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Economic impact assessment of Micro-level Agrometeorological Advisory Services (MAAS) for farm profitability: A comparative benefit-cost analysis of rice, vegetable and field crop farmers in Mahasamund district of Chhattisgarh

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Abstract

Weather forecasts in all temporal ranges are desirable for effective planning and management of agricultural practices. The development of response strategy can help farmers to realize the potential benefits of using weather-based agrometeorological information in minimizing the losses due to adverse weather conditions, thereby improving yield, quantity and quality of agricultural productions. In fact, short and medium-range weather forecasts play a significant role in making short term adjustments in daily agricultural operations. Weather information is translated into farm level action oriented advice by the agricultural scientists. Mahasamund district comes under trans-Mahanadi area where the soils are very light (sandy loam) and hence the impact of climate change is easily discernible. In view of this decreasing rainfall pattern, Mahasamund district is chosen for the study on climate resilience on agriculture and also to examine the farmer's adaptability under AICRPAM-National Innovations on Climate Resilient Agriculture (NICRA) project. The present study has been conducted to evaluate and compare the Benefit-Cost (B:C) ratio of farmers adopting MAAS (Micro-level Agro-advisories) and non-MAAS farmers across selected field crops and vegetables crops based on block level forecast and thereby assessing the economic impact of MAAS on agricultural production and farm profitability. B:C ratio for MAAS farmers was found to be significantly higher over non-MAAS farmers during two years of survey and analysis.

Keywords: Forecast, economic impact, crops, profitability, B:C ratio

Introduction

Agriculture remains a crucial part of India's socio-economic development, supporting the livelihood and food security of a large segment of the population. Nevertheless, factors such as climate variability, increasing input costs and inefficient use of resources are progressively impacting agricultural production and the profitability of farms. The economic viability of any agricultural technology or advisory service is commonly assessed using the Benefit-Cost (B:C) ratio which measures the relationship between the gross returns obtained and the total cost incurred in crop production. The B:C ratio is a useful indicator for evaluating the financial efficiency and comparative advantage of different farming practices and technologies (Doll and Orazem (1984) ^[2]).

Micro-level Agrometeorological Advisory Services (MAAS) based on block level forecast provide weather-based advisories tailored to local conditions, enabling farmers to make informed decisions regarding sowing, irrigation, fertilizer application, plant protection measures and harvesting operations. By integrating weather forecasts with crop management recommendations, MAAS helps farmers to optimize the use of agricultural inputs, reduce unnecessary expenditures and enhance productivity.

Comparing the B:C ratio between MAAS adopters and non-adopters offers valuable insights into the program's economic effectiveness. This evaluation helps policymakers, extension

agencies and researchers determine whether adopting MAAS significantly boosts farm income and resource-use efficiency. Additionally, empirical proof of MAAS adoption's profitability can foster wider acceptance and spread of advisory services within farming communities. Therefore, the present study aims to evaluate and compare the Benefit-Cost (B:C) ratio of farmers adopting MAAS and non-MAAS farmers across selected crops thereby assessing the economic impact of MAAS on agricultural production and farm profitability

Materials and Methods

(A) Economic Analysis of B:C ratio for Rice Farmers

The study was conducted in selected villages of Chhattisgarh namely Jhalkhamharia & Sirgidi for the period 2024-25 & 2025-26 of Mahasamund district where the Micro-level Agro-Advisory Service (MAAS) programme has been implemented under NICRA-AICRPAM project. The study area represents a predominantly rice-based farming system under diverse methods of crop establishment, including transplanting, broadcasting as well as dry seeding (*Khurra Boni*).

Sampling Procedure: The study was based on the 9 rice growing farmers which were categorized into two groups based on their utilization of MAAS advisories:

1. MAAS adopters
2. Non-MAAS adopters

For the economic analysis of rice cultivation, detailed cost and return data were collected from representative sample farmers belonging to both categories. The selected respondents were actively engaged in rice cultivation during the study period.

Data Collection: Primary data were collected through personal interviews using a pre-tested structured questionnaire. Information regarding input use, operational expenses, crop yield and returns was obtained directly from the respondents. The major cost components considered for analysis included land preparation, seed, Farmyard manure, Fertilizers, Plant protection chemicals (pesticides and herbicides), Labour, Irrigation, Harvesting, Transportation and Miscellaneous expenses. The prevailing Minimum Support Price (MSP) of paddy was considered while estimating the gross returns from rice cultivation

Economic Analysis of Benefit-Cost (B:C) Ratio of Vegetables and Other Field Crops

The present study and survey made for NICRA-AICRPAM domain villages for different crops other than rice was conducted in selected villages of Chhattisgarh namely Jhalkhamharia & Sirgidi for the period 2024-25 & 2025-26 of Mahasamund district where the Micro-level Agro-Advisory Service (MAAS) programme has been implemented.

Sampling Procedure: The study was based on the four rice growing farmers which were categorized into two groups based on their utilization of MAAS advisories:

1. MAAS adopters
2. Non-MAAS adopters

For the economic analysis of vegetables and other field crops namely wheat, groundnut, maize, bottle gourd, bitter gourd (2024-25) & turmeric, groundnut, arhar, bittergourd, urad (2025-26). Detailed cost and return data were collected from representative sample farmers belonging to both categories.

Data Collection: During the study, data pertaining to the cost of cultivation and returns from different crops namely wheat, maize, groundnut, arhar, bottle gourd, bitter gourd, turmeric and urad etc. were collected from MAAS and Non-MAAS farmers from the period 2024-25 and 2025-26. Information on various cost components, including expenditure on seed, fertilizers, plant protection chemicals, labour, irrigation, machinery and other operational inputs, was recorded on a per-acre basis.

Economic Analysis

The economics of rice production as well as vegetable and other field crops for the period 2024-25 & 2025-26 were assessed by estimating the total cost of cultivation, gross return, net return, and Benefit-Cost (B:C) ratio for both MAAS and non-MAAS farmers.

The following formulas were used

The total cost of cultivation was estimated by summing all variable and fixed costs incurred in crop production.

Total Cost of Cultivation (Rs./acre) = Sum of all variable and operational costs incurred during crop production.

Gross return was calculated by multiplying the total produce obtained with the prevailing market price of the respective crop.

Gross Return (Rs./acre) = Total Paddy or vegetable/other field crops Yield (q/acre) × Market Price or MSP (Rs./q)

Net return was obtained by subtracting the total cost of cultivation from the gross return

Net Return (Rs./acre) = Gross Return (Rs./acre) – Total Cost of Cultivation (Rs./acre)

Benefit-Cost (B:C) is calculated as the ratio of gross returns to the total cost of cultivation. A B:C ratio greater than one indicates that the enterprise is economically profitable. This concept is consistent with the principles of benefit-cost analysis described by Shively (2012) ^[9].

Benefit-Cost (B:C) Ratio = Gross Return/Total Cost of Cultivation

B:C ratio greater than one indicates that the enterprise is economically profitable, while a higher B:C ratio reflects greater economic efficiency and better returns on investment.

Statistical Analysis: The collected data were compiled, tabulated and analyzed using simple descriptive statistical techniques such as averages and ratios. The estimated B:C ratios of MAAS and Non-MAAS farmers were compared to assess the profitability and economic benefits associated with the adoption of Meteorological Agro Advisory Services. The study aimed to assess the impact of the MAAS programme on the profitability and economic sustainability of rice cultivation as well as vegetable and other field crops in the study area.

Results and Discussion

Economic analysis for Rice Farmers (2024-25)

The economic analysis of rice cultivation for the period 2024-25 indicated that both MAAS-adopted and Non-MAAS farmers obtained profitable returns from rice production, as shown by B:C ratios exceeding 2.5 in all cases. Among the MAAS

adopters, the B:C ratio was 3.32 under broadcasting and 3.03 under transplanting methods while among Non-MAAS farmers, it was 2.86 and 2.94, respectively. The highest profitability was recorded for the MAAS farmer practicing broadcasting, with a B:C ratio of 3.32, indicating that every rupee invested generated ₹3.32 in gross returns. In the year 2024-2025, highest total cost of cultivation observed in transplanted rice ₹ 24550 acre⁻¹ under MAAS adopters. Although the cost of cultivation was marginally higher in some MAAS cases due to machinery service charges, the resulting increase in crop productivity substantially improved farm income. MAAS adopters achieved highest paddy yield of 22-24 quintal acre⁻¹. The superior economic performance of MAAS adopters can be attributed to timely field preparation, efficient crop establishment, reduced drudgery and improved resource-use efficiency. The present findings are in conformity with Diao *et al.* (2014) ^[1]. Researchers observed that mechanization service delivery significantly and contributes to increased farm income and

profitability among smallholder farmers.

Although the profitability varied across cultivation methods, MAAS adopters generally demonstrated better economic performance due to optimized input use, timely crop management and adoption of weather-based advisories. The higher net returns and favorable B:C ratios among MAAS farmers suggest that agrometeorological advisory services can contribute to improved resource-use efficiency and farm profitability. Overall, the findings highlight the economic benefits of MAAS adoption in rice cultivation and support the role of weather-informed decision-making in enhancing farmers' income and sustainability. The findings are in agreement with previous studies, which reported that farmers adopting agrometeorological advisory services achieved higher profitability, improved resource-use efficiency and better benefit-cost ratios through timely weather-based farm management decisions (Maini & Rathore, 2011; Rathore *et al.*, 2011; Dupdal *et al.*, 2021) ^[6, 8, 3].

Table 1: B:C ratio for rice cultivation for MAAS and non-MAAS farmers (Year 2024-25)

Input / Operational expenses Details	MAAS Adopted Farmers		Non- MAAS Farmers	
	Laxmikant Sahu, Village Sirgidi Crop - Rice (Broadcasting)	Keshav Ram Sahu, Village Sirgidi Crop - Rice (Transplanting)	Gulzar Dhruw Crop - Rice (Broadcasting)	Deepak Nishad Crop - Rice (Transplanting)
Land Preparation (Rs acre ⁻¹)	4700	9900	2900	4300
Seed Cost (Rs acre ⁻¹)	1350	1050	1240	1050
Manure Cost (Rs acre ⁻¹)	600	0	0	700
Fertilizer Cost (Rs acre ⁻¹)	1950	2500	2000	2200
Pesticides\Herbicide Cost (Rs acre ⁻¹)	2100	3000	3300	3500
Labour Cost (Rs acre ⁻¹)	2400	900	3400	3100
Irrigation Cost (Rs acre ⁻¹)	900	900	0	0
Harvesting	3500	2300	2300	3500
Transporting	1800	1800	1200	1500
Miscellaneous Cost (Rs acre ⁻¹)	1200	2000	1000	1200
Total Cost (Rs acre ⁻¹)	20,500	24550	17340	21050
Total Paddy Yield (q acre ⁻¹)	22 Qtl.	24 Qtl.	16 Qtl.	20 Qtl.
Gross Income (Rs. acre ⁻¹)	68200	74400	49600	62000
Net Profit (Rs acre ⁻¹)	47700	49,850	32,260	40950
Benefit Cost (B:C) ratio	3.32	3.03	2.86	2.94

Economic analysis for Vegetables and Other Field Crops (year 2024-25)

The economic advantage of MAAS adoption was also evident in different crops in the year 2024-2025. Among the crops evaluated, highest B:C ratio was observed in Bitter gourd 3.9 followed by wheat 3.78 whereas under non-MAAS adopters highest B:C ratio was observed in wheat crop (2.73). The B:C ratio ranged from 1.91 to 4.43 among MAAS farmers, whereas it varied from 1.70 to 3.32 among Non-MAAS farmers (Table-2). These findings are supported by Pingali *et al.* (2019) ^[7], who reported that mechanization enhances productivity and profitability in diversified farming systems. The Food and Agriculture Organization (FAO, 2022) ^[4] also emphasized that mechanization service models improve access to modern agricultural technologies and contribute significantly to increased farm income especially among smallholder farmers.

The economic analysis of wheat, groundnut, maize, bottle gourd and bitter gourd cultivation for the period 2024-25 revealed that both MAAS and Non-MAAS farmers achieved positive economic returns, as indicated by B:C ratio greater than one for all crops. However, MAAS adopters consistently recorded higher B:C ratios than Non-MAAS farmers, demonstrating the

economic advantage of utilizing weather-based agrometeorological advisory services. Among MAAS farmers, the B:C ratio ranged from 1.91 in bottle gourd to 3.90 in bitter gourd, whereas among Non-MAAS farmers it ranged from 1.70 (bottlegourd) to 2.73 (wheat). The highest profitability was observed in bitter gourd cultivation, where MAAS farmers achieved a B:C ratio of 3.90 compared to 2.34 among Non-MAAS farmers. Similarly, wheat (3.78 vs. 2.73) and groundnut (3.37 vs. 2.70) exhibited substantially higher returns among MAAS adopters. Although bottle gourd cultivation involved higher production costs, MAAS farmers still obtained better economic efficiency (B:C ratio of 1.91) than Non-MAAS farmers (1.70).

Overall, the results indicate that adoption of MAAS contributes to improved profitability and resource-use efficiency across different crops by enabling farmers to make timely and informed management decisions regarding sowing, irrigation, fertilizer application and plant protection measures. The consistently higher B:C ratios among MAAS farmers highlight the positive role of agrometeorological advisory services in enhancing farm income and promoting sustainable agricultural production.

Table 2: B:C Ratio for For MAAS and Non-MAAS farmers (Year 2024-25)

Crops	Total Cost of Cultivation (Rs./acre)		Gross Return (Rs./acre)		Net Return (Rs./acre)		Benefit Cost (B:C) ratio	
	MAAS Farmers	Non-MAAS	MAAS	Non-MAAS	MAAS	Non-MAAS	MAAS	Non-MAAS
Wheat	17450	17580	66000	48000	48550	30420	3.78	2.73
Groundnut	23110	23600	78000	66000	54890	42400	3.37	2.7
Maize	19200	17900	50600	43700	31400	26100	2.63	2.44
Bottle Guard	135800	106900	260000	190000	124200	83100	1.91	1.7
Bitter Gourd	114400	100000	450000	234000	335600	134000	3.9	2.34

Economic analysis for Rice Cultivation during 2025-26 -In terms of profitability in the year 2025-2026 for the MAAS adopters, the benefit-cost (B:C) ratio ranged from 2.73 to 3.19, whereas the non-MAAS farmers recorded comparatively lower B:C ratios ranging from 2.86 to 2.94 (Table-1). The highest B:C ratio (3.19) was observed in transplanted rice cultivated by a MAAS adopter (Lokesh Kumar), followed by another MAAS farmer (Gajanand Dhruw) with a B:C ratio of 3.01. The higher profitability was primarily attributed to reduced land preparation and labour costs resulting in greater net profits. MAAS adopted farmers total cost of cultivation is lowest for Shri Chain Singh (₹ 20400 acre⁻¹) but obtained lowest total paddy yield (18 quintal acre⁻¹) whereas highest total cost of cultivation is (₹ 21600 acre⁻¹) of Gajanand Dhruw and highest total paddy yield obtained is 22 quintal acre⁻¹ by Lokesh Kumar. Consequently, MAAS adopters obtained higher gross income (₹68,200 acre⁻¹) and net profit (₹46,800 acre⁻¹) than non-MAAS farmers. These results are in agreement with the findings of Sims and Kienzle (2017) ^[10]. Researchers reported that farm mechanization improves operational efficiency and profitability by reducing labour requirements and ensuring timely agricultural operations. Maini and Rathore (2011) ^[6] also reported that farmers following agrometeorological advisories achieved 10–15%

higher yields and 2–5% lower cultivation costs than non-users. Among the respondents, the highest B:C ratio (3.19) was recorded for a MAAS adopter practicing transplanted rice cultivation, demonstrating the potential of MAAS interventions to increase farm profitability. Although variations in cultivation methods and input use were observed across farmers, the overall results suggest that adoption of MAAS technologies contributes positively to reducing production costs relative to returns and improving farm income. The higher profitability observed among MAAS adopters may be attributed to efficient resource utilization, timely farm operations, and improved crop management practices facilitated through weather-based agro-advisories, which are known to enhance farm productivity and economic returns (Gittinger, 1982; Rathore *et al.*, 2011; Venkatasubramanian *et al.*, 2014) ^[5, 8, 11]. Therefore, promotion and wider dissemination of MAAS-based agricultural advisories and technologies can play a significant role in enhancing the economic sustainability and profitability of rice cultivation. Strengthening farmers' access to weather-based agro-advisories, scientific crop management practices and extension services may further improve agricultural productivity and income generation in the study area.

Table 3: B:C ratio for rice cultivation for MAAS and Non-MAAS farmers (2025-26)

Input / Operational expenses Details	MAAS Adopted Farmers			Non-MAAS Farmers	
	Gajanand Dhruw, Village Jhalkhamharia Crop - Rice (Transplanting)	Lokesh Kumar Sahu, Village Sirgidi Crop – Rice (Transplanting)	Shri Chain Singh Dhruw, Village Jhalkhamharia Crop- (Khurra boni/ dry seeding)	Gulzar Dhruw Crop - Rice (Broadcasting)	Deepak Nishad Crop - Rice (Transplanting)
Land Preparation (Rs acre ⁻¹)	600	600	600	2900	4300
Seed Cost (Rs acre ⁻¹)	1150	1050	1300	1240	1050
Manure Cost (Rs acre ⁻¹)	700	0	700	0	700
Fertilizer Cost (Rs acre ⁻¹)	2400	2300	2300	2000	2200
Pesticides\Herbicide Cost (Rs acre ⁻¹)	4000	3700	4500	3300	3500
Labour Cost (Rs acre ⁻¹)	750	750	500	3400	3100
Irrigation Cost (Rs acre ⁻¹)	900	1200	600	0	0
Harvesting	3200	3200	3200	2300	3500
Transporting	1200	1200	1200	1200	1500
Miscellaneous Cost (Rs acre ⁻¹)*	6700	7400	5500	1000	1200
Total Cost (Rs acre ⁻¹)	21600	21400	20400	17340	21050
Total Paddy Yield (q acre ⁻¹)	21 Qtl.	22 Qtl.	18 Qtl.	16 Qtl.	20 Qtl.
Gross Income (Rs. acre ⁻¹)	65100	68200	55800	49600	62000
Net Profit (Rs acre ⁻¹)	43500	46800	35400	32,260	40950
Benefit Cost (B:C) ratio	3.01	3.19	2.73	2.86	2.94

Economic analysis for Vegetables and other crops cultivation during 2025-26: The B:C ratio under MAAS adoption ranged from 2.79 in turmeric to 4.43 in arhar whereas non-MAAS farmers recorded B:C ratio in the range of 2.34 in bittergourd to 3.32 in arhar in the year 2025-2026 (Table-4). Among all crops, arhar exhibited the highest profitability under MAAS adoption with a B:C ratio of 4.43 followed by urad (3.61), groundnut (3.57) and bitter gourd (3.32). The gross returns obtained by

MAAS farmers were substantially higher across all crops, bitter gourd cultivation generated a gross return of ₹3,90,000 acre⁻¹ under MAAS compared to ₹2,34,000 acre⁻¹ under non-MAAS conditions. Similar results were reported by Pingali *et al.* (2019) [7], who highlighted that mechanization services significantly improve farm profitability and resource-use efficiency in developing countries.

Table 4: B:C Ratio of Vegetables for MAAS and Non-MAAS farmers

Crops	Total Cost of Cultivation (Rs./acre)		Gross Return (Rs./acre)		Net Return (Rs./acre)		Benefit Cost (B:C) ratio	
	MAAS Farmers	Non-MAAS	MAAS	Non-MAAS	MAAS	Non-MAAS	MAAS	Non-MAAS
Turmeric Wheat	57300	43350	160000	104000	102500	60650	2.79	2.40
Groundnut	23500	23600	84000	66000	60500	42400	3.57	2.7
Arhar	24350	21700	108000	72000	83650	50300	4.43	3.32
Bittergourd	120450	100000	390000	234000	269550	134000	3.23	2.34
Urad	16600	7350	60000	20000	43400	12650	3.61	2.72

Conclusion

The economic analysis of rice cultivation during 2024–25 and 2025–26 revealed that MAAS farmers earned profitable returns over non-MAAS farmers with B:C ratios exceeding 2.50 in all cases. MAAS adopters consistently achieved higher profitability, recording B:C ratios of upto 3.32 in 2024–25 and an average B:C ratio of 2.98 in 2025–26 compared to 2.90 among Non-MAAS farmers. The higher returns among MAAS adopters were attributed to efficient resource utilization, timely farm operations and improved crop management facilitated through weather-based advisories. These findings indicate that MAAS adoption enhances farm profitability and resource-use efficiency, supporting the role of agrometeorological advisory services in promoting sustainable rice production and increasing farmers' income. The economic analysis of vegetables and other field crops during 2024–25 and 2025–26 revealed that MAAS adopters consistently obtained higher B:C ratios, gross returns and net returns than Non-MAAS farmers across all crops studied. The B:C ratio ranged from 1.91–4.43 among MAAS farmers compared to 1.70–3.32 among Non-MAAS farmers. Higher profitability among MAAS adopters reflects the benefits of weather-based advisories in improving crop management, optimizing input use and enhancing productivity. The results demonstrate that MAAS is an effective tool for increasing farm income, improving economic efficiency and promoting sustainable agricultural production systems.

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