A Geographical Study on Growth Pattern and Development of Micro-Irrigation Sector in Karnataka: A Trend Analysis

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***Abstract*—Micro-irrigation has emerged as an important strategy for improving agricultural water-use efficiency, enhancing crop productivity and reducing pressure on groundwater resources in Karnataka. The Micro Irrigation (MI) sector in Karnataka has emerged as a cornerstone of the state's sustainable agriculture strategy, consistently ranking among India's top-performing states under the centrally sponsored 'Per Drop More Crop' (PDMC) scheme. Facing critical groundwater depletion in its vast arid and semi-arid tracts, Karnataka has aggressively scaled up drip and sprinkler adoption through substantial budgetary support and pioneering community engineering models. Driven by severe groundwater depletion in its arid regions, the state has achieved cumulative progress exceeding 2.23 lakh ha in recent budget cycles (As per the Press Information Bureau, 2026). The present study analyses the growth and spatial distribution of the micro-irrigation sector in Karnataka during 2015–2026 using a combination of statistical and geo-spatial techniques. The study focuses primarily on drip and sprinkler irrigation and examines changes in area covered, beneficiary participation, public expenditure and spatial concentration across districts.**

The Pearson correlation coefficient of 0.140 indicates a very weak positive relationship between government expenditure and the area covered under micro-irrigation. However, the p-value (0.764) is greater than 0.05, indicating that the relationship is not statistically significant at the 5% level. Therefore, the null hypothesis (H_0) is not rejected, while the alternative hypothesis is not supported. This suggests that, for the period 2016–17 to 2022–23, variations in government expenditure do not show a statistically significant linear relationship with the area covered under micro-irrigation. The study argues that the spatial pattern of micro-irrigation is strongly associated with horticultural intensity, groundwater dependence, drought vulnerability, cropping pattern and government intervention. Spatial informatics provides an effective framework for identifying high-, medium- and low-adoption zones and for supporting regionally differentiated water-management policies.

***Index Terms*—Micro-Irrigation, Drip irrigation, Sprinkler irrigation, Spatial Informatics, Karnataka, Agricultural Water Management, Trend Analysis**

I. Introduction

The MI sector promotes the efficient use of water by delivering it directly to the root zone of crops, thereby minimizing water losses and improving irrigation efficiency. It reduces the consumption of water, energy, fertilizers, and labour while supporting healthy crop growth and enhancing productivity through the precise application of water and nutrients. The adoption of micro-irrigation also encourages the cultivation of horticultural crops, increases cropping intensity, and facilitates the productive utilization of marginal and water-scarce lands. By reducing input costs and improving farm income and returns, micro-irrigation contributes significantly to sustainable agricultural development, strengthens farmers' livelihoods, and

promotes long-term food and nutritional security. MI sector in Karnataka serves as an important climate-resilience strategy for a state characterized by extensive arid and drought-prone areas and highly variable rainfall conditions. The state faces significant challenges, including recurrent droughts, declining groundwater levels, and a large dependence on rain-fed agriculture. In response to these challenges, Karnataka has increasingly promoted modern water-delivery technologies to improve water-use efficiency and sustain agricultural productivity.

The analysis indicates that micro-irrigation has emerged as an important component of water-efficient and climate-resilient agriculture in the state, although the pace and extent of adoption vary considerably across regions. Drip and sprinkler irrigation systems have been promoted through various subsidy-based government programmes, particularly in horticultural areas and regions experiencing water stress. Recent government initiatives demonstrate the continued policy emphasis on expanding MI coverage. The Karnataka Budget 2026–27, for instance, reports the adoption of micro-irrigation over approximately 2.23 lakh ha, benefiting around 2.36 lakh farmers. These developments highlight the growing role of micro-irrigation in conserving water, improving agricultural efficiency, strengthening farmers' resilience to climate variability, and promoting sustainable agricultural development in Karnataka.

II. Objectives of the Study

1. To assess the performance and significance of the micro-irrigation sector in Karnataka.
2. To examine the growth trends and changes in different types of micro-irrigation systems, particularly drip and sprinkler irrigation, in Karnataka.
3. To analyse the spatial distribution and regional variations of the micro-irrigation sector across the districts of Karnataka.

III. Research Hypothesis

1. There is a significant relationship between government expenditure and the area covered under micro-irrigation over the past few periods.

IV. Material and Methods

The study is based primarily on secondary data collected from various government departments, institutions, official reports, and published sources. The major sources of data include the Department of Agriculture, Government of Karnataka; Department of Horticulture, Government of Karnataka; Directorate of Economics and Statistics; Karnataka Economic Survey; Pradhan Mantri Krishi Sinchayee Yojana (PMKSY); Ministry of Agriculture and Farmers Welfare, Government of India; NABARD; Karnataka State Remote Sensing Applications Centre (KSRSAC); and Karnataka State Natural Disaster Monitoring Centre (KSNDMC). In addition, relevant information has been obtained from reputed journals, research articles, magazines, official documents, government publications, annual reports, newspapers, and reliable

institutional websites. These secondary sources provide the necessary information for analysing the growth, performance, spatial distribution, and development of the micro-irrigation sector in Karnataka.

Statistical Techniques for Data Analysis: The study employed both quantitative statistical techniques and spatial distribution analysis. The analytical methods included percentage analysis, Compound Annual Growth Rate (CAGR), linear trend analysis, and the exponential growth model. The data were analysed using SPSS 21, EViews, Gretl, and MS Excel software.

Linear Trend Analysis

$$Y = a + bX$$

Where,

Y = micro-irrigation area

X = time

a = intercept

b = annual trend coefficient.

Pearson Correlation Analysis: The relationship between government expenditure on micro-irrigation programmes and area covered under micro-irrigation in Karnataka can be examined using the Pearson correlation coefficient. This analysis helps determine whether higher public expenditure is associated with greater micro-irrigation coverage.

V. An Overview of Micro Irrigation Sector in Karnataka: Significance and Growth

The MI sector is an important solution for improving water use efficiency in agriculture. This is because it delivers water directly to crops with minimal losses. The government is implementing the PDMC initiative to promote efficient water use at the farm level. It is a centrally sponsored scheme. It supports micro-irrigation systems - drip irrigation and sprinkler irrigation. MI programme is being promoted both by central and state sector schemes, by providing different kinds of financial, institutional and technical support. These technologies are promoted primarily as – firstly, to save water in irrigated agriculture, secondly, strategy to increase income and reduce poverty, and thirdly, to enhance the food and nutritional security of rural households. The real thrust on promoting MI adoption largely started with the recommendations of the task force on micro irrigation programme in 2004. The Pradhan Mantri Krishi Sinchayee Yojana (PMKSY) with the very important component of PDMC – MI, is being implemented since 2015-16. The PDMC component focuses on improving water use efficiency at the farm level through promotion and support of precision or MI which includes drip and sprinkler irrigation unit's distribution at

subsidized rates. As per the Government order, during 2025-26, the Micro Irrigation programme is implemented under Pradhana Manthri Rashtriya Krishi Vikas Yojana (PMRKVY) Per Drop More Crop (PDMC). During 2025-26, an amount of Rs.44092.86 lakhs has been allocated and Rs.27059.81 lakhs has been spent up to end of December 2025 as against the releases of Rs. 38304.59 lakhs. The Area covered under Micro irrigation is 100956 ha.

VI. Results and Discussion

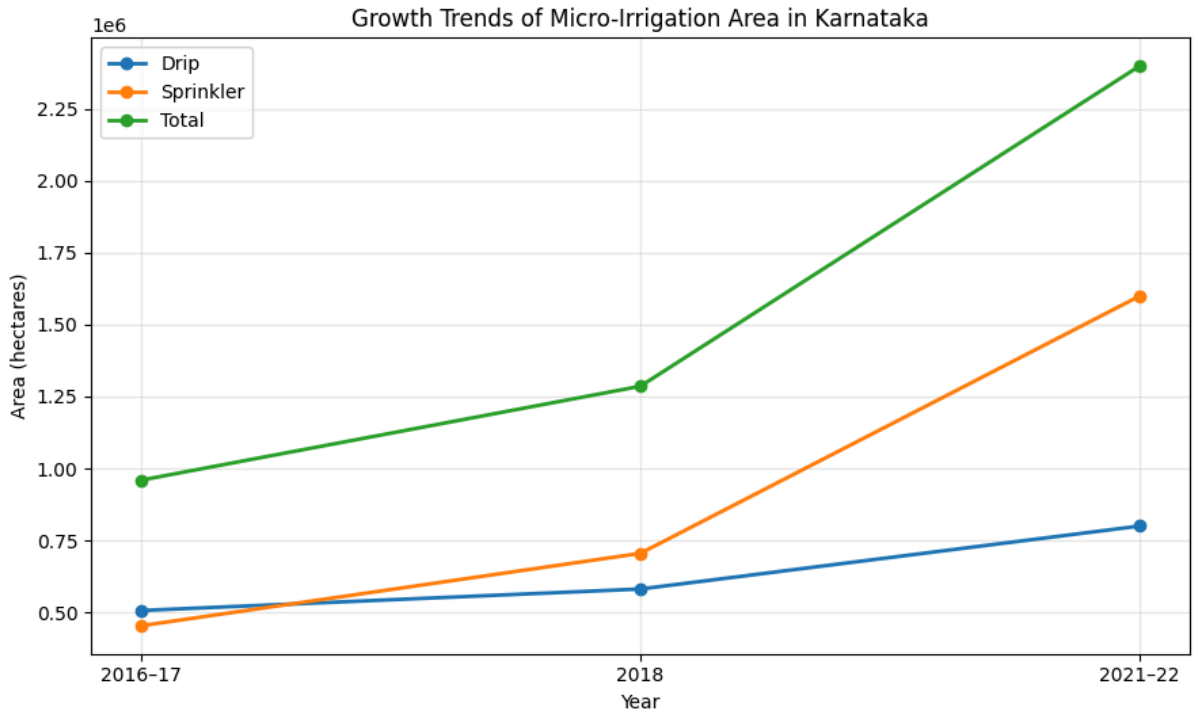
Growth in Trends of Micro Irrigation Sector in Karnataka

As of July 2026, PDMC has brought 115 lakh hectares under micro-irrigation since its inception. This accounts for about 8.11% of India's net sown area. In 2025-26, Maharashtra, Karnataka, Andhra Pradesh, Tamil Nadu, Gujarat, and Rajasthan recorded the highest areas covered by micro-irrigation under PDMC. The scheme benefited 12.30 lakh farmers and around 20% of the beneficiaries were women.

Table-1 Micro Irrigation System in Karnataka (2025)

Year	Drip (ha)	Sprinkler (ha)	Total (ha)
2016–17	506,202	453,181	**959,383**
2018	581,000	705,000	**1,286,000**
2021–22	800,000	1,600,000	**2,400,000**

Source: Government of Karnataka (2025), Research Report of Review of Agricultural Subsidies in Karnataka.



The table indicates a substantial expansion of micro-irrigation in Karnataka during the period 2016–17 to 2021–22. The total area under micro-irrigation increased from 959,383 hectares in 2016–17 to 2,400,000 hectares in 2021–22, representing an increase of approximately 150.2%. The area under drip irrigation increased from 506,202 hectares to 800,000 hectares, an increase of about 58.1%. This indicates a steady expansion of drip irrigation, which is particularly important for water-efficient cultivation and horticultural crops. The most significant growth was observed in sprinkler irrigation. Its coverage increased from 453,181 hectares in 2016–17 to 1,600,000 hectares in 2021–22, representing an increase of approximately 253.1%. Between 2018 and 2021–22 alone, sprinkler coverage more than doubled. Consequently, the share of sprinkler irrigation in the total micro-irrigation area increased considerably. In 2016–17, drip irrigation accounted for about 52.8% of the total area, while sprinkler irrigation accounted for 47.2%. By 2021–22, the corresponding shares were approximately 33.3% and 66.7%, respectively. This indicates a clear shift towards sprinkler-based micro-irrigation during the later period.

Fund Allocation and Expenditure of MI Sector

Under the Micro-Irrigation programme in 2025–26, Rs.44,092.86 lakh has been allocated, Rs.38,304.59 lakh released, and Rs.27,059.81 lakh spent up to December 2025, bringing 1,00,956 ha under micro-irrigation coverage and strengthening water-use efficiency.

Table-2

Status of Micro Irrigation Adoption, Expenditure and Subsidy in Karnataka

Year	MI adoption (ha)	Expenditure (Rs.in lakh)	Subsidy/ha (In Rs)
2016–17	176,021.8	36,569.40	20,775.49
2017–18	178,920.6	42,539.65	23,775.71
2018–19	182,512.1	44,036.77	24,128.14
2019–20	210,531.7	42,953.38	20,402.33
2020–21	241,571.0	63,289.56	26,199.15
2021–22	319,081.0	39,803.17	12,474.32
2022–23	129,397.0	44,414.57	34,324.27

Source: Government of Karnataka (2025), Research Report of Review of Agricultural Subsidies in Karnataka.

The data reveal a generally increasing trend in micro-irrigation adoption during 2016–17 to 2021–22, followed by a sharp decline in 2022–23. MI adoption increased from 176,021.8 hectares in 2016–17 to

319,081 hectares in 2021–22, representing an increase of about 81.3%. However, adoption declined substantially to 129,397 hectares in 2022–23, a fall of about 59.4% compared with 2021–22.

Finally, the 2022–23 level was about 26.5% lower than the 2016–17 level. Government expenditure showed considerable year-to-year fluctuations. It increased from Rs.36,569.40 lakh in 2016–17 to Rs.44,036.77 lakh in 2018–19, declined slightly in 2019–20, and then reached the highest level of Rs.63,289.56 lakh in 2020–21. Subsequently, expenditure declined to Rs.39,803.17 lakh in 2021–22, before increasing moderately to Rs.44,414.57 lakh in 2022–23. Despite the fluctuations, expenditure in 2022–23 was about 21.5% higher than in 2016–17. The subsidy per hectare also exhibited considerable variation. It increased from Rs.20,775.49 per hectare in 2016–17 to Rs.24,128.14 in 2018–19, followed by a decline to Rs.20,402.33 in 2019–20. The subsidy increased again to Rs.26,199.15 in 2020–21, but fell sharply to

Rs.12,474.32 in 2021–22, the lowest value during the study period. In 2022–23, however, the subsidy rose substantially to Rs.34,324.27 per ha, the highest value in the entire period.

Trend Analysis of Micro-Irrigation in Karnataka: A linear trend analysis was applied to examine the direction and magnitude of changes in micro-irrigation (MI) adoption, government expenditure, and subsidy per hectare. The trend equation is represented as:

$$Yt = a + bt$$

Where, Yt is the estimated trend value, a is the intercept, b is the annual trend coefficient, and t represents time.

Table –3 Results of Linear Trend Analysis for Micro Irrigation Sector in Karnataka

Indicator	Linear Trend Equation	Trend Coefficient (b)	R^2	Trend Direction
MI Adoption (ha)	Y = 176,932.84 + 7,125.19t	7,125.19 ha/year	0.064	Increasing
Expenditure (₹ lakh)	Y = 39,470.17 + 1,332.69t	₹1,332.69 lakh/year	0.112	Increasing
Subsidy/ha (₹)	Y = 20,280.69 + 718.38t	₹718.38/year	0.055	Increasing

Source: Compiled Data by Researcher

The linear trend analysis shows that all three indicators have positive trend coefficients, indicating an overall increasing tendency over the study period. The trend coefficient of 7,125.19 ha per year indicates that micro-irrigation adoption increased by an average trend magnitude of approximately 7,125 hectares annually. However, the R^2 value of 0.064 is very low, indicating that the linear trend explains only about 6.4% of the variation in MI adoption. The sharp decline from 319,081 ha in 2021–22 to 129,397 ha in 2022–23 considerably weakens the linear relationship. The expenditure has a positive trend coefficient of Rs.1,332.69 lakh per year, suggesting an overall upward movement in government spending. However, the R^2 value of 0.112 indicates that only about 11.2% of the variation is explained by the linear time trend. The considerable fluctuations, particularly the peak expenditure in 2020–21, contribute to the weak linear fit. The subsidy shows a positive trend coefficient of Rs.718.38 per hectare per year. Nevertheless, the R^2 value of 0.055 indicates that the linear trend explains only about 5.5% of the variation. The substantial fluctuations in subsidy levels, especially the sharp decline in 2021–22 and subsequent increase in 2022–23, indicate that the series does not follow a stable linear pattern.

Hypothesis Testing

H0: There is a significant relationship between government expenditure and the area covered under micro-irrigation over the past few periods.

H1: There is a significant relationship between government expenditure and the area covered under micro-irrigation over the past few periods.

Table – 4 Correlation Result for Area covered under MI and Expenditure in Karnataka

Variables	N	Pearson's r	p-value	Significance (5%)	Decision
MI adoption & Government expenditure	7	0.140	0.764	Not significant	Accept H_0

Source: Compiled Data by Researcher

The Pearson correlation coefficient of 0.140 indicates a very weak positive relationship between government expenditure and the area covered under micro-irrigation. However, the p-value (0.764) is greater than 0.05, indicating that the relationship is not statistically significant at the 5% level. Therefore, the null hypothesis (H_0) is not rejected, while the alternative hypothesis is not supported. This suggests that, for the period 2016–17 to 2022–23, variations in government expenditure do not show a statistically significant linear relationship with the area covered under micro-irrigation.

VII. Conclusion

The present study on the growth and spatial distribution of the Micro-Irrigation (MI) sector in Karnataka highlights the increasing importance of micro-irrigation in promoting efficient and sustainable water management in agriculture. The analysis of trends during the study period indicates that the area covered under micro-irrigation has generally increased, reflecting growing awareness among farmers and continued government support through subsidies and irrigation development programmes. The study also indicates a positive relationship between government expenditure and the expansion of micro-irrigation coverage. Increased financial allocation and expenditure have contributed to the adoption of drip and sprinkler irrigation systems, particularly in water-stressed and horticulturally important regions. The exponential growth analysis further demonstrates the long-term growth potential of the sector.During the seven-year study period, physical adoption recorded a sample mean of 205,433.60 hectares (SD = 60,721.48), reaching a peak of 319,081.00 ha in 2021–22 before dropping to 129,397.00 ha in 2022–23. Government expenditure averaged Rs.44,800.93 lakh per annum (SD = 8,600.63), peaking at Rs.63,289.56 lakh in 2020–21. Per-hectare subsidy allocations averaged Rs.23,154.20 (SD = 6,616.49), demonstrating an inverse relationship with physical adoption—hitting a low of Rs.12,474.32/ha during maximum coverage

(2021–22) and climbing to Rs.34,324.27/ha during minimum coverage (2022–23).Linear trend modeling (y = 7,125.19x + 176,932.84, R^2 = 0.0643) and log-linear exponential modeling (CGR = 1.85%, R^2 = 0.0196) both yielded statistically non-significant growth trajectories (p = 0.5834 and p = 0.7649, respectively).

Hypothesis testing resulted in accepting the null hypothesis (H0), confirming the absence of a statistically significant annual growth trend in micro-irrigation area expansion. Furthermore, Pearson's correlation analysis between government expenditure and physical adoption yielded r = 0.140$ (p = 0.764), confirming no statistically significant linear association. Financial outlay accounts for only 1.97% (r^2 = 0.0197) of the variance in annual physical adoption. The empirical evidence demonstrates that micro-irrigation expansion in Karnataka is characterized by high inter-annual volatility rather than sustained linear or exponential growth. The lack of correlation between financial outlays and physical coverage points to administrative processing delays, shifting unit cost structures, and reporting lags across fiscal cycles. Strategic policy interventions must prioritize GIS-based real-time tracking, predictable subsidy disbursements, and targeted spatial allocation to stabilize long-term adoption dynamics across the state's agro-climatic zones.

References

[1] Chandrakanth, M. G., Priyanka, C. N., Mamatha, P., & Patil, K. K. (2013). Economic benefits from micro irrigation for dry land crops in Karnataka. *Indian Journal of Agricultural Economics*, *68*(3), 326-338.

[2] Kannan, E. (2016). Micro-irrigation in Karnataka: Potential and Constraints for Adoption. In *Micro Irrigation Systems in India: Emergence, Status and Impacts* (pp. 59-69). Singapore: Springer Singapore.

[3] Kishore, P., Chand, S., & Srivastava, S. K. (2022). Potential area of micro-irrigation and its outreach across Indian states. *Indian Journal of Agricultural Sciences*, *92*(9), 1056-1060.

[4] Kalubhai, P. (2015). *Present Status and Prospects of Micro Irrigation System in Mahisagar District of Gujarat* (Doctoral dissertation, Doctoral dissertation, Anand Agricultural University, Anand, India).

[5] Kumar, M. D., Turral, H., Sharma, B. R., Amarasinghe, U. A., & Singh, O. P. (2008). Water saving and yield enhancing micro-irrigation technologies in India: when and where can they become best bet technologies?.

[6] Nagaraj, N., & Anitha, S. (2022). Impact of micro irrigation on groundwater savings, productivity, and profitability of principal crops in the Eastern Dry Zone and Central Dry Zone of Karnataka: a resource economic analysis. *Agricultural Economics Research Review*, *35*(1), 57-69.

[7] Sivanappan, R. K., Goyal, M. R., Chavan, V. K., & Tripathi, V. K. (2016). Micro Irrigation Technology in India: A Success Story. *Innovations in Micro Irrigation Technology, under the Book Series "Research Advances in Sustainable Micro Irrigation*, *10*, 1-46.

[8] Samuel, M. P., & Suresh, A. (2021). Micro irrigation developments in India: Techno-economic challenges. *fertigation technologies for micro irrigated crops*, 249-263.

[9] Suresh, A., KS, A., Jha, G., & Pal, S. (2019). Micro-irrigation development in India: an analysis of distributional pattern and potential correlates. *International Journal of Water Resources Development*, *35*(6), 999-1014.

[10] Suresh, A., & Samuel, M. P. (2020). Micro-irrigation development in India. *Current science*, *118*(8), 1163-1168.

[11] Viswanathan, P. K., Kumar, M. D., & Narayanamoorthy, A. (Eds.). (2016). *Micro irrigation systems in India: Emergence, status and impacts*. Springer.

[12] Viswanathan, P. K., Pathak, J., & Bahinipati, C. S. (2016). State of Development and Adoption of Micro Irrigation Systems in Gujarat. In *Micro Irrigation Systems in India: Emergence, Status and Impacts* (pp. 71-89). Singapore: Springer Singapore.