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RESEARCH PAPER

Untapped Potential of Groundwater Resources of Bihar

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ABSTARCT

Bihar is endowed with rich water resources due to the high precipitation, extensive river basin network, and alluvial aquifer with significant storage space for groundwater. Majority of its population is dependent on agriculture and related activities for their sustenance. However, there is uneven distribution of groundwater potentials due to variability of rainfall. Although evidence at the aggregate level indicates the under-utilization of groundwater resources in Bihar, there are few areas with depleting groundwater levels as well. This is indicated by the increase in the over-exploited and critical blocks from zero per cent to 1.5 and 2.2 per cent respectively. Irrigation being the predominant consumer of groundwater bears the prime responsibility of using this resource sustainably. Presently, groundwater irrigates 63% of the net irrigated area and its share has been rising. Various studies on water quality and quantity indicate that Bihar may experience severe scarcity of water in the nearby future. Water shortages will become chronic in this water surplus condition, necessitating quick remedial measures to conserve and protect this vital water supply. As groundwater is largely underutilized, there exists a huge scope to accelerate sustainable use of groundwater for harnessing a positive groundwater-agricultural development linkage. The untapped groundwater resource should be utilized by private and government agencies for irrigation.

HIGHLIGHTS

- The net annual draft has been always lower than the net annual recharge thus providing a scope for further utilization of groundwater in Bihar.
- An irregular trend in the water level was observed from the year 1995 to 2020. A decrease in water level was observed during the period 1995 to 2018; thereafter, a sharp rise was seen in the water level.

Keywords: Bihar, Depletion, Groundwater, Irrigation, Scarcity

Groundwater is a valuable resource to support agricultural, industrial and domestic activities in many parts of the world. India, the largest agricultural user of groundwater in the world, has seen are volutionary shift from large-scale surface water management to widespread groundwater abstraction. The utilization of groundwater exhibits extensive geographical variability. In contrast to the north-western and southern regions of India, where groundwater is over-exploited, the eastern area of the country continues to underutilize it for a variety of economic and non-economic reasons (Srivastava *et al.* 2012). A few locations have begun to experience groundwater depletion, even in the water-surplus eastern India, where groundwater is substantially under-utilized overall (Srivastava *et al.* 2018).

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Bihar is blessed with abundant surface and groundwater resources. Agriculture in Bihar is primarily reliant on the monsoon, which has become increasingly unpredictable in recent years due to climate change, causing regular floods and draughts across substantial parts of the state. Groundwater has been essential for irrigation and water supplies because surface water irrigation schemes like Gondak, Son, and Kosi have led to extensive water logging and soil salinization in command regions and the farmers are facing challenges of insufficient water supplies. Although the state receives average rainfall of 1009 mm each year, neither rainfall nor the allocation of water resources is consistent throughout the state, which results in inconsistent irrigation coverage in different areas.

In the last few decades, the state has experienced a serious water crisis in several parts of the state. The demand is increasing due to burgeoning population and industrialization which leads to a risk of insufficient supply. Climate change, unplanned and irrational use of water is affecting the groundwater recharge rates and availability. The high cost of irrigation in Bihar pushes farmers to over-economize on water use, which has detrimental effects on agricultural outcomes including low crop yields, increased susceptibility to draughts and heat-waves and low cropping intensity (Kishore 2020). However, the state's net irrigated area is just 30.44 lakh ha, while the gross irrigated area is 54.95 lakh ha, out of the 50.45 lakh ha net sown area and 72.64 lakh ha gross cropped area (Directorate of Economics & Statistics). The underutilization of groundwater resources in eastern states results in a missed opportunity to harness the positive linkages between groundwater and agricultural growth (Srivastava *et al.* 2014). In addition, groundwater depletion threatens the natural balance and results in inequity in its distribution and has detrimental financial effects on farmers (Sarkar 2011).

RESULTS AND DISCUSSION

Groundwater levels in Bihar

The water level during the pre-monsoon season varied from 0.02 mbgl (Patna) to 11.00 mbgl (Nawada). The majority of the wells (49 per cent) showed water level in the range of 2-5 m (Table 1). Shallow water levels of upto 2 m were observed in 25 per cent of the wells in northern part. About 2 per cent of the wells falls under deepest category of 10-20 m depth to water level and was recorded in Bhojpur, Buxar and Nawada district and patches of South Bihar Plain (SBP) also. Centrifugal pumps lose their effectiveness at groundwater levels higher than 8 to 10 mbgl and need to be switched with submersible pumps for the extraction of groundwater (Sekhri 2013). Further, in the post-monsoon period, the minimum and the maximum depth to water levels was recorded to be 0.10 mbgl (Darbhanga) and 16.00 mbgl (Rohtas) respectively (Table 1). In major area of the state, 56 per cent of the water level rests in range of 2-5 mbgl which covers almost entire SBP and large portion of North Bihar Plain (NBP) of Bihar state. The wells having water level of more than 10 mbgl was observed in 2 locations, which covers Bhagalpur and Jamui. Only 6 per cent of the wells had water levels in the range of 5-10 mbgl, which covered small patches at many locations in SBP. Sitamarhi, Sheohar, Gopalganj, Darbhanga district, and many more localized regions, largely in NBP, all have 38 per cent of their wells in the shallowest category of 0-2 mbgl. The groundwater level up to 2 mbgl is a water-logging situation. A persistent water-logging in the root zone (0-3 mbgl) is not favorable for optimum crop growth and necessitates effective drainage of the excess water.

An irregular trend in the water level was observed from the year 1995 to 2020. A decrease in water level was observed during the period 1995to 2018;

Table 1: Groundwater levels in Bihar in 2021

Season	Total No. of wells	Depth to water level (m bgl)		Distribution of monitoring wells across groundwater level (%)				
		Min.	Max.	0-2 m	2-5 m	5-10 m	10-20 m	> 20 m
Pre-monsoon	225	0.02	11.00	25	49	24	2	0
Post-monsoon	615	0.10	10.69	38	56	6	0	0

Source: *Central Groundwater Board.*

thereafter, a sharp rise was seen in the water level. The water table rose at the rate of 0.03 metres per year from the period 1995 to 2020. The water level was at a shallow depth of 4.19 metres in the year 2019 whereas; it was at a deepest depth of 6.27 metres in year 2018. Rainfall is the most important source of groundwater recharge and, therefore, variations in the rainfall pattern have a distinct effect on the area's groundwater regime. However, because to irregular rainfall that varies from year to year as well as siltation in the rivers, frequent floods in north Bihar and drought in south Bihar have nearly become a regular occurrence, severely harming the state's agrarian economy.

District wise groundwater levels in Bihar

Bihar state has been broadly divided into North Bihar Plain (NBP) consisting of areas falling to the north of the river Ganga and South Bihar Plain (SBP) consisting of areas falling to the south of the river Ganga and bordering Jharkhand state. The water level for the past twenty five years showed that the majority of the water level remains within 5-10 m (Table 2).

Table 2: District wise groundwater levels in Bihar (in m), 1995-2020

Districts	1995	2000	2005	2010	2015	2020
North Bihar Plain (NBP)						
Kishanganj	3.29	2.85	4.52	5.11	4.62	4.11
Araria	3.25	3.23	3.36	3.56	3.78	3.31
East Champaran	4.62	3.77	4.41	4.48	4.14	3.11
Madhubani	3.16	2.88	4.14	3.16	4.31	2.21
Sitamarhi	3.55	2.98	4.49	3.48	4.97	2.09
Supaul	2.67	3.03	2.94	2.96	2.82	2.99
West Champaran	4.10	3.48	5.18	4.85	3.78	3.59
Gopalganj	4.40	3.25	3.82	4.38	4.48	2.60
Siwan	4.90	6.73	4.21	5.78	5.43	3.37
Sheohar	4.00	3.58	5.46	3.16	5.68	2.08
Muzaffarpur	5.04	4.46	5.04	5.44	5.77	2.73
Samastipur	5.55	5.30	6.80	7.80	7.54	3.59
Vaishali	6.07	5.62	5.74	7.00	6.94	3.44
Darbhanga	2.90	3.24	4.89	4.05	5.59	2.57
Khagaria	6.30	6.57	6.39	7.55	6.18	4.95
Begusarai	6.64	6.28	7.31	7.94	7.20	4.90
Madhepura	3.10	3.72	3.48	4.38	4.36	3.75
Saharsa	2.80	3.36	3.78	4.25	3.58	3.11
Katihar	4.15	4.45	4.04	5.05	5.04	3.80
Purnia	3.28	3.54	3.75	4.43	4.62	3.65
Saran (Chhapra)	6.87	7.21	4.72	6.47	6.10	3.20
South Bihar Plain (SBP)						
Lakhisarai	6.33	6.41	7.74	8.43	8.72	5.04
Munger	5.35	5.19	6.21	7.28	7.17	4.46
Bhagalpur	5.09	4.68	5.41	6.81	6.95	6.85
Nalanda	4.36	4.91	4.80	5.84	6.88	3.96
Buxar	6.17	5.72	6.14	6.67	7.31	5.97
Banka	5.48	5.36	4.87	6.03	5.81	5.12
Jehanabad	4.40	5.44	5.42	7.09	5.57	3.39
Sheikhpura	6.34	5.41	5.98	7.27	6.47	4.04
Kaimur (Bhabua)	7.03	7.94	6.70	8.79	8.33	8.40
Jamui	8.19	7.79	8.63	9.30	8.26	6.14
Nawada	4.78	5.13	5.16	7.89	6.43	4.41
Arwal	4.80	5.35	4.74	6.93	5.76	3.98
Bhojpur	5.46	4.74	6.02	6.45	7.00	4.54
Rohtas	6.75	7.00	6.70	8.06	8.30	7.78
Patna	5.22	5.93	5.89	6.92	7.26	4.24
Aurangabad	5.82	6.14	6.04	7.59	7.66	5.36
Gaya	5.39	7.08	5.85	7.58	7.60	3.85
Bihar	4.96	5.04	5.27	6.06	6.00	4.22

Source: *Central Groundwater Board.*

During the period 1995 to 2020, most of the districts showed an increase in water level with only a few districts with decreasing water levels. The water level dropped in Purnia, Saharsa, Supaul, Bhagalpur, Kaimur, Kishanganj, Rohtas and Araria districts. Districts of Northern Bihar showed water levels in the range of 0-5 m. Due to shallow water level condition, pockets in the Northern Bihar, particularly in the Kosi and Gandak basins show water logging condition. The Southern Bihar districts depicted a deeper water level in the range of 5-9 m, which might be due to the poor and low potential aquifers in the region.

Groundwater Balance

The groundwater resources of Bihar from 2004 to 2022 reveals thatthe net annual draft has been always lower than the net annual recharge thus providing a scope for further utilization of groundwater in Bihar (Table 3). The groundwater balance has increased during the year from 19.8 bcm to 23.1 bcm due to the increase in annual recharge and draft. The annual round water recharge is significantly high in the Indus-Ganga-Brahmaputra alluvial belt in the North, East and North East India as rainfall is plenty and thick piles of unconsolidated alluvial formations are conducive for recharge (CGWB, 2022). The stage of groundwater extraction increased from 39.26 per cent in 2004 to 44.94 per

Table 3: Groundwater resources of Bihar, 2004-2020

Year	Net annual recharge (bcm)	Net annual draft (bcm)	Groundwater balance (bcm)	Stage of Groundwater Extraction (%)
2004	29.19	9.39	19.80	39.26
2009	28.63	9.79	18.84	43.33
2011	29.34	10.25	19.09	44.26
2013	31.31	10.36	20.95	44.69
2017	31.41	10.78	20.63	45.76
2020	28.05	10.33	17.72	51.14
2022	33.14	10.01	23.13	44.94

Source: *Dynamic Groundwater Resources of India, various issues.*

Table 4: Extent of groundwater exploitation in Bihar, 2004-2020

Category of block	2004	2009	2011	2013	2017	2020	2022
Over-exploited (> 100%)	—	—	—	—	12 (2.0)	7 (1.3)	8 (1.5)
Critical (> 90% and ≤ 100%)	—	—	—	—	18 (3.0)	5 (0.9)	12 (2.2)
Semi-Critical (>70% and ≤ 90%)	—	4 (1.0)	11 (2.0)	14 (3.0)	72 (13.0)	51 (9.5)	46 (8.6)
Safe (≤ 70%)	515 (100.0)	529 (99.0)	522 (98.0)	520 (97.0)	432 (81.0)	471 (88.2)	469 (87.7)
Total	**515**	**533**	**533**	**534**	**534**	**534**	**535**

Source: *Dynamic Groundwater Resources of India, various issues.*

cent in 2022. Stage of Groundwater extraction is the ratio of groundwater draft to the net annual ground water availability. If the value of the groundwater extraction of the assessment unit is less than 70 per cent, it is considered "safe" from the viewpoint of groundwater extraction (Table 3).

Extent of groundwater exploitation

A perusal of Table 4 gives the extent of groundwater exploitation in Bihar. In the year 2004, only four blocks fall under semi-critical condition and rest of the blocks were in safe category. The proportion of safe blocks decreased to 87.7 per cent in 2022 over the years and the percentage of semi-critical blocks reached 8.6 per cent. As the years passed the percentage of over-exploited and critical blocks reached 1.5 and 2.2 per cent respectively, earlier there were no over-exploited and critical blocks in the state.

Figure in parentheses indicates percentage to total

A perusal of the stage of groundwater abstraction for 2022 indicates that out of the total 535 assessment units, 469 assessment units have a stage of extraction within 70%, 46 fall in the range of extraction between 71-90% and 12 fall in the range of extraction between >90 and <100%. Only one assessment unit namely Nagarnausa (96.3%) of Nalanda district has more than 90%. Whereas, eight assessment units have a stage of extraction >100%.

Ultimate Irrigation Potential

A total of 117.54 lakh hectare has been estimated as ultimate irrigation potential in the state including major, medium and minor irrigation schemes, utilizing both surface and ground water (Table 5). While major and medium irrigation schemes have an ultimate potential of 53.53 lakh hectares, the minor irrigation has a potential of 64.01 lakh hectares. If this potential is exploited fully, it can more than cover the total cultivated area in the state. A decrease was observed in the utilized potential of major and medium irrigation from 90 per cent in 207-18 to 75.8 per cent in 2021-22. Out of the total created potential through the major and medium schemes, only 75.8 per cent has been utilized till 2021-22 and an irrigation potential of 24.2 per cent is lost. In minor irrigation sector, though 90 per cent of the created potential is utilized, yet a substantial portion of ultimate potential remains to be exploited.

Table 5: Source-wise Irrigation Potential Created and utilized under Government Schemes (Area in lakh ha.)

Type of Irrigation Potential	Ultimate Potential	2017		2018		2019		2020		2021	
		Created	Utilized	Created	Utilized	Created	Utilized	Created	Utilized	Created	Utilized
1. Major and Medium Irrigation	53.53	29.69	26.72 (90.0)	29.91	23.80 (80.0)	36.89	25.82 (70.0)	37.15	28.02 (75.4)	37.22	28.22 (75.8)
2. Minor Irrigation	64.01	40.79	36.7 (90.0)	41.12	36.99 (90.0)	43.58	39.22 (90.0)	44.76	40.28 (90.0)	45.27	40.74 (90.0)
2.1 Surface Irrigation	15.44	8.14	7.32 (90.0)	8.35	7.50 (90.0)	9.37	8.43 (90.0)	10.28	9.26 (90.0)	10.72	9.64 (90.0)
2.2 Ground Water	48.57	32.65	29.38 (90.0)	32.77	29.49 (90.0)	34.21	30.79 (90.0)	34.48	31.03 (90.0)	34.55	31.09 (90.0)
Total	117.54	70.48	63.42 (90.0)	71.03	60.79 (85.6)	80.47	65.04 (80.8)	81.91	68.3 (83.4)	82.49	68.96 (83.6)

Source : *Economic survey, GOB;* ***Note:*** *Figures in parantheses represents utilized potential as percentage of created potential.*

Along with the creation of new irrigation potential, it is also necessary to ensure that the already created irrigation potential is fully utilized. Due to heavy sedimentation and breach in the irrigation canal system, the created irrigation potential is sometimes not fully utilized.

CONCLUSION

There is enormous potential for further groundwater development in the state. The groundwater development stage is still below 50% in the majority of the blocks in the state. If a regular monitoring of trend of water level and the renewable groundwater resource is done, it can safely be increased up to 90%. Groundwater resources in Bihar are not being used to their full potential The excess runoff owing to water logging condition in the NGP can be harnessed by adequately deepening the water level. It is only possible by enhancing the groundwater development through sinking the tube wells. Deep tube wells can also be drilled to extract the groundwater, though in a conservative manner, from the deeper confined to semi-confined aquifers. Hard rock covered regions and marginal alluvial areas in the SGP should implement artificial groundwater recharge to increase the availability of groundwater resources.

Further, a few areas in the state are witnessing adepletion in groundwater level and a rise in the level up to the water-logging situation. This calls for a judicious and scientific development of available water resources and conjunctive use. In Bihar properly designed conjunctive use of surface water and ground water holds key to balanced development of available water resources which will also address the issues of water logging, pollution and water scarcity, water saving technologies and smart systems as relevant in different parts of the region.

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