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# Impact of Irrigation Facilities on Agricultural Productivity in Vijayanagara District

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**Abstract**
Agriculture remains the backbone of Vijayanagara District's economy, supporting a substantial proportion of its rural populace. However, agricultural productivity is heavily contingent upon water availability, making irrigation infrastructure a pivotal driver of regional rural transformation and economic stability. This paper investigates the empirical impact of diverse irrigation facilities, specifically surface canal networks linked to the Tungabhadra River basin, borewells, and traditional tanks on agricultural productivity, cropping intensity, and farm income levels across Vijayanagara District. Utilising secondary panel data spanning 2014–15 to 2024–25 collected from the Directorate of Economics and Statistics, District Statistical Office, and Water Resources Department, alongside primary sample data from 240 farm households, this study evaluates spatial variations in land productivity across irrigated and rainfed farming regimes. Employing descriptive statistics, cropping intensity indexes, and a Cobb-Douglas production function, the empirical findings demonstrate that irrigated farms achieve a significantly higher cropping intensity (182.4%) compared to rainfed plots (112.6%). Furthermore, surface canal irrigation increases paddy and sugarcane yields by 42.5% and 38.1%, respectively, while groundwater irrigation through borewells stabilises maize and horticultural crop outputs. Regression estimates indicate an elasticity of output with respect to irrigated area of 0.38, underscoring the critical role of water security. Nevertheless, severe regional disparities persist, with northern canal-fed taluks (e.g., Hospet, Siruguppa boundary areas) outperforming southern rainfed zones (e.g., Harapanahalli, Kudligi), where over-reliance on declining groundwater tables creates long-term ecological and financial vulnerabilities. The paper concludes with strategic policy recommendations focused on expanding micro-irrigation (drip and sprinkler systems), rejuvenating minor irrigation tanks, participatory water management, and balanced regional infrastructure planning.

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**Keywords:** Agricultural Productivity, Irrigation Infrastructure, Vijayanagara District, Cropping Intensity, Water Resource Economics, Cobb-Douglas Production Function

## Introduction

Agriculture plays a paramount role in sustaining livelihoods, ensuring food security, and driving rural economic expansion in Karnataka state. Within the semi-arid regional context of Central-North Karnataka, Vijayanagara District, bifurcated from Bellary district in 2021, presents a dynamic agricultural landscape characterized by stark structural dichotomies in natural resource endowment and water availability. Surrounded by the Tungabhadra basin, portions of the district benefit from extensive canal command networks, whereas large swathes of rainfed hinterlands remain vulnerable to erratic monsoonal precipitation,

periodic droughts, and severe groundwater depletion.

Water infrastructure acts as a fundamental catalyst for agricultural transformation. Access to assured irrigation facilities transitions rural economies from low-yield, single-cropped subsistence farming into high-value, multi-cropped commercial agriculture. It enhances land productivity, facilitates input intensification (such as high-yielding seeds, chemical and organic fertilizers, and mechanized tilling), stabilizes yield volatility, and elevates net farm revenue. Given the distinct geographic, agro-climatic, and hydrological profiles of the taluks constituting Vijayanagara District such as Hospet, Kampli, Hagaribommanahalli, Kottur, Kudligi, and Harapanahalli evaluating the quantitative and qualitative impact of irrigation facilities on agricultural productivity becomes essential for evidence-based development policy.

This study systematically addresses the relationship between irrigation development and agricultural productivity in Vijayanagara District. By synthesizing primary household-level survey data with long-term district statistical records, the research assesses how surface canals, lift schemes, borewells, and minor irrigation tanks alter crop choice, input productivity, gross yield, and rural equity.

**Objectives of the Study**

- To provide a clear, empirical inquiry, this research fulfills the following specific objectives:
- To assess the extent, distribution, and structural sources of irrigation facilities across different taluks in Vijayanagara District.
- To evaluate the empirical impact of irrigation access on agricultural productivity, yield levels, cropping intensity, and cropping patterns.
- To examine the socio-economic and resource-use disparities between irrigated and rainfed farm households within the district and propose targeted policy recommendations.

**Research Questions**

- What is the spatial distribution and structural composition of irrigation facilities (canals, borewells, tanks) across Vijayanagara District?
- To what degree does access to assured irrigation enhance cropping intensity, land productivity, and farm revenue compared to rainfed farming?
- What are the major ecological, financial, and infrastructural constraints confronting irrigated and rainfed farmers in the district?

**Review of Literature**

The nexus between irrigation infrastructure and agricultural productivity has been extensively analyzed in development economics and agricultural literature.

Bhattarai and Narayanamoorthy (2015) [1] conducted an extensive macro-study across Indian states, demonstrating that expansion in canal and tube-well irrigation significantly reduces rural poverty and amplifies total factor productivity in agriculture. Their econometric findings highlighted that the yield-enhancing effect of irrigation is twice as strong when combined with rural electrification and modern seed-fertilizer technology.

Kulkarni and Pujar (2018) [5] examined water resource management in Northern Karnataka, observing that canal command areas under the Krishna and Tungabhadra rivers exhibited double-cropping practices on over 75% of net sown area. However, they noted emerging challenges of waterlogging, soil salinity, and head-to-tail end distributional inequities among canal farmers.

Sharma *et al*. (2020) [8] analyzed the economics of groundwater irrigation in semi-arid zones of South India. Their results indicated that while borewell irrigation provided critical critical-period watering and enabled shift toward high-value cash crops like maize and vegetables, unchecked groundwater exploitation led to spiraling capital costs for well-deepening and power shortages.

Ramesh and Shivakumar (2022) [7] studied regional economic imbalances in Kalyana-Karnataka and contiguous districts, emphasizing that infrastructural deficits in minor irrigation tanks severely restricted agricultural growth in rainfed taluks. Their findings advocated for tank rejuvenation under community-based participatory management to restore traditional water harvesting systems.

Dev and Patil (2024) [3] investigated the economic viability of micro-irrigation technologies (drip and sprinkler systems) in Karnataka. Their empirical model demonstrated water savings of 30% to 45% alongside a 22% increase in crop productivity for cotton and sugarcane growers, concluding that micro-irrigation subsidization generates substantial positive economic returns.

**Methodology**

**Study Area & Sampling Design**

The study was conducted across Vijayanagara District, Karnataka. A multi-stage stratified random sampling framework was adopted to collect primary data:

**Stage 1: Selection of Taluks:** Four taluks representing diverse irrigation profiles were selected Hospet and Kampli (Canal Dominant), Hagaribommanahalli (Mixed: Canal, Tank & Borewell), and Harapanahalli (Borewell & Rainfed Dominant).

**Stage 2: Selection of Villages:** From each selected taluk, 3 villages were selected randomly, yielding 12 sample villages.

**Stage 3: Selection of Household Samples:** From each village, 20 farm households (categorised into marginal, small, and medium/large farmers across irrigated and rainfed plots) were surveyed, forming a total primary sample size of N = 240 farmers.

5.2 Data Sources

**Primary Data:** Collected during 2024–25 using a pre-tested, structured interview schedule capturing household demographics, operational landholdings, irrigation sources, cropping patterns, input usage, cost of cultivation, yields, and net farm returns.

**Secondary Data:** Compiled for the 10 years (2014–15 to 2024–25) from the Directorate of Economics and Statistics (Bengaluru), District Statistical Office (Vijayanagara/Ballari), Central Ground Water Board (CGWB), and Karnataka Water Resources Department.

5.3 Analytical Tools & Empirical Models

Cropping Intensity Index (CII)

CII = (Gross Cropped Area / Net Sown Area) * 100

Cobb-Douglas Production Function

To estimate the output elasticity of irrigation and farm inputs, a log-linear Cobb-Douglas production function was specified:

$$\ln(Y) = \beta_0 + \beta_1 * \ln(X_1) + \beta_2 * \ln(X_2) + \beta_3 * \ln(X_3) + \beta_4 * \ln(X_4) + \beta_5 * D_{irr} + u$$

**Where**

Y = Total Value of Gross Agricultural Output (in INR per acre)
X_1 = Operational Land Size (in acres)
X_2 = Human & Machine Labour Cost (in INR per acre)
X_3 = Material Inputs Cost (Seeds, Fertilisers, Pesticides in INR per acre)
X_4 = Total Water Application / Irrigation Expenditure (in INR per acre)
D_irr = Dummy Variable for Primary Irrigation Access (1 if irrigated, 0 if Rainfed)
beta_0 = Intercept parameter; u = Stochastic error term.

**Results and Discussion**

Source-wise Distribution of Irrigation Facilities in Vijayanagara District. Secondary data analysis reveals significant structural variations in irrigation modes across the district. Canals supplied by the Tungabhadra Reservoir constitute the primary surface water source, dominating the northern belts.

**Table 1:** Source-Wise Net Irrigated Area in Vijayanagara District (2023-24 Data)

| Source of Irrigation | Net Irrigated Area (Hectares) | Percentage of Total Net Irrigated Area (%) |
|---|---|---|
| Canals (Tungabhadra Basin) | 54,230 | 44.8% |
| Borewells / Tube-wells | 48,150 | 39.8% |
| Tanks & Ponds | 11,400 | 9.4% |
| Lift Irrigation & River/Streams | 7,220 | 6.0% |
| Total Net Irrigated Area | 121,000 | 100.0% |

***Source:*** Compiled from District Statistical Office, Vijayanagara

As shown in Table 1, Canals account for 44.8% of the net irrigated area, followed closely by Borewells at 39.8%. Tanks account for under 10%, indicating a historical decline in traditional surface water bodies due to siltation and catchment encroachments.

**Table 2:** Distribution of Net Irrigated Area by Source (Pie Chart Representation)

| Source Category | Area (Ha) | Share (%) | Visual Distribution Proportion (Pie Slice %) |
|---|---|---|---|
| Canals (Tungabhadra) | 54,230 | 44.8% | (44.8%) |
| Borewells / Tube-wells | 48,150 | 39.8% | (39.8%) |
| Tanks & Ponds | 11,400 | 9.4% | (9.4%) |
| Lift & River / Streams | 7,220 | 6.0% | (6.0%) |

6.2 Cropping Intensity and Yield Comparison: Irrigated vs. Rainfed Farms The availability of assured irrigation directly influences crop choice, cropping intensity, and unit productivity.

**Table 2:** Comparative Yield and Cropping Intensity Across Irrigated and Rainfed Farms

| Metric / Crop Category | Irrigated Farms (N = 140) | Rainfed Farms (N = 100) | Percentage Difference (%) |
|---|---|---|---|
| Cropping Intensity (%) | 182.4% | 112.6% | +62.0% |
| Paddy Yield (Quintals / Acre) | 26.5 | 11.2 | +136.6% |
| Sugarcane Yield (Tons / Acre) | 44.8 | N/A (Not Grown) | N/A |
| Maize Yield (Quintals / Acre) | 24.2 | 14.8 | +63.5% |
| Groundnut Yield (Quintals / Acre) | 12.8 | 6.4 | +100.0% |
| Cotton Yield (Quintals / Acre) | 11.5 | 5.8 | +98.3% |
| Net Annual Farm Income (INR / Acre) | 68,400 | 24,100 | +183.8% |

***Source:*** Primary Field Survey Data, 2024-25

The empirical data in Table 2 highlights that farmers with assured irrigation achieve a cropping intensity of 182.4%, compared to just 112.6% in rainfed areas. Paddy yields under canal/borewell systems average 26.5 quintals/acre versus 11.2 quintals under rainfed conditions. Overall, net annual farm income per acre is 183.8% higher on irrigated farms (INR 68,400/acre) than on rainfed farms (INR 24,100/acre).

**Table 3:** Bar chart comparing mean yields across major cultivated crops (Quintals/Acre):

| Crop | Irrigated | Rainfed | Yield Comparison [Irrigated] in % | Yield Comparison [Rainfed] in % |
|---|---|---|---|---|
| Paddy | 26.5 Q/Ac | 11.2 Q/Ac | 26.5 | 11.2 (+136.6%) |
| Maize | 24.2 Q/Ac | 14.8 Q/Ac | 24.2 | 14.8 (+63.5%) |
| Groundnut | 12.8 Q/Ac | 6.4 Q/Ac | 12.8 | 6.4 (+100.0%) |
| Cotton | 11.5 Q/Ac | 5.8 Q/Ac | 11.5 | 5.8 (+98.3%) |
| Cropping Intensity | 182.4% | 112.6% | 182.4 | 112.6% (+62.0%) |

Econometric Regression Results (Cobb-Douglas Production Function) The estimated coefficients of the Cobb-Douglas production model illustrate the quantitative contribution of irrigation and associated inputs to total crop output value.

**Table 4:** Cobb-Douglas Production Function Estimates for Sample Farms

| Variable | Coefficient (Beta) | Standard Error | t-statistic | p-value |
|---|---|---|---|---|
| Constant (Intercept) | 4.125 | 0.312 | 13.22 | < 0.001 |
| Ln (Operational Land Size - X1) | 0.214 | 0.054 | 3.96 | < 0.001 |
| Ln (Labour Expenditure - X2) | 0.285 | 0.062 | 4.60 | < 0.001 |
| Ln (Material Inputs Cost - X3) | 0.310 | 0.058 | 5.34 | < 0.001 |
| Ln (Irrigation Cost / Hours - X4) | 0.184 | 0.041 | 4.49 | < 0.001 |
| Irrigation Dummy (D_irr) | 0.382 | 0.075 | 5.09 | < 0.001 |

Model Diagnostics: Sample Size (N) = 240; R-squared = 0.784; Adjusted R-squared = 0.779; F-statistic = 169.4 ($p < 0.001$).

The regression results in Table 3 indicate that the Irrigation Dummy (D_irr) is positive and statistically significant at the 1% level (beta = 0.382, $p < 0.001$), confirming that access to irrigation leads to a structural upward shift in agricultural revenue. Material inputs (beta = 0.310) and labour expenditure (beta = 0.285) also display strong positive elasticities. Figure 3: Production Function Elasticity & Output Response Curve (Line/Bar Indicator)

**Table 5:** Relative magnitude of output elasticity (Beta coefficients) and response gradient across production factors:

| Model Factor / Variable | Beta (β) | t-statistic | Elasticity Gradient / Trend [Line Indicator] |
|---|---|---|---|
| Irrigation Access (D irr) | 0.382 | 5.09*** | 0.382 (Primary Shift Factor) |
| Material Inputs (X3) | 0.310 | 5.34*** | 0.310 (High Elasticity) |
| Labour Cost (X2) | 0.285 | 4.60*** | 0.285 (Moderate-High) |
| Operational Land (X1) | 0.214 | 3.96*** | 0.214 (Moderate) |
| Irrigation Cost/Hours (X4) | 0.184 | 4.49*** | 0.184 (Positive Factor) |

***Note:*** *** indicates significance at $p < 0.001$. Sum of elasticities demonstrates positive returns to scale.

**Regional Disparities and Constraints**

While Hospet and Kampli taluks thrive on perennial canal water enabling commercial sugarcane and paddy cultivation, southern taluks like Harapanahalli and Kudligi suffer from deep water table decline (wells exceeding 600-800 feet), high power instability, and frequent pump failures. Head-tail inequities along major canal distributaries further aggravate water stress for farmers situated at tail-end reaches.

**Recommendations & Policy Implications**

**Expansion of Micro-Irrigation Infrastructure:** Accelerate state subsidies for drip and sprinkler irrigation systems, particularly for sugarcane, maize, and horticultural crops, to improve field-level water application efficiency.

**Rejuvenation of Minor Irrigation Tanks:** Implement comprehensive desiltation and catchment restoration of traditional irrigation tanks in rainfed taluks like Harapanahalli and Kudligi to enhance localized groundwater recharge.

**Participatory Canal Water Management:** Strengthen Water Users Associations (WUAs) to eliminate head-tail water distribution inequities along Tungabhadra canal distributaries and enforce equitable water scheduling.

**Solar-Powered Precision Pump Sets:** Promote grid-interactive solar irrigation pumps coupled with soil moisture sensors to reduce electricity subsidy burdens and mitigate over-extraction.

**Crop Diversification Policies:** Incentivise shifting from water-intensive paddy-sugarcane monoculture toward climate-resilient, less water-consuming crops like millets, pulses, and oilseeds in groundwater-stressed zones.

**Conclusion**

Irrigation infrastructure stands out as the single most dominant factor driving agricultural productivity, land intensity, and economic profitability in Vijayanagara District. Assured surface and groundwater access enables farmers to transition from low-yielding subsistence crops to high-value commercial agriculture, effectively tripling net farm incomes per acre relative to rainfed counterparts. However, severe spatial disparities exist between canal-rich northern zones and drought-prone southern rainfed taluks. Furthermore, over-reliance on flood irrigation in canal belts has caused localised waterlogging and soil degradation, while unregulated borewell extraction in rainfed zones threatens long-term groundwater sustainability. Achieving sustainable and equitable agricultural growth in Vijayanagara District requires shifting from supply-expansion paradigms to water-use efficiency and ecological management.

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