46.16
1977		10,536	14.28	29,634	40.17	33,593	45.54
1989		7350	9.96	29,969	40.63	36,444	49.41
1999		2592	3.51	31,979	43.35	39,198	53.14
2010		2486	3.37	43,730	59.28	27,547	37.35
1967	Western Dhaka	10,031	14.27	24,675	35.09	35,615	50.65
1977		9967	14.17	25,235	35.89	35,115	49.94
1989		7433	10.57	25,952	36.90	36,932	52.52
1999		3705	5.27	28,723	40.85	37,882	53.87
2010		3034	4.31	33,771	48.03	33,516	47.66

urban developing area; Agriculture land/Vegetation/ fallow/bare land from Landsat5 TM, 26 October 2009. Data driven from these maps were arranged in Table 2 for further analyses of the result.

Seasonal wetland of eastern Dhaka is not out of invasion due to continuous growth of settlement and urban development. It was also affected by agricultural expansion (Table 3). From 1996 to 2009, seasonal wetland decreases near about 5% i.e. it has reduced from 21,271 ha to 18,323 ha where, settlement and urban development contributed almost 3% and agricultural activities 2%. However a study by JICA (1987) observed that many portions of the major drainage *khals* were subject to encroachment due to earth filling, deposition of city garbage and construction of building and roads.

In case of western Dhaka, it is seen that seasonal wetlands were reduced from 19,720 ha to 12,995 ha that causes about 10% reduction of area coverage, where

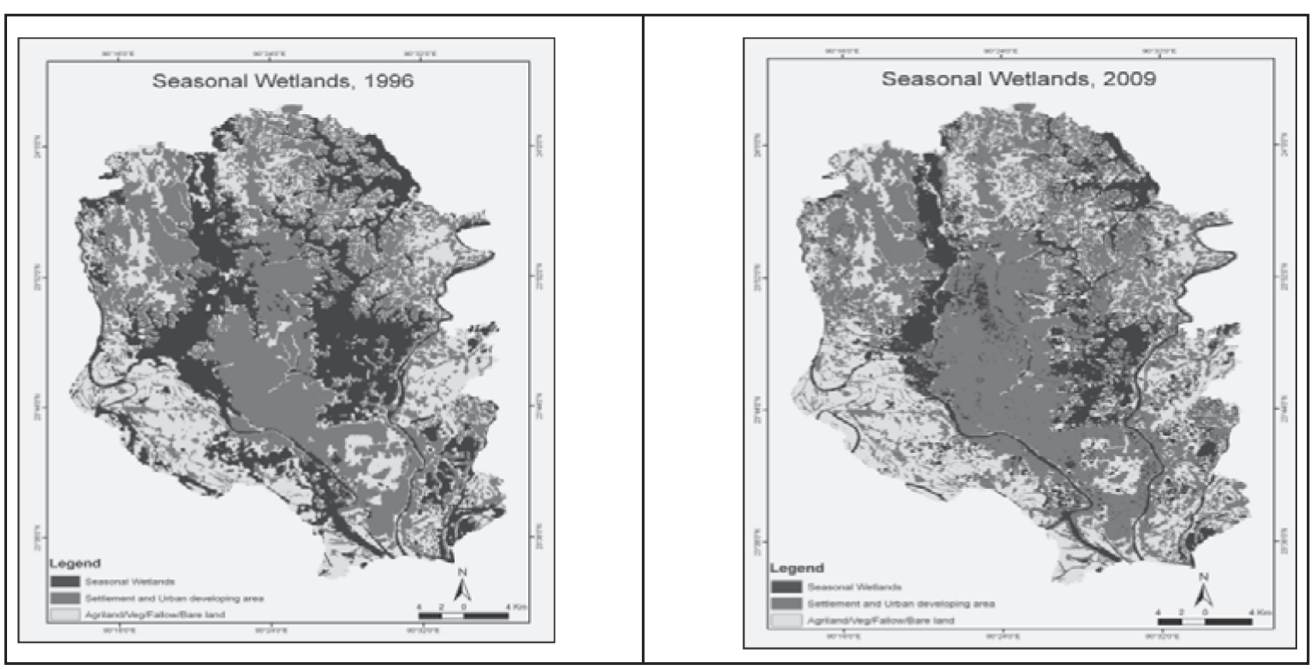

Figure 3: Seasonal wetlands derived from different satellite images.

Table 3: Comparison of different land-use types under the seasonal wetlands in the study area

Year	*Area*	*Seasonal wetlands*		*Settlements and urban development areas*		*Agricultural lands/vegetation/ fallow/bare land*	
		(ha)	*(%)*	*(ha)*	*(%)*	*(ha)*	*(%)*
1996	Eastern Dhaka	21,736	29.49	30,748	41.72	21,271	28.86
2009		18,323	24.86	32,719	44.39	22,735	30.85
1996	Western Dhaka	19,720	28.04	27,227	38.72	23,378	33.24
2009		12,995	18.48	31,747	45.20	25,561	36.35

settlement and urban development and agriculture are responsible for 7% and 3% respectively. Study revealed that this part of Dhaka is worse than eastern part in respect of seasonal wetland reduction. It was observed that the changing trend of wetland occurred due to settlement and urban development. But Islam et al. (2010) showed that land filling and encroachment are the main reason for changing wetlands in the city.

Conclusion

The development and expansion of Dhaka city is getting on indiscriminately without considering the sustainability as its population is increasing dramatically. Therefore urbanization activities stresses on wetlands and wetlands are losing its ecological and environmental value consequently. However the study indicated that due to rapid urbanization and unplanned development, both seasonal and permanent wetlands are degrading. The wetlands are continuously transforming into settlements, and other commercial purposes, which is neither sustainable nor environmental friendly. Existing trend of land development is contradictory to goal of the 'environmental' and 'social equity' of the city. It is revealed from the study that the permanent wetlands were reduced in DND area from 4.15% to 1.16% during 1967 to 2010. Along with it agricultural land reduced from 49.92% to 30.19%. On the contrary, settlement and urban development area increased to 68.67% from 45.93% for the same period. Consequently in DND area, agriculture is the most affected followed by wetland. But in eastern Dhaka wetland was reduced the most (11.07%) than agricultural land (8.81%) as a consequence of settlement increasing. Same result was found for western Dhaka in wetland reduction, but agriculture was less affected than in eastern Dhaka. In case of seasonal wetland both in eastern and western Dhaka, wetland is decreasing mostly due to settlement and urban development, whereas, agricultural land is decreasing in eastern Dhaka and increasing in western Dhaka as the result showed. It is true that urbanization in Dhaka city and its vicinity would not be stopped, but these should be based on further specific studies and the hydrological system of the area. Demand driven unplanned expansion should be strictly controlled to conserve the existing wetlands.

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