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Development of Irrigation in Haryana

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Abstract: In a geographical study, it is essential to study the cropping pattern because it plays a vital role in finding an agricultural transformation of an area. The present paper attempts to study source of Haryana, depicting the changes in source of irrigation in the state, taking two points of time, i.e., 1990-91 and 2020-21. The data used in this study were sourced from various editions of the Statistical Abstracts of Haryana. The findings indicate a significant transformation in the irrigation patterns and structure of the state over the years, with tubewells and canals emerging as the primary sources of irrigation. The adoption of tubewell irrigation varies across districts, depending on technological feasibility and natural conditions, with certain areas relying heavily on tubewells. However, the overuse of groundwater has led to a decline in the sustainability of tubewell irrigation in some regions. Canal irrigation has also diminished due to the underperformance of surface irrigation systems, market failures, and the inability of public sector agencies to provide adequate irrigation water. This study offers valuable insights into the evolving irrigation structure and the factors influencing the sustainability of irrigation sources in Haryana, which can inform policymakers and stakeholders in the development of sustainable irrigation strategies.

Introduction:

Irrigation plays a pivotal role in agricultural development by ensuring a stable supply of water to crops, which is crucial for maintaining and increasing agricultural productivity, especially in regions prone to inconsistent rainfall. The significance of irrigation extends beyond just sustaining crop growth; it influences various aspects of agricultural and economic development.The significance of irrigation in agriculture cannot be understated. It not only ensures a steady supply of water to crops, critical in dry periods, but also facilitates the growth of multiple cropping cycles per year, which significantly boosts annual agricultural output. According to Brouwer, Goffeau, and Heibloem (1985), "Irrigation increases the possibilities for the crop selection and allows for cultivation of more high-value crops, which need more

water than cereals." This strategic usage of water through irrigation systems enhances both the quantity and quality of agricultural produce, ensuring food security and providing the raw materials The rice-wheat cropping pattern in Haryana has long been the backbone of the state's agricultural economy, reflecting both its agronomic practices and the region's irrigation infrastructure. Over the past three decades, from 1990 to 2020, this cropping pattern has undergone significant changes, driven by factors such as technological advancements, water availability, market dynamics, and climate conditions. Haryana, being a major producer of both rice and wheat, has seen a steady rise in the area under cultivation of these crops, particularly in the regions with extensive irrigation systems. However, this temporal analysis also highlights the challenges faced in sustaining such a cropping pattern, including issues like soil degradation, water scarcity due to over-reliance on irrigation, and the need for crop diversification. The shift in cropping patterns, the adoption of improved seed varieties, and changes in government policies have influenced the cultivation trends. This analysis aims to explore the evolution of the rice-wheat cropping system in Haryana, assessing its impacts on productivity, resource management, and sustainability over the past three decades. Understanding these changes is crucial for formulating strategies to address the future agricultural needs of the state while balancing environmental concerns and the growing demand for food.

Study area:

Haryana, a small state with a significant presence, is located in the northwestern part of India. It was formed on November 1, 1966, following the bifurcation of the erstwhile Punjab under the Punjab Reorganisation Act, creating two distinct states—Punjabi-speaking Punjab and Hindi-speaking Haryana. The origin of the name 'Haryana' has sparked much debate, with various interpretations. According to the *Imperial Gazetteer of India*, the name 'Haryana' is likely derived from the word ‘Hari’, meaning green, possibly reflecting the region's once lush and fertile landscape. provides an in-depth analysis of Haryana as the study area for this research. The chapter focuses on the physical, geographical, and socio-economic characteristics that shape the state's agricultural landscape. The aim is to offer a detailed background of the region, its natural resources, climatic conditions, and agricultural infrastructure, which are crucial for understanding the impact of irrigation on agricultural productivity and development.

Agro-climatic zone

Economic and Statistical Organization, Planning Department Haryana, (2007) has divided the state into four agro climatic zones which are conducive for a different variety of crops. In Agro

climatic Zones the Districts included are:

1. Northern Panchkula, Ambala, Yamunanagar, Kurukshetra, Karnal, Panipat
2. Central Kaithal, Jind, Sonipat, Rohtak, Jhajjar
3. Western Bhiwani, Hisar, Fatehabad, Sirsa
4. Southern Faridabad,Gurgaon, Rewari, Mahendragarh.(fig.1.1)

Objectives:

- Development of sources of irrigation in Haryana from 1990-91 to 2020-21.

Database and Methodology:

The methodology for this study is designed to comprehensively analyse the source of irrigation in Haryana. In the study secondary data has been used. The bar diagram, line graph and many methods has been employed.

The study will focus on the period from 1990-91 to 2020-21, capturing the long-term effects of irrigation expansion, technological advances, and shifts in agricultural policy.

Table 1Major Irrigation Projects in Haryana

	Project Name	Type of Initiative	Description of Activity	Area Covered (in hectares)	Districts Benefited
1	Western Yamuna Canal	Expansion	Expansion to increase irrigation capacity	25,000	Karnal, Panipat, Sonipat
2	Bhakra Canal	Upgrade	Modernization of canal gates and lining	40,000	Hisar, Sirsa, Fatehabad
3	Gurgaon Canal System	New Installation	New canal system for southern regions	15,000	Gurgaon, Mewat
4	Rajiv Gandhi Lift Canal	Expansion	Extended reach to new agricultural lands	30,000	Bhiwani, Jhajjar
5	Sprinkler Subsidy Program	Initiative	Subsidies for farmers to adopt sprinkler systems	Varies	Statewide
6	Drip Irrigation Project	New Installation	Installation of drip irrigation systems	20,000	Ambala, Kurukshetra
7	Modernization of Tubewells	Upgrade	Upgrading old tubewells to reduce water wastage	Varies	Multiple districts

Western Yamuna Canal Expansion (1991): This project was aimed at expanding the capacity of one of Haryana's oldest and most significant canal systems, enhancing water availability for multiple districts. Bhakra Canal Upgrade (1995): Involved structural improvements to ensure

more efficient water flow and reduce losses due to seepage or evaporation. Gurgaon Canal System Installation (2000): A strategic initiative to support agriculture in regions with less developed irrigation infrastructure. Rajiv Gandhi Lift Canal Expansion (2005): Extended the reach of a crucial lift canal system to new areas, particularly benefiting arid regions. Sprinkler Subsidy Program (2010): State-sponsored subsidies to promote water-efficient sprinkler systems among farmers across Haryana. Drip Irrigation Project (2015): Focused on installing water-saving drip irrigation technologies in districts with high-value crop production. Modernization of Tubewells (2020): Targeted upgrade to existing tubewells, focusing on enhancing efficiency and reducing groundwater depletion.

Canal Irrigation

Canal irrigation has played a pivotal role in shaping Haryana's agricultural landscape, contributing significantly to its success as one of India's leading agricultural states. The state's canal irrigation system is primarily fed by the Bhakra-Nangal and Sirhind canals, which bring water from the Sutlej and Yamuna rivers, respectively. These canals have transformed vast areas of Haryana, especially in the northern and western regions, into highly productive agricultural land. Canal irrigation has been instrumental in ensuring the cultivation of water-intensive crops like rice, sugarcane, and wheat, boosting the state's agricultural output and making it a key contributor to India's food grain production. Over the years, Haryana has expanded and modernized its canal infrastructure, improving the efficiency of water distribution to farmers. However, despite its successes, the system faces challenges such as waterlogging, salinity, and the declining availability of water in the major canals. These issues have raised concerns about the long-term sustainability of canal irrigation, making it essential for the state to focus on water conservation, better management practices, and the adoption of alternative irrigation technologies like drip and sprinkler systems to complement the existing canal infrastructure.

Irrigation is essential for agriculture, and it can be sourced from various means. The most reliable sources are those that involve sufficient storage or rivers with consistent flows throughout the crop season. However, rivers cannot supply water to all regions, so irrigation in some areas must rely on canals or groundwater lifting. Canal water, much like river water, cannot reach every location, creating a significant need for lifting irrigation, either through groundwater or canal water.

Canal irrigation is economically beneficial for farmers, offering ease of access, regular water supply, and reliable water flow to fields. Under the Indus Waters Treaty, the rights to the eastern rivers—Ravi, Beas, and Sutlej—were allocated to Punjab. The canal systems in

Haryana, as they exist today, are primarily inherited from the undivided Punjab state (Gupta, 2000)

Canal Systems Serving Haryana

Haryana's canal irrigation network includes three major gravity canal systems and four major lift canal commands:

(i)Western Jamuna Canal (WJC) System, including lift irrigation schemes for Jui, Sewani, Loharu, and Jawahar Lal Nehru Canal.

(ii)Bhakra Canal System.

(iii)Gurgaon Canal System and Agra Canal System.

Each of these systems has distinct characteristics:

Bhakra Canal System receives assured water supplies from the stored water in the Sutlej River at the Bhakra Reservoir. It also receives surplus Ravi-Beas water diverted via the Beas-Sutlej Link Channel at Pandoh.

Western Jamuna Canal System is dependent on the flow of the Yamuna River, whichh fluctuates depending on the river's seasonal behavior.

Gurgaon Canal System is served by Yamuna water during the monsoon season for about 100 days and by Ravi-Beas water during the rest of the year.

Table. 2 Net Area under Irrigation by Canals in Haryana

Districts/Agro climatic Zones	**Canals (Net Area, 000hac)**		**Percent to Net Irrigated Area**	
	1990-91	2020-21	1990-91	2020-21
Ambala	1.00	3	1.20	3.09
Punchkula	-		-	0.00
Yamunanagar	3.00	2	3.26	2.78
Kurukshetra	11.50	28	8.65	15.23
Karnal	34.00	56	19.60	19.10
Panipat	50.00	40	40.32	34.63
Northern	**99.50**	**129**	**16.43**	**13.60**
Kaithal	99.00	77	46.70	20.23
Sonipat	74.00	24	56.50	31.55
Rohtak	161.00	75	66.95	62.36

Jhajjar	-	52	-	4.23
Jind	125.60	217	59.90	73.18
Central	**459.66**	**445**	**57.98**	**47.09**
Faridabad	37.50		40.12	0.00
Palwal	-	21	-	29.06
Gurgaon	11.50	-	13.55	1.67
Mewat	-	14	-	11.63
Rewari	4.00	-	4.28	1.38
Mahendragarh	5.00	1	6.84	17.14
Southern	**57.50**	**36**	**16.89**	**11.46**
Bhiwani	105.00	58	62.50	53.31
Hisar	395.50	206	87.50	75.99
Fatehabad	-	63	-	51.77
Sirsa	242.50	269	88.16	80.89
Charkhi Dadri	-	26	-	25.11
Western	**742.50**	**622**	**83.02**	**57.41**
HARYANA	1359.00	1232	51.61	41.13

Source: Statistical Abstract of Haryana (various issues)

The data on net area under irrigation by canals in Haryana across various districts or agro-climatic zones highlights changes in the reliance on canal irrigation from 1990-91 to 2020-21. Based on the percentage of net irrigated area under canal irrigation in 2020-21, districts are categorized into different ranges. Districts such as Hisar, Sirsa, and Rohtak remain highly reliant on canal irrigation, with Hisar (75.99percent) and Sirsa (80.89percent) showing very high percentages. The Western zone, including these districts, traditionally had a significant reliance on canal irrigation, but this has decreased over time. Other districts, including Jind (73.18percent) and Bhiwani (53.31percent), still have a solid share of canal irrigation but have seen some decline from earlier years.

In contrast, areas like Karnal (19.10percent) and Panipat (34.63percent) have seen a reduction in canal irrigation, with their dependence on it moving into the mid-range category. Districts such as Kurukshetra (15.23percent), Sonipat (31.55percent), and Mahendragarh (17.14percent) have moderate levels of canal irrigation, although some of these areas show an improvement in recent years. On the lower end of the spectrum, districts like Ambala (3.09percent), Yamunanagar (2.78percent), and Faridabad (0.00percent) have minimal or no reliance on canal

irrigation, signaling a shift to alternative irrigation methods or a reduction in canal water availability.

Overall, the data reflects a general decrease in canal irrigation across Haryana, especially in regions that once had heavy reliance on it. This trend suggests a possible transition toward other irrigation practices or a decline in the capacity of canal systems, which could be influenced by factors such as changing water availability or infrastructure limitations. The shift in reliance on canal irrigation, particularly in areas like Gurgaon, Faridabad, and Palwal, also indicates broader agricultural adaptation strategies across the state.

Haryana Irrigation department achieved 100 percent target in canal linking. Rice cultivation and the HYV seeds increased the demand of water which could not be met through rainfall alone and the caused the great reliance on tube well irrigation. So, this level has only achieved by the increase of canal and tube well irrigation facilities in the Haryana.

Further in 2020-21, net area under irrigated reached to 2973 thousand hectares from 2600 thousand in 1990-91 with addition to 373 thousand hectares. Net area irrigated by canals has decreased 51.61 percent to 41.13 percent from 1990-91 to 2020-21. It means that canal irrigation area has decreased; due to tube well irrigation has increased from 1990-91 to 2020-21. Moreover, Government and private banks have provided easy bank loans for installation of tube well/ pumping sets and other irrigation facilities. Sirsa district is on top position with 80.89 percent to net irrigated area by the canals whereas Punchkula took the last position. It means that area under tube well irrigation grew at much faster pace than area under canal irrigation. In 2001 both major source of irrigation i. e. canals as well as tube well became almost equal contribution in irrigation development, contribution 49.39 percent and 50.10 percent irrigated respectively. When we see the zone wise canal irrigated area, the western agro-climatic zone (Sirsa, Bhiwani and Hisar) has top position with 68.91 percent to the total irrigated area followed by Central agro-climatic zone (Rohtak, Sonipat and Jind). While in northern agro-climatic zone (Ambala, Yamunanagar, Karnal and Panipat) has lowest canal irrigated area.

Table 3: Haryana, Zone-Wise Area under Canal Irrigation (1990-91 and 2020-21)

Zone	1990-91		2020-21	
	Net Area (,000 ha)	percent to Net Irrigated Area	Net Area (,000 ha)	percent to Net Irrigated Area
Northern Agro-Climatic Zone	99.5	16.43	129	13.60
Central Agro-Climatic Zone	459.5	57.98	445	47.09
Southern Agro-Climatic Zone	57.5	16.89	36	11.46
Western Agro-Climatic Zone	742.5	83.01	622	57.41
Haryana	1359	51.61	1232	41.13

Source: Compiled by researcher

The table presents data on the area under canal irrigation across different agro-climatic zones of Haryana, comparing two time points: 1990-91 and 2020-21. In 1990-91, the total net area under canal irrigation in Haryana was 1,359,000 hectares, which accounted for 51.61percent of the net irrigated area in the state. By 2020-21, the total net area under canal irrigation had decreased to 1,232,000 hectares, making up 41.13percent of the state's net irrigated area.

Looking at the zones individually, the Northern Agro-Climatic Zone saw a slight increase in area under canal irrigation, from 99,500 hectares in 1990-91 (16.43percent of the net irrigated area) to 129,000 hectares in 2020-21 (13.60percent of the net irrigated area). This suggests a growing but relatively smaller reliance on canal irrigation in this zone over the period.

In the Central Agro-Climatic Zone, the area under canal irrigation slightly decreased from 459,500 hectares in 1990-91 (57.98percent of the net irrigated area) to 445,000 hectares in 2020-21 (47.09percent of the net irrigated area). This reflects a trend of reduced dependence on canal irrigation, possibly due to changes in irrigation practices or the increased use of other water sources.

The Southern Agro-Climatic Zone experienced a decrease in canal-irrigated area, from 57,500 hectares (16.89percent of the net irrigated area) in 1990-91 to 36,000 hectares (11.46percent) in 2020-21, highlighting a significant shift away from canal irrigation in favor of other water sources or agricultural practices.

The Western Agro-Climatic Zone, traditionally the largest beneficiary of canal irrigation, saw a substantial decline in its share of canal-irrigated area, from 742,500 hectares in 1990-91 (83.01percent of the net irrigated area) to 622,000 hectares in 2020-21 (57.41percent). This

drop reflects a decrease in the relative reliance on canal irrigation in the face of other sources like groundwater.

Overall, the table indicates a decrease in the share of canal irrigation in Haryana's agricultural landscape, with a shift towards other sources of water for irrigation. This could be attributed to various factors, including the growing reliance on groundwater, the expansion of micro-irrigation technologies, and changes in cropping patterns.

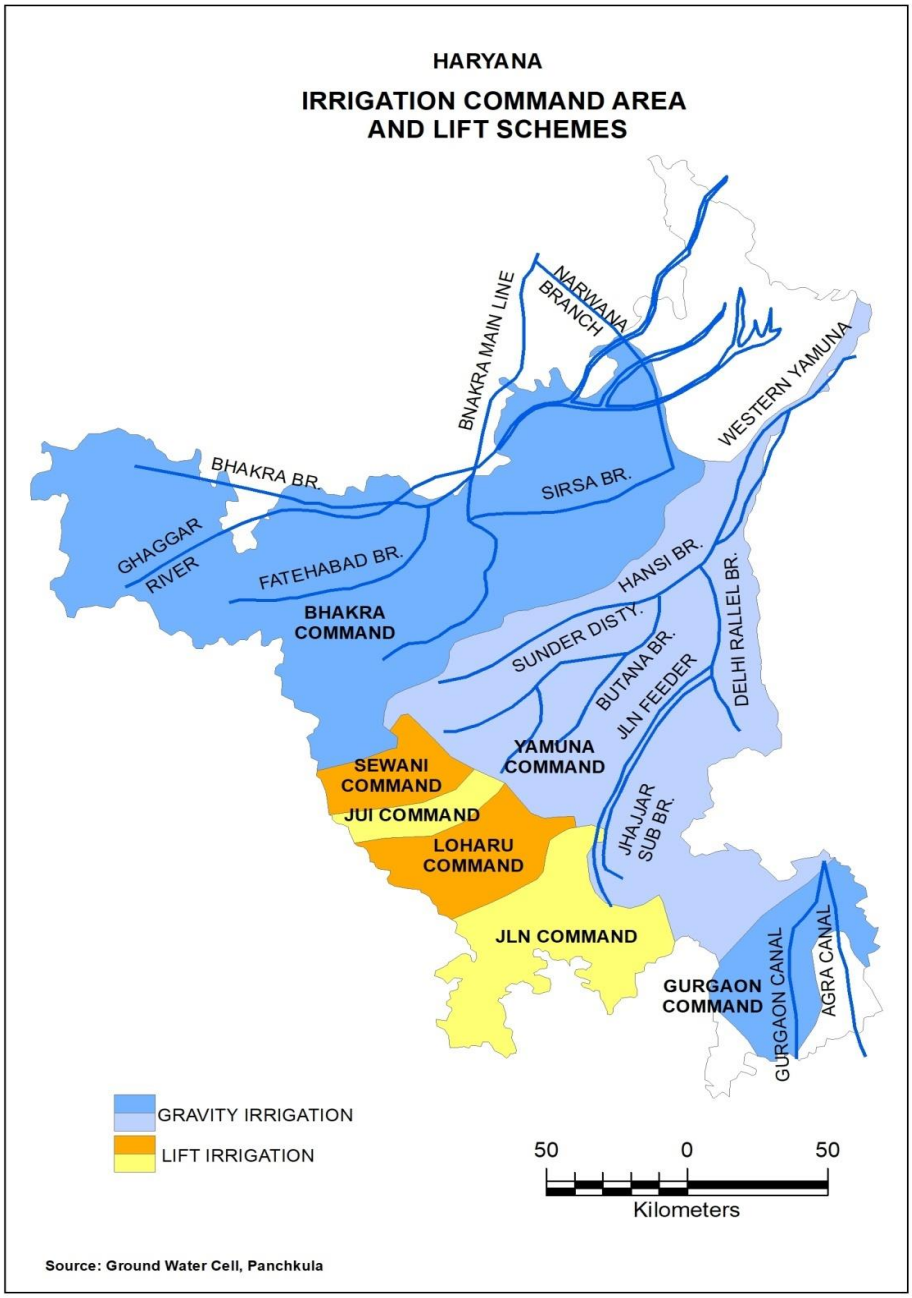


Fig. 1

Irrigation command area and lift irrigation schemes are crucial components of Haryana's water management strategy, ensuring effective distribution of water to agricultural fields. The term "irrigation command area" refers to the area of land that can be irrigated through a particular irrigation system, such as a canal, where water is distributed to farmers based on the system's capacity. Haryana has developed an extensive irrigation command area, primarily under canal irrigation, which has significantly increased the agricultural productivity of the state. The major canal systems, including the Bhakra-Nangal and Sirhind canals, provide water to vast regions, creating extensive command areas that support the cultivation of water-intensive crops like rice and wheat.

In addition to canal irrigation, Haryana also relies on lift irrigation schemes, especially in areas where gravity-based canal irrigation is not feasible due to topographical constraints. Lift irrigation involves pumping water from rivers, ponds, or other water sources to higher elevations, where it can then be distributed to the fields. This scheme has been particularly beneficial in areas with limited access to surface water and where groundwater levels are declining. Lift irrigation systems are implemented through various projects across Haryana, helping to enhance water availability in otherwise arid or semi-arid regions. Together, both the irrigation command areas and lift schemes play a crucial role in supporting Haryana's agricultural economy, ensuring that water resources are efficiently utilized to meet the demands of the growing agricultural sector. However, the sustainability of these systems remains a challenge due to issues such as water scarcity, inefficient distribution, and the increasing pressure on existing water resources.

Tube-well irrigation in Haryana

Tube-well irrigation allows for the extraction of groundwater to irrigate crops, providing a reliable water source during periods of low rainfall. The technology has been instrumental in supporting year-round farming and the diversification of crops beyond traditional seasons. As noted by Dhawan (2000), "The spread of tube-well irrigation in Haryana has been phenomenal, primarily due to the state's encouragement of groundwater development as a strategy to increase agricultural output and improve rural livelihoods." This shift has not only increased agricultural productivity but also contributed to groundwater depletion, raising concerns about sustainability.

The government of Haryana has implemented various policies to promote the sustainable use of tube wells, including subsidies for electricity and the installation of energy-efficient pumps. These policies have been critical in making tube-well irrigation economically viable for

farmers. According to Kaur et al. (2007), "Subsidies in electricity for agriculture have made it possible for farmers in Haryana to adopt tube-well irrigation extensively, which has led to significant increases in agricultural productivity."

Table 4 Haryana: Area under Irrigation by Different Sources (In Lakh Hectares)

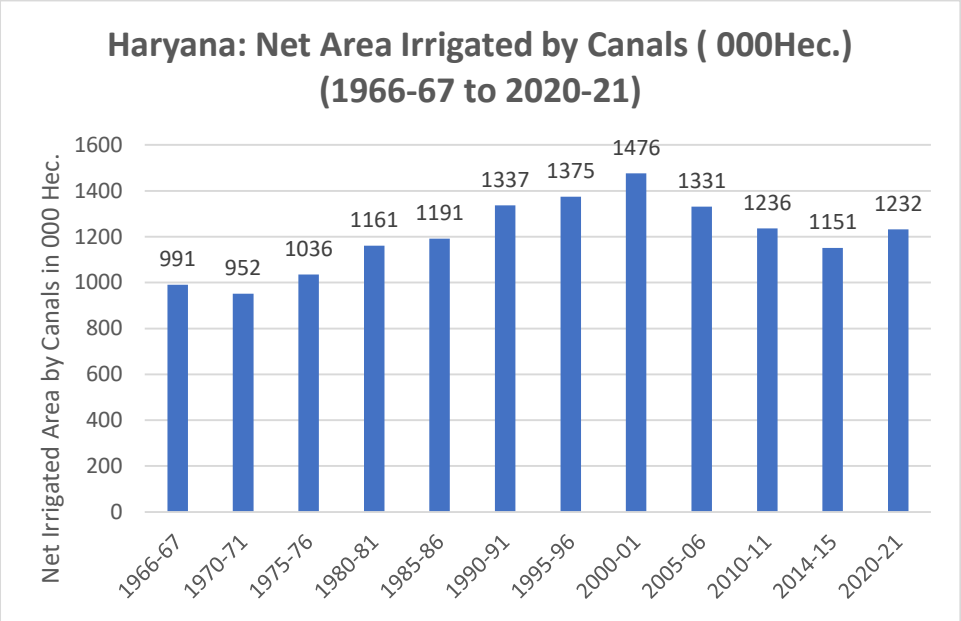
Years	Canals	Tube wells	Others	Total	percent to net area sown
1966-67	9.91	0	3.02	12.93	37.8
1970-71	9.52	0	5.8	15.32	43.0
1975-76	10.36	6.82	0.36	17.54	48.4
1980-81	11.61	9.41	0.32	21.34	59.2
1985-86	11.91	10.42	0.15	22.48	62.2
1990-91	13.37	12.48	0.15	26	72.2
1995-96	13.75	12.52	0.33	27.6	77.0
2000-01	14.76	14.67	0.15	29.58	83.9
2005-06	13.31	15.91	0.14	29.36	82.3
2010-11	12.36	16.50	0.01	28.87	82.1
2014-15	11.51	18.18	0.00	29.73	84.4
2020-21	12.32	21.56	0.00	33.88	93.0

Source: Statistical Abstract of Haryana, 2020-21

Development of Canal Irrigation

Since the independence, the Government of Haryana gave up top priority to improving the agricultural production. The state has now turned out to be one of the most agriculturally developed states of India. Development in irrigation facilities has become a main factor for tremendous agricultural development. In 1990-91, about 51.62 per cent of net area has the canal irrigated. The district Sirsa (88.16) has on top position with high percent of irrigated area by the canals whereas district Ambala (1.20) has very low percent of net irrigated area by the same source.

Figure. 2: Haryana: Net Area Irrigated by Canals (000 Hec.) (1966-67 to 2020-21)



Source: Statistical Abstract of Haryana 2020-21

Figure (3.3. The lines describe the changes in the net irrigated area in Haryana, India, focusing on the area irrigated by canals from 1966 to 2021. Haryana has a total of 1.45 million hectares of cultivable land, and the canal irrigation system has played a key role in enhancing agricultural productivity. In 1966-67, the area irrigated by canals was 9.91 lakh hectares (991,000 hectares), marking the beginning of canal-based irrigation in the state. By 1980-81, this area had increased significantly to 11.61 million hectares, reflecting substantial growth in irrigation infrastructure. The trend continued in 1990-91, with the irrigated area rising to 13.37 million hectares, demonstrating ongoing investments and agricultural expansion. However, by 2020-21, the area irrigated by canals declined to 12.32 million hectares, a decrease from the 1990-91 figure. This decline can be attributed to several factors, including water scarcity, reduced canal water availability, and changing agricultural practices. Despite the initial growth, the irrigated area by canals faced challenges in more recent years, leading to a slowdown and eventual reduction.In the decade 1990-91, net area irrigated by canals was 1359 thousand hectares. In the same decade, there was two main source of irrigation; one was canals and another was tube well. Since the formation of the state, canal has been the major source of irrigation. It contributed 51.61 percent to the net irrigated area.

Table. 5 Net Area under Irrigation by Canals in Haryana

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Table 6*: Haryana, Zone-Wise Area under Canal Irrigation (1990-91 and 2020-21)*

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Haryana	1359	51.61	1232	41.13

Source: Compiled by researcher

In 2020-21, the area irrigated by canals decreased significantly. The net area irrigated by canals is 1234.65 thousand hectares. Due to great expansion in groundwater exploitation, the percentage of canal irrigation declined.

Tube Well Irrigation in Haryana

Tube wells are a significant means of irrigation. Groundwater is water extracted for irrigation by mean of wells, generally known as tube wells. This method has flourished in the dry land and changed it into green land. Irrigation from groundwater through tube well and wells are considerable. In 2020-21, the country accounts about 49 percent of the total irrigated area, but in the state, the total irrigated area is about 63.33 percent during the same decade. During the same decade, the growth of the ground water abstraction structure has been increased. This was due to execution of technically positive projects for development. Tube well gives a good indication about the nearness of water table whereas irrigation from canals is an old practice. Here, it plays a negligible role in the farming activities in Haryana.

Tube-well irrigation allows for the extraction of groundwater to irrigate crops, providing a reliable water source during periods of low rainfall. The technology has been instrumental in supporting year-round farming and the diversification of crops beyond traditional seasons. As noted by Dhawan (2000), "The spread of tube-well irrigation in Haryana has been phenomenal, primarily due to the state's encouragement of groundwater development as a strategy to increase agricultural output and improve rural livelihoods." This shift has not only increased agricultural productivity but also contributed to groundwater depletion, raising concerns about sustainability.

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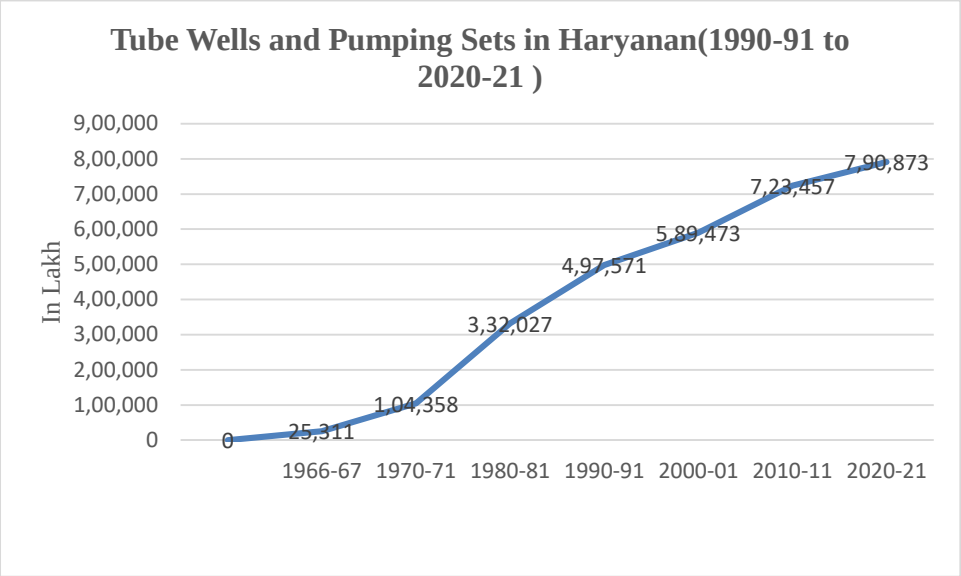
Figure 3: Tubewell and Pumping Sets in Haryana (1990-91 to 2020-21)



Source: Statistical abstract of Haryana

The growth of tube wells in the state is not even. This development in tube well density reveals the growth of ground water resources. Table 3.1 reveals the source-wise irrigation in the state which indicates that the tube wells have highest contribution in irrigation in the study area. Though, the tube wells become the main source of irrigation in Haryana. By providing easy bank loan, the government of Haryana also encouraged the setting up of tube well. The government also undertook the installation of tube well through Haryana state minor irrigation. The districts of Haryana, which hold the top three positions in tube well irrigation, are Yamunanagar, Rewari and Ambala. These districts have the highest percent of net irrigated area by tube well irrigation whereas Sirsa and Hisar have lowest tube well irrigated area.

In 2020-21, irrigation by tube well dominated in all irrigation facilities in the state of Haryana. The share of net irrigated by tube well reached 63.33 percent whereas share of net irrigated by canal area declined to 41.50 percent. The table provided offers data about the net area irrigated by tube wells in Haryana in two distinct years, 1990-91 and 2020-21, highlighting both the area under tube wells (in thousands of hectares) and the percentage of the total irrigated area that is served by tube wells. This data is crucial for understanding the progress made by Haryana in expanding its irrigation infrastructure over three decades. Below is a detailed explanation of the above.

Table 7 Net Area under Irrigated by Tube Wells in Haryana (1990-91 and 2020-21)

Districts/Agro climatic Zones	Tubewells (Net Area, 000hac)		Percent to Net Irrigated Area	
	1990-91	2020-21	1990-91	2020-21
Ambala	77.50	145	93.37	99.3
Punchkula	-	22	-	82.6
Yamunanagar	89.00	109	96.74	100
Kurukshetra	114.00	111	85.75	99.3
Karnal	139.50	144	80.45	100
Panipat	74.00	57	59.68	100
Northern	**494.00**	**588**	**81.59**	**96.86**
Kaithal	103.00	116	48.58	100
Sonipat	56.50	128	43.30	100
Rohtak	79.50	61	33.07	100
Jhajjar	-	68	-	83.8
Jind	84.00	36	40.10	100
Central	**323.00**	**409**	**40.76**	**96.8**
Faridabad	56.00	31	59.90	100
Palwal	-	80	-	95.2
Gurgaon	69.50	43	86.34	100
Mewat	-	71	-	77.3
Rewari	89.50	126	95.72	1001
Mahendragarh	68.00	120	93.15	78.8
Southern	**283.00**	**471**	**83.15**	**91.88**
Bhiwani	63.00	181	37.50	81
Hisar	56.50	129	12.50	93.1
Fatehabad	-	155	-	98.7
Sirsa	32.50	125	11.85	97.7
Charkhi dadri		70		85.7
Western	**152.00**	**660**	**16.99**	**91.24**
HARYANA	1252	2128	47.55	63.33

Source: Statistical Abstract of Haryana (various issue

Table 3.5 showing the zone-wise area under tube well irrigation from 1990-91 to 2020-21. The given table shows a wonderful growth in tube well irrigation in Haryana since the onset of Green Revolution. The percent of net area irrigated by tube well has increased from 47.55 percent to 57.02 percent during the time period. The area irrigated by tube well increased significantly from 1252 thousand hectares to 1681 thousand hectares from 1990-91 to 2020-21. This can be interpreted that tube well e data based on five categories: Above 80percent, 60-80percent, 40-60percent, 20-40percent, and Below 20percent.

Table 8: Haryana, Zone-wise Area under Tube well Irrigation from 1990-91 and 2020-21

Zones	**1990-91**		**2020-21**	
	Net Area (,000 ha)	**Percent to Net Irrigated Area**	**Net Area (,000 ha)**	**Percent to Net Irrigated Area**
Northern Agro-Climatic Zone	494	81.59	588	96.86
Central Agro-Climatic Zone	323	40.76	409	96.80
Southern Agro-Climatic Zone	283	83.11	471	91.88
Western Agro-Climatic Zone	152	16.99	660	91.24
Haryana	1252	47.55	2128	63.33

Source: Statistical Abstract of Haryana (various issues

Other Sources of Irrigation in Haryana:

The other sources of irrigation in Haryana are likes tanks, Wells, duct and springs. From the ancient India, tanks are a local water harvesting system. In tank irrigation, the rainwater is stored in a large tank. This stored water is used during the summers when most of the water in the river dries up and it becomes difficult to do irrigation. Well and tank does not play any significant role in the agricultural economy of Haryana. Because tanks and wells irrigation systems have faced neglect. However, Khul irrigation is very common in Panchkula and Ambala districts. In Haryana, farmers create small Khuls and then divert the water of these khul to their fields. The Khul irrigation is very common in Siwalik Hills tracks. In 1990-91, the area irrigated by other sources was more than the year 2014-15.

Table 9: Haryana, Zone-wise Area under Other Sources of Irrigation from 1990-91 and 2020-21

Zones	1990-91		2020-21	
	Net Area (,000 ha)	Percent to Net Irrigated Area	Net Area (,000 ha)	Percent to Net Irrigated Area
Northern Zone	12.00	1.98	2.00	0.25
Central Zone	10.00	1.26	0.00	0.00
Southern Zone	0.00	0.00	0.00	0.00
Western Zone	0.00	0.00	0.67	0.04
Haryana	22.00	0.84	2.67	0.05

Source: Statistical Abstract of Haryana, 1990-91 to 2020-21

Conclusion:

Irrigation plays a pivotal role in agricultural sectors, particularly in regions like Haryana, where agriculture forms the backbone of the economy and sustains most of its population. Given Haryana's semi-arid climate and erratic monsoonal rainfall patterns, irrigation is not just a facilitator of agricultural activity but a critical necessity for ensuring food security and sustainable farming practices.

In 1966-67, canal irrigation accounted for 75.6percent of the net irrigated area, demonstrating the state's heavy reliance on canals for irrigation. Over time, the area under canal irrigation continued to rise, reaching 1.23 million hectares in 2020-21, up from 991 thousand hectares in 1966-67. The western and central agro-climatic zones remain highly dependent on canal irrigation, with 57.41percent and 47.09percent of the irrigated area in these zones served by canals as of 2020-21.

An analysis of irrigation expansion from 1990-91 to 2020-21 reveals that although the area under canal irrigation decreased from 1.37 million hectares to 1.23 million hectares, its share in the total net irrigated area declined from 51.61percent to 41.13percent. This shift can primarily be attributed to the massive growth of tube well irrigation. The introduction of HYV seeds in the 1960s made irrigation essential for crop production, and the state provided various

incentives, such as credit facilities and subsidized electricity, to promote tube well irrigation. As a result, the area under tube well irrigation surged increasing its share of net irrigated area from 47.55percent to 6 In conclusion, the spatio-temporal analysis of the rice-wheat cropping system in Haryana highlights the dynamic nature of the state's agricultural practices over time. From 1990 to 2020, Haryana has seen substantial shifts in the area under rice and wheat cultivation, driven by advances in irrigation infrastructure, technological adoption, and changing climatic conditions. While the rice-wheat rotation continues to dominate the state's agricultural landscape, challenges such as water scarcity, soil degradation, and the over-reliance on monoculture cropping have emerged. The analysis underscores the need for sustainable practices, such as crop diversification, efficient water management, and soil health restoration, to ensure the long-term viability of the rice-wheat system. As Haryana's agricultural sector faces increasing pressures, a balanced approach combining technological innovation with environmental stewardship will be essential for maintaining productivity and sustainability in the future.

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