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CHANGING CLIMATE AND SURFACE AND GROUND WATER RELATED ISSUES IN DHAKA

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ABSTRACT

The study focuses on Dhaka's present condition in water sector considering both climate change and human induced issues in a broader aspect. It attempts to find the changes in local rainfall and temperature along with ground water and surface water condition. The study finds that in the last 50 years Dhaka is facing 0.018 degree Celsius per year increase in average temperature. Seasonal average rainfall trends show an overall increase ranging from 0.007 mm to 0.042 mm per year, though a decreasing trend is seen in maximum pre-monsoon and maximum monsoon rainfall in the last 50 years. The future projection shows that annual average temperature will predominantly increase in the upcoming years. Analysis also revealed that the reduction rate of ground water level in Dhaka is about 1 m per year and Dhaka's wetland has reduced to a shocking 1.37% from 38.27% in the last 40 years.

Keywords: *Climate Change, Dhaka, Ground Water, Rainfall, Surface Water, Temperature.*

1. INTRODUCTION

Dhaka is the capital of Bangladesh. It is also the center of economic development and rapid urbanization. As the city has its own hype as the hub of all the industries, major corporate business and education, it is also slowly losing its natural resources. Dhaka has an enormous population, having around 11,875 thousand people living in an area of 1,464 km^2 with a growth rate of 1.8% according to Bangladesh Bureau of Statistics (BBS, 2011). Resources such as wetlands, peripheral rives, greeneries are being swallowed by sky scrapers, housing and need of urbanization. The need to alleviate poverty, sustain economic growth, attain decent standard of living and fulfill the increasing demand of the ever increasing population, justifies the need to urbanize and industrialize, but not at a cost of losing natural resources. Wetlands of Dhaka are natural drainage system and they carry the runoff through the rivers towards the downstream. The wetlands are being encroached and filled up for urbanization. Quality of water is also deteriorating due to unauthorized discharging of raw waste and waste water into the peripheral khals and rivers. Demand for fresh supply water is met by abstracting ground water uncontrollably. Climate change, on the other hand has an impact over local rainfall and temperature, which makes the already vulnerable water sector more at risk.

The overall objective of the study is to analyze the present scenario of surface water and ground water condition in Dhaka city along with the climatic condition, both in the past and the projected future, to provide a holistic understanding of Dhaka's future risk to be exposed to a more vulnerable climatic condition in a very constrained water resources condition. The specific objectives are-

- Analyze the climatic condition of Dhaka along with future projection
- Review present condition of Dhaka's water sector, both ground water and surface water

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2. LOCATION OF THE STUDY AREA

The study area is the Dhaka metropolitan area (Figure 1). The peripheral rivers surrounding the area are Turag, Balu, Tongi Khal and Buriganga. Dholai khal, Gerani khal, Segunbagicha khal, Begunbari khal, Dhanmondi lake, Ramna lake, Crescent lake and Gulshan lake, all are part of the unique wetland system of Dhaka. For rainfall and temperature analysis, the whole area is considered under the meteorological station of Dhaka of Bangladesh Meteorological Department (BMD). For groundwater analysis, three areas within the metropolitan were selected-Lalbagh, Motijheel and Mirpur. The whole area is considered to find the extent of surface water encroachment.

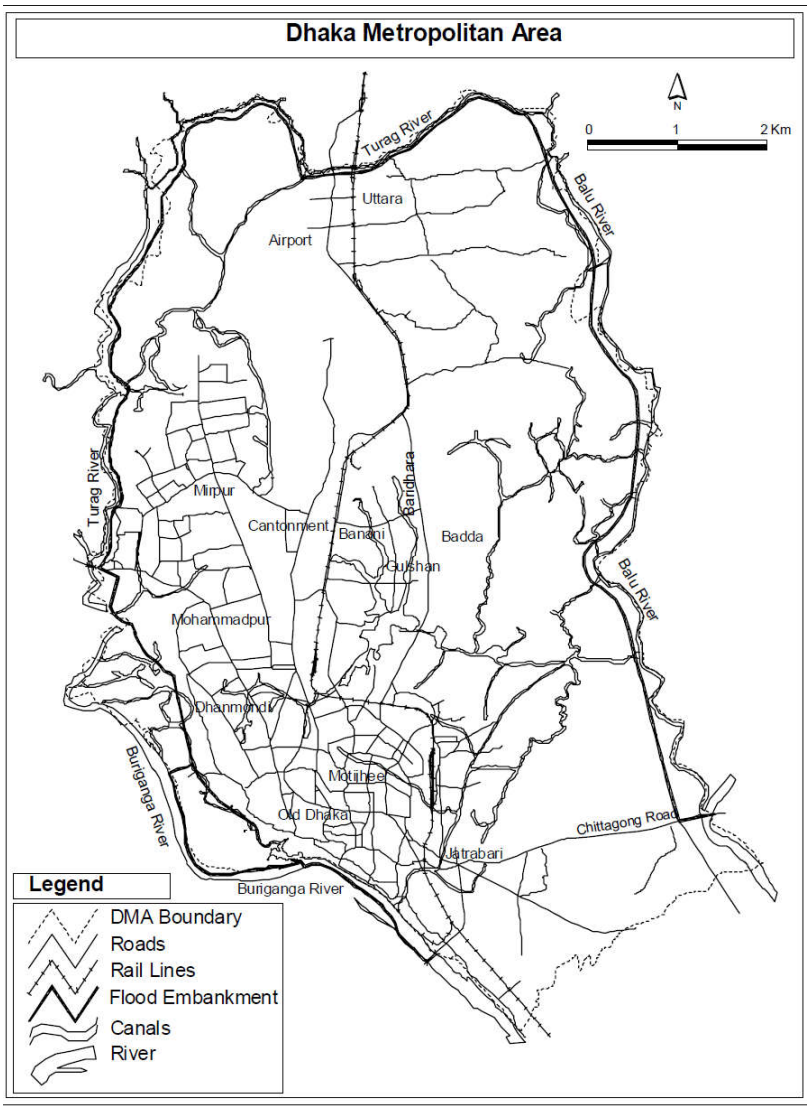


Figure 1 Map of the study area (Dhaka metropolitan area) source: (Tawhid, 2004)

3. METHODOLOGY

Climatic parameters i.e. rainfall and temperature are analyzed to find historical trend. Analysis includes annual average, annual maximum and seasonal average and seasonal maximum of the parameters. The season is distributed such as December-January-February as dry period, March-April-May as premonsoon, June-July-August-September as monsoon and October-November as post monsoon. For the analyses, daily data from 1961-

2008 is used which is collected from BMD. Using Statistical Package for the Social Sciences (SPSS) tool, the correlation value (Pearson) and statistical significance of the correlation (using two tailed test) is found out. Climatic prediction data of 2020-2070 (decadal) is collected from Institute of Water and Flood Management (IWFM), Bangladesh University of Engineering and Technology (BUET) on a basis of monthly projection to further evaluate the future scenario in Dhaka. Dhaka's present ground water scenario is assessed by analyzing ground water data at specific points of Bangladesh Water Development Board (BWDB) well. The selected stations are DHA-009(Lalbagh), DHA-010(Mirpur) AND DHA-013(Motijheel), where recent abstraction of ground water has been extensive. Further focus has been given in analyzing the extent of encroachment of the wetlands in Dhaka from collected satellite image analyses of two different years, one from 1967 (Corona Space Photo) and another from 2010 (Landsat5 TM Satellite Image), to visualize the change in Dhaka's wetland within 40 years time span. Some review has also been done considering the surface water quality. Thus, Dhaka's vulnerability in an ever increasing demand of water resources is evaluated in a broader scale, considering human induced changes and climate change.

4. ANALYSIS AND RESULT

4.1. Climatic Parameter Analysis of Dhaka

Dhaka's climate in the last 50 years time span (1961-2008) has been through extensive change. The findings are shown in Table 1 and Table 2.

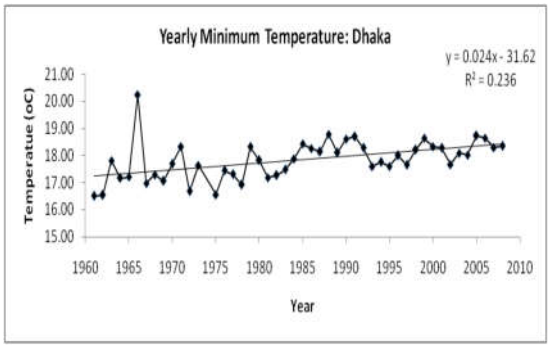
Table 1 Statistical analysis of Temperature: Dhaka

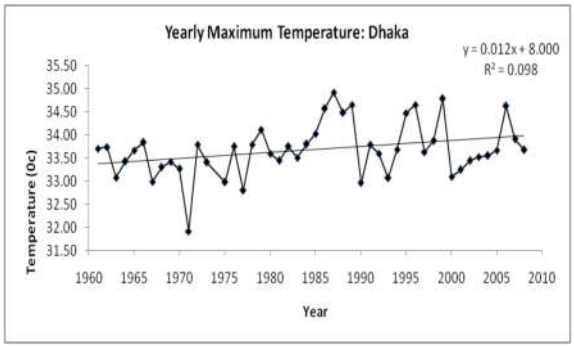
Parameters	Timespan	Trend	Change per year	Correlation (r)	Significance (Two tailed Test)
Maximum Temperature	1961-2008	Increasing	0.012 degree Celsius	0.315	Correlation is significant at 0.05 level
Minimum Temperature	1961-2008	Increasing	0.024 degree Celsius	0.486	Correlation is significant at 0.01 level
Average Temperature	1961-2008	Increasing	0.018 degree Celsius	0.547	Correlation is significant at 0.01 level

Table 2 Statistical analysis of Rainfall Data: Dhaka

Parameters	Time span	Trend	Change per year	Correlation (r)	Significance (Two tailed Test)
Maximum Pre Monsoon Rainfall	1961-2008	Decreasing	0.131 mm	-0.096	Not significant
Maximum Monsoon Rainfall	1961-2008	Decreasing	0.097 mm	-0.059	Not significant
Maximum Post Monsoon Rainfall	1961-2008	Increasing	0.626 mm	0.236	Not significant
Maximum Dry Season Rainfall	1961-2008	Increasing	0.097 mm	0.157	Not significant
Average Pre Monsoon Rainfall	1961-2008	Increasing	0.007 mm	0.053	Not significant
Average Monsoon Rainfall	1961-2008	Increasing	0.014 mm	0.084	Not significant
Average Post Monsoon Rainfall	1961-2008	Increasing	0.042 mm	0.235	Not significant
Average Dry Season Rainfall	1961-2008	Increasing	0.007 mm	0.234	Not significant

The increase in temperature in Dhaka's climate is on an average 0.018 degree Celsius per year that is an increase of 1.8 degree Celsius in 100 years. Maximum and minimum temperatures also show an increasing trend of 1.2 and 2.4 degree Celsius in 100 years respectively. The results are statistically significant as significance value is <0.05.





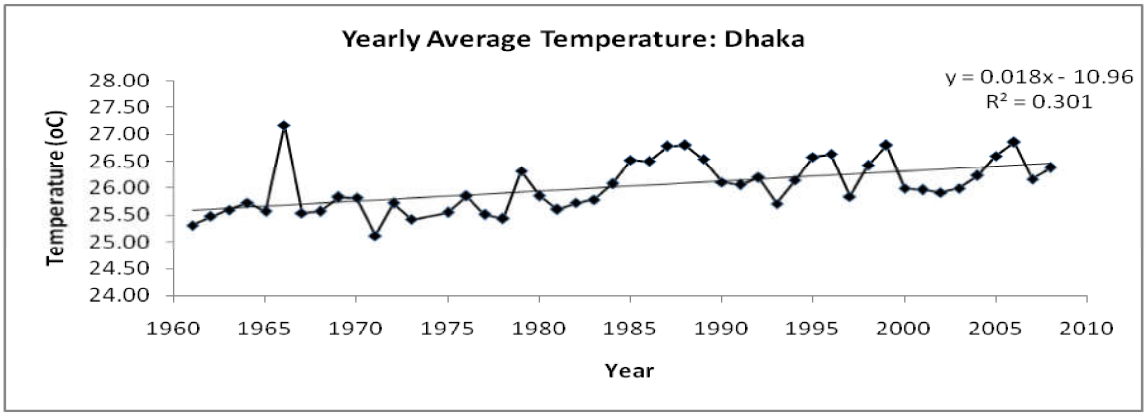


Figure 2 Changes in yearly average, maximum and minimum temperature of Dhaka (1961-2008)

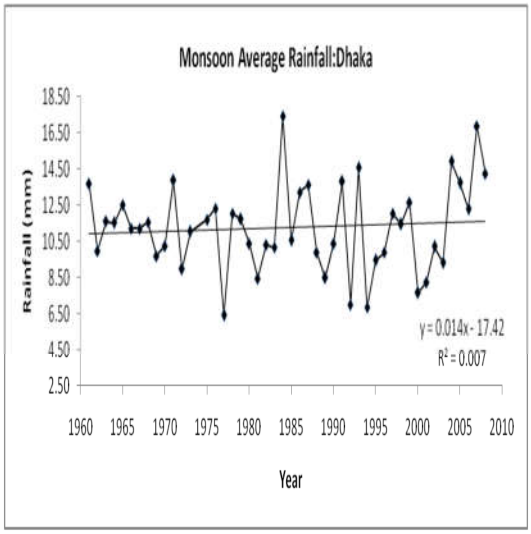


Figure 3 Trend in monsoon average rainfall of Dhaka (1961-2008)

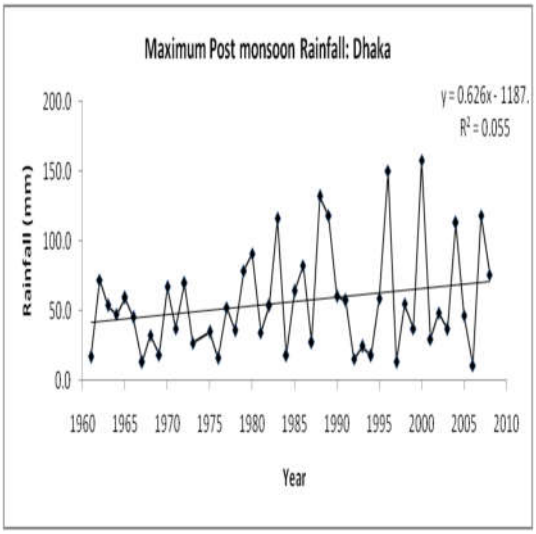


Figure 4 Trend in post monsoon maximum rainfall of Dhaka (1961-2008)

From the rainfall analyses done in this study, season wise variation is seen. Seasonal average rainfall trends show an overall increase ranging from 0.007 mm to 0.042 mm increase per year. Decreasing trend is seen in maximum pre-monsoon and maximum monsoon rainfall whereas maximum dry season and maximum post monsoon seasonal rainfalls show increase in trend.

Intergovernmental Panel on Climate Change (IPCC) highlights that Bangladesh is warming with an increasing trend of about 1°C in May and 0.5°C in November during the 14 year period from 1985 to 1998. It also says that rainfall has also increased - on average, decadal rain anomalies have been above long term averages since 1960s (IPCC, 2007). So it can be said that global climate change has an impact over regional climate which is evident from Dhaka's historical trend analysis of climate. Dhaka is the most vulnerable city to climate change impacts according to a report by World Wide Fund for Nature (WWF) among 11 vulnerable cities (WWF, 2009).The vulnerability is scored with a total consideration of environmental exposure, storm threat, sea-level rise, flooding/drought, socio-economic Sensitivity, population, assets threatened and inverse adaptive capacity. Dhaka scores an alarming 9 out of 10 which shows the threatening future of the city in a changing climate (WWF, 2009).

How changing climate will affect our local climatic parameters has been analyzed in a study using PRECIS regional climate model in IWFM, BUET. The projection is carried out considering A1B emission scenario. The projected data is collected which is on a monthly basis and from that dataset the yearly average is analyzed (Table 3).

Table 3 Future projection of temperature and rainfall Data (A1B scenario): Dhaka

Year	Pre Monsoon Average Rainfall (mm)	Monsoon Average Rainfall (mm)	Post Monsoon Average Rainfall (mm)	Dry Season Average Rainfall (mm)	Annual Average Temperature (Degree Celsius)
1990	7.91	10.09	3.31	0.71	23.51
2000	3.61	6.4	0.78	0.39	25.48
2010	12.05	6.86	1.59	0.34	25.38
2020	3.37	7.7	2.01	0.4	26.07
2030	5.48	9.61	3.43	0.25	26.09
2040	14.04	12.27	2.23	0.85	26.92
2050	20.78	7.6	0.81	1.22	27.05
2070	22.47	8.86	1.25	0.13	28.40

Source: Analyzed from the open source data (monthly RCM data of Dhaka projected with PRECIS in IWFM, BUET) provided at the site http://teacher.buet.ac.bd/akmsaifulislam/climate/index.htm

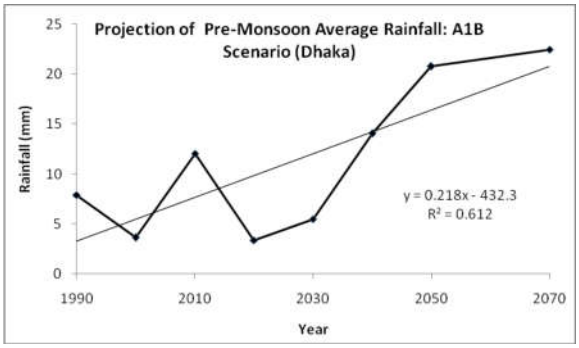


Figure 5 Projection of yearly pre-monsoon average rainfall

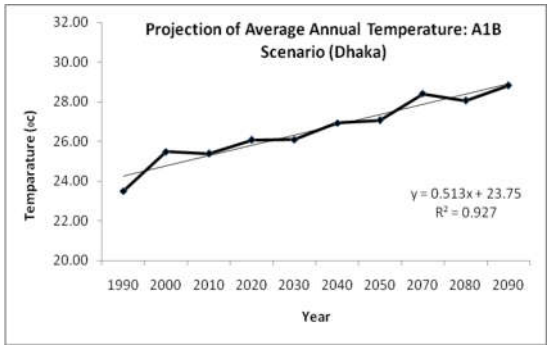


Figure 6 Projection of yearly average temperature

It can be derived from the analysis that temperature and rainfall has an increasing rate in future projection. The projection shows that pre-monsoon rainfall will predominantly increase though the monsoon, post monsoon and dry season rainfall show insignificant changes. The projection also evidently shows that annual average temperature will increase in future.

4.2. Analysis of Groundwater Condition of Dhaka

As risk of climate change is making Dhaka vulnerable to water related hazards, population increase and increase in demand in water sector from various sectors such as industry, domestic supply, agriculture etc. creates much problem is a sustainable water allocation option. As population has increased and urbanization has advanced, surface water has been subjected to extensive pollution and exploitation, both by industrial effluents and domestic wastes. Hence ground water has been a target for abstraction and the rate of abstraction has never decreased. At present, DWASA is operating 421 deep tubewells and 4 water treatment plants on the bank of the surrounding rivers. Only 18% of demand is met by these plants and the remaining 88% is met by groundwater abstraction (Akter et. al., 2009). As demand increases due to high population more abstraction occurs, leading to further depletion of ground water table. Recharge rate is further slowed down by lowered percolation rate due to infrastructural intervention and thick clay layer (aquiclude) over the aquifer system. The concrete layer made by human and natural aquiclude is hampering natural percolation of rainfall, flood water and horizontal inflow. In this study three BWDB stations were selected to find trend of groundwater reduction. The selected stations are DHA-009(Lalbagh), DHA-010(Mirpur) AND DHA-013(Motijheel). The analyses are shown in Figure 7.

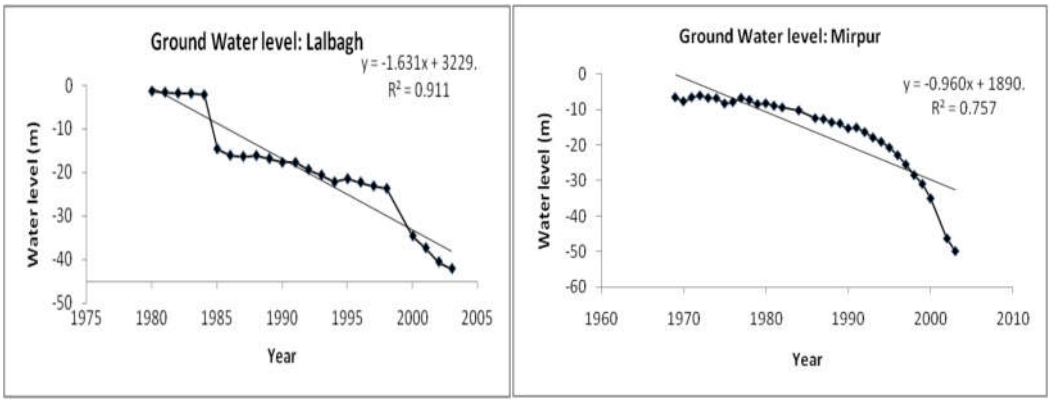


Figure 7 Yearly average trend in ground water level reduction in Dhaka city

From the analyses it is seen that ground water is reducing at an alarming rate. The reduction rate is about 1 m per year with a correlation (r) of 0.955 out of 1 (SPSS analysis) in Lalbagh thana. Mirpur also has a decreasing rate of about 1 m per year and BWDB well data of 2003 shows it has gone 60 m down from the R.L. considered which is a reduction of about 50m from the water level of 1970. The analysis of ground water level at Motijheel also shows decreasing trend. Such extent of abstraction of ground water has an overall impact on Dhaka's stressed water sector and environmental sustainability.

The quality of the ground water is also a major concern as this is supplied to household and domestic purposes for cleaning, bathing, drinking and other purposes. (Ahmed et. al., 1999) concludes that occasional surveys of inorganic groundwater quality demonstrate an apparently progressive movement of lower quality water into the aquifer from the South-West of Dhaka. (Hasan and Burgess, 1999) study makes a remark on the fact that this might be due to the induced recharge of water from the river Buriganga. Arsenic contamination in the groundwater of Dhaka is also alarming. The British Geological Survey of 1998 found 37% of the groundwater sources in Dhaka had Arsenic level above 0.05 mg/l (Smith et. al., 2000) which is the standard set by the Environment Conservation Rules, 1997 for drinking water (ECR, 1997) whilst World Health Organization (WHO) guideline standard is 0.01 mg/l. The study of (Hasan and Ali, 2010) finds that the ground water of Dhaka has Manganese higher than both the ECR, 1997 and WHO guideline standard levels exceeding them by 77.4% and 44.6% respectively.

4.3. Analysis of Surface Water Condition of Dhaka

For better understanding of Dhaka's surface water stresses at present, satellite image analysis of 1967 and 2010 of Dhaka city was collected from Center for Environmental and Geographic Information Services (CEGIS). The analysis shows significant reduction in the wetland scenario of Dhaka.

Table 4 Change of wetland area in Dhaka city

Year	% of wetland area within total area	Wetland Area (Ha)
1967	38.27	20685
2010	1.37	5519

(*Source:* CEGIS, 2012)

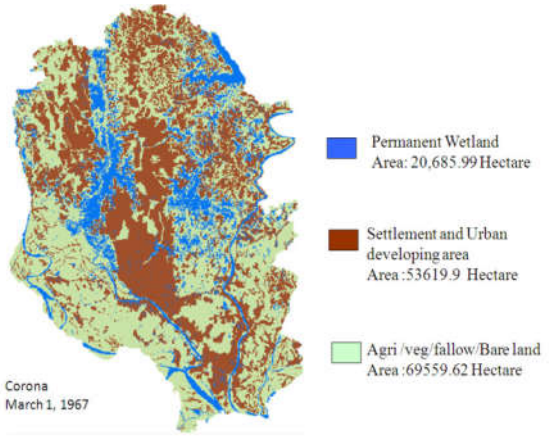


Figure 8 Permanent wetland of Dhaka city (year:1967) (*Source :*CEGIS, 2012)

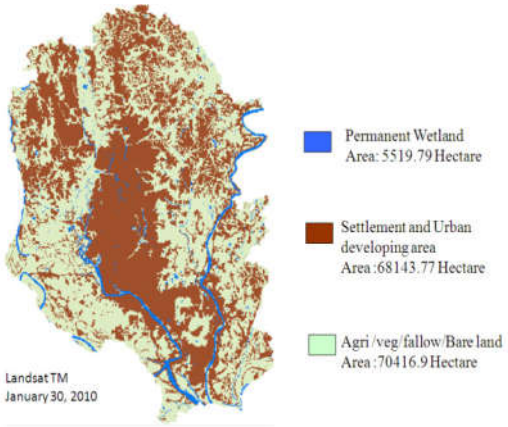


Figure 9 Permanent wetland of Dhaka city (year:2010) (*Source :*CEGIS, 2012)

In another study, the water bodies and lowlands reduction has been shown by 32.57% and 52.58%, respectively during 1960 and 2008 (Islam et. al., 2010a). Whereas this study, shows that the wetland percentage of the total area of Dhaka was 38.27% in 1967 and in 2010 it is only 1.37% of the total area. It is seen from the figures and data that Dhaka has lost most of its wetland. Unplanned construction of water management structure, diversion of water supply for irrigation, industry and domestic purposes reduce wetland water volume. Extensive increase of population within the city might have caused these diminishing changes. Buriganga, Tongi Khal, Balu, Shitlakhya and Turag, all are subjected to encroachment.

Added to this a huge amount of industrial waste flows to these rivers each day. Studies show that the level of all the water quality parameters i.e. Dissolved Oxygen (DO), Biological Oxygen Demand (BOD), Chemical Oxygen Demand (COD), Turbidity, Color and pH do not meet the standard level set by ECR, 1997. Especially in dry season (January to March), concentration of BOD and COD increased and DO content became low (Hasan et. al., 2009). A recent study shows that effluent discharge from industries have a big impact on the water quality of the Lakhya river (Islam et. al, 2010b) which flows by the East side of Dhaka. It shows that in the downstream of the Polash and Ghorasal urea fertilizer factory at Lakhya river the level of BOD_5 was 11 to 14 mg/l; the level of COD was 18 to 23 mg/l; the dissolved oxygen (DO) level was 3.78 to 4.1 mg/l and the total suspended solid (TSS) was 27 to 62 mg/l. ECR, 1997 suggests that the standard level of BOD_5 (at 20^0C) should be 0.2 mg/l, COD 4 mg/l, DO 6 mg/l and TSS about 10 mg/l in case of drinking water. From this review it can be seen that in some cases the water quality parameters in the river Lakhya exceeds the standards for drinking water broadly. Result of another study shows that different points considered in the rivers of Buriganga, Turag and Balu had BOD and DO level far beyond standard limits set by Department of Environment (Begum and Ahmmed, 2010); BOD_5 (at 20^0C) level ranging from 27 to 85 mg/l, COD 56 to 150 mg/l, DO 3.2 to 5 mg/l and TSS 57 to 76 mg/l in different collection points. DO level dropping to 0.11 mg/l was also observed in another study in case of Turag in the month of February (Rahman et. al., 2012).

5. CONCLUSION

The increased precipitation rate due to the estimated changes to occur in near future in our climate, will increase drainage congestion in Dhaka as all natural wetlands are being encroached and filled for settlement and agricultural activities. The daunting condition will aggravate as groundwater condition is more upsetting. Increase in temperature might make lives of the city dwellers more difficult in this all encompassing hazardous environment. In the present rate of increase of population, Dhaka has a very looming future not far from today, as water is becoming the most stressed natural resources in this city, both due to human interference and the possible impact of changing climate.

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