Effect Of Rainfall On Groundwater Level Fluctuations In Chapai Nawabgonj District

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Abstract
The study was conducted in five Upazilas under Chapai Nawabgonj district from 2007 to 2011 to evaluate the effect of rainfall on groundwater level fluctuation. Rainfall and groundwater fluctuation data were collected from BMDA, Rajshahi and evapotranspiration data were collected from IWM, Dhaka. The data were analyzed to show the rainfall variations, runoff, infiltration and groundwater fluctuation levels in different years.
The results illustrate that rain started usually in May and ended in September and little or no rainfall occurred during the rest of the year. The study results show that the maximum rainfall occurred throughout June -August and at the same time the estimated runoff and infiltration showed the maximum as expected. The maximum water table was found during July-September due to rainwater infiltration. The results also observe that the minimum water table was shown throughout March – May, during irrigation period of the area. This study illustrates that there were no significant change in rainfall and infiltration patterns during the study period, but the overall ground water table was declining day by day due to over withdrawal of groundwater for irrigation purpose.

Keywords: fluctuation, infiltration, rainfall, runoff, table, water

1. Introduction

Bangladesh is the land of rivers, a number of rivers crossed over it but the surface water is not enough to meet irrigation water demand in dry season. Agriculture in Bangladesh depends on irrigation during the dry eight months starting from November ending in June. Groundwater is the major water source for domestic and irrigation purposes.
In general, the term groundwater or subsurface water refers to the water that occurs below the surface of the earth. About 30% of the earth fresh water stores in underground aquifer (The Encyclopedia of Earth, website). It is the purest form of water and as its stores in underground for long periods and it can be available at a small capital cost and its value to mankind is unlimited. It is also flows over long distances through the aquifers and it is available to a very large number of people at their firms. The infiltrated water after meeting the soil moisture deficiency percolates deeply and becomes groundwater. The groundwater is free from pollution and is very useful for domestic use in small towns and isolated farms. In arid regions, ground water is often the only reliable source of water for irrigation. It could be wisely managed and protected against undue exploitation and contamination by pollutants or salt water. The potentiality of groundwater attracted the attention of agricultural engineers, civil engineers, geologists, geophysicists and scientists from various disciplines (Reddi, 1986).

Groundwater is basically a dynamic resource that may be expressed as the quantity of water measured by the difference between optimum and minimum water table within the aquifer,

which is principally recharged from monsoon rainwater for the rest of the year. Exploitation or over withdrawal of groundwater resources imposes stress on groundwater regime distorting the aquifer recharge-withdrawal equilibrium and as a result, a continuous decline in water table may occur causing much adverse surface and subsurface environmental effect (Garg, 1976). Groundwater recharge is influenced not only by climate variability but also human intervention including, unsustainable withdrawal and groundwater abstraction. Groundwater-fed irrigation is conducted to cultivate high-yielding rice during the dry season in South Asia, where India and Bangladesh represent the world second and fourth biggest rice-producing nations respectably (Scott and Sharma 2009; IRRI 2010)

In Bangladesh, total annual (2004-2005) irrigation water use was estimated to be -246 Km^3 of which 18km^3 comes from groundwater (Siebert et al. 2010) via a range of pumping technologies. Recent studies in India and Bangladesh reported that a groundwater level (0.1-o.5 m/year) was declining indicating reduction in aquifer storage for unsustainable groundwater abstraction for both irrigation and urban water supplies.

In India, Punjab and Haryana are experiencing very rapid decline in water tables. This can threaten future food security in the country (Tribune News service, 2006).

Water demand is increasing rapidly due to population growth and socioeconomic development in recent time, needed to take a holistic approach in this sector. A few researches on groundwater level fluctuation in Barind area so far have been reported. But these are not enough for recent groundwater level declining needed further investigation into the study area. The main objective of this study was to evaluate the rainfall effect on groundwater level fluctuations in Chapai Nawabgonj District.

2. Materials and Methods

2.1. Study Area

The study area is a district in the northern part of Bangladesh, named Chapai Nawabgonj. The district consists of five Upzilas, namely Nawabgonj, Shibgonj, Gomostapur, Nachol and Bholahat and it lies under the Barind tract and has an area of 1744.33km^2. The main rivers of the district are the Ganges and Mahanadi. It is located between 24.7300 north latitude and 88.2000 east longitude.

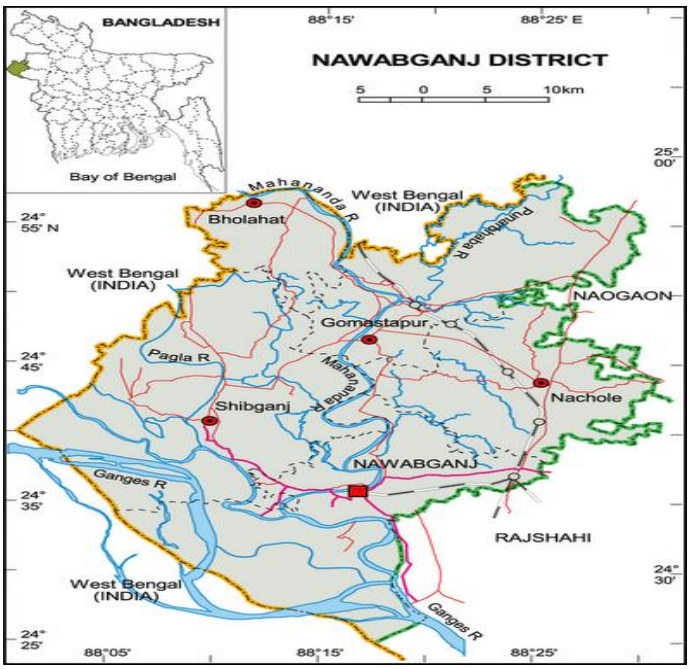

Fig: 1. Map of the Study Area (Chapai Nawabgonj district).

2.2. Data Collection

Groundwater level fluctuation and rainfall data were collected from the head office of Barind Multipurpose Development Authority (BMDA) and evopotranspiration data were collected from the Institute of Water Modeling (IWM), Dhaka of the study area for five years from 2007 to 2011.

2.3. Runoff

The portion of precipitation which appears in the surface stream of either perennial or intermittent nature is called runoff. This is the flow collected from a drainage basin and appearing at an outlet of the basin. The runoff is more uniform compared to precipitation, while the precipitation is sporadic and irregular in nature. This contrast between precipitation and runoff is due to the storage effects of the surface layers of the earth. Runoff can be calculated using the following equation,

$$R=K_b \times P \qquad \text{(i)}$$

Where P and K_b are the rainfall and the runoff coefficient, respectively.

2.4. Infiltration

Water entering the soil at the ground surface is called infiltration. It is the process by which water enters the surface strata of the earth. The infiltrated water first meets the soil moisture deficiency, if any, and further the excess water moves vertically downwards to reach the groundwater table. Infiltration can be calculated from equation (ii).

$$I= P-ET-R \qquad \text{(ii)}$$

Where, I, P, ET and R indicate the infiltration, rainfall, evapotranspiration and runoff, respectively.

3. Results and Discussions

3.1 Rainfall Variation

The monthly rainfall variations of five Upzilas of the study area during 2007-2011 are shown in Figs. 1-5. The maximum rainfall was found throughout June to September during the rainy season of the area. The minimum rainfall was found between February and April and very little or no rainfall occurred during November- January in the study area. The study results also illustrate that the maximum rainfall was recorded at Shibgonj in July, 2007, Shibgonj in June, 2008, Gomostapur in September, 2009, Gomostapur in June, 2010, and Shibgon in August, 2011.

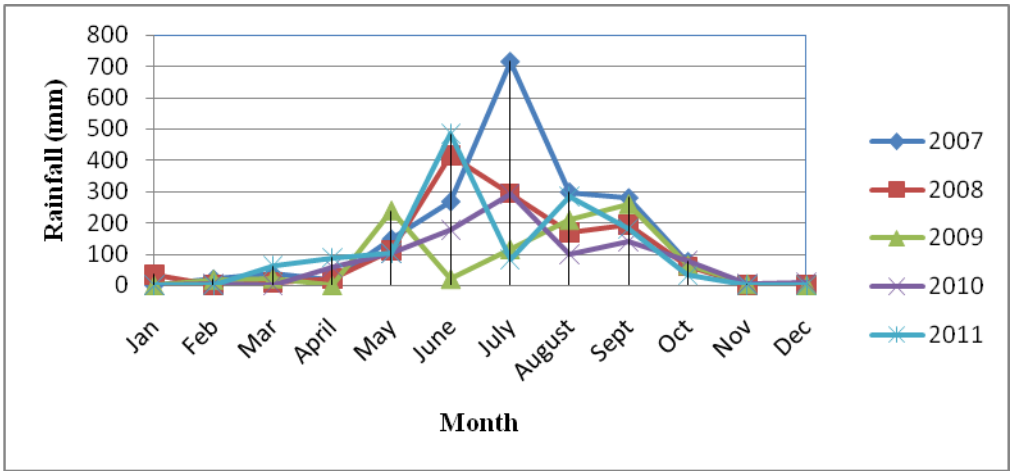

Fig.1. Monthly rainfall variation at Nawabgonj.

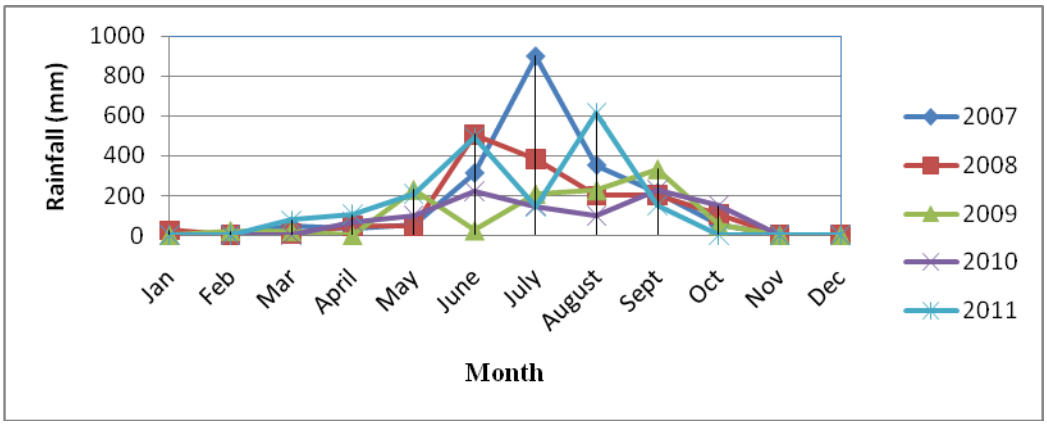

Fig. 2. Monthly rainfall variation at Shibgonj.

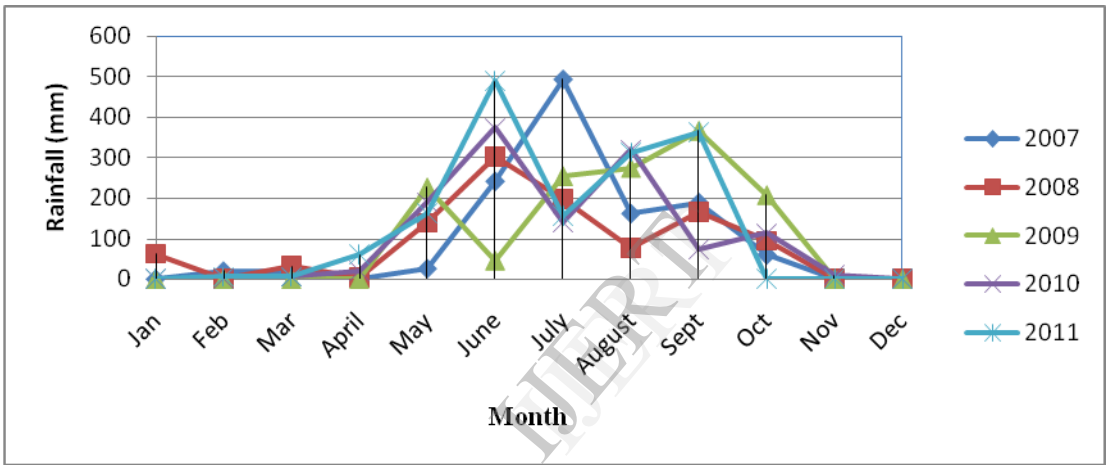

Fig. 3. Monthly rainfall variation at Gomostapur.

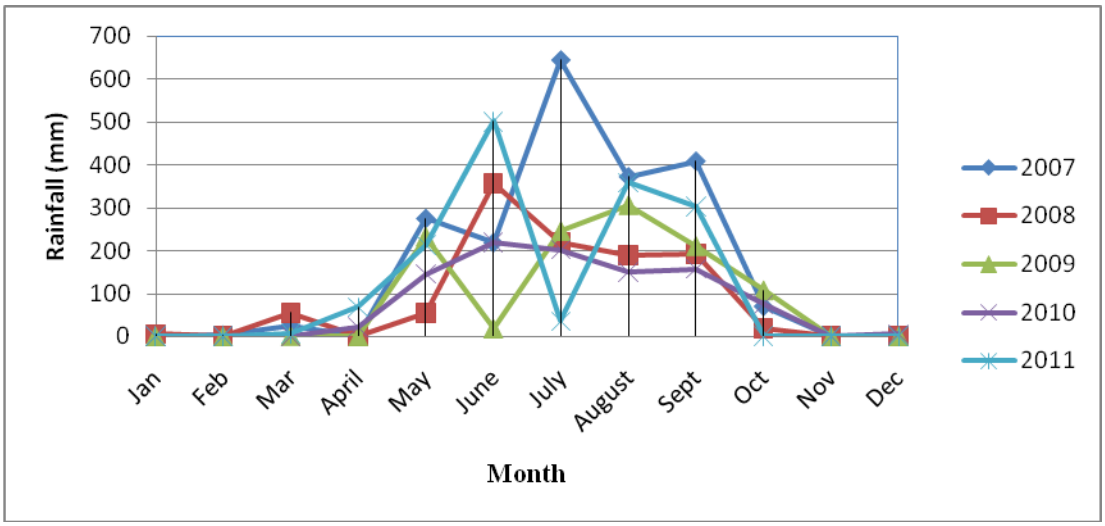

Fig.4. Monthly rainfall variation at Nachol.

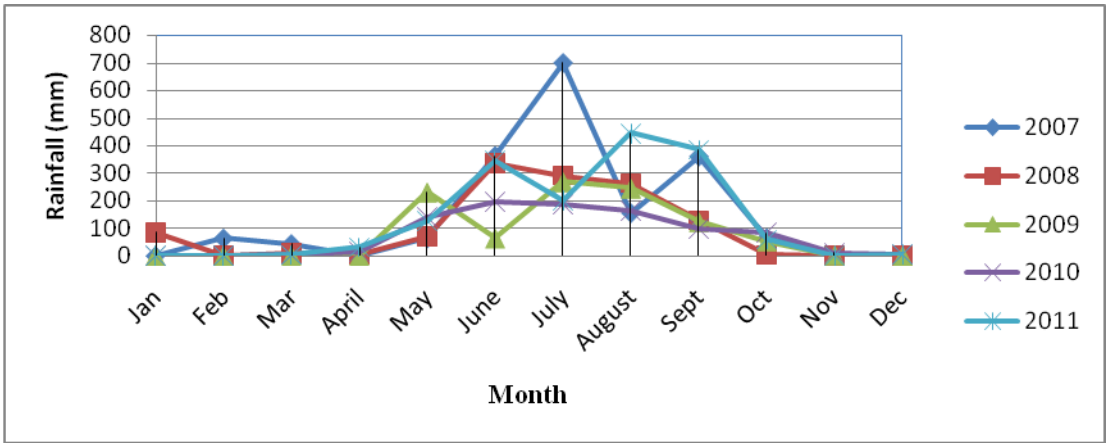

Fig.5. Monthly rainfall variation at Bholahat.

Table1
Annual rainfall of five Upazilas of Chapai Nawabgonj District during 2007-2011.

Year	Nawabgonj (mm)	Shibgonj (mm)	Gomostapur (mm)	Nachol (mm)	Bholahat (mm)	Chapai Nawabgonj Dristrect (mm)
2007	1858	1972	1213	2018	1811	1774
2008	1302	1514	1074	1088	1198	1235
2009	946	1110	1378	1117	989	1107
2010	962	1005	1248	974	896	1016
2011	1314	1793	1551	1487	1603	1549

The maximum annual rainfall recorded was 1774 mm in 2007. Since then, rainfall was gradually decreasing for consecutive three years, but in 2011, the annual rainfall increased 532 mm from 1017 mm recorded in the previous year. The results show that Nachol Upazila received the highest rainfall 2018 mm in 2007 and Bholahat Upazila received the lowest rainfall 896 mm in 2010 during the study period of the area. The average rainfall received in Chapai Nawabgonj district was 1336 mm during 2007-2011 (not shown in the table).
A report showed that the rainfall recorded was about 1738 mm in 1981 and 798 mm was recorded in 1992 in the Barind area suggesting yearly rainfall variations (Banglapedia Website). The rainfall data of the study also show a wide variation of rainfall depending on area and year.

3.2 Estimated Runoff

The results show that the maximum estimated runoff was found in 2007 during the study period as the rainfall received. Since then, runoff was gradually decreasing for consecutive three years, but it was increased in all Upzilas of the district in 2011 as expected due to higher rainfall received in this year.
The highest runoff estimated was 303mm in 2007 in Nachol Upzila and the lowest runoff was 134 mm in 2010 at Bholahat Upazila during the study period.

Table2
Estimated runoff of five Upazilas of Chapai Nawabgonj District during 2007-2011

Year	Nawabgonj (mm)	Shibgonj (mm)	Gomostapur (mm)	Nachol (mm)	Bholahat (mm)
2007	279	296	182	303	272
2008	195	227	161	163	180
2009	142	167	207	168	148
2010	144	151	187	146	134
2011	197	275	233	223	240

3.3 Estimated infiltration

The infiltration data of Chapai Nawabgonj district illustrate that the highest infiltration was estimated in 2007 during the study period as the maximum rainfall received, since then, infiltration was gradually decreasing for consecutive three years, but the increased amounts of infiltration was estimated in 2011 compared to the previous year in all Upzilas as expected due to higher rainfall received in this year. The estimated highest infiltration was 1694 mm in 2007 at Nachol Upzila and the lowest infiltration was 737 mm in 2010 at Bholahat Upazila.

Table3
Estimated infiltration of five Upazilas of Chapai Nawabgonj District during 2007-2011.

Year	Nawabgonj (mm)	Shibgonj (mm)	Gomostapur (mm)	Nachol (mm)	Bholahat (mm)
2007	1556	1652	1010	1694	1519
2008	10855	1265	891	905	996
2009	781	923	1156	933	822
2010	793	836	1038	808	737
2011	1095	1538	1298	1246	1338

3.4 Relation between rainfall and Water level fluctuation

The analysis results show that annual rainfall of the district decreased for consecutive three years from 1774 mm in 2007 to 1016 mm in 2010, but 1549 mm rainfall was recorded in 2011, which was 513 mm higher than previous year (Table 4). The similar trend observes in runoff and infiltration data as these were estimated from rainfall data during 2007 to 2011.The results show a good relation among the parameters indicating that the higher amount was the rainfall, the higher amounts were the estimated runoff and infiltration.

Table4
Annual rainfall, runoff and infiltration of Chapai Nawabgonj District during 2007-2011.

Year	Rainfall (mm)	Runoff (mm)	Infiltration (mm)
2007	1774	266	1486
2008	1235	185	1028
2009	1107	166	923
2010	1016	153	842
2011	1549	233	1303

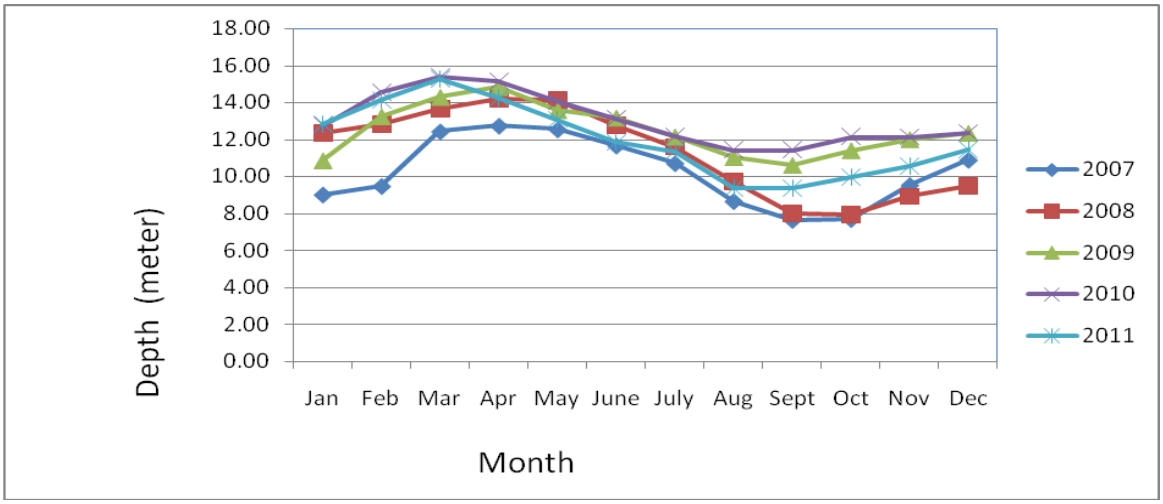

Fig. 6. Monthly water table fluctuations of Chapai Nawabgonj district during 2007 – 2011.

The figure shows a good trend of water table fluctuations of Chapai Nawabgonj district during 2007 to 2011 (Fig. 6). The results illustrate that the overall water table level showed minimum in 2007 and maximum in 2010. An elevated water level is seen 2011 due to higher amount of rainfall received in the area. The graphs show wave like fluctuation curves, where the highest depletion occurred during March-April and then the water table increased slowly and reached minimum during September-October and again slowly decrease until rain started in May. The study results reveal that a good relation between rainfall and water table fluctuations was observed where the groundwater table was recharged by the rainfall. However, the overall yearly water table declining trend indicate that unsustainable withdrawal of groundwater for irrigation and domestic purposes were played a vital role in water table fluctuations in the study area.

Conclusion

The study results illustrate that the maximum rainfall occurred during July-August and little or no rainfall was recorded during December-February. Thus the maximum runoff and infiltration were estimated during July-August. The monthly water table fluctuation data showed an elevated water table during September-October indicating groundwater recharged by rainwater infiltration, and then the water table declined continuously and reached the lowest level throughout March- May, the irrigation period of the study area. The study results illustrated that groundwater level fluctuations largely depended on rainfall pattern, but the yearly groundwater table declining trend is suggesting that unsustainable withdrawal of groundwater was the main cause of water table depletion in the study area.

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