A Study on Groundwater Irrigation Expansion in Bihar

ABSTARCT

Water use has increased by more twice the rate of population growth over past century, although there is ~~no~~worldwide water scarcity as such, an increasing number of area are chronically short of water. There has been a substantial increase in irrigated area in last thirty -five years. The NIA in Bihar has increased from 28.08 lakh ha in 1985 to 30.44 lakh ha in 2020.The total annual replenishable groundwater potential of Bihar has been estimated as 33.15 billion cubic meters with an annual extraction of 13.50 bcm.A total of 117.54 lakh hectares has been estimated as ultimate irrigation potential in the state, including major, medium and minor irrigation schemes, utilizing both surface and ground water.If the available potential is exploited fully, it can more than cover the total cultivated area in the state. Considering the interest of both present and futuregenerations attention needs to bedirected towards use of ground water on sustainable basis and promoting various sources ofsurface water.

Keywords: Bihar, Depletion, Groundwater, Irrigation, Scarcity

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Introduction

Groundwater is a vital resource, with a large fraction of the population relying on the resource directly or indirectly for livelihoods. Recently~~Presently~~, about 60 per cent of irrigated agriculture depends on groundwater (World Bank, 2012). Given India's growing population, achieving food security would be extremely difficult, and water shortages will make it much more difficult. Agricultural production of India was stabilized by system canal irrigation, but it was unable to supply all of the water demand for irrigation. It was necessary to develop groundwater resources and gradually use them in order to meet the irrigation requirements of intensive agriculture. Since the start of the Green revolution, groundwater replaced surface water as the main source of irrigation in India. Modern drilling methods, inexpensive or free power, electric-operated pumping systems and the absence of effective groundwater laws have encouraged unrestrained use of groundwater in the country (Patle et al., 2015). Farmers also prefer groundwater because they have more control over the quantity and time of water delivery (Srinivasan & Kulkarni, 2014).

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In India, the green revolution wasable to combatfood shortages in thecountry due togroundwater irrigation. However, at present theeffects of overdoses such as prematurefailure of

resources, decreased groundwaterdischarge and depletion of water tables are evident(Chandrakanth *et al*., 2004; Nagaraj *et al*., 2005).Since independence, the area irrigated bygovernment canals has decreased by 2.4 percent,while that irrigated area by wells has increased by3.9 percent (Kumar *et al*., 2003). It has become themain source of growth in irrigated area over thepast ~~3~~three decades. The primary source of irrigated cropproduction in the country is groundwater.Groundwater is being widely used forcrop production. Undoubtedly agricultural productivity ofirrigated land is higher than that of un-irrigated land. Presentstudy is attempted with the main objectives of findinggrowth of irrigated area under groundwater Bihar.

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METHODOLOGY

To fulfil the objectives of the study secondary data was collected from Central Ground Water Board, Directorate of Economics & Statistics,Economic Survey and Department of Water Resources.

Tabular method of analysis has beenextensively used in the study. Beside this, CompoundAnnual Growth Rate (CAGR) of area under surface water irrigation andground water irrigation has been estimated in the study.

Compound annual growth rate: Growth rates are measures of past performance of economic variables and are commonly used as summaries of trends. The growth rates were estimated to study the percentage increase or decrease in the selected variable per unit of time. The growth rate was estimated using the exponential growth function of the form

$$Y_t = ab^t e^{Ut}$$

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Log transformation of the above function is

$$\ln Yt = \ln a + t (\ln b) + u$$

$$\ln b = \ln (1+r)$$

where, $b = 1+r$

$$r = b - 1$$

$$r = [\text{Antilog } (\ln b) - 1]$$

The compound growth rates were calculated using the formula

$$\textbf{CGR (\%)} = \mathbf{r \times 100}$$

Where,Yt = area/production/yield/export of major spices for the year 't'

t = Time variable

a = Constant

ln b = Regression coefficient of time

u = Error term, and

r = CGR

RESULTS AND DISCUSSIONS

Water Resources of the Bihar

The state of Bihar possesses abundant groundwater and surface water resources. In addition to rainfall, the internal rivers of the state provide a generous amount of its water supply. These rivers contribute to the state's hydrothermal energy production, in addition to providing water for irrigation. In addition, they influence the Bihar plain and serve as a medium for the transportation of water, supply fishes for the fishing industry and enrich the natural resources of the state in many other ways. The state also has a groundwater supply that is used for industry, agriculture and drinking.

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Surface water availability

The river system in Bihar is the main source of surface water, apart from rainfall, which has multiple minor sources and is currently inconsistent. One of the most significant features of the river system in the state is the principal role of Ganga, which provide water for daily use by habitants for drinking, industry, irrigation, other commercial applications and recharges the underground water. The Ganga, which is the major river, is joined by tributaries that originate in the Himalayas. Other rivers originate in the plateau region and flow northward to join the Ganges or one of its associated rivers. There are numerous rivers in Bihar which contribute a lot to the people of Bihar.

Groundwater availability

Bihar state is blessed with a substantial replenishable groundwater resource in the unconsolidated aquifers in Gangetic alluvial plains, which covers more than two-third of its geographical area. The total annual replenishable groundwater potential of Bihar has been estimated as 33.15 billion cubic meters (bcm) with an annual extraction of 13.50 bcm (Table 1). The annual extractable groundwater of the state is 30.04 bcm, which is 7.55 per cent of the total groundwater resources of the country. After leaving aside nearly 44.21 per cent for domestic and industrial uses, a total of 16.76 bcm (55.79 per cent of the total available) is available for irrigation (CGWB, 2022). The stage of groundwater extraction is 44.94 per cent. This is below the country's overall stage of groundwater extraction of 60.08 per cent. Only 1.5 per cent of the state blocks are over exploited. As the groundwater development in Bihar is in the safe zone, it can be harnessed to a great magnitude in order to boost irrigation facilities in the state.

Table 1: Groundwater availability and utilization in Bihar and Bhagalpur, 2022

Particulars	Bihar	Bhagalpur
Annual replenishable GW resources (bcm)	33.15	0.75
Net groundwater availability (bcm)	16.76	0.44
Annual extractable groundwater resource (bcm)	30.04	0.68
Current annual groundwater extraction (bcm)	13.50	0.24
Stage of groundwater development (per cent)	44.94	34.58
Safe blocks (%)	87.66	100
Semi-critical blocks (%)	8.60	0
Critical blocks (%)	2.24	0
Over-exploited blocks (%)	1.50	0

Source: Central Groundwater Board, 2022

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The annual replenishable groundwater for Bhagalpur district in 2022 was estimated at 0.75 bcm. The annual extractable groundwater resource stood at 0.68 bcm with an annual extraction of 0.24 bcm, leaving a net groundwater availability of 0.44 bcm. The stage of groundwater development was 34.58 per cent with all the blocks under safe category.

Ultimate irrigation potential

In Bihar, agriculture is still highly reliant on rainfall. Due to recent climate change, the average annual rainfall is around 1000 mm, varying across the state. The agricultural economy of the state depends on the extent of irrigation infrastructure. The irrigation system is broadly divided into three categories: (i) Major irrigation scheme which covers Culturable Command Area (CCA) of more than 10,000 ha.; (ii) Medium irrigation scheme which covers CCA between 2000 and 10,000 ha.; and (iii) Minor irrigation scheme which covers upto 2000 ha of CCA.

The results in t~~T~~able 2 shows the details of the ultimate irrigation potential and current utilization in Bihar for the last five years i.e. from 2017 to 2021. A total of 117.54 lakh hectares has been estimated as ultimate irrigation potential in the state, including major, medium and minor irrigation schemes, utilizing both surface and ground water. 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

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in the state (under all three schemes). 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, a substantial portion of ultimate potential remains to be exploited.

The advantages of investing in irrigation are realized only when there is an efficient utilization of the created irrigation potential (Fig. 1). The water use efficiency of major and medium irrigation projects in Bihar during the ~~years~~period 2017-18 to 2021-22is presented in ~~Table~~ table 2. The ratio of actual irrigation to created irrigation potential is known as utilization efficiency. The overall utilization efficiency in 2017-18 was 65.10 per cent which has increased to 75.80 per cent in the year 2021-22. Among the agricultural season, the utilization efficiency was highest during the hot weather season (96.6 %) followed by rabi (92.7 %) and kharif (87.7 %) seasons in the year 2017-18. The utilization efficiency was the highest during the kharif season (97.5 %), followed by rabi season (96.2 %) and hot weather season (85.2 %) in 2021-22. As only 75 per cent of the created potential has been utilized, there still is potential to exploit it further.

Table 2: Source-wise irrigation potential created under government schemes,2017-2021

Type of Irrigation Potential	Ultimate Potential	2017		2019		2021	
		Created	Utilized	Created	Utilized	Created	Utilized
(a) Major and Medium Irrigation	53.53	29.69	26.72 (90.0)	36.89	25.82 (70.0)	37.22	28.22 (75.8)
(b) Minor Irrigation	64.01	40.79	36.7 (90.0)	43.58	39.22 (90.0)	45.27	40.74 (90.0)
(i) Surface Irrigation	15.44	8.14	7.32 (90.0)	9.37	8.43 (90.0)	10.72	9.64 (90.0)
(ii) Ground Water	48.57	32.65	29.38 (90.0)	34.21	30.79 (90.0)	34.55	31.09 (90.0)
Total	**117.54**	**70.48**	**63.42 (90.0)**	**80.47**	**65.04 (80.8)**	**82.49**	**68.96 (83.6)**

Source : Economic survey, GoB

Note: Figures in parantheses represents utilized potential as percentage of created potential

The total area irrigated during 2019-20 to 2021-22 through various minor irrigation sources is presented in Table 3. In 2019-20, only 42.80 per cent of the area was irrigated through tanks (including Ahars and Pyne) which increased to 84.80 per cent in 2021-22. Ahars and Pyne are traditional irrigation systems of Bihar. Ahars, with earthen bund on three sides, collects water from

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natural drainage or through pynes (local name of the diversion channel), which diverts water from the river. The area irrigated by private and state tubewells under minor irrigation scheme was 56.80 per cent in 2019-20 which drastically reduced to 14.60 per cent in 2021-22.

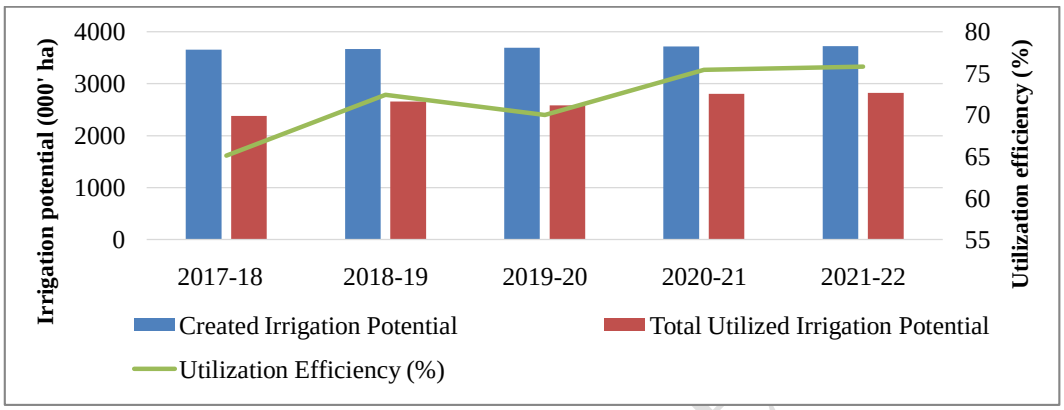

Figure. 1: Water utilization pattern of major and medium irrigation schemes (2017-18 to 2021-22)

Table 3: Area brought under irrigation through minor irrigation sources (2019-20 to 2021-22)

Source	2019-20	2020-21	2021-22
Tanks (including Ahars andPyne)	66429 (42.80)	91320 (77.60)	43016 (84.80)
Tubewells (Private and State)	88175 (56.80)	26360 (22.40)	7400 (14.60)
Other Sources (Lift Irrigation)	640 (0.40)	80 (0.10)	280 (0.60)
Total	155244 (100)	117760 (100)	50696 (100)

Note : Figures in parentheses indicate percentage share to total
Source : Department of Minor Water Resources, GoB

Trends and shifts of water use mechanisms in Bihar

There has been a substantial increase in irrigated area in last thirty -five years. The NIA in Bihar has increased from 28.08 lakh ha in 1985 to 30.44 lakh ha in 2020. During this period, a structural shift can be observed in the relative share of different sources of irrigation in NIA over the years. The share of canal irrigated area decreased slightly from 34.6 per cent during 1985-86 to 31.4 per cent during 2020-21. While, the share of tubewell irrigated area increased from 33.2 per cent during 1985-86 to 62.4 per cent during 2020-20 (Fig. 2). The share of tank and other sources of irrigation have declined over the same period. A drastic decrease in share of other sources was observed from 27.8 per cent to 4.4 per cent during the period 1985 to 2020.

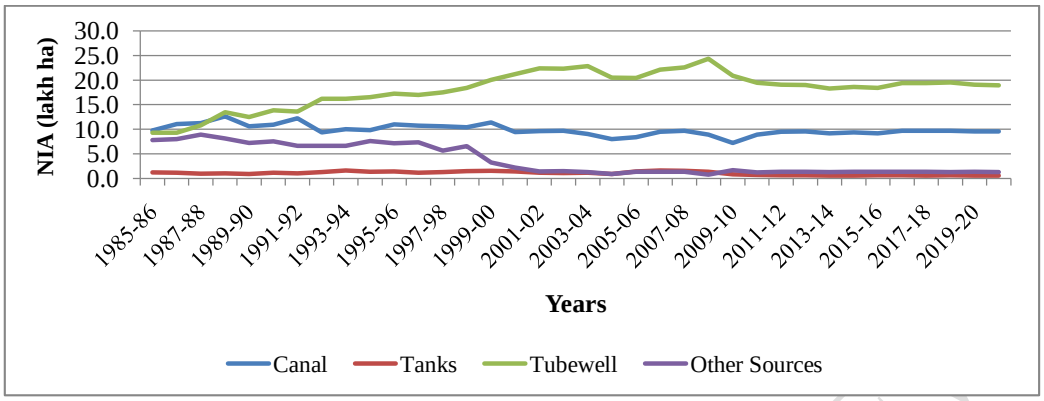

Figure. 2: Trends of different sources of irrigation in Bihar

The growth rate of canal, tank and other sources irrigated area showed a negative trend during the period 1985-2020 (Table 4). On the other hand, the growth of tubewell irrigation was found to be 1.58 per cent during the same period and was significant at 1 per cent. A high growth rate was seen in tubewell irrigated area in almost all the time periods, more particularly during 1985-90. The growth rate for tubewell irrigated area was 9.23 per cent in 1985-90, 3.81 in 1991-96 and 5.46 in 1997-2002 and was significant in all the time periods.

Table 4: Period-wise compound growth rate of area irrigated by sources, Bihar

Time Period	Canal	Tank	Tubewell	Others
1985-1990	1.61	-2.89	9.23***	-1.65
1991-1996	-0.55	2.43	3.81**	2.48*
1997-2002	-2.43	-4.54	5.46***	-28.15***
2003-2008	1.79	7.90	1.98	-3.45
2009-2014	4.04	-5.63**	-2.20**	-0.58
2015-2020	0.49	-1.88**	0.33	-1.07*
1985-2020	-0.59***	-2.37***	1.58***	-6.69***

Note: *** Significant at 1 per cent, ** Significant at 5 per cent, * Significant at 10 per cent
Source: Directorate of Economics & Statistics, GoI

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The net irrigated area by canal, tank and other sources showed an overall decline during the period 2000-2020 in Bhagalpur. By the year 2004-05, none of the areas in Bhagalpur were under canal irrigation, but in 2009-10, it increased again but at a constant rate (Fig. 3). On the other hand, the share of NIA by tubewell showed a tremendous increase from 57 per cent in 2000-01 to 91 per cent in 2020-21. Highest increase was observed during the year 2007-08 which was 97 per cent.

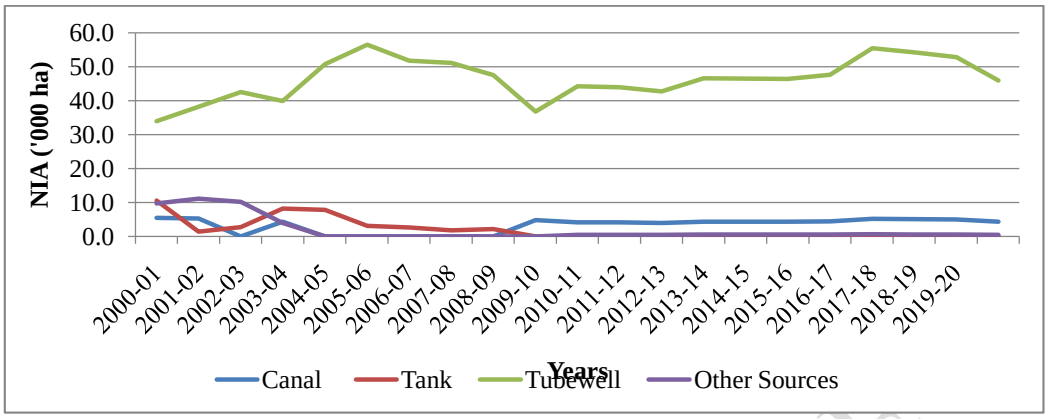

Fig. 3: Trends of different sources of irrigation in Bhagalpur

The canal irrigated area showed an annual growth rate of 5.38 per cent during the period 2000-01 to 2020-21, which was significant at 5 per cent (Table 5). The growth rate for tank and other sources irrigated area showed a decreasing trend at 9.25 and 12.77 per cent respectively. It was negatively significant at 1 per cent. Whereas, tubewell irrigated area showed a growth rate of 1.05 per cent, which was significant at 5 per cent level of significance. The growth rate of tubewell was 8.84 per cent during the period 2000-01 to 2004-05, which was the highest among all the studied period. During the same period a drastic decrease was observed for canal and other sources irrigated area.

Table 5:Period-wise compound growth rate of area irrigated by sources, Bhagalpur

Period	Canal	Tank	Tubewell	Other sources
2000-2004	-30.13	12.14	8.84**	-42.75*
2005-2009	-	-26.69*	-2.27	-
2010-2014	1.56	-	1.57	1.74
2015-2020	0.68	-	3.83	-0.63
2000-2020	**5.38****	**-9.25*****	**1.05****	**-12.77*****

Note: *** Significant at 1 per cent, ** Significant at 5 per cent, * Significant at 10 per cent
Source: Directorate of Economics & Statistics, GoI

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There is enormous potential for further groundwater development in the state. The available net groundwater resource for irrigation is 10.01 bcm. The state's irrigation intensity can be increased by effectively using this volume. The excess run off owing to water logging condition in the NGPcan be harnessed by adequately deepening the water level. This can only be achieved by enhancing groundwater development through sinking tube wells.

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CONCLUSIONS

Use of surface water is declining and ground water isincreasingly used in crop production. The share of canal irrigated area had decreasing while the share of tubewell irrigated area increased.On the other hand, increase inpopulation calls for expansion of agricultural output. This isnot possible without use of irrigation water either from waterbodies on the surface or from the stock of ground water.Considering the interest of both present and futuregenerations attention of academicians, planners needs to bedirected towards use of ground water on sustainable basis.Simultaneously this entails for promoting various sources ofsurface water.

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