



International Journal of Research in Agronomy

E-ISSN: 2618-0618
P-ISSN: 2618-060X
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NAAS Rating (2026): 5.20
www.agronomyjournals.com
2026; SP-9(4): 435-439
Received: 15-02-2026
Accepted: 19-03-2026

Tanisha
Student of Agriculture, Chandigarh
University, Chandigarh, India

Rehmat
Student of Agriculture, Chandigarh
University, Chandigarh, India

Navjot Singh Gill
Faculty of Agriculture, University
Institute of Agricultural Sciences,
Chandigarh University,
Chandigarh, India

Gurshaminder Singh
Head of Department, University
Institute of Agricultural Sciences,
Chandigarh University,
Chandigarh, India

Assessment of farm machinery status and utilization among farmers in selected districts of Punjab

Tanisha, Rehmat, Navjot Singh Gill and Gurshaminder Singh

DOI: <https://www.doi.org/10.33545/2618060X.2026.v9.i4Se.5438>

Abstract

Farm mechanization of farming is important for increasing the productivity of farming, labour-saving and timely completion of farm operations. This research evaluates the level of adoption and use of farm machinery by 120 farmers in some districts of Punjab - SAS Nagar (Mohali), Fatehgarh Sahib and Rupnagar - based on primary data gathered through structured questionnaire and analysed using statistical methods.

The results indicate a high level of mechanization, particularly in land preparation and harvesting. Tractors (100%), cultivators (95%), and rotavators (94%) were widely used, while combine harvesters were adopted by 87.5% of farmers. Ownership patterns reveal that essential machinery such as tractors (90%) and levellers (85%) are largely owned, whereas expensive equipment like combine harvesters (15%) and straw reapers (16%) are mostly accessed through rental services. Adoption of sowing and crop protection machinery remains moderate, with 47.5% using happy seeders and 60% using power sprayers.

Socio-economic factors such as landholding size and income significantly influence machinery adoption, with small farmers relying more on custom hiring services. The study highlights a mixed mechanization model combining ownership and rental systems and emphasizes the need for policy support to enhance equitable access to farm machinery for sustainable agricultural development.

Keywords: Farm machinery adoption, Punjab agriculture, agricultural machinery, agricultural implements

Introduction

Agriculture is a key sector of the Indian economy, providing employment to millions of people. Yet the productivity and sustainability of agriculture is under threat from labour shortage, increasing labour costs and the need to boost production to feed a growing population. Against this backdrop, farm mechanization becomes an important technology in enhancing the efficiency of agriculture. Farm mechanization is the application of agricultural machinery and equipment for carrying out a range of farming activities including soil preparation, planting, irrigation, crop protection, harvesting and post-harvest operations. Mechanization not only helps in reducing labour requirements but also helps in timely conduct of farming operations, increases crop yield and farm income. As a result, mechanization has become a key element in agricultural modernisation and sustainable agricultural development (Khandai *et al.*, 2024) ^[3].

In India, the level of farm mechanization has increased considerably during the last few decades due to technological advancements, government support, and rising labour scarcity. The share of mechanical power in Indian agriculture has increased significantly compared with animal and human labour, reflecting the gradual transformation of traditional farming systems into more technology-driven agricultural practices. For instance, studies have shown that the availability of farm power has increased substantially over the years, with mechanical power contributing the majority of the total farm power used in agricultural operations. This shift toward mechanization has played a vital role in improving agricultural productivity and reducing drudgery for farmers (Mehta C.R. *et al.*, 2024) ^[5].

Among the Indian states, Punjab is considered one of the most mechanized agricultural regions due to its intensive cropping systems and high level of agricultural development. The widespread adoption of tractors, combine harvesters, rotavators, seed drills, and other modern farm implements has significantly transformed agricultural practices in the state. Mechanization

Corresponding Author:
Gurshaminder Singh
Head of Department, University
Institute of Agricultural Sciences,
Chandigarh University,
Chandigarh, India

has particularly contributed to the efficiency of operations in the dominant rice–wheat cropping system and has enabled farmers to manage agricultural activities within limited time windows between crop seasons. Research conducted in Punjab indicates that the adoption of farm machinery has played an important role in increasing productivity and improving operational efficiency in farming systems (Buttar *et al.*, 2023) ^[1], (Kumar Lohan *et al.*, 2019) ^[4].

Despite the relatively high level of mechanization in Punjab, significant disparities still exist in the ownership, access, and utilization of farm machinery among farmers. Many small and marginal farmers are unable to purchase expensive machinery and therefore depend on custom hiring services or shared machinery systems. Furthermore, most previous studies on farm mechanization have largely focused on state-level or regional analyses, often overlooking village-level variations in machinery ownership and usage patterns. Understanding these localized differences is important for designing targeted policies and extension strategies that can improve access to agricultural machinery for farmers. Therefore, the present study aims to assess the status of farm mechanization among farmers in selected villages of Fatehgarh Sahib, SAS Nagar (Mohali), and Rupnagar districts of Punjab by analyzing the availability, adoption, and utilization patterns of farm machinery at the village level.

Materials and Methods

The present study was conducted to assess the status of farm mechanization among farmers in selected districts of Punjab, which are SAS Nagar, Rupnagar and Chamkaur Sahib. A systematic research methodology was adopted to collect and analyze primary data from the respondents. The studies involved a field survey using a structured questionnaire and personal interviews to obtain information related to farmers' socio-economic characteristics, farm size, agronomic practices, ownership and utilization of agricultural machinery, and related costs. The collected data were compiled, tabulated, and analyzed using suitable statistical tools to derive meaningful conclusions regarding the level and pattern of farm mechanization among farmers.

Study Area

The present study was conducted in selected districts of Punjab state, India. The districts of SAS Nagar (Mohali), Fatehgarh Sahib, and Rupnagar were purposively selected as the study area due to their proximity to Chandigarh University and their active agricultural practices. Agriculture is one of the primary occupations in these districts, with farmers predominantly cultivating crops such as wheat, rice, and maize under the well-known rice–wheat cropping system of Punjab. The region is characterized by relatively high levels of agricultural development and the widespread use of farm machinery such as tractors, seed drills, rotavators, and combine harvesters. The selection of these districts provided a suitable context for assessing the status and utilization of farm mechanization among farmers at the village level.

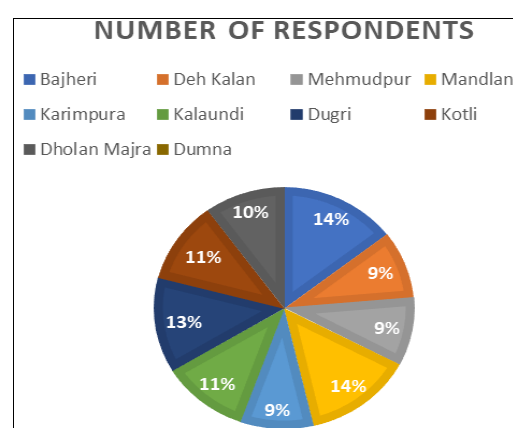
Sampling Procedure

A multistage sampling procedure was followed for the selection of respondents for the study. A total of ten villages, namely Bajheri, Deh Kalan, Mehmudpur, Mandlan, Karimpura, Kalaundi, Dugri, Kotli, Dholan Majra, and Dumna, were selected from the study area. From each village, farmers were selected randomly to ensure fair representation of the farming

population. In total, 120 farmers were selected as respondents for the study. The selected farmers were interviewed using a structured questionnaire to collect information related to their socio-economic characteristics and the availability and use of farm machinery.

Data Collection

Primary data for the present study were collected through a field survey using a structured and pre-tested questionnaire. The selected respondents were personally interviewed to obtain reliable information regarding their socio-economic characteristics, farm size, availability and ownership of farm machinery, hiring practices, and the utilization of agricultural implements for different farming operations. Personal interviews helped ensure clarity in responses and allowed the researcher to gather accurate and detailed information directly from the farmers. The collected data were carefully recorded and compiled for further analysis.



Data Analysis

The data collected from the respondents were carefully compiled, coded, and organized for statistical analysis. Descriptive statistical tools such as frequency, percentage, and mean were used to summarize the socio-economic characteristics of farmers and the status of farm machinery ownership and utilization. In addition, correlation analysis was employed to examine the relationship between selected socio-economic variables and the adoption of farm mechanization. The Chi-square test was also applied to determine the association between categorical variables related to farm mechanization practices. The statistical analysis helped in identifying patterns, trends, and significant relationships within the dataset, thereby enabling meaningful interpretation of the results. All computations and graphical representations were performed using Microsoft Excel and SPSS software.

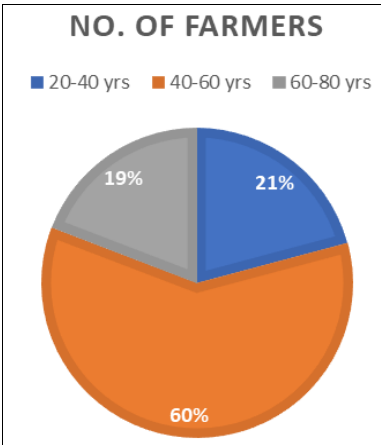
Results and Discussion

The results of the present study are presented and discussed in this section based on the data collected from the respondents during the field survey. The analysis focuses on the socio-economic characteristics of the farmers and the status of farm mechanization in the selected villages. The findings have been organized into different subsections to provide a clear understanding of the availability, ownership, and utilization of farm machinery among farmers. The results are presented using appropriate tables and graphical illustrations to highlight the patterns and trends observed in the study area. The findings are also discussed in relation to existing studies and the practical implications for improving farm mechanization among farmers.

Socio-Economic Profile of Farmers

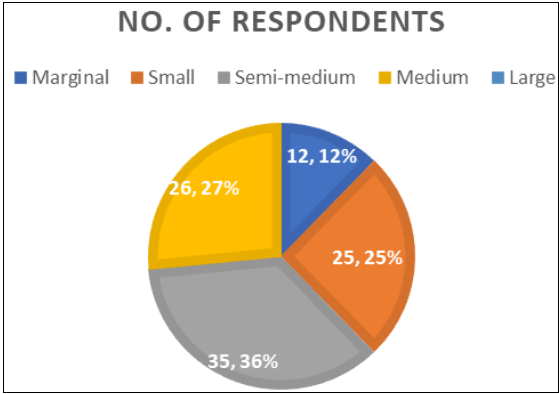
Age is a crucial socio-economic factor that influences farmers’ decision-making, risk-taking ability, and adoption of modern agricultural technologies. The distribution of respondents across different age groups reveals that a majority of farmers (60%) belong to the middle age group of 40–60 years, indicating a balanced combination of experience and openness to improved farming practices. About 20.83% of the respondents fall within the younger age group of 20–40 years, who are generally more inclined toward innovation and adoption of new technologies. Meanwhile, 19.17% of farmers belong to the older age group of 60–80 years, who are more likely to rely on traditional methods due to their long-standing experience. Thus, the predominance of middle-aged farmers in the study area suggests a moderate to high potential for the adoption of farm mechanization.

Age group	No. of respondents (n=120)	Percentage (%)
20-40 yrs	25	20.83
40-60 yrs	72	60
60-80 yrs	23	19.17



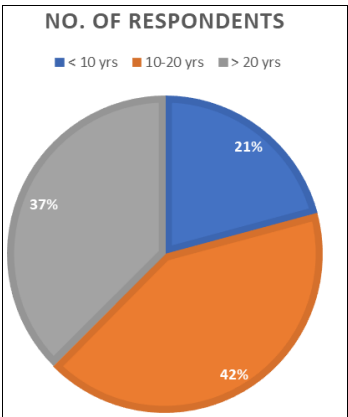
Farm size is a major determinant of the adoption and use of agricultural machinery. Farmers with larger landholdings are generally more capable of owning farm machinery due to stronger economic capacity, whereas small and marginal farmers often depend on custom hiring services. The distribution of respondents based on landholding size indicates that the largest proportion (29.17%) belongs to the semi-medium category, followed by medium farmers (21.7%) and small farmers (20.83%). Large farmers constitute 18.33% of the respondents, while marginal farmers account for only 10%. This distribution suggests that a considerable share of farmers falls within the semi-medium to medium categories, indicating moderate potential for ownership and adoption of farm machinery, while smaller farmers may rely more on shared or rented mechanization services. The detailed distribution is presented in Table 2 and depicted in Figure 2.

Landholding category	No. of respondents (n=120)	Percentage (%)
Marginal	12	10
Small	25	20.83
Semi-medium	35	29.17
Medium	26	21.7
Large	22	18.33



Farming experience reflects the level of practical knowledge and skills acquired by farmers over time. Farmers with greater experience often possess better knowledge of crop management practices and machinery utilization, although they may sometimes prefer traditional methods. The distribution of respondents based on farming experience shows that a majority (41.66%) have 10–20 years of experience, indicating a strong presence of moderately experienced farmers. Additionally, 37.5% of respondents have more than 20 years of experience, reflecting a substantial proportion of highly experienced farmers. Meanwhile, 20.83% of farmers have less than 10 years of experience, representing relatively newer entrants who may be more open to adopting modern technologies. This distribution suggests a balanced mix of experience levels, with significant potential for both traditional knowledge and adoption of improved farm mechanization practices. The detailed distribution is presented in Table 3 and illustrated in Figure 3.

Farming Experience (years)	No. of respondents (n=120)	Percentage (%)
< 10	25	20.83
10-20	50	41.66
>20	45	37.5



Status of Farm Machinery

Ownership of Farm Machinery

Ownership of farm machinery is a key indicator of the level of mechanization and economic capacity of farmers in the study area. The data reveal that farmers tend to own commonly used primary and secondary tillage implements, reflecting their regular necessity in day-to-day agricultural operations. In

contrast, machinery that is costly, highly specialized, or used only during specific operations is largely accessed through rental services. This indicates a clear preference for selective ownership, where farmers invest in essential equipment while relying on custom hiring for expensive or less frequently used machines. Overall, the pattern highlights a mixed approach to mechanization, combining ownership with dependency on rental services, which helps optimize costs and resource utilization among farmers.

Farm Machinery	Owned (%)	Rented (%)
Tractor	90	10
Cultivator	84	16
Mould board plough	25	75
Disc harrow	78	22
Rotavator	40	60
Seed drill/ seed-cum-fertilizer drill	42	58
Happy seeder	35	65
Combine harvester	15	85
Leveller	85	15
Straw reaper	16	84
Paddy transplanter	0	100
Thresher	8	92

Machinery Utilization Pattern

Machinery Used for Land Preparation

The pattern of machinery utilization for land preparation indicates that tractors form the backbone of farm operations in the study area, being universally used by farmers. Implements such as cultivators and rotavators are also widely adopted, highlighting their importance in achieving efficient soil preparation and timely field operations. In contrast, the use of mould board ploughs is relatively limited, suggesting that farmers prefer modern and less labor-intensive implements over traditional ploughing methods. Overall, the utilization pattern reflects a clear shift toward mechanized and efficient land preparation practices, with emphasis on equipment that enhances productivity and reduces time and labour requirements.

Machinery	No. of Farmers	Percentage (%)
Tractor	120	100
Rotavator	113	94
Cultivator	114	95
Mould board plough	30	25

Machinery used for sowing

The utilization pattern of machinery for sowing and planting operations reflects a selective adoption of mechanized tools among farmers in the study area. Seed drills and advanced seeding machines are commonly used, indicating a growing awareness of the benefits of precision sowing and efficient input use. However, the absence of planters suggests limited diversification in planting technologies, possibly due to factors such as cost, suitability to cropping patterns, or lack of awareness. Overall, the pattern highlights a gradual shift toward improved sowing technologies, while also indicating scope for further adoption and expansion of advanced planting equipment among farmers.

Machinery	Number of Farmers	Percentage (%)
Seed drill	42	35
Planter	0	0
Happy /super/ smart seeder	57	47.5

Machinery used for harvesting

The utilization pattern of harvesting machinery in the study area

shows a strong preference for combine harvesters, indicating a high level of mechanization in harvesting operations. Farmers tend to rely on integrated machines that can perform multiple functions efficiently, reducing labour requirements and saving time during peak harvesting periods. In comparison, the use of standalone equipment such as reapers and threshers is relatively limited, suggesting a gradual shift away from traditional and semi-mechanized methods. Overall, the pattern reflects increasing adoption of advanced harvesting technologies, driven by the need for efficiency, timeliness, and cost-effectiveness in farm operations.

Machinery	Number of Farmers	Percentage (%)
Combine Harvester	105	87.5
Reaper	36	30
Thresher	15	12.5

Machinery used for crop protection

The utilization of machinery for crop protection in the study area indicates a clear inclination toward mechanized spraying methods. Farmers are increasingly adopting power-operated sprayers due to their efficiency, better coverage, and ability to reduce labor and time compared to manual methods. However, the continued use of knapsack sprayers suggests that a segment of farmers still relies on conventional equipment, possibly due to factors such as lower cost, smaller landholdings, or ease of operation. Overall, the pattern reflects a gradual transition toward improved and efficient crop protection technologies, while traditional methods still maintain relevance among certain groups of farmers.

Machinery	Number of Farmers	Percentage (%)
Knapsack Sprayer	48	40
Power Sprayer	72	60

Factors Influencing Machinery Adoption

The adoption of farm machinery among farmers is influenced by a range of socio-economic and institutional factors that determine farmers' capacity and willingness to invest in mechanized technologies. Landholding size is considered one of the most significant determinants of machinery adoption, as farmers with larger operational holdings tend to adopt farm machinery more readily due to economies of scale and the need for timely completion of agricultural operations. Larger farm sizes enable farmers to spread the fixed cost of machinery over a greater area, making mechanization economically viable (Quan & Doluschitz, 2021) ^[6].

Similarly, farm income plays a crucial role in influencing mechanization decisions since the purchase, maintenance, and operation of farm machinery require substantial capital investment. Farmers with higher agricultural income or better financial resources are therefore more likely to adopt mechanized technologies to improve productivity and reduce production costs (Jena & Tanti, 2023) ^[2]. Educational level of farmers also contributes significantly to the adoption of agricultural machinery, as educated farmers tend to have better awareness of modern agricultural technologies and are more inclined to adopt innovative practices that enhance farm efficiency and productivity. In addition, availability of agricultural labour is another important factor influencing mechanization adoption. Increasing rural labour shortages and rising wage rates often encourage farmers to substitute manual labour with machinery to ensure timely farm operations and improve labour efficiency (Quan & Doluschitz, 2021) ^[6].

Furthermore, government support in the form of subsidies, institutional support, and mechanization programs plays a crucial role in accelerating the adoption of agricultural machinery by reducing financial barriers and improving farmers' access to modern equipment. Studies have shown that access to government subsidies and institutional support significantly enhances farmers' likelihood of adopting mechanized technologies (Ranabhat *et al.*, 2025) ^[7].

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