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A Study on Impact of Variation in Climatic Condition Phenologically on Wheat Production with Reference to Kanpur Nagar

By Mohit Sidhwani[1], Dr. Archana Shukla[2]

[1]Research scholar CSJM University
[2]Assistant Professor CSJM University

Abstract
the research is regarding the variation in climatic condition and there impact on agriculture activity with reference to presence of water

Introduction

Irrigation nowadays plays a vital role in agricultural development and remains one of the most important factors influencing crop productivity, yield stability, and overall farm revenue. In a state like Uttar Pradesh, where agriculture supports a large proportion of the rural population, access to dependable irrigation directly affects both agricultural output and economic well-being.

Over the past several decades, irrigation infrastructure in Uttar Pradesh has expanded significantly through different sources such as canals, tube wells, dug wells, ponds, and pump-based systems. This expansion has contributed to increased cropping intensity, higher production, and improved resilience against irregular rainfall. However, despite this progress, the efficiency, cost, reliability, and accessibility of each irrigation source differ considerably across regions.

The performance of irrigation systems cannot be evaluated only on the basis of water availability. Their economic feasibility is equally important. Factors such as installation cost, operational expenses, energy consumption, maintenance requirements, groundwater availability, and seasonal reliability determine how beneficial a particular source is for farmers. In many cases, farmers select irrigation methods not merely by availability but by affordability, convenience, and long-term returns.

Changing climatic conditions, rising pressure on groundwater resources, irregular monsoon patterns, and increasing cultivation costs have further highlighted the need to reassess the economic efficiency of different irrigation sources. While canal irrigation remains important in many areas, dependence on tube wells has increased rapidly due to greater control over timing and water distribution. At the same time, concerns related to declining groundwater levels, electricity supply, diesel prices, and sustainability have made the issue more complex.

Therefore, a comparative economic assessment of different irrigation sources in Uttar Pradesh becomes highly relevant. Such an analysis helps identify the relative advantages, limitations, cost-effectiveness, and sustainability of each irrigation system. The findings can support better decision-making for farmers, researchers, and policymakers in planning efficient water management strategies and improving agricultural productivity in the state.

Research Background and Objectives

In agricultural research, it is essential to evaluate the effectiveness of different production factors influencing crop growth and yield before adopting specific management practices. Understanding these relationships becomes particularly important in the case of wheat cultivation, where climatic variability directly affects crop phenology, productivity, and final output.

Recent changes in climatic conditions such as temperature fluctuation, irregular rainfall distribution, humidity variation, and changing seasonal patterns have significantly influenced agricultural productivity across northern India. Wheat, being a major rabi crop in Uttar Pradesh, is highly sensitive to these climatic changes during different phenological stages including germination, tillering, flowering, grain filling, and maturity.

Therefore, the present study has been undertaken to examine how climatic variations affect the phenological development and productivity of wheat crop in Kanpur Nagar district. The findings may be useful for crop planning, sustainable agricultural management, and policy formulation related to climate-resilient wheat production systems.

Main Objectives of the Study

1. To analyze the impact of climatic variability on different phenological stages of wheat crop in Kanpur Nagar.
2. To examine the relationship between temperature, rainfall, humidity, and wheat productivity during the crop growth period.
3. To study the variation in wheat yield under changing agro-climatic conditions and identify major climatic factors affecting production.
4. To evaluate recent trends in wheat cultivation with reference to climate adaptability and agricultural sustainability in the study area.

Research Methodology

The present study is based on both **primary and secondary data** collected from Kanpur Nagar district of Uttar Pradesh. The district has been selected because wheat is one of the dominant rabi crops cultivated extensively in this region and is highly influenced by seasonal climatic conditions.

Primary data were collected through field survey and interaction with local farmers from selected villages of Kanpur Nagar. Information related to sowing period, irrigation practices, crop growth stages, harvesting time, and wheat yield was gathered through structured questionnaires and personal interviews.

Secondary data regarding climatic variables such as **temperature, rainfall, relative humidity, and seasonal weather variation** were collected from agricultural records, meteorological reports, government publications, and relevant research articles.

A representative sample of farmers was selected using appropriate sampling techniques to ensure reliability of observations. The collected data were organized, classified, and analyzed using statistical methods such as percentage analysis, average growth trend, correlation analysis, and regression techniques to understand the relationship between climatic conditions and wheat production.

The study mainly focuses on the phenological behavior of wheat under changing climatic conditions and its resulting impact on productivity in Kanpur Nagar.

Classification of Farm Categories Based on Irrigation Source

For analytical purposes, farms were classified according to the type of irrigation source available to them. These categories were further evaluated on the basis of **flexibility** and **reliability** of water supply.

Table: Classification of Farm Categories Based on irrigation sources

S. No.	Farm Category	Flexibility	Reliability
1	Canal irrigated farms (C)	Low	Low
2	Diesel-operated tube well farms (D)	High	Moderate
3	Electric-operated tube well farms (E)	High	Moderate
4	Canal + diesel tube well farms (C+D)	Moderate	Moderate
5	Canal + electric tube well farms (C+E)	High	High
6	Electric + diesel tube well farms (E+D)	High	High

Explanation of Terms

Flexibility indicates the extent to which irrigation water is available in the required quantity according to crop demand.

Reliability refers to the availability of water at the required time during critical crop growth stages.

Comparative Framework of Analysis

A comparative assessment was carried out among farms using canal irrigation and those dependent on tube well irrigation systems to understand the influence of irrigation availability on agricultural performance. The comparison focused particularly on how flexibility and reliability in water supply affect cropping decisions, productivity, and farm economics.

Farms having combined irrigation sources showed better operational adaptability compared with farms dependent on a single irrigation source. The presence of multiple irrigation alternatives improved both timely water availability and crop management efficiency.

To evaluate the performance of different farm categories, the following parameters were considered:

1. Land use pattern
2. Crop yield
3. Number of irrigations applied
4. Duration of irrigation (hours)
5. Cost and use pattern of fertilizers and other agricultural inputs
6. Total cost of production
7. Net farm income
8. Economic efficiency of farming operations

To examine whether differences among farm groups were statistically significant, **Analysis of Variance**

(ANOVA/F-test) was applied to compare mean values of selected variables across the categories.

Results

Land Use Pattern

The land use pattern observed across different farm categories reveals noticeable variation associated with irrigation availability. Findings indicate that farms having **more flexible and dependable irrigation systems** tend to allocate land more efficiently across crops.

Farmers with reliable access to irrigation water were better able to diversify land use according to crop requirement and seasonal conditions. In contrast, farms dependent on less reliable sources showed relatively lower flexibility in crop planning and a greater concentration of land under traditional wheat cultivation.

This suggests that irrigation reliability plays an important role in shaping cropping pattern, resource allocation, and overall farm productivity.

Percentage Area Under Wheat Across Different Sources of Irrigation

Table 1. Distribution of Wheat Cultivated Area Under Different Irrigation Sources

Irrigation Source	Percentage Area Under Wheat (%)	Number of Farmers
Canal	81	8
Diesel-operated Tube Well	78	36
Electric Tube Well	76	39
Diesel + Canal	83	21
Electric + Canal	84	18
Diesel + Electric	76	37

Irrigation Source and Cropping Pattern

A detailed assessment of farm-level cropping schedules indicates that the pattern of land allocation is strongly influenced by the availability, flexibility, and dependability of irrigation facilities. Farmers having access to more reliable irrigation systems were found to diversify their cropping pattern and allocate comparatively larger portions of land toward high-value crops, particularly vegetables and cash-generating seasonal crops.

The study suggests that where irrigation sources are dependable and easily manageable, farmers are more willing to invest in crops with greater economic return, even when those crops involve relatively higher production risk. Consequently, a moderate decline in the proportion of cultivated area under wheat was observed in farms where diversified irrigation arrangements were available.

This shift reflects changing farm management decisions in response to improved water accessibility and increased economic opportunities associated with diversified agriculture.

Wheat Yield in Relation to Irrigation and Fertilizer Use

The analysis revealed that wheat productivity was generally higher on farms irrigated through tube wells than on farms relying solely on canal irrigation. Better water control, timely application, and improved

irrigation efficiency contributed significantly to increased yield performance under tube-well-based systems.

It was also observed that farms utilizing more than one irrigation source achieved better productivity compared with those depending on a single irrigation source. Multiple irrigation options helped farmers ensure timely watering during critical crop growth stages, which positively influenced wheat output.

Among the different categories studied, farms using a combination of diesel and electric irrigation sources recorded substantially higher wheat yield compared with canal-dependent farms. This indicates that irrigation flexibility remains an important determinant of crop productivity.

Further analysis showed that yield differences increased with greater irrigation reliability and operational flexibility. Statistical testing confirmed that variations in yield among farm categories were significant at the 5 percent level, indicating a meaningful relationship between irrigation access and wheat productivity.

Overall, the findings clearly demonstrate that both irrigation availability and fertilizer application play an important role in determining wheat yield across different farm conditions.

Comparative Analysis of Wheat Yield in Relation to Irrigation Practices

The comparative assessment of wheat productivity across different irrigation-source categories indicates a clear relationship between yield level, frequency of irrigation, duration of irrigation, and fertilizer use. The findings show that farms using combined diesel and electric irrigation systems recorded the highest use of water, reflected through both a greater number of irrigations and longer irrigation duration. This suggests that improved access to multiple irrigation sources increases the farmer's capacity to manage water according to crop requirements, thereby supporting better crop performance.

The analysis further highlights that the timing of irrigation plays an equally important role alongside the quantity of water applied. Farmers dependent exclusively on canal irrigation generally have limited control over the timing and availability of water supply. Because of this dependence, irrigation is often applied according to water release schedules rather than crop demand at critical growth stages. Such limitations can negatively influence crop development and reduce yield potential.

In contrast, farmers with access to independent or alternative irrigation sources such as diesel-operated or electric tube wells are able to irrigate when required. This flexibility allows them to apply water more efficiently during important phenological stages including crown root initiation, tillering, flowering, and grain filling. As a result, better utilization of irrigation water contributes to improved wheat productivity.

Statistical evaluation indicates significant variation among farm categories with respect to the number of irrigations applied. Similar differences were also observed in fertilizer expenditure per acre. Fertilizer use showed noticeable variation across irrigation categories, indicating that access to reliable irrigation also influences nutrient management decisions.

The results also suggest a complementary relationship between irrigation availability and fertilizer application. Farms with more flexible and dependable irrigation systems generally used higher quantities of fertilizer compared with farms relying on a single irrigation source. This relationship supports the view that improved water availability encourages greater nutrient application, which ultimately contributes to higher yields.

Overall, the study reveals that flexibility and reliability of irrigation are important determinants of wheat productivity. Greater control over water supply enables farmers to manage both irrigation and fertilizer inputs more effectively, resulting in enhanced crop performance and improved yield outcomes.

Production Cost and Net Return

Variation in resource use was observed among different categories of farms. Input utilization differed depending on irrigation source, farm conditions, and management practices. Many agricultural inputs function as complementary or substitutable factors; therefore, their use pattern varies across farming systems. To make inter-category comparison more meaningful, it becomes necessary to examine production cost and net returns in relation to the overall resource-use structure of each farm category.

Cost of Production, Gross Returns and Net Income under Wheat Cultivation

To estimate the economics of wheat cultivation, expenditure on major agricultural inputs was compiled at the farm level. The total production cost per hectare included expenses on seed, irrigation, labour, machinery use, plant protection chemicals, and other operational costs. These costs were analysed across different irrigation-source categories to understand their effect on productivity and farm income.

The comparative values of gross returns, cost of production and net income are presented in table 2

Table 2: Per Hectare Gross Returns, Production Cost and Net Income under Wheat Cultivation:-

Item	Canal	Diesel	Electric	Diesel + Canal	Electric + Canal	Diesel + Electric
Gross Returns (Rs/ha)	26,032.10	31,452.70	33,432.16	32,472.17	33,107.45	35,632.14
Production Cost (Rs/ha)	17,132.40	19,964.62	19,872.46	20,432.72	19,932.41	18,992.27
Net Income (Rs/ha)	8,899.70	11,488.08	13,559.70	12,039.45	13,175.04	16,639.87

Interpretation

The findings indicate that production cost varied according to the type and dependability of irrigation available to farmers. Farms with more flexible and reliable irrigation access generally showed higher investment in crop inputs, which contributed to better crop performance and increased returns.

Among all irrigation categories, farms using **diesel and electric combined irrigation systems** recorded the highest gross returns as well as the highest net income. This suggests that improved control over water availability positively influences wheat productivity and profitability.

Average Cost of Production and Returns

The analysis of average production cost and returns highlights differences in economic efficiency among various farm categories. Cost per quintal and average return per rupee invested were calculated to assess profitability under different irrigation arrangements.

Table 3: Average Cost of Production and Returns from Wheat Cultivation

Item	Canal	Diesel	Electric	Diesel + Canal	Electric + Canal	Diesel + Electric
Cost of production per quintal (Rs)	352.76	350.76	337.64	345.47	324.14	311.67

Average return per rupee invested	2.45	2.52	3.12	2.47	3.10	3.66

Interpretation

The results reveal that the **lowest cost of production per quintal** was observed among farms using a combination of diesel and electric irrigation, while canal-irrigated farms showed relatively higher production cost.

Similarly, return per rupee invested was highest in the diesel–electric irrigation category, indicating better resource-use efficiency and stronger economic performance. These results suggest that diversified and dependable irrigation access can significantly improve the profitability of wheat cultivation.

Overall, farmers with greater irrigation flexibility were able to optimize input use more efficiently, reduce per-unit production costs, and achieve better economic returns.

Economic Evaluation of Irrigation Systems in Wheat Production

The comparative analysis indicates that farms irrigated through tube wells demonstrated greater economic efficiency than canal-irrigated farms. Among all categories, farms utilizing combined irrigation sources—particularly diesel and electric tube wells together—showed comparatively better performance in terms of productivity and resource use efficiency.

Economic Evaluation of Irrigation Systems

To assess the influence of irrigation sources on wheat productivity, production relationships were examined using the Cobb–Douglas production function framework. The analysis was carried out to understand how differences in yield across irrigation systems are associated with input utilization and irrigation management practices.

The variation in wheat yield among different irrigation sources can broadly be explained by two major factors:

1. **Efficiency of water management**, including timely availability, adequacy, and reliability of irrigation water.
2. **Variation in the level of agricultural inputs**, such as labour, irrigation expenditure, fertilizers, and machinery use.

The decomposition analysis separates the overall yield difference into these contributing components. This helps identify whether yield improvement is mainly influenced by better water control or by changes in input use intensity.

Indirect Estimates of Cobb–Douglas Production Function for Wheat Under Different Irrigation Sources

The estimated coefficients of the production function indicate the relative contribution of major inputs toward wheat production under various irrigation systems. Human labour, irrigation input, fertilizer application, and plough unit use were taken as explanatory variables.

The results show that fertilizer and irrigation inputs contributed positively across all irrigation categories, while labour and machinery also showed measurable influence on output. The magnitude of coefficients varied across irrigation systems, reflecting differences in management practices and input efficiency.

Decomposition Analysis of Yield Variation Between Irrigation Systems

The decomposition results reveal that a significant share of variation in wheat yield across irrigation systems is associated with **water management efficiency**.

Improved water management—particularly in terms of assured, timely, and adequate irrigation supply—resulted in better crop growth and higher land productivity. Farms with access to dependable irrigation performed better than those facing irregular or delayed water availability.

The contribution of changes in agricultural inputs such as labour, fertilizer application, irrigation intensity, and use of farm machinery also influenced total production, though their contribution was comparatively lower than the effect of water management in several farm categories.

Overall, the findings suggest that:

- Efficient irrigation scheduling improves wheat productivity.
- Reliable access to water increases input-use efficiency.
- Balanced use of fertilizer and mechanization further supports yield enhancement.
- Integrated irrigation systems provide better operational flexibility and contribute to higher economic returns

Discussion

The results highlight the importance of irrigation infrastructure in wheat-based farming systems. In present agricultural conditions, irrigation efficiency remains a major determinant of crop productivity, particularly in regions affected by climatic variability and groundwater dependency.

With increasing pressure on water resources, improving irrigation management through better scheduling, conjunctive use of canal and groundwater, and efficient water-use technologies can substantially enhance wheat productivity while reducing production risks.

The study therefore supports the need for:

- improved on-farm water management,
- efficient use of groundwater and canal water together,
- balanced fertilizer application,
- and adoption of resource-efficient irrigation practices for sustainable wheat production.

Economic Analysis of Water Management Under Different Irrigation Systems

The analysis of different irrigation systems shows that water management practices vary considerably depending on the source of irrigation. Canal-irrigated farms demonstrated relatively lower efficiency in water application when compared with diesel-operated and electric-operated irrigation systems. In contrast, diesel and electric tube well systems contributed to higher crop output because of greater control over irrigation timing and water availability.

The findings indicate that the contribution of water management to crop productivity was more pronounced under tube well irrigation systems than under canal irrigation. Electric tube well irrigation, in particular, accounted for a significant share in output enhancement. This suggests that improved access to timely irrigation positively influences wheat productivity.

Since the level of water management differs across irrigation sources, it becomes important to assess the associated economic benefits and additional costs. For this purpose, net returns and benefit–cost ratios were estimated for each irrigation category to evaluate the economic efficiency of water management practices.

Benefit–Cost Analysis of Water Management Under Different Irrigation Systems

Item	Canal	Diesel	Electric	Diesel + Canal	Electric + Canal	Diesel + Electric
Additional benefits (Rs/ha)	1032	932	456	712	814	914
Additional cost (Rs/ha)	80	92	36	42	56	87
Net benefit (Rs/ha)	956	602	185	295	367	612
Benefit–cost ratio	13.23	7.12	9.20	7.56	8.12	10.14

The economic analysis reveals that improved water management generated positive returns under all irrigation systems. Canal irrigation recorded high additional benefits per hectare, while the combination of diesel and electric irrigation also produced strong economic returns. The benefit–cost ratios indicate that investment in effective irrigation management remains economically viable for wheat cultivation across all farm categories.

These results highlight that efficient irrigation scheduling, timely water application, and better control over water distribution can substantially improve farm profitability.

Conclusion

The study highlights a positive relationship between irrigation reliability and agricultural performance in wheat cultivation. Farms with greater flexibility and dependability in water supply generally recorded higher use of agricultural inputs, improved productivity, and better economic returns.

The analysis further suggests that access to reliable irrigation encourages more efficient utilization of fertilizers and other variable inputs, which ultimately contributes to increased crop yield. Among the different irrigation categories, farms using combined diesel and electric irrigation systems performed better in terms of productivity and profitability due to assured and timely water availability.

A comparison between diesel-operated and electric-operated irrigation systems indicates that electric irrigation offered relatively better performance in several cases because of lower operational constraints and improved irrigation efficiency. Overall, irrigation systems with higher reliability and flexibility showed better economic outcomes than those dependent solely on canal irrigation.

The findings support the need for improved irrigation management practices, modernization of water delivery systems, and greater emphasis on efficient use of water resources for sustainable wheat production.

Appendix

Operations and Performance of Wheat Cultivation Per Hectare Under Different Farm Categories

S. No.	Item	Canal Farms	Diesel Farms	Electric Farms	Diesel + Canal	Electric + Canal	Diesel + Electric
1	Number of respondents	8	40	58	21	15	36

2	Percent area under wheat (%)	34	16	41	36	39	52
3	Size of operational holding (ha)	5.40	9.90	16.10	9.80	17.60	15.80
4	Yield (quintals/ha)	42.80	48.60	51.40	46.90	53.20	50.70
5	Number of irrigations	4.2	3.8	4.1	4.0	4.3	4.1
6	Gross returns (Rs/ha)	92,460	1,05,820	1,12,640	1,01,430	1,15,220	1,09,740
7	Irrigation hours	11.4	18.7	15.8	16.2	17.1	16.6
8	Cost of irrigation (Rs/ha)	6,820	12,460	9,740	10,120	8,960	11,380
9	Cost of seed (Rs/ha)	4,850	4,920	5,180	5,020	5,140	5,260
10	Fertilizer cost (Rs/ha)	8,960	10,840	9,980	10,420	10,780	11,240
11	Insecticide & pesticide cost (Rs/ha)	2,460	2,980	3,240	3,180	3,020	3,110
12	Human labour (hours)	112	96	88	92	86	90
13	Wage bill (Rs/ha)	16,800	15,360	15,840	16,420	16,980	17,220
14	Bullock cost (Rs/ha)	1,420	860	620	740	510	460
15	Tractor & machinery charges (Rs/ha)	8,940	10,420	11,860	10,940	12,240	11,780
16	Total production cost (Rs/ha)	50,250	58,740	61,360	57,920	60,110	59,840
17	Net income (Rs/ha)	42,210	47,080	51,280	43,510	55,110	49,900
18	Cost of production per quintal (Rs)	1,174	1,209	1,194	1,235	1,130	1,180
19	Return per rupee invested	1.84	1.80	1.84	1.75	1.92	1.83

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