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## Economic impact of technology adoption: An analysis in winter paddy cultivation in Jorhat district of Assam, India

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### Abstract

The present study examines the economic impact of technology adoption in winter paddy cultivation in Jorhat district of Assam, India, with particular emphasis on improved crop establishment methods. The study compares three rice establishment systems: traditional manual transplanting (farmer practice), wet direct seeding using a drum seeder (WDSR), and mechanical line transplanting using a rice transplanter (MPTR). The analysis was based on comparative data on cost of cultivation, productivity, gross return, net return, and benefit-cost ratio. The common cost of cultivation was estimated at ₹45,682 per hectare, while establishment-specific costs were ₹11,690/ha for traditional manual transplanting, ₹2,180/ha for WDSR, and ₹8,940/ha for MPTR. The total gross cost of cultivation was ₹57,372/ha under traditional practice, compared with ₹47,862/ha under WDSR and ₹54,622/ha under MPTR. WDSR reduced the cost of cultivation by 16.58%, while MPTR reduced it by 4.79% compared with traditional transplanting. Productivity increased from 4.24 t/ha under traditional practice to 4.76 t/ha under WDSR and 5.01 t/ha under MPTR. At a paddy price of ₹2,300 per quintal, WDSR generated the highest net return of ₹61,618/ha, followed by MPTR at ₹60,608/ha and traditional practice at ₹40,148/ha. The B:C ratios were 1.69, 2.29, and 2.11, respectively. WDSR consequently provided the highest economic efficiency, while MPTR achieved the highest productivity. The findings indicate that adoption of improved rice establishment technologies can substantially enhance farm profitability, reduce production costs and dependence on manual labour, and improve the economic sustainability of winter paddy cultivation in Assam. Strengthening access to farm machinery, custom-hiring services, quality seed, and technical support could facilitate wider adoption of these technologies among rice farmers in the region.

**Keywords:** Winter paddy, technology adoption, WDSR, mechanical transplanting, cost of cultivation, net return, B:C ratio

### Introduction

The agricultural economy of Assam, a State in India's northeast, is overwhelmingly dominated by a single crop of rice. This crop with numerous varieties had till recently characterized the State's agricultural landscapes, especially during the *kharif* season. Importantly, the culture of Assam was so deeply rooted in rice farming and its allied activities that it was popularly known as a land of rice culture. Rice is a common source of subsistence, nourishment, and sustainability for the people of Assam. The ecological conditions of the State, traditions, and aspirations of the people get largely reflected in the cultivation of rice and its traditional management. Like some other parts of the country, in Assam also, rice farming has undergone a notable change in its practice, production, and position in the State's economy. The growing adoption of high-yielding rice varieties and associated modern inputs and implements by the farming community has transformed the State's ecology and economy to the extent that it demands a thorough investigation of its various facets and issues including the competition it has to face with the newly introduced crops. However, the profitability of winter paddy cultivation is increasingly influenced by rising labour costs, labour scarcity during peak agricultural operations, and the need to improve productivity while controlling production costs. In this context, technological interventions in crop establishment have considerable potential to improve the economic efficiency of rice production. A large number of rice growers are

adopting the traditional system of cultivation growing traditional varieties, broadcasting method without line transplanting, using very low amount of fertilizers. On the other hand, as a result of the impact of APART project and other demonstrations of Krishi Vigyan Kendra number of farmers are adopting the technology of wet direct seeding using drum seeder and line transplanting using mechanical transplanter. Therefore, the present study was undertaken to analyse the comparative economics and impact of technology adoption on winter paddy cultivation in Assam.

### Methodology

The study was conducted at Jorhat district of Assam during the financial year 2023-24. A total of 200 number of farmers were selected randomly for data collection out of which 100 farmers were selected for data collection on traditional manual transplanting method, 50 farmers were selected for data collection on wet direct seeding using drum seeder method and 50 farmers were selected for mechanical transplanting method using mechanical transplanter. On the other hand, total variable cost is considered as the gross cost of cultivation in the present study.

### Findings and Discussion

The present analysis evaluates the economic impact of adopting improved rice establishment technologies in winter paddy cultivation in Jorhat district of Assam, India. Three establishment methods were compared: traditional manual transplanting (farmer practice, FP), wet direct-seeding using a drum seeder (WDSR), and mechanical line transplanting using a rice transplanter (MPTR). The comparison is based on cost of cultivation, productivity, gross return, net return, and benefit-cost (B:C) ratio. The price of paddy was considered at ₹2,300 per quintal, corresponding to the Minimum Support Price (MSP) used for the 2024–25 production season.

### Cost Structure and Economic Implications of Technology Adoption

The common cost of cultivation for winter rice, excluding establishment-specific operations, was estimated at ₹45,682 per hectare. This common expenditure included land preparation,

puddling, bund making, leveling, fertilizer and pesticide application, harvesting, post-harvest operations, and fertilizer and manure costs. Among the common cost components, FYM constituted a major expenditure at ₹10,000/ha, followed by harvesting at ₹6,250/ha and post-harvest operations at ₹5,000/ha. Puddling using a rented power tiller involved an expenditure of ₹4,500/ha, while expenditure on MOP, urea and SSP amounted to ₹2,376, ₹1,056 and ₹1,500 per hectare, respectively.

The establishment-specific expenditure differed substantially among the three systems. WDSR required only ₹2,180/ha, compared with ₹8,940/ha under MPTR and ₹11,690/ha under traditional manual transplanting. Therefore, the establishment stage itself provides an important source of economic differentiation among the technologies.

Under WDSR, the major additional expenditure consisted of seed (₹1,080/ha), seed carrying and sowing labour (₹1,000/ha), and drum seeder hiring (₹100/ha). The relatively low establishment cost reflects the replacement of conventional nursery raising and manual transplanting with direct sowing.

Mechanical transplanting required a higher establishment expenditure because of nursery and machinery-related operations. The total additional cost was ₹8,940/ha, including seed, nursery preparation, seedling handling, polythene sheet, labour for supplying seedling trays, and a transplanter hiring charge of ₹3,750/ha. Although this system substantially mechanizes transplanting, the machinery and mat-nursery requirements increase the initial cost of establishment.

Traditional manual transplanting recorded the highest establishment-specific expenditure of ₹11,690/ha. The largest component was manual transplanting itself, costing ₹6,250/ha, followed by seedling uprooting and carrying at ₹1,750/ha and nursery preparation at ₹1,250/ha. The high labour requirement makes this system particularly sensitive to increases in wage rates and shortages of agricultural labour.

### Comparative Cost of Cultivation

The total cost of cultivation was ₹57,372/ha under traditional manual transplanting, ₹47,862/ha under WDSR, and ₹54,622/ha under MPTR (Table 5).

| Technology                       | Gross cost (₹/ha) | Cost saving over traditional system (₹/ha) | Cost reduction (%) |
|----------------------------------|-------------------|--------------------------------------------|--------------------|
| Traditional manual transplanting | 57,372            | —                                          | —                  |
| WDSR – drum seeder               | 47,862            | 9,510                                      | 16.58              |
| MPTR – mechanical transplanting  | 54,622            | 2,750                                      | 4.79               |

The adoption of WDSR resulted in the largest reduction in cultivation expenditure. Compared with traditional manual transplanting, WDSR reduced the gross cost by ₹9,510/ha, or 16.58%. The corresponding reduction under MPTR was ₹2,750/ha, or 4.79%.

The cost advantage of WDSR is particularly important from the perspective of small and medium farmers because lower production expenditure reduces the amount of working capital required for crop establishment. It also reduces farmers'

exposure to fluctuations in agricultural wage rates during the peak transplanting period.

### Impact on Paddy Productivity

Technology adoption was associated not only with lower production costs but also with increased paddy productivity. Traditional manual transplanting recorded a productivity of 4.24 t/ha, whereas WDSR and MPTR produced 4.76 and 5.01 t/ha, respectively (Table 5).

| Technology                       | Productivity (t/ha) | Increase over traditional system (t/ha) | Increase (%) |
|----------------------------------|---------------------|-----------------------------------------|--------------|
| Traditional manual transplanting | 4.24                | —                                       | —            |
| WDSR – drum seeder               | 4.76                | 0.52                                    | 12.26        |
| MPTR – mechanical transplanting  | 5.01                | 0.77                                    | 18.16        |

WDSR increased productivity by 0.52 t/ha (12.26%) over traditional transplanting, while MPTR increased productivity by 0.77 t/ha (18.16%). Thus, mechanical transplanting achieved the highest yield advantage, although WDSR also demonstrated a

substantial productivity improvement.

The higher productivity under the improved establishment methods suggests that technological interventions can contribute to more efficient crop establishment and better crop stand.

Mechanical line transplanting, in particular, provides more uniform plant spacing and planting depth, which can support improved crop establishment and crop management. Direct seeding through WDSR eliminates transplanting shock and allows rice to be established without the conventional uprooting and replanting process.

| Technology                       | Gross return (₹/ha) | Increase over traditional (₹/ha) | Increase (%) |
|----------------------------------|---------------------|----------------------------------|--------------|
| Traditional manual transplanting | 97,520              | —                                | —            |
| WDSR – drum seeder               | 1,09,480            | 11,960                           | 12.26        |
| MPTR – mechanical transplanting  | 1,15,230            | 17,710                           | 18.16        |

WDSR generated an additional gross return of ₹11,960/ha over traditional practice, whereas MPTR generated an additional ₹17,710/ha. The higher gross return under MPTR was primarily attributable to its higher productivity.

Therefore, mechanical transplanting demonstrated the strongest impact on gross revenue, while WDSR provided a more pronounced advantage through the combined effects of

### Impact on Gross Returns

The economic advantage of increased productivity becomes more apparent when translated into gross returns. At a paddy price of ₹2,300 per quintal, the gross returns were estimated at ₹97,520/ha under traditional transplanting, ₹1,09,480/ha under WDSR, and ₹1,15,230/ha under MPTR.

increased productivity and reduced cultivation cost.

### Impact on Net Returns

Net return provides a more comprehensive measure of the economic impact of technology adoption because it accounts for both production costs and gross revenue.

| Technology                       | Gross cost (₹/ha) | Gross return (₹/ha) | Net return (₹/ha) | Increase in net return over traditional (₹/ha) |
|----------------------------------|-------------------|---------------------|-------------------|------------------------------------------------|
| Traditional manual transplanting | 57,372            | 97,520              | 40,148            | —                                              |
| WDSR – drum seeder               | 47,862            | 1,09,480            | 61,618            | 21,470                                         |
| MPTR – mechanical transplanting  | 54,622            | 1,15,230            | 60,608            | 20,460                                         |

WDSR recorded the highest net return of ₹61,618/ha, followed closely by MPTR at ₹60,608/ha. Traditional manual transplanting generated a considerably lower net return of ₹40,148/ha.

Adoption of WDSR increased net return by ₹21,470/ha, equivalent to approximately 53.48% over traditional practice. MPTR increased net return by ₹20,460/ha, or approximately 50.96%.

This finding is particularly significant. Although MPTR produced a higher yield and gross return than WDSR, its higher establishment expenditure reduced the net-return advantage. WDSR, by contrast, combined a moderate productivity increase with a substantial reduction in production costs, resulting in the highest net return.

### Benefit-Cost Ratio and Investment Efficiency

The B:C ratio provides an indication of the relative economic efficiency of investment in the different establishment methods. The reported B:C ratios were 1.69 for traditional manual transplanting, 2.29 for WDSR, and 2.11 for MPTR.

| Technology                       | B:C ratio | Improvement over traditional (%) |
|----------------------------------|-----------|----------------------------------|
| Traditional manual transplanting | 1.69      | —                                |
| WDSR – drum seeder               | 2.29      | 35.50                            |
| MPTR – mechanical transplanting  | 2.11      | 24.85                            |

WDSR recorded the highest B:C ratio of **2.29**, indicating the highest economic efficiency among the three systems. MPTR also performed substantially better than traditional practice, with a B:C ratio of 2.11.

The improvement in the B:C ratio demonstrates that technological adoption can increase returns relative to production expenditure. WDSR was particularly advantageous because its low establishment cost allows farmers to obtain higher economic returns with comparatively lower investment.

### Impact on Labour Requirement and Farm Operations

One of the most important economic impacts of rice establishment technology is its effect on labour demand.

Traditional manual transplanting is highly labour-intensive. The establishment process includes nursery bed preparation, seedling uprooting, transportation of seedlings to the main field, and manual transplanting. In the present cost structure, manual transplanting alone required 25 man-days/ha, costing ₹6,250/ha. The adoption of WDSR replaces these labour-intensive transplanting activities with direct sowing. The technology requires only four man-days/ha for seed carrying and sowing, in addition to a nominal drum-seeder hiring charge. Consequently, WDSR has considerable potential to reduce peak-season labour requirements.

Mechanical transplanting also reduces the dependence on manual transplanting labour. However, it requires mat-nursery preparation, seedling handling, tray management, and access to a rice transplanter. Thus, the technology shifts the nature of labour demand from manual transplanting towards machine operation and nursery management.

For farmers Assam, where timely completion of rice establishment is important, these technologies can help address labour shortages and facilitate more timely crop establishment. Reduced dependence on manual labour may also become increasingly important as rural wage rates rise and agricultural labour availability becomes more uncertain.

### Comparative Economic Impact of Technology Adoption

The overall economic impact can be represented through the changes in cost, productivity and profitability relative to traditional manual transplanting.

| Indicator                | WDSR   | MPTR   |
|--------------------------|--------|--------|
| Reduction in gross cost  | 16.58% | 4.79%  |
| Increase in productivity | 12.26% | 18.16% |
| Increase in gross return | 12.26% | 18.16% |
| Increase in net return   | 53.48% | 50.96% |
| B:C ratio                | 2.29   | 2.11   |

The results indicate two distinct dimensions of technological impact. WDSR demonstrates greater economic efficiency through cost minimization, while MPTR demonstrates greater productivity enhancement.

WDSR is therefore particularly attractive, where farmers face constraints in capital and labour availability. Its lower establishment cost reduces the financial burden on farmers while providing a substantial yield improvement. MPTR, on the other hand, is attractive where farmers have access to custom-hiring services and machinery and seek to maximize productivity while reducing manual transplanting requirements.

### Broader Economic Implications for Jorhat District

The findings have implications beyond the individual farm level. If the technologies are adopted on a larger scale in winter paddy cultivation, the resulting reduction in production costs and improvement in productivity could contribute to higher farm incomes and greater economic stability among rice-growing households.

The adoption of WDSR can potentially improve farmers' liquidity because of its lower upfront establishment expenditure. Farmers can also cultivate larger areas with the available labour force because direct seeding reduces the need for large numbers of workers during the transplanting period.

Mechanical transplanting has the potential to create demand for custom-hiring services, machinery operators, mat-nursery services, and equipment maintenance, thereby contributing to rural service-sector activities. At the same time, access to machinery through farmer groups, cooperatives, self-help groups, farmer producer organizations, or custom-hiring centres

can reduce the constraint imposed by the high individual purchase cost of machinery.

At the farm level, increased productivity under both technologies enhances the supply of marketable paddy. At the regional level, widespread adoption could contribute to improved rice production and farm-level income, provided that farmers have timely access to quality seed, machinery, irrigation, technical knowledge, and appropriate crop-management practices.

### Relative Advantages of the Three Systems

The economic results demonstrate the following ranking:

#### Based on lowest cost

WDSR > MPTR > Traditional manual transplanting

Based on productivity:

MPTR > WDSR > Traditional manual transplanting

Based on net return:

WDSR > MPTR > Traditional manual transplanting

Based on B:C ratio:

WDSR > MPTR > Traditional manual transplanting

Thus, WDSR emerges as the most economically efficient technology under the conditions represented by the study data, whereas MPTR provides the highest productivity advantage.

**Table 1:** Common Cost of cultivation of winter rice(₹/ha)

| Sl. No. | Items/Operations                             | Quantity/ha | Units | Cost/unit | Cost/ha |
|---------|----------------------------------------------|-------------|-------|-----------|---------|
| 1       | Seed                                         |             |       |           |         |
| 6       | Ploughing (Rented tractor)                   | 1           | -     | 2250      | 2250    |
| 7       | Harrowing (Rented tractor)                   | 1           | -     | 2250      | 2250    |
| 8       | Puddling(Rented power tiller)                | 2           | -     | 2250      | 4500    |
| 9       | Layout/ Bund making                          | 8           | MDs   | 250       | 2000    |
| 10      | Laddering and leveling                       | 8           | MDs   | 250       | 2000    |
| 21      | Fertilizer application                       | 3           | MDs   | 250       | 750     |
| 22      | Top dressing (02 times)                      | 4           | MDs   | 250       | 1000    |
| 23      | Gap filling/ thinning                        | 4           | MDs   | 250       | 1000    |
| 24      | Pesticide application                        | 3           | MDs   | 250       | 750     |
| 25      | Harvesting                                   | 25          | MDs   | 250       | 6250    |
| 26      | Post harvest operation (Threshing to drying) | 20          | MDs   | 250       | 5000    |
| 27      | Fertilizers and manure                       |             |       |           | 0       |
|         | 1. FYM                                       | 10          | ton   | 1000      | 10000   |
|         | 2. Urea                                      | 132         | kg    | 8         | 1056    |
|         | 3. SSP                                       | 125         | kg    | 12        | 1500    |
|         | . MOP                                        | 66          | Kg    | 36        | 2376    |
| 28      | Pesticide (LS)                               |             |       |           | 1000    |
| 29      | Herbicides                                   | LS          |       |           | 2000    |
|         |                                              |             |       |           | 45682   |

**Table 2:** Additional Cost of cultivation under establishment method – WDSR (Drum seeder)

| Sl. No. | Items/Operations                            | Quantity/ha | Units | Cost/unit (₹) | Cost/ha (₹) |
|---------|---------------------------------------------|-------------|-------|---------------|-------------|
| 1       | Seed                                        | 30          | Kg    | 36            | 1080        |
| 2       | Seed carrying and Sowing (WDSR Drum seeder) | 4           | MDs   | 250           | 1000        |
| 3       | Drum seeder hiring charge                   | 1           |       | 100           | 100         |
|         |                                             |             |       | Total:        | 2180        |

**Table 3:** Additional Cost of cultivation under establishment method – MPTR (Mechanical transplanting by rice transplanter)

| Sl. No. | Items/Operations                                                             | Quantity/ha | Units | Cost/unit (₹) | Cost/ha (₹) |
|---------|------------------------------------------------------------------------------|-------------|-------|---------------|-------------|
| 1       | Seed                                                                         | 40          | Kg    | 36            | 1440        |
| 2       | Land preparation for nursery and mat nursery including rented tractor charge | LS          |       |               | 1000        |
| 3       | Mat Nursery preparation and sowing                                           | 3           | MDs   | 250           | 750         |
| 4       | Mat nursery seedling uprooting and carrying to main field                    | 2           | MDs   | 250           | 500         |
| 5       | Polythene sheet for mat nursery                                              | LS          |       |               | 1000        |
| 6       | Labour for supplying seedling trays                                          | 2           | MDs   | 250           | 500         |
| 7       | Transplanter hiring charge                                                   | 3750        | Rs/ha | 3750          | 3750        |
|         |                                                                              |             |       | Total         | 8940        |

**Table 4:** Additional Cost of cultivation under establishment method – Manual transplanting (FP)

| Sl. No. | Items/Operations                                                             | Quantity/ha | Units | Cost/unit (₹) | Cost/ha (₹) |
|---------|------------------------------------------------------------------------------|-------------|-------|---------------|-------------|
| 1       | Seed                                                                         | 40          | Kg    | 36            | 1440        |
| 2       | Nursery bed preparation and sowing                                           | 5           | MDs   | 250           | 1250        |
| 3       | Land preparation for nursery and mat nursery including rented tractor charge | LS          |       |               | 1000        |
| 4       | Uprooting of seedlings for manual transplanting and carrying to main field   | 7           | MDs   | 250           | 1750        |
| 5       | Transplanting (Manual)                                                       | 25          | MDs   | 250           | 6250        |
|         |                                                                              |             |       | Total:        | 11690       |

**Table 5:** Comparative expenditure (₹/ha) and Comparative productivity (ton /ha)

| Method of establishment   | Traditional system<br>(manual transplanting) | Wet Direct seeding<br>using drum seeder | Line transplanting using<br>mechanical transplanter |
|---------------------------|----------------------------------------------|-----------------------------------------|-----------------------------------------------------|
| Gross Cost                | 57372.00                                     | 47862.00                                | 54622.00                                            |
| Production (Main Product) | 4.24                                         | 4.76                                    | 5.01                                                |

**Table 6:** Comparative Economics (₹/ha)

| Method of establishment    | Traditional system<br>(manual transplanting) | Wet Direct seeding<br>using drum seeder | Line transplanting using<br>mechanical transplanter |
|----------------------------|----------------------------------------------|-----------------------------------------|-----------------------------------------------------|
| Gross Cost                 | 57372.00                                     | 47862.00                                | 54622.00                                            |
| Gross Return               | 97520.00                                     | 109480.00                               | 115230.00                                           |
| Net Return                 | 40148.00                                     | 61618.00                                | 60608.00                                            |
| B:C based on variable cost | 1.69                                         | 2.29                                    | 2.11                                                |

Price per quintal paddy is considered as ₹ 2300 (MSP for paddy during 2024-25)

Conclusion

The analysis demonstrates that technological interventions in rice establishment can substantially improve the economic performance of winter paddy cultivation in Assam. Compared with traditional manual transplanting, both WDSR and MPTR reduced production costs, increased productivity, improved gross returns, and generated substantially higher net returns. Among the technologies evaluated, WDSR using a drum seeder provided the highest overall economic advantage. It reduced the gross cost of cultivation from ₹57,372/ha under traditional practice to ₹47,862/ha, representing a saving of ₹9,510/ha. At the same time, productivity increased from 4.24 to 4.76 t/ha. These combined effects increased net return from ₹40,148/ha to ₹61,618/ha and improved the B:C ratio from 1.69 to 2.29. Mechanical transplanting using a rice transplanter produced the highest productivity of 5.01 t/ha, an 18.16% increase over traditional transplanting. It generated a gross return of ₹1,15,230/ha and a net return of ₹60,608/ha. However, its higher establishment cost meant that its net return and B:C ratio were marginally lower than those of WDSR. The findings therefore suggest that technology adoption can be an important pathway for improving the profitability and economic sustainability of winter paddy cultivation in Jorhat district. WDSR appears particularly suitable for farmers seeking to reduce production costs and labour dependence, while MPTR offers considerable potential for farmers seeking higher productivity through mechanized transplanting. Wider adoption of these technologies should be supported through timely availability of machinery on a custom-hiring basis, technical training, access to quality seed, nursery-management support, and appropriate extension services. Overall, the evidence indicates that the transition from labour-intensive traditional transplanting towards direct seeding and mechanized transplanting can enhance farm profitability, improve resource-use efficiency, reduce peak-season labour dependence, and strengthen the economic viability of winter rice cultivation in Assam.

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