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Original Research Paper

Estimation of Groundwater Recharge Potential of Domagor-Pahuj Watershed Using Water Table Fluctuation Method

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ABSTRACT

Groundwater is one of the important sources of potable water. The water table fluctuation method was used to evaluate the annual variations in water level rise and to estimate the groundwater recharge during pre interventions and post interventions phase of Domagor-Pahuj watershed development. The area experiences an average annual rainfall is 880 mm. The estimates of average annual water table fluctuation and change in groundwater storage volume of randomly selected thirty wells of pre-interventions and post-interventions phases of watershed were 3.03 to 4.34 million m^3, and 1.52 to 2.18 million m^3, respectively. The total annual groundwater recharge potential estimated for the areas was 1.47 million m^3 before intervention and 2.06 million m^3 after intervention.

INTRODUCTION

Water is indispensable for any life system to exist on earth and is a very important component for the development of any society. It has been observed that the total water resources in India are estimated to be around 1869 km^3/year, while the average utilizable surface water in the country as on 2001 is 1123 km^3 (Government of India 2010). The Green Revolution during the 1970s along with advanced technology of water pumping, made a significant impact on groundwater use; the number of borewells increased from less than one million during 1960s to 20 million by 2009 in India (Dewandel et al. 2010).

Rainfall is the major source of recharge to groundwater. Part of the rain water that falls on the ground is infiltrated into the soil. This infiltrated water is utilized in filling the soil moisture deficiency while the remaining portion percolates down to reach the water table, which is termed as rainfall recharge to the aquifer. Artificial recharge, as defined by the Central Ground Water Board (CGWB) of India, is a process of augmenting a groundwater reservoir at a rate that exceeds natural conditions of replenishment (CGWB 2003). The specific objective of this study is to analyse positioning of WHS and its impact on groundwater recharge in open/ dug wells.

MATERIALS AND METHODS

The study was carried out in Domagor-Pahuj watershed, which is located at Jhansi district in Bundelkhand, central India. The total area of the watershed is 1676 hectares which comprises of three villages namely Domagor, Dhikoli and Nayakhera. The watershed is located between 25°28'-25°31' N latitude and 78°25'-78°28' E longitude (Fig. 1). The Domagor-Pahuj watershed has a semi arid tropical climate with an average annual temperature ranging from 24°C to 25°C. The annual rainfall of Bundelkhand region varies from 800 to 1300 mm, about 90% of which is received during south-west monsoon period. The major part of the rainfall is received during the month of July and August. The total rainy days/year vary from 30-45 in the region with an average of 37 days. The distribution of rainfall is very erratic. The soils of the watershed are classified according to their texture and colour into four distinct series namely *Rakar* and *Parwa* in red soils and *Kabar* and *Mar* in black soils. The red soils are coarse grained upland soils while black soils are heavy soils and distributed in low lying areas of the watershed.

Open shallow dug wells are the only means of water harvesting in the watershed. These wells are situated in unconfined aquifers above the vast granite massif and have low specific yield. At the study site, a number of open wells were positioned both upstream and downstream of RWH structure. Total 30 geo-referenced dug wells were selected as observation points in the watershed for measuring the water levels in these wells during pre and post-monsoon seasons. The water table in these open wells was monitored at monthly intervals for groundwater data. Depth of monitored wells ranged between 6 and 15 m with an average depth of 8 m. Diameter or width of the majority of dug wells is 4-7 m but may be as high as 10 m. Water in these wells is being used for agriculture and domestic purposes.

Groundwater level fluctuation and specific yield method and rainfall infiltration method is a well accepted technique for estimating groundwater recharge (Groundwater Resource Estimation Methodology 2009). For weathered granite, gneiss and schist with low clay content under hard rock areas, a value of specific yield varies from 1 to 3 percent and rainfall infiltration factor varies from 10 to 15 percent of normal rainfall. Groundwater recharge in Domagor-Pahuj watershed was estimated during pre monsoon and post-monsoon periods before (2010) and after (2012) interven-

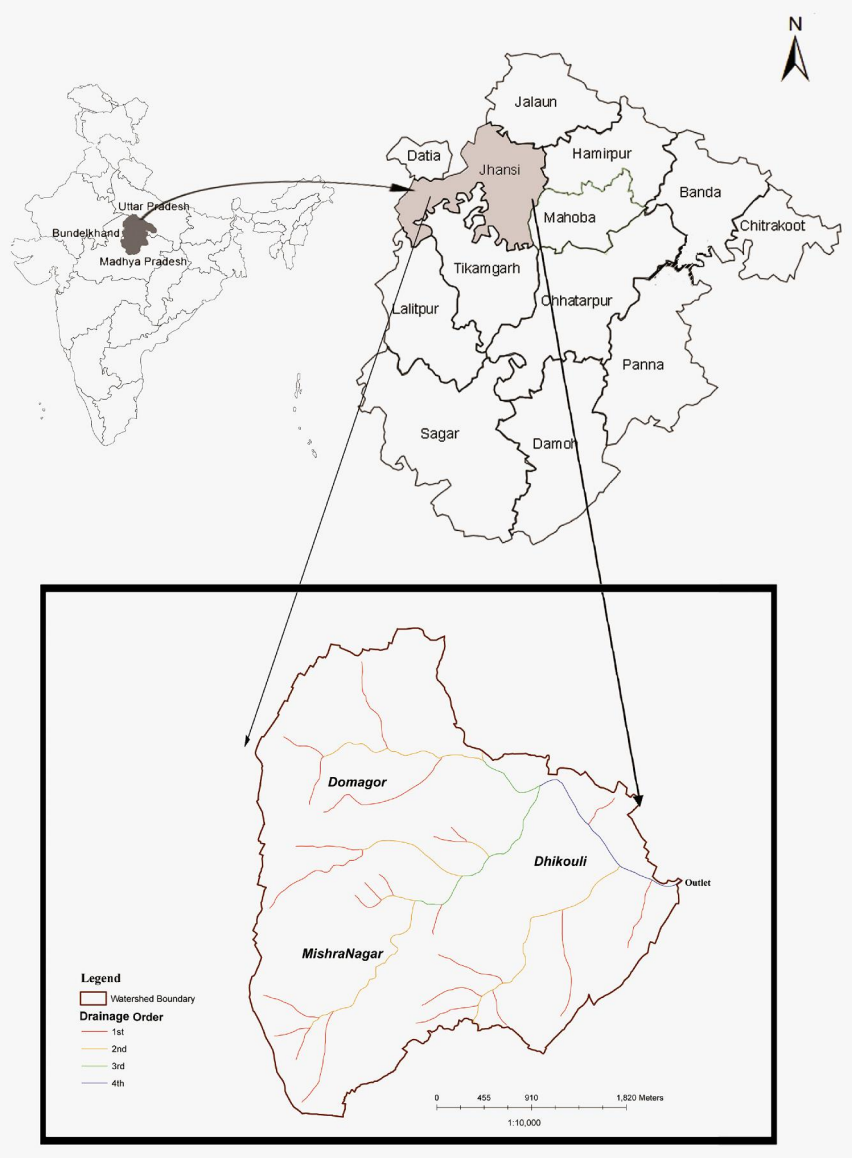

Fig. 1: Location of study area in the Domagor-Pahuj watershed.

tion phase of watershed development.

Groundwater level fluctuation and specific yield method:

S = Area × Average water table fluctuation × Specific yield ...(1)

Where, S = Change in groundwater storage volume during pre and post-monsoon periods

Rainfall infiltration method:

Annual groundwater recharge = Area × Average rainfall × Infiltration factor ...(2)

RESULTS AND DISCUSSION

The results of this study provide a quantitative description of the effect of groundwater recharge induced by RWH on the water supply of adjacent wells of the Domagor-Pahuj watershed, Bundelkhand region, Central India. This study effectively utilized data of groundwater level well. Data on hydraulic head in open wells were recorded at monthly time scale between 2010 and 2012. The findings of this study are based on the data collected during 3-year of field work. The total amount of rainfall received during the monsoon period in the years 2010, 2011 and 2012 was 718.4 mm, 1289.2mm and 825.5mm, respectively with average rainfall of 944.36 mm. Rainwater harvesting during rainy season in ephemeral streams at appropriate interval is the only option to recharge of shallow open dug wells. Groundwater recharge mainly took place during June-October and was negligible during rest of the year.

In pre-intervention phase of watershed development, water table in monitored wells varied between 2.71-12.80m in pre-monsoon and 1.04-9.06m during and post-monsoon, respectively. After intervention of watershed, the water table ranged between 2.61m to 12.03m in pre-monsoon to 0.92-7.28 m in post-monsoon season. The average water table in pre and post-intervention during pre-monsoon is 7.73 m and

Table 1: Groundwater level fluctuation in wells of Domagor-Pahuj watershed (pre and post-monsoon).

Village	Well No.	Pre-Intervention			Post- Intervention		
		Pre-monsoon (m)	Post-monsoon (m)	Fluctuation (m)	Pre-monsoon (m)	Post-monsoon (m)	Fluctuation (m)
Dhikauli	1	5.20	5.19	0.01	5.15	3.50	1.65
	2	2.78	2.50	0.28	2.61	1.89	0.72
	3	4.08	3.87	0.21	3.88	2.98	0.90
	4	4.50	4.15	0.35	4.37	3.42	0.95
	5	4.85	3.49	1.36	4.56	2.77	1.79
	6	3.25	1.04	2.21	3.06	0.92	2.14
	7	3.42	2.08	1.34	3.18	1.47	1.71
	8	3.90	2.17	1.73	3.78	1.26	2.52
	9	4.25	2.50	1.75	4.08	1.82	2.26
	10	4.30	2.08	2.22	4.04	2.08	1.96
Nayakhera	11	9.55	3.77	5.78	9.26	3.80	5.46
	12	10.40	9.06	1.34	9.98	5.42	4.56
	13	8.35	5.28	3.07	7.85	2.70	5.15
	14	9.15	4.15	5.00	8.88	4.00	4.88
	15	10.55	6.89	3.66	10.13	5.7	4.43
	16	11.35	4.25	7.10	10.67	3.55	7.12
	17	10.70	3.49	7.21	10.59	5.77	4.82
	18	12.80	4.29	8.51	12.03	4.90	7.13
	19	12.00	7.17	4.83	11.4	4.20	7.20
	20	10.55	5.75	4.80	10.23	4.12	6.11
Domagor	21	10.00	6.37	3.63	9.3	2.7	6.60
	22	9.55	5.57	3.98	9.26	1.87	7.39
	23	8.60	5.19	3.41	8.26	7.28	0.98
	24	9.85	5.90	3.95	9.26	2.05	7.21
	25	9.77	6.60	3.17	9.48	2.15	7.33
	26	10.00	8.25	1.75	9.6	2.35	7.25
	27	7.30	5.14	2.16	6.79	1.78	5.01
	28	6.65	4.48	2.17	6.45	1.55	4.90
	29	7.95	4.53	3.42	7.63	1.80	5.83
	30	6.33	5.90	0.43	5.95	1.60	4.35
	Minimum	2.78	1.04	0.01	2.61	0.92	0.72
	Maximum	12.80	9.06	8.51	12.03	7.28	7.39
	Average	7.73	4.70	3.03	7.39	3.05	4.34

4.70 m respectively, while in post-monsoon season, the average water table measures 7.39 m and 3.05 m, respectively. Water availability at the end of monsoon was dependent on two main components: (i) carry-over groundwater reserves from the previous years; and (ii) groundwater recharge in current year. Fluctuation of hydraulic head in open wells was recorded at monthly intervals. On an average, 3.03 m and 4.34 m difference in hydraulic head (difference in water table) is recorded in open wells before and after monsoon during pre and post-intervention phases (Table 1). Singh et al. (2014) recorded on an average, 4.0 m difference in hydraulic head in open wells before and after the monsoon period for Garhkundar watershed of Bundelkhand region. Garg & Wani (2013) also reported on an average, 4.5m difference in hydraulic head (difference in water table) in open wells before and after the monsoon period in Kothapalli watershed of semi arid tropics. The water table fluctuation in pre and post-intervention varied between 0.01-8.51m and 0.72-7.39m, respectively. The change in groundwater storage volume during pre and post-monsoon period was estimated by groundwater level fluctuation and specific yield method. The change in groundwater storage volume of watershed during pre and post-intervention was observed to be 1.523 and 2.184 million m^3. The different parameters for estimation of water potentiality are summarized in Table 2. Approximately 43.45 per cent of the groundwater recharge was estimated during post-intervention phase over the pre-intervention in watershed. This is due to construction of series of RWHS on ephemeral drains in watershed. Similar artificial recharge proportions ranging from 52-83 percent were recorded in wells downstream of an Indian RWH structure situated in a similar hard rock terrain (Sukhija et al. 2005). As reported in the GEC Report (2009) for weathered granite, gneiss and schist with low clay content under hard rock areas a rainfall infiltration factor of 10-15 percent of normal rainfall and for unweathered granite terrain 5-10 percent of normal rainfall. In this study, an average of 10 percent and 14 percent during, before and after intervention, respectively rainfall infiltration factor considered for calculating annual groundwater recharge potential of the watershed area. Average annual rain fall of the study area was considered to be 880 mm. The total annual groundwater recharge potential estimated for the areas was 1.47 million m^3 before intervention and 2.06 million m^3 after intervention by rainfall infiltration factor.

Table 2: Different parameters of water potentiality.

A	Average of water table (m) Pre-intervention	
	• Pre-monsoon	7.73
	• Post-monsoon	4.70
B	Average of water table (m) Post-intervention	
	• Pre-monsoon	7.39
	• Post-monsoon	3.05
C	Change in groundwater storage volume during pre and post-monsoon periods by water table fluctuation method ((million m^3/year)	
	• Pre-intervention	1.523
	• Post-intervention	2.184
D	Increasing groundwater storage volume in wells (percent) through intervention	43.45
E	Annual groundwater recharge by rainfall infiltration factor method (million m^3/year)	
	• Pre-intervention	1.47
	• Post-intervention	2.21
F	Increasing groundwater potential in wells (percent) through intervention	40

CONCLUSIONS

This study provides a vital quantitative description of the impact of groundwater recharge induced by RWH on the water supply and quality of wells in semi arid region of India. Water table of dug wells was utilized to investigate the surface to groundwater interaction between RWH structures and adjacent wells. Results of this study indicate that the change in groundwater storage volume during pre and post- monsoon period was increased after the construction RWH structure in the watershed. The groundwater availability has been increased by 0.66 million m^3 (43.45 percent) after intervention as compared to before intervention, and total annual groundwater recharge potential was increased up to 50 percent.

REFERENCES

CGWB 2003. Rainwater harvesting techniques to augment groundwater. Central Ground Water Board, Ministry of Water Resources, Faridabad, India, 29 pp.

Dewandel, B., Perrin, J., Ahmed, S., Aulong, S., Hrkal, Z., Lachassagne, P., Samad, M. and Massuel, S. 2010. Development of a tool for managing groundwater resources in semi-arid hard rock regions: Application to a rural watershed in South India. Hydro. Proc., 24: 2784-2797.

Garg, K.K. and Wani, S.P. 2013. Opportunities to build groundwater resilience in the semi-arid tropics. Ground Water, 51(5): 679-691. DOI: 10.1111/gwat.1007.

Government of India 2010. Water Availability, Ministry of Water Resources. http://wrmin.nic.in/index1.asp?linkid=189&langid=1. Extracted in January 2010.

Groundwater Resource Estimation Methodology 2009. Report of the Groundwater Resource Estimation Committee (GREC), Ministry of Water Resources, Government of India, New Delhi.

Singh, R., Garg, K.K., Wani, S.P., Tewari, R.K. and Dhyani, S.K. 2014. Impact of water management interventions on hydrology and ecosystem services in Garhkundar-Dabar watershed of Bundelkhand region, Central India. J. of Hydro., 509: 132-149.

Sukhija, B.S., Reddy, D.V., Nagabhushanam, P. and Nandakumar, M.V. 2005. Efficacy of percolation ponds as artificial recharge structures and the controlling factors. J. Geol. Soc. India, 66: 95-104.