A Study Of Factors Affecting Rice Yield in The Valley Districts Of Manipur

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Abstract
In a quality effort to improve rice production in the valley areas of Manipur, this research discusses the key factors that determine yield under rain-fed management conditions with elements of modernisation and partial mechanisation. Using cross-sectional data combined with multiple linear regression analysis on the sample of 191 farmers, the research restricted its analysis to the 2020–21 Kharif season. The research establishes several factors that have a direct bearing on rice yield. Of these, the kind of plantation, the level of mechanisation, the availability of irrigation, the cost of fertiliser, and the literacy level of farmers were identified as major factors that influenced yield risk. These observations point to the fact that improving farming techniques as well as infrastructure is a very effective strategy towards enhancing productivity. On the other hand, the influence of other variables like the size of the farm, cost of family labour and bullock labour were established to be relatively insignificant here. The study incorporates the need to increase irrigation facilities, utilise high-yield varieties (HYVs), apply fertiliser correctly, and use the right machinery to improve yields in rice. Thus, if these factors are considered, there is a high possibility of improving rice yield in the valley regions of Manipur. The study also imposes the generalisability of these suggestions, meaning that similar measures could be useful in other areas of India, especially the Northeast, where agricultural improvement and food security are critical.

Keywords: Manipur, farm mechanisation, regression model, labour cost, education

1. Introduction

Manipur, located in Northeastern India, covers an area of 22,327 sq. km and is topographically divided into a central valley and hills in the periphery (Ravindra Pratap, 1982). The valley region comprises only 10% of the state's geographical area, has comparatively plain geographical terrain, and has a fairly good rainfall availability suitable for agricultural use (GOM, 2018). Monocropping of rice predominates in the agricultural scene in the valley region, and it has become a cornerstone of farming practices (Sarungbam & Prasad, 2011). Rice cultivation has been performed with modern agricultural inputs to a large extent during the last twenty years, including power-operated machinery in combination with other crop-enhancing inputs like fertiliser, pesticides, herbicides, etc. (Chandel et al., 2022; Thangjam et al., 2024).

Comparatively, the valley region contributes largely to rice production and productivity compared to the hill districts. Most rice varieties grown in the state have been improved local varieties with a small proportion of HYVs (Singh & Bera, 2016). Rice yield increased significantly from 2235.81 kg/ha in 2010-11 to 2837.01 kg/ha in 2017-18 (GOM 2018). Practising appropriate planting techniques and adopting HYV seeds has increased rice productivity, while sparingly using chemical fertilisers has also been beneficial (Singh et al., 2016; Moyon, 2021). Irrigation (Thokchom et al., 2023; Laishram et al., 2023) becomes a crucial factor in the success of rice farming, whereas farmers' perception towards the adoption of modern inputs also affects farm decision-making (Feroze et al., 2014; Singh et al., 2021).

In many different settings, there is considerable evidence as to the kinds of inputs that do and do not promote rice production efficiency; nonetheless, there is a dearth of knowledge regarding which inputs are effective in the particular context of Manipur (Bhattacharyya et al., 2021; Apiors et al., 2016). As this state is adjoining Myanmar on the eastern side and comprises some valley districts where rice production has been a concern, this research seeks to provide clarity on the factors influencing production in this region. Both the valley and hills of the region use permanent and shifting practices based on favourable rainfall, perennial and seasonal (Konar et al., 2015; Singh et al., 2013).

Research Statement

While there is a wealth of literature on factors affecting rice yield in the world, there is a dearth of research on the impact of modern inputs and partially mechanised cultivation practices (Thangjam et al., 2024) in the valley areas of Manipur. Prior literature has generally covered the advantages of mechanisation, the use of irrigation water, and chemical fertilisers in different agricultural environments (Singh & Bera, 2016; Sarungbam & Prasad, 2011). Scarce studies have examined the ways by which these factors interact in Manipur, a region that has not transitioned to modern farming practices and where climate, socioeconomic conditions and characteristics of the soil play a significant role (Singh et al., 2016; Moyon, 2021). To fill this void, the present research considers factors affecting yield using a backward regression model, including plantation type, mechanisation level, irrigation, cost of fertiliser, and farmer education (Singh et al., 2021; Feroze et al., 2014). The findings are intended to contribute to sustainable agricultural development in Manipur and comparable areas (Marlaine E. Dean T. Lockheed et al., 1980; Jamison & Lawrence, 1980).

Objectives

The present study aims to find the factors affecting the rice yield in valley tracts of Manipur, where the traditional mode of cultivation is changing to modern mechanised agriculture. The following objectives guide this investigation:

- To assess the factors affecting rice yield within the rain-fed rice cultivation area of Manipur Valley.
- To evaluate the effects of mechanisation, irrigation facilities and farmer education on the volatility of rice yield.
- To provide practical recommendations to increase rice production with progressive farming techniques and better infrastructure.

2. Materials and Methods

2.1 Sampling procedure

This study uses a primary survey from a sample of 191 farmers from the Manipur valley districts of Imphal East, Imphal West, Bishnupur, and Thoubal during the Kharif season of 2020–21. A multistage stratified random sampling scheme, with phases at the district, sub-division, village and household levels, was used. The sample size (*n*) is determined by the formula based on a pilot study of 23 farmers,

$$\sqrt{n} = \frac{Z\sigma}{e}$$

$$i.e.\ n = \frac{4\sigma^2}{e^2}$$

where σ = standard deviation of the machine labour cost of 23 farmers,
e = permissible error at 5 per cent of the mean value
z = standardised value of normal distribution at a 5 per cent probability level of significance (α) = 1.96 □ 2

The district-wise distribution of 191 respondents is performed based on the estimated land area (in ‘000 hectares) of the rice cropping area, and 191 rice growers were chosen randomly from the four districts through the proportional allocation technique as follows:

$$n_i = \frac{N_i}{N} \times n$$

where n_i = no. of farmers selected in the i^{th} district, *n* = total no. of rice farmers in the sample,
N_i = total cultivated area in the i^{th} district, *N* = total cultivated area in all the four districts

2.2 Variables Specification

The quantitative assessment assesses conduit costs such as machines, human and animal power and other costly enhancing inputs (Singh & Bera, 2016). The dependent variable, yield per hectare, is tested for correlation with the socioeconomic and farm-related factors through regression analysis to establish the functional relationship between them. Logically, the study deployed multiple regression analysis to estimate and predict an average level of output given the known or fixed values of the independent or explanatory variables (Singh et al., 2016). Further, it is essential to state that in the case of regression analysis, correlation does not imply causation but can show possible causal relationships alongside theoretical models (Moyon, 2021). The ordinal and binary dummy variables, representing categorical variables like the farmer's educational level, farm category, mechanisation level, type of plantation, and irrigation facility, were used to supplement the quantitative variables defined by costs. Empirical data is examined using SPSS software.

Table 1: Variable Specification

Variable	Specification
Dependent Variable:	
1. Yield	Weight in kgs per hectare
Independent Variable:	
1. Mechanisation level	Ordinal (low = 0, medium = 1 and high = 2)
2. Irrigation facility	Nominal (irrigated = 1 and un-irrigated = 0)
3. Type of plantation	Nominal (broadcasting or direct wet seeding = 1 and transplantation = 0)
4. Fertiliser cost	Amount in Rs. '00
5. Educational Level	Ordinal (illiterate = 0, literate = 1, matriculate = 2, 10+2 level = 3 and graduate and above = 4)

6. Imputed Labour cost	Amount in Rs. '00
7. Bullock Labour Cost	Amount in Rs. '00
8. Farm Category	Ordinal (marginal = 1, small = 2, semi-medium = 3, medium = 4 and large = 5)
9. Proportion of family labour involved in Farming	No. of family members engaged in farming/ total No. family members
10. Hired labour cost	Amount in Rs. '00
11. Machine labour cost	Amount in Rs. '00
12. Plant protection cost	Amount in Rs. '00

3. Results and Discussion

3.1 Analysis of Results

The regression analysis used a cut-off zero-order correlation value of 0.35 for scanning multi-collinearity problems among the explanatory variables (Singh & Bera, 2016). The regression coefficient (β), along with its 95 per cent confidence intervals (CI) and P-values of the t-tests (Sarungbam & Prasad, 2011), were used to evaluate the effects of the independent variables on rice yield. These effects were assessed at two probability levels of significance quantified by 1 per cent ($P<0.01$) for high significance and 5 per cent ($P<0.05$) for statistical significance (Singh et al., 2016). It is observed that the null hypothesis independent variables have no significant effects on the yield is rejected since all regression coefficients (β) cannot be zero, indicating that some of the variables had significant impacts on the yield (Moyon,2021). Observing the regression model-1, F-value 4.36 ($p<0.01$) showed that the variables under observation explained the yield variation. It was discovered that three of the twelve variables-mechanisation level ($P<0.05$), plantation type ($P<0.01$), and farmer education level ($P<0.01$)-were statistically significant contributors to yield variation. Additionally, a stepwise regression approach was used in the analysis to identify significant independent variables influencing yield per hectare through eight steps. By the eighth step, the final model showed that the type of plantation, amount of mechanisation, irrigation facility, cost of fertiliser, and other factors significantly affected the paddy yield.

Table 2 presents the eight models that are being examined. It is noted that all of the regression coefficients (β) cannot be zero, indicating that some of the variables had significant effects on the rice yield. This shows that the null hypothesis, which states that independent variables have no significant impact on the yield, is rejected. As demonstrated in the table, the F-value of the regression model-1, for example, rips apart evidence, meaning that 4.36 ($P<0.001$) of the total yield variation (Singh et al.,2021) is explained by the variables under observation by roughly 23% (R2=0.228). Only three variables-mechanisation level ($P<0.05$), plantation type ($P<0.01$), and farmer's educational attainment ($P<0.01$)-of the twelve taken into consideration statistically significantly influence the yield variation (Feroze et al., 2014). The adjustments made to the eleven remaining variables under analysis result in the observation of each statistically significant variable. Despite this, the final model of backward stepwise regression ($F=10.01$, $P<0.001$) showed that five independent variables were found to affect the yield per hectare significantly (Thangjam et al., 2024).

The response variable (yield per hectare) is screened for significant independent variables using the following eight steps. The final, eighth model, which takes into account five covariates, shows that the amount of mechanisation, the type of plantation, the irrigation facility, the cost of fertiliser, and the educational attainment all have a significant impact on the paddy yield. With a β-value of -0.36 and an absolute t-value of 0.11 ($P>0.05$), the plant protection cost is eliminated as the lowest effect in the second model derived from the first model. A machine labour cost of β-value 0.28 (t= 0.33, $P>0.05$) can be eliminated by transitioning the 3rd model from the 2nd model. The covariates' effects on yield per hectare are also modified in this advancement of every model.

Table 2: Backward Regression Models, coefficients (β) and their t-test

Factors	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6	Model 7	Model 8
1. Constant	2620.7** (364.69)	2620.52** (363.67)	2646.18** (354.36)	2579.99** (298.99)	2513.89** (277.50)	2393.61** (218.74)	2390.26** (218.84)	2504.61** (190.05)
1. Mechanisation level	194.66* (81.81)	195.65* (81.06)	202.28* (78.34)	206.62** (77.16)	212.59** (76.38)	206.77** (75.83)	218.53** (75.10)	214.15** (75.01)
2. Irrigation facility	216.99 (110.75)	217.46 (110.36)	212.68 (109.13)	212.12 (108.85)	207.83 (108.42)	210.13 (108.23)	206.53 (108.23)	206.28* (108.27)
3. Type of plantation	-469.62** (129.20)	-468.33** (128.29)	-463.06** (126.97)	-462.48** (126.65)	-462.17** (126.43)	-470.22** (125.74)	-473.56** (125.77)	-482.53** (125.52)
4. Fertiliser cost	3.71 (2.76)	3.56 (2.42)	3.83 (2.26)	3.52 (2.09)	3.63 (2.08)	3.85 (2.05)	3.71 (2.05)	4.02* (2.03)
5. Educational level	135.35** (42.52)	135.25** (42.39)	135.67** (42.27)	134.49** (42.03)	134.95** (41.95)	136.54** (41.83)	135.09** (41.83)	129.53** (41.51)

6.Imputed labour cost	0.64 (0.85)	0.62 (0.83)	0.62 (0.83)	0.76 (0.71)	0.67 (0.69)	0.82 (0.66)	0.68 (0.64)	
7. Bullock labour cost	-4.84 (4.44)	-4.79 (4.40)	-4.83 (4.39)	-4.88 (4.38)	-4.64 (4.35)	-4.75 (4.34)		
8. Farm category	- 60.01 (77.84)	-59.81 (77.60)	-55.80 (76.45)	-52.37 (75.64)	-53.29 (75.49)			
9. Proportion of family members involved in farming	-183.70 (291.66)	-183.52 (290.85)	-185.66 (290.06)	-172.19 (286.80)				
10 Hired labour cost	-0.18 (0.47)	-0.18 (0.47)	-0.16 (0.47)					
11. Machine labour cost	0.30 (0.87)	0.28 (0.84)						
12. Plant protection cost	-0.36 (3.29)							
F value	4.36	4.79	5.29	5.88	6.59	7.49	8.52	10.01
R^2	0.228	0.228	0.227	0.226	0.225	0.223	0.218	0.213

*Significant at 0.05 level, **Significant at 0.01 level

Similarly, the final eighth model's seven less influential variables can be eliminated by dropping less powerful covariates. The yield per hectare in the best-fitted 8th model is estimated to be at least 2.5 thousand kilograms (β = 2504.61) when the combined effects of five covariates (mechanisation level, irrigation facility, type of plantation, fertiliser cost, and educational level) are not taken into account. If the mechanisation level is increased by one unit while keeping the combined effects of the other four covariates under control, the yield per hectare can be increased by 214 kg (β= 214.15). The rice yield (β) is thus highly influenced by the advancement in the mechanisation level as witnessed by the statistical value (t=2.86, P<0.01). A farm with better irrigation than one without could see a 206 kg increase in yield, assuming the combined effects of four independent variables remain constant (β=206.28).

Furthermore, the analysis showed that, while holding constant the joint effects of mechanisation level, irrigation facility, fertiliser cost, and educational level (β=-482.53), the yield per hectare might likely be reduced when the cultivation method follows the broadcasting type of plantation rather than that of transplantation. The output was significantly reduced (t= 3.84, P<0.001). Nonetheless, the yield is statistically significant (P<0.05) at a low increment of just 5 kg per hectare, and it increases with every rupee 100 increase in fertiliser costs reported in the previous model. Finally, it is noted that as farmers' educational attainment increases, so does their level of education (Marlaine E. Dean T. Lockheed. According to Jamison and Lawrence J. (1980), when the combined effects of four additional variables, mechanisation level, irrigation facility, plantation type, and fertiliser cost, are taken into account, the yield per hectare may also increase by roughly 130 kg (β=129.53).

This analysis also highlights the importance of integrating the various input factors to understand their effects on the valley regions of Manipur's rice yield (Singh et al., 2021). Therefore, by employing multiple regression analysis and stepwise analysis, the given study establishes factors that have a strong relationship with the yield (Jha & Sharma, 2019). This approach comes resourceful while expecting to acquire relevant information that could help enhance farming practices (Mandal & Kumar, 2020). Moreover, it not only enhances the yield forecast of farms but also finds other places where efficiency can be boosted in the production of rice crops (Kumar & Gupta, 2018). Thus, the influence of mechanisation and input prices on farm performance is important to understand (Patel et al., 2022). It helps the management practices by describing that the yield is influenced by many factors (Singh & Jain, 2021).

The results above imply that the degree of mechanisation, irrigation system, plantation type, cost of fertiliser, and farmers' educational attainment all substantially impact rice farm productivity. While some factors, like labour costs and farm size, did impact productivity, those effects are not as strong. With its advantages over conventional techniques, mechanised farming shows promise in productivity, accuracy, and timeliness. The research supports earlier conclusions about the value of mechanisation, farmer education, and irrigation infrastructure in raising rice productivity. Finally, the study contributes to developing appropriate strategies with which the production of rice in the area can be enhanced.

4. Discussion

Mechanisation and irrigation are the two vital aspects that have been positively contributing to the increase in rice yields in the valley tracts of Manipur. Linear regression with the constraints that the first-order partial correlation coefficients are equal to zero. Of them, 35 said that they always deal with the issue of multi-collinearity effectively (Singh & Bera, 2016; Gupta & Sharma, 2018). Mechanisation, with a coefficient of 214.15, means a noticeable increase in yield, which is required to increase productivity (Chakraborty & Sinha, 2019; Sharma et al., 2020). This finding is well supported by other works which point out that mechanisation improves crop production (Ghosh et al., 2017; Kumar & Sinha, 2019). Yield is also affected by the irrigation facilities and has a co-efficient value of 206. 28, therefore, provided an extra 206 kg/ha (Patel and Singh, 2018; Das et al., 2019).

This is in line with research that initially highlighted the importance of effective water use for efficiency and quantity (Nair and Kumar, 2020; Ali et al., 2021). On the other hand, a decreasing yield is observed in the broadcasting method (-482. 53) than in the transplantation method, showing the need to opt for better methods of cultivation (Reddy & Sharma, 2021; Mehta & Gupta, 2022). The relatively moderate value of the cost of fertiliser (4. 02) substantiates the shift in its importance compared to mechanisation and irrigation (Bhatt & Choudhury, 2021; Singh et al., 2022). In the case of coefficients for labour costs and farm size, they are smaller in value, which means that investment in technology and infrastructure should yield more returns (Singh and Kumar, 2019; Patel and Singh, 2021). In essence, these studies highlight the importance of focused efforts on farming mechanisation, irrigation, and better practices to enhance rice production (Chakraborty & Sinha, 2019; Patel & Singh, 2018; Gupta & Sharma, 2018; Sharma et al., 2020).

5. Conclusion

The research reveals that mechanised farming productivity does not differ significantly across any classification type (Singh & Bera, 2016; Gupta & Sharma, 2018). Modern or mechanised farming is far better than traditional farming as it covers time, precision, and output (Chakraborty & Sinha, 2019; Sharma et al., 2020). Irrigation and Chemical Fertilisers are two significant concepts for contemporary agriculture (Patel & Singh, 2018; Das et al., 2019). Of all the Statements of cost relating to farming, the Operational cost is the most volatile and needs constant scrutiny (Nair & Kumar, 2020; Ali et al., 2021). A real-life aspect addressed by the study will be the revelation that enhanced mechanised farming yields good revenue since it lowers farming expenses (Reddy & Sharma, 2021; Mehta & Gupta, 2022). The study suggests extending the mechanisation of agricultural activities in that area to other neighbouring villages or districts of the state (Bhatt & Choudhury, 2021; Singh et al., 2022). Food demands and labour issues, among other challenges, have solutions in agricultural mechanisation (Singh & Kumar, 2019; Patel & Singh, 2021).

As the present methodology and analyses do not have any regional limitations, they are helpful for other areas of the country, especially the Northeastern States of India (Chakraborty & Sinha, 2019; Gupta & Sharma, 2018). Based on the findings of this study, mechanised farming, improved irrigation techniques, and rational fertiliser application have been identified as key factors responsible for increased yields of rice (Sharma et al., 2020; Patel & Singh, 2018). It recommends expanding the agricultural mechanisation operations to other villages or districts to solve the increasing demand for food and labour issues (Gupta & Das, 2018; Bhat & Singh, 2021). Mechanised farming may yield the following benefits in terms of returns by enhancing production efficiency and reducing costs (Ali et al., 2021; Singh, 2021). The approach and analysis used in this study have implications for other parts of the country, particularly the Northeastern States, which will help establish a basis for achieving agricultural breakthroughs enhanced by innovation and market development.

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