

Original Research Article

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Modeling of Rainfall and Ground Water Fluctuation of Gonda District Uttar Pradesh, India

Dinesh Kumar Vishwakarma^{1*}, Rohitashw Kumar², Kusum Pandey³,
Vikash Singh⁴ and Kuldeep Singh Kushwaha⁵

^{1,2}College of Agricultural Engineering and Technology, Sher-e-Kashmir University of Agricultural Sciences and Technology of Kashmir, Shalimar Campus Srinagar – Jammu and Kashmir, India

³Department of Soil and Water Conservation Engineering, Punjab Agricultural University, Ludhiana, Punjab 141004, India

⁴Department of Farm Engineering, Institute of Agricultural Sciences, Banaras Hindu University, Varanasi 221005

⁵Centre of Water Engineering and Management, Central University of Jharkhand – 835205, India

**Corresponding author*

ABSTRACT

Various quantitative analyses are required for complex and dynamic nature of water resources systems to manage it properly. Groundwater table fluctuations over time in shallow aquifer systems need to be evaluated for formulating or designing an appropriate groundwater development scheme. This paper demonstrates a methodology for modeling rainfall- runoff and groundwater table fluctuations observed in a shallow unconfined aquifer Gonda District Uttar Pradesh. The rainfall recharge contributed to its annual increment in the ground in water reserve which in turn is reflected in the rise of water table during the post monsoon period. The linear regression model between water table and annual rainfall was derived by Karl Pearson's method. The coefficient of correlation between rainfall and ground water table was found -0.70. The value of statistical errors of R^2 , ME, RMSE and EC were found to be 0.438, 0.213365 and -0.92173 respectively. The fitted models, values of fluctuation determination R^2 was found to be significant close to observed value. It has been found that fluctuation was more as compare the availability. A good correlation was found between seasonal rainfall and change in ground water level. The increment in ground water reserve, correlation between climatic parameter and ground water level showed positive and negative relationship. Highest correlation was found in rainfall and ground water level. The developed equation may be adopted for reasonable estimate of ground water table depth at piezo metric stations based on depth for the effective planning and management of ground water resources of the basin.

Keywords

Precipitation,
Ground water
recharge, Ground
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fluctuation, Karl
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Introduction

Indian agriculture received the highest priority in irrigation development in successive five year plan under ground water. Groundwater is one of the major sources of supply for domestic, industrial, and agricultural purposes. Various quantitative analyses are required for complex and dynamic nature of water resources systems to manage it properly (Adhikary *et al.*, 2012). More than half of the total irrigation done through ground water, the share of ground water in the total irrigated area under increasing form 30 percent in 1960-61 to 58.77 percent in 1999-2000 (Chandra, 1979; CGWB, 1995; Hiscock *et al.*, 2002). The area underground water is increasing progressively as this is the most reliable and cost effective source of irrigation. The rainfall recharge contributed to its annual increment in the ground water reserve which in turn is reflected in the rise of water table during the post monsoon period (Kumar and Seethapathi, 2002). Estimation of water table is essential for planning and developing the resources. With increasing the demand of water for both agriculture and industrial use, it is urgent need to develop ground water resources. Groundwater table fluctuations over time in shallow aquifer systems need to be evaluated for formulating or designing an appropriate groundwater development scheme. Models can be simple images of things or can be complex, carrying all the characteristics of the object or process. They represent (Chen *et al.*, 2002; Daliakopoulos *et al.*, 2005; Adhikary *et al.*, 2012).

The fluctuation of water table is mainly depending upon the precipitation received in the area and ground water utilization by various purposes (Chand *et al.*, 2005). Simulation of ground water behavior is required to predict water table fluctuation in response to varying ground water pumping and recharge conditions (Bhattacharya, 2007;

Romani, 2009). Ground water model are widely used for simulation of ground water behavior. The present study of modeling of rainfall and ground water fluctuation of Gonda District was conducted to evaluate the relationship between rainfall and ground water fluctuation.

Materials and Methods

The study was conducted to develop the model for the predicted and relationship between rainfall and ground water fluctuation of Gonda district (U. P.) through regression analysis and correlation between rainfall and water table depth.

Study area

The study conducted at Gonda districts of Uttar Pradesh, which is located between 26°47' and 27°20' north latitude and 81°30' and 82°46' east longitude. The holy rivers Saryu and Ghaghara pass through the district. The fluvial soils deposits of these two rivers, making it one of the most productive soils in the Tarai region. The average summer temperature is nearly 34°C with average rainfall is 1152mm (Fig. 1).

The ground water data from 2000-2010 was collected from ground water department of Gonda district which is summarized in Table 1. The ground water data, regression correlation was analyzed. The rainfall (mm) is denoted by "X" whereas depth of water table (m) is denoted by "Y" using Karl Pearson's Methods.

The quantitatively performance of model as regard to computation of water table was compared with one another by determining several statistical measures such as mean error (ME), root mean square error (RMSE) and efficiency coefficient (EC) were used. These criteria can be calculated from Equation's. 1,

2, and 3, respectively (Willmott *et al.*, 2012):

$$ME = \frac{1}{N} \left| \sum_{i=1}^N (P_i - O_i) \right|$$

$$RMSE = \frac{1}{N} \left| \sum_{i=1}^N (P_i - O_i)^2 \right|^{0.5}$$

$$EC = 1 - \frac{\sum_{i=1}^N (P_i - O_i)^2}{\sum_{i=1}^N (O_i - \bar{O})^2}$$

Where *N* is the total number of data, *P* and *O* are referred to the predicted and observed data, respectively, and \bar{O} is the mean value of observed data.

Results and Discussion

The hydrological measurement and collection of hydrological data used in the study was collected. The Karl Pearson’s method was used for predicting ground water table. The statistical errors (Coefficient of efficiency and root mean square error) were determined to judge the adequacy of the model, qualitative and quantitative. The comparison of observed and predicted water table are resented and discussed in this section. The rainfall data and observed water table depth during 2000 to

2010 is shown in table 1. It is evident from table 1 that maximum water table depth fluctuate was found 5.77m during 2009.

On the basic of 11 years data regression equation water table and annual rainfall of Gonda district was derived by Karl Pearson’s method. The coefficient of correlation between water table and rainfall was -0.70. It is evident from Table 1 that the ground water table in Gonda varies 4.20 to 5.77. It’s evident from the data that the water table changed according to rainfall. The rainfall in Gonda district varies from 797.13 to 1375.73 mm. The annual predicted water table in (m) of study area is shown in table 2. The developed equation model (regression line) which was used is given below

$$Y' = -0.0021 X + 6.8424$$

Where,

Y’= predicted water table

X = observed rainfall

Table.1 Rainfall and depth of water table during 2000-2010

Year	Rainfall (mm) (X)	Depth of water table (m) (Y)
2000	979.81	4.45
2001	1190.45	4.23
2002	811.75	4.67
2003	1230.32	4.28
2004	931.79	5.54
2005	1140.67	4.20
2006	997.47	4.46
2007	797.13	5.77
2008	973.45	4.76
2009	1375.73	4.27
2010	1035.56	4.38

Table.2 Annual observed and predicted water table in (m) of Gonda District (U.P.)

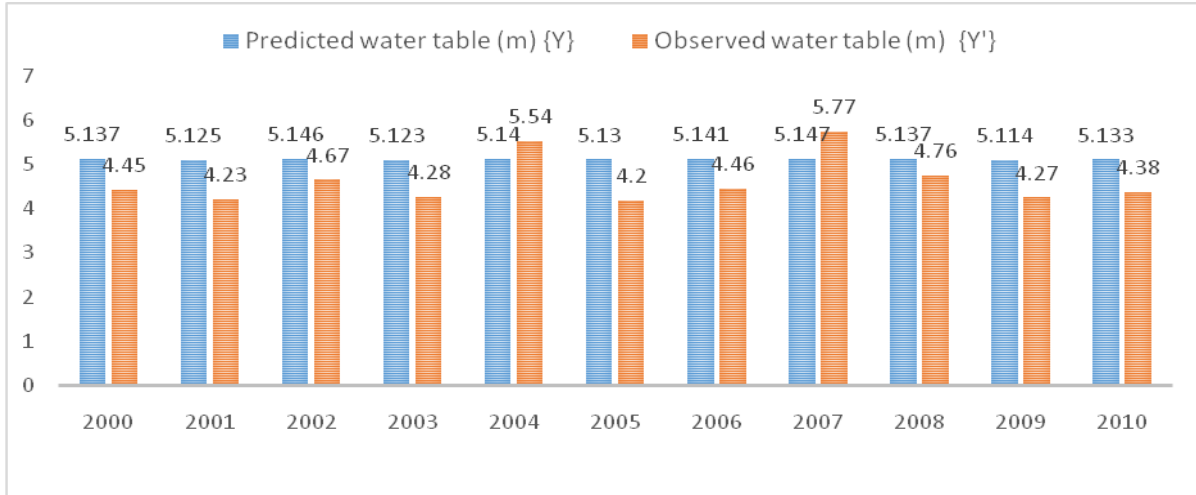


Fig.1 Location map of the area

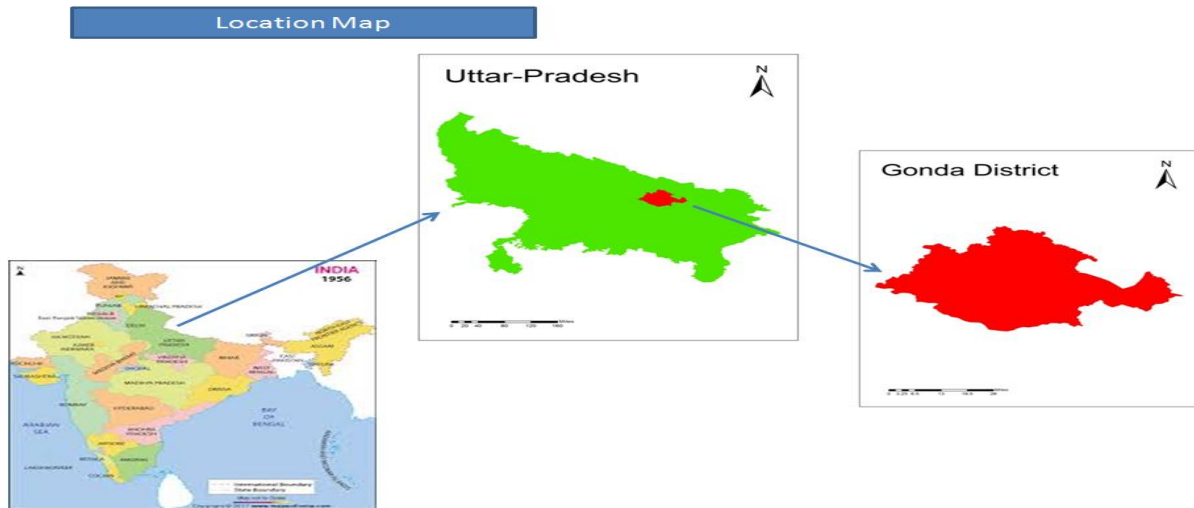
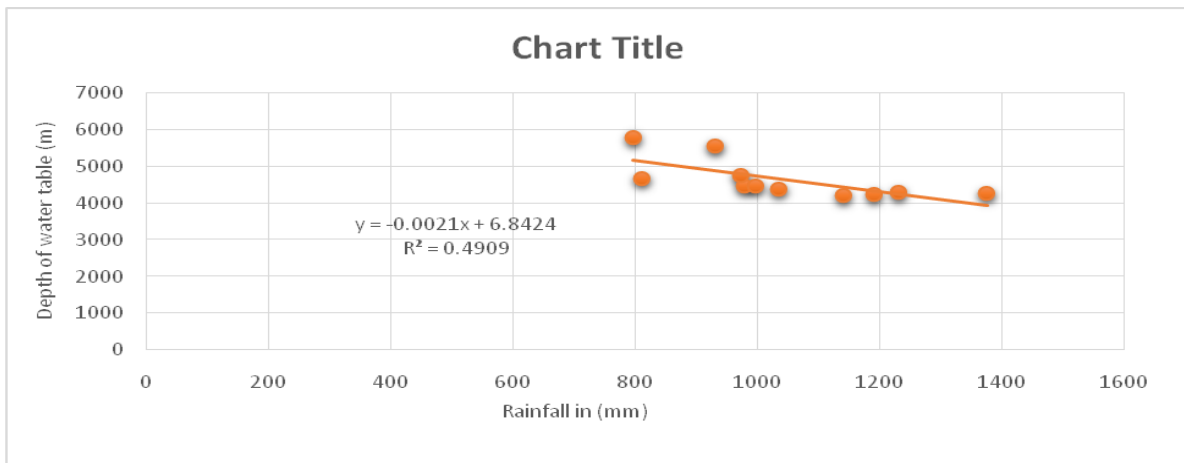


Fig.2 Correlation and regression line between rainfall and ground water table



The error statistics results have been evaluated through R^2 , ME, RMSE and EC. The value of R^2 , RMSE and EC were found between predicted and observed value is 0.438, 0.496636, 0.213365 and -0.92173 respectively. The higher value of R^2 , effective planning and management can do for ground water resource in the area. The efficiency coefficient indicates a very satisfactory model performance while a value in the range 80% - 90%. The annual Observed and Predicted water table is summarized in Table 2. It is evident from Table 2 that error statistics are in good agreement with predicted and observed value of water table. Mean error (ME), root mean square error (RMSE) and efficiency coefficient (EC) were found in between predicted and observed ground water table is 0.496636, 0.213365 and -0.92173 respectively (Fig. 2).

In conclusion, the linear regression model between water table and annual rainfall of Gonda district was derived by Karl parson's method. The correlation between predicted and observed value of ground water table is 0.438. The value of R^2 , ME, RMSE and EC between predicted and observed ground water table using liner regression model were found to be 0.438, 0.496636, 0.213365 and -0.92173 respectively. The fitted models, values of fluctuation R^2 was found to be significant indicating good fit of model. The modeled value of R^2 was 67%. It has been found that fluctuation in water table was more as compare to availability. The developed equation may be adopted for reasonable estimate of ground water table depth at piezo metric stations.

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