



## Profitability of Mechanised Rice Farming in the Valley Districts of Manipur

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### ABSTRACT

This paper analyses the efficiency of mechanisation on the cost of cultivation and profitability of rice farming in the valley districts of Manipur, based on a field survey from 191 farm households. It calculates farming costs and evaluates profitability using net income and the benefit-cost ratio (BCR), across three mechanisation levels: low, medium, and high. Findings indicate that higher mechanisation is positively associated with net income, whereas medium mechanisation is economically inefficient due to higher costs and suboptimal resource use. Low-mechanised farms incur high labour costs, leading to low profitability. The study recommends policies to enhance the profitability of rice cultivation by promoting appropriate mechanisation through custom hiring networks.

### INTRODUCTION

Agriculture is crucial to Manipur's rural economy, with rice cultivation as its primary focus, ensuring food security and employment (Kanta and Roma, 2016; Thangjam and Jha, 2020). Despite improvements in rice productivity over the past decade, challenges such as rising farm wages and persistent delays in the timely availability of fertiliser (Somarendro 2019) underscore the need for progressive agricultural mechanisation to enhance efficiency and profitability. The valley districts play a more significant role in rice production compared to the hill districts (Motilal et al. 2023). While total rice production is increasing, the area under cultivation is decreasing, indicating higher productivity per unit area (Chanu and Devi 2024). Mechanisation, including the use of tractors, power tillers and harvesters, significantly



enhances agricultural tasks, saving time and labour while improving yields through the use of high-yielding varieties, mechanised tillage, and improved irrigation facilities.

Agricultural mechanisation significantly impacts farm efficiency, input trends, and profitability. A shortage of agricultural labour and the need to enhance farm productivity are among the main drivers of increased farm mechanisation in India (Vijayakumar S et al., 2021). The adoption of modern machinery enhances operational timeliness and efficiency, potentially increasing yields and the value of production. However, transitioning from traditional to capital-intensive farming alters cost structures, necessitating economic assessments. In Manipur, the adoption of mechanisation is uneven across districts and farm sizes, highlighting the need to evaluate the economic viability of mechanised rice farming to inform future agricultural development initiatives.

National studies highlighted the positive impacts of mechanisation on productivity, but there is a lack of specific empirical data for Manipur. Most existing research focuses on the adoption and availability of machinery, with few assessing overall cost-effectiveness at different mechanisation levels. Studies often overlook important cost categories, such as the imputed rental value of land and family labour, leading to inadequate evaluations of economic viability. Given the challenges in Manipur's agriculture, including fragmented landholdings and limited access to machinery, this research aims to analyse the profitability of rice farming across the mechanisation levels using a full-cost accounting approach. The study will examine cost structures, yield variations, and benefit-cost ratios, aiming to provide insights to guide policymakers and stakeholders in enhancing farm income and productivity while promoting sustainable mechanisation strategies in Manipur's rice sector.

## **MATERIALS AND METHODS:**

### **Study Area and Sampling Procedure**

The present study is based on field survey data collected during the 2020-21 period from the four valley districts of Manipur: Imphal East, Imphal West, Bishnupur, and Thoubal. A four-stage stratified random sampling selects the sample households at the district, sub-division, village and household levels. The sample size ( $n$ ) is determined by the formula based on a pilot study of 23 farmers,

$$\sqrt{n} = \frac{z\sigma}{e}; \quad n = \frac{4\sigma^2}{e^2}$$

i.e. where  $\sigma$  = 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 the normal distribution at a 5 per cent probability level of

significance ( $\alpha$ ) = 1.96  $\approx$  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 four districts

It involves calculating both the imputed and the actual expenses on hiring power-operated farm implements, human and animal labour, and crop-enhancing inputs, such as seeds, fertilisers, and pesticides, to estimate the profitability of annual paddy output per hectare using randomly selected 191 farming households.

### **Data Collection and Analysis**

Primary data were collected for the 2020-21 cropping season using a pre-tested schedule, primarily to capture the variable cultivation costs per hectare for both own and hired inputs, including labour, seed, fertiliser, and machinery hire charges. It involves estimating both the imputed and the actual expenses for hiring power-operated farm implements, human and animal labour, and crop-enhancing inputs (such as seeds, fertilisers, and pesticides), to assess the profitability of annual paddy output per hectare using randomly selected 191 farming households. Fixed costs, such as interest on fixed capital, land revenue, and land rental value, are estimated. Net returns and the Benefit-Cost Ratio (BCR) were calculated based on yield and various cost items at the prevailing local market prices at the time of the survey.

To estimate the cost of production, the costs at various stages of farm operations are added. The cost of cultivation and profitability of rice production were estimated using the cost concepts recommended by the Commission for Agricultural Costs and Prices (CACP), Government of India, with suitable modifications to accommodate local farming conditions and data availability. The cost concepts were categorised into Cost A1, A2, B1, B2, C1, and C2 as follows.



Total working capital = Hired human labour + Machine labour + Bullock labour + Fertiliser cost + Plant protection expenditure + Irrigation charges + seed cost + Land revenue

Interest on working capital = @ 6% of total working capital

Cost A1=Total working capital + interest on working capital

Cost A2 =A1 + rent paid for leased land

Rental value of land =  $\frac{1}{6}$  × value of produce-revenue

Interest on Fixed Capital =12% of the rental value of land

Cost B1=Cost A1 + interest on fixed capital

Cost B2=Cost B1 + rental value of land + rent paid for lease-in land

Cost C1=Cost B1 + family Labour

Cost C2=Cost B2 + family Labour

Value of produce = Market value of rice per kg.

Net income = Value of produce-Cost

Benefit-Cost Ratio (BCR) =  $\frac{\text{Value of produce (VoP)}}{\text{cost}}$

The hiring and imputed cost of mechanised inputs, bullocks, and human labour are calculated based on what households pay per hectare or hour in their locality. The total expenses include the cost of hired human labour, machinery, animal and material inputs, such as fertiliser, pesticides, and rent paid for leased land. The paper considers the importance of family labour, land rent, and interest on fixed capital.

### **Operational Definition of Mechanisation Levels**

Farming households were pre-classified into three groups based on their level of mechanisation: low, medium, and high. Under low mechanisation, only a tractor or power tiller is used, limited to primary tillage and transportation of paddy from the cultivating fields. Transplanting, weeding, and harvesting are performed manually. Medium mechanisation involves the use of machinery for tillage, and at least two other primary operations utilise power-operated machinery. In comparison, high mechanisation involves



the integrated use of machinery for most operations, such as seed-bed preparation, reaping, threshing, and transportation, excluding transplantation, which is fully manual across all three levels.

**Table 1-Extent of mechanisation in paddy cultivation**

Mechanisation level	No. of Mechanised operations	Number of households
High	4	85 (44.5)
Medium	3	72 (37.7)
Low	2	34 (17.8)

Source: Field Survey (Figures in parentheses are the percentages)

Farmers in the study area have engaged in varying levels of mechanisation in paddy cultivation, influenced by the availability of machinery and equipment. As indicated in Table 1, farmers are classified into three groups based on the extent of machinery adoption in farming: High, Medium, and Low. The High category covers 44.5% of the total cultivating households, representing operations where machinery is accessible and where innovative farmers have maximised its use. The medium category includes machinery for land preparation, harvesting, and transporting crops, accounting for 37.7% of the total. The Low category has mechanised only two operations, land preparation and threshing, accounting for 17.8 % of the total sample.

## RESULTS AND DISCUSSION

### Working Capital and Cost Structure

The cost structure illustrated in Table 2 indicates per-hectare farming expenses across the low, medium, and high levels of mechanisation. As mechanisation progresses from low to high, a distinct substitution effect is evident, in which costs associated with hired human and bullock labour decrease, while machine labour costs rise correspondingly (Chinnapa et al. 2018). It is observed that hired labour costs peak at Rs. 28427.64 per hectare in medium mechanisation, but decline at higher mechanisation levels to Rs. 25810.70 per hectare, implying that increased automation lessens the dependence on hired labour. Conversely, machine labour costs rise with mechanisation, increasing from Rs. 19126.73 to Rs. 23570.87 per hectare, which reflects a greater capital investment in machinery.

**Table 2: Farming cost under three mechanisation levels (in Rs. per hectare)**

Sl. no.	Items	Mechanisation level			Overall
		Low	Medium	High	
1.	Hired labour cost	27711.89	28427.64	25810.70	27003.00
2.	Bullock Labour Cost	839.43	504.69	261.74	436.90
3.	Machine Labour Cost	19126.73	23012.33	23570.87	22667.41
4.	Seed Cost	1101.05	1100.98	1100.78	1100.89
5.	Fertiliser expenditure	5335.09	4873.89	4821.74	4921.91
6.	Plant Protection Charges	4209.99	3381.08	3118.09	3382.68
7.	Irrigation charges	546.98	509.70	710.43	616.14
8.	Land Revenue	400.00	400.00	400.00	400.00
Total Working Capital		59271.16	62210.31	59794.35	60425.27

Source: Field Survey

Additional expenses for crop-enhancing inputs, such as fertilisers and plant protection, tend to decrease with greater mechanisation. For instance, plant protection costs reduced from Rs. 4209.99 to Rs. 3118.09 per hectare, likely attributable to the implementation of precision farming (Jat et al., 2019). It is observed that seed and irrigation expenses remain stable, with the seed cost at around Rs. 1100 per hectare; however, irrigation expenses spike to Rs. 710.43 under high mechanisation, possibly due to the use of irrigation pump-sets, which increase with the extent of mechanisation.

### Estimated Cost Comparison

Table 3 provides a detailed breakdown of estimated or derived cost items for farming operations across three mechanisation levels: low, medium, and high. The table shows that medium mechanisation has the highest working capital requirement of Rs. 3732.62 per hectare, likely due to higher operational expenses associated with farming. This pattern is consistent with findings from Northeast India, where studies have noted that partial mechanisation often increases short-term credit requirements due to higher operating expenditures without fully realising efficiency gains. Contrastingly, high-mechanised category farms show a slight reduction at Rs. 3587.66 per hectare, possibly due to efficiency gains. For leased land, low mechanised farms incur the highest Rent of Rs. 12065.52 per hectare, while the high category has the

lowest Rent of Rs. 8870.47 per hectare, because highly mechanised farms may own more land or depend less on leased land. Similar reductions in cost have been reported in Manipur, where the adoption of power tillers and paddy transplanters has been shown to lower operational interest burdens by improving timeliness and reducing labour-related delays (Devi & Singh, 2017; Singh et al., 2021).

It reveals that interest on working capital is highest for medium mechanisation at Rs. 3732.62 per hectare, which aligns with the higher working capital needs noted across semi-mechanised paddy systems in Northeast India. The rental value of land increases with mechanisation from Rs. 12837.18 to Rs. 13769.46 per hectare, suggesting higher land productivity. This trend is also documented in studies from Manipur and neighbouring states, where mechanisation has been associated with improved land preparation, timely transplanting, and reduced crop losses, leading to higher land valuations and increased rental demand (Singh & Devi, 2019; Gogoi et al., 2020).

**Table 3- Estimated cost items under three levels of mechanisation (in Rs. per hectare)**

Sl.no.	Cost items	Mechanisation levels			
		Low	Medium	High	Overall
1	Interest on Working Capital	3556.27	3732.62	3587.66	3631.74
2	Rent for the lease of land	12065.52	9743.05	8870.47	8870.47
3	Cost A1	62827.43	65942.92	63382.01	64160.68
4	Cost A2	74892.95	75685.98	72252.48	73031.15
5	Rental value of land	12837.18	13068.60	13769.46	13382.15
6	Interest on Fixed Capital	1540.46	1568.23	1652.34	1605.86
7	Cost B1	64367.89	67511.16	65034.34	65766.53
8	Cost B2	89270.59	90322.81	87674.27	88019.15
9	Family labour cost	15544.27	14746.37	11814.35	13407.31
10	Cost C1	79912.16	82257.53	76848.69	79173.84
11	Cost C2	104814.86	105069.19	99488.62	101426.46

Source: Field Survey

Among all-paid-out costs, medium mechanisation has the highest Cost A1 of Rs. 65942.92 per hectare, indicating higher input expenses for fuel, labour, maintenance, etc. Meanwhile, mechanisation slightly reduces to Rs. 63382.01 per hectare, likely due to increased automation replacing manual labour. Low mechanised farms have the highest per-hectare cost at Rs. 74892.95, driven by the higher charges for



rented land. Following the same trend, the high category has the lowest per-hectare costs at Rs. 72252.48 and a land rental value of Rs. 13769.46, reinforcing the efficiency benefits. After accounting for opportunity costs, high mechanisation has the highest per-hectare imputed land value and interest on fixed capital, at Rs. 13769.46 and Rs. 1652.34, respectively. This reveals that these farms operate on more valuable land and invest more in power-operated machinery.

Additionally, when the imputed family labour cost is added, the medium class remains expensive, at Rs. 82257.53 per hectare, but the high class achieves greater savings at Rs. 76848.69 per hectare. The cost of family labour also diminishes with greater mechanisation, falling from Rs. 15544.27 to Rs. 11814.35 per hectare, signifying a decrease in manual labour. Lastly, high mechanisation has the lowest Cost C2 of Rs. 99488.62 per hectare, the most cost-efficient category in the long run.

### Farm Income Analysis:

Farm income is analysed under different farming cost conditions by subtracting various cost items from the value of produce. Table 4 reveals that per-hectare farm productivity grows as the mechanisation level increases, following Rs. 79423.08 at low, Rs. 80811.62 for medium and Rs. 85016.75 for high level, while the overall average is Rs. 82692.87. All mechanisation levels yield positive income per hectare under Costs A1, A2, and B1, with highly mechanised farms having a greater advantage over low- and medium-category mechanised farms. For instance, the high mechanised category farms get profit at Rs. 21634.74, Rs. 12764.27 and Rs. 19982.41 per ha. under Cost A1, A2 and B1, showing profitability before accounting for full capital costs continuing up to Cost B1, under which all three farm categories get a positive return on farming income.

**Table 4- Farming Income according to mechanisation level (in Rs per hectare)**

Sl. No.	Farm Income	Mechanisation level			
		Low	Medium	High	Overall
1.	Value of Produce	79423.08	80811.62	85016.75	82692.87
2.	Net income 1	16595.65	14868.70	21634.74	18532.19
3.	Net income 2	4530.13	5125.64	12764.27	9661.72
4.	Net income 3	15055.19	13300.46	19982.41	16926.34
5.	Net income 4	-9847.51	-9511.19	-2657.52	-5326.28
6.	Net income 5	-489.08	-1445.91	8168.06	3519.03



7.	Net income 6	-25391.79	-24257.57	-14471.87	-18733.59
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Source: Field Survey

In contrast, all farms under three mechanisation levels incur losses at the Cost C2 level, with Rs. 25391.79 per ha for low-mechanised farms, including family labour and land rents, thereby eroding profits. However, it is observed that high mechanisation consistently outperforms with Rs. 21634.74 per ha under cost A1 and at Rs. 16595.65 for low-category farms, demonstrating efficiency gains (Srivastava 2006). It can be inferred that mechanised farms struggle with higher labour costs, resulting in lower net income. The finding suggests that high mechanisation reduces labour dependency, optimises input use, and boosts gross income to Rs. 85016.75 per ha, compared to Rs. 79423.08 for low-mechanised farms. Profits vanish under comprehensive cost definitions (C2), emphasising the need for scale or price support.

### Benefit-cost ratios (BCRs)

Benefit-Cost Ratios (BCRs) provide a standard metric for assessing economic efficiency; a ratio greater than one indicates that total revenue exceeds total cost, thereby signalling economic viability under that cost definition. The BCR<sub>1</sub>, BCR<sub>2</sub>, and BCR<sub>3</sub>, based on paid-out expenses, corresponding to Cost A1, A2, and B1, respectively, are all significantly greater than 1 across all mechanisation levels. Table 5 shows that BCR1 ranges from 1.23 (medium) to 1.34 (high), indicating strong operational efficiency and liquidity when only immediate cash expenditures and certain fixed costs are considered. The critical thresholds for the six BCR categories are BCR 4-6, which cover land and family labour costs. Since Cost B2 includes the imputed rental value of owned land, BCR<sub>4</sub> acts as a critical test of whether the operation generates returns adequate to justify the land market value.

**Table 5: Benefit-Cost Ratios (BCR) according to mechanisation level**

Sl. No.	BCR Items	Mechanisation level			Overall
		Low	Medium	High	
1	BCR 1	1.26	1.23	1.34	1.29
2	BCR 2	1.06	1.07	1.18	1.13
3	BCR 3	1.23	1.20	1.31	1.26
4	BCR 4	0.89	0.89	0.97	0.94
5	BCR 5	0.99	0.98	1.11	1.04
6	BCR 6	0.76	0.77	0.85	0.82



Source: Field Survey

All BCR values, except the first three, are below 1.0: low (0.89), medium (0.89), and high (0.97). The proximity of the high mechanisation ratio (0.97) to the 1.0 threshold indicates that, while highly mechanised farms are closest to covering all costs excluding family labour, they still fail to generate returns that match the opportunity cost of their owned land. All C2 values below 1 are 0.85, indicating that full cost recovery is challenging without subsidies or higher yields. Overall, higher mechanisation improves BCRs, but profitability declines when all implicit costs, such as family labour, are included. The cost of rice cultivation could be further reduced by mechanising the various activities involved (Kanta and Roma, 2016).

### **Conclusion and Implications**

The level of mechanisation has a profound impact on the profitability of rice farming in the study area. High mechanisation results in superior economic performance, as demonstrated by the highest produce value at Rs 85016.75 per hectare and the lowest comprehensive total cost of production (Cost C2) at Rs 99488.62 per hectare. Furthermore, high mechanisation is the only regime capable of covering all paid costs, fixed capital costs, and the imputed value of family labour, achieving a BCR of 1.11.

Despite strong liquidity with high BCRs 1, 2, and 3, all mechanisation levels fail to achieve actual economic viability when the opportunity costs of owned resources are accounted for in the total cost under BCR 6, which is less than or equal to 0.85. The operation is sustained by the farmer accepting returns significantly below the market value of their land and capital. The primary barrier to achieving full economic viability under BCR 6 (greater than 1) is the imputed rental value of owned land, as demonstrated by the failure of all levels to meet the Cost B2 benchmark of BCR 4, which is less than or equal to 0.97. The finding confirms that returns on agriculture are generally inadequate to justify the opportunity cost of holding valuable land assets for production. The low variability across mechanisation levels further reinforces the reliability of these findings.

The study highlights the rising costs of rice farming and indicates that enhanced mechanisation is key to reducing costs and improving income. It recommends that the Manipur government reallocate subsidies from high-cost ownership to medium-scale precision equipment, such as transplanter and threshers. Additionally, it emphasises the importance of promoting custom hiring through financial support to establish Custom Hiring Centres. It suggests providing training and demonstrations to prove the benefits of medium-level mechanisation and proper machinery maintenance.



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