

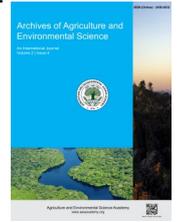


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ORIGINAL RESEARCH ARTICLE



Comparative socio-economic analysis of manual and mechanized transplantation method of spring rice (*Oryza sativa*) production in Chitwan, Nepal

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ABSTRACT

This study aimed to assess and compare the socioeconomic aspects of mechanized and manual transplantation methods in spring rice production. A survey was conducted in 2024 through pre-tested interview schedules and Key Informant Interviews (KIIs) to collect primary data, while secondary data were collected from relevant publications. A total of 90 farmers (45 using manual transplantation and 45 using mechanized transplantation) were selected through simple random sampling from two purposively chosen municipalities. Among the respondents, 51.1% continued using the traditional manual transplantation method, while 48.9% adopted the mechanized transplantation method, citing cost-effectiveness as a key factor. Similarly, 36.69% of labour cost was accounted for total cost of production in manual transplantation method whereas only 23.45% of labour cost was accounted for total cost of production in mechanized transplantation method. The average gross margin per hectare in mechanized transplantation method (NPR 93325.25/ USD 681.58) was higher than the manual transplantation method (NPR 64654.561/ USD 472.19). Using mechanized transplantation method was more profitable (BCR: 1.76) than using manual transplantation method (BCR: 1.50) in spring rice production. The findings indicated that mechanized transplantation method significantly ($p < 0.05$) reduces dependence on labour and enhances profitability in spring rice production. Therefore, I creased promotion of mechanization, along with policy measures and access to appropriate machinery, could reverse the productivity decline and improve the economic resilience of rice farmers in Chitwan, Nepal.

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INTRODUCTION

Rice is the daily staple for over 3.5 billion people, more than half of the global population and the majority of the world's poor (Mohidem *et al.*, 2022). In Nepal, rice ranks first among the cereal crops in terms of area 14,77,789 ha, production of 54,86,472 metric tonnes and productivity of 3.79 mt/ha (MOALD, 2024). Rice alone contributes 13.60% to agriculture GDP in the fiscal year 2022/2023 (MOALD, 2023). Rice is grown in three major ecological regions, which are Terai and Inner Terai (60-900 masl), mid hills (900-1,500 masl) and Mountains/High hills

(1,500 - 3,050 masl). Major portion of the rice is produced from terai region so terai is known as 'Grain basket of Nepal' (Sherestha *et al.*, 2025). In Chitwan district, which is located in the central Terai, productivity of spring rice (4.80 mt/ha) is higher than that of the main season rice (3.83 mt/ha), but in recent years, area and production of spring rice have decreased and there are concerns regarding local food security and sustainability. Spring rice, also known as Chaite rice, is planted in late February or early March and is transplanted 30 to 40 days later, during the Nepali month of "Chaitra". Rice seedling transplantation

either manual or mechanical, greatly impacts agricultural sustainability and productivity (Thapa *et al.*, 2024). Traditionally, rice transplantation in Nepal is performed manually, a labour-intensive and time-consuming process characterized by uneven plant spacing, delayed planting, increased use of seeds, and high vulnerability to weeds. With demographic changes and increasing rural labour shortages, especially in areas such as Chitwan, mechanized transplantation has become a potential alternative. It utilizes rice transplanters to plant in an efficient and uniform manner, reducing labour costs and improving productivity (Devkota *et al.*, 2020). However, adoption remains low due to factors such as scattered landholdings, low knowledge, and a lack of access to mat-type nursery techniques (Poudel *et al.*, 2020a; Sapkota *et al.*, 2021a). Despite government efforts, such as the Prime Minister Agriculture Modernization Project (PMAMP), which encourages mechanization in Chitwan's primary rice-growing municipalities, empirical evidence comparing manual and mechanized spring rice methods is insufficient (Sapkota *et al.*, 2021a; Thapa *et al.*, 2024).

This study evaluates and compares the socioeconomic and productivity aspects of manual and mechanical transplantation methods in Chitwan spring rice production. It aids in determining which approach is most efficient and economically viable for increasing productivity and labour utilization. The findings will help policymakers, development agencies, and farmers to make evidence-based decisions, leading to better agricultural practices, higher farm profits, and more robust food security in Chitwan and other rice-producing regions of Nepal.

MATERIALS AND METHODS

Study area

Ratnanagar and Khairahani municipalities of Chitwan were purposively selected for the study as they are the command area of rice production and PMAMP has been providing farm mechanization solutions to local farming communities.

Sampling procedure and data collection

A total of 90 respondents were selected for the study, comprising 45 farmers who used manual transplantation and 45 farmers who used mechanized transplantation method in spring rice production. The respondents were selected by using a simple random sampling method so that all eligible farmers in the population had an equal chance of being selected. A pre-tested interval schedule, field observation and key informant interview were used to collect primary information. Secondary information was collected from different relevant literatures.

Methods and techniques of data analysis

Data collected from survey were tabulated and analysed using MS Excel, SPSS and STATA. Socio-demographic and economic characteristics were analysed using simple descriptive statistics. The following analyses were done.

Cost of production

Cost of production was calculated by summing the variable cost and overhead cost incurred in both manual and mechanized transplantation method of spring rice production. Variable cost included seed cost, fertilizers and micronutrient cost, main land preparation cost, nursery land preparation cost, farmyard manure cost, irrigation cost, transportation cost, harvesting and threshing cost, machine transplantation cost and labour cost. The cost of human labour in rice production was calculated based on pre- and post-cultivation activities, including seed bed preparation, transplanting, weeding, fertilizer and pesticide application, harvesting and threshing activities, etc. (Sapkota *et al.*, 2021b). Similarly, overhead cost included land rent cost, stationary cost, electricity cost, meetings cost and repairing cost.

Total cost of production = Σ of cost all variable inputs+ Σ of overhead cost

Gross return

Gross return was calculated using product sales income from grains and straw. Following Poudel *et al.* (2021b), returns from rice grains and straw were calculated by multiplying the total volume of output by the selling price after harvesting. The gross return was computed by adding the returns from both grains and straw.

Gross return = {(price of rice grain \times total amount of rice grain) + (price of rice straw \times total amount of rice straw)}

Gross margin

The gross margin associated with manual and mechanized transplantation method of spring rice production was calculated by deducting total cost of production from gross return.

According to Sapkota *et al.* (2021b), gross margin was calculated by using the following formula:

Gross Margin (NPR /ha) = Gross return (NPR /ha) – Total cost of production (NPR /ha)

Benefit cost ratio

The benefit cost ratio was calculated as a ratio of gross return and total cost of production in both manual and mechanized transplantation method of spring rice production and comparison was done. The benefit cost ratio was calculated by using the formula (Thapa *et al.*, 2024):

Benefit cost ratio (BCR) = Gross return/ Total cost of production

RESULTS AND DISCUSSION

Influence of socio-economic characters on the use of transplantation methods in spring rice production

The majority of respondents using both manual (55.6%) and mechanized (73.7%) rice transplantation methods were male, which shows that men are more involved in field-level farming work in Chitwan, especially when it comes to using machines (Table 1). Educated farmers were more likely to use mechanized transplantation, possibly because of their greater awareness of the benefits of new technology and their ready access to training and information (Khatiwada *et al.*, 2021). Most of the manual users (62.2%) depended mainly on agriculture, while mechanized users (55.6%) had other sources of income. This may be because people with other sources of income can invest in machines and reduce their reliance on labour (Dhakal *et al.*, 2020). Mechanized users had higher average incomes (NPR 692,444.44/ USD 5057.12) and larger rice fields (0.55 ha) than manual users (NPR 591,000.99/ USD 4316.25 and 0.37 ha, respectively), which likely makes machine adoption more accessible for them. 51.1% of respondents were using manual transplantation method following the tradition method as it has been passed down through generation of farmers, becoming a well-established and familiar practice. 48.9% of respondents were using mechanized transplantation method due to efficiency as it minimizes the cost of production and transplant seedlings much

faster and more accurately covering large area in less time. Membership in cooperatives and attendance in training programs were higher among mechanized user which exposed them to newer agricultural technologies (Huang *et al.*, 2024).

Comparative financial analysis of manual and mechanized transplantation method of spring rice production

Total cost of production

The total cost of production in manual transplantation method (NPR 127512.52/ha) was found to be higher than mechanized transplantation method (NPR 123900.32/ha) for spring rice production (Table 2). Expenses incurred in labour cost was high in manual transplantation method (NPR 43447.11/ha) as compared to the mechanized transplantation method (NPR 26870.98/ha). The labour cost occupied the major portion of cost of production in both manual (36.69%) and mechanized (23.45%) transplantation method of spring rice production. In the line of this finding, Poudel *et al.* (2020b) reported labour as the major attributing cost item in total cost of rice production in rice super zone, Jhapa. Manual transplantation has a greater labor cost since it is a labor-intensive technique that involves activities such as nursery raising, seedling excavation, and manual planting. However, mechanized transplantation minimizes the quantity of labor required, lowering the overall cost.

Table 1. Socio-economic characters of respondents using manual and mechanized transplantation methods.

Socio-economic characteristics	Manual transplantation	Mechanized transplantation
Gender	Male-25 (55.6) Female-20 (44.4)	Male-33 (73.3) Female-12 (26.7)
Level of education	Never been to school-13 (28.9) Primary level-11 (24.4) Secondary level-14 (31.1) College level-7 (15.6)	Never been to school-9 (20) Primary level-17 (37.8) Secondary level-15 (33.3) College level-4 (8.9)
Occupation	Only agriculture-28 (62.2) Business-13 (28.9) Government service-3 (6.7) Others-1 (2.2)	Only agriculture-25 (55.6) Business-10 (22.2) Government service-7 (15.6) Others-3 (6.6)
Average annual income	NPR 591000.00	NPR 692444.44
Average spring rice cultivated land	0.37 ha	0.55 ha
Main reason for preferred transplantation method	Cost effective-3 (6.6) Efficiency-11 (24.4) Small landholding-8 (17.9) Tradition-23 (51.1)	Cost effective-18 (40) Efficiency-22(48.9) Small landholding-2 (4.4) Tradition-3 (6.7)
Membership	Yes-14 (31.1) No-31 (68.9)	Yes-28 (62.2) No-17 (37.8)
Training participation	Yes-23 (51.1) No-22 (48.9)	Yes-31 (68.9) No-14 (31.1)

Note: Figures in parentheses indicate percentage; Source: Field survey, 2024.

Total returns

The total returns from mechanized transplantation method (NPR 217225.87/ USD 1586.46) was found to be higher as compared to manual transplantation method of spring rice production (NPR 192167.09/ USD 1403.45). The total returns from spring rice production using manual transplantation method was NPR 192167.09/ha that is accounted from grain (86.74%) and straw (13.26%) (Table 3). Similarly, the total returns from spring rice production using mechanized transplantation method was NPR 217225.87/ha that is accounted from grain (87.55%) and straw (12.45%). Mechanized transplantation enhances operational efficiency, ensuring timely planting and uniform seedling spacing, which leads to improved plant establishment and higher yields. Bhatt *et al.* (2024) reported that the average total returns from spring rice production in Kanchanpur district of Nepal was NPR 126, 735.82/ha that is accounted from grain (87.34%) and straw (12.66%).

Price and productivity

The average productivity of spring rice grain using manual and mechanized transplantation method were 5.58 mt/ha and 6.92 mt/ha, respectively. This significant difference indicates mechanization's economic efficiency, which decreases variable costs (especially labour) while increasing productivity and profitability. The average price of spring rice grain in the study area was calculated NPR 2730/quintal. Chaite-5, PR and Hardinath-1 were the mostly cultivated spring rice varieties in the study area. Subedi *et al.* (2020) also reported the profitability and resource use

efficiency of rice production in Jhapa district of Nepal.

Gross margin

The gross margin of spring rice production using mechanized transplantation method (NPR 93325.25/ha) was comparatively higher than using manual transplantation method (NPR 64654.57/ha). It shows that mechanized transplantation method is financially sounder than manual transplantation of spring rice production. The gross margin of rice production in Jhapa district and Saptari district of Nepal was NPR 53531/ha and NPR 20979.32/ha, respectively (Sah *et al.*, 2022).

Benefit cost ratio

The benefit cost ratio using manual transplantation (1.50) was comparatively lower than using mechanized transplantation (1.76) method in spring rice production (Table 4). A BCR of 1.76 indicates that the farmer earns 1.76 units, for every 1 unit of cost (NPR 1) incurred in mechanized transplantation method. Although both approaches generate BCR values greater than one, showing financial feasibility, mechanized transplantation provides a higher return due to its efficiency in lowering labor costs, enhancing operational timeliness, and increasing yields. The BC ratio of spring rice production in both manual and mechanized transplantation method in Chitwan were found greater than 1.51 and 1.14 in Pyuthan and Dang districts, respectively (Bhusal *et al.*, 2020). Thus, mechanized transplantation is more advantageous and economical than manual transplantation in the production of spring rice, as demonstrated by the comparison of BCR values.

Table 2. Average cost of production in manual and mechanized transplantation methods.

S. No.	Cost items	Manual transplantation (NPR /ha)	Mechanized transplantation (NPR /ha)
1	Seed	4287.45 (3.62)	1232.34 (1.08)
2	Nursery land preparation	992.28 (0.84)	3907.16 (3.41)
3	Main land preparation	17322.77 (14.63)	19436.21 (16.96)
4	Machine transplantation	0	7458.84 (6.51)
5	Fertilizers and micronutrient	10147.15 (0.89)	10521.79 (1.08)
6	Farm Yard Manure (FYM)	19254.49 (16.26)	18188.76 (15.87)
7	Plant protection	4281.45 (3.62)	4022.68 (3.51)
8	Irrigation	1036.38 (0.88)	862.86 (0.75)
9	Labour	43447.11 (36.69)	26870.98 (23.45)
10	Transportation	9283.85 (7.84)	10957.55 (9.56)
11	Harvesting and threshing	11634.94 (9.83)	13435.78 (11.72)
	Total variable cost (NPR /ha)	121687.88 (95.1)	119895 (93.9)
	Total overhead cost (NPR /ha)	5824.65 (4.92)	7005.53 (6.11)
	Total cost of production (NPR /ha)	127512.52 (100)	123900.32 (100)

Note: Figures in the parentheses indicate percent; Source: Field survey, 2024.

Table 3. Average returns in manual and mechanized transplantation methods.

S. No.	Returns items	Manual transplantation (NPR /ha)	Mechanized transplantation (NPR /ha)
1.	Rice grains	166686.58 (86.74)	190164.76 (87.55)
2.	Rice straw	25480.51 (13.26)	27061.11 (12.45)
	Total	192167.09 (100)	217225.87 (100)

Note: Figures in the parentheses indicate percent; Source: Field survey, 2024.

Table 4. Financial indicators in manual and mechanized transplantation methods.

Indicators	Manual transplantation (NPR /ha)	Mechanized transplantation (NPR /ha)
Gross returns	192167.09	217225.57
Total cost of production	127512.52	123900.32
Gross margin	64654.57	93325.25
Benefit cost ratio	1.50	1.76

Source: Field survey, 2024.

Conclusion

Despite over half of the respondents citing agriculture as their primary activity, the survey found that Chitwan's total spring rice production is still not enough to satisfy local demand. Respondents with formal education were more likely to embrace modern technologies for spring rice farming, indicating that educational background significantly influenced technology adoption. The majority of respondents kept on using manual transplantation method following the tradition from past generations, while the majority of respondents used mechanized transplantation method due to cost effectiveness. Farmers with diverse occupation, higher yearly earnings, involvement in farmer groups, and participation in agricultural training programs were significantly more likely to use mechanical methods. In terms of productivity, mechanized transplantation outperformed manual method, resulting in higher yields. Furthermore, mechanical transplantation had a larger gross margin and benefit-cost ratio, indicating that it generates more profit per unit area and better returns on investment. These studies collectively demonstrate that mechanized transplantation is more economically efficient and profitable than traditional manual method, and its adoption is driven by socioeconomic and institutional factors.

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DECLARATIONS

Author contribution statement: Conceptualization: G.T. and Y.K.; Methodology: G.T.; Software and validation: G.T. and Y.K.; Formal analysis and investigation: G.T.; Resources: G.T.; Data curation: G.T.; Writing—original draft preparation: G.T.; Writing—review and editing: G.T.; Visualization: G.T.; Supervision: G.T.; Project administration: G.T.; Funding acquisition: Y.K. All authors have read and agreed to the published version of the manuscript.

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