Assessment of Ground Water fluctuation and Recharge due to rainfall in Barind Area under Greater Rajshahi District (North Western Part of Bangladesh)

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***Abstract*— Now-a-days groundwater crisis of the projected area is highlighted. Water plays an important role in development of agricultural facilities in all parts of the world. Ground water condition of an area is mainly depending on geology, hydrology, hydrologic parameter, soil properties, recharge and discharge, hydraulic characteristics of aquifer. An important component of water balance equation is ground water recharge. This paper focuses mainly on the causes of groundwater fluctuation and the trend of groundwater level fluctuation as well as to determine the amount of recharge in Barind area by rainfall infiltration. The fluctuation of ground water level, variation of monthly rainfall, its infiltration and runoff data are analyzed in the barind area under greater Rajshahi district (North Western Part of Bangladesh) namely Niamatpur, Nachole, Gomostapur, Nawabgong and Shibgong in different month of year. The vertical change in storage is not same through the year due to rainfall & infiltration for characteristics of soil in study area. The maximum and minimum depth of water table found in month of April–May and August–September respectively. Monthly variation of rainfall follows the usual pattern of monsoon with heavy rains from June to September. The maximum infiltration as well as runoff also occurred from June to September due to maximum rainfall and the infiltration and runoff is negligible due to very little rainfall during the rest of the year.**

***Index Term*-- Fluctuation of groundwater level, hydrologic parameter, infiltration, rainfall, and runoff.**

I. INTRODUCTION

Global groundwater storage is roughly equal to the total amount of freshwater stored in the snow and ice pack, including the north and south poles. This makes it an important resource which can act as a natural storage that can buffer against shortages of surface water, as in during times of drought. Groundwater makes up about twenty percent of the world's fresh water supply, which is about 0.61% of the entire world's water, including oceans and permanent ice. The increase of ground water can be achieved by infiltration of rainfall, recharge by seepage, surface flow etc. With the increasing use of groundwater for agricultural, municipal, industrial need the annual extraction of groundwater are far in excess of net average recharge from natural sources. Consequently groundwater is being withdrawn from storage and water levels are declining resulting in crop failure, adverse salt balance and sea waters intrusion in costal aquifers and land subsidence in areas draft resulting compaction of sediment. In order to maintain groundwater supplies indefinitely the hydrological equilibrium must exist between all water entering and leaving the basin. The management of groundwater is essential to obtain desired economic benefits. Maximum economic and beneficial use can obtain by coordinating groundwater and surface water resource. The proper management of groundwater resources requires an adequate knowledge of extent of the storage, the rate of discharge, the rate of recharge to groundwater body as well as the use of economical means of extraction. Sometimes it may be necessary to apply the artificial recharging to reservoir so that it may supplement the natural recharge [1, 2].

In Bangladesh ground water is the largest source of fresh water. Most of the urban & rural area, people, industries, city centre, headquarter depends on ground water. A number of rivers crossed over Bangladesh but the sources of surface water are not sufficient to fulfill the total requirement. Bangladesh is an agricultural country where agriculture largely depends on irrigation process during dry season (mid October to mid June) since rainfall is minimum. Groundwater supplies 75% of water in dry season irrigation and almost all municipal water supplies. Thus, ground water is the major source of water that is used for municipal water supply and irrigation purposes. Therefore it is very important to investigate the condition of ground water recharge in Barind area especially at Rajshahi zone, North West of Bangladesh. It is very important to increase of ground water for agriculture, municipal and industrial needs. The main aim of this paper is to achieve the following specific objectives: Investigation of the fluctuation of ground water table as well as to evaluate the amount of recharge from the available rainfall data and find out the change in storage of ground water at the study region. Finally, the investigation of soil characteristics and assessment of the environmental impact due to ground level fluctuation.

II. THE STUDY AREA

The part of greater Rajshahi, Dinajpur, Rangpur and Bogra District of Bangladesh and Indian territorial Maldah District of West Bengal is geographically identified as Barind Tract. The Rajshahi Barind Tract is located in between 24 degree 23 minute to 25 degree 15 minute north latitude and 88 degree 2

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minute to 88 degree 57 minute east longitude [3, 4]. Greater Rajshahi District is called north-western part of Bangladesh. Chapai Nawabgonj and Naogaon district both are situated in greater Rajshahi district. The upazilas of Nawabgonj, Nachole, Shibgonj and Gomostapur under Chapai Nawabgonj and Niamatpur under Naogaon districts are selected as study area.

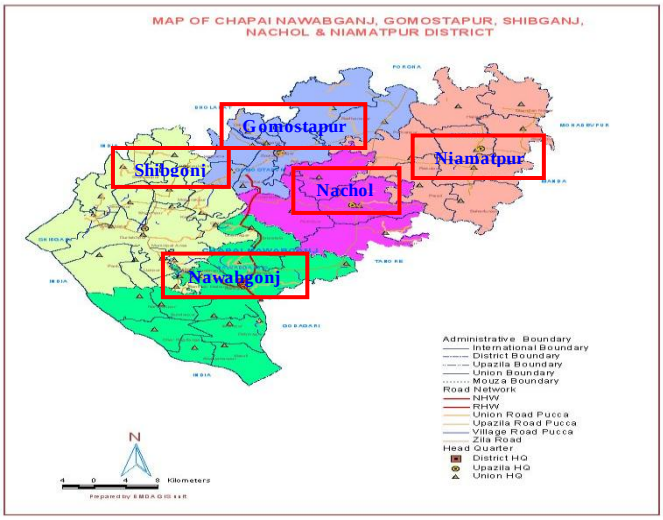


Fig. 1. Map showing the study area indicating five Upazila

A. *Location and extent*

The Barind Integrated Area Development Project (BIADP) is located in the Brand tract situated in the northern portion of Bangladesh. The part of greater Rajshahi, Nawabgonj, Dinajpur, Rangpur, Jaipurhat, Gaibanda and Bogra district of Bangladesh and the lndian territorial Maldah district of West Bengal is geographically identified as Barind tract. The hard red soil of this area is varying significant in comparison with respect to the other part of the country. The Rajshahi Barind tract is located in between 24 degree 23 minute to 25 degree 15 minute north latitude and 88 degree 2 minute to 88 degree 57 minute east longitude [5].

B. *Topography*

The landscape comprises mainly in the eastern part, dissected and undulating in western part. In the dissected areas top to the landscapes, that is the summits are level, the slopes and valley sides are terraced locally rounded dome shaped summit occurs due to closer dissection. The land is classified as follows [3]:

a) High land (H.L): Land above normal flood level.
b) Medium high land (M.H.L): Land flooded up to a depth of 7.62 cm during monsoon season but water level in the fields in normally 15.24 or less by the end of August.
c) Medium land (M.L): Land flooded from 0.92 m - 1.83 m depth during the monsoon season.
d) Low land (L.L): Land flooded above 1.83 m depth during the monsoon season.

C. *Soil & soil association*

The Barind tract is nearly level over most of the extent, but is hilly and dissent by narrow vallents (bodes) in the west. Major soils are mixed yellowish brown and grayish loam to clay loam. The total cultivated area being 1.44 million acres, out of which 34% is loamy, 10% sandy, 49% clayey, and 7% others [5].

D. *Climate*

There are two main season, separated by transition season. The monsoon season lasts from May/June until September & the dry season from November to February is sunny and relatively cool. The climate of the project area is more and less the average for the country as a whole characterized by the two distinct seasons the wet season from June to September and the dry season during rest of the year [5]

E. *Temperature*

The average temperature of the project area varies between 8^0C to 44^0C. January and February are the coolest month, when temperature falls below 8^0C. Summer starts abruptly in March and is characterized by a hot north westerly wind and a rapid increase in mean daily relative humidity from 60% to 85%. Temperature as high as 45^0C is experienced for some time during summer season [6].

F. *Rainfall*

The monthly distribution of rainfall in the project follows the usual pattern of monsoon with heavy rains starting in May and ending in September and very little of no rainfall during the rest of the year. Rainfall area varies from about 1500 to 2000 mm [5].

G. *Evaporation*

Minimum evaporation occurs in the months from November through February when monthly evaporation varies from 55.88 to 60.96mm. Maximum rate is generally observed in month of March to May when monthly evaporation varies from 140 to 162mm.But evaporation is observed only 60 to 125mm at the month of June to September [5].

H. *Specific Yield*

The volume of water, expressed as percentage of the total volume of the saturated aquifer, that can be drained by gravity is called the specific yield. The specific yield is calculated by Jacobs's method [7].

III. Data Collection and Analysis

A. *Collection of Data*

Rainfall data, Static water level data, Boring log and Static discharge data and Weekly time drawdown data required for the study of the area of Niamatpur, Nachole, Gomostapur, Nawabgonj and Shibgonj Upazilla have been collected from the zonal office of Barind Multipurpose Developrnent Authority (BMDA) [6]. Ground water level fluctuation data, Evaporation data has been collected from the head office of Barind Multipurpose Development Authority (BMDA) [8].

B. *Data Analysis*

The collected data were analyzed as following manner-

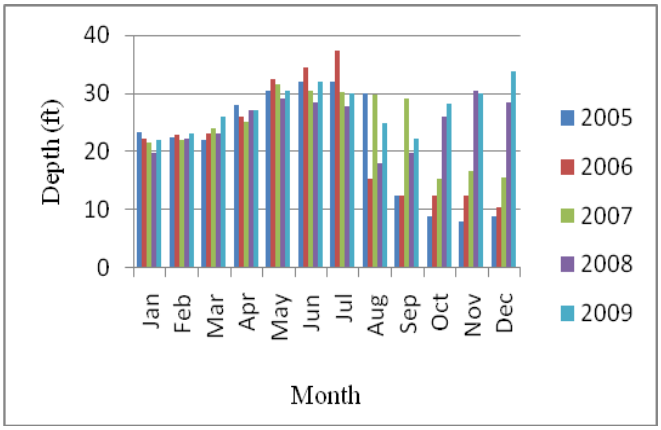
a) Analysis of monthly fluctuation of ground water level at Niamatpur, Nachole, Gomostapur, Nawabgonj and Shibgonj Upazila.

b) Analysis of the yearly variation of maximum and minimum ground water table at that region.
c) Determination of change of ground water storage at that region.
d) Determination of vertically ground water recharge individually in study area.
e) Normal graphs of maximum and minimum depth of water table from ground surface.
f) Semi-log graphs use for calculation specific yield.

C. Analysis of groundwater level fluctuation:

A groundwater level, whether it may be water table of an unconfined aquifer or the pizeometric surface of confined aquifer, indicates the elevation of atmospheric pressure of the aquifer. Any phenomenon that can produce a change in pressure on the groundwater will cause the ground water level changing. The variation in groundwater table in any area in a year cindering the maximum and minimum level is said to be fluctuation of the ground table in area of study [9].

The fluctuation of groundwater level generally caused due to- Change in groundwater storage, direct fluctuation of atmospheric pressure in contact with ground surface, deformation of aquifers, overdrawn of groundwater, natural causes such as earthquake flow to wind, secular and seasonal variation. The yearly variation of groundwater level at the study sites are given in the following fig.2.



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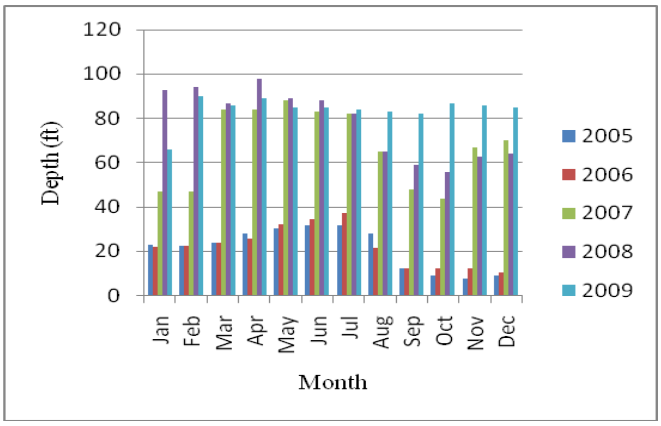

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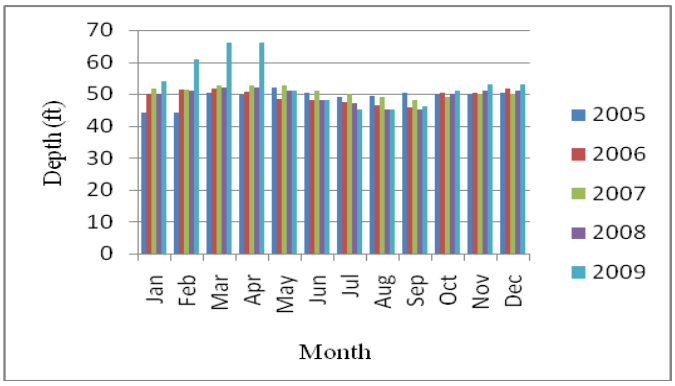

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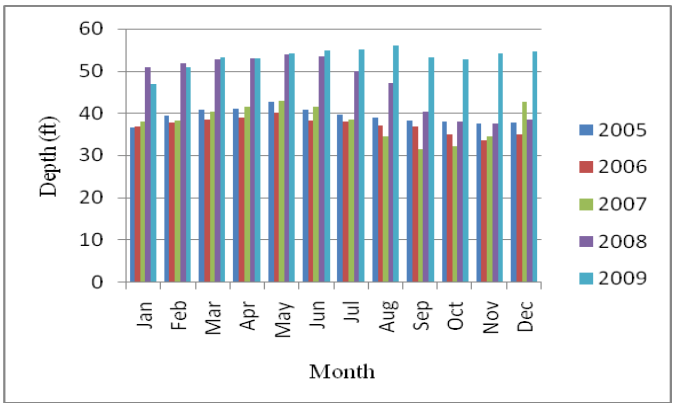

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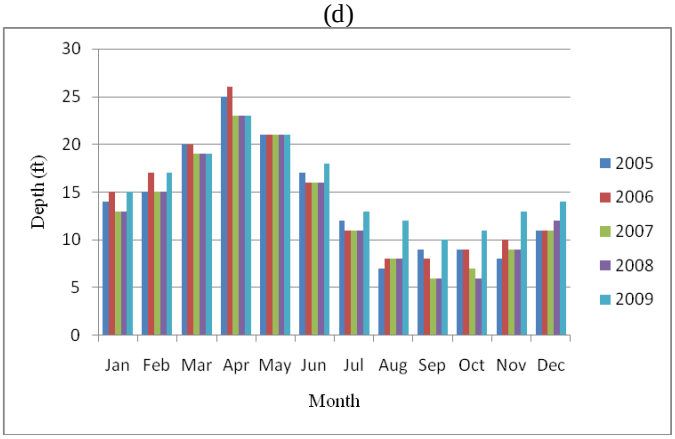


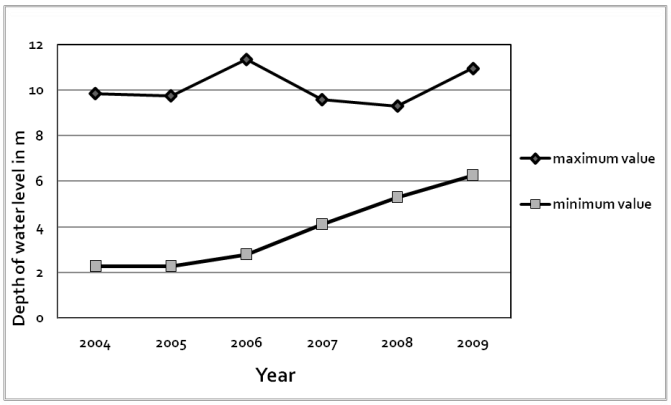
(e)

Fig. 2. Yearly fluctuation of groundwater level at (a) Niamatpur, (b) Nachole, (c) Gomostapur, (d) Nawabgonj and (e) Shibgonj Upazila.

D. Analysis of the maximum & minimum depth of water table from ground surface

In analysis of the maximum and minimum depth of water table from ground level graphs were plotted with year on the X-axis and depth of water table (in meter) from ground surface on the Y-axis. The maximum depth of water table occurs in April-May. The groundwater table is the highest depth from ground surface is assumed to be dry season.

In the month August-September the water table is the lowest in the ground surface and hence it has the minimum depth to ground level. This is the monsoon season. The variation of maximum and minimum groundwater level is analyzed station wise prior and after the installation of deep tube-wells are shown in the fig. 3.



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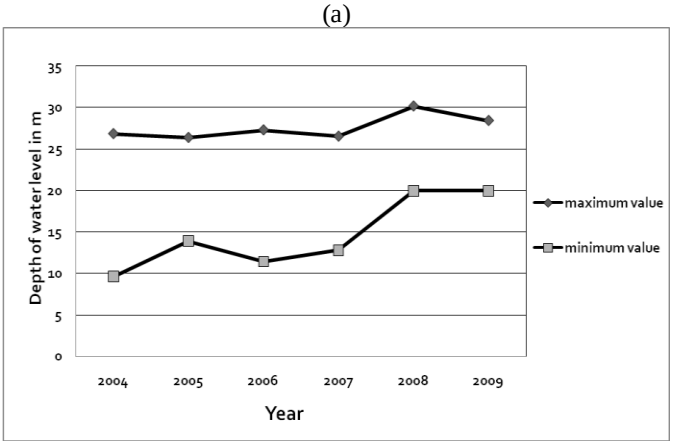

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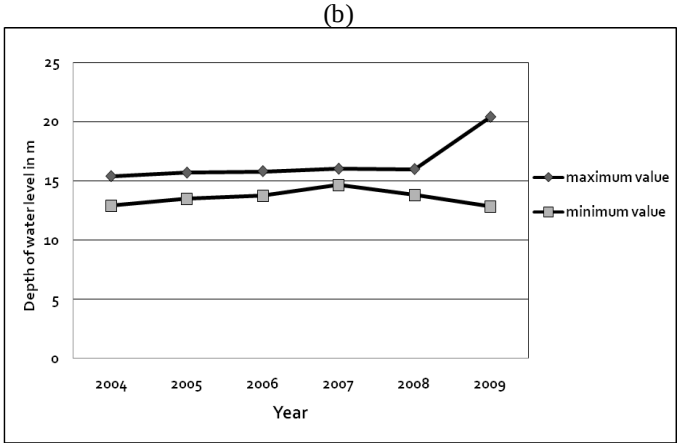

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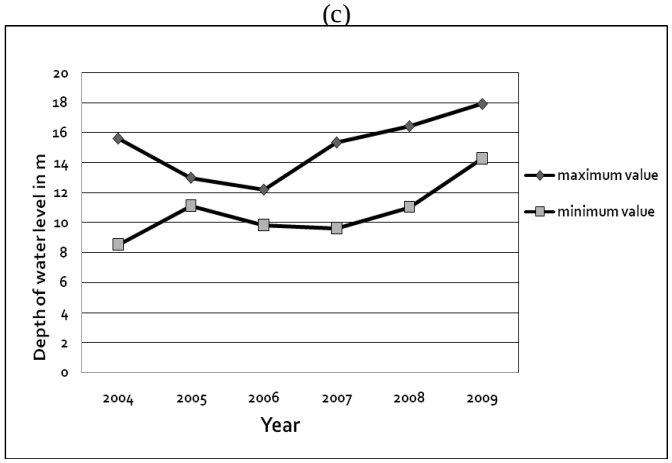

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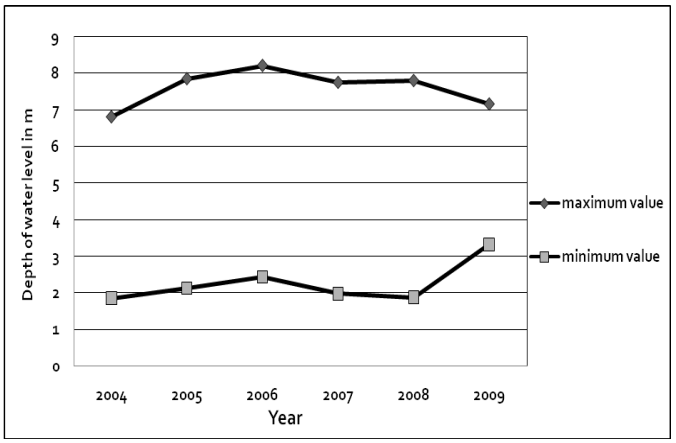

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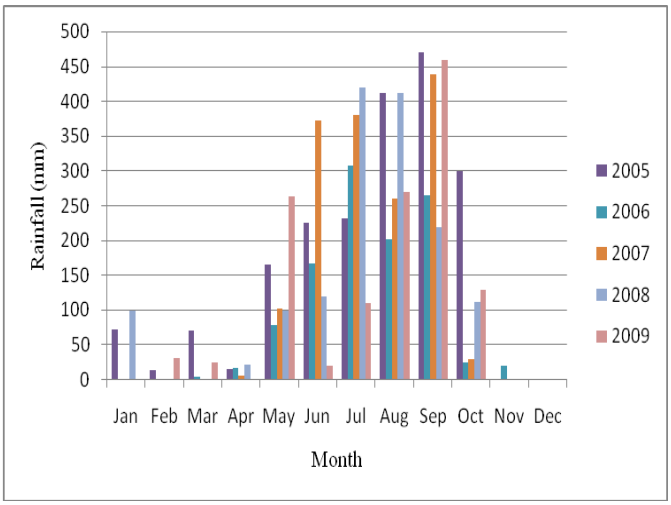
Fig. 3. Yearly variation of maximum and minimum groundwater level at (a) Niamatpur, (b) Nachole, (c) Gomostapur, (d) Nawabgonj and (e) Shibgonj Upazila.

E. Analysis of monthly rainfall at various regions

The monthly distribution of rainfall follows the usual pattern of monsoon with heavy rains starting in May & ending in September and very little of no rainfall during the rest of the year. The monthly variation of rainfall at various stations are shown in fig. 4.



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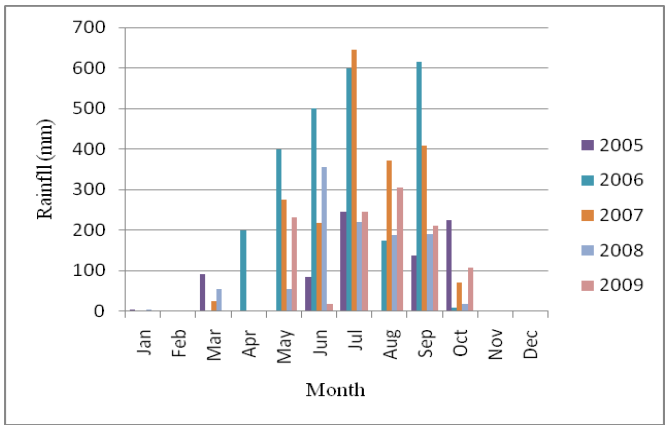

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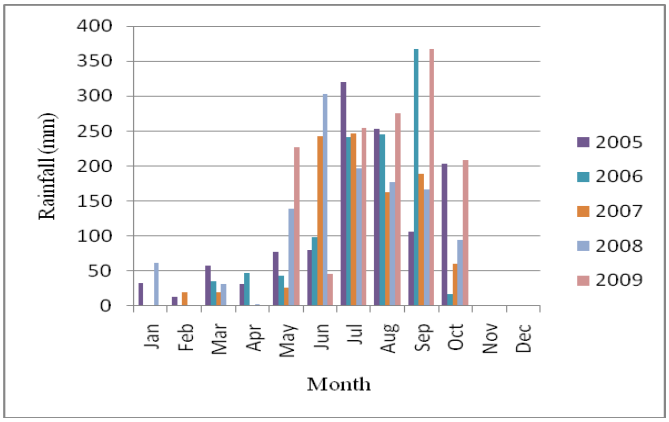

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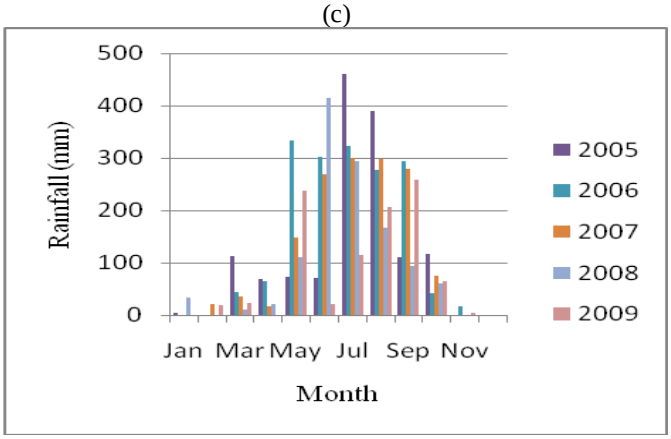

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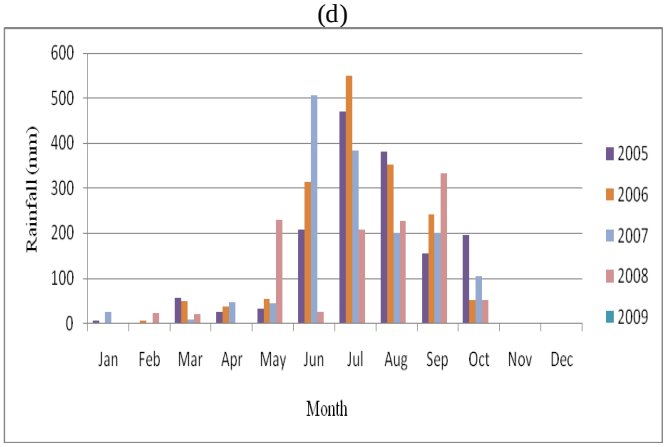

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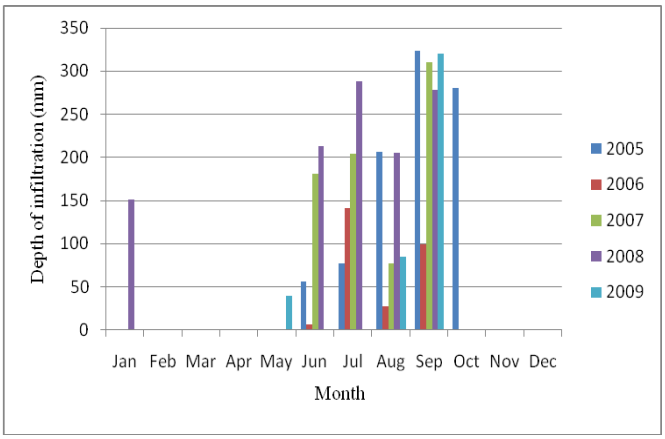
Fig. 4. Monthly variation of rainfall at (a) Niamatpur, (b) Nachole, (c) Gomostapur, (d) Nawabgonj and (e) Shibgonj Upazila.

F. Analysis of the 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 furthers the excess water moves vertically downwards to reach the ground water table. This vertical movement is called percolation. The maximum infiltration occurred at June to September due to maximum rainfall at this month and other month there is no infiltration due to a little rainfall. The monthly variation of infiltration rate is shown in the following fig. 5.



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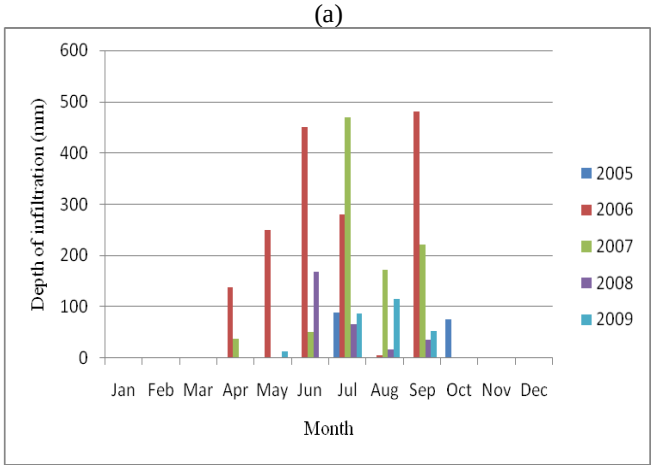

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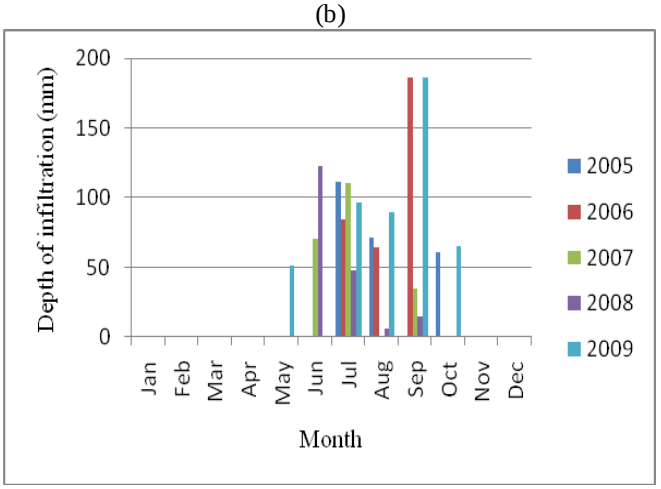

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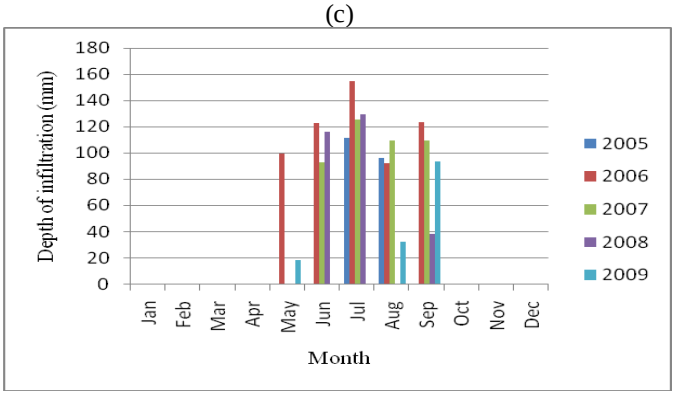

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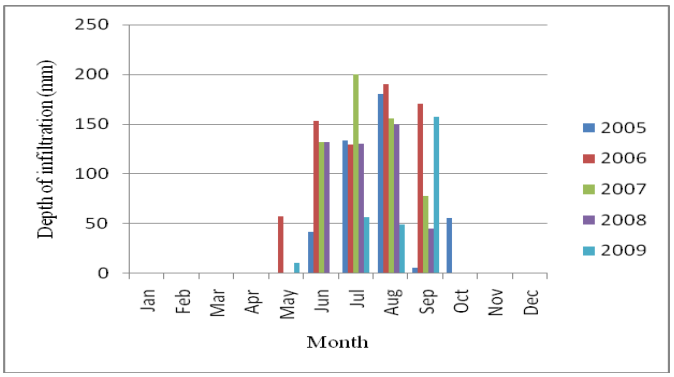

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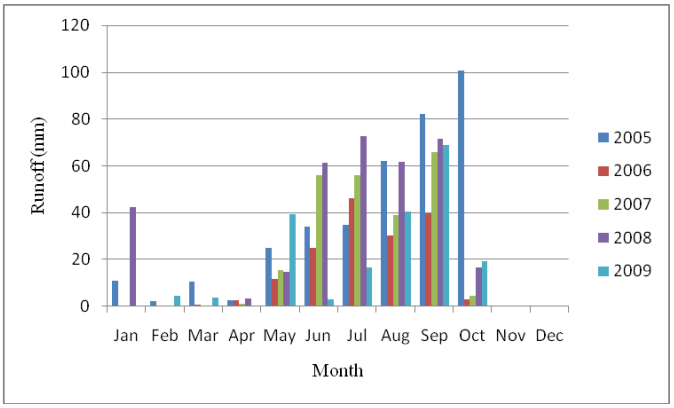
Fig. 5. Monthly variation of infiltration at (a) Niamatpur, (b) Gomostapur, (c) Nachole, (d) Shibgonj and (e) Nawabgonj Upazila.

G. *Analysis of the surface runoff due to rainfall*

The portion of precipitation which appears in the surface stream of either perennial or intermittent nature is called runoff. The factors affecting runoff is climatic factor i.e. (a) type of precipitation, (b) rainfall intensity, (c) duration of rainfall, (d) areal distribution of rainfall, (e) direction of storm movement, (f) other climatic factor that affect evaporation and evapo-transpiration. The physiographic factor is, (a) land use, (b) type of soil, (c) area of the basin, (d) shape of the basin, (e) slope and elevation. The maximum runoff occurred at June-Sep because rainfall of that month is maximum. According to Batlw the runoff from a catchment can be expressed as R = kb.p. Where, p is the monsoon rainfall and is the runoff coefficient kb which is depend on the type of catchment and nature of monsoon rainfall. For the cultivated land the runoff coefficient 15%. The variation of monthly runoffs in individual years in different region is shown in fig. 6.



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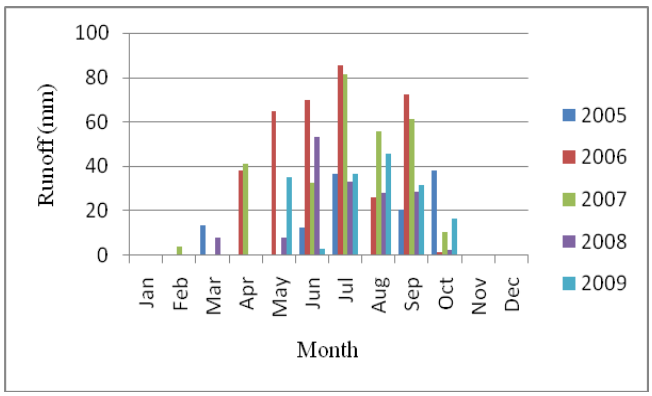

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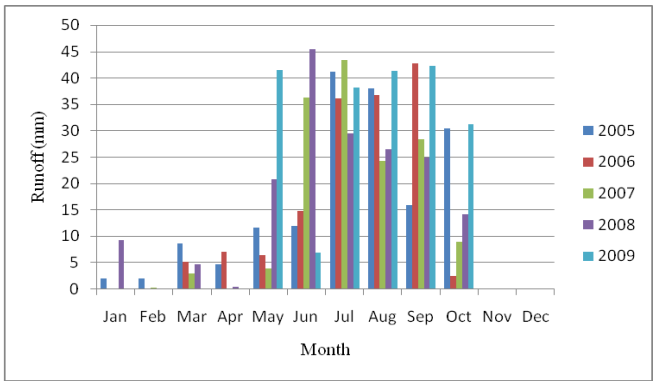

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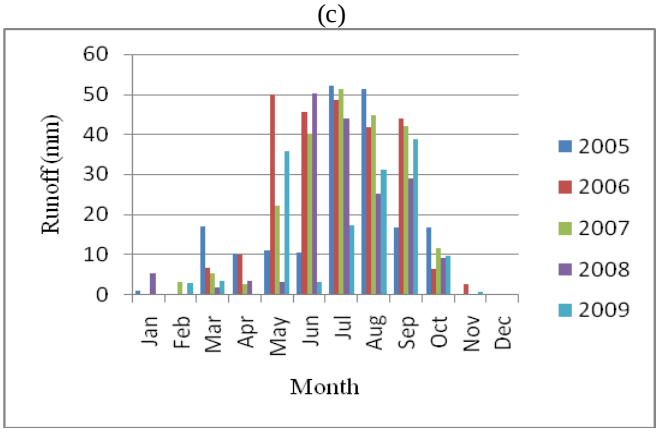

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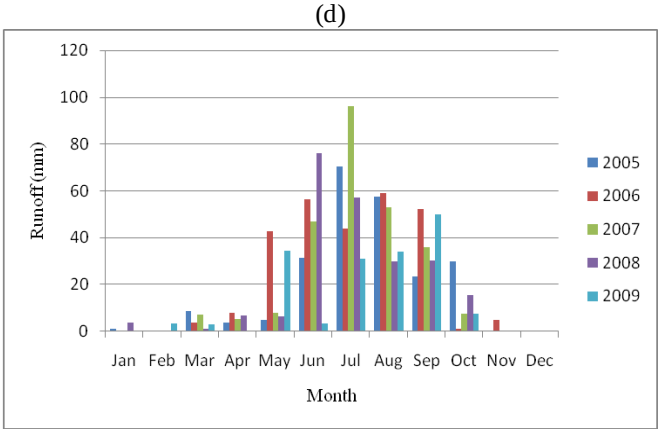

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Fig. 6. Monthly variation of runoff at a) Niamatpur, (b) Nachole, (c) Gomostapur, (d) Nawabgonj and (e) Shibgonj Upazila.

IV. Results and Discussions

A. *Groundwater level fluctuation*

Fluctuation of ground water level is different in magnitude depending on the extraction and recharge for different location. For this study groundwater level of Barind area of greater Rajshahi have been analyzed. All available data of Niamatpur, Nachole, Gomostapur, Nawabgonj & Shibgonj have been considered for preparing hydrographs. Ground water level fluctuation of different region of different year is shown in figure 2. At Niamatpur available data for period 2005 to 2009 have been analysis. The water level varies from 2.27m to 11.35m. Maximum water level value is 11.35m in 2006 & minimum value 2.27 m in 2005. At Nachole available data for period 2005 to 2009 have been analysis. The water level varies from 9.6m to 30.15m. Maximum water level value

is 30.15m in 2006 and minimum value 9.6m in 2004. At Gomostapur available data for period 2005 to 2009 have been analysis. The water level varies from 12.85m to 20.4m. Maximum water level value is 20.4m in 2009 and minimum value 12.85m in 2009. At Nawabgang available data for period 2005 to 2009 have been analysis. The water level varies from 8.51m to 17.91m. Maximum water level value is 17.91m in 2009 and minimum value 8.51m in 2005. At Shibgang available data for period 2005 to 2009 have been analysis. The water level varies from 1.85m to 8.21m. Maximum water level value is 8.21m in 2006 & minimum value 1.85m in 2005. The maximum fluctuation of ground water occurs in Nachole upazila and it is almost 99.2 ft in the month of April.

B. Change in ground water storage depending upon groundwater fluctuation, rainfall infiltration and runoff

The monthly variation of rainfall in the study area follows the usual pattern of monsoon with heavy rains starting in May & ending in September and very little of no rainfall during the rest of the year. The maximum infiltration occurred from June to September due to maximum rainfall at these month and other month there is no infiltration due to very small amount of rainfall. The maximum runoff occurred at June- Sep because rainfall of that month is maximum. In the calculation it was observed that change in ground water storage vary in different observation region and in different area. At Nawabgonj the maximum change in ground water storage is 78436.67 million m^3 in 2005 and minimum is 15377.57 million m^3 in 2006. At Niamatpur, the maximum change in ground water storage is 84268.8 million m^3 in 2006 and minimum 39325.44 million m^3 in 2008. At Nachole, the maximum change in ground water storage is 43314.75 million m^3 in 2005 and minimum 21192 million m^3 in 2009. At Gomostapur, the maximum change in ground water storage is 27456.39 million m^3 in 2009 and minimum 7979.4 million m^3 in 2008 and At Shibgonj, the maximum change in ground water storage is 34118 million m^3 in 2008 and minimum 22118.25 million m^3 in 2009. Change of storage depend on fluctuation of water table if water is fluctuated large than change of ground water storage is large.

V. Conclusion

The ground water level in the study area rises and falls continuously with the advance of wet and dry season peak value in month of May to September. Analysis of records of groundwater level of study area maximum 29.15m at Nachole in 2008 & minimum 1.88m at Shibgonj in 2008. Minimum linear fluctuation is 0.18m/year at Shibgonj & maximum fluctuation is 1.8m/year at Nachole. In the study area, the rainfall is not sufficient however the amount of rainfall occurred in several month mainly rainy seasons which we cannot use for irrigation purpose. Ground water storage is not very high in comparison with demand and vertical recharge is not equal in all this areas. It is found that the ground water recharge is maximum in Niamatpur & minimum in Gomostapur. In the study area, the characteristic of soil is not favorable to infiltration of rainfall. The soil of study area is clay type which affects infiltration. Therefore, a little amount of rainfall is infiltrated. On the other hand change of ground water storage is large. If the present rate of groundwater withdrawal is continued, there is a great possibility of land subsidence in future. Well casing can collapse under the strain of subsiding formations. Subsidence also increases the flood hazard of already low areas. One possibility of avoiding this through artificial recharge.

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