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"Assessing the Impact of Water Availability and Micro-Irrigation on Horticultural Crop Production: A Case Study of Baruipur Subdivision, (West Bengal, India)".

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Abstract

Water scarcity and inefficient irrigation practices remain critical constraints to sustainable agricultural production, particularly in horticulture. This study examines the impact of water availability and irrigation systems on horticultural crop production in the Baruipur subdivision of West Bengal, India. Based on primary data collected from 300 farm households during 2024–2025, complemented by secondary sources, the study analyzes irrigation sources, adoption of micro-irrigation (MI), farmer perceptions, and agro-economic outcomes.

Descriptive statistics and comparative analysis indicate that pond irrigation (64.33%) is the dominant source, followed by tubewells (18.67%). Approximately 43.33% of farmers reported moderate to severe water scarcity. Adoption of micro-irrigation significantly improves water-use efficiency, yield, and profitability. However, high initial costs, institutional barriers, and infrastructure limitations constrain adoption. The study suggests that strengthening policy support, improving irrigation infrastructure, and enhancing farmer awareness are essential for sustainable horticultural development.

Keywords : Water availability; Micro-irrigation; Horticulture; Water-use efficiency; Farmer perception; Sustainable agriculture;

Introduction: Water is a fundamental input in agricultural production and a key determinant of food security. Globally, irrigated agriculture accounts for nearly 40% of food production while covering only about 20% of cultivated land (Borsato et al., 2020). Increasing population pressure, climate variability, and urban expansion are intensifying competition for water resources, particularly affecting water-intensive sectors such as horticulture (Uhlenbrook et al., 2022).

Micro-irrigation technologies, including drip and sprinkler systems, offer an efficient solution by delivering water directly to the root zone, thereby minimizing losses due to evaporation and deep percolation (Yang et al., 2023). Empirical evidence suggests that MI improves crop yield, quality, and farm income while conserving water resources.

The Baruipur subdivision, located in the coastal region of West Bengal, faces unique hydrological challenges such as tidal influence, soil salinity, waterlogging, and poor drainage. Historical embankment construction has exacerbated these issues, leading to siltation and increased flood vulnerability (Ghosh & Mistri, 2020). These factors make efficient irrigation management essential for sustaining horticultural productivity..

1. Materials and Methods

1.1 Study Area:

The study was conducted in the Baruipur subdivision of South 24 Parganas district, West Bengal,India . The area lies in the lower Gangetic delta and accounts for about 29.36% of the district's population. According to the Census of India (2011), the literacy rate of the district is 77.45%, indicating a moderately developed socio-economic profile with significant dependence on agriculture and allied activities..

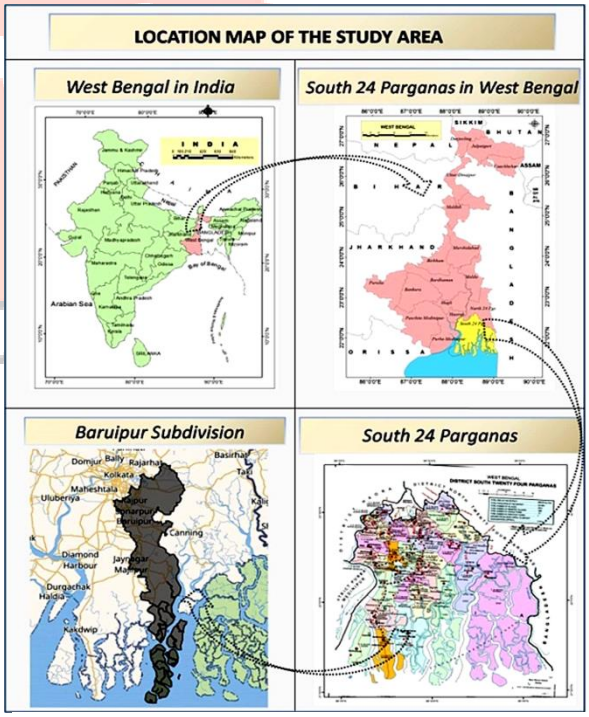


Figure 1: Location map of the study area showing Baruipur subdivision in South 24 Parganas district, West Bengal, India.

The region experiences a tropical monsoon climate with three distinct seasons: summer (March–June), monsoon (June–September), and winter (November–February). The average annual rainfall is about 1,579 mm, with temperatures ranging from 10°C to 41°C and relative humidity varying between 50% and 90%.

Soils are predominantly alluvial, ranging from silty clay to silty clay loam, with high water retention capacity. Irrigation depends on both groundwater (shallow and deep tube wells) and surface water sources such as rivers, canals, and ponds. However, salinity intrusion, tidal effects, and poor drainage

create challenges for efficient water management, making the area suitable for studying irrigation practices and horticultural productivity.

1.2 Data Collection:

Table1: Water source availability in the study area

The study is based on both primary and secondary data. It adopts an evaluation research design to assess the economic impact of efficient water use by comparing farm performance before and after the adoption of irrigation technology among selected farmers. Primary data were collected through a structured and pre-tested questionnaire administered to both adopters and non-adopters of micro-irrigation. The inclusion of non-adopters enabled the study to examine the underlying reasons for non-adoption of the technology.

A total of 300 farm households were selected through random sampling across the entire Baruipur subdivision. The field survey was conducted during the agricultural year 2024–2025.

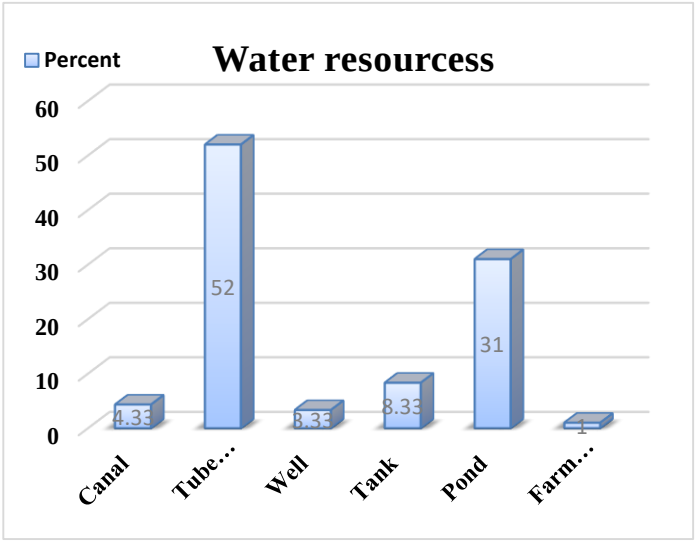
1.3 Analytical Framework:

The study employs a combination of quantitative and qualitative approaches. Descriptive statistics are used to summarize key variables, while comparative analysis between adopters and non-adopters evaluates differences in economic performance and resource use. Perception-based analysis captures farmers' understanding of water productivity. A conceptual framework linking water availability, irrigation technology, and productivity outcomes is used to interpret the results.

2. Results and Discussion:

2.1 Water Sources for Irrigation:

The distribution of irrigation sources shows a strong dependence on local water bodies.



N = 300; Data source: Field Survey

Tube wells are the primary source, used by 52% of adopters, followed by ponds at 31%, together accounting for 83% of total usage. This indicates limited access to formal irrigation infrastructure and reliance on decentralized water systems.

Water Source	Number of farmers	Percent
Canal	13	4.33
Tube well	156	52
Well	10	3.33
Tank	25	8.33
Pond	93	31
Farm Pond	3	1.00

Figure 2: Source of water for irrigation

2.2 Water Scarcity and Availability:

Water scarcity remains a significant issue in the study area. The largest proportion of farmers (43.33%) report 32.00% who faced occasional scarcity. A smaller share (12.00%) indicated no scarcity, while 8.67% reported acute scarcity. Only 4.00% of respondents experienced excess water. These patterns indicate that a majority of farmers are affected by varying degrees of water shortage, likely driven by seasonal variability and inadequate water storage, which contribute to uneven water availability throughout the year.

Table 2 : Water situation in the Baruipur sub-division

Water Situation	No.	Percent
Excess water	12	4.00
No scarcity	36	12.00
Occasional Scarcity	96	32.00
Scarcity	130	43.33
Acute Scarcity	26	8.67

N = 300; Data source: Field Survey

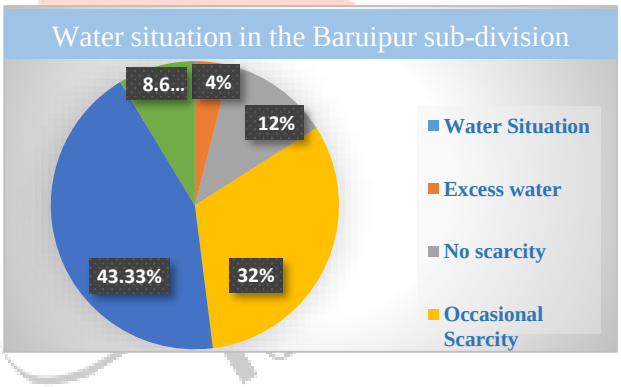


Figure 3: Water situation in the Baruipur sub-division

2.3 Rainfall Characteristics:

The distribution of farmers' perceptions regarding rainfall during the reference year (2024–2025) indicates that the majority experienced normal conditions. Specifically, 74.33% of the respondents (223 farmers) reported average rainfall, suggesting relatively stable climatic conditions for agricultural activities. In contrast, 11.33% of the adopters perceived rainfall as high, while 13.66% (41 farmers) reported low rainfall. A negligible proportion of respondents (0.66%) indicated extremely low rainfall. Overall, the findings suggest that rainfall during the study period was predominantly within the normal range, with limited instances of extreme variability.

Table 3: Rainfall situation and impact on horticulture crop in the study area

Rainfall situation	No of farmers	Percent
Heavy	34	11.33
Average	223	74.33
Low	41	13.66
Very low	2	0.66

N = 300; Data source: Field Survey

2.4 Adoption of Micro-Irrigation:

Micro-irrigation plays a vital role in enhancing agricultural efficiency by reducing water wastage and lowering irrigation costs, thereby improving farmers' economic returns. However, the findings of the present study suggest that a substantial proportion of farmers (41.66%) adopted micro-irrigation about ten years ago, while 22.33% have been using the technology for more than a decade. This indicates that micro-irrigation is not a recent phenomenon but has been well established among a large section of farmers. The increasing use of sprinkler and drip irrigation systems thus reflects a gradual but steady transition toward more efficient, resource-conserving, and technologically advanced irrigation practices in the agricultural sector.

Table 4. Micro Irrigation adaptation station in Baruipur sub-division

Starting year	**No.**	**Percent**
Current Year	6	2
Last Year	8	2.66
2 Years ago	22	7.33
3 years ago	27	9
5 years ago	45	15
10 years ago	125	41.66
More than 10 years	67	22.33

N = 300; Data source: Field Survey

2.5 Impact of Micro-Irrigation on Productivity:

The responses of adopters highlight the key agronomic advantages of micro-irrigation (MI), particularly in terms of productivity and resource use efficiency. A majority of respondents (60.66%) reported that micro-irrigation increases crop yield and overall output, indicating that productivity enhancement is the most widely perceived benefit.

In addition to yield improvement, 19% of farmers recognized water-saving as a key advantage, reflecting awareness of the technology's role in efficient water management. A smaller proportion of respondents identified cost-reducing benefits in terms of input use: 10.33% reported a reduction in labour requirements, while 3.66% observed decreased fertilizer use. This study highlights the need for enhanced extension efforts to improve farmers' understanding of the full range of advantages associated with micro-irrigation.

Table 5. Impact of Micro Irrigation in Baruipur sub-division

Impact of Micro-Irrigation	**No of cultivators**	**Percent**
Micro irrigation increases yield / output	182	60.66
Micro irrigation saves water/reduces water use	57	19
Micro irrigation reduces fertilizer use	11	3.66
Micro irrigation reduces pest problems/ pesticide use	13	4.33
Micro irrigation reduces weed problem	6	2

Micro irrigation reduces labour use	31	10.33

N = 300; Data source: Field Survey

Water availability (38.33%) and soil quality (34%) are identified as major determinants of production.

2.6 Economic Implications:

Micro-irrigation contributes significantly to enhancing overall farm performance by increasing farm income, reducing input costs—particularly those related to water and labour—and improving crop quality and marketability. By ensuring efficient water use and better nutrient management, it supports higher productivity and more consistent crop output, which in turn can fetch better prices in the market. However, the extent of these benefits is not uniform across all farmers, as it largely depends on factors such as farm size, type of crops cultivated, and access to financial and technical resources.

2.7 Overall assessment of water uses:

This study shows that while only 15% of adopters thought MI performed well, the remaining 45% thought it performed excellently. The total response demonstrates unequivocally that adopters are mainly happy with MI. Additionally, they felt that MI had increased water usage efficiency. A third of the users said the system was effective because it cut input costs, and 28.33 percent said using MI raised earnings and profits. The finding that virtually all adopters were positive they will keep using MI and even increase its use was the most encouraging.

Table 6. Overall assessment of water uses in Baruipur sub-division

Overall assessment	**No.**	**Percent**
Overall performance of Micro Irrigation	45	15.00
Performance on Improving Water Use Efficiency	135	45.00
Performance on reducing input cost (such as Fertilizers, Pesticides, Labour, Electricity)	85	28.33
Performance on increasing incomes/profits	35	11.67

N = 300; Data source: Field Survey

3. Constraints and Challenges:

This study highlights several challenges faced by adopters of micro-irrigation (MI).Key constraints include:

- High initial investment cost (28%)
- Inadequate water (11.33%)
- Limited access to subsidies (14.33%)
- Declining groundwater levels (9%)

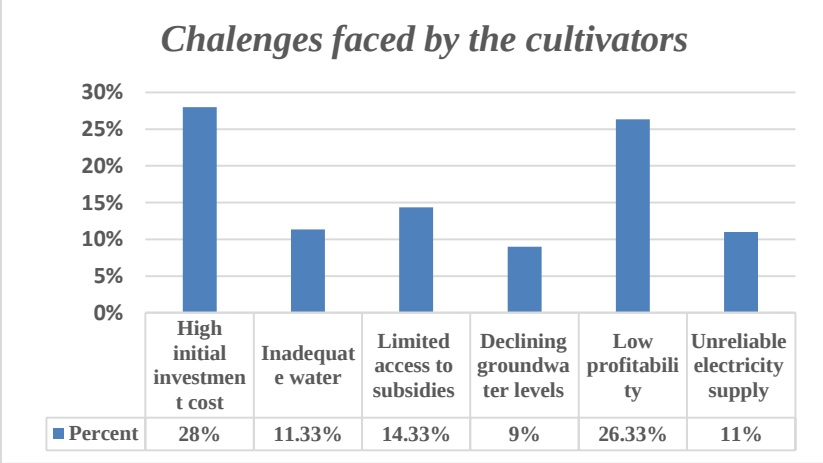


Figure 4: Constraints and Challenges of farmers in Baruipur Subdivision

- Low profitability (26.33%)
- Unreliable electricity supply (11%)

These challenges indicate structural and institutional barriers to adoption.

4. Discussion:

The findings align with existing literature that emphasizes the role of micro-irrigation in enhancing water-use efficiency and productivity. However, adoption is uneven due to socio-economic constraints. The dependence on pond irrigation reflects adaptive strategies in response to environmental conditions but also indicates infrastructural gaps.

The study suggests that improving institutional support mechanisms and addressing financial constraints can significantly enhance adoption rates and productivity outcomes.

5. Policy Implications:

The study suggests several policy and operational improvements to enhance water resources and it's effectiveness and adoption of micro-irrigation (MI) systems.

- Strengthen subsidy programs and ensure transparency
- Invest in irrigation infrastructure and water storage systems
- Promote farmer training and extension services
- Encourage public-private partnerships in irrigation technology
- Improve rural electrification for irrigation support
- Develop efficient marketing systems for horticultural produce
- Implement of Rainwater Harvesting. etc.

6. Conclusion:

Water availability and irrigation practices significantly influence horticultural productivity in the study area. Micro-irrigation emerges as a viable solution for improving water-use efficiency and farm income. However, its adoption is constrained by financial, infrastructural, and institutional barriers. A comprehensive policy approach integrating technology, infrastructure, and capacity building is essential for sustainable agricultural development.

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