Conserving Wetlands: Valuation of Indirect Use Benefits of a Wetland of Dhaka

Rezwana Rafiq, Md. Shahabul Alam, Md. Mafizur Rahman, and Ishrat Islam

***Abstract*—Wetlands act as natural sponges that trap and slowly release waters over time and help in controlling floods. At the same time, they retain water and provide time for infiltration of water for groundwater recharge. But these intangible benefits are not properly assessed in developing countries. The significant problem is that such benefits cannot be evaluated as the same way as the market goods. In this context, nearly 11 sq. km area of the western flood plain of Dhaka is selected as the study area. To evaluate the flood control function of the site, Damage Cost Avoided Method is applied. And to evaluate the ground water recharge function at first total recharge quantity in a year is estimated than the quantity is valuated. Finally, the estimated value of these indirect use benefits of the site amounts to USD 0.13 million per sq. km in a year.**

***Index Terms*—Economic valuation, indirect use benefits, damage cost avoided method, wetland management.**

I. INTRODUCTION

Due to the biological, ecological, social, cultural and economic values, wetlands are very rich and diverse ecosystems in the world. The benefits provided by the wetlands are innumerable and these values are often lost due to the lack of knowledge about the vital functions performed by them. As wetlands and the functions they provide become increasingly scarce, the conventional view of treating wetlands as a free resource is being increasingly questioned. The lack of pricing of wetland functions is one of the main determinants of inefficient, inappropriate and excessive use of wetland [1]. In this context, economic valuation methods have been widely applied to evaluate the benefits of wetland and to ensure its wise and sustainable management [2]-[5].

Dhaka, the capital of Bangladesh is experiencing rapid population growth day by day. To meet the need of this ever increasing people, city is expanding outward, but in an unplanned way. This situation has largely contributed to the encroachment of wetlands by land filling for residential, commercial and other infrastructure development purposes. In 2005 only 16.9% of Dhaka's land area remains as wetland. If the current rate of loss of wetland continues, before the year 2035 all temporary wetlands of Dhaka will disappear [6]. Due to the subsequent loss of wetlands in and around Dhaka, it has become more vulnerable to river flooding and heavy rainfall as these wetlands act as the natural retainer of storm water, channelize the water and maintain natural drainage system. Moreover, the adverse impact of climate change will prone Dhaka to frequent flooding and heat stress in the nearer future. Along with other response measures it is very necessary to conserve the wetlands in and around Dhaka to combat against these devastating disasters. Hence, the understanding about the conservation and wise management of these wetlands is of much importance in the context of environmental and economic vulnerability.

In Dhaka Metropolitan Development Plan (DMDP): Structure Plan (1995-2015) and Urban Area Plan (1995-2005) certain areas are defined as main flood flow zones which are either permanently (rivers) or seasonally flooded (flood lands) and as sub-flood flow zones which are either temporarily or seasonally flooded (flood lands) [7]. Whereas in Detailed Area Plan (DAP), the areas under main flood flow zones and sub-flood flow zones are brought under a broad category termed as flood flow zones [8]. But in all these plans there is no specific management policy or way to conserve such wetlands. The lack of appropriate pricing of the benefits of these wetlands leads to its low-prioritization in national conservation strategy.

The economic value of wetland includes both use and non-use values. Wetland use values are associated with a diverse and complex array of direct and indirect uses. Direct uses of wetlands involve both commercial (marketed value) and non-commercial activities whereas indirect use values such as nutrient retention, flood control, storm protection and ground water recharge are un-marketed, financially unrewarded and are only indirectly connected to economic activities [3]. It is more challenging to evaluate the indirect use benefits of wetlands because these are intangible benefits and not commercially traded in the market. As a result, most often such kind of important functions of wetlands are ignored by people. So, the values of non-market services of wetlands need to be expressed in monetary terms so that their values can be understood and can be weighted on the same scale as commercially traded services.

Several initiatives are found in the recent research approaches regarding the process, trend, context and consequences of loss of wetland in different parts of Dhaka Metropolitan Area [6], [9]-[11]. The research work of [12] focuses on estimating total economic benefits of Tanguar Haor but the unavailability of data confines their study only to the application of direct methods for estimating economic benefits of some limited resources such as agriculture and

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Rezwana Rafiq and Ishrat Islam are with Department of Urban and Regional Planning, Bangladesh University of Engineering and Technology (BUET), Dhaka-1000 (e-mail: rezwana@urp.buet.ac.bd, ishratislam@urp.buet.ac.bd).

Md. Shahabul Alam is with Department of Civil and Geological Engineering, University of Saskatchewan, Saskatoon, SK S7N 5A9, Canada (e-mail: sabuj1469@yahoo.com).

Md. Mafizur Rahman is with Department of Civil Engineering, Bangladesh University of Engineering and Technology (BUET), Dhaka-1000 (e-mail: mafizur@gmail.com).

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fisheries on the basis of some secondary sources. But no research has been conducted concentrating on valuing indirect benefits of wetlands of Dhaka.

Thus, we attempt to focus on determining economic valuation of indirect use benefits of a wetland of Dhaka in this research. For both time and resource constraints the study is only confined with estimating the flood control and ground water recharge functions of wetland. The paper concludes with some policy implications in light of the results. The rest of the paper is organized as follows. Section 2 presents the study area, methodology developed for the study and the data collection process. In Section 3 important results of this study are presented and policy implications are summarized in the last section.

II. Methods and Data

A. Study Area Profile

This study focuses on the flood plains of Dhaka. Flood plains refer to areas that undergo periodic flooding as river channel overflows with flood water [12]. To conduct the study, a total area of around 11 sq.km of flood plains or flood flow zones demarcated in Detailed Area Plan in Goran Chatbari and Uttar Kaundia mouza have been selected. These two mouza are extended from approximately 23˚47' latitude to 23˚50' latitude and from 90˚18' to 90˚21' longitudinal area.

Fig. 1. Views of Study Area

These areas are situated at the western part of Dhaka city and is low lying cut across by Turag river and its khals and are designated by the Structure Plan as Flood Plains (Fig. 1). It is under the Special Planning Zone (SPZ) 17.3 (Flood Zone West) [7]. The average elevation of the study area is around 3 meter. This area retains water for about 5 to 6 months. In addition to river flood water they also store huge volume of rain water in every monsoon. In the site any kind of land filling as well as conversion of land is strictly prohibited [7].

B. Data Collection

All required data for the calculation of economic values of flood control function and ground water recharge function of the floodplains under the study are collected mainly from Bangladesh Water Development Board (BWDB) in different years such as 2007 and 2010. Moreover, some relevant literature like published and unpublished books, reports, journals and web documents are also reviewed to develop the concepts and to have required data for the assessment methods.

C. Method for Valuation of Flood Control Function

Wetlands function as natural sponges that trap and slowly release surface water, rain, snowmelt and flood waters over time. Wetlands and adjacent floodplains often form natural floodways that convey flood waters from upland to downstream points. This combined water storage and braking action lowers downstream flood heights and protecting downstream property owners from flood damage. The holding capacity of wetlands thus helps in controlling floods. Some valuation techniques estimate benefits directly while some others estimate costs as a proxy for benefits. For instance, in Damage Cost Avoided method the costs that would be incurred if the ecosystem function are not present are used as a reasonable approximation of the benefits. The underlying assumption is that the benefits are as great as the costs involved in repairing, avoiding or compensating for damage [1].

In the study, we have estimated the economic value of flood prevention function of wetland by using the Damage Cost Avoided method. This method can be applied by using two different approaches. One approach is to estimate potential damages to property if flooding were to occur. In this case, the researcher would estimate the probable damages to property if the wetlands are not preserved. A second approach would be to determine whether nearby property owners have spent money to protect their property from the possibility of flood damage, for example by purchasing additional insurance or by reinforcing their basements However, the two approaches do not produce the same estimate. If avoidance costs are expected to be less than the possible damages, people would pay to avoid those damages [13]. In our study, the monetary value of potential flood damage is estimated which assumes that the flood damage would incur due to the absence of the wetlands in its present form.

D. Method for Valuation of Ground Water Recharge Function

Wetlands connected to groundwater systems or aquifers are important areas for groundwater exchange. They retain water and so provide time for infiltration to occur. Groundwater, in turn, provides water for drinking, irrigation, and maintenance of stream flow and lake and reservoir levels. During periods of low stream flow the slow discharge of groundwater often helps to maintain minimum water levels. The intricate connections of wetland with groundwater, stream flow, and lake and reservoir water levels make them essential in the proper functioning of the hydrologic cycle [14].

Estimating the rate of aquifer replenishment is the most difficult one of all measures in the evaluation of groundwater resources. No single comprehensive estimation technique can yet be identified from the spectrum of those available, which gives reliable results. Rainfall is the most important source of ground water recharge. Based on the studies undertaken by different scientists and organizations regarding correlation of ground water recharge fluctuation and rainfall, some empirical relationships have been developed for computation of natural recharge to ground water from rainfall. One of these empirical formulas is the ‘Chaturvedi Formula’, widely used in India [15]. In our study while valuing the ground water recharge function of the study area at first we have estimated the annual quantity of recharged ground water by using the 'Chaturvedi Formula' and then this quantity of water is valuated. Based on the water level fluctuations and rainfall amounts in Ganga-Yamuna doab, Chaturvedi in 1973, derived an empirical relationship to arrive at the recharge as a function of annual precipitation (when rainfall exceeds 40 cm) is given below:

$$R_r = 2.0(P-15)^{0.4}$$

where,
R_r = Net recharge due to precipitation during the year, in inches; and
P = Annual precipitation, in inches.

This formula was later modified by further work at the U.P. Irrigation Research Institute, Roorkee and the modified form of the formula is-

$$R_r = 1.35(P-14)^{0.5}$$

The Chaturvedi formula has been widely used for preliminary estimations of groundwater recharge due to rainfall. It may be noted that there is a lower limit of the rainfall, below which the recharge due to rainfall is zero. The percentage of rainfall recharged commences from zero at P = 14 inches, increases upto 18% at P = 28 inches, and again decreases. The lower limit of rainfall in the formula may account for the soil moisture deficit, the interception losses and potential evaporation [15].

After quantifying the recharged ground water it is then valuated by applying the market cost of making this water usable. In true, ground water services are difficult to evaluate because much of the information required for valuation is not readily available. Market trades can provide useful data for valuation, but most of the services provided by ground water are not traded in market [16].

III. Results and Discussions

A. Valuation of Flood Control Function

It is previously mentioned that the flood control function of the study area is valuated by estimating the cost of damage which would occur if the floodplains are filled up or not preserved. We have conducted all the calculations by using ArcGIS 9.2 and Microsoft Excel 2007 software. The step-by-step process of estimation is shown below:

1) Calculation of inundation areas

At the first stage of the calculation, total area is divided into some small pockets of areas. Within those small pockets at certain points land elevation data are collected. To find out the depth at those certain points their data of elevation are deducted from datum. Here, we have assumed datum by considering the average elevation of surrounding land area. Then the volume of the retained water in those small pockets of areas is estimated by multiplying the average depth with their respective areas. The aggregated volume of retained water is derived by summing up the volume of water in all the small pockets of areas that is calculated previously. After that, the area of inundation is calculated by dividing the volume of retained water by the depth of inundation of flood during 2007.

Finally, it is calculated that total 1,535.21 acre (6,212,986.07 square meter) of area would be inundated with the flood level of 1.5 m (Flood level during the flood of 2007) if the floodplains of the study area are filled up or not preserved.

2) Calculation of flood affected people

In the Detailed Area Plan [8], residential land uses are categorized into three types. The respective population density of those three categories is also proposed in DAP. From the field survey and google earth image it is identified that the settlements, occupation pattern etc of the surrounding area of the study area are similar to rural homestead category. For rural homestead type of settlement proposed population density is 15 persons per acre. According to the previous calculation of inundation areas and the proposed population density, if total inundated area due to flood is 1535.21 acre then total number of affected people would be 23028 persons.

3) Calculation of loss due to flood

Due to the unavailability of data and the extent of the study, flood loss is calculated only by considering the number of affected people. Losses in other sectors due to flood such as crops, infrastructure, housing etc are not calculated here.

The duration of flood in the year 2007 in the study area is 26 days [17]. It is assumed that in those days people are stuck at home by the flood water, could not go outside for work and could not earn money. The World Bank sets the income poverty line at USD 1.25 a day per person in 2008 for international comparisons. Here, the poverty line is determined by finding the total cost of all essential resources that an average human adult consumes in a year [18]. Due to the data unavailability it is also assumed that in the year 2010, the extent and duration of flood was just like the flood occurred in 2007. Thus, by considering all these factors the monetary loss to the affected people due to flood in the year 2010 is calculated and is shown below:

Proposed Population Density	= 15 (persons/acre)
Total number of affected people	= 23028
Duration of Inundation	= 26 days
Total loss due to flood	= USD 1.25 × 26 × 23028
	= Tk 101.25 × 26 × 23028
	[1 USD = Tk 81]
	= Tk 60,621,519

B. Valuation of Ground Water Recharge Function

The step-by-step calculation for valuing the ground water recharge function for the site is given below:

1) Calculation of recharged quantity of ground water

At first the quantity of ground water recharge in a year in the study area is determined by using the following modified Chaturvedi formula:

$$R_r = 1.35(P-14)^{0.5}$$
$$= 1.35\ (80\text{-}14)^{0.5}$$
$$= 10.97 \text{ inch/year}$$

Here, the average annual rainfall in Dhaka is 2000mm = 80 inch [19]. As the total area of the floodplains is 2656.355 acre, the volume of this recharged ground water (in cubic meter) in the study area in a year will be as follows:

= R_r × Total area of the floodplains
= 0.278 m × 1074987.29 m^2
[1 inch= 0.0254 m and1 acre = 4046.8564 m^2]
= 2988468.67 m^3

2) Pricing of recharged ground water

Dhaka Water and Sewerage Authority (DWASA), a government controlled service organization is solely responsible for providing water to the residences, industries and commercial establishments of Dhaka city. It supplies water to the inhabitants of Dhaka by their deep tube-wells and surface water treatment plants. A good quality of ground water is extracted by those deep tube-wells from the aquifer extending between 50 to 120 meter [20].

A substantial amount of energy (electricity) is expended to pump out and treat the ground water for our use. The average energy expenditure of different pump stations for the production of one cubic meter water from the deep tube-wells by DWASA is used to evaluate the recharged quantity of ground water in a year in the study area.

From Appendix, Table I, it is calculated that on an average Tk 1.39 is spent in a month for the production of 1 cubic meter water through deep tube-wells by DWASA. That means, in the year 2010 on an average Tk 17 is spent by DWASA for the production of 1 cubic meter of water. Accordingly, the price of the recharged ground water in the study area in the year 2010 would be-

= Total recharged quantity of ground water × Production cost of one unit of water

= 2988468.67 × 17
= Tk 5,08,03,967

Thus, the total economic value from both of these indirect use benefits of the flood plains in the study in the year 2010 is estimated to Tk 111.43 million or USD 1.38 million [1USD = Tk 81] and per sq. km economic value of the site is USD 0.13 million.

IV. Conclusion and Policy Implications

Today, most planning and development decisions are taken on economic grounds. Economic valuation of wetland represents an important area for a clear understanding about the role of natural systems in economic development. Wetland is complex multifunctional system and thus possesses significant economic value. But globally they are under heavy pressure. The main reason is the lack of awareness of the value of the conserved wetlands and its functions. The current trend of wetland loss leads to many countries to adapt different policies to ensure wetland conservation as well as its sustainable way of use. The quantification of significant values of wetlands is the first step to its sustainable planning and use.

It is a difficult task to justify the protection of wetland in a city like Dhaka where pressure on land is very high and market force is dominant. The traditional wise use of wetland of Dhaka reflects its harmonious co-existence with its inhabitants that means to leave it in its natural state [6]. The alarming rate of loss of wetland has made the environmentalists, socialists and planners very much concerned about this issue. They are trying to raise their voice against the conversion of wetland by private land developer companies. The debate against the conversion of wetland will be more valid if the conservation benefits that means direct and indirect use benefits forgone from the conversion of wetland can be quantified and evaluated.

Under such situation, the research would address the following implications in making policies for the conservation of wetland of Dhaka:

In this research, the indirect use benefits of a wetland of Dhaka are identified and their economic values are assessed. It will help the environmentalists, socialists, planners and the policy makers to figure out the yearly benefits that can be earned from various indirect services of wetland. Taking into account of the opportunity cost of loss of indirect uses of wetland will lead to a lower level of conversion of wetland.

Another very important issue leading to the conservation of wetland is climate change. Climate change will affect Dhaka primarily in two ways- through floods and heat stress. The melting of glaciers and snow in the Himalaya and erratic changes in temperature and rainfall will lead to more frequent flooding. The water logging and drainage congestion due to river floods and excessive rainfall during monsoon are already causing very serious damage [21]. It is very difficult for a rapidly growing urbanized area to manage such heavy rainfall within a short duration.

To combat against the heat stress of climate change impact we will need more water. Due to rapid urbanization, the demand for water is increasing at a high rate and a significant portion of the need are fulfilled from ground water source. Due to the large quantity of extraction of ground water, year by year the ground water table is depleting at an alarming rate (3m per year) [20]. In such condition, the existence of wetlands can replenish the aquifer and can enrich our source of ground water.

Adaptation is the way to address climate change impacts. Wetland conservation as detention area is one of the adaptation measures. That is why, conservation of low lying areas, retention ponds and flood plains for accommodating excessive water is a burning issue to response against climate change impacts. To justify the conservation issue of wetland and to address the devastating consequences of climate change as well as flood and heat, government has to evaluate the yearly flood control and ground water recharge function of wetland and this research would assist that purpose.

This valuation will also help the decision-makers to take account of many competing interests in deciding how best to use wetland. Information on the economic values of indirect uses can greatly assist in identifying the effective policies and sectoral priorities regarding conservation of wetlands of Dhaka. For example, if the government decides to conserve wetland of Dhaka, then this research will provide valuable information about the amount of compensation that is needed to be given to the landowners for the indirect use benefits of the wetland.

To find out the total economic value of a wetland of Dhaka this research would guide to a large extent. Moreover, the valuation techniques used in the study will be a guidance to assess economic valuation of indirect uses of other wetlands of Dhaka.

Actually, conserving wetland is a moral obligation as its existence is very much essential for the survival of urban life. A private landowner may claim that he earn higher returns by converting wetland for residential, commercial or other development purposes rather conserving it. It is because of the fact that a large number of ecological functions and important services provided by wetland to society such as storm protection, flood control, disaster prevention, nutrient retention, micro-climate stabilization are neither sold nor have market price. From social point of view, the benefits of conserving wetland must outweigh the value of development benefit. Moreover, development benefits are not renewable but wetland benefits are renewable. This study would act as a backdrop for studying and valuing other intangible benefits of wetlands of Dhaka.

Thus, it can be concluded that, wetlands in Dhaka must be conserved if the short term as well as long term benefits of wetlands is considered. The long term benefits include providing of food security and water supply, preventing from climate change and flood, maintaining ecosystem and other such functions. To ensure the sustainable management of wetland, policies should be formulated in addressing these facts.

APPENDIX

TABLE I: ELECTRICITY UNIT AND BILL OF DIFFERENT WATER PUMP STATION IN DHAKA CITY

Name of Water Pump Stations	Production of Water (M^3/Month)	Electricity Unit		Electricity Bill in Tk (including PFC charge, Demand charge, VAT)
		Off-Peak	Peak	
Mohammadia Housing	138329	26639	7896	167039
Rafiq Housing	174881	39530	1216 6	274796
Dhaka Udan	83700	16925	8615	84095
Monsurabad	119334	22368	6504	135344
Tikkapara	120014	22892	8032	164613
Iqbal Road	83600	26858	9444	174708

Source: DWASA, 2010 cited in Anwar, 2010

REFERENCES

[1] K. R. Turner, R. Brouwer *et al.*, "The Economics of Wetland Management," *Managing Wetlands: An Ecological Economics Approach*, R. K. Turner, J. C. J. M. v. d. Bergh and R. Brouwer Ed. Edward Elgar Publishing Limited, Cheltenham, UK, 2003.

[2] B. E. Barbier, M. Acreman, and D. Knowler. (1997). "Economic Valuation of Wetlands, A Guide for Policy Makers and Planners," IUCN Publication Unit, Ramsar Convention Bureau Gland, Switzerland. [Online]. Available: http://liveassets.iucn.getunik.net/downloads/03e_economic_valuation_of_wetlands.pdf.

[3] V. T. Ramachandra, R. Rajinikanth, and G. V. Ranjini, "Economic Valuation of Wetlands," *Journal of Environmental Biology*, vol. 26, pp. 439-447, 2005.

[4] T. Boyer and S. Polasky, "Valuing Urban Wetlands: A Review of Non-market Valuation Studies," *The Society of Wetland Scientists*, vol. 24, no. 4, pp. 744-755, 2004.

[5] T. M. Nhuan, H. N. Ninh *et al.* (2003). Economic Valuation of Demonstration Wetland Sites in Vietnam. *Vietnam Wetland Component Report*, Hanoi-Vietnam. [Online]. Available: http://cmsdata.iucn.org/downloads/06_vietnam_economic_valuation_of_wetland_sites.pdf.

[6] I. Islam, *Wetlands of Dhaka Metro Area: A Study from Social, Economic and Institutional Perspectives*, A H Development Publishing House, Dhaka, Bangladesh, 2008.

[7] DMDP, *Dhaka Metropolitan Development Plan (1995-2015): Urban Area Plan (1995-2005)*, Vol. II, Rajdhani Unnayan Kartripakkha, Dhaka, 1997.

[8] DMDP, *Dhaka Metropolitan Development Plan (1995-2015): Detailed Area Plan*, Rajdhani Unnayan Kartripakkha, Dhaka, 2010.

[9] M. S. Sultana, "Analysis of Changing Scenario of Wetlands in Dhaka City Using Remote Sensing and GIS," Unpublished Post Graduate Diploma Thesis, Inst. of Water and Flood Management, Bangladesh Univ. of Engg. and Technology, Dhaka, Bangladesh, 2005.

[10] M. J. Hoque, "Impact of Private Land Development on the Environment of the Eastern Fringe Area of Dhaka," Unpublished Ph.D Thesis, Dept. of Urban and Regional Planning, Bangladesh Univ. of Engg. and Technology, Dhaka, Bangladesh, 2004.

[11] A. S. Satu, Z. M. C. Sadeque, and R. Akhter, "Studies on Problems and Issues Regarding Wetland: Case Study Ashulia," Unpublished Undergraduate Thesis, Dept. of Urban and Regional Planning, Bangladesh Univ. of Engg. and Technology, Dhaka, Bangladesh, 2004.

[12] M. A. H. M. Billah, and H. S. M. M. Khan, "Interfacing of Ecology and Economics: A New Paradigm for Sustainable Wetland Management in Bangladesh," *Bangladesh Environment 2000: An Outcome of ICBEN-2000*, F. M. Ahmed Ed. Bangladesh Poribesh Andolon (BAPA), Dhaka, Bangladesh, 2000.

[13] D. M. King, and M. J. Mazzotta. (2000). "Ecosystem Valuation," US Department of Agriculture. [Online]. Available: http://www.ecosystemvaluation.org/.

[14] J. P. Michaud. (2001). At Home with Wetlands: A Landowners Guide. Dept. of Ecology, State of Washington. [Online]. Available: http://www.ecy.wa.gov/programs/sea/pubs/90031/index.html.

[15] C. P. Kumar, "Groundwater Assessment Methodology," in Proc. 23rd Annual Convention of AHI and National Seminar on Water Resources Management and People's Participation, Baroda, 2004.

[16] L. W. Canter, C. W. Abdalla *et al*., *Valuing Ground Water: Economic Concepts and Approaches*, Committee on Valuing Ground Water, Water Science and Technology Board, Commission on Geosciences, Environment and Resources, National Research Council, National Academy Press, Washington, USA, 1997.

[17] BWDB, *Annual Flood Report 2007*, Flood Forecasting and Warning Center, Processing and Flood Forecasting Circle, Bangladesh Water Development Board, Dhaka, Bangladesh, 2007.

[18] The World Bank. (2008). *Poverty Data: A Supplement to World Development Indicators 2008*, Development Data Group, The World Bank, Washington, USA. [Online]. Available: http://siteresources.worldbank.org/DATASTATISTICS/Resources/WDI08supplement1216.pdf.

[19] BWDB, *Annual Flood Report 2010*, Flood Forecasting and Warning Center, Processing and Flood Forecasting Circle, Bangladesh Water Development Board, Dhaka, Bangladesh, 2010.

[20] S. M. Anwar, "Potentials for Water Conservation in Dhaka City," Unpublished Post Graduate Thesis, Dept. of Civil Engineering, Bangladesh Univ. of Engg. and Technology, Dhaka, Bangladesh, 2010.

[21] M. Alam and M. D. G. Rabbani, "Vulnerabilities and Responses to Climate Change for Dhaka," *Environment and Urbanization*, vol. 19, pp. 81-97, 2007.

Rezwana Rafiq was born in Dhaka, Bangladesh. Her date of birth is February 22, 1984. She obtained her Bachelor and Masters degree both on Urban and Regional Planning from BUET on 2007 and 2011 respectively.

She is now serving is an Assistant Professor at the Department of Urban and Regional Planning at Bangladesh University of Engineering and Technology (BUET). Before joining BUET, she served as an Assistant Town Planner at RAJUK, the Capital Development Authority in Bangladesh. Her research interests are in wetland preservation, economic valuation of natural resources, environmental planning, and transportation planning.

Ms. Rafiq is a member of Bangladesh Institute of Planners (BIP). She had been awarded with University Grand Commission Scholarship, Dean List Award, Board Scholarship and University Technical Scholarship.

Md. Shahabul Alam was born in Naogaon, Bangladesh on November 15, 1977. He was graduated in civil engineering from Bangladesh University of Engineering and Technology (BUET), Dhaka, Bangladesh in 2004. Later the author obtained a higher degree in master of water resources from Catholic University of Leuven and Free University of Brussels, Belgium in 2010 under the Belgian government VLIR-UOS scholarship.

He basically works as a Sub-Divisional Engineer in Bangladesh Water Development Board. Currently, he is working as a Research Assistant in the Department of Civil and Geological Engineering at the University of Saskatchewan, Saskatoon, Canada.

Md. Alam is a member of Institution of Engineers, Bangladesh (IEB). He achieved several national and international awards/scholarships such as education board scholarship, dean's undergraduate scholarship and Belgian government VLIR-UOS scholarship.

Md. Mafizur Rahman was born in Dhaka, Bangladesh on August 25, 1968. He obtained his Bachelor and Masters degree both on Civil Engineering from Bangladesh University of Engineering and Technology (BUET). Later he completed his PhD degree in Civil and Environmental Engineering from the University of Tokyo, Japan.

He is now working as a Professor in the Department of Civil Engineering at BUET and engages in overseas Collaborating and Local research work, Consultancy, Teaching, Research guidance of the graduate level students in their research work, Lecture in the Undergraduate and the post graduate level. He is also serving as the Director of ITN (International Training Network), BUET, supported by the World Bank and Danida and involve in the low cost water supply sanitation and solid waste management in Bangladesh. His research interest lies in climate change impacts on food security, climate change and water environment, alternate water resources in urban and rural areas of developing countries, ground water pollution and recharge, environmental and water Resources engg. with GIS application, urban air pollution and impact of climate change.

Prof. Rahman is a member of Institute of Engineers Bangladesh (IEB), International Water Association, UK, Japan Society of Civil Engineers, American Society of Civil Engineers. He was awarded The University Blue (BUET) in 1994 for the overall excellence both in academic as well as in games and athletics. He also achieved The Chancellor's Award for merit position in the Higher Secondary Exam in Dhaka Board and also Huang Award from University of Tokyo for the contribution to research activities.

Ishrat Islam was born in Dhaka, Bangladesh on March 29, 1965. She completed her Bachelor degree from the Department of Architecture in Bangladesh University of Engineering and Technology (BUET). Later she completed her Masters degree in Urban Planning from the University of Akron, Ohio, USA. She obtained her PhD in Urban Planning from Ritsumeikan University Kyoto, Japan.

She is now serving as a Professor at the Department of Urban and Regional Planning at BUET. She engaged in various national research and policy related works, Consultancy, Research guidance of the graduate level students in their research work, Lecture in the Undergraduate and the post graduate level. She also worked as a planner in Medina County Planning Commission and in Summit County Planning Commission in USA. Her research interest broadly lies in land use planning and urban design. She authored a book titled *Wetland of Dhaka City: A Study from Social Economic and Institutional Perspective* by A H Development Publishing House, Dhaka in 2009.

Prof. Islam is a member of Bangladesh Institute of Planners, Bangladesh Institute of Architects, Bangladesh Regional Science Association.