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Spatial Analysis of Canal Irrigation in Bhiwani District: An Intra-Block Analysis

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ABSTRACT

This study examined the spatio-temporal dynamics of canal irrigation in Bhiwani District from 1980-81 to 2020-21. By analyzing intra-block variations, the research identified trends in canal irrigation expansion and its impact on agricultural productivity. The findings revealed a consistent increase in canal irrigation, with significant disparities among blocks due to geographical, infrastructural, and climatic factors. The study highlighted the role of government interventions and water management practices in improving irrigation coverage. The study also explored how the availability of canal irrigation influenced cropping patterns and yield improvements in different blocks. It assessed the socio-economic impact of irrigation on farmers, highlighting the correlation between improved water access and agricultural income. Additionally, the research investigated challenges such as water scarcity, maintenance issues, and the need for modernization in canal irrigation systems. Moreover, the analysis provided insights into the effectiveness of past and current government policies in promoting canal irrigation. The study underscored the importance of integrating advanced technologies such as remote sensing and GIS for better water management. Recommendations for sustainable water resource utilization and policy interventions were presented to ensure long-term agricultural viability in the district. Canal irrigation played a vital role in supporting agriculture, particularly in semi-arid regions such as Bhiwani District, Haryana. This study provided a spatio-temporal analysis of canal irrigation across different blocks within the district, examining changes over four decades from 1980-81 to 2020-21. The research evaluated the impact of irrigation expansion on agricultural productivity, highlighting the disparities caused by geographical and infrastructural factors. Findings indicated a steady increase in canal irrigation, improving crop yields and reducing reliance on erratic rainfall.

However, challenges such as inefficient water distribution, infrastructure maintenance, and climate change effects persisted. The study emphasized the need for sustainable water management policies, technological advancements in irrigation, and government interventions to ensure long-term agricultural sustainability and equitable water access.

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Introduction

Irrigation played a crucial role in sustaining agriculture, particularly in semi-arid regions such as Bhiwani District, Haryana. Canal irrigation had historically been a major source of water for agricultural activities. Over the past decades, the expansion and efficiency of canal irrigation significantly influenced cropping patterns and agricultural productivity. This study aimed to analyze the trends, variations, and factors affecting canal irrigation in Bhiwani District across different blocks over time. According to Sharma and Singh (2019), irrigation infrastructure development was a critical factor in improving agricultural productivity in semi-arid regions of India. The expansion of canal irrigation helped reduce dependence on erratic monsoonal rainfall, thereby enhancing food security (Kumar et al., 2020).

However, disparities existed among different regions due to variations in topography, soil quality, and government interventions (Patel & Verma, 2021). Furthermore, recent studies highlighted the role of technology in improving irrigation efficiency. Remote sensing and GIS applications enabled better monitoring and management of water resources (Choudhary et al., 2022). In the context of Bhiwani District, integrating such technologies provided valuable insights into water distribution and helped policymakers make informed decisions. Additionally, previous research emphasized the socio-economic impact of irrigation. Studies suggested that improved irrigation facilities led to increased crop yield and rural employment opportunities (Gupta & Mehta, 2018). However, challenges such as water scarcity, canal maintenance, and equitable water distribution persisted, necessitating further investigation and policy interventions (Rao et al., 2017).

The historical development of canal irrigation in India had shown that investments in infrastructure led to substantial agricultural growth (Banerjee et al., 2016). However, ineffective water distribution and lack of periodic maintenance in some regions resulted in suboptimal utilization of resources (Mukherjee & Das, 2018). Bhiwani District reflected similar patterns, where government intervention and infrastructural advancements drove irrigation expansion but with varying efficiency across blocks.

Climate change also emerged as a significant factor influencing irrigation efficiency. According to Jha and Bhattacharya (2021), increasing temperatures and erratic rainfall patterns heightened the dependency on irrigation systems, requiring adaptive strategies for sustainable water use. In Bhiwani, the semi-arid climate further accentuated the need for robust irrigation management to ensure year-round agricultural productivity. Another aspect influencing irrigation efficiency was farmers' adaptation to modern techniques. Studies indicated that the adoption of water-saving irrigation practices such as drip and sprinkler irrigation was slow due to financial constraints and limited awareness (Mishra & Roy, 2019). Promoting these practices in Bhiwani District could have enhanced water efficiency and reduced pressure on canal irrigation systems. Lastly, policy measures and government schemes played a crucial role in shaping irrigation patterns in Haryana. The Pradhan Mantri Krishi Sinchayee Yojana (PMKSY) and other state-level initiatives aimed to improve irrigation access and efficiency (GoI, 2020).

Study Area

Bhiwani District, located in the southwestern part of Haryana, had a semi-arid climate with low rainfall and high dependency on irrigation. The district consisted of multiple administrative blocks, including Bhiwani, Tosham, Loharu, Kairu, Siwani, Bahal, and Bhiwani Khera. The region's topography and soil characteristics influenced irrigation patterns, with canals serving as a primary water source for agriculture. According to Singh et al. (2021), the geographical location of Bhiwani played a significant role in its irrigation dependency, with canal irrigation being the primary source due to limited groundwater availability. The region was characterized by alluvial soil, which had moderate water retention capacity, making canal irrigation an essential aspect of sustaining agricultural activities. Topographical variations also impacted the distribution of irrigation facilities across the district. Research by Verma and Gupta (2020) indicated that certain blocks, such as Bhiwani and Tosham, benefited from relatively better canal network accessibility, whereas blocks like Siwani and Loharu experienced challenges due to their undulating terrain and distance from primary water sources.

Climate conditions further dictated the irrigation requirements in Bhiwani District. According to Mehta et al. (2019), the region received an average annual rainfall of approximately 400-500 mm, which was insufficient to meet the agricultural water demand. Consequently, canal irrigation played a crucial role in ensuring stable crop yields, particularly for wheat, mustard, and bajra, which were the predominant crops grown in the district.

Additionally, government initiatives influenced the irrigation infrastructure in Bhiwani. Studies by Rao and Kumar (2022) suggested that projects under Haryana's water resource management programs improved canal efficiency, but challenges such as water distribution equity and infrastructure maintenance persisted. Policymakers needed to focus on sustainable measures to enhance water use efficiency across different blocks.

Objectives

i. To analyze the temporal changes in canal irrigation from 1980-81 to 2020-21 in Bhiwani District.

ii. To examine intra-block variations in the share of canal irrigation.
iii. To assess the factors influencing the expansion or decline of canal irrigation.
iv. To provide recommendations for improving irrigation management and water resource utilization.

Database & Methodology

This study was based on secondary data collected from government reports, agricultural records, and survey data. The methodology involved: Collection of block-wise canal irrigation data from various sources such as the Survey of India, agricultural department reports, and remote sensing images. Comparative analysis of irrigation coverage across different decades using statistical and GIS-based mapping techniques. Identification of trends, disparities, and contributing factors influencing canal irrigation in different blocks. Interpretation of findings to suggest policy implications for sustainable water resource management. The data have been utilized for the period from 1980-81 to 2020-21. The thematic maps pertaining to the present work have been prepared in the ArcGIS map.

Result & Discussion

Canal Irrigations in Bhiwani District, 1980-81 to 2020-2021

In 1980-81, canal irrigation played a crucial role in the agricultural landscape of Bhiwani District, Haryana. The block-wise distribution of canal irrigation varied across the district. Bhiwani Block had the highest share of canal irrigation, accounting for 37.4%, followed closely by Tosham Block at 34.8%. Other blocks, such as Bahal, Kairu, and Loharu, also had significant shares of canal irrigation, with 32.34%, 32.07%, and 31.72%, respectively. Bhiwani Khera, with 29.21%, and Siwani Block, with 22.89%, had relatively lower shares. Overall, the district's average share of canal irrigation stood at 31.49%. This variation in canal irrigation distribution reflected the reliance on this critical water resource across different regions within Bhiwani (Table 1).

In 1990-91, the share of canal irrigation in Bhiwani District increased across various blocks compared to the previous decade. Bhiwani Block had the highest share, with 53.85%, indicating a substantial dependence on canal irrigation. Tosham Block followed with 50.11%, while Bahal, Kairu, and Loharu Blocks also recorded significant shares, at 46.57%, 46.18%, and 45.67%, respectively. Bhiwani Khera had a share of 42.06%, and Siwani Block remained the lowest with 32.96%.

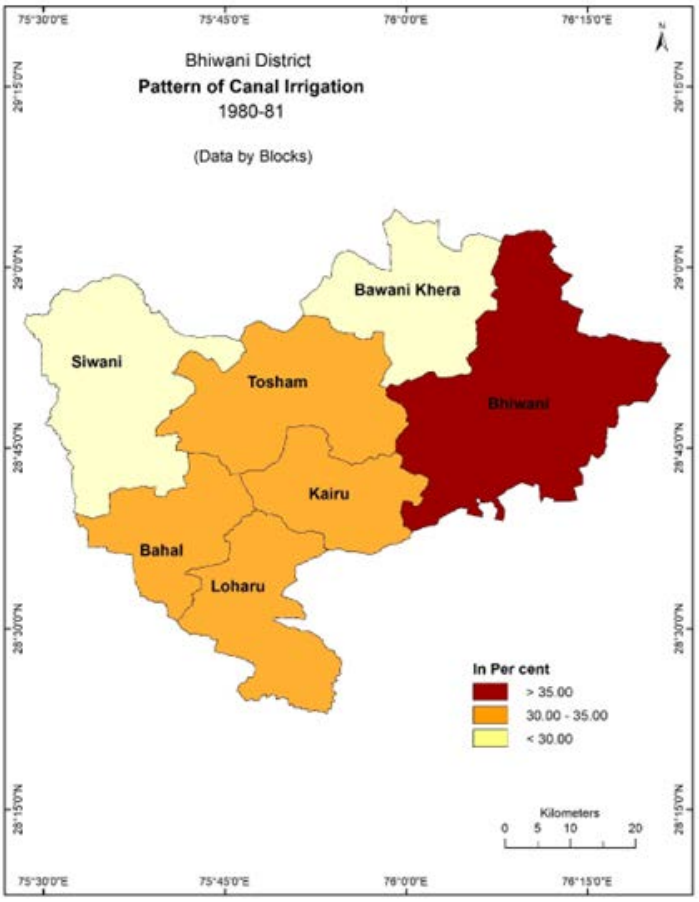
The overall average share of canal irrigation for the district rose to 45.34%, reflecting an increase in the utilization of canal irrigation as a key water source for agriculture during this period. In 2000-01, the share of canal irrigation in Bhiwani District continued to increase, with significant variations across different blocks. Bhiwani Block had the highest share of canal irrigation at 60.32%, marking a notable rise from previous years. Tosham Block also experienced a substantial increase, reaching 56.12%. Other blocks, such as Bahal (52.15%), Kairu (51.73%), and Loharu (51.16%), maintained a considerable reliance on canal irrigation. Bhiwani Khera Block had a share of 47.1%, while Siwani Block remained the lowest, with 36.91%. On average, the district's canal irrigation share rose to 50.78%, indicating the growing importance of this irrigation source for agricultural sustainability in Bhiwani during 2000-01.

Table 1: Block wise Share of Canal Irrigation in Bhiwani District, 1980-81 to 2020-21

Sr. No.	Blocks	1980-81	1990-91	2000-01	2010-11	2020-2021
1.	Bhiwani	37.40	53.85	60.32	63.94	72.25
2.	Bhiwani Khera	29.21	42.06	47.10	49.93	56.42
3.	Tosham	34.80	50.11	56.12	59.49	67.22
4.	Loharu	31.72	45.67	51.16	54.22	61.27
5.	Kairu	32.07	46.18	51.73	54.83	61.96
6.	Siwani	22.89	32.96	36.91	39.13	44.21
7.	Bahal	32.34	46.57	52.15	55.28	62.47
Bhiwani District		**31.49**	**45.34**	**50.78**	**53.83**	**60.83**

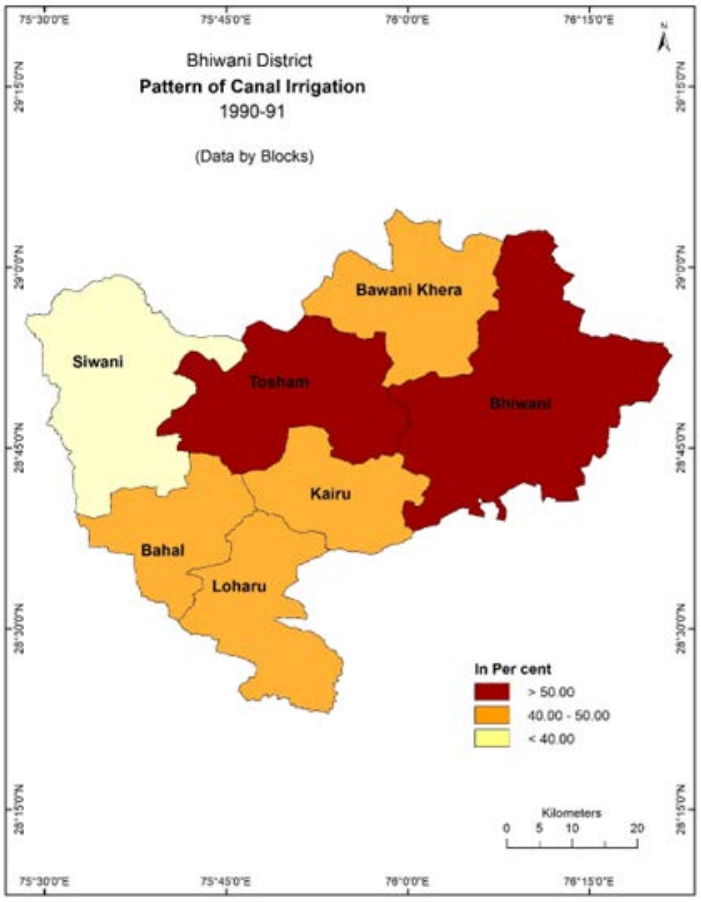
Source: Compiled by Researcher based on the various reports.

In 2010-11, canal irrigation remained a crucial source of water for agriculture in Bhiwani District, with significant variations in its share across different blocks. Bhiwani Block recorded the highest share of canal irrigation at 63.94%, which was attributed to its proximity to major canal systems and better irrigation infrastructure. Tosham Block followed with 59.49%, benefiting from similar infrastructure improvements (Map 4).



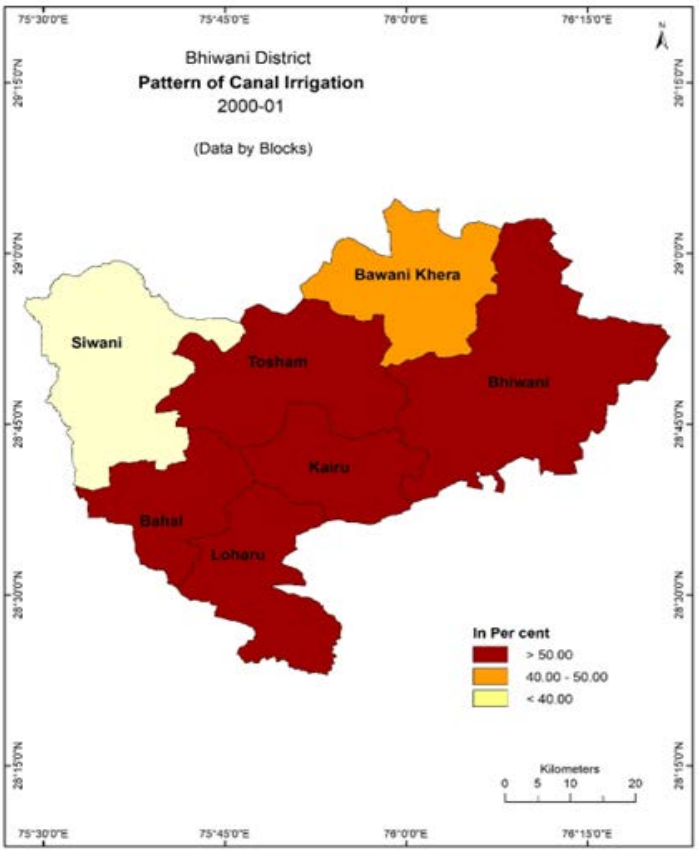
Source: Based on table 1

Map 1



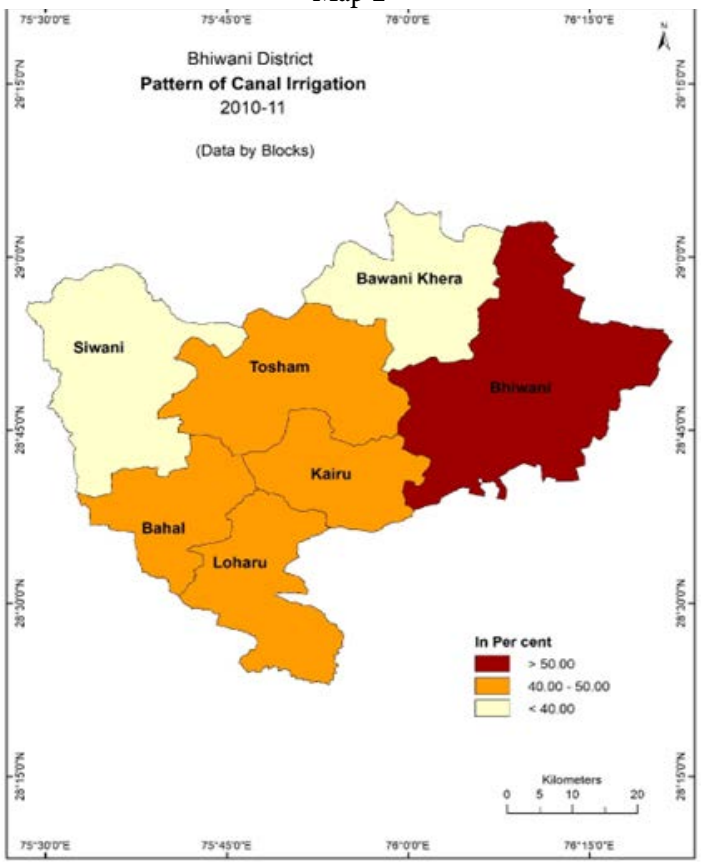
Source: Based on table 1

Map 2



Source: Based on table 1

Map 3



Source: Based on table 1

Map 4

Bahal (55.28%), Kairu (54.83%), and Loharu (54.22%) also had significant shares, reflecting the expansion of canal networks and improved water management practices in these areas. Bhiwani Khera recorded a share of 49.93%, while Siwani, with the lowest share at 39.13%, likely faced challenges related to water distribution and geographical limitations. The overall district average rose to 53.83%, indicating the growing dependence on canal irrigation to support agricultural productivity in response to limited rainfall and increasing water demand in the region.

Canal Irrigations in Bhiwani District, 2020-21:

In Bhiwani District for the year 2020-21, the distribution of canal irrigation across different blocks revealed varied levels of irrigation support and infrastructure development. The block of Bhiwani led with the highest share of canal irrigation at 72.25%. This high percentage was attributed to its historical significance as a major agricultural hub, with substantial investment in canal infrastructure and effective water management practices that maximized the use of available water resources. Tosham followed with 67.22% canal irrigation coverage. This block benefited from favorable geographical conditions, including flat terrain and better water retention capabilities. Additionally, efforts to upgrade and maintain canal networks contributed to its relatively high irrigation share. Bahal recorded a 62.47% share in canal irrigation, which might have been due to recent initiatives aimed at improving irrigation infrastructure and expanding canal networks to support local agriculture. Such improvements likely enhanced water availability for farming activities in the region.

On the other hand, Bhiwani Khera and Loharu had shares of 56.42% and 61.27%, respectively. In these blocks, the levels of canal irrigation might have been constrained by factors such as limited water resources, variations in soil types, and the need for further investment in irrigation infrastructure. The effectiveness of canal systems in these areas might also have been influenced by seasonal variations and maintenance practices. Kairu had a canal irrigation share of 61.96%, reflecting ongoing efforts to balance irrigation needs with available resources. Localized improvements in canal infrastructure and water management strategies played a role in achieving this level of coverage. Siwani, with the lowest share at 44.21%, may have faced challenges such as less favorable topographical conditions, lower rainfall, or inadequate canal infrastructure. These factors contributed to its lower percentage of canal irrigation, suggesting that additional resources and development efforts were needed to enhance irrigation coverage in this block.

Overall, the average share of canal irrigation in Bhiwani District stood at 60.83%. This average reflected a concerted effort to improve irrigation practices across the district, although there were disparities among blocks that highlighted the need for targeted interventions to address local challenges and improve irrigation efficiency throughout the region.

Conclusion

The analysis of canal irrigation in Bhiwani District revealed a steady increase in its coverage over the past four decades. While certain blocks like Bhiwani and Tosham showed significant improvements due to better infrastructure and water availability, other areas such as Siwani still lagged behind due to geographical and infrastructural constraints. Sustainable irrigation management was crucial for maintaining agricultural productivity in semi-arid regions. Future policies needed to focus on improving canal maintenance, optimizing water distribution, and integrating modern irrigation technologies such as drip and sprinkler systems. Additionally, enhancing farmers' awareness and access to financial support for irrigation improvements could have significantly impacted agricultural outcomes. Encouraging participatory irrigation management and community-driven initiatives could also have led to more efficient water use and long-term sustainability. Overall, the findings underscored the need for targeted interventions to address regional disparities and ensure equitable access to irrigation resources in Bhiwani District. A balanced approach that combined infrastructural development, policy implementation, and technological advancements was key to achieving sustainable agricultural growth in the region.

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