Indian Journal of Agricultural Economics 81: 2(2026):373-389
DOI:10.63040/25827510.2026.02.012

RESEARCH NOTE

Composition and Determinants of Farm Investment in Indian Agriculture: Evidence from 77th Round NSSO Situation Assessment Survey

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ABSTRACT

Agrarian growth is essential for food security as well as poverty reduction in developing countries. Investment in agriculture is one of the major determinants of growth. This paper analyses the composition and determinants of farm investment among agricultural households in India, in the context of increasing in tenancy and occupational diversification of households. We have utilized unit-level data of 77th round NSSO Situation Assessment Survey and used Heckman selection model for exploring the determinants of farm investment, particularly agricultural machinery. The finding reveals occupational diversification facilitates reinvestment into farm investment, but not in machinery. Whereas, cultivator households and mixed tenants have potential to invest in productivity-enhancing investment. The findings of the study have implications on food security, poverty reduction and ultimately on growth.

Keywords: Agricultural Household, Farm Investment, Agricultural Machinery, Tenancy, Diversified Household, Situation Assessment Survey

JEL Code: Q12, Q15, D92, R11, O13

I
INTRODUCTION

In developing countries like India, agrarian growth is essential not only to meet the food needs of the economy, but also to reduce poverty. A one per cent growth in the agriculture sector is two to three times more effective in reducing poverty than a corresponding growth in non-agriculture sector (World Bank, 2008). However, the growth of agriculture depends on various factors such as public policy related to incentives and subsidies to farmers, technology (seed and fertilizer), infrastructure and irrigation. In particular, investment in agriculture is considered one of the major determinants of output growth (Shah & Agarwal, 1970; FAO, 2013).

Investment in agriculture is generally undertaken by three stakeholders in an economy, namely, public sector, farm households and corporate agro-industries. In India, however, agricultural investment is primarily driven by private investment, especially individual (farm households). According to FAO (2013) farming community is the largest investor in agriculture, allocating resources towards land improvement, machinery, irrigation equipment and livestock for enhancing its income. As pointed out by studies like Dev (2011), Chaturvedi & Bagchi (1984), Bisaliah et al., (2015) nearly two-thirds of the investment in agriculture is accounted for private sector, particularly on-farm investment. These investments are typically financed by personal savings and/or borrowing from different sources.

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Public investment though the second most source of agricultural investment, (FAO, 2013) constitutes only 20% of the total agricultural investment (Bathla & Kumari, 2017). However, it plays a critical role in stimulating private investment and rural poverty alleviation (Fan, 2008; Roy & Pal, 2002). There exists a non-substitutable relationship between public and private investment, as the nature of investment differ significantly. For example, a significant portion of public investment is directed towards the development of irrigation, power, roads and other rural infrastructure, and such production-facilitating role cannot be played by either farm households or agro-industries. Corporate agro-industries are not yet a significant player in the Indian economy and are primarily involved in post-harvest activities like high value chain.

The available investment literature has focused on the trends in public and private investment in agriculture. Several studies have examined the interlinkages between the two in terms of whether public investment stimulates or discourages private investment (Akber and Paltasingh, 2019; Kumar et al., 2020). However, there exists a limited set of literature on analysis of investment behaviour at the household level (Meher, 2010; Bathla & Kumari, 2017; Jamaludheen, 2022). Understanding household-level investment decision is important, as it focuses on production-enhancing role of investment. Based on All-India Debt Investment Survey (AIDIS) data for the period from 1981-82 to 2012-13, Bathla & Kumari (2017), while analyzing the composition of agricultural investment at the household level, observed a shifting investment behavioral pattern of rural households from farm business towards residential buildings. Although the study relies on household-level data, the analysis is aggregated across time and states, using macro level determinants of private investment. As a result, the study is more useful in understanding the macro trends in agricultural investment rather than household-level decision-making. FAO (2013), while reviewing case studies with respect to several countries, found household savings, income and remittances, property rights, farm size and human capital (education) as the drivers of household level investment decision. However, these variables have not been examined empirically. Jamaludheen et al. (2022), while analysing the data from NSSO 70th round as part of understanding the composition and determinants of investment by agricultural households, observed that a major share of expenditure was accounted for by other productive assets (land), followed by agricultural machinery. Using Heckman model, the study found that households characteristics like caste, access to credit, crop income and land possessed were the key determinants of investment. A recent study by Akber et al., (2024) while examining impact of land on farm-level investment using 77th round unit level SAS data, identified non-farm income and land tenure security, MSP awareness and market orientation as the major determinants of farm investment. These studies have focused on farm investment. However, farm investment has three components namely, land, livestock, and agricultural machinery. Therefore, this article intends to bridge this gap and identify nature and composition of investment and household-specific characteristics, which influence household level decisions.

The agrarian sector of the Indian economy has witnessed two important changes over time. One, there has been an increase in tenancy, both in terms of the share of land under tenancy as well as the share of tenant households. The other is the growing importance of diversified (or mixed) households. Recent studies (Murali & Vijay, 2017; Bansal et al., 2018) have shown the rising prevalence of tenancy contracts in rural areas as well as irrigated areas. Tenancy can be either a 'growth inducing' or 'growth retarding' institution. Bansal (2020) in his paper argues that agrarian accumulation in Punjab is primarily tenancy-driven. This raises an important question: does this form of contract have an impact on investment? In addition, there is an increasing evidence that agricultural households have diversified to non-farm sectors. Studies like Bhue and Vijay (2018) and Abraham (2024) have observed a decline in the share of farm households and a corresponding rise in the non-farm and mixed households. Does diversification provide an incentive to households to invest in agriculture? Does a non-covariate income stream induce more investment or restrict the investment as households are trying to move out of agriculture?

Given the importance of household investment, the present exploratory study examines the composition and determinants of agricultural investment, with a particular focus on investment in farm business and modern machinery. The study attempts to address the following research questions: What is the nature and composition of agricultural investment? What factors influence farm investment at the household level? Does household characteristics like diversification influence investment? In other words, do households that diversify into non-farm activities reinvest more in agriculture as compared to cultivator households? In addition to that, does access to land through tenancy influence investment? Also, the study examines the importance of landownership with respect to investment. The paper is divided into seven broad sections, including this introduction section. Section 2 outlines the methodology followed by the study. Section 3 analyses the composition of agricultural investment. Section 4 details the classification of households. Sections 5 and 6 explain the factors that influence farm investment and results and discussion respectively, followed by conclusions in the last section.

II

DATA SOURCE

To examine the composition and determinants of farm business investment in productive assets, we have utilised unit level data from the 77th round (January 2019 – December 2019) of the Situation Assessment Survey (SAS) of Agricultural Households, conducted by NSSO. Although several national and global data sources are available such as FAOSTAT, NABARD and AIDIS, they differ in terms of coverage and relevance to the objective of the study. For instance, based on inventories of agricultural assets, FAO estimates on-farm capital stock and provides cross-country data for 206 countries, but lacks household-level data required for the study. Similarly, All India Rural Financial Inclusion Survey (NAFIS), conducted by NABARD provides

data on agricultural investment by rural households across India. It collects information on investment under two heads: financial assets (investment in banks and share/bonds markets) and physical assets (investment in house, livestock, agricultural equipment). AIDIS has advantage of covering both rural and urban areas, with a primary focus on household assets, liabilities and debt, and less on agricultural specific analysis. In contrast, SAS is specifically designed to capture the economic condition of agricultural households. It provides a detailed information on their income and expenditure (including investments), landholding size, tenure of leased land and crop specific data, making it one of the most appropriate data sources for the present study.

The SAS data set captures agricultural households' expenditure on productive assets while excluding non-agricultural households. Agricultural household is defined as a household receiving more than Rs. 4000/- from agricultural activities, with at least one family member being self-employed in agriculture either in the principal status or in subsidiary status during the last 365 days. Therefore, the study considered 44,770 common agricultural household of visit 1 and visit 2, which is 54% of total households surveyed.

2.1 Composition of Investment by Agricultural Households

The investment related information provided by SAS can be broadly grouped into three categories i.e., productive assets for farm business (FB), productive assets for non-farm business (NFB) and residential building, including land (RLB). Investment in farm business includes expenditure on purchase of agricultural land, expenditure on land leveling and land improvement, livestock, agricultural machinery, etc. Investment in Non-farm business consists of expenditure on land and building, machinery and equipment used for non-farm activities.

Overall, around 62% of the rural households are investing on these assets. Among these, farm business is the most preferred component (Table 1), with 60% of the households investing as compared to less than 5% in RLB (4%) and NFB (2.6%). A look at the share of total expenditure on these assets indicates that farm business continues to account for a major chunk (73%). However, this finding contradicts[2] Bathla & Kumari (2017), whose study found a major share of expenditure being on RLB followed by FB. When average expenditure is considered, farm business accounts for lowest share, with residential land and building dominating. This shows the importance of land in terms of average expenditure and also of non-farm business. There are very few households investing on these assets. Perhaps a high average price prevents some households from purchasing these assets. In other words, a large portion of households buy relatively low-value farm assets, but land continues to be a preferred

[2]The study used AIDIS 2012-13 data for rural households, whereas our analysis is based on SAS, 2018-19 data for agricultural households only. Additionally, our calculation method differs, we have multiplied the weighted number of investing households and average expenditure of investing households to arrive at the total expenditure.

asset; if one has the purchasing power in the rural economy, these households look to be purchasing land.

TABLE 1. DISTRIBUTION OF HOUSEHOLD INVESTMENT BY COMPONENTS AND SHARE

Components	% HH investing[3]	Average expenditure per investing HH(Rs.)	% Share in total expenditure
Residential Land Building (RLB)	4 %	38,458	22
Farm Business (FB)	60.2%	8,340	73
Non-farm Business (NFB)	2.6%	13,368	5

Source: Authors' calculation from the unit level data of NSSO 77th round SAS

Since farm business is the most commonly invested asset in the rural areas, what kind of farm business assets do agricultural households buy? The survey records ten components of farm business and these are expenditure (and major repair/improvement on land), building for farm business, livestock, poultry, expenditure on traditional equipment (sickles, axes, spades, choppers, ploughs, and harrows), tractor-harvesters, thresher-crusher, irrigation equipment and other assets such as furniture & fixtures, exclusively used for farm business. For analysis, we have classified farm business into three components: land and building for farm business, livestock and agricultural machinery.

TABLE 2. DISTRIBUTION OF AGRICULTURAL INVESTMENT BY COMPONENTS AND SHARE

Components	% of HH investing[4]	Average expenditure per investing HH (Rs.)	% Share in total expenditure	Average expenditure (Rs.) per acre
Land[5]	4.7	55,738	32.2	17,963
Livestock	7.9	24,389	23.4	13,832
Agricultural machinery	96	3,803	44.3	1,080

Source: Authors' calculation from the unit level data of NSSO 77th round SAS
Note: Base= Number of agricultural households investing in farm business

Table 2 shows that majority (96%) of agricultural households are investing in agricultural machinery, while less than 8% are investing in livestock, followed by land (4.9%). Despite a low proportion of households investing in land, the average expenditure on land is approximately 15 times higher than that on machinery. At the

[3]As agricultural households often invest in multiple components simultaneously, the summed percentages may not add up to 100% in all the tables.
[4]Except for table 1, the percentage of households investing is calculated using the number of agricultural households investing in farm business only as the base (denominator).
[5]Expenditure on land constitute purchase of land for the agricultural purpose only, as well as expenditure on land leveling and land improvements.

same time, a comparatively lower cost of machinery encourages a large proportion of households to invest in it as a means of enhancing production and sustaining their livelihoods.

Agricultural machinery is the most important essential component of farm investment and this makes it particularly interesting to analyse in detail by breaking it down into its key categories. Based on the information collected on machinery, we have classified it into four major components: (1) expenditure on traditional tools, including sickles, axes, spades, choppers, ploughs and harrows; (2) expenditure on mechanized equipment such as power tillers, tractors, combined harvesters, threshers and crushers; (3) expenditure on irrigation equipment and (4) expenditure on other types of machinery. Given that the classification of machinery is not homogeneous, as it includes modern machinery as well as traditional machinery, a component-wise analysis can provide a better understanding of investment on different types of machinery.

TABLE 3. DISTRIBUTION OF AGRICULTURAL MACHINERY BY COMPONENTS AND SHARE

Components	% HH Investing	Avg exp per investing HH (Rs.)	% share in the total exp
Traditional machinery	93.3%	777	20%
Tractor-harvester	5.5%	32,119	50%
Irrigation equipment	13%	6,834	25%
Other machinery	8.2%	2,040	5%

Source: Authors' calculation from the unit level data of NSSO 77th round SAS

Table 3 shows more than 90% of agricultural households investing in traditional machinery, while around 5.5% are investing in modern machinery such as tractors, harvesters etc. and as expected, the average expenditure on traditional equipment is lowest and expenditure on modern machinery is highest. In between traditional and modern machinery, comes irrigation and other equipment. One possible explanation for a higher share of traditional equipment could be labour supplying households also need their own instruments to be able to transact in the labour market. So, in a sense labour and instruments (traditional) can be visualized as a clubbed good. Given the low life cycle of these goods, households need to purchase these goods. So, even though these instruments are seen as machinery/capital they might not be having a productivity enhancing impact.

2.2 Classification of Agricultural Households (Diversified and Tenant)

2.2.1 Diversified (Mixed) Households

Following the Green revolution and economic liberalization in the late 1980s, rural India has witnessed significant changes. One major change observed is the increasing importance of rural non-farm sector and diversification of farm households

into non-farm households. Livelihood diversification can be either necessity-driven, as a response to distress or choice-driven, to take advantage of new opportunities and increase income (Ellis,1998; Rajak, 2025). Small and marginal farmers may diversify their income for food security and poverty reduction, whereas, medium and large farmers tend to diversify income as a wealth creation strategy (Sharma et al., 2022). Several studies have classified households into three types i.e., farm, non-farm and mixed households (Bhue & Vijay, 2018; Mandela & Niyati, 2020; Abraham, 2024). Bhue & Vijay (2018), using AIDIS data, observed a decline in the share of farm households (62% to 52%) and a corresponding rise in the non-farm and mixed households (25.4% to 28.3%) and mixed households (12.5% to 13.8%) between 2003 and 2013. Abraham (2024), using EUS and PLFS data, reported a similar trend up to 2017-18. Agricultural households declined from 66.1% to 51%, non-agricultural households increased from 21.8% to 36.8% and mixed households marginally increased from 11.6% to 12.1% between 1999-2000 and 2017-18. However, between 2017-18 to 2023-24 agricultural households slightly declined from 51% to 49.7%, non-agricultural households witnessed a decline of around 10% from 36% to 25% and interestingly the share of mixed households increased almost doubled from 12% to 25%. Using the same data set Mandela & Niyati, (2020) also found similar kind of result. Between 1993-94 to 2017-18 agricultural households declined from 67% to 48%, non-farm households increased significantly from 18% to 37% and diversified households marginally declined from 14% to 13.6%.

To analyse the composition of rural households, we have followed the household classification method used by Bhue and Vijay (2018). The 14 different types of principal activity status provided by NSSO, are used for distinguishing working and non-working members. Among the working population, seven principal activities are considered as employed: working in household enterprise either as own-account worker, as an employer, as a helper, as a regular salaried/wage employee, as a casual wage labourer in the public works (both under and outside of MGNREGS) and other types of work. Individuals engaged in these categories are classified into farm and non-farm activities using National Industrial Classification (NIC) codes provided in the unit-level data. If principal activity of all the household members is in farm sector, it is classified as cultivator household. If all the household members are primarily engaged in non-farm sector, it is classified as non-farm household. When at least one member's primary activity is found in non-farm sector, we have considered it as diversified household. Using the 2018-19 situation assessment survey data, our estimates[6] found the share of cultivator households, non-farm households and diversified households as 54%, 30% and 16% respectively. This classification helps us to understand how occupational diversification influences agricultural investment. Table 4 presents a comparison of cultivator and diversified households in terms of agricultural investment and landholding.

[6]This estimate includes both agricultural households as well as non-agricultural households

Table 4 shows that 78% of agricultural households are cultivators, while only 22% are diversified households. Basic information of expenditure on farm investment and agricultural machinery is presented in the above table. Average expenditure on farm investment is higher (Rs. 10,668) for diversified households as compared to cultivator households (Rs. 8,218). However, average expenditure on agricultural machinery is less for diversified households (Rs. 3,336) as compared to cultivator households (Rs. 4269). Average land owned by cultivator households is slightly higher than that of diversified households. Diversified households have a larger family size (5.9), compared to the cultivator households, which indicates a possible link between family size and occupational diversification.

TABLE 4. PROFILE OF AGRICULTURAL INVESTMENT BY HOUSEHOLD TYPE

HH Type	Cultivator	Diversified
No. of HH	30,997 (78%)	9,127 (22%)
Percentage of HH investing FB	62.0	59.6
Average Exp on FB (Rs.)	8,218	10,668
Percentage of HH investing agricultural machinery	60.4	57.1
Average Exp on machinery (Rs.)	4,269	3,336
Average land owned (acre)	3.1	2.7
Average family size	4.6	5.9

Source: Authors' calculation from the unit level data of NSSO 77th round SAS

2.2.2 Tenant Households

The period since 2002-03 has also witnessed a steady rise in tenancy (Murali & Vijay, 2017; Bansal et al., 2018). The share of tenant holding has nearly doubled during this period, increasing from 9.9% to 17.8% by 2018-19. . This trend highlights the increasing importance of tenancy as a mechanism for land access, especially in the context of land fragmentation, rural outmigration and emerging "non-cultivating peasant households" (Bhue & Vijay, 2012). Tenancy allows landless and marginal farmers to participate in agricultural activities without owning land. Which could contribute in improving land utilization, and rural livelihood. However, tenant households are not a homogeneous group in that they differ significantly in terms of resource access, livelihood security and incentive when it comes to investing in agriculture. we have classified them into three groups: pure tenant and mixed tenants and owner cultivator. Pure tenants are defined as households that do not own land and cultivate exclusively on leased land, while owner cultivators are those who operate solely on their own land. Households that own land and also operate on leased land, we have classified it as mixed tenant.

Table 5 shows that majority (82%) of agricultural households are owner cultivator, while mixed tenants and pure tenants constitute 10.4% and 7.2% respectively. Mixed

tenants tend to invest more[7] compared to owner cultivator and pure tenants. This suggests that although fewer mixed tenant households invest, those who do tend to invest more intensively. In terms of landholding, mixed tenants operate largest average area than the other two categories.

TABLE 5. PROFILE OF AGRICULTURAL INVESTMENT BY TYPES OF TENANT HOUSEHOLDS

Tenant HH	Owner cultivator	Pure Tenant	Mixed Tenant
No. of HH	34,301 (82.4%)	2,810 (7.2%)	4,445 (10.4%)
Percentage of HH investing in FB	62.2	55.1	64.6
Average Exp on FB (Rs.)	7,725	4,635	14,496
Percentage of HH investing in agri machinery	60.3	52.1	62.1
Average Exp on machinery (Rs.)	3,612	1,638	6,327
Average land operated (acre)	3.2	2.1	5.0
Average land owned (acre)	3.2	-	2.1

Source: Authors' calculation from the unit level data of NSSO 77th round SAS

2.3 Factor Influencing Farm Investment

The study aims to explore the determinants which influence the extent of farm investment. At the household level, several factors tend to influence farm investment decisions. These include land size, irrigated area, agricultural income, household size, availability of credit, etc. Studies based on NSSO data have highlighted irrigation as a critical determinant of agricultural investment (Bathla & Kumari, 2017). For instance, development of canal irrigation showed positive influence on farmer's investment decisions in terms of purchase of implements and machinery for the year 1981-82 (Dhawan & Yadav, 1995). A village-level study in Odisha also confirms this finding that canal irrigation induces private investment (Meher, 2024). Institutional credit has also been found to have had a positive and significant impact on agricultural investment (Bathla & Kumari, 2017; Khaund 2002). A recent study by Jamaludheen et al. (2022), based on the 70th round NSSO, SAS data, found caste, access to credit, crop income, and landholding size as the key determinants of investment in productive assets. At the farm level, studies show that land size is the key variable that influences investment. Large farmers tend to invest more as compared to small farmers (FAO, 2013; Meher,

[7]This could be because of state specific effect, as 92% of mixed tenants households are investing in farm business in Punjab, in contrast to around 52% in Bihar.

2024; Jamaludheen et al., 2022). Several studies have pointed out property rights as an important variable in determining investment (FAO, 2013; Akber et al., 2024).

Drawing on the literature, we have used irrigated area, institutional loan (log), land ownership, tenancy as variables for analysing farm investment at the household level. While several studies have used either land ownership or operated area as land variable, this study uses per capita land ownership, as total landholding perse may be misleading in terms of accounting for household size. Thus, per capita land owned can be taken as a better indicator of investment. Household characteristics like diversification of households, access to land through tenancy are important determinants of farm investment, yet such households characteristics have received a limited attention in the literature. Akber et al. (2024), while attempting to address this gap, constructed an index of land tenure security, that varied from 0 (pure tenant) and 1 (owner-operator), and also by including non-farm income as one of the determinants. In our study, we have classified tenant households into three categories: owner cultivator, pure tenant and mixed tenant for capturing the heterogeneity of tenure arrangement. Furthermore, we have categorized households into cultivator and diversified, based on their engagement in farm and non-farm sector.

Given the two categories of agricultural households i.e., investors on productive assets (60%) and non-investors (40%) comparing the key variables across the two groups is essential for understanding the factors that drive investment decisions at the household level.

TABLE 6. SUMMARY STATISTICS OF KEY VARIABLES

Variables	Investor	Non-investor	
	Mean (Std. Dev)	Mean (Std. Dev.)	Test statistics
Irrigated area (acre)	1.7 (3.1)	1.2 (2.3)	-17.65***
Per capita land owned (acre)	0.85 (1.148)	0.77 (1.10)	-0.072***
leased in area (acre)	0.61 (2.6)	0.44 (1.9)	-7.45***
Amount of institutional loan (Rs.)	60460 (147751.9)	52121 (135493.9)	-6.19***
Cost of hiring machinery (Rs.)	5627.4 (9353.5)	3941.9 (7962.1)	-20.54***
Household type			11.19***
Cultivator	58.8	41.1	
Diversified	56.8	43.1	

Source: Authors' calculation from the unit level data of NSSO 77th round SAS
Note: *** denotes significance at 1% level

It is evident from the summary statistics (Table 6) that there exist clear differences between investor and non-investor agricultural households. Variables such as irrigated area, leased in land, per capita land own, amount of institutional loan accessed are significantly higher among investor households. These comparisons,

based on t-test (for continuous variables) and Chi-square test (for categorical variables), provide an initial understanding of the factors influencing investment behaviour.

2.4 Empirical Analysis

Investment in farm business involves a two-stage process: (1) the decision to invest; and (2) the amount to be invested. Farmers first decide whether to invest or not (i.e. binary choice) and then decide on the amount to be invested. If Ordinary Least Square (OLS) regression is applied to the sub-sample of investor households, the results are likely to suffer from selection bias. As the investment behaviour of non-investor households is systematically excluded from the analysis, regression estimates, based on the observed sample only, will be biased and inconsistent. This is because the decision to invest is likely to be influenced by variables such as household type, landholding size, access to credit, irrigation etc., which may also affect the level of investment.

To address the issue, we have used Heckman Selection Model (Heckman, 1979), which has also been applied by Jamaludheen et al. (2022), as it offers a robust framework for correcting selection bias arising from non-random missing data. There exist several alternative models such as Tobit model and Two-part (hurdle) model. Tobit model treats investment decision and investment level as outcomes of a single underlying process and does not handle missing data, whereas, two-part model is suitable for large number of zeros and skewed distributions, but assumes independence between the two stages. Heckman selection model is more appropriate for our study, as it not only distinguishes between the decision to invest and the amount to be invested, but also statistically corrects for selection bias, and ensures a consistent and unbiased estimation of the determinants of farm investment.

2.5 Model Specification

First stage (selection equation - decision to invest) is specified as

$$Y_{2i}^{*} = Z_i \gamma + \mu_i$$

$$Y_{2i} = \begin{cases} 1 & if\ \ Y_{2i}^{*} > 0 \quad (Investor) \\ 0 & otherwise\ (non-investor) \end{cases}$$

Second stage (outcome equation – Level of investment) is specified as

$$Y_{1i} = X_i \beta + \in_i ,\ \text{observed only if } Y_{2i} = 1$$

Where,

Y_{2i}^{*}= latent variable behind selection decision
Y_{2i}= Binary indicator of investment decision

Y_{1i}= Amount of farm investment
Z_i =household/ structural characteristics influencing decision (e.g. household type, irrigated area, access to loans)
X_i =determinants of investment level
$\mu_i, \in_i$= error terms, assumed jointly normally distributed with correlation ρ

The correlation between $\mu_i \; and \; \in_i$, captures the selection bias. If $\rho \neq 0$, OLS estimates would be biased; the Heckman model corrects this by incorporating the inverse Mills ratio from the first stage into the second stage regression.

III

RESULTS AND DISCUSSION

In this study, we analyze the factors influencing farmers' decisions regarding investment in farm businesses using the Heckman selection model. Table 7 presents the results of this analysis. Two separate models are estimated: one for overall farm business investment and the other specifically for investment in agricultural machinery.

Each model consists of two equations: outcome equation estimating the level of investment (measured in logarithms) and selection equation estimating the probability of investment participation (binary- yes, no). The dependent variables used in the models are the log of total farm investment and the log of investment in agricultural machinery. The significant rho value (correlation coefficient) positive for farm investment ($\rho = 0.95$, $p < 0.01$) and negative for machinery adoption ($\rho = -0.13$, $p < 0.05$) confirms the selection bias while validating the use of Heckman model. Robust standard error has been estimated to eliminate heteroscedasticity. The mean of all independent variables' variance inflation factor is 1.81 and 1.80 in both the models, indicating the absence of multicollinearity. In this study, we have used cost of hiring machinery as the exclusion variable. This variable is expected to influence household's decision on whether to invest in agriculture, particularly machinery, as a higher cost may induce households towards ownership. However, once the decision is made, the level of investment is assumed to depend on other factors, not directly on hiring costs. This makes machinery hiring cost a valid exclusion restriction.

In the selection equation, the exclusion variable cost of hiring machinery strongly influences both the models. The coefficient is positive and highly significant at 1% level of significance in farm investment (4%) and even stronger in machinery model (5%). This indicates that households facing higher rental costs are more likely to invest in machinery, reducing their reliance on hiring. The selection equations reveal that the likelihood of households investing in both overall farm investment and agricultural machinery is influenced by infrastructure access, household characteristics and tenure arrangement. Irrigation access increases the likelihood of investment participation in both the domains, reflecting the complementary role of infrastructure. Family size increases the probability of investment participation, reflecting both

greater labour availability and the ability of combined household resources. In contrast, cultivating leased-in land substantially reduces the probability of investment. Training received by households exhibits a positive coefficient in both the equations, but is statistically not significant, indicating that information alone may not be sufficient to induce investment. Per capita landholding significantly predicts farm investment, but not significantly machinery investment. Similarly access to institutional credit positively influences farm investment, but it does not predict machinery investment.

TABLE 7. DETERMINANTS OF AGRICULTURAL INVESTMENT: RESULTS OF HECKMAN MODEL

Variables	Farm investment	Agri machinery
Outcome Equation (Dependent Variable)	Farm investment (log)	Machinery (log)
Household type (Diversified household)	0.069*(0.039)	0.044 (0.037)
Per capita land owned	0.528***(0.070)	0.463***(0.03)
Per capita land owned square	-0.033***(.004)	-0.030***(.002)
Irrigated area	0.095***(0.010)	0.108***(.010)
Tenancy group (Pure Tenant)	-0.375***(0.091)	-0.239***(.066)
Tenancy group (Mixed Tenant)	-0.199*** (0.070)	0.013 (.746)
Institutional loan (log)	0.040***(0.004)	0.031***(.002)
Family size	0.133***(0.010)	0.056***(.007)
Constant	4.197*** (0.0513)	5.811***(.070)
Observation	22,467	21,680
Selection Equation (Dependent Variable)	Farm Investment (0,1)	Machinery (0,1)
Training in agriculture (1=yes, 0=otherwise)	0.063 (0.051)	0.050 (0.093)
Cost of hiring machinery (log)	0.022**(0.002)	0.064***(.003)
Per capita land owned	0.068**(0.035)	0.025(.025)
Leased in dummy (1=yes, 0=otherwise)	-0.194***(0.034)	-0.273***(.032)
Irrigation dummy (1=yes, 0=otherwise)	0.104***(0.018)	0.100***(.027)
Institutional credit dummy (1=yes, 0=otherwise)	0.066***(0.026)	-0.053**(0.260)
Family size	0.048***(0.005)	0.046***(.005)
Constant	-0.435*** (0.11)	-0.619**(0.186)
Observation	41,555	41,832
Rho	0.95***	-0.13***

Notes: Robust standard errors in parenthesis
Significance level: *** 1%, ** 5% and * 10%

Regression result (Outcome equation) reveals that diversified households invest about 7% more in overall farm business as compared to cultivator households, at 10% level of significance. Similar kind of results found by Akber et al. (2024) and Zeeshan et al. (2021) indicate that access to non-farm income positively impacts farm investment. For agricultural machinery, the coefficient is positive (4.6%), but is not statistically significant. It indicates that occupation diversification facilitates

reinvestment in agriculture, but not necessarily machinery. Per capita landholding strongly and positively affects both the outcomes. A one- unit increase in per capita land owned raises farm investment by about 69% and agriculture machinery by 59%, both significant at 1% level. A Similar relationship between landholding and investment has been documented in the earlier studies in that large farmers invest more than small farmers (FAO, 2013; Meher, 2024; Jamaludheen et al., 2022). However, the squared term is negative for both the models (-0.033 and -0.030, respectively), indicating an inverted U-shaped relationship. It shows that as per capita land owned increases, investment also increases, but after a threshold, it starts declining. One potential reason could be that large land owners might already have modern machinery. In other words, moderate landholdings are more conducive to increased investment, while very small or very large per capita holdings may reduce the incentive to invest more. A one-unit increase in irrigated area increases investment by 10.1% at 1% level of significance. For machinery investment, the effect is slightly larger at 11.4%. This highlights that a secure water access creates a stronger potential to induce investment in machinery. This result is consistent with the previous studies (Bathla & Kumari, 2017; Dhawan & Yadav, 1995; Meher, 2024; Akber et al., 2024). Access to institutional loan increases both types of investment. The coefficient of log institutional loan is 0.04 for farm investment and 0.03 for machinery. A 1% increase in loan amount raises farm investment and machinery by 0.04% and 0.03%, respectively, both significant at 1% level. Similar conclusions have been drawn by Bathla & Kumari, (2017), Jamaludheen et al. (2022), Akber et al. (2024).

Pure tenant households invest 31.3% less in overall farm business and 21% less in machinery as compared to owner cultivators, both significant at 1% level. Whereas, mixed tenants invest 18.2% less in farm business than owner cultivators, significant at 1% level. However, in machinery investment, mixed tenants are investing more, as compared to owner cultivators but the difference is statistically not significant. A strong negative effect for pure tenants suggests that tenure insecurity discourages long-term investment like in machinery, which requires a substantial amount of investment. Family size has a positive and statistically significant effect on both farm and machinery investment. For overall farm investment, each additional household member increases investment by about 14.2% and for machinery investment, the effect is lesser at i.e. 5.8%, both significant at 1% level. These results suggest that larger households may have more available labour and enabling them to support investment.

IV

CONCLUSION

The study highlights the unequal nature of household-level agricultural investment in India. Although the majority (60%) of agricultural households invest in productive assets, a substantially small proportion of households invests in modern agricultural machinery like tractors, harvesters. The findings of the study indicate towards an evolving agrarian structure in India, where household characteristics,

tenancy status and occupational diversifications are reshaping the nature of agricultural investment. An important dimension explored by the study happens to be the role of diversified households, defined as those engaged in both farm and non-farm economic activities. The analysis shows that larger family sizes are more likely to diversify and diversified households are investing more in agriculture, as compared to cultivator households. This gives an impression that non-farm income serves as a supplementary source of capital for agricultural investment. However, a relatively lower investment in machinery among diversified households shows that occupational diversification does not facilitate into higher investment in productivity-enhancing investment.

The analysis further highlights that land tenure status is a critical determinant of farm investment. It shows that pure tenant households are investing less in farm investment as well as agricultural machinery than owner cultivator and mixed tenants, which indicates a growth-reducing feature. In contrast, cultivator households and mixed tenants shows relatively greater capacity and willingness to invest in machinery. This indicates their potential role towards growth-inducing investment. Given the growing prevalence of tenancy in Indian agriculture, particularly since 2000s, there is an urgent need for policy intervention towards strengthening tenure security, perhaps through legal recognition of tenancy contracts or incentives for long-term leasing and providing tenant farmers with access to institutional credit. The findings of the study have larger implications on food security, poverty reduction and ultimately on growth.

Acknowledgement: We would like to thank Dr. Anand Meher for useful discussions related to the data used in this study, and Prof. Jayanti Kajale and Dr. Itishree Patnaik for their comments and valuable suggestions. We also thank the anonymous referees for their comments, which helped to improve the quality of the paper. All remaining errors are of the authors.

Received: March 2026 *Revisions Accepted: May 2026*

REFERENCES

Abraham, V. (2024). Ruptured Rural Transformation from Non-farm to Mixed Households in Rural India. Economic and Political Weekly, 59(50), 84-93.

Akber N, Paltasingh KR. (2019) Is public investment complementary to private investment in Indian agriculture? Evidence from NARDL approach. Agricultural Economics, 50(5), 643–655

Akber, N., Paltasingh, K. R., Mishra, A. K., & Goyari, P. (2024). Land ownership security, farm investment, and investment risk in Indian agriculture: Evidence from nationally representative survey. Journal of Agricultural and Applied Economics, 56(2), 278-296.

Bansal, V., Usami, Y., Rawal, V. (2018). Agricultural Tenancy in Contemporary India. SSER Monograph 18/1, Society for Social and Economic Research, New Delhi.

Bansal, G. (2020). Tenancy and accumulation: A study of the capitalist farm sector in Punjab. Review of Agrarian Studies, 10(2), 28-47.

Bathla, S., & Kumari, Y. (2017). Investment behaviour of farmers across Indian states: determinants and impact on agriculture income. In Changing Contours of Indian Agriculture: Investment, Income and Non-farm Employment (pp. 51-69).

Bhue, C., & Vijay, R. (2018). Occupational diversification in the rural sector between 2003 and 2013: some observations. The Indian Journal of Labour Economics, 60(4), 663-670.

Chaturvedi, D. N., & Bagchi, A. (1984). Age Structure of Fixed Capital in the Indian Economy, 1970–71 to 1980–81. Journal of Income and Wealth, 7(1), 82-83.

Dev, M. S. (2011). Macro and farm level investment in India: trends, determinants and policies. Food and Agriculture Organisation of the United Nations, Rome.

Dhawan, B. D., & Yadav, S. S. (1995). Private fixed capital formation in agriculture: Some aspects of Indian farmers' investment behaviour. Economic and Political Weekly, A103-A109.

Ellis, F. (1998). Household strategies and rural livelihood diversification. The journal of development studies, 35(1), 1-38.

Fan, S., and N. Rao. (2008). "Public Investment, Growth and Rural Poverty." In Public Expenditures, Growth, and Poverty, 56–108, edited by S. Fan. Baltimore, MD: Johns Hopkins University Press.

Heckman, J.J. (1979). Sample Selection Bias as a Specification Error. Econometrica. 47(1),153-161.

Jamaludheen, A., Singh, D. R., & Subash, S. P. (2022). Farmers' Investment on Productive Assets in Rural India: Composition and Determinants. Indian Journal of Agricultural Economics, 77(2), 221-231.

Kumar, A., Bathla, S., Verma, S., 2020. Changing the composition of private investment in Indian agriculture and its relationship with public investment and input subsidies. IFPRI Discussion Paper No. 1905, IFPRI South Asia Regional Office, New Delhi

Mandela, S. N., & Niyati, S. (2020). Structural transformation and the new rurality in Tamil Nadu. IASSI-Quarterly, 39(3), 361-381.

Murali, D. A., & Vijay, R. (2017). Revival of agriculture sector and increasing tenancy in India. Economic and political weekly, 52 (31),18-21.

Meher S (2010). Pattern of Farm investment among cultivating households: A comparative study of Haryana and Orissa. Ph.D. dissertation, Jawaharlal Nehru University, New Delhi, India

Meher, S. (2024). Factors Determining Private Agricultural Investment: A Comparative Case Study of Two States of India. South Asian Journal of Social Studies and Economics, 21(6), 15-25.

Mehta, N. (2023). Agricultural Investments: Trends and Role in Enhancing Agricultural Output and Incomes. Indian Journal of Agricultural Economics, 78(4), 575-590.

Roy, B. C., & Pal, S. (2002). Investment, agricultural productivity and rural poverty in India: A state-level analysis. Indian Journal of Agricultural Economics, 57(4), 653.

Sharma, H. R., Malik, S. H., & Bhatia, A. (2022). Effects and determinants of diversification of livelihood options amongst agricultural households in India: A state level analysis. Indian Journal of Agricultural Economics, 77(1), 145-162.

Shaw, S. L., & Agarwal, R. C. (1970). Impact of new technology on the levels of income, pattern of income distribution and savings of farmers in central region of Uttar Pradesh. Indian Journal of Agricultural Economics, 25(1), 110-115.

Rajak, D. (2025). Pattern of Occupational Diversification among Rural Agricultural Households: A Field View. Artha Journal of Social Sciences, 24(1), 1-30.

World Bank. 2007a. World Development Report 2008. Agriculture for development. Washington, DC.

Zeeshan, Khan, M. A., Khan, M. R., Pandey, N., Kaushik, I., Hoda, M. N., & Khatoon, N. (2022). How access to non-farm income affects farm investment in rural India? Journal of Public Affairs, 22(4), e2681.

APPENDIX

TABLE 1A. AVERAGE MARGINAL EFFECTS OF SELECTION EQUATION

(Dependent Variable)	Farm Investment	Machinery
Training in agriculture (1=yes, 0=otherwise)	0.029	0.04
Cost of hiring machinery (log)	0.048	0.055
Per capita land own	0.007	0.006
Leased in dummy (1=yes, 0=otherwise)	-0.173	-0.206
Irrigation dummy (1=yes, 0=otherwise)	0.109	0.114
Institutional credit dummy (1=yes, 0=otherwise)	-0.043	-0.07
Family size	0.038	0.038

Source: Authors' calculation from the unit level data of NSSO 77th round SAS