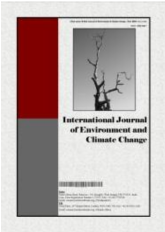

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Impact of Rainwater Recharging on the Yield of Borewells at the GKVK Campus, Bengaluru

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Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

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ABSTRACT

The study was conducted to analyze the effect of recharging the borewells through rooftop rainwater and runoff water harvesting from open fields during the year 2020-21. Nine borewells were chosen for the study, with seven borewells using various recharge strategies and two borewells serving as controls. The yield from these borewells is measured at 15-day intervals on a regular basis. During the *Kharif* season of 2020-21, three borewells (BW1, BW3, and BW5) measured a constant discharge of 0.3 lps, 0.4 lps and 3.2 lps respectively, four borewells (BW2, BW4, BW6, and BW7) measured a rise in discharge from 2.4-2.8 lps, 2.3-2.4 lps, 2.2-2.6 lps, and 1.6-2 lps, respectively, and two borewells (BW 8 and BW9) without any recharge technique measured a drop in discharge from 3-2lps and 2.4-2lps, respectively. During the subsequent Rabi season five borewells (BW1, BW2, BW3, BW4 and BW6) showed a constant discharge of 0.3lps, 2.8lps, 0.4lps, 2.4lps and 2.6lps respectively, two borewells (BW5 and BW7) continued to have an increased discharge 3.2-3.4lps and 1.8-2 lps, respectively and the two control borewells (BW 8 and BW9) continued to show a decrease in the discharge from 2-1.8lps and 1.9-1.8lps, respectively. As a result, the procedure of recharging of borewells through rainwater had a significant impact on borewell yield. The yield of recharged borewell had shown an increase in discharge or had a constant discharge during the Rabi season.

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Keywords: Borewell recharge; filtration unit; gravel pack; yield.

1. INTRODUCTION

In India, groundwater is a valuable resource. India is the world's greatest consumer of groundwater. The World Report [1] estimates that roughly 230 km³ of groundwater is used each year, accounting for nearly one-fourth of total global usage. Groundwater is used in more than 60 percent of irrigated farmland and 85 percent of drinking water supply.

The subsurface reservoirs are the technically feasible alternative to store the surplus runoff generated by monsoon. These subsurface geological formations can be considered as a Warehouse for storage of water. Apart from lithological parameters, favorable geological structures and physiographic units, whose proportions and shape allow for the preservation of a significant volume of water in porous and permeable strata, would be examined [2]. The underground ground water storage of will have an advantageous influence on the existing water available for multiple uses regime.

The country's groundwater resources are rapidly diminishing due to increasing population and inadequate surface water. More than a third portion of the country's population lives in water stressed areas and this number is set to grow due to depleting groundwater and rise in urbanization. India is one among the 17 countries facing extremely high water stress. India’s water stress has increased since the last few decades as more and more borewells were dug to extract groundwater in a huge quantity.

Groundwater recharge is the process of replenishing an aquifer with water from land surface usually expressed as an average rate of mm of water per year, similar to precipitation. Sources like stream and lake or pond seepage, irrigation return flow from canals and fields, inter aquifer flow and urban recharge are the alternatives of precipitation that forms a recharge. In contrast to natural methods of recharge, artificial recharging techniques are one of the best methods to replenish groundwater. Artificial recharging aims to reduce or even reverse groundwater declines, protect fresh groundwater in coastal aquifers from saline water intrusion, and store surplus surface water such as monsoon rainfall and waste water for future use.

Two major sources contribute to the Annual Replenishable Ground Water Resource: rainfall and other sources (including canal seepage, return flow from irrigation, seepage from water bodies and artificial recharge due to water conservation structures). Rainfall accounts for roughly 67 percent of the country's Annual Replenishable Ground Water Resource, while other sources account for 33 percent [3]. Because the southwest monsoon is the most common source of rainfall in the country, the *Kharif* period of cultivation accounts for roughly 73 percent of the country's Annual Replenishable Ground Water Recharge.

The annual replenishable groundwater potential in the country is estimated to be about 43.2 Mha-m. Extensive usage of groundwater for the past couple of years has resulted in the decrease in the groundwater levels. Therefore an augmentation in the level of groundwater resources through various recharging techniques should be given prime importance. Hence the present investigation was conducted to analyze the impact of rainwater harvesting and runoff water for recharging of borewells on the yield.

2. MATERIALS AND METHODS

The current study was conducted at several locations across the GKVK campus during the *Kharif* (July-October) and Rabi (October-March) seasons of the year (June 2020 to March 2021) using nine borewells. The experimental site is located in Karnataka's Eastern Dry Zone (Bengaluru Rural, Bengaluru Urban, Ramanagara, Kolar, Chikkaballapur, Tumkur), consists of an area of 1.808 M ha. The annual rainfall ranges from 679.1 – 988.9 mm and more than 70 percent of it is received during the Kharif season. The soils are sandy loam in major areas, lateritic in the remaining areas and belong to alfisols. Major crops of the area are Finger millet, Rice, Pulses, Maize and Oilseeds.

The nine different borewells are numbered as BW1, BW2, BW3, BW4, BW5, BW6, BW7, BW8 and BW9. Among them seven borewells (BW1 to BW7) are subjected to various recharging techniques and the control borewells (BW8 and BW9) are with no recharge technique. The borewell BW 1 was subjected to rooftop water harvesting with a screen filter and the borewells BW 2, BW 3, BW 4 and BW 5 were having the individual filtration units to recharge the borewell.

The BW7 and BW8 are having the recharge through runoff plots. The two borewells numbered as BW8 and BW9 are not having any recharge treatment techniques considered as control.

The observation of borewell yield was recorded at a 15 days interval by collecting water with a measuring tub per unit time and the discharge was calculated by adapting a volumetric method.

3. RESULTS AND DISCUSSION

The experiment is conducted as per the experimental plan as detailed under materials and methods. The results of the experiment are detailed further under the following titles.

3.1 Estimation of Volume of Water Available for Recharging the Borewells

The rainfall recorded at the GKVK campus during the year 2020-21 was 1182.2 mm in 69 rainy days. It is estimated that about 201.81 mm [4] i.e 18% of the total annual rainfall can be recharged using suitable recharging techniques. Whereas rooftop (RCC roof) rainwater harvesting allows 90 percent of total rain available [5] for recharge.

The highest one day rainfall recorded during the study period was 93.6 mm and it is estimated that it had generated a runoff of 54.04 mm for open fields. During this event, the BW 6 and BW 7 received the highest volume of water through the runoff plots which accounted for 272.68 m³ (Table 1). Tyagi [6] used various approaches to observe groundwater recharge and found that the majority of groundwater recharge occurred between July and September.

The highest rainfall recorded during the Rabi season was 42 mm and it is estimated that it had generated a runoff of 16.8 mm for open fields. The borewells BW and BW7 received the maximum runoff volume that accounted for 100.93 m³ (Table 2).

The results of the borewell recharged revealed that the bore wells numbered BW1, BW3 and BW5 are recharged through roof top water harvesting, showing no fluctuation in yield during the *Kharif* season. The reason can be attributed to lower volume of runoff for recharging when compared to open fields. While the bore wells numbered BW2, BW4, BW6 and BW7 showed an increase in the yield after 10th, 9th, 8th and 10th runoff events respectively. The bore wells numbered 8 and 9 have shown a gradual decline in the yield after the 5th and 10th runoff events respectively (Table 3).

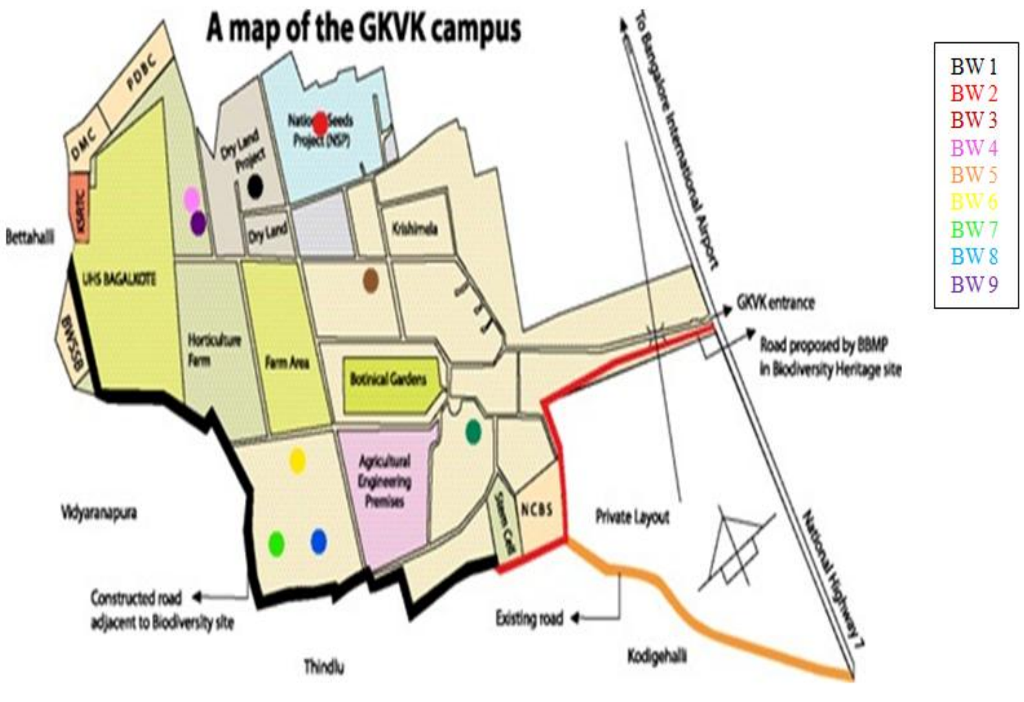

Fig. 1. A map of the GKVK campus

Table 1. Estimation of runoff water (m³) availability for the recharge of borewell during *Kharif* season

RO events	Date	RO. causing rain (mm)	Cum. RF (mm)	RO (mm)	BW 1 RO vol (m³)	BW 2 RO vol (m³)	BW 3 RO vol (m³)	BW 4 RO vol (m³)	BW 5 RO vol (m³)	BW 6 RO vol (m³)	BW 7 RO vol (m³)
Catchment Area (m²)					203	1133	600	574	400	8094	8094
1	25-5-20	27.6	27.6	4.15	5.04	28.12	14.90	14.25	9.93	33.59	33.59
2	27-5-20	12.4	40.0	-	2.26	12.63	6.60	6.40	4.46	-	-
3	28-5-20	18.6	58.6	0.83	3.39	18.95	10.04	9.60	6.69	6.71	6.71
4	30-5-20	44.2	102.8	13.90	8.07	45.03	23.86	22.83	15.91	112.5	112.5
5	12-6-20	27.6	130.4	4.15	5.04	28.12	14.90	14.25	9.93	33.59	33.59
6	25-6-20	10.0	140.4	-	1.87	10.19	5.40	5.16	3.60	-	-
7	26-6-20	29.4	169.8	5.03	5.37	29.95	15.87	15.18	10.58	40.71	40.71
8	4-7-20	9.8	179.6	-	1.79	9.98	5.09	5.06	3.52	-	-
9	9-7-20	23.8	203.4	2.51	4.34	24.25	12.85	12.29	8.56	20.31	20.31
10	10-7-20	14.4	217.8	-	2.63	14.67	7.77	7.43	5.18	-	-
11	11-7-20	5.6	223.4	-	1.02	5.70	3.02	2.89	2.01	-	-
12	14-7-20	5.2	228.6	-	0.95	5.29	2.80	2.68	1.87	-	-
13	17-7-20	15.2	243.8	0.19	2.77	15.48	8.20	7.85	5.47	1.53	1.53
14	20-7-20	15.0	258.8	0.16	2.74	15.38	8.10	7.74	5.40	1.29	1.29
15	21-7-20	52.8	311.6	20.10	9.64	53.80	28.51	27.27	19.00	162.68	162.68
16	24-7-20	65.8	377.4	30.20	12.02	67.05	35.53	33.99	23.68	244.43	244.43
17	30-7-20	12.0	389.4	-	2.19	12.22	6.48	6.19	4.32	-	-
18	3-8-20	10.0	399.4	-	1.82	10.19	5.40	5.16	3.60	-	-
19	9-8-20	6.8	406.2	-	1.24	6.92	3.67	3.51	2.44	-	-
20	10-8-20	5.2	411.4	-	0.95	5.09	2.80	2.68	1.87	--	-
21	12-8-20	12.8	424.2	-	2.33	13.04	6.91	6.61	4.60	-	-
22	18-8-20	10.2	434.4	-	1.86	10.39	5.50	5.26	3.67	-	-
23	31-8-20	10.0	444.4	-	1.82	10.19	5.40	5.16	3.60	-	-
24	1-9-20	7.2	451.6	-	1.31	7.33	3.88	3.71	2.59	-	-
25	2-9-20	9.6	461.2	-	1.75	9.78	5.18	4.95	3.45	-	-

RO events	Date	RO. causing rain (mm)	Cum. RF (mm)	RO (mm)	BW 1 RO vol (m^3)	BW 2 RO vol (m^3)	BW 3 RO vol (m^3)	BW 4 RO vol (m^3)	BW 5 RO vol (m^3)	BW 6 RO vol (m^3)	BW 7 RO vol (m^3)
26	3-9-20	34.6	495.8	7.80	6.32	35.25	18.64	17.87	12.45	63.12	63.12
27	4-9-20	19.4	515.2	1.04	3.54	19.76	10.47	10.02	6.98	8.41	8.41
28	9-9-20	93.6	608.8	54.04	17.10	95.37	50.54	48.35	33.69	272.68	272.68
29	10-9-20	6.2	615.0	-	1.13	6. 31	3.34	3.20	22.32	-	-
30	21-9-20	10.0	625.0	-	1.82	10.19	5.40	5.16	3.60	-	-
31	30-9-20	41.0	666.0	11.80	7.49	41.77	22.14	21.18	14.76	95.50	95.50
32	4-10-20	6.8	672.8	-	1.24	6.92	3.67	3.51	2.44	-	-
33	10-10-20	12.2	685.0	-	2.22	12.40	6.58	6.30	4.39	-	-
34	11-10-20	6.0	691.0	-	1.09	6.11	3.24	3.09	2.16	-	-
35	13-10-20	8.0	699.0	-	1.40	8.15	4.32	4.13	2.88	-	-
36	21-10-20	61.2	760.2	26.59	11.18	62.36	53.04	31.61	22.03	215.21	215.21
37	23-10-20	10.6	770.8	-	1.93	10.80	5.72	5.47	3.81	-	-
38	24-10-20	6.2	777.0	-	1.13	6.31	3.34	3.20	2.23	-	-
Total					**135.55**	**744.38**	**439.10**	**346.04**	**299.67**	**1312.26**	**1312.26**

BW – borewell
RO – runoff
RF - Rainfall

Table 2. Estimation of runoff water availability for the recharge of borewell during Rabi season

RO event	**Date**	**RO causing rain (mm)**	**Cum. RF (mm)**	**RO (mm)**	BW **1 RO vol (m^3)**	BW **2 RO vol (m^3)**	BW **3 RO vol (m^3)**	BW **4 RO vol (m^3)**	BW **5 RO vol (m^3)**	BW **6 RO vol (m^3)**	BW **7 RO vol (m^3)**
Catchment Area (m^2)					203	1133	600	574	400	8094	8094
1	6-11-20	42.0	777.0	12.47	7.67	42.79	22.68	21.69	15.12	100.93	100.93
2	13-11-20	5.0	782.0	-	0.91	5.09	2.70	2.58	1.80	-	-
3	17-11-20	5.2	787.2	-	0.95	5.29	2.80	2.68	1.87	-	-
4	27-11-20	15.2	802.4	0.19	2.77	15.48	8.20	7.85	5.47	1.53	1.53
5	1-7-21	11.4	813.8	-	2.08	11.61	6.15	5.88	4.10	-	-
6	20-2-21	23.4	837.2	2.36	42.75	23.84	12.63	12.08	8.42	19.10	19.10
7	21-2-21	14.6	851.8	-	2.66	14.87	7.88	7.54	5.25	-	-
Total					**59.79**	**118.97**	**63.04**	**60.30**	**42.03**	**121.56**	**121.56**

Table 3. Impact of runoff water recharge on the yield of bore well (litres/sec) measured at 15 days interval during *Kharif* season of 2020 at the GKVK campus

RF/RO events	BW 1	BW 2	BW 3	BW 4	BW 5	BW 6	BW 7	BW 8	BW 9
1	0.3	2.4	0.4	2.3	3.2	2.2	1.6	3.0	2.4
2	0.3	2.4	0.4	2.3	3.2	2.2	1.6	3.0	2.4
3	0.3	2.4	0.4	2.3	3.2	2.2	1.6	3.0	2.4
4	0.3	2.4	0.4	2.3	3.2	2.2	1.6	3.0	2.4
5	0.3	2.4	0.4	2.3	3.2	2.2	1.6	2.8	2.4
6	0.3	2.4	0.4	2.3	3.2	2.2	1.6	2.8	2.4
7	0.3	2.4	0.4	2.3	3.2	2.2	1.6	2.8	2.4
8	0.3	2.4	0.4	2.3	3.2	2.6	1.6	2.8	2.4
9	0.3	2.4	0.4	2.4	3.2	2.6	1.6	2.8	2.4
10	0.3	2.8	0.4	2.4	3.2	2.6	1.8	2.0	2.0
11	0.3	2.8	0.4	2.4	3.2	2.6	1.8	2.0	2.0

Table 4. Impact of runoff water recharge on the yield (litres/sec) of bore well measured at 15 days interval during Rabi season at the GKVK campus

RF/RO events	BW 1	BW 2	BW 3	BW 4	BW 5	BW 6	BW 7	BW 8	BW 9
1	0.3	2.8	0.4	2.4	3.2	2.6	1.8	2.0	1.9
2	0.3	2.8	0.4	2.4	3.3	2.6	1.8	2.0	1.9
3	0.3	2.8	0.4	2.4	3.3	2.6	1.8	2.0	1.9
4	0.3	2.8	0.4	2.4	3.3	2.6	1.8	2.0	1.9
5	0.3	2.8	0.4	2.4	3.3	2.6	1.8	2.0	1.9
6	0.3	2.8	0.4	2.4	3.3	2.6	1.8	2.0	1.9
7	0.3	2.8	0.4	2.4	3.3	2.6	2.0	2.0	1.8
8	0.3	2.8	0.4	2.4	3.3	2.6	2.0	2.0	1.8
9	0.3	2.8	0.4	2.4	3.4	2.6	2.0	1.9	1.8
10	0.3	2.8	0.4	2.4	3.4	2.6	2.0	1.9	1.8
11	0.3	2.8	0.4	2.4	3.4	2.6	2.0	1.9	1.8

The runoff events viz 8^{th}, 9^{th}, 10^{th} are having the cumulative rainfall of 615 mm, 666 mm and 699 mm respectively. While the borewell numbered BW 2 and BW 7 measured the increased yield after the 10^{th} runoff events. Further borewell numbers BW 4 and BW 6 yielded the increase in borewell yield after the 9^{th} and 8^{th} event respectively. The findings of Bharadwaj *et al* [7] are consistent with the findings of this study. They investigated the influence of recharge on the Aravali watershed and found that recharge was significant, with runoff contributing significantly to recharge. The borewell numbers BW 8 and BW 9 have shown a decline in yield after 5^{th} and 10^{th} runoff events respectively and the reason is attributed to no recharge treatment measures to these borewells.

Borewell recharge findings demonstrated a distinct yield trend during the rabi season. The yields of borewells BW 1, BW 2, BW 3, BW 4, and BW 6 were unchanged, whilst the yields of borewells BW 5 and BW 7 increased following the 9^{th} and 7^{th} rain events, respectively. After the 7^{th} and 8^{th} occurrences, the yields in the control borewells designated BW 8 and BW 9 exhibited a progressive reduction (Table 4). The findings of Kaledondhkar *et al.* are consistent with the findings of this study [8-9] They studied the artificial replenishment of groundwater through tubewells and reported that the recharge wells performed well without lowering the discharge rate.

4. CONCLUSION

Rooftop and runoff water harvesting techniques have recharged the bore wells during *Kharif* season and the influence of this can be seen in the rabi season, when the recharged bore wells exhibited a trend of stable output or an increase in yield. However open fields with borewells receiving the highest quantity of runoff water had a profound influence in yielding higher quantities of borewell water. The borewells BW 1 and BW 3 had a constant discharge of 0.3 lps and 0.4 lps, respectively. The borewells BW 2, BW 4, BW 5, BW 6 and BW 7 showed an increased discharge in the range of 2.4-2.8 lps, 2.3-2.4 lps, 3.2-3.4 lps, 2.2-2.6 lps and 1.6-2 lps, respectively. The control borewells BW 8 and BW 9 showed a decline in discharge from 3-1.9 lps and 2.4-1.8 lps, respectively. The bore wells that were considered as control showcased a declining trend in the quantification of yield during rabi season. Therefore the study reveals that the borewell recharge helps in augmenting groundwater, to an extent of quantity is replenished.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

REFERENCES

1. World report, India groundwater: A Valuable but Diminishing Resource; 2012. Available:https://www.worldbank.org/en/news/feature/2012/03/06/india-groundwater-critical-diminishing
2. CGWB (Central Ground Water Board, Ministry of Water Resources), Annual Report; 2019.
3. Envistats- India. Ministry of Statistics and Program; 2018.
4. Chaturvedi RS. A Note on the Investigation of GroundWater Resources in Western Districts of Uttar Pradesh". Annual Report, U. P. Irrigation Research Institute. 197386-122.
5. Rooftop Water Harvesting Manual technical details. Available:http://www.rainwaterharvesting.org/downloads/rooftop_rwh.pdf.
6. Tyagi NK. Conjunctive use of fresh canal and Saline ground waters in the saline tracts, Annual report for, Central Soil Salinity Research Institute, Karnal. 1982;92-93.
7. Bharadwaj SP, Dhuruvanarayan VV, Sharma AK, Singh JP 1989, Fortunes takes a turn in Aravali Watershed, Indian Farming. 1989;39(9):11-13.
8. Kaledhonkar MJ, Singh OP, Ambast SK, Tyagi NK, Tyagi KC, Artificial Groundwater Recharge through Recharge Tube wells. J. Agric. Engg. IE. 2002;(I):28-31.
9. Groundwater Resource Estimation Methodology, Report of Groundwater Resource Estimation Committee, Ministry of Water Resources; 2009.

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