Impact of Water Intensive Cash Crops on Groundwater Depletion in Rajasthan

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Abstract: Groundwater is a major source of freshwater as well as vital natural resource for Rajasthan which contributes a significant portion of the drinking and irrigation water requirements for the state. Increasing demand for irrigation, household and industrial region, coupled with inadequate rainfall, unsustainable extraction practices for irrigation and lack of management techniques have led to depletion of groundwater level and resulted in water scarcity in many regions of the state. People in some regions are excessively dependent and using ground water through tubewell which is leading to groundwater consumption at faster rate than it can be replenished naturally. This is causing water level to decline unremittingly. Groundwater pumping out for irrigation remains the primary cause of groundwater depletion which causes water scarcity crisis. The study utilizes statistical data of groundwater level, rainfall and irrigation to understand the dynamics of groundwater level fluctuations. The research analyses the trends in groundwater level, the impact of water intensive crops production on groundwater depletion, identifies critical zone of depletions of groundwater and the overall health of groundwater resources in the state. Study emphasises on the implementation of rainwater harvesting, enhancement of public awareness regarding water conservation, promotion of efficient irrigation techniques such as drip and sprinkler system, community-based water management initiatives such as Johar, etc. and revitalisation of traditional water bodies such as stepwells, baori and ponds etc. Paper will provide useful insights that will assist and pave the way towards the concrete efforts by water resource managers, policy makers and local peoples to prevent groundwater continued depletion and promote sustainable water management.

Keywords: Depletion, fluctuation, groundwater, irrigation, replenish, rain water harvesting, revitalisation, unsustainable extraction, water intensive crops, water management, water scarcity etc.

I. INTRODUCTION

Groundwater is water that exists underground in saturated zone beneath the land surface and the upper surface of saturated zone is known as the water table. Groundwater is a finite resource and aquifers can become depleted when extraction rates exceed replenishment or recharge rates. Groundwater reserves that took millions of years to form are vanishing in decades the status of groundwater development stage in the Rajasthan is quite unique and very critical as compared to other states. Almost all parts of the state facing exploitation beyond annual replenishable quantity. Substantial groundwater level declines are being witnessed both in hard rock and alluvial areas. Groundwater depletion is a serious environmental concern which is mainly caused by the overexploitation or extraction of groundwater for various uses particularly agriculture and by factors like deforestation and overuse due to increasing population and urbanization, these human activities combined with impact of climate change, strain groundwater resources leading to declining water tables.

There is a dynamic balance of water level in aquifer between groundwater recharge, storage and discharge. If recharge exceeds discharge the volume of water in storage will increase and ground water levels will rise but if discharge exceeds recharge the volume of water in a storage will decrease and water level will fall.

“Rajasthan geography and climate make it uniquely vulnerable”. The monsoon rainfall is the primary source of groundwater replenishment in Rajasthan. When there is no rain there is no recharge. Climate change, rising temperature and drought etc. has worsen the situation. The greatest challenge is the failure to comprehend the relationship between rainfall and groundwater level. If farmers stop groundwater extraction, recovery is possible in 10 to 20 years but demand exceed supply of groundwater requirement for irrigation. Thus, aquifer have been overused in an arid and semi-arid region because natural replenishment cannot keep up with groundwater withdrawal. The groundwater monitoring is being carried out through a network of observation wells - The National Hydrograph Network Stations (NHS).

Groundwater and surface water has been used for irrigation of crops throughout the ages. Irrigation has acquired increasing importance in agriculture the world over. The irrigated area has increased during last few decades in India. Now India is the largest user of groundwater (71 billion cubic meters) globally and extracts more than the United States and China combined. In 1950, after independence net irrigated area was 20.80 million hectares which has increased to 68.6 million hectares in 2020-21. With almost one-fifth of that area India has the highest irrigated land in the world. According to last year report of groundwater board Haryana and Punjab are the only states where groundwater is exploited or extracted more than Rajasthan. In Haryana and Punjab 90% of groundwater is used for irrigation while in Rajasthan 80-85% groundwater is used for irrigation in Rajasthan which shows Rajasthan's heavy reliance on groundwater for irrigation in agriculture. In Rajasthan groundwater level is depleting so fast because of high demand of groundwater in water intensive crops like wheat,pulses,oil seeds etc. irrigation. Only 15% of groundwater is used for domestic purpose and 2% for industrial purpose. In India the green revolution which was responsible for combating food shortage in the country has been very successful due to the ground water irrigation. Since independence the area irrigated by government canals has decreased by 2.4% while the irrigated area by well haa increased by 3.9%.

Tubewell technology in the groundwater is responsible for a rise in cropping intensity as well as high water intensive cropping pattern. The reason for groundwater irrigation is, it produces significantly less waste due to conveyance and farmers have more flexibility in adjusting the timing and amount of water applied to the crops needs. Since 1970 wells and tube wells have been the major source of irrigation in Rajasthan.

II. STUDY AREA

Rajasthan is the largest state in India with 3,42,239 Sq. km geographical area which is 10.41% of total geographical area of India. It is situated between 23°3” to 30°11” north latitudes and 69°29” to 78°17” east longitudes. Rajasthan is a state with low rainfall, intense summer with high temperature, high diurnal variations of temperature, low humidity and high evaporation. The Aravali hill range forms the main water divide in Rajasthan. Luni is the only river in west of Aravalli’s and the drainage in remaining area of western Rajasthan is internal and the streams are lost in the desert. Chambal, Banas, Banganga, Sahibi, Mahi, Kantali are the rivers in eastern Rajasthan. The drainage pattern is dendritic in Rajasthan. The normal annual rainfall in Rajasthan is 549 mm, 90% of which is received from southwest monsoon from June to September. Rajasthan economy has undergone considerable transformation in the recent past years with agriculture (including livestock) providing one fourth of the state GDP. More than 60% of population depends on agriculture for their livelihood. Rajasthan is heavily dependent on groundwater for irrigation in agriculture fields and 80 to 85% of the extracted groundwater is used for irrigation.

III. OBJECTIVES

(1) To analyse current status of groundwater and rainfall pattern in Rajasthan.
(2) To evaluate groundwater level and irrigation trend prevailing in Rajasthan.
(3) To analyse the adverse impact of cash crops and water intensive crop production on groundwater level in Rajasthan.
(4) To understand the reason for farmers switching on the cash crop or high irrigation demanding crops.

IV. HYPOTHESIS

(1) Null hypothesis: There is no impact of increasing irrigation on groundwater level in Rajasthan.
(2) Alternative hypothesis: Increasing irrigation have significant impact on depleting groundwater level in Rajasthan.

V. DATA SOURCES AND METHODOLOGY

The study is mainly based on secondary data published by government and non-government organizations. The data are collected from *Dynamic Groundwater Resources of Rajasthan 2023, Agricultural Statistics of Rajasthan 2022-23*, *official site of Central groundwater department.* Some data taken from newspapers articles in *Rajasthan Patrika* and Internet sources.

To analysis the impact of irrigation on groundwater level *Mann Kendalls rank correlation test,* referred as *Kendalls tau coefficient test* which is a non-parametric method is used. It is a more useful statistical test for assessing short term trends in homogeneous data. The *Mann kendalls test* checks the null hypothesis of no impact versus the alternative hypothesis of the existence of increasing or decreasing (positive /negative) impact on depletion of groundwater level.

$t = C\text{-}D/C\text{+}D$ or $t = nc\text{-} n\mathbf{D}/n(n\text{-}1/2)$

C = The number of concordant pairs

D = The number of discordant pairs

tau-b values vary from -1 (perfect inversion or 100% negative association) to + 1 (perfect agreement or 100% positive association). The absence of correlation is indicated by a zero value.

VI. RESULTS AND FINDING

"Irrigation is the main culprit for depletion of groundwater in Rajasthan". Farmers are shifting to growing water intense crops like wheat, cash crops like sugarcane, oil seeds, pulses etc which is main reason of depleting groundwater level at fast pace in Rajasthan bringing the groundwater level at alarming state in Rajasthan.

Sl.No.	CROPS	AREA IN HECTARE
1.	CEREALS	3719255
2.	PULSES	952744
3.	OILSEEDS	5035603
4.	SUGARCANE	3435
5.	CONDIMENTS &SPICES	926810
6.	FRUITS AND VEGETABLES	201581
7.	FIBERS	793831
8.	DRUG &NARCOTICS	469209
9.	FODDER CROPS	474848
10.	OTHERS	5575

Table-I Irrigated Area under various crops in Rajasthan,2022-23

Source: Agricultural Statistics of Rajasthan,2022-23

Data of irrigated area under various crops 2020-23 reveals that maximum groundwater for irrigation is used under oil seeds irrigation which is about 5035603 hectares followed by cereals (3719255 hectares), condiments and spices (926810 hectares), pulses (952744 hectares) etc. Oil seeds and pulses and wheat in cereals are water intensive crops which are grown for earning more financial profit but these crops are responsible for depleting groundwater level.

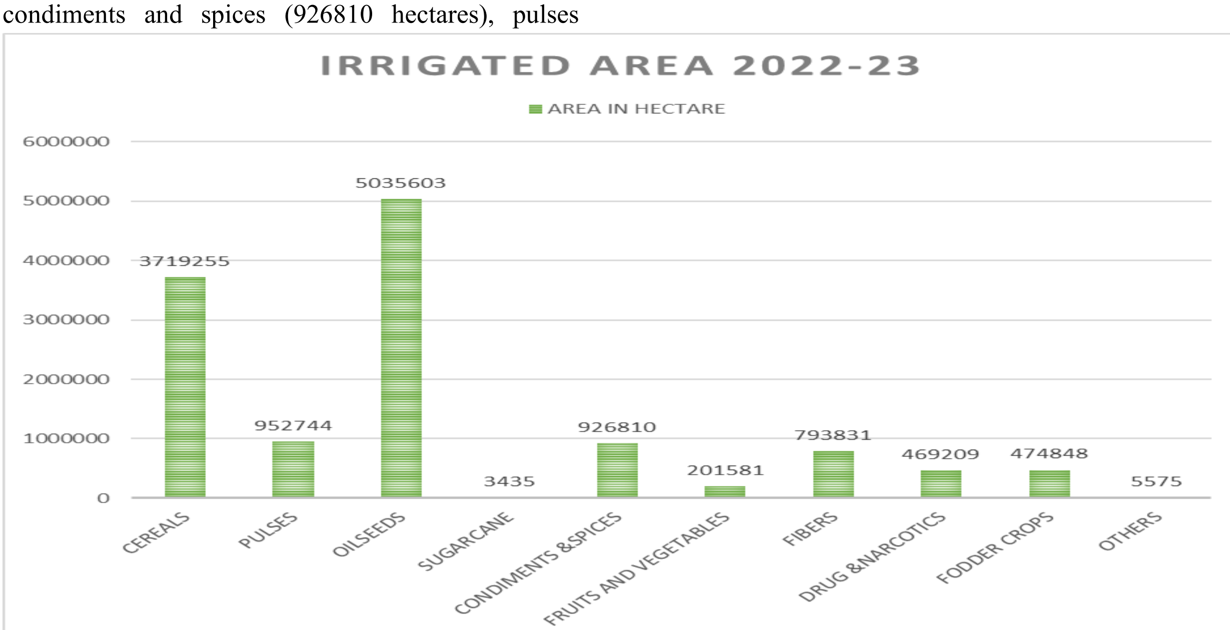

Table-II District wise Ground Water Recharge and Extractable groundwater resource in Rajasthan(ham), 2023

Sl.No	Name of District	Total Annual Ground Water Recharge	Annual Extractable Ground Water Resource	Difference of ground water recharge and extractable ground water
1.	AJMER	37959.01	34163.11	3795.90
2.	ALWAR	79675.78	71708.20	7967.58
3.	BANSWARA	23168.41	20851.56	2316.85
4.	BARAN	64982.4	58927.68	6054.72
5.	BARMER	38354.2	34518.77	3835.43
6.	BHARATPUR	39669.18	36266.73	3402.45
7.	BHILWARA	45109.39	40614.58	4494.81
8.	BIKANER	30882.57	27870.51	3012.60
9.	BUNDI	33065.90	30422.15	2643.75
10.	CHITTAURGARH	34553.28	31097.97	3455.31
11.	CHURU	15993.73	14789.51	1204.22
12.	DAUSA	27927.45	25134.69	2792.76
13.	DHAULPUR	27509.55	25039.51	2470.04
14.	DUNGARPUR	22466.42	20241.59	2224.83
15.	GANGANAGAR	47966.76	43170.10	4796.66
16.	HANUMANGARH	22490.26	20241.22	2249.04
17.	JAIPUR	72587.12	65328.40	7258.72
18.	JAISALMER	10547.77	9492.99	1054.78
19.	JALOR	47948.84	43781.98	4166.86
20.	JHALAWAR	55627.73	50295.40	5332.33
21.	JHUNJHUNUN	24551.09	22095.98	2455.11
22.	JODHPUR	40205.29	36733.61	3471.68
23.	KARAULI	33817.60	30563.02	3254.58
24.	KOTA	51575.18	46417.67	5157.51
25.	NAGUR	62676.39	56643.77	6032.62
26.	PALI	32150.48	28935.41	3215.07
27.	PRATAPGARH	22764.24	20488.37	2275.87
28.	RAJSAMAND	11585.02	10426.48	1158.54
29.	SWAIMADHOPUR	44228.05	39805.24	4422.81
30.	SIKAR	36899.45	33209.52	3689.93
31.	SIROHI	29777.35	26799.63	2977.72
32.	TONK	44229.07	40031.53	4197.54
33.	UDAIPUR	32254.00	29028.56	3225.44

Source: Dynamic Ground Water Resources of Rajasthan 2023

The fact that overall status of groundwater is associated with factors like low rainfall, limited groundwater storage availability, groundwater salinity in many areas. The latest study of the Central Groundwater Board has revealed that the groundwater level has declined mainly in the eastern, South Western, North eastern and North central region of the state. Rajasthan saw a 3.74% increase in groundwater extraction for irrigation from 2013 to 2023. As for 2023 data the top 5 districts in term of groundwater extraction are Alwar, Jaipur, Nagaur, Jodhpur and Jalore, together account for about one third of Rajasthan's groundwater extraction for that year. The South and South Eastern districts of Rajasthan have good groundwater level with more vegetation cover and healthy rainfall. The North Eastern district of the study area has recently become severely affected while Western districts have historically been a severe groundwater level depletion area.

The data of annual groundwater recharge and annual groundwater extraction for irrigation 2023 reveals that Alwar stands at first position in extraction of groundwater followed by Jaipur, Nagaur, Jodhpur etc where as Rajsamand is at last position in extraction of groundwater followed by Dungarpur, Hanuman, Banswara, Churu, Ganganagar, Pratapgarh. That means these districts are having high groundwater level.

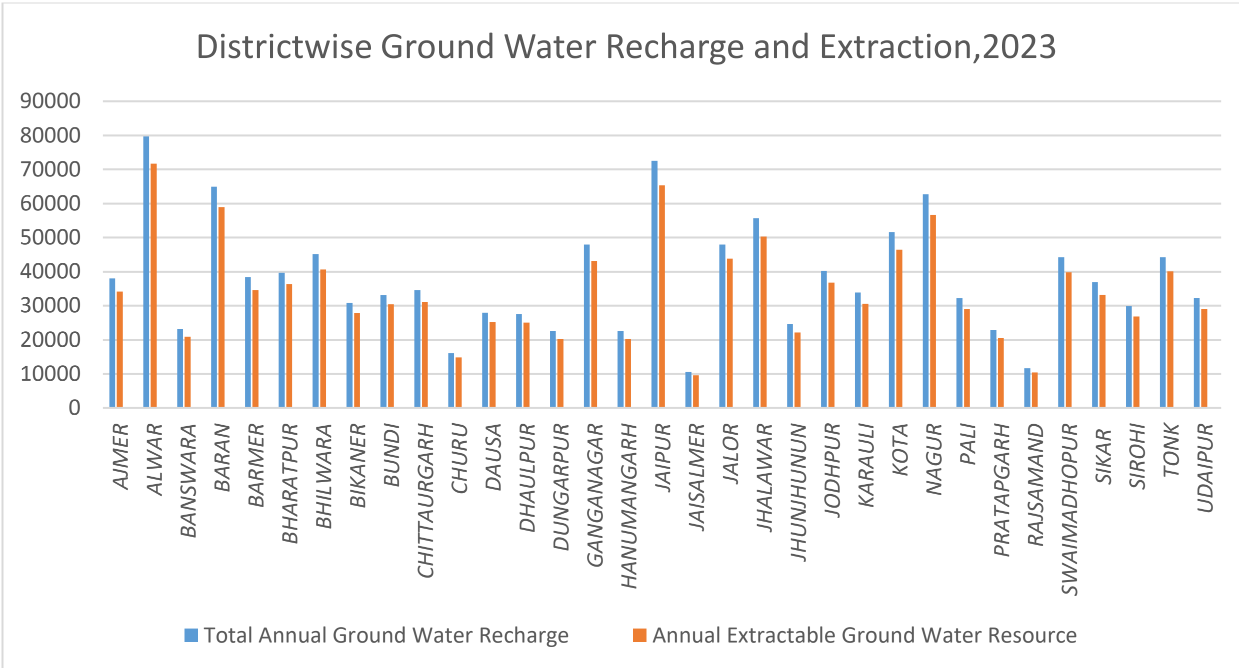

Table-III Mann Kendall Correlation between Annual Ground water recharge and Current annual ground water extraction for Irrigation

Sl.No	Name of District	Total Annual Ground Water Recharge (ham) (X)	Current Annual Ground Water Extraction for Irrigation (ham) (Y)	Rx	Ry	C	D
1.	AJMER	37959.01	47462.83	1	1	32	0
2.	ALWAR	79675.78	113255.21	2	2	31	0
3.	BANSWARA	23168.41	11598.17	3	6	27	3
4.	BARAN	64982.4	67411.74	4	3	29	0
5.	BARMER	38354.2	37805.31	5	9	24	4
6.	BHARATPUR	39669.18	37331.9	6	16	17	10
7.	BHILWARA	45109.39	60213.29	7	28	5	21
8.	BIKANER	30882.57	28462.85	8	5	24	1
9.	BUNDI	33065.90	27292.16	9	7	23	1
10.	CHITTAURGARH	34553.28	46512.33	10	21	11	12
11.	CHURU	15993.73	15419.69	11	8	21	1
12.	DAUSA	27927.45	47521.68	12	4	21	0
13.	DHAULPUR	27509.55	29417.68	13	18	13	7
14.	DUNGARPUR	22466.42	11227.75	14	17	13	6
15.	GANGANAGAR	47966.76	16989.18	15	12	16	2
16.	HANUMANGARH	22490.26	11247.76	16	10	17	0
17.	JAIPUR	72587.12	107004.97	17	13	15	1
18.	JAISALMER	10547.77	30418.32	18	14	14	1
19.	JALOR	47948.84	75036.44	19	25	7	7
20.	JHALAWAR	55627.73	54683.43	20	27	5	8
21.	JHUNJHUNUN	24551.09	35396.64	21	15	11	1
22.	JODHPUR	40205.29	78476.56	22	24	6	5
23.	KARAULI	33817.60	43466.39	23	23	6	4
24.	KOTA	51575.18	40190.84	24	11	9	0
25.	NAGUR	62676.39	88158.52	25	22	6	2
26.	PALI	32150.48	41633.64	26	19	7	0
27.	PRATAPGARH	22764.24	25665.32	27	30	3	3
28.	RAJSAMAND	11585.02	10057.26	28	26	4	1
29.	SWAIMADHOPUR	44228.05	56358.79	29	31	2	2
30.	SIKAR	36899.45	51368.58	30	32	1	2

31.	SIROHI	29777.35	29160.36	31	29	1	1
32.	TONK	44229.07	29959.39	32	33	0	1
33.	UDAIPUR	32254.00	24219.38	33	20	0	0
						∑C=421	∑D=107

Ꞇ =(C-D) /(C+D) =421-107 / 421+107 = -314/528 = (- 0.59)

Ꞇ = n_c-n_d / n(n-1)/2 Here n=33,

Ꞇ= (421-107) / 33{(33-1)/2} = -314/33*16 = -314 /528 = (- 0.59)

Mann Kendalls rank correlation is calculated through data of annual groundwater recharge and annual groundwater extraction for irrigation in year 2023 and we found that there is a moderate negative correlation (-)0.59 in annual groundwater recharge and annual groundwater extraction for irrigation. This shows that more amount of groundwater is extracted for irrigation than its recharge due to which ground water level is depleting at alarming rate. Dungarpur, Hanuman, Banswara, Churu, Ganga nagar, Pratapgarh, Udaipur are in better state in comparison of other districts of Rajasthan due to rainfall and dense vegetation. But groundwater level in Alwar, Jaipur, Nagaur, Jodhpur, Jalore, Bara, Bhilwara is depleting at high speed because farmer in these districts are diverting towards growing wheat (water intense cereal crop), pulses, cash crops like sugarcane etc. to earn more financial profit. In the pursuit of increasing income or financial profit, the distance from crops that helps in recharging groundwater and drought resistance crops like millets, bajra and jowar increasing while the farmers attraction towards pulses and cash crops etc or high-yield production crops has increased.

Thus the null hypothesis is rejected and alternative hypothesis has proved that there is a Moderate negative correlation (-0.59) in groundwater recharge and groundwater extraction for irrigation.

For decades water hungry wheat ruled the fields but now as water sources are vanishing even drought resistance crops like mustard and millets are struggling under erratic rainfall and rising temperature. Earlier the farmer use open irrigation, then they shifted on sprinkler and now they switched to drip irrigation. Since 1970 wells and tubewells have been the major source of irrigation in Rajasthan. The proportion of tubewells to net irrigated area has increased in last years while contribution of canal in irrigation has been decreasing in recent years. The treasure of groundwater is getting depleted rapidly and the efforts of farmers to increase their income are also getting adversely affected.

VII. CONCLUSION

Farmers in Rajasthan have abandoned traditional crops like millets, mustard, grams, jowar etc. which are deep rooted crops and drought resistant crops. Only one crop Bajra seems to have the potential to decrease the depletion or overextraction of groundwater for irrigation but unlike southern states where millets can be grown in rabi season as well, Rajasthan climate restricts millets cultivation to just kharif season making it a supplementary crop rather than a primary one.

Policy reforms are needed to prevent groundwater depletion by regulating and monitoring water withdrawal under the subsidized power tariff. A holistic approach taking all aspects into consideration shall need to be adopted. Rajasthan has enacted number of legislations in the recent time to regulate water resources and incentivize rainwater harvesting. Some major legislations enacted by states includes "The Rajasthan water resource regulatory act 2012", and "The Rajasthan river basin and water resources planning act 2015". Suitable locations in nalas and gullies should be utilized for the construction of check dams, sub surface dams, ponds etc for ensuring stagnation of water and thus its infiltration underground for augmenting groundwater storage. The liquid urban waste can be recycled through aquifers to improve their quality and pumped out for reuse in irrigation. Urban and Industrial water waste should not be intermixed. It is crucial to implement groundwater conservation strategies and water harvesting system in the study area to prevent further harm to the available groundwater.

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