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RESEARCH PAPER

Profitability Analysis of Rice (*Oryza sativa* L.) Farming in Northeastern Hill Region of India: Micro-Economic Insights

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ABSTRACT

This study examined the profitability of rice farming and its socioeconomic determinants in the Northeastern Hill (NEH) region of India. To achieve this, a multistage sampling technique was used to collect cross-sectional data from six rice-producing districts in the region in 2022. A total of 300 participants were directly interviewed using a structured questionnaire. In addition to descriptive analysis, benefit-cost and functional profitability analyses of rice were conducted. The results of the cost-benefit analysis indicate that rice farming is a profitable activity in the NEH region, as the estimated cost of production was lower than the return in the selected study areas. However, profitability differs among farmers in different agro-climatic situations, and those who opt for high-yielding varieties (HYV) are more profitable in rice cultivation than those who use local varieties. Farmers in the Sub-Tropical Plain Zone and Mild Tropical Plain Zone who were in the high category of profitability in HYV rice cultivation, particularly those who used RC Maniphou-7 and RC Maniphou-13 varieties, had notably high profitability. Despite being profitable in cultivation, the Alpine zone exhibits the highest profit gap between HYV (Pant Dhan-10) and local varieties (Attey Dhan). The study also indicated that, among the selected variables, education and family size had a positive and significant influence on the profitability of rice production for the pooled data. However, variables such as the involvement of middlemen and price fluctuations, were found to have a negative impact on profitability in rice production. Furthermore, these factors vary among farmers in different Agro-Climatic Zones (ACZs) in a region. Hence, addressing these variables and tailoring policies to the specific conditions of each ACZ are crucial for promoting sustainable and profitable rice production.

HIGHLIGHTS

- Rice farming is a profitable activity in the NEH region, as the estimated cost of production was lower than the return.
- Profitability differs among farmers in different agro-climatic situations, and those who opt for high-yielding varieties (HYV) are more profitable in rice cultivation than those who use local varieties.
- Farmers in the Sub-Tropical Plain Zone and Mild Tropical Plain Zone cultivating HYV rice varieties such as RC Maniphou-7 and RC Maniphou-13 had notably high profitability level.
- Despite being profitable in cultivation, the Alpine zone exhibits the highest profit gap between HYV (Pant Dhan-10) and local varieties (Attey Dhan).
- The variables such as the involvement of middlemen and price fluctuations, were found to have a negative impact on profitability in rice production.

Keywords: Rice, profitability, determinants, agro-climatic zones, northeastern hill

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In India, agriculture plays a vital role, supporting the livelihoods of more than 70% of rural households, contributing around 17% to national GDP, and engaging nearly 58% of the total population. Despite the significant strides in country's food grain production, from a meagre 51 million tons in 1950-51 to a remarkable record production of 330.5 million tons in 2022-23, the issue of disproportionate profitability persists among farmers in India. In addition, landholding sizes have been declined over the years, from 2.3 hectares in 1970-71 to 1.37 hectares in 2000-01and further to 1.08 hectares in 2016 (Agriculture Census 2015-16). A total of 54.6% of the workforce, consisting of 118.7 million cultivators and 144.3 million agricultural labourers, are engaged in agriculture and its allied sectors (Census, 2011). However, the percentage of workers in agrarian sector has declined. As per the latest annual Periodic Labour Force Survey (PLFS) report of NSSO for the period 2021-22 (July-June), the share of labour employment in agriculture and allied sectors of India is 45.5%, which is declined from 46.5% in 2020-21, but the figure has been improved from 42.5% than that of during 2018-19.

Addressing the dual challenges of a rising population on one side and a diminishing workforce in the smallholder farming system, it becomes imperative to enhance both food production and profitability in India, with a specific focus on major food crop rice in NEH region. Rice dominates as the primary food crop in the NEH Region of India, spanning over 8.51 lakh hectares with an average productivity of 2.38 t/ha. This figure lags the national average of 2.71 t/ha for the year 2020-21(Ministry of Agriculture and Farmers Welfare, GoI, 2021). The HYV programme, coupled with improved technology development, has played a pivotal role in significantly augmenting food grain production in the NEH region. The increasing yield potential of HYVs, surpassing those of local cultivars, not only elevate productivity, but also generate additional employment opportunities, fostering socioeconomic transformation of smallholder farmers (Singh *et al.* 2018). Rice is the most popular source of food and is considered as a strategic crop mostly produced by smallholder farmers in various agro-ecological zones of the region (Mauki *et al.* 2023). The welfare of rice farmers depends on their net returns on rice production. Farmers' profit margins increase when high output meets commodity prices in prevailing input price regimes. Enhanced profit creates higher disposable income and increases the likelihood of improved standards of living for farm households, resulting from increased expenditure. The cost-effectiveness of rice farming depends on the amount of output and the unit price. The profitability of rice production is determined by whether the returns exceed the investment costs of the production process (Hoque and Haque, 2014). When the cost-effectiveness of rice cultivation is favorable, farmers extend their activities beyond seed production and household consumption. Previous research has indicated high levels of inefficiency in modern rice cultivation, with a mean profit efficiency of 77%, suggesting that approximately 23% of the potential profit is lost due to technical, allocative, and scale inefficiencies in modern rice production. Factors contributing to profit loss in rice cultivation include post-harvest losses in both quantitative and qualitative terms in rice crops. Biophysical factors (biotic and abiotic), socio-economic conditions, management practices, institutional factors, and policy considerations significantly influences the profitability of rice cultivation (Balasubramanian and Sombilla, 2000). In fact, in agriculture, profitability assumes a substantial role in the decision-making process of farmers and serves as a crucial factor in achieving economic efficiency (Pumihic, 2023). The economic efficiency of a farm or any other organization defines as a reflection of several critical economic and financial components and acts as an appropriate indicator for proper decision-making process (Bumbescu, 2015). Despite the extensive literature on the adoption of intensification practices in rice production systems in India, there is a notable scarcity of studies focusing on profitability and its determinants across agro-climatic zones in the NEH region. The present study therefore, was designed with the specific objectives i) to assess the level of net farm profit and their profit gaps between HYV and local varieties of rice across agro-climatic zones in NEH region and ii) to explore the socio-economic factors responsible for their net farm profits across agro-climatic zones in NEH region.

MATERIALS AND METHODS

Locale of the study

The study was conducted in the Northeastern Hill states comprising of Arunachal Pradesh, Manipur,

Meghalaya, Mizoram, Nagaland, Sikkim and Tripura, representing different agro-climatic zones/ situations.

Sampling design

A multistage sampling technique was employed to establish the study area and select the respondents. Initially, a comprehensive list of Krishi Vigyan Kendras (KVKs) and districts was compiled, emphasizing on the criteria that more than 50% of their geographical area within a specific agro-climatic zone (ACZ). Subsequently, two districts were purposively chosen under each of the six ACZs, prioritizing those with the highest area coverage under rice cultivation and where KVKs had been operational with complete staff for at least last one decade. From each selected district, one KVK-adopted village (under DFI) with relatively larger areas under rice cultivation was purposively chosen (Table 1). The final sample consisted of randomly sampled 25 farmers practicing both HYV and Local rice varieties from each adopted village. Therefore, the total sample size was determined as (6 ACZ × 2 districts) × 25 farmers, resulting in a final sample size of 300 respondents.

Data collection

This study was based on both primary and secondary data sources.

Analytical Techniques

The farm budget analysis encompassing Total Revenue (TR), Gross Margin (GM), Gross Cost (GC), Gross Profit Ratio (GPR), Benefit-Cost Analysis (BCA) and Net Farm Income/Profit (NFP) was employed to estimate the production and profitability of rice production. Multiple regression analysis was used to determine the factors that influence the profitability of rice production. In this study, the Gross Margin, representing the difference between Total Revenue (TR) and Total Variable Cost (TVC), served as the key metric for estimating the profitability of rice production systems. This choice was influenced by the fact that the Gross Margin (GM) is a valuable planning tool, particularly in situations where fixed capital plays a negligible role in an enterprise (Bwala and John 2018). The gross margin model is expressed as:

$$GM = TR - TVC$$

Table 1: Profile of villages selected under different ACZ in NEH region

ACZ	State	Districts with > 50% of its geographical area under ACZ	Area under rice cultivation (ha) in the district	% area coverage under rice against total cropped area of the district	Name of selected adopted village under DFI
Alpine Zone (>3500MSL)	Arunachal Pradesh	West Siang	1057	52.24	Soi
	Sikkim	West Sikkim	1588	20.00	Sankhu
Temperate Sub-Alpine Zone (1500-3500 MSL)	Nagaland	Tuensang	14070	49.16	BothanPou
	Nagaland	Zunheboto	14900	55.25	Chingmelin Village
Sub-Tropical Hill Zone (1000-1500 MSL)	Mizoram	Lunglei	16,325	72.25	Rawpui
	Meghalaya	Jaintia Hill	36479	49.00	Niawkmai
Sub-Tropical Plain Zone (400-1000 MSL)	Manipur	Bishnupur	31480	64.17	Kumbi
	Manipur	Thoubal	26190	54.58	Ukhongsang
Mild-Tropical Hill Zone (200-800 m)	Mizoram	Mamit	3932.4	58.00	Darlak
	Manipur	Churachandpur	31180	48.75	Saihenjang
Mild Tropical Plain Zone (≤ 200 m)	Nagaland	Dimapur	9120- (Jhum) 40330- (WTRC)	75.08	Maova
	Tripura	Dhalai	58041	59 .00	Maharani

Where: *GM* = Gross Margin (₹ /ha)

TR = Total Revenue (₹ /ha)

= *P. Q*, where, *P* = Output price (₹ /ha) and *Q* = Output in quantity (q/ha)

TVC = Total Variable Cost (₹ /ha) including labour-both family and hired (man-days), seeds, fertilizers, pesticides, fungicides, irrigation, transportation etc.

The profitability ratio was used to examine farmers' costs and returns. This is because the gross margin, though necessary, is not a sufficient tool to determine the profitability level of an enterprise. Furthermore, profitability ratios are a class of financial metrics used to assess an enterprise's ability to generate earnings compared to its expenses and other relevant costs incurred during a specific period (James, 2009). Hence the model is presented as:

$$\text{Gross Profit Ratio} = \frac{\text{Gross Margin (GM)}}{\text{Total Revenue (TR)}} \times 100$$

Where, TR = P.Q (P = Output price in ₹ /ha, Q = Output in quantity (q/ha)

Benefit-cost analysis (BCA) is a technique for evaluating an enterprise or investment by comparing the economic benefits of an activity with its economic costs. The benefit-cost ratio (BCR) is calculated as the present value (PV) of benefits divided by the present value (PV) of costs:

$$BCR = \frac{PV(B)}{PV(C)},$$

(Criteria: if B/C > 1 farming is feasible, if B/C ≤ 1 farming is not feasible).

Net farm income/ profit (NFP) was used to calculate the profitability of the farm. The net farm income of an enterprise is obtained by subtracting the estimated total cost for the enterprise from its gross output. When the enterprise gross margin is calculated, the variable costs were taken into account, but not fixed costs. Now, in calculating the enterprise profit, the total cost of production-both fixed as well as variable costs were considered. To find the production and profitability of rice farming in rainfed area, the following analysis is used.

$$Profit\ (\pi) = TR - TC$$

$$= P.Q - (TVC + TFC)$$

Where: π = Profit (₹/ha)

TR = Total Revenue (₹ /ha)

TC = Total Cost (₹ /ha)

P = Output Price (₹ /ha)

Q = Output in quantity (q/ha)

TVC = Total Variable Cost (₹/ha) including labour-both family and hired (man-days) (for operations such as land clearing, ploughing and harrowing, sowing, transplanting, fertilizing, weeding and moulding, spraying, reaping, cleaning and packing, transportation), bullock labour, machine labour, seeds, fertilizers, manures, pesticides, fungicides, irrigation charges, transportation etc.

TFC = Total Fixed Cost (₹/ha) which includes land rent and tax, interest, depreciation on implements and farm building, tools (hoe, spade, sickle, sprayer, paddy weeder, basket, knife etc.), contribution, and other indirect cost. The study also estimated the level of profit gap, which is the different between the optimum and the actual inputs allocated by farmers at a certain amount of costs production (Saghaian, 2013). Socio-economic characteristics of the farmers are important parameters for determining the level of the farmers' knowledge and their managerial skill in agricultural activities, and hence, 12 independent variables were selected based on perceived significance in their contribution and review of literature. These variables were measured with the help of structured schedules in the light of the set objectives which were taken into consideration in the regression analysis.

The multiple regression analysis to identify the factors that affect the profitability of rice farming was employed. The equation model is:

$$Y = b_1x_1 + b_2x_2 + \ldots\ldots\ldots\ldots b_nx_n + C.$$

Where, *Y* = the dependent variable of the regression (a normalized profit with an output price)

X_1 = Age (Years)

X_2 = Education (formal education)

X_3 = Family type (Categorical; score: 1 for joint; 2 for nuclear)

X_4= Family size (Number of people; Score: family member 1-4 = 1; 5-6 = 2; 7-9 = 3 and ≥ 10 = 4)

X_5 = Operational land holding (Hectares; Score: 0-0.99ha = 1; 1-1.99 ha = 2; 2-3.99 ha = 3; ≥4 ha = 4)

X_6 = Primary occupation (Categorical; score: farming = 1; other = 2)

X_7 = Annual income (₹)

X_8 = Farming experience (Years)

X_9 = Accessibility of Market Outlets (score: Yes = 1; No = 0)

X_{10} = Involvement of Middlemen (score: Yes = 1; No = 0)

X_{11} = Accessibility of market information (score: Yes = 1; No = 0)

X_{12} = Price fluctuations (score: Yes = 1; No = 0)

C = constant, b_i's (i = 1,2…….n) are the regression coefficients (parameters), which represent the value at which the criterion variable changes when the predictor variable changes.

RESULTS AND DISCUSSION

Net farm profit in HYV and local rice cultivation

The findings regarding net farm profit in the cultivation of HYV and Local rice varieties under different agro-climatic conditions in the NEH region are presented in Table 2.

The results indicated that all farmers (100%) in the Alpine Zone and Sub-Tropical Hill Zone were situated at a medium level of net farm profit in HYV rice cultivation (₹ 12506-59092), followed by the Mild-Tropical Hill Zone (88%), and the Temperate Sub-Alpine Zone (76%). Additionally, the majority of farmers (84%) in the Sub-Tropical Plain Zone and Mild Tropical Plain Zone (80%) were observed to have a high level (> ₹ 59092) of net farm profit in HYV rice cultivation in their farming situations. The study also revealed that all farmers (100%) in the Sub-Tropical Plain Zone, Mild-Tropical Hill Zone, and Mild Tropical Plain Zone were positioned at the medium level (₹ 12506-59092), followed by the Temperate Sub-Alpine Zone (84%) and Alpine Zone (64%) in rice cultivation of local varieties. However, the majority of farmers (72%) in the Sub-Tropical Hill Zone were found to have a low level of net farm profit (< ₹ 12506) in the cultivation of local rice varieties. This study identified notable variations in net farm profit across different agro-climatic zones in the NEH region for both HYV and local rice varieties. While the Alpine and Sub-Tropical Hill Zones consistently exhibited medium net farm profits in HYV rice cultivation, the Sub-Tropical Plain and Mild Tropical Plain Zones showed a majority of farmers attaining high profits. In contrast, local rice varieties depicted a diverse scenario, with the subtropical hill zone witnessing a majority of farmers experiencing low net farm profits. These findings highlight the need for targeted interventions and strategies for specific agro-climatic conditions to enhance the profitability of rice cultivation.

Profitability analysis of rice production

The economics of rice production, categorized

Table 2: Agro-Climatic Zone (ACZ)-wise distribution of respondents based on net farm profit in HYV rice cultivation

ACZ	Respondents (n=50)												Mean	S.D.
	Low (<₹ 12506)				Medium (₹ 12506-59092)				High (> ₹ 59092)					
	f		%		f		%		f		%			
	HYV	Local	HYV	Local	HYV	Local	HYV	Local	HYV	Local	HYV	Local		
ACZ-1	0	9	0.00	36.0	25	16	100.00	64.00	0	0	0.00	0.00		
ACZ-2	6	4	24.00	16.00	19	21	76.00	84.00	0	0	0.00	0.00	35799	23293
ACZ-3	0	18	0.00	72.00	25	7	100.00	28.00	0	0	0.00	0.00		
ACZ-4	0	0	0.00	0.00	4	25	16.00	100.00	21	0	84.00	0.00		
ACZ-5	0	0	0.00	0.00	22	25	88.00	100.00	3	0	12.00	0.00		
ACZ-6	0	0	0.00	0.00	5	25	20.00	100.00	20	0	80.00	0.00		

ACZ-1: Alpine Zone, ACZ-2: Temperate Sub-Alpine Zone, ACZ-3: Sub-Tropical Hill Zone, ACZ-4: Sub-Tropical Plain Zone, ACZ-5: Mild-Tropical Hill Zone, ACZ-6: Mild Tropical Plain Zone.

by Agro-Climatic Zones (ACZ), are summarized in Table 3. It outlines the average total cost, total revenue, gross margin, net farm profit, gross profit ratio (GPR), gross profit margin, and benefit-cost ratio (BCR) for rice farmers (both HYV and local) in different study areas.

The results presented in the table 3 reveal that among the HY rice varieties, highest gross profit margin (GPM) in percentage (66.90%) was observed in cultivation of RC Maniphou-7 under Sub-Tropical Plain Zone with B:C ratio of 3.02. This was followed by RC Maniphou-13 (65.50%) with B:C ratio 2.89

Table 3: Agro-climatic zone-wise profitability analysis in rice farming

ACZ	District	Variety	Total Revenue (₹/ha) 1	Total Cost (TFC+TVC) (₹/ha) 2	Gross margin (₹/ha) (TR-TVC) = 3	Net Farm Profit (₹/ha) (1-2) = 4	Gross Profit Ratio (GPR) (3/1) = 5	GPR in % (Gross profit margin)	B:C Ratio (TR/TC)	Profit gap between HYV and Local (%)
ACZ-1	West Siang & West Sikkim	HYV (Pant Dhan-10)	71810	40250	31560	31560	0.439	43.90	1.78	
		Local (Attey Dhan)	49200	37900	11300	11300	0.229	22.90	1.29	20260 (64.19)
ACZ-2	Zunheboto & Tuensang	HYV (IR-64)	69500	31675	37825	37825	0.544	54.40	2.19	
		Local (Tiesecyouli)	61850	30700	31150	31150	0.504	50.40	2.01	6675 (17.64)
ACZ-3	Lunglei & Jaintia Hills	HYV (Shasharang)	63250	32925	30325	30325	0.479	47.90	1.92	
		Local (Lespah)	43950	31750	12200	12200	0.277	27.70	1.38	18125 (59.76)
ACZ-4	Bishnupur & Thoubal	HYV (RC Maniphou-7)	142665	47162	95503	95503	0.669	66.90	3.02	
		Local (Drumphou)	81600	46562	35037	35037	0.429	42.90	1.75	60466 (63.31)
ACZ-5	Mamit & Churachandpur	HYV (Gomati)	69000	38400	30600	30600	0.443	44.30	1.79	
		Local (Daw)	54100	36305	17795	17795	0.328	32.80	1.49	12805 (41.84)
ACZ-6	Dimapur & Dhalai	HYV (RC Maniphou-13)	107000	36900	70100	70100	0.655	65.50	2.89	
		Local (IR-8)	56900	30700	26200	26200	0.460	46.00	1.85	43900 (62.62)

ACZ-1: Alpine Zone, ACZ-2: Temperate Sub-Alpine Zone, ACZ-3: Sub-Tropical Hill Zone, ACZ-4: Sub-Tropical Plain Zone, ACZ-5: Mild-Tropical Hill Zone, ACZ-6: Mild Tropical Plain Zo.

under Mild Tropical Plain Zone, IR-64 (54.40%) in Temperate Sub-Alpine Zone with B:C ratio 2.19 and Shasharang (47.90%) with B:C ratio of 1.92 in Sub-Tropical Hill Zone. The other important two high yielding rice varieties were Gomati and Pant Dhan-10 with gross profit margin of 44.30% (B:C ratio = 1.79) and 43.90% (B:C ratio = 1.78) in Mild-Tropical Hill Zone and Alpine Zone respectively. While in case of local rice varieties, highest gross profit margin (50.40%) was found in cultivation of Tiesecyouli with B:C ratio 2.01 in Temperate Sub-Alpine Zone. This was followed by IR-8 (46%) with B:C ratio 1.85 in Mild Tropical Plain Zone, Drumphou (42.90%, B:C ratio = 1.75) in Sub-Tropical Plain Zone, Daw (32.80%, B:C ratio = 1.49) in Mild-Tropical Hill Zone**,** Lespah (27.70%, B:C ratio = 1.38) in Sub-Tropical Hill Zone and Attey Dhan (22.90%, B:C ratio = 1.29) in Alpine Zone.

Further, present study revealed that the farmer adopting local variety (Attey Dhan) in the Alpine zone declined their profit by 64.19 percent over the high yielding variety (Pant Dhan-10). This was followed by a 63.31 percent gap between RC Maniphou-7 (HYV) and Drumphou (Local) in the Sub-Tropical Plain Zone; a 62.62 percent gap between RC Maniphou-13 (HYV) and IR-8 (Local) in the Mild Tropical Plain Zone; and a 59.76 percent gap between Shasharang (HYV) and local var. Lespah in the Sub-Tropical Hill Zone.

Further 41.84 percent gap between Gomati (HYV) and local Daw in the Mild-Tropical Hill Zone, and 17.64 percent gap was found between IR-64 (HYV) and local Tiesecyouli in the Temperate Sub-Alpine Zone. The corresponding values of the benefit–cost ratio (BCR) for both HYV and local rice varieties indicate that rice farming is a profitable activity. However, these estimates vary among farmers under different agro-climatic conditions in the region. These results align with the findings of Akter *et al.* (2019) on the factors determining the profitability of rice farming in Bangladesh. Other studies conducted by Rahman *et al.* (2015) and Islam *et al.* (2017) also affirmed the profitability of rice production in Bangladesh. However, profitability may differ in various areas owing to the widespread adoption of modern rice technology, input availability, land fertility, and other factors. The overuse of fertilizers and pesticides, coupled with climate change, also causes issues such as the loss of biodiversity, soil fertility, and contamination of groundwater with arsenic. Above findings reveal diverse gross profit margins and benefit-cost ratios for various rice varieties, across the agro-climatic conditions. Significant profit gaps between specific varieties highlight the need for customized strategies. The benefit-cost ratio varies among farmers under different conditions, indicating rice farming profitability.

Socio-economic determinants of rice production profitability

Multiple regression analysis was employed to ascertain the relative influence of each independent variable in explaining the variation in the dependent variable. Twelve independent variables, namely, age, education, family type, family size, operational landholding, primary occupation, annual income, farming experience, accessibility of market outlets, involvement of middlemen, accessibility of market information and intelligence, and price fluctuations, were included in this study. The predictive power of each multiple regression analysis was assessed by calculating the coefficient of determination (R^2). To test the statistical significance of the regression coefficients, '*t*' values were also computed. The results, compiled from data across all agro-climatic zones and presented in Table 4, provide insights into the factors influencing the net farm profit in rice cultivation.

The findings revealed that two variables, specifically the education and family size of the respondents, play a significant role in influencing net farm profit in rice cultivation. The corresponding '*t*' values of 1.9750 and 2.8951 indicate their positive and statistically significant contributions to farmers' level of net farm profit. This suggests that higher levels of education and larger family sizes positively impact the profitability of rice cultivation. On the other hand, two variables, namely the involvement of middlemen and price fluctuations, show statistically significant negative 't' values of -1.9135 and -3.7489. These results imply that actively reducing the participation of middlemen and mitigating the effects of price fluctuations can consistently enhance the efficiency and profitability of rice production. The emphasis on reducing the negative impact of these variables aligns with agricultural economic principles, in which minimizing intermediary

Table 4: Multiple regression analysis of independent variables and dependent variable

Independent variables	Net Farm Profit (Dependent variable)		
	'b' value	't' value	'p' value
Age	75.89	0.6448	0.5195
Education	3242.63	1.9750*	0.0492
Family type	4734.87	0.7722	0.4406
Family size	2492.89	2.8951**	0.0040
Operational land holding	1895.32	1.4473	0.1488
Primary occupation	14668.92	1.2341	0.2181
Annual income	-0.01575	-0.5397	0.5897
Farming experience	719.60	0.6127	0.5405
Accessibility of Market Outlets	1798.732	0.6478	0.5176
Involvement of Middlemen	-5291.99	-1.9135*	0.0466
Accessibility of market information and intelligence	1058.72	0.4013	0.6884
Price fluctuations	-11784.56	-3.7489**	0.0015
R^2 value	0.598		
'F' value	4.614		

**Significant at 0.05 level of probability; ** Significant at 0.01 level of probability..*

involvement and stabilizing prices are often associated with increased farmer profitability. The findings are consistent with previous studies by Hyuha *et al.* (2007) and Amaza and Maurice (2005), particularly concerning the positive influence of education on profit levels in agriculture. The positive influence of education on profitability suggests that informed and educated farmers may be better equipped to make strategic decisions, adopt modern farming practices, and navigate the market dynamics more effectively. The coefficient of determination (R^2) value of 0.598 indicates that collectively, the 12 independent variables considered in the study explain approximately 59.80% of the total variation in respondents' net farm profit in rice cultivation. This relatively high R^2 value underscores the importance of these selected variables for understanding and predicting variations in net farm profits among rice farmers.

In nutshell, this detailed analysis sheds light on the influence of various factors on net farm profits from rice cultivation. Education and family size emerged as positive contributors, while the active involvement of middlemen and price fluctuations negatively influenced profitability. These insights provide valuable information for policymakers, extension services, and farmers in formulating strategies to enhance rice farming profitability with potential implications for sustainable agricultural development.

Agro-climatic zone wise multiple regression analysis

The ACZ-wise findings of the multiple regression analyses are presented in Table 5. The results indicate that certain variables exert a significant influence on net farm profits in rice farming across different agro-climatic zones (ACZs).

In Alpine zones, variables such as age, education, family type, operational landholding, annual income, and involvement of middlemen were found to have a significant influence on net farm profits in rice farming. In the Temperate Sub-Alpine Zone, only age and education were significant, while in the subtropical hill zone, five variables-family size, annual income, accessibility of market outlets, involvement of middlemen, and accessibility of market information and intelligence were identified as influential. In the subtropical plain zone, four variables namely; age, family size, operational landholding, and accessibility of market information and intelligence were significant. The Mild-Tropical Hill Zone was significant for three variables: education, operational landholding, and farming experience. Lastly, in the Mild Tropical Plain Zone, age and operational landholding were the only

Table 5: ACZ-wise multiple regression analysis of independent variables towards profitability in rice cultivation

Independent variables	Net Farm Profit (Dependent variable)					
	'b' value ('t' value)					
	ACZ-1	**ACZ-2**	**ACZ-3**	**ACZ-4**	**ACZ-5**	**ACZ-6**
Age	108.52	115.60	-102.98	1013.27	541.02	321.99
	(2.783**)	(2.801**)	(-1.208)	(2.929**)	(1.398)	(4.179**)
Education	1542.04	1273.15	1183.09	3272.46	1422.58	966.89
	(2.609*)	(2.451*)	(0.941)	(0.690)	(2.387*)	(0.879)
Family type	-6219.60	-3802.09	-2046.03	-21412.8	-336.02	-4806.57
	(-3.822**)	(-0.722)	(-0.595)	(-0.722)	(-0.495)	(-0.759)
Family size	267.11	994.45	851.75	6706.56	2666.51	-848.98
	(0.387)	(0.837)	(2.825*)	(2.712**)	(1.227)	(-1.458)
Operational land holding	1003.87	1503.30	-1099.31	12363.38	13065.41	3158.75
	(2.682**)	(1.520)	(-0.490)	(2.507*)	(4.257**)	(2.819**)
Primary occupation	-242.92	336.62	142.92	1272.34	2472.33	1508.6
	(-0.061)	(0.056)	(0.031)	(0.457)	(0.557)	(0.245)
Annual income	-0.03	-0.003	-0.027	0.104	-0.053	0.026
	(-2.209*)	(-0.225)	(-1.797*)	(0.772)	(-0.519)	(1.390)
Farming experience	1175.89	1274.61	5271.06	-2194.59	3951.42	88.133
	(6.792)	(1.324)	(7.567)	(-0.432)	(2.323*)	(0.076)
Accessibility of Market Outlets	552.66	140.92	3701.18	-3573.36	5593.85	845.34
	(0.541)	(-0.109)	(2.175*)	(-0.450)	(1.165)	(0.491)
Involvement of Middlemen	-2303.01	849.29	-5387.69	-7042.55	-2657.86	-1739.42
	(-2.064*)	(0.623)	(-3.01**)	(-0.935)	(-0.696)	(-1.036)
Accessibility of market information and intelligence	401.13	1292.04	5374.81	5110.5	1605.59	2071.42
	(0.389)	(1.086)	(2.690**)	(2.071*)	(0.403)	(1.367)
Price fluctuations	1671.32	1386.79	-1002.83	-1238.25	-1454.14	2542.53
	(1.175)	(0.857)	(-0.571)	(-0.1.272)	(-0.291)	(1.536)
R^2 value	0.923	0428	0.728	0.592	0.733	0.580
'F' value	37.185	2.308	9.252	4.474	10.737	4.263

**Significant at 0.05 level of probability; ** Significant at 0.01 level of probability.*

variables with a significant impact on net farm profit in rice production. These significant variables were considered the dominant limiting factors affecting the profitability of rice farming, both for HYV and local varieties, under different ACZs. This indicates the importance of appropriate strategies and policies that address the specific challenges faced by farmers in each agro-climatic zone. The F-value of the estimated models was 4.614 for all farmers and varied across ACZs (37.185, 2.308, 9.252, 4.474, 10.737, and 4.263 for ACZ 1 to ACZ 6, respectively), all of which were found to be significant. This suggests that the explanatory variables used in the study were important in explaining the variations in returns of rice across different agro-climatic conditions. Furthermore, the specific R^2 values for each agro-climatic zone were; 0.923 for ACZ 1, 0.428 for ACZ 2, 0.728 for ACZ 3, 0.592 for ACZ 4, 0.733 for ACZ 5, and 0.580 for ACZ 6. These values indicate that the explanatory power of the model was substantial, exceeding 0.5. This finding suggests that a significant proportion of the variation in net farm profits can be explained by the variables used in the model estimation. The substantial R^2 values for each ACZ further highlight the reliability and effectiveness of the model in elucidating the complexities of net farm profit variations in rice farming in different agro-climatic contexts. In all, these findings emphasize the need for region-specific approaches in designing developmental programs and strategies, considering the identified significant variables that positively influence rice production and profitability in different ACZs.

CONCLUSION AND POLICY IMPLICATIONS

In conclusion, this study revealed the inherent profitability of rice production for farmers adopting HYVs across diverse ACZs in the NEH region. In particular, farmers cultivating HYVs consistently showed higher net farm profits than those opting for local varieties. This prompts the need for targeted seed replacement programs, particularly for local rice varieties in the NEH states. The accessibility of financial services has emerged as a crucial factor in resolving challenges, such as labor shortages and the continuous adoption of modern agricultural technologies and crop varieties. In-depth insights from the multiple regression analysis underscore the positive impact of education and family size on net farm profit in rice cultivation, while variables such as the involvement of middlemen and price fluctuations show negative effects. These findings offer valuable guidance for policymakers, technocrats, and extension functionaries by emphasizing the significance of appropriate approaches to developmental programs across different ACZs. This study offers key policy implications including the promotion of seed replacement initiatives such as farmers participatory seed production, enhanced financial accessibility, strengthened extension and advisory services, and government interventions to regulate market prices and provide input subsidies in enhancing farmers net income in the region. It is suggested that the government agencies including state extension workers should educate the farmers to use recommended package of practice in rice cultivation through extension and capacity building programmes. KVKs located at different agro-climatic zones in the region may develop region-specific strategies and organise capacity building programs, awareness and sensitization workshops to provide knowledge and skill empowerment to farmers in scientific rice farming. Weather risk mitigation through crop insurance program, and continuous technology backstopping and monitoring are crucial to boost rice production and ensure profitability and sustainability in rice production across the agro-climatice zones in the region. Integrating these policy recommendations will contribute to building a resilient and profitable rice-farming sector, ultimately supporting the livelihoods of farmers, and fostering agricultural sustainability.

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REFERENCES

Agricultural Census. 2015-16. All India report on number and area of operational holdings. Ministry of Agri. & Family Welfare, GoI: New Delhi, India. https://agcensus.nic.in/document/agcen1516/T1_ac_2015_16.pdf

Akter, T., Parvin, M.T., Mila, F.A. and Nahar, A. 2019. Factors determining the profitability of rice farming in Bangladesh. *Journal of Bangladesh Agricultural University*, **17**(1): 86-91.

Amaza, P.S. and Maurice, D.C. 2005. Identification of factors that influence technical efficiency in rice-based production systems in Nigeria. *Rice Policy and Food Security in sub-Saharan Africa*, **70**: 70-81.

Balasubramanian, V., Bell, M. and Sombilla, M. 2000. Yield, profit, and knowledge gaps in rice farming: Causes and development of mitigation measures. *Bridging the rice yield gap in the asia-pacific region*, 163: 163-177.

Bumbescu, S. 2015. Analysis Models of Profitability In Agriculture. Bulletin of Taras Shevchenko National University of Kyiv Economics. https:// www.researchgate.net/ publication/ 305197118

Bwala, M.A. and John, A.U. 2018. Profitability analysis of paddy production: A case of agricultural zone 1, Niger State Nigeria. *Journal of the Bangladesh Agricultural University*, 16(1): 88-92.

Mauki, C., Jeckoniah, J. and Massawe, G.D. 2023. Smallholder rice farmers profitability in Agricultural Marketing Co-operative Societies in Tanzania: A case of Mvomero and Mbarali districts. *Heliyon*, **9**(6): e17039.

Hoque, M.Z. and Haque, M.E. 2014. Socio-economic factors influencing profitability of rice seed production in selected areas of Bangladesh. *The Agriculturists*, **12**(1): 33-40.

Hyuha, T.S., Bashaasha, B., Nkonya, E. and Kraybill, D. 2007. Analysis of profit inefficiency in rice production in Eastern and Northern Uganda. *African Crop Science Journal*, **15**(4): 243-243.

Islam, Z., Begum, R., Sharmin, S. and Khan, A. 2017. Profitability and productivity of rice production in selected coastal area of Satkhira district in Bangladesh. *International Journal of Business, Management and Social Research*, **3**(1): 148-153.

James, C. 2009. Financial Statement Analysis in Accounting: Liquidity Ratio Analysis, Balance Sheet Assets and Liabilities. *Journal of Financial Stability.*

Pumihic, M.B. 2023. Profitability of Actors in the Value Chain of Commercial Rice. *International Journal Of Engineering, Business And Management*, **7**(3): 58-66.

Rahman, M.C., Nafisa, C.N.B., Hossain, M.R., Rahaman, M.S. and Chowdhury, A. 2015. Comparative profitability and efficiency analysis of rice farming in the coastal area of Bangladesh: The impacts of controlling saline water intrusion. *IOSR Journal of Agriculture and Veterinary Science,* **8**(10): 89-97.

Singh, K.J., Feroze, S.M., Singh, R. and Das, A. 2018. How profitable is rice cultivation in hills of northeastern region of India: a case study of Manipur. *Economic Affairs,* **61**(2): 327-334.

Sujarwo and Sayed S. 2013. Profit gap analysis on the small-scale production of shallot: a case study in a small village in east java province of Indonesia, Department of Agricultural Economics, University of Kentucky.

Saghaian, S.H. 2013. Profit Gap Analysis on the Small Scale Production of Shallot: A Case Study in a Small Village in East Java Province of Indonesia, Department of Agricultural Economics, University of Kentucky.