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Investment intensity in farm mechanization among paddy, cotton and maize farmers of Telangana: A comparative analysis

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ABSTRACT

Investment in farm mechanization is often treated as a direct indicator of technological advancement, yet the level of machinery use on a farm need not correspond to the value of machinery owned by the household. The present study examined the investment pattern of mechanized and non-mechanized farmers across paddy, cotton and maize production systems in Telangana. An ex-post facto design was followed in Jagtial, Nalgonda and Siddipet districts. The sample comprised 240 farmers, with 80 farmers representing each crop and 40 mechanized and 40 non-mechanized farmers within every crop group. Farmers using machinery in at least four major crop operations were treated as mechanized. Investment in farm mechanization was classified into five categories, from very low (Rs. 5,000-Rs. 3,64,000) to very high (Rs. 14,41,000-Rs. 18,00,000). The distribution was dominated by the very-low-investment category in both groups, but the concentration was consistently lower among mechanized farmers. Overall, 70.00 per cent of mechanized farmers were in the very-low category compared with 88.33 per cent of non-mechanized farmers. Medium investment accounted for 20.83 per cent of mechanized farmers and 9.17 per cent of non-mechanized farmers. Within the mechanized group, the medium-investment share was highest in maize (25.00%) followed by cotton (22.50%) and paddy (15.00%). Only 5.00 per cent of mechanized farmers and 0.83 per cent of non-mechanized farmers were in the combined high and very-high categories. A supplementary two-category comparison showed that 30.00 per cent of mechanized farmers, against 11.67 per cent of non-mechanized farmers, invested above the very-low category; The pattern points to a predominantly capital-light form of mechanization in which farmers make selective investments in affordable equipment while high-value ownership remains uncommon.

Keywords: Farm mechanization, Investment intensity, Machinery ownership, Paddy, Cotton, Maize, Telangana

Introduction

Farm mechanization is generally associated with timely field operations, relief from power bottlenecks and greater operational efficiency, but its economic meaning cannot be understood from machine use alone (Pingali, 2007; Rajkhowa *et al.*, 2021) [1, 2]. For farm households, an equally important question is how much capital is actually committed to machinery and related equipment. This distinction matters because machinery use and machinery ownership are not the same phenomenon. A farmer may mechanize several operations through hired services while owning only a few relatively inexpensive implements, whereas ownership of one high-value machine does not necessarily mean that the entire production process is mechanized. Studies from South Asia have similarly emphasized that access to machinery services can broaden mechanization beyond the relatively small group of farmers able to make large capital investments (Biggs *et al.*, 2011; Mottaleb *et al.*, 2017) [3, 4].

Investment therefore provides a useful window into the economic structure of mechanization. It indicates whether farm households are moving towards individual ownership of costly machinery, limiting purchases to frequently used equipment, or depending on rental and service markets for capital-intensive operations. Household-level evidence from India shows that ownership and investment in farm machinery vary markedly across farm and agro-ecological situations, while rental markets remain an important part of the mechanization process (Sarkar, 2020) [5]. Similar evidence from smallholder agriculture shows that the capital requirement of machinery can constrain ownership even when demand for mechanized operations is strong (Mottaleb *et al.*, 2016) [6]. Thus, when mechanized and non-mechanized farmers are compared, the difference in investment may appear as a gradual shift across investment classes rather than a simple contrast between machinery owners and non-owners.

The crop context can further shape this pattern. Paddy, cotton and maize differ in the sequence of operations, machinery requirements and timing pressure, and Indian studies have shown that the extent and form of mechanization are heterogeneous across crops, regions and production environments (Bhattarai *et al.*, 2018; Sarkar, 2020) [7, 5]. A crop-wise comparison can therefore reveal whether the investment profile is common

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across production systems or is being driven by a particular crop. In the present study, investment was examined separately for paddy, cotton and maize farmers and then pooled to understand the overall structure.

The paper addresses a focused empirical question: how is investment in farm mechanization distributed among mechanized and non-mechanized farmers, and what does that distribution reveal about the nature of mechanization in the study area? The analysis is intentionally centred on the study data. Rather than treating low ownership expenditure as equivalent to low mechanization, the paper interprets investment together with the operational classification of farmers. This approach is particularly relevant in Telangana, where custom-hiring arrangements have been promoted as a means of extending access to costly machinery without requiring every farmer to own the asset (Yugender Reddy *et al.*, 2022) [8]. The interpretation therefore remains grounded in the observed investment categories and in the field observation that many farmers invested first in relatively affordable equipment, whereas only a small proportion purchased tractors and other high-cost implements.

Objectives

- To describe the crop-wise distribution of mechanized and non-mechanized farmers across different investment categories.
- To compare the overall investment structure of mechanized and non-mechanized farmers

Materials and Methods

The study formed part of a broader investigation on farm mechanization in Telangana and followed an ex-post facto research design. Three districts were included for the selected crop situations: Jagtial for paddy, Nalgonda for cotton and Siddipet for maize. The analytical

sample consisted of 240 farmers. Each crop group contributed 80 respondents, comprising 40 mechanized and 40 non-mechanized farmers. Thus, the pooled comparison contained 120 mechanized and 120 non-mechanized farmers.

For classification purposes, farmers who used modern machinery in at least four major farm operations were treated as mechanized farmers; those using machinery in fewer than four operations were placed in the non-mechanized group. The classification was based on the extent of operational mechanization rather than on ownership of any single machine. This distinction was important for the present analysis because a farmer could use mechanized services without making a large private investment in machinery.

Investment in farm mechanization was recorded as the amount committed to machinery and related equipment and was grouped into five categories used in the study: very low (Rs. 5,000-Rs. 3,64,000), low (Rs. 3,64,000-Rs. 7,23,000), medium (Rs. 7,23,000-Rs. 10,82,000), high (Rs. 10,82,000-Rs. 14,41,000) and very high (Rs. 14,41,000-Rs. 18,00,000). Frequencies and percentages were calculated for each crop and for the pooled sample.

Results

Crop-wise investment pattern

The crop-wise distribution showed a common pattern across paddy, cotton and maize: the very-low-investment category remained dominant in both mechanized and non-mechanized groups, but its share was consistently smaller among mechanized farmers. The difference was therefore not a shift from low investment to widespread high-value ownership. Instead, mechanized farmers were more frequently represented in the medium category, with only a small fraction reaching the high or very-high categories.

Table 1. Crop-wise distribution of farmers according to investment in farm mechanization ($n = 240$)

Category	Paddy		Cotton		Maize		Overall	
	M	NM	M	NM	M	NM	M	NM
	($n = 40$)	($n = 40$)	($n = 40$)	($n = 40$)	($n = 40$)	($n = 40$)	($n = 120$)	($n = 120$)
	$f(\%)$	$f(\%)$	$f(\%)$	$f(\%)$	$f(\%)$	$f(\%)$	$f(\%)$	$f(\%)$
Very Low (Rs.5,000- Rs.3,64,000)	29 (72.50)	37 (92.50)	28 (70.00)	35 (87.50)	27 (67.50)	34 (85.00)	84 (70.00)	106 (88.33)
Low (Rs.3,64,000- Rs.7,23,000)	2 (5.00)	0 (0.00)	2 (5.00)	1 (2.50)	1 (2.50)	1 (2.50)	5 (4.17)	2 (1.67)
Medium (Rs.7,23,000- Rs.10,82,000)	6 (15.00)	3 (7.50)	9 (22.50)	4 (10.00)	10 (25.00)	4 (10.00)	25 (20.83)	11 (9.17)
High (Rs.10,82,000- Rs.14,41,000)	1 (2.50)	0 (0.00)	1 (2.50)	0 (0.00)	2 (5.00)	1 (2.50)	4 (3.33)	1 (0.83)
Very high (Rs.14,41,000- Rs.18,00,000)	2 (5.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	0 (0.00)	2 (1.67)	0 (0.00)
Total	40 (100.0)	40 (100.0)	40 (100.0)	40 (100.0)	40 (100.0)	40 (100.0)	120 (100.0)	120 (100.0)

Note: M = mechanized; NM = non-mechanized. Figures in parentheses are percentages.

Among paddy farmers, 72.50 per cent of the mechanized group fell in the very-low-investment category, compared with 92.50 per cent of the non-mechanized group. Medium investment accounted for 15.00 per cent of mechanized paddy farmers and 7.50 per cent of non-mechanized paddy farmers. Paddy was the only crop in which a very-high-investment category appeared, representing 5.00 per cent of mechanized farmers. No non-mechanized paddy farmer was recorded in the low, high or very-high categories.

Among cotton farmers, 70.00 per cent of mechanized farmers and 87.50 per cent of non-mechanized farmers had very low investment. The medium category contained 22.50 per cent of mechanized cotton farmers, more than twice the 10.00 per cent recorded among non-mechanized cotton farmers. High investment was confined to 2.50 per cent of the mechanized group, while 2.50 per cent of non-mechanized cotton farmers were in the low category.

The maize group showed the highest share of medium investment among mechanized farmers. Although 67.50 per cent still belonged to

the very-low category, 25.00 per cent were in the medium category and another 5.00 per cent were in the high category. Among non-mechanized maize farmers, 85.00 per cent were in the very-low category, 10.00 per cent in the medium category and 2.50 per cent each in the low and high categories. Thus, maize displayed the clearest movement away from the very-low category within the mechanized group, but even here high investment remained uncommon.

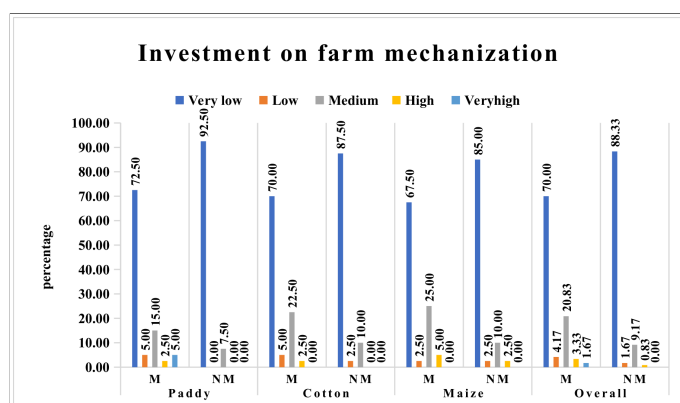


Figure 1. Distribution of farmers according to their investment on farm mechanization

Pooling the three crop groups reinforced the same pattern. Seven out of every ten mechanized farmers were still in the very-low-investment category, but this proportion was substantially lower than the 88.33 per cent observed among non-mechanized farmers. The main redistribution occurred in the medium category, where 20.83 per cent of mechanized farmers were represented compared with 9.17 per cent of non-mechanized farmers. High and very-high investment together accounted for only 5.00 per cent of mechanized farmers and 0.83 per cent of non-mechanized farmers.

The overall difference is clearer when the distribution is read as a shift in intensity rather than as a contrast between ownership and non-ownership. The share of farmers above the very-low category was 18.33 percentage points higher in the mechanized group (30.00% versus 11.67%). Across individual crops, the corresponding gaps were 20.00 percentage points in paddy, 17.50 percentage points in cotton and 17.50 percentage points in maize. The consistency of these gaps indicates that the pattern was not dependent on a single crop group.

Discussion

The strongest feature of the data is the coexistence of mechanization with low private capital investment. Mechanized farmers invested more than non-mechanized farmers in relative terms, but the distribution did not shift towards widespread high-value ownership. Seventy per cent of mechanized farmers remained in the very-low category, and only five per cent occupied the high and very-high categories combined. The contrast between the groups therefore lies mainly in the movement from very low to medium investment, not in a broad transition to the upper end of the investment scale. This finding is consistent with the wider distinction made in mechanization research between access to mechanical power and ownership of the machinery that supplies it (Binswanger, 1986; Sarkar, 2020) [9, 5].

This distinction is important for interpreting the meaning of mechanization in the study area. The field observation accompanying the original table indicated that many farmers had invested primarily in relatively affordable equipment such as sprayers and drip or sprinkler irrigation systems. Only a small proportion had invested in tractors and other modern implements because of the high initial cost. Read together with the operational definition of mechanized farmers, this suggests that mechanization was often achieved through a mixed pathway: selective ownership of lower-cost assets combined with access to more expensive machinery without necessarily purchasing it. Such a pathway is economically plausible in smallholder settings, where machinery-service markets and custom hiring can spread ma-

chine use while reducing the capital burden associated with individual ownership (Parray *et al.*, 2016; Mottaleb *et al.*, 2017; Parashunath *et al.*, 2018) [10, 4, 11].

The crop-wise results add another layer to this interpretation. The medium-investment category among mechanized farmers increased from 15.00 per cent in paddy to 22.50 per cent in cotton and 25.00 per cent in maize. Yet the upper investment categories remained thin across all three crops. In paddy, a small 5.00 per cent segment reached the very-high category, while no cotton or maize farmer did so. This concentration at the lower and middle parts of the investment distribution indicates that crop-specific machinery needs may influence how farmers allocate capital, but the basic structure of selective rather than heavy ownership is common across the study. The result also agrees with the broader Indian evidence that machinery use and investment are not uniform across crops and agro-ecological regions (Bhattarai *et al.*, 2018; Sarkar, 2020) [7, 5].

The non-mechanized group also deserves careful interpretation. A very-low-investment share of 88.33 per cent does not mean that these farmers had no machinery exposure. The study classification was based on the number of operations mechanized, not on complete absence of machinery use. The data therefore capture a continuum: some non-mechanized farmers made modest investments or used machinery in a limited number of operations, while the mechanized group used machinery more extensively and, on average, showed a stronger movement into the medium and higher investment categories. This continuum is consistent with the service-based character of mechanization observed in South Asian smallholder agriculture, where farmers may obtain machine services without owning the corresponding equipment (Biggs *et al.*, 2011; Mottaleb *et al.*, 2016) [3, 6].

Implications from the study

The findings show why mechanization and machinery ownership should be treated as separate indicators. In this sample, extensive machinery use could coexist with very low private investment. Future assessments of mechanization in similar settings should therefore record both the number of operations mechanized and the manner in which machinery is accessed, an approach that is also supported by the literature distinguishing machinery ownership from hired or service-based access (Sarkar, 2020; Mottaleb *et al.*, 2017) [5, 4].

The dominance of the very-low and medium categories suggests that farmers were selective in committing capital. For high-cost machinery, strategies that improve timely access may be more relevant than assuming that every farm household should own the asset. The data do not by themselves identify the best institutional model, but they clearly show that high-value individual ownership was not the dominant route to mechanization in the study area. Evidence from India and Telangana likewise points to custom hiring as one practical route for improving access to machinery where individual purchase is constrained by capital requirements (Parray *et al.*, 2016; Yugender Reddy *et al.*, 2022) [10, 8].

The crop-wise differences also indicate that investment support should not be designed as a uniform package. Maize and cotton mechanized farmers showed a larger medium-investment share than paddy farmers, whereas only paddy contained a very-high-investment segment. Any programme intended to influence farm-level investment would benefit from considering the operation-specific machinery requirement of each crop rather than applying the same ownership expectation across production systems.

Conclusion

The study presents a clear picture of investment intensity behind farm mechanization in three major crop situations of Telangana. Mechanized farmers were less concentrated in the very-low-investment category and more strongly represented in the medium category than non-mechanized farmers. This pattern was consistent in paddy, cotton and maize. Even so, high and very-high investment remained rare, and 70.00 per cent of mechanized farmers continued to fall within the very-low category. The evidence therefore does not support

a view of mechanization as a simple transition from low investment to widespread ownership of expensive machinery. Instead, the observed pathway was predominantly selective and capital-light. Farmers appeared to invest first in affordable, frequently used equipment, while high-cost ownership was confined to a small minority. For research and programme planning, the key lesson is to distinguish machinery use from machinery ownership and to recognize that meaningful mechanization can occur without equally large private capital investment.

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