

RESEARCH ARTICLE

ECONOMIC IMPACT OF AGRICULTURAL MECHANIZATION IN GUJRANWALA DISTRICT'S RICE FARMING, PAKISTAN

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ABSTRACT

This study evaluates the economic impact of mechanization adoption in rice farming within the Gujranwala district of Punjab in 2024. A total of 150 rice farmers were surveyed using a structured questionnaire and categorized into mechanized and non-mechanized groups based on their use of machinery. Cost and revenue assessment were carried out for both groups, the comparison of average costs and revenues between mechanized and non-mechanized farmers was performed using a t-test through SPSS software. The mean production cost was estimated to be PKR 84,080.34 per acre. It was found that land preparation, harvesting and threshing, and human labor costs were significantly higher in non-mechanized farming. Mechanized farms had a lower average total cost of production compared to non-mechanized farms. The average revenue from rice production was significantly higher for mechanized farmers (PKR 165,142/acre) compared to non-mechanized farmers (PKR 151,823.33/acre). Additionally, mechanized farms demonstrated a higher net profit and benefit-cost (B:C) ratio (1.56) compared to non-mechanized farms (1.36). The findings demonstrate that mechanized rice farming has lower production costs and higher yields, which increase overall profitability. Therefore, the adoption of mechanization for rice cultivation in the Gujranwala district is strongly recommended.

KEYWORDS

Mechanization, Rice, Production cost, Net income, labor, B:C ratio

1. INTRODUCTION

Agriculture plays a crucial role in Pakistan's economy, contributing 22.9% to its GDP and growing steadily at an annual rate of 1.55%. It employs 37.4% of the workforce and is the primary source of income for 62% of the rural population. Rice is the most important cereal crop globally, serving as the primary food for over 50% of the world's population (Bandumula, 2018). In Pakistan, rice is a key crop that significantly impacts food consumption, financial stability, the availability of food, and eradicating poverty (Abdullah et al., 2015; Javed et al., 2020). Rice is also a vital crop in Pakistan, yielding around 9.3 million tons annually (GOP, 2022). This crop is not only vital for domestic food supply but also contributes significantly to the nation's foreign exchange revenues. In the fiscal year 2020-21, Pakistan exported basmati rice worth more than US\$800 million, earning a total of USD 2 billion from rice exports (REAP, 2021). Punjab province produces over 80% of the fine rice in Pakistan due to its favourable climate and soil conditions. The districts of Gujranwala, Sialkot, Hafizabad, Okara, Sheikhpura, Nankana, Jhang, and Mandi Bahauddin are responsible for more than 70% of Pakistan's basmati rice production (Ashfaq et al., 2017).

Despite advancements in rice varieties and farming methods, rice productivity in Pakistan remains low at 2.64 tons per hectare, compared to the global mean of 4.71 tons per hectare (Chauhan et al., 2017; FAO STAT, 2020). Conventional farming methods and limited use of modern technology contribute to this productivity gap in Pakistan (Aslam, 2016; Saboor, 2014). In the 2022-23 period, rice cultivation in Pakistan covered

2,976 thousand hectares, marking a 15.9 per cent decrease from the 3,537 thousand hectares recorded in the previous year. This reduction in production was also reflected in the yield, dropping from 9.323 million metric tons in 2021-22 to 7.322 million metric tons in 2022-23, which equates to a negative growth rate of 21.5 per cent (Economic Survey of Pakistan, 2023). The decrease in the area of production may be attributed to various factors, such as high labour intensity, low level of mechanization, low economic efficiency, and farmers not willing to plant. Rising labor wages, increased fertilizer costs, and rising water requirements in traditional rice farming have drastically lowered the margin of profit, which detrimental impact on farmers' motivation for cultivating rice (Nawaz et al., 2022).

Mechanization is viewed as one of the greatest engineering accomplishments of the 20th century. It simplifies and eliminates labor-intensive tasks, substitutes for labour shortages, and boosts productivity (Rahman et al., 2021). It has direct economic effects on land and labor productivity to meet the living challenges and increase productivity in a sustainable way (Alam et al., 2019). Efficient management practices like mechanical transplanting of rice (MTR) and, the use of combine harvesters can narrow the yield gap and reduce the harvesting losses in rice cultivation, according to (Islam, 2016). Mechanization in agriculture, along with better crop inputs, has increased yields by 10-15% (Chandra Nath et al., 2017). To address labor shortages and high production costs, mechanization is proposed as a solution (Upreti, 2010). Nowadays, farmers are forced to employ mechanization due to labor scarcity and a

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high labor wage rate.

Although Pakistan is an agricultural country, agricultural mechanization is still in its early stages (Abbas et al., 2017). In past few years, small-scale farmers in developing nations have faced significant problems like a lack of workers due to the urbanization of rural areas as well as increased labor prices (Liu et al., 2020; Paudel et al., 2019; Wang et al., 2016; Zhou et al., 2018). These problems pose serious challenges to farm production and appropriate cultivation, particularly for labor-intensive commodities like rice and wheat. Despite the significant benefits that agricultural mechanization can bring, its acceptance rates are still low in developing nations (Adekunle et al., 2016; Benin, 2015; Zhou et al., 2018).

The availability and affordability of machinery at the right time remain a challenge, hindering agricultural progress (GOP, 2020). Compared to the neighboring countries, Pakistan agricultural sector is less developed, relying primarily on tractors and basic land preparation tools due to limited technological advancements (FAO, 2012). Although the use of farm machinery can enhance yields and lower labour requirements, the high initial capital investment often restricts small-scale farmers from purchasing such equipment's (Akram et al., 2020). Expecting a labor shortage in Pakistan, agricultural experts are pushing for mechanized rice farming, starting with trials in Punjab province. This initiative, part of the Rice Productivity Enhancement project since 2020, lacks socio-economic evidence on the viability and acceptance of mechanized transplanting.

The purpose of this study is to assess how agricultural mechanization has affected rice farming in the Gujranwala district economically. Specific objectives include comparing the cost of production, yield, and profitability between mechanized and non-mechanized farms, and evaluating the net-benefit cost of both farming practices. Additionally, the study aims to explore the labor dynamics and identify the potential barriers to the adoption of mechanization in rice farming. The significance of this research lies in its potential to inform policy decisions and agricultural practices in the region. By highlighting the economic advantages of mechanization, the study can encourage farmers to adopt modern farming techniques, thereby enhancing their productivity and income. Furthermore, the findings can aid in formulating targeted interventions and support mechanisms to facilitate the transition to mechanized farming. The knowledge gathered from this research may assist to the development of more efficient and sustainable agricultural practices in the region, ultimately promoting the growth and resilience of the rice farming sector.

2. MATERIALS AND METHODOLOGY

2.1 Study Site

Gujranwala is a prominent city situated in the Punjab province of Pakistan, located in located between latitudes 31°47'36", 34°34'2" North and longitudes 73°38'52", 74°34'55" East. Gujranwala ranks as the second-largest rice-producing area in Punjab (Junaid et al., 2014). The mean annual precipitation in the study area ranges from approximately 22 mm, with variations across different parts of the district. The maximum temperature during the summer months typically reaches around 42°C, while the minimum temperature in winter can drop to around 5-7°C.

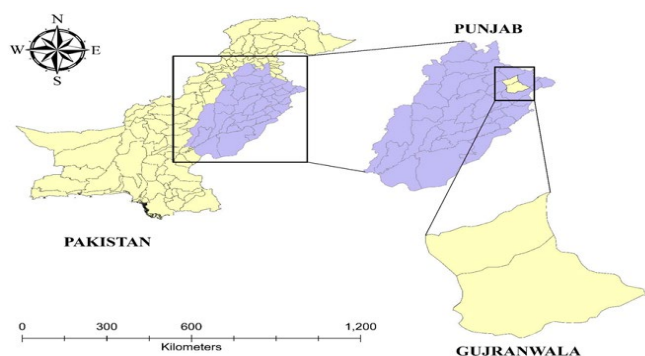


Figure 1: Map of study area Gujranwala district, Punjab, Pakistan

The area's irrigation system, primarily fed by the Chenab River, plays a crucial role in sustaining its agricultural output. Additionally, modern farming techniques and mechanization have significantly boosted productivity in recent years. Gujranwala's agriculture not only supports the local economy but also contributes to the overall food supply of the country. The city's commitment to agricultural innovation continues to enhance its reputation as a key player in Pakistan's agrarian sector

2.2 Selection of Rice Farmers

The district agriculture department in Gujranwala, Punjab, provided a list of registered rice growers. Data collected from three tehsils (Kamoke, Gujranwala City and Nowshera Virkan) of district Gujranwala, a total of 150 rice farmers, consisting of 75 mechanized and 75 non-mechanized farmers, were selected using a stratified sampling technique. From each tehsil, 50 farmers were selected, of which 25 were mechanized and 25 were non-mechanized. The farmers were divided into two groups according to the machinery they used:

- Mechanized farmers (Those farmers who utilize machinery such as tractors for land preparation, mechanical transplanters for transplanting, engine or battery-operated sprayers, and combine harvesters or reapers for harvesting).
- Non-mechanized farmers (farmers who perform most operations, including transplanting, spraying, and harvesting, manually by human labor).

2.3 Data Type and Collection

A pre-validated, structured questionnaire that had undergone pre-testing was used to collect primary data. This data was further corroborated through meeting with farmers, regional leaders, and other relevant stakeholders. Secondary data were sourced from a variety of articles, research papers, and books published by institutions and organizations, including the Food and Agriculture Organization (FAO), the National Bureau of Statistics Pakistan (NBSP), the Pakistan Agricultural Research Council (PARC), and the Agriculture Development Farms. The collected data were coded, organized, and entered into a computer system. IBM SPSS and Microsoft Excel were used for the final analysis, which included standardizing local measurements. Using descriptive statistics, such as mean, frequency, and percentage, the socioeconomic traits of the farmers were investigated.

2.4 Production Costs

The analysis of production costs considered both variable and fixed costs. Variable costs encompassed expenses related to land preparation, transplanting, irrigation, chemical fertilizers and harvesting for both types of farmers and labor hiring costs for different farm operations. Fixed costs include land taxes and maintenance costs, with the land tax in the study area amounting to 450 PKR per acre.

$$\text{Total Cost of production} = \text{Fixed Costs} + \text{Variable Costs} \quad (1)$$

2.5 Net Revenue

Net Revenue is the overall income generated from the scale of grain and straw outputs. For land rent, they have to give a specific amount of 8-10 mound (1mound=40 kg) or they can pay the amount directly from grains so I calculate the average rent cost from it just for one crop.

$$\text{Net Revenue} = (\text{Revenue from grains} + \text{Revenue from straw}) - \text{Land rent} \quad (2)$$

2.6 Net Profit

Net profit serves as a crucial economic drive for farmers, playing a pivotal role in incentivizing them to enhance their paddy yield. It stands as a fundamental motivation, encouraging farmers to strive for increased productivity in their rice cultivation endeavors.

$$\text{Net profit} = \text{Gross Revenue} - \text{Total cost of production} \quad (3)$$

2.7 Benefit-Cost Evaluation

The following formula was used to calculate the benefit-cost (B:C) ratio:

$$\text{Benefit cost ratio} = (\text{Net revenue} / \text{Total production cost}) \quad (4)$$

2.8 Henry Garrett Ranking Approach

Henry Garrett's ranking approach was employed to assess the primary reasons for utilizing machinery in rice cultivation, as well as the obstacles faced in mechanization (Henry Garrett's, 1969). In this approach, farmers were contacted to rank various reasons and limitations based on their significance. The rankings provided by the respondents were then translated into numerical scores using a specific formula. This method allowed for a quantitative analysis of the qualitative data gathered from the farmers, offering a clear picture of the most pressing factors driving the use of machinery and the main challenges encountered in the process of mechanization. This technique not only facilitated the understanding of

farmers' perspectives but also provided a structured way to prioritize the issues at hand, enabling more effective decision-making and policy formulation. The ranking assigned by the respondents were converted into numerical score values using the formula provided below:

$$\text{Percentage position} = \frac{100 (R_{ij} - 0.5)}{N_{ij}} \quad (5)$$

Where,

R_{ij} = Rank assigned to the ith variable by the jth respondent

N_j = Total number of variables ranked by jth respondents

To determine the importance of various factors, the ranks assigned to each factor were first converted into percentage positions. These percentage positions were then translated into numerical scores by consulting Henry Garrett's reference table. For each factor under consideration, the scores given by individuals were aggregated to get a total score. Subsequently, the total score was divided by the number of respondents to determine the average score for every factor. The factor with the highest average score was identified as the most crucial factor, indicating its greater significance compared to the others. This method ensures a systematic and quantitative assessment of the relative importance of different factors based on the collected data.

3. RESULTS AND DISCUSSION

This section outlines the socioeconomic characteristics of rice growers, focusing on factors such as age, education, land holding and tenancy status. It also addresses the key elements influencing rice production among farmers in Gujranwala district.

3.1 Socio-Economic Characteristics of the Farmers

Socioeconomic characteristics, including age, education, land holding and tenancy status, significantly influence the crop production. Older farmers tend to be less technical efficient in their agricultural, while younger farmers are generally more industrious. Additionally, farmers with higher education and experience demonstrate greater efficiency compared to those who are illiterate or less experienced. According to (Nwele, 2016), education can significantly influence decision-making processes, such as the adoption of farm innovations like advanced agricultural machinery. The data indicate that 98% of household heads were male, while 2% were female, highlighting the male dominance within the rice farming community. The majority (52%) of rice farmers were between the ages of 46 and 60 years. Additionally, 18% of household heads were illiterate, 36% had received primary education, and only 6.67% had attained above college-level education or higher. Regarding landholding sizes, 41.33% of the farmers had medium-sized landholdings (2-4 hectares), and 32% of farmers had small-sized landholdings (1-2 hectares).

| Parameters | Frequency | Percentage |
|--------------------------------------|-----------|------------|
| Gender | | |
| Male | 147 | 98 |
| Female | 3 | 2 |
| Age | | |
| 30-45 years | 45 | 30 |
| 46-60 years | 78 | 52 |
| Above than 60 years | 27 | 18 |
| Education | | |
| Illiterate (No schooling) | 27 | 18 |
| Primary (up to 5 years of education) | 54 | 36 |
| Junior high school | 38 | 25.33 |
| High school | 21 | 14 |
| Graduation or above education | 10 | 6.67 |
| Land Holding | | |
| Small (1 to 2 ha) | 48 | 32 |
| Medium (2-4 ha) | 62 | 41.33 |
| Large (more than 4 ha) | 40 | 26.67 |

3.2 Source of Information Regarding Mechanization in rice Farming

According to the study found that 48% of the participants learned about machinery usage in rice production from Progressive farmers and Media. This was followed by Adaptive research farms (ARF) in Gujranwala, Punjab (34%) and agriculture machinery households (18%) as illustrated in Table 2.

| Source | Frequency |
|----------------------------------|-----------|
| Adaptive research farms(ARF) | 51 (34) |
| Progressive Farmers and Media | 72 (48) |
| Agriculture machinery households | 27 (18) |
| Total | 150 |

Note: Number's in parentheses represent the percentage

3.3 Training for Agricultural Mechanization

According to table 3 just 8% of the participants had previously received training in agricultural mechanization.

| Training | Frequency |
|----------|-----------|
| Yes | 12 (8) |
| No | 138 (92) |
| Total | 150 |

Note: Number's in parentheses represent the percentage

3.4 Reasons for Employing Machinery

Data indicate that the primary reason farmers use machinery is to enhance production, followed by desire to expedite farm work, address the shortage of human labour and animal power, reduce costs and lessen physical strain.

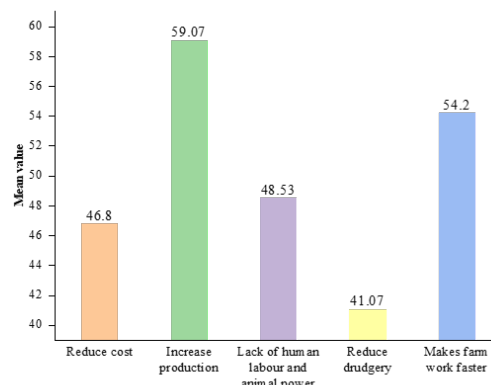


Figure 2: Reasons behind using machinery by the respondents Gujranwala district, 2023

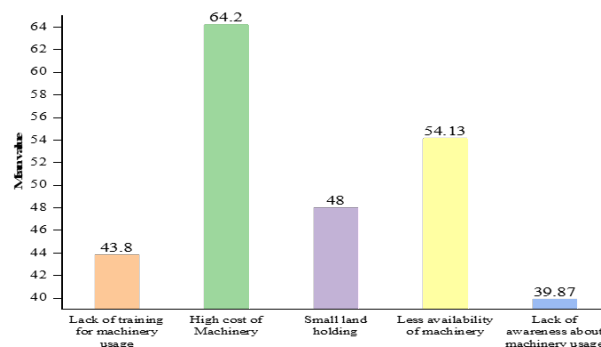


Figure 3: Constraints in adoption of machinery by the respondents Gujranwala district, 2023

3.5 Constraints of Mechanization

The data its revealed that the high cost of machinery was the primary constraint to mechanization in the study area, followed by less availability

of machinery, small landholding, insufficient training on machinery use and lack of awareness related machinery applications.

3.6 Production Cost

| Particulars | Mechanized farmer [75] | Non- Mechanized farmer [75] | Overall [N=150] | t-value |
|---|------------------------|-----------------------------|------------------|-----------|
| A. Variable costs | 82120 (99.46) | 85140.67 (99.47) | 83630.34(99.46) | - 8.498* |
| Land preparation (Tillage and puddling) | 11945.33 (14.47) | 12446.67 (14.54) | 12196 (14.50) | - 6.427* |
| Seedling preparation cost | 5786 (7.01) | 5648 (6.60) | 5717 (6.80) | 3.378* |
| Rice transplanting | 12729.33 (15.42) | 12121.33 (14.16) | 12425.33 (14.78) | 5.992* |
| Irrigation cost | 14839.34 (17.97) | 14879.34 (17.38) | 14859.34 (17.67) | - 0.431 |
| Fertilizers cost | 18321.33 (22.19) | 18381.33 (21.48) | 18351.33 (21.82) | - 0.741 |
| Plant protection cost (Herbicide and weedicide) | 5889.33 (7.13) | 5926.67 (6.92) | 5908 (7.03) | - 0.865 |
| Harvesting and Threshing cost | 8088 (9.80) | 9884 (11.55) | 8986 (10.69) | - 9.178* |
| Human Labor cost | 4521.34 (5.48) | 5853.33 (6.84) | 5187.34 (6.17) | - 18.487* |
| B. Fixed cost (land tax) | 450 (0.54) | 450 (0.53) | 450 (0.54) | |
| Total Production Cost | 82570 (100) | 85590.67 (100) | 84080.34 (100) | - 8.498* |

Numbers in parentheses represent the percentage of each respective column. An asterisk (*) indicate significant at 5% level of significance

The overall average cost of rice production was PKR 84,080.34 per acre. Mechanized rice farms had a lower average total production cost (PKR 82,770 per acre) compared to non-mechanized rice farms (PKR 85,590.67 per acre), with this difference being statistically significant at the 5% level. Similarly, the average variable cost was lower for mechanized farms (PKR 82,120 per acre) than for non-mechanized farms (PKR 85,140.67 per acre).

Fertilizer costs constituted the largest portion of the total costs for both mechanized (22.19%) and non-mechanized (21.48%) farms, due to the high prices of fertilizers in Pakistan. Additionally, human labor and harvesting and threshing costs were significantly higher in non-mechanized farms compared to mechanized farms, with these differences also being statistically significant at the 5% level.

3.7 Production Revenue

| Particulars | Mechanized farmer [75] | Non- Mechanized farmer [75] | Overall [150] | t-value |
|---|------------------------|-----------------------------|---------------|----------|
| Revenue from Rice | 165142 | 151823.33 | 158482.66 | 15.958* |
| Revenue from dry Straw/stalk | 3634.67 | 4561.34 | 4098.01 | -13.888* |
| Average Land rent for 1 crop for an acre | 40250 | 40250 | 40250 | |
| Gross Revenue (after paying land rent) | 128526 | 116134.67 | 122330.67 | 14.541* |

* indicate significant at a 5%.

From table 5, it has been noted that the revenue from mechanized rice is significantly higher (PKR. 1,65,142/acre) as compared to (PKR. 1,51,823.33/acre). The land rent was different at different locations of the study district so we calculated the average land rent of one crop for both farmers and then calculated the Gross revenue, you can also see it's also higher in mechanized farmers and the difference is also significant.

3.8 Net Profit and Benefit-Cost Ratio

| Particulars | Mechanized farmer [75] | Non-Mechanized farmer [75] | Overall [150] | t-value |
|---------------------------|------------------------|----------------------------|---------------|----------------|
| Net Profit | 45956.67 | 30544 | 38250.34 | 19.051* |
| Benefit-Cost ratio | 1.56 | 1.36 | 1.46 | 19.893* |

* indicate significant at a 5% level of significance

Table 6 presents that the benefit-cost ratio in rice cultivation that is impacted by mechanization. It is evident that rice production is profitable in the study region because the net profit is positive and the benefit-cost ratio was greater than one (1). Nonetheless, mechanized farms had a noticeably larger net profit, with a value of PKR 45,956.67 per acre, compared to PKR 30,544 per acre for non-mechanized rice farms. It means we can profit 38,000 PKR per hectare by using mechanized production patterns. (Khatiwada et al., 2021) also found that mechanized farms have lower production costs and higher yields compared to non-mechanized farms. Similarly, (Mottaleb et al., 2016) observed that mechanized farming leads to higher profitability due to reduced labor dependency and increased productivity. This difference primarily results from the higher rice production observed in mechanized farms, along with lower production costs. Implementing mechanization in rice cultivation

decreases the labor needed and consequently lowers production costs (Kumar et al., 2014)(Singh et al., 2011).

4. CONCLUSION

This study indicates that rice production is financially viable in both mechanized and non-mechanized farms. However, the benefit-cost (B:C) ratio is greater for mechanized farms (1.56) than for non-mechanized farms (1.36), with this difference being statistically significant. The average total rice production and revenue per acre are significantly greater in mechanized farms (PKR 165,142) than in non-mechanized farms (PKR 151,823.33). Mechanized farming yields an additional profit of PKR 38,000 per hectare compared to traditional methods. Non-mechanized farming requires more human labor, which is challenging during peak seasons due to labor shortages. Therefore, adopting mechanization in rice cultivation is recommended as it increases production, reduces labor costs, and enhances profitability. The main constraint in mechanization adoption for farmers is the high cost of machinery, the government should provide subsidies to farmers so they can purchase agricultural machinery.

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