

IMPACT OF THE RIVER YAMUNA ON GROUNDWATER REGIME IN EASTERN HARYANA-INDIA

INDER JEET, Rohtak

ABSTRACT : Of increasing importance is the effect on the water table of man's withdrawal of groundwater. The installation of vast number of wells from which water is withdrawn in great volume by powerful pumps has profoundly altered natural balance of groundwater recharge and discharge. Present study is concerned with eastern Haryana, which is subject to wide rainfall fluctuations from year to year and from season to season. The Yamuna is the only perennial source of surface water, that shows a difference between maximum and minimum discharge of the river during rainy and dry seasons and does not meet the full requirements of irrigation. Therefore, farmers depend upon groundwater for assured source of irrigation. Consequently, the contribution of groundwater to total water supply of the state is maximum in the fresh water zone of this river tract and groundwater depletion is taking place. The main research problem from geographical point of view is to establish relationship between groundwater depletion and the distance from the Yamuna river. It is expected that it should decline imperceptibly as one moves west of the river.

INTRODUCTION

Fast depleting groundwater in fresh water zones in Haryana has necessitated a critical appraisal of the present use, future needs and strategies to be adopted for tackling the water resource problem at the earliest. In fact, unplanned development of groundwater resources at the fast pace has resulted in depletion of groundwater. Groundwater depletion due to overexploitation has become a matter of deep concern among geographers and hydrologists (pant, 1987, Pathak, 1990 and Dhawan 1995). Overexploitation of groundwater does not signify total exhaustion but depletion of the stock of groundwater. A feature of such depletion is a permanent lowering of groundwater table.

Approximately 80 per cent of the total population of the state is largely dependent on agriculture. Haryana, after Punjab, is the highest contributor of wheat and rice to the central pool. Agriculture contributes about 40 per cent of the state's total income on account of the assured supply of water and development of irrigation facilities. It is interesting that 76 per cent of the area under crops is irrigated in the otherwise acute water scarcity state.

The Yamuna forms the boundary between Haryana and Utter Pradesh. Haryana has no perennial river of its own except the Yamuna due to certain geogriphical constraints. The irrigation of a bulk of agricultural land depends upon the flow in the Western Yamuna Canal, which takes off from the Yamuna at Tajewala. The canal has maximum carrying capacity of

12,500 cusecs, but runs to its full capacity only during three months of the rainy season. The maximum flow during the dry weather, therefore, varies between 2,000 to 4,000 cusec only, depending upon snow melt (Hand Book on Irrigation Statistics, 1993). Agricultural growth, therefore, is greatly handicapped due to insufficient canal water during the peak-sowing season. This is the reason why farmers have switched over to groundwater for supplementing irrigation during the lean period. With limited scope of increasing availability of surface water, there is almost 20-fold increase in the number of shallow tubewells. It increased from 0.28 lacs in 1966-67 to 5.42 lakh in 1994-95 in the state. Presently more than 60 per cent tubewells are operating in the study area (Statistical Abstract of Haryana, 1995). The contribution of groundwater to the total water supply is maximum in the fresh water zone, along the Yamuna River. Therefore, due to rapid use of groundwater resources by these tubewells, the water table has shown a declining trend. Hence the paper has one specific objective as follows:

1. To establish the relationship between the distance from the river Yamuna and falling water table in study area.

HYPOTHESIS

The main research problem from geographical point of view is to establish relationship between groundwater depletion from the river Yamuna. The hypothesis developed for testing is that groundwater depletion declines imperceptibly as one moves away from the river.

STUDY AREA AND ITS DELINEATION

The study area is the eastern part of Haryana State. The Yamuna is an important perennial river of the area under study. It passes a high annual discharge during the rainy season. Its total annual flow is estimated to be 13 billion

cubic metres (10.5 MAF) which corresponds to a discharge of 15000 cubic feet/second. Out of this total flow, Haryana's share has been allocated as 6.2 billion metres of water, which is not sufficient to meet the needs of farmers (The Tribune, 1993). Not only this, but the difference between the maximum and minimum discharge of the river during rainy and dry seasons is remarkably high as is evident from the Table 1.

Table1:

Difference between Dry and Rainy Seasons's Discharge of the Yamuna River

Season	Site	Discharge cubic Feet/Second
Rainy	Tajewala	2,05,000
Dry	Tauewala	2531

Source: The Tribune, 19 July 1993, Chandigarh.

The fluctuations in canal discharge are a limiting factor for successful crop farming. Therefore, farmers depend upon groundwater for assured source of irrigation. Consequently, the contribution of groundwater to total water supply of the State is the maximum in the fresh water zone. The latest survey results show that during the past decade the water level in fresh water zone has declined by 1.31 meters to 7.47 metres along the Yamuna river (The Tribune, 1993).

The study area stretches from Ambala in the north to Mahendergarh in the southwest. Though some districts like Rewari and Mahendergarh do not fall locationally within the fold of eastern part of the State, yet the entire region is considered to be the eastern part because they are facing similar kind of problem of groundwater depletion.

According to the studies made by Geological Survey of India, the thickness of bedrock is very deep and it goes up to 3000 metres in Yamunanagar and Karnal district. The surface

recharge to this area is provided by rainfall, seepage by the Yamuna river and recycled water. Therefore, rainfall infiltration and surface percolation are the significant factors, which build up the groundwater resource of this area. The aquifers occur in unconfined to semi-confined conditions in most part of the area.

The alluvial sediments form an important repository of groundwater and as such it is necessary to determine the nature of these sediments together with their lateral and vertical extensions. In the Yamuna basin the alluvial sediments consist of medium sand beds represented by clay beds (Chadha, 1983). More importantly, the thickness of the alluvium steadily decreases from north to south and also towards the western boundary. The water table falls from northern parts to the western and central parts of the State. The water table again rises in Mahendergarh district. In Gurgaon, it slopes towards the Sahibi river and in Faridabad, water table generally slopes towards the Yamuna.

In the case of average annual rainfall, values are maximum in the northeastern side of Haryana with isohyet of 1100 mm. rainfall passing through the blocks of Naraingarh, Bilaspur and Chhachhrauli. Rainfall goes on decreasing from northeast to southwest direction bordering Rajasthan State with an isohyet of 300 mm. Similarly, the coefficient of variation also increases in the same direction from 25 per cent to 45 per cent. This shows that variation of rainfall is much larger in southwest portion of the study area.

Rainfall is the main source of the availability of moisture. The amount of rainfall in counter balanced by temperature conditions. It is an important element in meteorology on which other elements like evaporation, humidity and evapotranspiration depend. In May and June

the average maximum temperature reaches up to 41° C. Between October and January there is a remarkable drop in both maximum and minimum values. During these months-monthly minimum temperature drops up to 14° C. These values indicate the scorching summers and severe winters in the area. During summers, due to high temperature values, the potential evapotranspiration (PE) of May and June varies between 214 and 240 mm. But in the winter months of December and January it varies between 40 to 60 mm. Further the annual PE varies from 1617 mm in the north to 1680 mm in the south.

The observations presented in the foregoing paragraphs demonstrate clearly that geology, geohydrology and meteorology have spatial and temporal variations. Another noteworthy aspect is that average annual PE is everywhere more than average annual rainfall. Consequently, the amount of rainfall infiltration to the groundwater is meagre in the entire region. Thus the alternative of seepage recharge through the Yamuna river is left to build up the groundwater regime.

DATA AND METHODOLOGY

The study is based on secondary data. Groundwater Directorate located at Karnal publishes data in Cyclostyled reports known as Monitoring Reports twice (June and October) in a year. The Directorate and Central Groundwater Board have various hydrograph stations in the study area, they provide data for the study of water table behavior incorporated in Monitoring Reports. With the help of these reports, a water table fluctuation map (Fig.1) is prepared to analyse the water table behaviour. The State has fixed large number of hydrograph stations (more than 1600), mostly open wells all over the state and approximately 812 hydrograph stations are situated in the

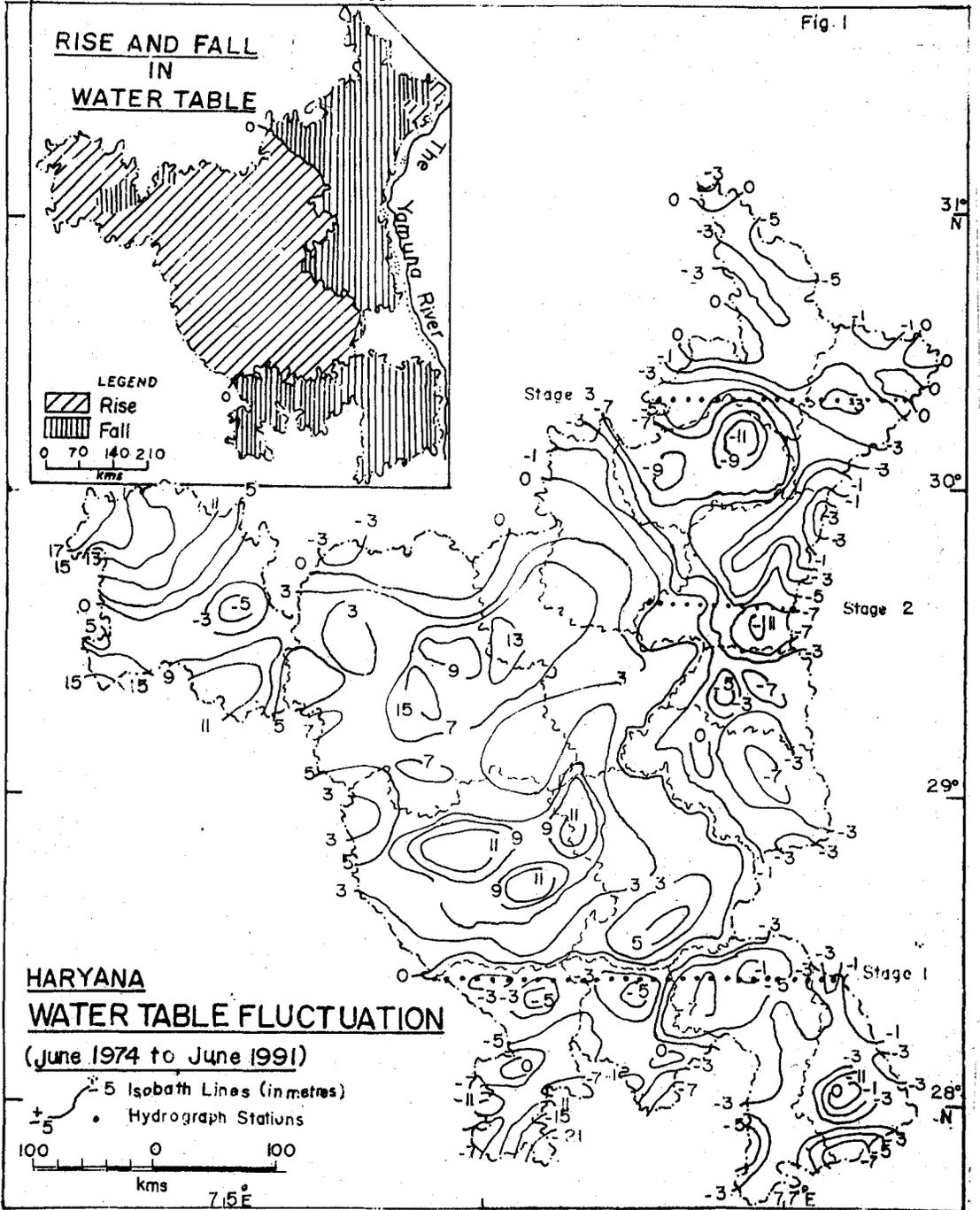


Fig. 1 : Haryana - Water Table fluctuation (June 1974 to June 1991)

study area. Systematic sampling method is used for the selection of hydrograph stations. A grid of suitable size has been formed by drawing westward lines from the Yamuna river and north south over the study area. The

intersection point defines and produces a sample point. Point falling on intersecting point or in the vicinity is selected as representative sample. Thus, altogether, 57 such hydrograph stations are considered for this investigation

Table 2:

Distance From the River Yamuna and Change in Depth of Water Table since 1974-91

Stage 1			Stage 2			Stage 3		
Sr. No	Distance from the Yamuna	Change in depth to water (m)	Sr. No	Distance from the Yumuna	Change in depth to water (m)	Sr. No	Distance from the Yamuna(km)	Change in depth to (m)
1	5	-2.00	1	5	-8.00	1	5	-0.50
2	10	-2.00	2	10	-6.00	2	10	-0.80
3	15	-2.00	3	15	-2.00	3	15	-1.00
4	20	-2.00	4	20	-2.00	4	20	-1.00
5	25	-2.00	5	25	-3.00	5	25	-1.00
6	30	-2.00	6	30	-4.00	6	30	-1.00
7	35	-2.00	7	35	-5.00	7	35	-0.30
8	40	-2.00	8	40	-5.00	8	40	-1.60
9	45	-4.00	9	45	-5.00	9	45	-1.60
10	50	-5.00	10	50	-2.00	10	50	-1.70
11	55	-5.00	11	55	.000	11	55	-1.80
12	60	-5.00	12	60	-0.20	12	60	-1.80
13	65	-5.00				13	65	-1.90
14	70	-5.00				14	70	-1.90
15	75	-5.00				15	75	-1.90
16	80	-2.00				16	80	-1.90
17	85	-2.00						
18	90	-2.00						
19	95	1.00						
20	100	-0.60						
21	105	-0.80						
22	110	-1.00						
23	115	-7.00						
24	120	-7.00						
25	125	-10.0						
26	130	-13.0						
27	135	-12.0						
28	140	-11.0						
29	145	-10.0						

(Table. 2). A sample of this size covers about 7 percent in terms of total number of hydrograph stations in the study area. The westward line of stage 1, from the Yamuna covers Faridabad, Gurgaon, Rewari and Mahendergarh district. This line passes almost towards the northern fringe of these administrative blocks. Twenty nine hydrograph stations fall on this line from the river Yamuna in the east to the zero metre isobath line in the west covering a distance of 145 km. Stage 2 includes only Karnal district with twelve hydrograph stations. This line on stage two extends up to 60 km from the main river to the zero metre contour line in the west. Stage 3 comprises Yamunanagar and Ambala districts the northern most districts of the study area sixteen hydrograph stations fall on this line. This line of stage 3 stretches up to 80 km from east to west (Fig 1).

These three stages are drawn taking into consideration the geohydrology, geomorphology, groundwater conditions, and groundwater quality of the area. However, it is tried to maintain a uniform distance between these lines.

Predictor Variable

Distance from the river Yamuna is the predictor variable. The three lines drawn from east of the river Yamuna to the western boundary of the study area denote the three stages of the analysis. On each line, a distance of 5 km (approximately) between each hydrograph station is chosen to observe the impact of river on the groundwater regime.

Criterion Variable

The fluctuations in the water table depth since 1974-91 is the another variable known as dependent variable. If there were no recharge to or outflow from the groundwater in a basin the water table would eventually become

horizontal. Contrary to it, water discharged from an aquifer or recharged into an aquifer represents increase and decrease of depth to water table. Therefore, in the present context, an appraisal is made to understand that how much seepage recharge is available with the distance from this river.

Association study between water table depth and distance from the Yamuna river is made by employing correlation regression technique on the lines drawn westward from the Yamuna river. To test hypothesis developed for the study that groundwater table declines imperceptibly as ones moves away towards west from the Yamuna river, null hypothesis of no difference is set up and put it to rigorous testing procedure.

$$H_0: u_1 = u_2$$

But as a researcher, the interest lies in the alternative of the assumption of no difference. Nevertheless, researcher believes that the truth is contradictory to the assumption. Likewise opposite of null of hypothesis, which is called alternative of research hypothesis is developed.

$$H_1: u_1 \neq u_2$$

To test the hypothesis of no difference *t* test is employed to accept or reject the null hypothesis beyond the reasonable doubt.

$$t = r : \sqrt{N-2/1-r^2}$$

The product moment correlation coefficient (*r*) is used to find out the strength of relationship. Hydrographs are prepared and analyzed by least square method to obtain the water level trend (Fig.2). This is of great importance in terms of our ability to make predictions because the least squares line $Y = a + bx$ is minimized (Mathews, 1981 and Ebdon, 1985).

ANALYSIS OF THE RESULTS

Below the summary model statistics in information regarding the contribution of

Fig. 2

REGRESSION OF DEPTH TO
WATER TABLE ON DISTANCE
FROM THE YAMUNA RIVER,
EASTERN HARYANA

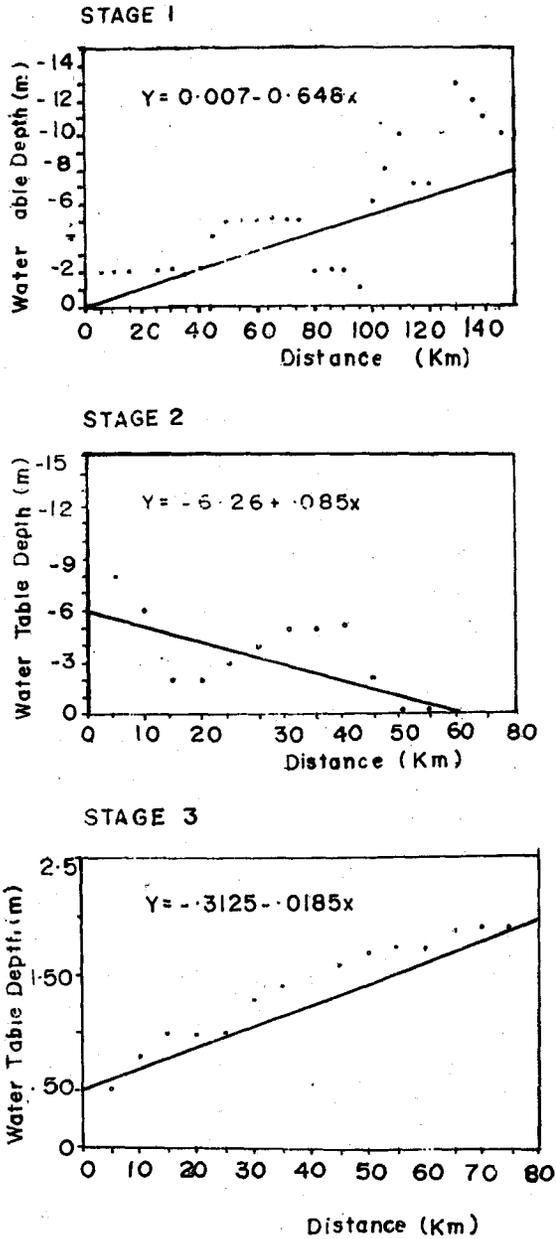


Fig. 2 : Regression of depth of water table on distance from the Yamuna River-Eastern Haryana

Penal 1: Bivariate Regression For the Effect on Distance from the Yamuna River on Depth of Water Table For Stage 1.

Sr. No	Variable	B	SE B	Beta (β)	T	Sig T
1	Distance	-.064828	.013349	-.682821	-4.856	0.000
2	Constant	0.000	1.146366		0.000	1.000

Penal 2: Bivariate Regression For the Effect of Distance from the Yamuna River on Depth of Water Table For Stage 2.

Sr. No	Variable	B	SE B	Beta (β)	T	Sig T
1	Distance	.085455	.033588	.626858	2.544	0.0292
2	Constant	-6.260606	1.235987		-5.065	.0005

Penal 3: Bivariate Regression For the Effect of Distance from the Yamuna River on Depth of Water Table For Stage 3.

Sr. No	Variable	B	SE B	Beta (β)	T	Sig T
1	Distance	-0.18529	.0048	-.71806	-3.860	.0017
2	Constant	-.51250	.232063		-2.208	.0444*

independent variable in the model (Penal 1, 2 and 3) for three stages (Fig.1). Reading from left to right, we see the first statistics is the partial unstandardised beta (B) for distance from the Yamuna River. We note that B is -0.0648 in panel 1 for stage 1, .0854 in panel 2 for stage 2 and -.0185 in panel 3 for stage 3. these values of B in all these three panels show the partial slope for distance from the river Yamuna. The unstandardised partial slope in panel 1 means that for each unit increase in distance from the river Yamuna (independent variable) there will be an increase of -.0648 units in the depletion of water table depth. Panel 2 shows a different picture that with the increase in the distance from the Yamuna river there is an decrease of .0854 units in the depth to water table. Panel 3 shows an increase of -.0185 units in the depth to water table.

The next important reported statistic is the standardized partial slope BETA (β) for distance from the Yamuna river, reported as -

.6828 for stage 1 (panel 1), .6268 for stage 2 and -.7180 for stage 3 (panel 3). This value tells how much standard deviations change in the independent variable will affect the dependent variable, also in standard deviation units. This is an important statistic because it is a measure of the relative importance of the independent variables in the equation.

Y intercept (CONSTANT) which represents the value of Y when independent variable is equal to zero. If we wished to predict the water table depth with distance points we would use the $Y = a + bx$ formula. For the present study, regression equation and line for all three stages are: for stage 1, $Y = 0.007 - 0.648x$; (panel 1, Fig. 2a) for stage 2, $Y = -6.26 + .085x$; (panel 2, Fig. 2b) and for stage 3, $Y = -.3125 - .0185x$ (panel 3, Fig. 2c).

The most important part of the analysis is the testing of the hypothesis. If our computed t value is equal to or greater than the critical value, we reject the null hypothesis. It is found

that for stage 1, the calculated t (4.86) with 27 df, which is greater than critical t value (2.052) with alpha set at 0.05, we reject the hypothesis of no relationship. In other words there is a less than 5 percent chance that two variables are unrelated and we are 95 per cent certain of the relationship that as we move away from the river Yamuna depth to water table will increase imperceptibly. We also reject the hypothesis of no relationship for stage 2 where computed t value (2.54) is greater than the critical t value (2.22) with 10 df. Even stage 3 also rejects the null hypothesis in this case computed t value is 3.860 and the critical t is 2.145.

CONCLUSION

Statistically it is proved that the depth to water table declines as we move westward from the river Yamuna imperceptibly. It appears that

fresh groundwater quality in the vicinity of the river Yamuna plays an important role in the high rate of groundwater depletion owing to its suitability for agriculture and other purposes inspite of high rate of groundwater recharging from river itself and Bhakra Canal system. But as we move away from this river towards the west, groundwater quality deteriorates and its suitability for different use declines accordingly. Consequently, near to the river Yamuna, there is high seepage recharge and fresh groundwater quality are important factors which immediately build up the groundwater reservoir and away from the river owing to no perennial source of surface water, high groundwater discharge takes place. Consequently, water table recedes rapidly as one moves away from the river. Hence, it is suggested to put some managerial steps to curb this problem of groundwater depletion.

REFERENCES

- Chadha, D.k. (1983) "Geology", *Studies for the Use of Saline Water in the Command Area of Irrigation project*, Unpublished Report No. 1.2. of HSMITC, Karnal.
- Dhawan, B.D. (1995) *Groundwater Depletion, Land Degradation and Irrigated Agriculture In India*, New Delhi, Commonwealth Publisher.
- Ebdon, D. (1985) *Statistics in Geography*, Oxford, Basal Blackwell Limited.
- Handbook on Irrigation Statistics*, 1993, Government of Haryana, Chandigarh.
- Mathews, J.A. (1981) *Quantitative and statistical Approaches to Geography -A Practical Manual*, Oxford Pergamon press.
- Pant, N. (1987) "Groundwater Depletion, *Economic and Political Weekly*, 22(6): 219-220.
- Pathak, B.D. (1990) *Hydrology of India*, Central Board of Irrigation and Power, New Delhi.
- Statistical Abstract of Haryana*, 1995, Government of Haryana, Chandigarh.
- The Tribune, 19 July 1993, P.8.

ADDRESS OF THE AUTHOR

Inder Jeet

Sr. lecturer, Dept. of Geography,
University College, M.D. University,
Rohtak-124001