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# Profitability of Vegetable Cultivation under Groundwater Condition in Karnataka, India

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***Authors' contributions***

*This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.*

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## ABSTRACT

The study assessed the profitability and water use efficiency of vegetable crops, specifically cabbage and cauliflower, in comparison to cereal crops like ragi and maize in Karnataka during 2020-2021. Data were collected from 120 farmers using a multistage purposive sampling design. The results indicated that vegetable crops had significantly higher gross and net returns than cereal crops. Additionally, the water use efficiency of cabbage and cauliflower was superior, meaning they utilized water more effectively to generate economic returns. The benefit-cost ratio also favoured the vegetable crops, demonstrating that they were more profitable compared to ragi and maize. Overall, the findings highlighted that under groundwater conditions, vegetable crops performed better in terms of profitability and water efficiency, suggesting that promoting vegetable cultivation could enhance farm incomes and optimize water use in Karnataka.

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## 1. INTRODUCTION

Groundwater is an important natural resource for meeting our country's water needs. Since 1970s, groundwater irrigation in India has grown at a rapid rate, accounting for more than 60 per cent of the total irrigated land in the country. The share of borewell irrigation in India increased from 1 per cent in 1960-61 to 60 per cent in 2006-07. There are currently over 27 million wells and bore wells, with borewells accounting for more than half of them. The proportion of groundwater used for irrigation increased in every decade (Anon., 2008; Anon., 2020).

Karnataka is one of the most water-starved states in India and is characterized by the highest concentration of drought-prone area. With all the available supply of surface and groundwater in the state (761 TMC), only 34 per cent of the gross cropped area is irrigated leaving the bulk of the area under dryland agriculture relying on monsoon. Thus, the demand for irrigation water is increasing, as irrigation is a very critical input for enhancing agricultural productivity and farmer's income. Since agriculture is the major consumer of surface and groundwater (90%), the biggest challenge is reducing the consumptive use of water in agriculture so that the saved water could be optimally utilized to bring more area under irrigation (Nagaraj, 2020; Tham-Agyekum, 2023; Rajkhowa, 2024).

Horticulture is an essential industry among the land-based agricultural systems. Horticultural Industry is a fast emerging and most remunerative sector in our country. Karnataka occupies a prominent place in the horticulture map of the country. It provides excellent opportunities in raising the income of the farmers even in dry tracts. Irrigation for horticultural crops is more compared to other crops. Water is the source of life and a precious resource for agriculture and is essential for economic and social development (Krishna et al., 2013).

Karnataka occupied 7th position in India's vegetable production with 8.82 million tonnes. Karnataka is one of the leading states in Southern India with a great potential for horticultural development. The state is blessed with ten agro-climatic regions suitable for growing a variety of fruits and vegetables round the year. The major districts growing horticultural crops in the state are Kolar, Hassan, Belagavi, Kodagu, Bengaluru, Shimoga, Vijayapura and Dharwad (Bhat, 2017).

The Bengaluru rural district of Karnataka is endowed with good natural resources and is known for the cultivation of many agricultural and horticultural crops. The cultivation of vegetables requires uninterrupted water supply especially for cole crops, which was very much possible with the help of a groundwater source. Therefore, an attempt is made in the present study to evaluate the water use efficiency of vegetable crops versus cereal crops to determine their relative effectiveness in utilizing water resources and to analyse the profitability of vegetable cultivation under groundwater condition in Bengaluru rural district of Karnataka.

## 2. METHODOLOGY

### 2.1 Data Collection

The present study was conducted in the selected villages of the Bengaluru Rural district of Karnataka. The random sampling procedure was followed for the selection of villages from the selected taluks. In all, 10 villages, five from each taluk which were known for the cultivation of cole crops were selected for the study. The number of respondents selected from each village were 12 farmers. Thus, 120 farmers were selected for the study. The primary data obtained from selected farmers using pre-tested schedule through personal interview for evaluating the objectives of the study. The information regarding cropping input use and output realized, various aspects of agriculture and groundwater irrigation were collected. The data was analysed using descriptive statistics, ratios functional and financial analysis to meet the objectives of the study.

### 2.2 Analytical Tools

#### 2.2.1 Cost and returns analysis

The costs were categorized into fixed and variable costs. The definition and computation of various cost components are as follows.

**I. Fixed Costs:** This includes cost items which do not vary with the level of production. The fixed cost items included are:

a. **Land Revenue**: Land revenue was charged at the rates imposed by the government.
b. **Depreciation:** Straight line method of compounding of depreciation was used for assessing the depreciation on farm asset used in crop production.
c. **Rental Value of Land:** The prevailing rate in the study area was considered
d. **Interest on fixed capital:** It was calculated at the rate of 12 per cent per annum on the total value of fixed assets

**II. Variable Costs:** Costs which vary with the level of production are included in this category. The items included under this are given below.

a. **Labour Cost:** The cost of hired human labour was calculated based on the actual wage payment. The cost of family labour was imputed by multiplying a number of man-days with the prevailing wage rate. Machine labour was measured in hours and valued at prevailing hourly rates in the area.
b. **Cost of Inputs:** Cost of various inputs like fertilizers, seeds, plant protection chemicals, FYM and others were calculated using the actual payment made by the farmers. Owned farm inputs were valued at current prices while non-farm inputs were imputed at prevailing prices.
c. **Interest on Working Capital:** Interest on working capital for the duration of the crop was worked out by taking the prevailing bank interest rate of 7 per cent per annum.

**Cost of cultivation:** Cost of cultivation for different crops were worked out by adding variable cost to the fixed cost and expressed on per acre basis.

**Gross returns:** Gross returns were obtained by multiplying the total product with their unit prices.

**Net returns:** Net returns were computed by subtracting the total costs from the gross returns.

**Returns per rupee of expenditure:** It was arrived at by dividing the gross returns with the total cost.

Net returns from well irrigation is the gross returns from gross irrigated area minus the cost of production of all irrigated crops. The cost of cultivation of all irrigated crops includes the cost of irrigation.

To calculate the Irrigation Intensity (II), Gross Irrigated Area (GIA) was calculated by adding of irrigated area under all crops in all seasons (Kharif, Rabi, Summer and including Perennials). Net Irrigated Area (NIA) is the irrigated area under all crops.

**Cropping intensity (CI)** = (GCA/NCA) x 100

Where GCA: Gross cropped area; NCA: Net cropped area

**Irrigation intensity (II)** = (GIA/NIA) x 100

### 2.2.2 Water use efficiency

There are two types of water use efficiency namely, Agronomic Water Use Efficiency and Economic Water Use Efficiency. Agronomic Water Use Efficiency is worked out by dividing the physical output by the volume of water used which is measured in terms of Kg per acre inch. Economic Water Use Efficiency is worked out by dividing the net returns by the volume of water used which is measured in terms of Rs per acre inch.

## 3. RESULTS AND DISCUSSION

### 3.1 Cost and Returns of Different Crops Grown under Groundwater Source of Irrigation in the Study Area

The cost and returns of different crops grown under groundwater source of irrigation is presented taluk-wise and overall for the district in Table 1. The per acre cost of cultivation of cabbage was found to be higher in the Nelamangala taluk i.e., ₹ 48400.56 when compared to the Hoskote taluk which was ₹ 46676.56. However, the crop yield was more in the case of Hoskote taluk (134.83 qtls/ac) than in Nelamangala taluk (120.96 qtls/ac). Gross returns was ₹ 148313 in Hoskote and in Nelamangala it was ₹ 145152. The net returns realized was ₹ 101636.40 and ₹ 96751.44, respectively in Hoskote and Nelamangala taluks. Returns per rupee spent was higher at 3.18 in the case of Hoskote whereas, it was 3.00 in the case of Nelamangala. In the Hoskote taluk, cabbage production seems to be more profitable compared to the Nelamangala taluk as the returns per rupee spent was high. Though the cost of cultivation was higher in Nelamangala taluk, yield was less due to lack of management practices adopted by farmers and due to irregular irrigation, as opined by respondents during survey which reduced the head weight of the crop. Whereas in case of Hoskote taluk, most of

the farmers cultivated hybrid variety which performs better and which weighs up to 2 to 2.5 Kg per unit which increased the yield level. The above results are in line with Raveesha (2020) who conducted a study on economic perspectives of well-irrigated agricultural farms in hard rock areas of Karnataka.

The yield, gross returns, net returns and returns per rupee spent on cauliflower were recorded highest in the Hoskote taluk (145.80 q, ₹ 182250, ₹ 140938 and 4.41 respectively) as against Nelamangala taluk (138.20 q, ₹ 145110, ₹ 101188.30 and 3.30 respectively). Cauliflower was prone to pest and diseases which reduced the yield level in Nelamangala taluk whereas in the Hoskote taluk, farmers adopted nutrient management in which they applied manures and fertilizers at right time. Adopted water management practices by irrigating at regular interval for optimum moisture which gives maximum growth and yield and adopted disease management by both chemical and natural methods to control pest and diseases. The results obtained align with the study conducted by Amarnath *et al* (2019) on crop planning in different irrigation systems of Coimbatore district, Tamil Nadu

In case of ragi, crop yield was found to be 15.03 and 14.31 quintals in the Hoskote and the Nelamangala taluk respectively. The average cost of cultivation was ₹. 22173.33 whereas average gross and net returns were ₹ 46593 and ₹ 24419.67 respectively. The returns per rupee spent worked out to be higher in Hoskote taluk (2.10) against Nelamangala taluk (1.85).

The per acre cost of cultivation of maize was highest in Nelamangala taluk (₹ 24164.63) followed by Hoskote taluk (₹ 22717.76). The gross returns for Hoskote and Nelamangala taluk were ₹ 47250 and ₹ 48,300 respectively. Net returns in both the taluks were ₹ 24532.24 and ₹ 24135.37 and returns per rupee spent was 2.22 and 2.19 respectively. Crop yield was 22.50 and 21 quintals in Hoskote and Nelamangala taluks, in that order. The above results were in consistent with findings of Anupama (2018) who conducted research on conjunctive use of irrigation water in Tungabhadra command area and found that the return per rupee of expenditure on maize was 1.47 and 21 quintal per acre was the yield.

The above findings revealed that returns per rupee spent on all the major crops were higher in the case of the Hoskote taluk compared to the Nelamangala taluk. The returns realized were higher in the selected vegetables viz., cabbage and cauliflower compared to other cereals like ragi and maize grown under groundwater irrigation. This indicated the profitability of the vegetables production compared to ragi and maize. The farmers of the region justified the utilization of precious resource for profitable cultivation.

### 3.2 Water Use Efficiency of Major Crops Grown under Groundwater Irrigation in Study Area

The water use efficiency of major crops grown under groundwater irrigation is presented in Table 2. Technical efficiency and economic efficiency of water were calculated for better interpretation of the results. As vegetables are water-intensive crops, groundwater was mainly utilized for vegetables compared to cereal crops. In Hoskote taluk groundwater was extracted and used for the production of cabbage, cauliflower, ragi and maize was to the extent of 6.70, 7.69, 3.88 and 2.65 acre-inches, respectively. More groundwater was utilized for cabbage and cauliflower production as these crops require more amount of water for their growth and sustenance compared to cereals. The yield obtained in cabbage and cauliflower by using groundwater was about 20.12 and 18.95 quintals per acre-inch respectively. Whereas in the case of ragi and maize, the groundwater usage, correspondingly, was less i.e., 3.88 and 2.65 acre-inch compared to the vegetable crop and the yield obtained by usage of groundwater was 4.38 and 8.49 quintals per acre-inch. The net returns obtained from per acre-inch of water used is called economic efficiency of water use. The economic efficiency of water use was found to be highest in the case of cauliflower (₹ 18420.35 per acre-inch) followed by cabbage (₹ 15034.29 per acre-inch), maize (₹ 9257.44 per acre-inch) and ragi (₹ 7781 per acre-inch). The findings are in line with Jha et al (2017) who conducted a study on Yield, water productivity, and economics of vegetable production under drip and furrow irrigation in the eastern plateau and hill region of India.

The technical efficiency of water use was found to be the highest in cabbage, cauliflower, maize and ragi with 18.28, 18.27, 7.78 and 3.86 quintals per acre-inch respectively in Nelamangala taluk. The net return per acre inch of water used was the highest in cabbage (₹ 14427.37 acre-inch) followed by cauliflower (₹ 13333 acre-inch), maize (₹ 8939.02 acre-inch) and ragi (6153.36 ₹/acre-inch). The above

findings suggested that among the major crops grown under groundwater irrigation, the water use efficiency was found to be higher in cabbage and cauliflower compared to cereals. The yield and net returns found to be highest in the case of vegetables in both the taluks and for the study area as a whole. The results of the study are in line with the research findings of Ashok (2017), Gupta et al (2020) and Anupama (2018). The usage of groundwater was found to be profitable for vegetable cultivation was further substantiated by the water use efficiency measures used in the study.

### 3.3 Comparative Economic Performance of the Crops Grown under Groundwater Irrigation

Table 3 depicts the comparative economics of crops grown under groundwater sources of irrigation. In the Hoskote taluk, the per-acre cost of cultivation of cabbage, cauliflower, ragi and maize were ₹ 46676.56, ₹ 41312.05, ₹ 22173.33 and ₹ 21276.47 respectively. The gross returns was highest in the case of cauliflower followed by cabbage, ragi and maize. The cost of water per acre-inch (₹ 4767.80) was more in the case of cauliflower and lowest in the case of maize (₹ 1643). The output obtained by using groundwater was 20.12, 18.95, 8.50 and 3.88 quintals in cabbage, cauliflower, maize and ragi respectively. The net returns per acre-inch of water was ₹ 18327.44 in cauliflower followed by cabbage (₹ 15169.61), maize (₹ 9801.33) and ragi (₹ 6293.72) similar results were observed by Raghupathi and Kumar (2018). Among the major crops grown under groundwater source, the yield was higher and water used was less in cabbage when compared to cauliflower whereas, in cereals, yield was higher in maize compared to ragi.

**Table 1. Cost and returns of different crops grown under groundwater source of irrigation in the study area**

**(₹/acre)**

| Sl. No | Crop | Unit | Hoskote | Nelamangala | Overall |
|---|---|---|---|---|---|
| 1 | **Cabbage** | | | | |
| | Cost of cultivation | Rs/acre | 46676.56 | 48400.56 | 47538.54 |
| | Crop yield | Quintal/acre | 134.83 | 120.96 | 127.89 |
| | Price realized | Rs/quintal | 1100.00 | 1200.00 | 1150.00 |
| | Gross returns | Rs/acre | 148313.00 | 145152.00 | 147073.50 |
| | Net returns | Rs/acre | 101636.40 | 96751.44 | 99534.96 |
| | Returns per rupee spent | | 3.18 | 3.00 | 3.09 |
| 2 | **Cauliflower** | | | | |
| | Cost of cultivation | Rs/acre | 41312.05 | 43921.72 | 42616.86 |
| | Crop yield | Quintal/acre | 145.80 | 138.20 | 142.00 |
| | Price realized | Rs/quintal | 1250.00 | 1050.00 | 1150.00 |
| | Gross returns | Rs/acre | 182250.00 | 145110.00 | 163300.00 |
| | Net returns | Rs/acre | 140938.00 | 101188.30 | 120683.10 |
| | Returns per rupee spent | | 4.41 | 3.30 | 3.83 |
| 3 | **Ragi** | | | | |
| | Cost of cultivation | Rs/acre | 22173.33 | 23991.78 | 23082.54 |
| | Crop yield | Quintal/acre | 15.03 | 14.31 | 14.67 |
| | Price realized | Rs/quintal | 3100.00 | 3100.00 | 3100.00 |
| | Gross returns | Rs/acre | 46593.00 | 44361.00 | 45477.00 |
| | Net returns | Rs/acre | 24419.67 | 20369.22 | 22394.46 |
| | Returns per rupee spent | | 2.10 | 1.85 | 1.97 |
| 4 | **Maize** | | | | |
| | Cost of cultivation | Rs/acre | 21276.47 | 22454.56 | 21865.49 |
| | Crop yield | Quintal/acre | 22.50 | 21.00 | 21.75 |
| | Price realized | Rs/quintal | 2100.00 | 2300.00 | 2200.00 |
| | Gross returns | Rs/acre | 47250.00 | 48300.00 | 47850.00 |
| | Net returns | Rs/acre | 25973.53 | 25845.44 | 25984.51 |
| | Returns per rupee spent | | 2.22 | 2.15 | 2.19 |

**Table 2. Water use efficiency of crops grown under groundwater irrigation in the study area**

**(N= 120)**

| Sl. No | Crop | Technical efficiency | | | Economic efficiency | | |
|---|---|---|---|---|---|---|---|
| | | Output (quintals) | Water used (acre-inches) | Water use efficiency (quintals/ acre-inch) | Net return (₹/acre) | Water used (acre-inches) | Water use efficiency (₹/acre-inch) |
| **Hoskote** | | | | | | | |
| 1 | Cabbage | 134.83 | 6.70 | 20.12 | 101636.40 | 6.70 | 15169.61 |
| 2 | Cauliflower | 145.80 | 7.69 | 18.95 | 140938.00 | 7.69 | 18327.44 |
| 3 | Ragi | 15.03 | 3.88 | 3.88 | 24419.67 | 3.88 | 6293.72 |
| 4 | Maize | 22.50 | 2.65 | 8.49 | 25973.53 | 2.65 | 9801.33 |
| **Nelamangala** | | | | | | | |
| 1 | Cabbage | 120.96 | 6.62 | 18.27 | 96751.44 | 6.62 | 14615.02 |
| 2 | Cauliflower | 138.20 | 7.56 | 18.28 | 101188.30 | 7.56 | 13384.70 |
| 3 | Ragi | 14.31 | 3.70 | 3.86 | 20369.22 | 3.70 | 5505.19 |
| 4 | Maize | 21.00 | 2.70 | 7.78 | 25845.44 | 2.70 | 9572.38 |
| **Overall** | | | | | | | |
| 1 | Cabbage | 127.89 | 6.65 | 19.23 | 99534.96 | 6.65 | 14967.66 |
| 2 | Cauliflower | 142.00 | 7.62 | 18.63 | 120683.10 | 7.62 | 15837.68 |
| 3 | Ragi | 14.67 | 3.80 | 3.86 | 22394.46 | 3.80 | 5893.27 |
| 4 | Maize | 19.92 | 2.60 | 7.66 | 25984.51 | 2.60 | 9994.04 |

**Table 3. Comparative economic performance of the crops grown under groundwater irrigation**

**(N= 120)**

| Sl. No | Particulars | Cabbage | Cauliflower | Ragi | Maize |
|---|---|---|---|---|---|
| **I.** | **Hoskote** | | | | |
| 1 | Cost of cultivation per acre | 46676.56 | 41312.05 | 22173.33 | 21276.47 |
| 2 | Gross returns per acre | 148313.00 | 182250.00 | 52793.00 | 47250.00 |
| 3 | Net returns per acre | 101636.40 | 140938.00 | 24419.67 | 25973.53 |
| 4 | Water use per acre (acre inch) | 6.70 | 7.69 | 3.88 | 2.65 |
| 5 | Net returns per acre-inch of water (Rs) | 15169.61 | 18327.44 | 6293.72 | 9801.33 |
| 6 | Output per acre (quintals) | 134.83 | 145.80 | 15.03 | 22.50 |
| 7 | Output per acre-inch of water (quintals) | 20.12 | 18.95 | 3.88 | 8.49 |
| 8 | Cost of water (per acre) | 4154.00 | 4767.80 | 2405.60 | 1643.00 |
| II. | **Nelamangala** | | | | |
| 1 | Cost of cultivation per acre | 48400.56 | 43921.72 | 23991.78 | 22454.56 |
| 2 | Gross returns per acre | 145152.00 | 145110.00 | 47299.00 | 48300.00 |
| 3 | Net returns per acre | 96751.44 | 101188.30 | 20369.22 | 25845.44 |
| 4 | Water use per acre (acre inch) | 6.62 | 7.56 | 3.70 | 2.70 |
| 5 | Net returns per acre-inch of water (Rs) | 14615.02 | 13384.70 | 5505.19 | 9572.38 |
| 6 | Output per acre (quintals) | 120.96 | 138.20 | 14.31 | 21.00 |
| 7 | Output per acre-inch of water (quintals) | 18.27 | 18.28 | 3.86 | 7.77 |
| 8 | Cost of water (per acre) | 3839.60 | 4384.80 | 2146.00 | 1566.00 |
| III. | **Overall** | | | | |
| 1 | Cost of cultivation per acre | 47538.54 | 42616.86 | 23082.54 | 21865.49 |

| Sl. No | Particulars | Cabbage | Cauliflower | Ragi | Maize |
|---|---|---|---|---|---|
| 2 | Gross returns per acre | 147073.50 | 163300.00 | 50010.00 | 47850.00 |
| 3 | Net returns per acre | 99534.96 | 120683.10 | 22394.46 | 25984.51 |
| 4 | Water use per acre (acre inch) | 6.65 | 7.62 | 3.80 | 2.60 |
| 5 | Net returns per acre-inch of water (Rs) | 14967.66 | 15837.68 | 5893.27 | 9994.04 |
| 6 | Output per acre (quintals) | 127.89 | 142.00 | 14.67 | 19.92 |
| 7 | Output per acre-inch of water (quintals) | 19.23 | 18.63 | 4.86 | 7.66 |
| 8 | Cost of water (per acre) | 3990.00 | 4572.00 | 2280.00 | 1560.00 |

In the Nelamangala taluk, the extent of groundwater used per acre in cauliflower, cabbage, ragi and maize was 7.56, 6.62, 3.70 and 2.70 acre-inches respectively. The net returns was highest in cauliflower (₹ 101188.30) followed by cabbage (₹ 96751.44), maize (₹ 25845.44) and ragi (₹ 20369.22). The cost of water in cauliflower was highest i.e., ₹ 4384.80 and lowest in maize (₹ 1566). Among the major crops, water used per acre was more in the case of vegetables compared to cereals and similarly the net return per acre-inch of water was also highest in vegetables indicating the use of groundwater for the production of vegetables was more profitable than the cereals. Though the cereals require less water but returns were not profitable compared to vegetables. Comparable results were observed in the study conducted by Ashok (2017) and Siddaiah & Raveesha (2020).

## 4. CONCLUSION

It is evident from the above study that Choice of right crops, pumping right volume of water, focusing not on more crop per drop, but on the strategy of net returns per rupee of the cost of water are crucial. However, as observed in this study there are some crops (cabbage and cauliflower) which performed well under groundwater. This highlights the need for comparative evaluation of crops grown under groundwater in the farmers' fields. The BC ratio analysis of vegetable crop and other crops was beneficial in demonstrating and convincing the farmers for adoption of crops to be grown under groundwater. Such type of study can be helpful in framing guidelines for crop selection and influence farming community to adopt crops which gain higher profit instead of other crops. The results have proved that the farmers growing vegetable crop under groundwater condition gain higher profit compared to other crops. Thus, the key economic message is that it would be wise on the part of the farmers to grow crops which reap higher profits.

## DISCLAIMER (ARTIFICIAL INTELLIGENCE)

Author(s) hereby declare that NO generative AI technologies such as Large Language Models (ChatGPT, COPILOT, etc) and text-to-image generators have been used during writing or editing of this manuscript.

## COMPETING INTERESTS

Authors have declared that no competing interests exist.

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