



Determining the Changeability of Groundwater Level in the Southwestern Part of Bangladesh using Geographic Information System (GIS): A Spatio-Temporal Analysis

S. M. Saify Iqbal¹, Md. Juel Rana Kutub², Premanondo Debnath¹, Nishat Falgunnee¹, Shahreen Muntaha Nawfee¹, Shahadat Islam Sojib³

¹MS Student, Department of Geography and Environment, Faculty of Earth and Environmental Science, University of Dhaka

²Lecturer, Department of Geography, Faujdarhat Cadet College

³MS Student, Department of Oceanography, Faculty of Earth and Environmental Science, University of Dhaka

Received: 30/10/2015

Accepted: 09/11/2015

Published: 30/12/2015

Abstract

Groundwater is one of the most important freshwater sources in Bangladesh which is used for drinking, household chores and irrigation. Due to high population pressure and excessive withdrawal, this important resource is under a lot of pressure. This study was designed to assess the present groundwater condition of the southwestern part of Bangladesh. Groundwater depth data of 231 wells from 20 districts were collected from Bangladesh Water Development Board (BWDB) and analyzed in ArcGIS 10.1 and Microsoft Excel 2010. Data analysis showed that all over the year, groundwater lies beneath 0 to 10 m of sediment in the southwestern part of this country. During the pre-monsoon season, groundwater level ranges from 6 to 10 m in Magura, Rajbari, Jhenaidaha and its adjacent areas, but when the monsoon starts water level varies from 4 to 7 m except some parts of Magura as the monsoon season is characterized by heavy rainfall. On the other hand, water level varies from 1-4 m in the coastal areas of the southwestern part of this country. Basically, the larger values are mostly associated with urban areas having groundwater level ranging between 6 and 12 m. During the monsoon season, there is a wide disparity of groundwater condition except the coastal zone as it shows homogeneity. So significant variation in groundwater depth was observed throughout the study area. The impact of the urbanization was seen clearly which leads to the lowering of groundwater level that can cause the catastrophic events like earthquake, subsidence and pollution in this country.

Key Word: Groundwater, Freshwater Source, Monsoon, ArcGIS 10.1, Water Table.

1 Introduction

Water resource, especially groundwater works as a feeder for the domestic, agriculture, industry and waste disposal use which is a pre-required condition for the economic and social development of any country [1]. It is considered as one of the most inevitable parts of the hydrologic cycle. It is the largest potential freshwater source in the hydrological cycle, larger than all the surface lakes and streams combined. It is estimated that 8340000 cubic km of water is present beneath the surface of the Earth [2]. In Bangladesh, it is the single most important fresh water source for urban areas. Groundwater is not an independent source of water. It interacts with the surface water through various mechanisms and contributes to the other freshwater sources. Groundwater plays a vital role for hydraulic power and energy production, but these productions have decreased from 70% to 40% in 2004 [2]. It is widely used in the minimum level of the technological and energy availability because of its high quality [3] and is more attractive to the

consumers for its more comparative per unit volume value than surface water and its local availability, reliability to drought [4]. It is also considered as a vital resource for the developing countries, because it is the prime source of agricultural, industrial and domestic uses [5].

The favorable hydrological and geological condition of Bangladesh indicates high potential groundwater storage. Most of the unconsolidated and estuarine sediments from Pleistocene to the recent fluvial land of Bangladesh form the prolific aquifers, which indicate the high reserve of groundwater [6, 7]. The aquifer's productivity depends on the lithological characteristics of soil, where soil porosity is very significant. This unconsolidated sediment can reserve a large volume of groundwater [8]. Groundwater level in the shallow aquifers of Ganges_Brahmaputra_Meghna (GBM) is dynamic and characterized by the monsoonal rainfall [9]. This shallow aquifer's depth is less than 80 m [10]. The seasonal variation of groundwater level in

S. M. Saify Iqbal, MS Student, Department of Geography and Environment, Faculty of Earth and Environmental Science, University of Dhaka, Bangladesh. Email: dusaify@gmail.com, Cell No: +8801755882482.

Ganges_Brahmaputra_Meghna (GBM) area is very considerable both in temporal and spatial scales and which is ranged from 2 to 8 m [11].

Bangladesh is a country of huge population (14 million), according to the 2011 population census report [12]. Agriculture is the primary occupation of the people. It depended on surface water and the monsoonal rainfall during the 1970s [13], but now 79.1% of the cultivated land use groundwater through irrigation [14, 15]. Urban areas of Bangladesh face huge water crisis during the dry season and the groundwater table of those areas are rapidly decreasing [16]. The quality of groundwater in Bangladesh which is a prime source of supplying water for most of the cities is also deteriorating due to the pollution of groundwater by sewage and excessive exploitation [17]. The northeastern and southeastern part of Bangladesh is mostly occupied by the hilly and coastal floodplain areas which were formed by the unconsolidated tertiary and Pleistocene sediments derived from the tertiary rock [18]. The coastal areas are characterized by salinity and an active floodplain which are flooded regularly by the high tide [19]. Groundwater level is declining rapidly due to some natural and man-made causes all over the country. Southwestern part of the country is also suffering from groundwater scarcity. This study was conducted in the southwestern part of Bangladesh comprising twenty districts. On the account of fluvial and ocean activity, most of the districts are located closer to the coastal areas. For the mighty Sundarban forest (the largest mangrove forest of the world), this region does not experience huge disaster caused by the different types of natural hazards every year. Tropical cyclone, storm surge, devastating flood etc. are the most common natural hazards occurred in the coastal region [20].

Table 1: Number of Wells in the Southwestern Part of Bangladesh (Source: BWDB, 2014)

Name of the Area	Number of Wells	Name of the Area	Number of Wells
Bagerhat	2	Khulna	9
Jhalakati	2	Chuadanga	10
Patuakhali	3	Pirojpur	10
Barguna	5	Narail	11
Madaripur	5	Gopalganj	15
Bhola	6	Magura	15
Satkhira	6	Jessore	17
Barisal	7	Faridpur	21
Meherpur	8	Rajbari	21
Jhenaidaha	22	Kushtia	36

2 Methodology of the Study

The goal of this study is to gain knowledge on the groundwater depth status of some selected regions of Bangladesh. A total of 20 districts from the southwestern part of the country were selected comprises diverse physiographic condition and topography. This study is based on secondary data. Monthly data of groundwater depth of distinct 231 wells located within the several districts of the southwestern part of Bangladesh were collected from the Bangladesh Water Development Board (BWDB). At first, monthly data were classified into three different seasons (pre-monsoon, monsoon and post-monsoon) to find out the

seasonal variation of groundwater depth of the study area. Following it, collected data were checked, corrected, filtered and summarized to month. After that, well locations were plotted with X and Y co-ordinate value and Z value. Then interpolation was done by IDW (Inverse Distance Weighted) tool in ArcGIS 10.1 to make a continuous raster, converted from a discontinuous feature in order to illustrate a continuous groundwater level. Finally, groundwater level was classified to determine the highest and lowest value.

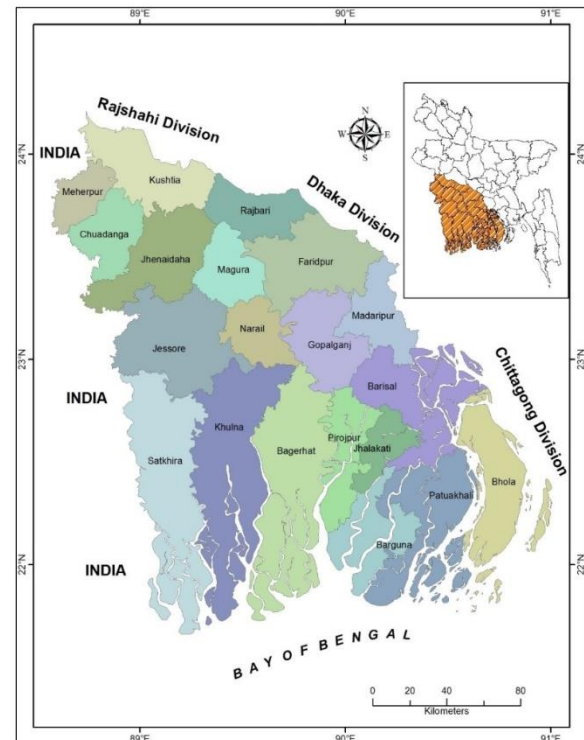


Figure 1: Map of the Study Area

3 Results and Findings

3.1 Variation of Water Level during the Pre-Monsoon Period

Figure 3 illustrates groundwater depth variation during the pre-monsoon period (Feb-May). It shows that groundwater level ranges from 0 to 10 m during this time. From the following map it can be observed that groundwater depletion rate is the highest in Magura, Rajbari, Kushtia and some part of Meherpur, Chuadanga, Jhenaidaha, Faridpur, Jessore and Satkhira varies from 6-10 m. On the contrary, groundwater fluctuation rate is the lowest in the coastal areas ranges from 1-4 m. In Patuakhali, Jhalakati and Barguna district, the groundwater table ranges from 1-3 m. The water table is moderate (4-6 m) was observed in some parts of Narail, Faridpur and Jessore during data analysis. There is one exception that a little part of Jhenaidaha, Chuadanga and Kushtia district experience low fluctuation rate.

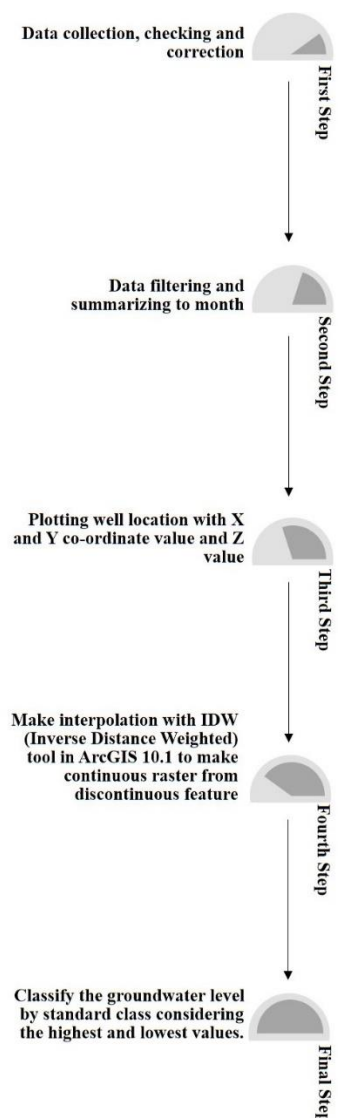


Figure 2: Methodology of the Study

3.2 Variation of Water Level during the Monsoon Period

In this period (Jun-Sep), huge rainfall is observed in our country. In 2010, approximately 5016 mm (197.5 in) rainfall was measured [20]. Groundwater level varies differently from June to September. From the following map, we can see that groundwater level ranges from 4-7 m in most of the parts of Magura, Kushtia, Jhenaidaha and Rajbari district during the month of August and September because of heavy rainfall which basically starts from June. During the monsoon period, groundwater level was observed between 9 and 10 m in some parts of Magura district. As time increases from the beginning of the rainy season, the fluctuation rate

of the groundwater table starts to decrease. It remains closer to the ground surface in the interior coastal areas of Bangladesh in the monsoon season varies from 1-3 m.

3.3 Variation of Water Level during the Post-Monsoon Period

During the month of October and November, the groundwater table ranges from 3-7 m in most of the districts named Meherpur, Kushtia, Rajbari, Faridpur, Magura, Madaripur, Gopalganj, Jhenaidaha, Chuadanga and Jessore because of heavy rainfall in the rainy season. But at the time increases, the groundwater table starts to diminish from the surface varies from 6-9 m in almost each part of Kushtia, Chuadanga, Magura, Rajbari and Jhenaidaha. Furthermore, the groundwater table is always closer to the surface in the coastal areas of the southwestern part of this country. However, owing to the low level of urbanization and prevalence of scattered settlement, groundwater depletion is minor within this part of the country. At the same time, people usually prefer surface water to be used vigorously for their daily usage and the opportunity of the groundwater to be replenished, is more due to less development of urban structure. As a result, the dry season scenario of groundwater depletion in this part of Bangladesh is not marked worthy.

4 Conclusions

Bangladesh is located in a zone of sufficient annual precipitation and also it has the proximity to the major river systems. But still it is not capable of utilizing its opportunities due to lack of proper management and effective implementation of the knowledge concerning the groundwater situation of Bangladesh. From this research, significant variation of groundwater depth has been observed throughout the study area. The groundwater situation has been found to be the worst in Magura, Meherpur, Jhenaidaha, Kushtia and Rajbari. The water table remains closer to the ground surface all over the year in the coastal districts of Bangladesh. We must keep in mind that groundwater plays a very significant role to meet up the need of daily water demand of the residents living in the cities of the developing countries like Bangladesh. In most of the parts of the developing world, the instantaneous progression of groundwater exploitation happened from 1970 to 1990 [21]. The overwhelming demand owing to increasing population, principally stimulates the rising depletion rate. And if this falling trend of groundwater level continues, then it may invite land subsidence, groundwater pollution, and other environmental hazards. In order to revive the jeopardized condition caused by groundwater deficiency, knowledge-based management measures should be initiated.

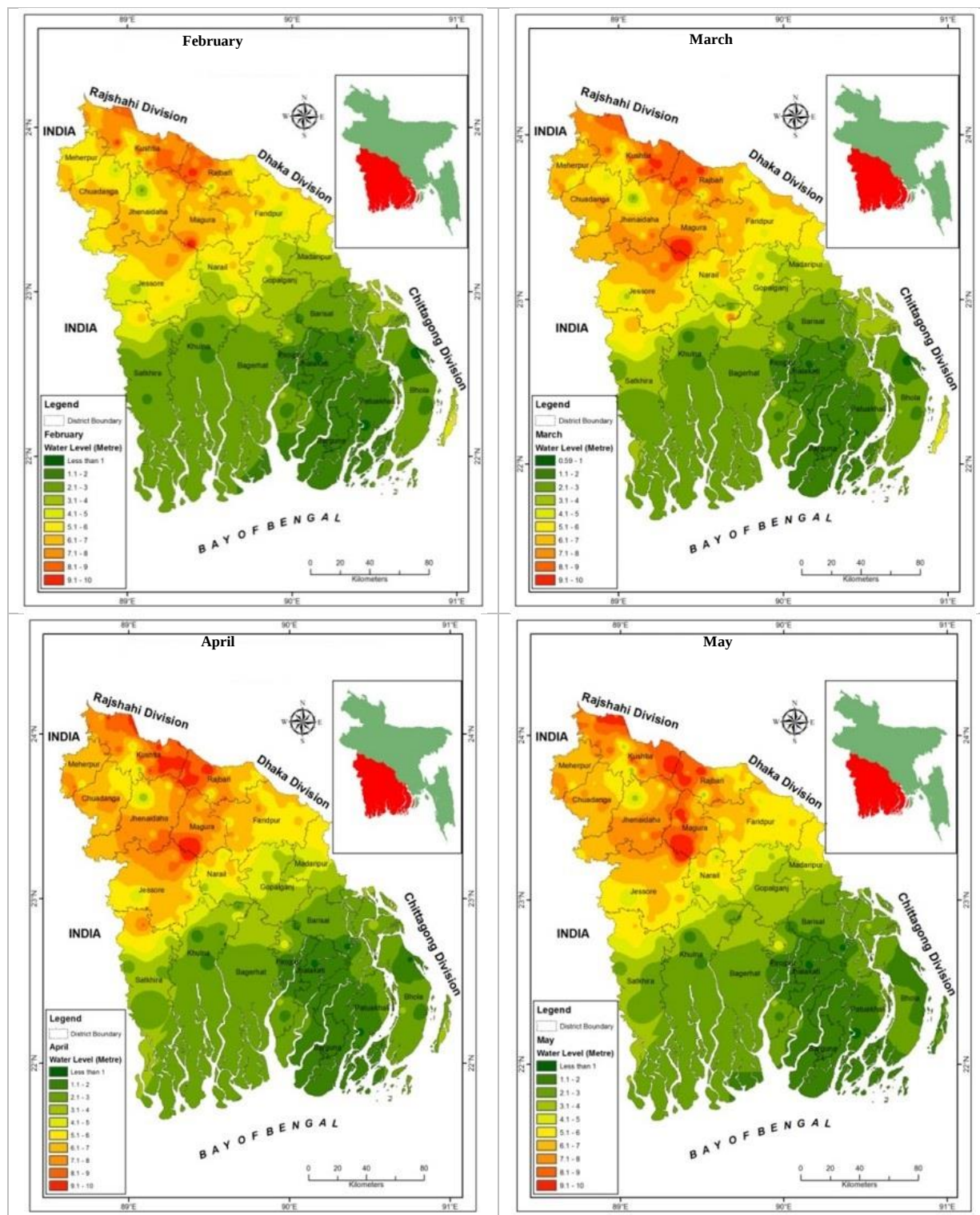


Figure 3: Groundwater Level Fluctuation Scenario during the Pre-Monsoon Period

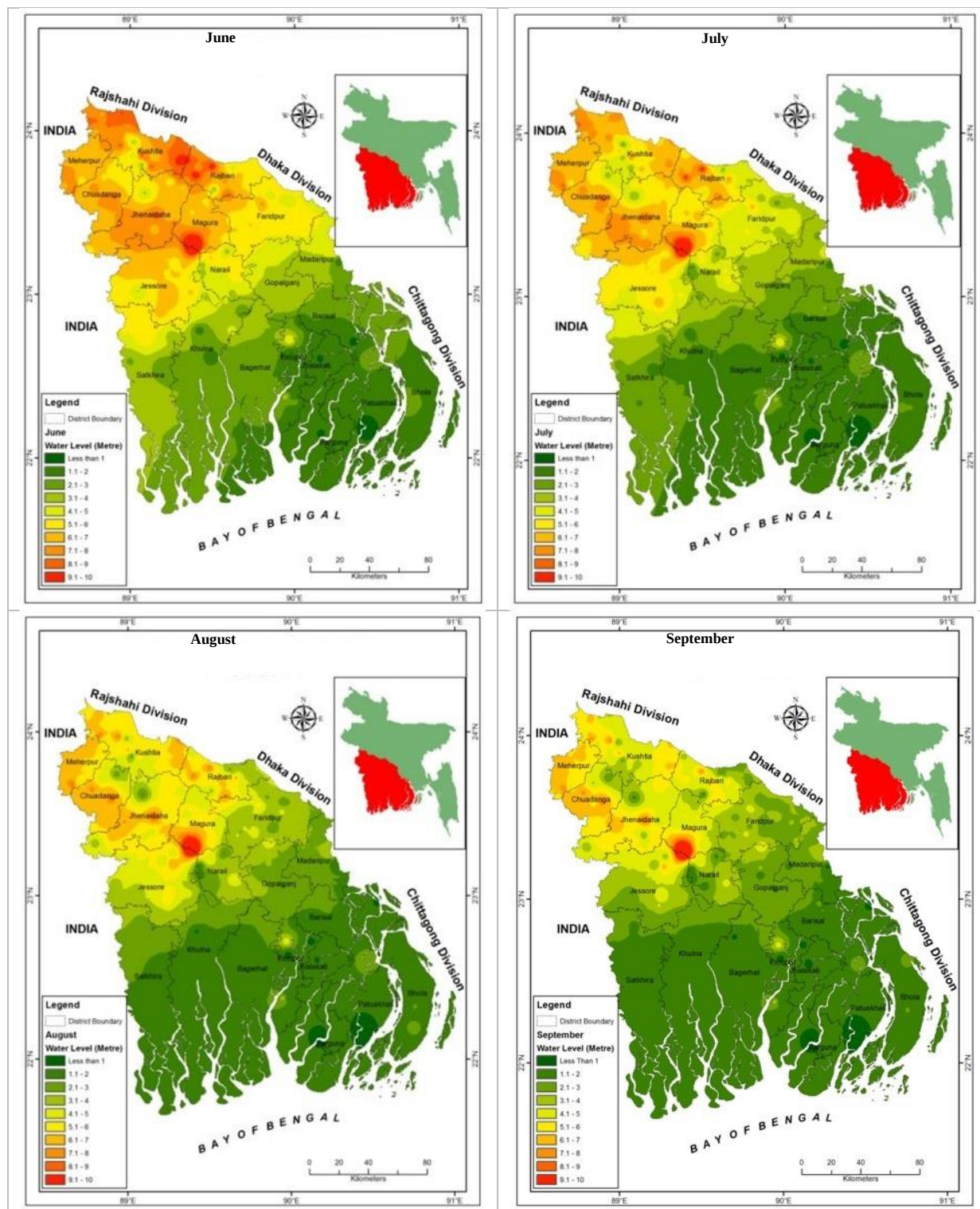


Figure 4: Groundwater Level Fluctuation Scenario during the Monsoon Period

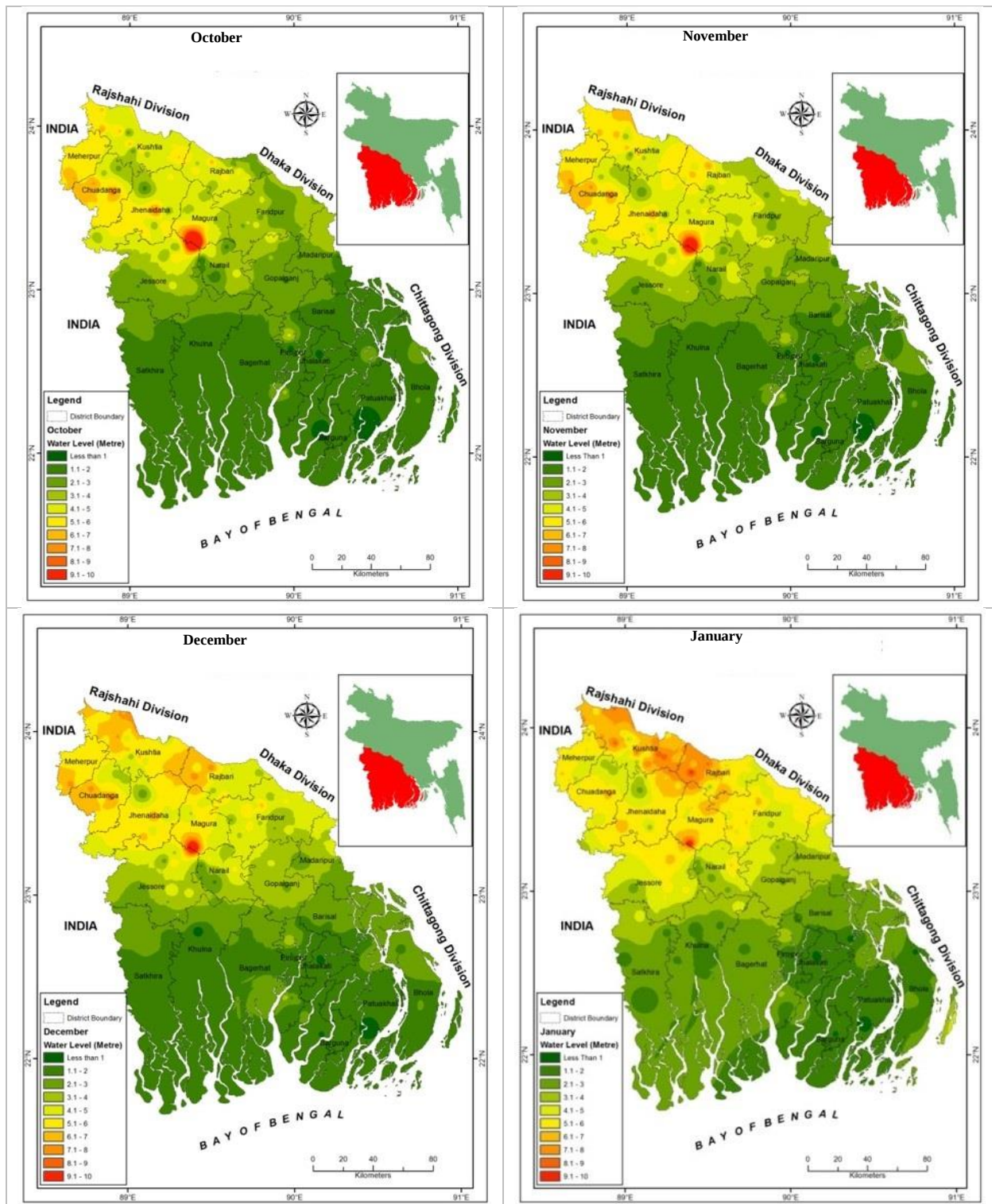


Figure 5: Groundwater Level Fluctuation Scenario during the Post-Monsoon Period

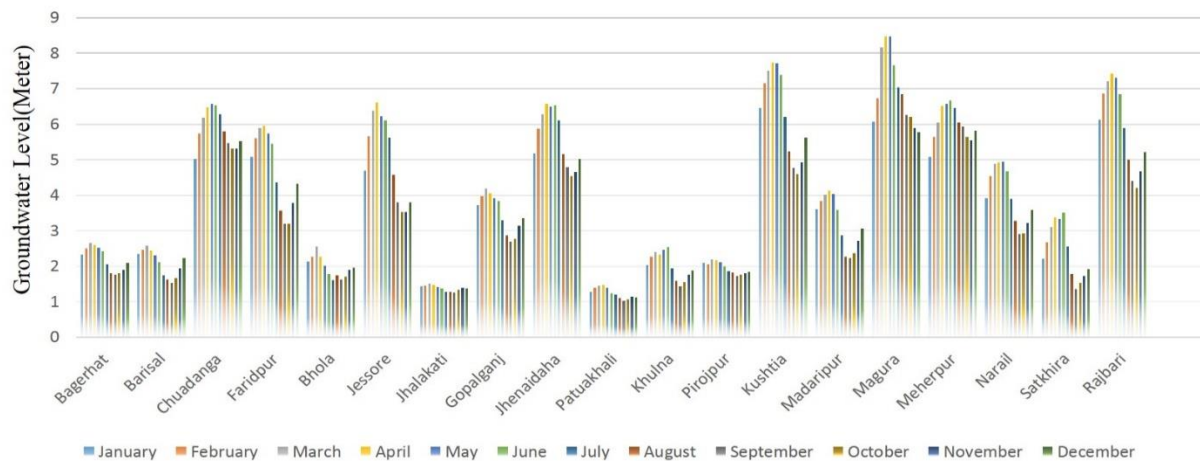


Figure 6: Average Monthly Variation of Groundwater Level

5 Acknowledgements

We would like to express our heartiest gratitude to Professor Dr. Towhida Rashid, Department of Geography and Environment, Faculty of Earth and Environmental

Science, University of Dhaka and the authority of Bangladesh Water Development Board (BWDB) for their incessant assistance.

References

- 1-Nwankwoala, H.O., 2011. An integrated approach to sustainable groundwater development and management in Nigeria. *Journal of Geology and Mining Research*. 3 (5), 123-130.
- 2-Oyebande, L., 2004. Power generation and development in the Nigeria's power sector. *Int. J. Hydropower Dams*. 6, 213-219.
- 3-Shah, T., 1993. Groundwater markets and irrigation development: political economy and practical policy. Oxford University Press, Bombay.
- 4-Water for Life, World Water Assessment Programme. (2003). *UN World Water Development Report: Water for people*.
- 5-Hoque, M.A., Hoque, M.M. and Ahmed, K.M., 2007. Declining groundwater level and aquifer dewatering in Dhaka metropolitan area, Bangladesh: Causes and quantification. *Hydrogeology Journal*. 15(8), 1523-1534.
- 6-Oteze, GE., 2006. Management approaches for Nigeria's water resources. *J. Min. Geol.* 42(1), 15-20.
- 7-Zahid, A. and Ahmed, S.R.U., 2013. Groundwater Resources Development in Bangladesh: Contribution to Irrigation for Food Security and Constraints to Sustainability.
- 8-United Nations Environment Programme. (2003). *Groundwater and its susceptibility to degradation: A global assessment of the problem and options for management. Kenya, Nairobi*.
- 9-Shamsudduha, M., Chandler, R.E., Taylor, R.G. and Ahmed, K.M., 2009. Recent trends in groundwater levels in a highly seasonal hydrological system: the Ganges-Brahmaputra-Meghna Delta. *Hydrol. Earth Syst. Sci.* 13, 2373-2385. Available at: <http://discovery.ucl.ac.uk/59581/>
- 10-Klump, S., Kipfer, R., Cirpka, O.A., Harvey, C.F., Brennwald, M.S., Ashfaq, K.N.,... Badruzzaman, A.B.M., Hug, S.J. and Imboden, D.M., 2006. Groundwater dynamics and arsenic mobilization in Bangladesh assessed using noble gases and tritium. *Environ. Sci. Technol.* 40, 243-250.
- 11-British Geological Survey (BGS) and Department of Public Health Engineering (DPHE) Govt. of Bangladesh; rapid investigation phase, Final Report DPHE-BGS. (2001). *Arsenic Contamination of Groundwater in Bangladesh*.
- 12-Alam, S., 2012. Country Experience: Bangladesh population and housing census 2011.
- 13-Villholth, K.G., 2006. Groundwater assessment and management: Implications and opportunities of globalization. *Hydrogeol. J.* 14, 330-339.
- 14-Bangladesh Agricultural Development Corporation. (2010). *Minor Irrigation Survey Report*.
- 15-Ali, M.H., 2011. Fundamentals of Irrigation and On-farm Water Management. *Springer-Verlag New York Inc. New York*, 1, 18.
- 16-Rashid, H., 1991. Geography of Bangladesh. The University Press Limited, Dhaka, Bangladesh.
- 17-Menon, S., 1998. Groundwater management: need for sustainable approach. Proceedings of the seminar on Artificial Recharge of Groundwater. Central Groundwater Board, Ministry of Water Resources, New Delhi. December.
- 18-Rashid, H., 1991. Geography of Bangladesh. The University Press Limited, Dhaka, Bangladesh.

- 19-Rashid, H. and Pramanik, M.A.H., 1990. Visual Interpretation of Satellite Imagery for Monitoring Floods in Bangladesh. *Springer-Verlag New York Inc. U.S.A.*
- 20-British Geological Survey and Mott MacDonald Ltd (UK). (1999). *Groundwater Studies for Arsenic Contamination in Bangladesh. Phase-I: Rapid. Investigation Phase.*
- 21-Akhter, H., Ahmed, M.S. and Rashed, K.B.S., 2009. Spatial and Temporal Analysis of Groundwater Level Fluctuation in Dhaka City, Bangladesh. *Asian Journal of Earth Science. 2* (2), 49-57.