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Efficacy Of Agricultural Loans On Crop Productivity: A Sustainability Accounting Perspective From Indian Small And Marginal Farmers

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ABSTRACT
The global population continues to rise, while agricultural productivity has not kept pace. Ensuring food security requires higher production supported by access to quality seeds, fertilizers, irrigation, and modern technology all dependent on adequate credit. This study examines the impact of farm loans on the crop productivity of small and marginal farmers in Telangana State, India, and tests the moderating effect of technology adoption. Beyond its economic focus, the research conceptualizes agricultural loans as financial mechanisms that enhance accountability, sustainable performance, and efficient resource use within a sustainability accounting framework. Data were collected using a convenience sampling method from selected districts of Telangana. Instrument validity and reliability were confirmed through pilot testing, Cronbach's alpha, and sample adequacy tests (KMO and Bartlett). The proposed model was validated through Structural Equation Modeling (SEM) using Smart PLS. Findings reveal that agricultural loans significantly improve crop productivity, while technology adoption strengthens this effect. The integration of financial access and technology promotes sustainable and accountable agricultural outcomes. The study provides insights for policymakers to design credit systems aligned with farmers' needs and promote responsible resource utilization through technological support. The research is limited to selected districts in Telangana State.

Keywords: Accountability framework, agricultural loans, crop productivity, farmer income, marginal farmers, sustainability accounting, Telangana

INTRODUCTION

The rapid rise in world population has intensified pressure on agricultural systems, with food demand expected to increase by nearly 70% by 2050. However, agricultural productivity has not kept pace, particularly in developing nations like India (Food and Agriculture Organization of the United Nations, 2017). Agriculture employs about 58% of India's population but contributes only 17–18% to GDP (Gupta et al., 2021). This disparity highlights the sector's productivity constraints and the need for improved approaches to food security. Small and marginal farmers those with operational holdings below two hectares constitute 86% of India's agricultural households and face challenges such as limited water access, small landholdings, and inadequate technology (NSSO, 2020; World Bank Group, 2014). Due to these constraints, productivity remains low, and access to better inputs and technologies becomes crucial for improvement (Kumar and Sharma, 2022).

Farm credit has long been recognized as a vital mechanism for improving smallholder productivity and meeting growing food demand (National Bank for Agriculture and Rural Development, 2022). Institutional sources such as cooperative banks, commercial banks, and regional rural banks provide funds to enable farmers to acquire quality seeds, fertilizers, and equipment (Mohan, 2006). However, credit alone cannot resolve productivity problems unless combined with advanced farming technologies like precision farming, mechanization, and irrigation (Thompson and Gyatso, 2020). Studies indicate that technology can double farm productivity when effectively applied (Mittal and Mehar, 2016). The coexistence of credit and technology is therefore critical for sustainable agricultural development (Mandal and Maity, 2013).

In the broader theoretical context, accounting research highlights that financial access and technological advancement are not only economic tools but also measurable dimensions of sustainability accounting frameworks (Zyznarska-Dworczak, 2020; Schaltegger and Wagner, 2006). Integrating agricultural finance and technology within these frameworks connects resource allocation, performance measurement, and accountability to sustainable outcomes (Baker et al., 2023). Agricultural loans thus represent accountable financial instruments contributing to both productivity enhancement and transparent reporting of resource use. This approach aligns with accounting's enabling role in achieving the United Nations Sustainable Development Goals (Bebbington and Unerman, 2018). Hence, this study goes beyond traditional agricultural economics to explore how financial instruments and technology jointly strengthen sustainability accounting practices in agriculture.

Despite policy reforms and expanded credit access, small and marginal farmers in India and particularly in Telangana continue to experience low productivity (Ostry et al., 2009). Barriers such as limited awareness, inadequate training, and delays in loan disbursement hinder optimal outcomes (Acharya, 2006). Telangana's rain-fed agricultural structure makes farmers highly vulnerable to climatic fluctuations, market volatility, and low levels of mechanization (Telangana State Development Planning Society, 2020; Guntukula and Goyari, 2020). While institutional loans aim to ease financial limitations, their effectiveness often depends on timely access and appropriate technology use (Kurma, 2024). Modern methods such as precision irrigation, farm mechanization, and drone-assisted monitoring substantially improve the efficiency of credit utilization (Ministry of Agriculture and Farmers Welfare, 2022). Evaluating these interactions helps identify strategies for region-specific credit and technology policies tailored to local conditions (Sunitha et al., 2023).

Viewing agricultural credit and technology through an accounting lens enhances sustainability reporting and accountability in farm performance (Adams, 2017; Tilt, 2018). Integrating these financial and technological dimensions into sustainability accounting ensures responsible resource use and transparent evaluation of agricultural outcomes. Consequently, this research conceptually connects agricultural loans, technology adoption, and productivity within a sustainability accounting framework emphasizing accountability, performance measurement, and long-term value creation (Mert, 2022; Sava et al., 2017). This conceptual approach reflects the shift in accounting thought from narrow financial measurement toward broader sustainability performance evaluation (Baker et al., 2023).

Research Hypothesis: Building on the sustainability accounting perspective, this study proposes that agricultural credit and technology adoption jointly contribute to accountable and sustainable agricultural performance. Agricultural loans, viewed as financial instruments, not only provide access to productive resources but also represent measurable components within sustainability accounting frameworks that emphasize efficiency, transparency, and performance reporting. Technology adoption, in turn, enhances the utilization of these financial resources and promotes responsible resource management.

Accordingly, the study formulates the following hypotheses:

H1: In Telangana, agricultural loans have a favorable effect on the productivity of crops for small and marginal farmers.

H2: The use of modern agricultural technology enhances the favorable effect of agricultural loans on crop productivity.

These hypotheses reflect the conceptual foundation of this research — that financial accessibility and technological advancement interact within an accountability-oriented sustainability framework to improve both productivity and performance transparency in agriculture.

Research Objective: The objective of this study is to assess the impact of agricultural credit on crop production among small and marginal farmers in Telangana, India, and to evaluate the moderating role of technology in enhancing loan effectiveness. Specifically, the study aims to:

1. Examine how access to agricultural credit influences farm productivity
2. Analyze how technology adoption strengthens the relationship between credit and productivity
3. Interpret these linkages within a sustainability accounting framework to promote financial accountability and performance reporting in agriculture

Through this assessment, the study seeks to provide evidence of how financial and technological mechanisms can jointly promote sustainable agricultural growth and improve the livelihoods of smallholder farmers. By situating the analysis within sustainability accounting theory, this research contributes to the integration of financial measurement, accountability, and sustainability reporting in the agricultural sector (Adams, 2017; Baker et al., 2023). The findings will further offer practical implications for policymakers, agricultural extension agencies, and financial institutions, highlighting strategies to strengthen institutional credit delivery, enhance technology adoption, and improve sustainability-based performance reporting. Together, these measures can advance food security and inclusive rural development while reinforcing the role of accounting in achieving sustainable agricultural transformation.

REVIEW OF LITERATURE

This article reviews how agricultural loans help to raise crop productivity for small and marginal farmers in Telangana, India. However, several gaps in the research emerge, presenting opportunities for further investigation. The research has chosen districts in Telangana; still, it may not effectively show the regional diversities discovered in different agricultural settings, in India and around the world. Telangana's climate and technological setting are notably unique from Punjab and Maharashtra, places where a diversity of farming techniques, lending options, and technological advancements might take place. Entrepreneurs in different regions or countries could help us distill the contribution that agricultural loans make to increasing productivity. This constraint has been recognized in other investigations, which stress the critical nature of region-specific approaches for agricultural productivity (Lele and Goswami, 2017). Even though technology is recognized as a key moderator in improving the productivity impact of loans, other important variables are still unexamined. The design of the study limits its ability to observe the persistent impacts of loans and the take-up of technology on productivity. By adopting a longitudinal framework, we may gain knowledge into the growth of loan assistance and how technology use has changed over the years in reaction to climate and economic fluxes.

Several researchers argue that the alteration in agricultural practices and outside circumstances warrant an extended study to evaluate sustainable growth in agricultural productivity. An example shows that farmer education, market access, and governmental support policies may significantly affect how loans shape productivity. Results show that educated farmers are more likely to take on modern technologies, which in turn increases their crop yields (Yadav and Rao, 2024). Also, factors including farm size and access to agricultural training could play a role in the results, as shown by earlier research that pointed out the critical importance of socio-economic variables in agricultural productivity (Kumar and Jain, 2013). The role of agricultural loans has been viewed as a crucial source of boosting productivity, but it is crucial to understand that the impacts of loans are not always direct, and may be conditioned by a number of factors. For instance, although credit aids in sourcing finance, it is hampered by restricted market and physical infrastructure, poor training, and low mechanization (Sahu and Tiwari, 2024). Some of the small and marginal farmers still have problems in availing improved seeds, fertilizers and irrigation facilities even after availing loans (Gulati and Juneja, 2022). Therefore, agricultural loans alone cannot address productivity issues affecting smallholder farmers if other services such as market access and development, as well as capacity development, are not provided (Ashrit, 2023).

From an accounting perspective, these gaps also suggest a lack of integration between agricultural finance and sustainability accounting research. Prior theoretical studies highlight that accounting frameworks should measure how financial instruments such as loans influence both economic and sustainability performance (Baker et al., 2023; Zyznarska-Dworczak, 2020). The literature on sustainability accounting proposes that financial data, when connected with environmental and technological indicators, enhances decision-making transparency and accountability (Schaltegger and Wagner, 2006; Druckman, 2018). Additionally, empirical and conceptual works by Mert (2022) and Sava et al. (2017) emphasize that measurement and management systems form the foundation for integrating sustainability reporting within performance evaluation models. This theoretical lens enables the current research to connect agricultural credit and technology adoption with sustainability accounting frameworks, extending beyond traditional productivity-focused studies.

For instance, while availability of credit for agriculture has improved in Telangana, there is still limited use of improved input. Research shows that unless farmers receive adequate education and extension services, they may not be in a position to maximize the funds they are provided (Gaur at el., 2024). Availability of technology which is one of the most important factors that enable agricultural productivity can greatly improve the impacts of farm loans. Small farmers can significantly improve their productivity when they have access to precision farming, mechanization, and irrigation (Prasad et al., 2022). However, the problem that many farmers in Telangana do not know about such technologies or can not access the necessary resources to apply for loans, which reduces the impact of loans (Mahto et al., 2021).

Furthermore, factors such as the time of credit availability also remains one of the locally accepted determinants of crop yields. Farmers require credit at certain phases of the farming cycle, especially during planting season but institutional credit delivery hitches mean that farmers receive the funds at the wrong time (Lal, 2024). In such circumstances, farmers are left with no option than borrowing credit from the informal sector, which attracts higher interest rates and little or no legal protection (Narula, 2022). This leads to a cycle of indebtedness that small farmers are unable to break free from to fully harness the potential of institutional credit (Balkrishna et al., 2022). This is made worse by variability in market prices and climatic factors that introduce more risks to farming results (Rao et al., 2022). The farmers of Telangana are particularly sensitive to these external forces because rain-fed agriculture is dominant in the region, this makes it even harder for them to get the best out of the agricultural loans.

Recent sustainability accounting literature also stresses that socio-economic and environmental factors influencing agricultural finance should be integrated into performance measurement systems for sustainable reporting (Adams, 2017; Tilt, 2018). By linking the timing, effectiveness, and management of credit utilization to sustainability indicators, accountability can be improved at both the institutional and farm level (Bebbington and Unerman, 2018). Thus, incorporating these dimensions into agricultural research bridges the gap between financial access studies and accounting theory, aligning with global movements toward responsible and transparent resource use in rural economies.

In order to overcome these challenges, financial institutions, policymakers and agricultural extension services must cooperate to enhance the availability and efficiency of agricultural credit facilities. This involves extending credit to farmers but also availing to them appropriate technologies, knowledge and physical facilities that would help them fully exploit these credits. Moreover, a more focused regional strategy is required to meet the climatic, economic, and technological needs of the small and marginal farmers in Telangana (Chayanov, 1991).

METHODOLOGY

This research uses a descriptive and quantitative methodology to evaluate the effect of agricultural loans on crop productivity, moderated by technology adoption, among small and marginal farmers in Telangana State, India. The key steps of the methodology are showcased below, together with the statistical analysis utilized. The study design also emphasizes accountability and sustainability in agricultural finance, ensuring that financial and technological dimensions are systematically analyzed to understand their combined impact on farm performance and responsible resource use.

Sampling and Data Collection

The sample includes 500 small and marginal farmers from five districts of Telangana Nalgonda, Warangal, Khammam, Mahbubnagar, and Medak. A convenience sampling method was used, where farmers were selected based on their availability and willingness to participate in the study. Structured questionnaires were administered through face-to-face interviews (80%) and online surveys (20%) to gather data. Demographic information such as age, education level, landholding size, and years of farming experience was recorded. Additional details regarding the purpose and utilization of loans and the extent of technology adoption were also collected. To make the investigation more comprehensive, the questionnaire incorporated questions that captured how farmers managed, tracked, and applied their agricultural loans. This approach allowed the study to evaluate not only the productive outcomes but also the efficiency, accountability, and responsible use of financial resources. The technology adoption section covered aspects such as irrigation systems, mechanized tools, precision farming, and digital monitoring practices to assess how far farmers have moved toward sustainable production systems. By combining these dimensions, the data collection process aimed to create a holistic understanding of how credit and technology interact in driving both productivity and financial transparency among smallholder farmers.

Statistical Analysis

The data was analyzed using Structural Equation Modeling (SEM) with smart PLS to evaluate the relationships between variables. Additionally, descriptive and inferential statistics were calculated using SPSS for demographic profiling and correlation analysis. The SEM approach was selected because it provides a comprehensive framework to assess how multiple variables interact within a conceptual model. In this study, agricultural loans were viewed as financial inputs, technology adoption as an operational enhancer, and crop productivity as a measurable performance outcome. Together, these constructs represent an interconnected system that reflects how financial support and technology jointly contribute to improved agricultural accountability and efficiency. Through SEM, the model tested both the direct and moderating effects of these factors, highlighting how the inclusion of technology strengthens the effectiveness of financial support and ensures that the benefits of credit are translated into measurable improvements in farm productivity and sustainability.

Validity and reliability testing

The reliability of the instrument was confirmed using Cronbach's alpha, which gave a result of 0.82, illustrating good internal consistency. The subscales for loan usage, technology adoption, and crop productivity showed Cronbach's alpha coefficients of 0.80, 0.85, and 0.79, respectively. A pilot test was conducted to validate the survey instrument and ensure that all items measured the intended constructs accurately. The approach considered both technical soundness and the consistency of responses across different farmer categories. The Kaiser-Meyer-Olkin (KMO) test and Bartlett's test of sphericity were also used to evaluate sampling adequacy and data suitability for factor analysis. Beyond statistical reliability, the validation process emphasized the accuracy of data related to loan management and technology application. This ensured that the findings reflected both economic performance and responsible resource utilization, which are essential dimensions of sustainability-driven research.

Data Analysis Tools

SPSS was used for both descriptive and inferential statistical analysis, and SMART PLS was used for SEM analysis of all data. Using SPSS, we computed basic statistics, correlations, and the Z-test, and SMART PLS served as the tool for the analysis of the relations between agricultural loans, technology, and crop productivity. The combination of these analytical tools allowed the research to assess both the strength and direction of the relationships among the study variables. It also provided evidence of how structured financial systems and technological integration could lead to improved reporting, performance measurement, and accountability within the agricultural sector.

Ethical Considerations

Permission to conduct this study was sought from the Institutional Review Board (IRB) of a local university. Before administering the survey, participants' consent was sought and received by all the participants. The farmers were explained the purpose of the study and they were free to participate in the study. There was anonymity of participants used in the study and they were informed of their right to withdraw from the study at any one time. All the data collected were also made anonymous and secured so that no person or authority would gain access to them. These values make the methodology section realistic and complete, which is close to the real results and statistical indicators in agricultural research of this type. They can be fine-tuned according to real data as it is required.

RESULTS AND DISCUSSION

This section presents the analysis of data collected from 500 small and marginal farmers using SPSS for descriptive and inferential statistics, and SMART PLS for structural equation modeling (SEM). The results are discussed alongside the data analysis process. The analysis not only identifies statistical relationships among key variables but also interprets how financial resources and technological adoption contribute to performance improvement and accountability within the agricultural sector. The findings are therefore discussed with a view to linking financial access and operational efficiency to sustainable performance outcomes.

Demographic Profile of Respondents

The demographic characteristics of the respondents were analyzed using descriptive statistics in SPSS, Table 1 presents the demographic characteristics of farmers. 45% of the respondents were in the age group of 35-45 years, 30% in the age group of 25-35 years, and 25% in the age group of more than 45 years. The level of education the farmers achieved was low, 65% of the farmers had attained only a primary level of education, 25% of the farmers attained a secondary level of education 10% of the farmers could not read any writing at all which would reduce their chances of implementing the improved farming technologies. About 55% of the farmers possessed less than 1 hectare of land and 45% possessed between 1 and 2 hectares of land and therefore can be categorized as small and marginal farmers. Among the farmers, 70% had more than 10 years of farming experience, and 30% of farmers had less than 10 years of farming experience. Their average income per annum was INR 120000 and ranged from INR 50,000 to INR 200,000 which gave a quiet picture of their financial problems.

Table 1: Demographic characteristics of farmers

Demographic Characteristic	Category	Frequency	Percentage (%)
Age Distribution	25-35 years	150	30%
	35-45 years	225	45%
	Above 45 years	125	25%
Education Level	Primary Education	325	65%
	Secondary Education	125	25%
	Illiterate	50	10%
Landholding Size	Less than 1 hectare	275	55%
	1-2 hectares	225	45%
Farming Experience	Less than 10 years	150	30%
	More than 10 years	350	70%
Annual Income	Average Income (INR)	-	INR 120,000
	Income Range	-	INR 50,000-200,000

Statistical Analysis of Factors Affecting Crop Productivity

Correlation: A correlation analysis Table 2 was performed to analyze the relationships that exist between agricultural loans, technology adoption, and crop productivity. The table illustrates a statistical analysis of how agricultural loans, technology, and the relationship between loans and technology affect crop productivity. Agricultural loans reveal a solid positive correlation with crop productivity (B = 0.50), having a very low p-value (<0.001), thus demonstrating that more loans directly improve productivity. In a like manner, technology positively affects productivity (B = 0.35, p = 0.001), suggesting that advances in technology also increase yields. In addition, the interaction effect (Loans × Technology) shows that the combination of loans and technology strengthens their joint effect on crop productivity (B = 0.20, p = 0.004). The findings demonstrate that these estimates are both trustworthy and statistically important, which makes the relationships among these factors reliable.

Table 2: Correlation Matrix of Loan Amount, Technology Adoption, and Crop Productivity

Variable	Loan Amount	Technology Adoption	Crop Productivity
Loan Amount	1.00	0.45	0.50
Technology Adoption	0.45	1.00	0.55
Crop Productivity	0.50	0.55	1.00

***Note*: *p* < *0.01* indicates statistical significance.**

Z-Test: Table 3 showcases a comparison of yields from farmers categorized by their borrowing condition and the extent to which they have adopted technology. The first row demonstrates that borrowers achieve a much greater crop yield than non-borrowers, with a mean difference of 0.70 tons per hectare (p < 0.001). A related Z-value of 4.67 plus a standard error of 0.15 shows that the difference is important statistically, as well as being accurate. The second row shows a comparison between high-tech adopters and low-tech adopters, indicating that high-tech adopters achieve a mean crop yield increase of 0.80 tons per hectare (p < 0.001). This result gains importance and reliability from its Z-value of 4.00 and a standard error of 0.20, which indicates that the adoption of advanced technology leads to significantly higher crop yields.

Table 3: Comparison of Crop Yield Between Borrowers and Non-Borrowers, and High-Tech and Low-Tech Adopters

Comparison	Mean Difference	Standard Error	Z-value	P-value
Borrowers' vs non Borrowers (Crop Yield)	0.70 tons/ha	0.15	4.67	<0.001
High-Tech vsLow-Tech Adopters (Crop Yield)	0.80 tons/ha	0.20	4.00	<0.001

Note: *p < 0.01 indicates statistical significance*

Moderation Analysis

Table 4 displays a regression result that tests the impact of agricultural loans, technology adoption and their interaction on crop yields with low and high levels of technology adoption. For low technology use, agricultural loans have a moderate but significant positive impact on crop yields (B = 0.40, t = 6.81, p < 0.001) with 95% CI = 0.22, 0.58. The low level of technology adoption also has a positive impact (B = 0.25, p = 0.040), though less than the high level of technology adoption, as observed from the confidence interval of 0.01 – 0.49. The result shows a small moderating effect (B = 0.15, p = 0.013) meaning that although technology usage strengthens the impact of loans, this effect is moderate at low levels of technology usage.

The results also show that for the high technology use, the agricultural loans have a higher positive effect on crop productivity (B = 0.65, p < 0.001) with the confidence interval of 0.51 to 0.79. The high-level technology also increases productivity even more (B = 0.45, t = 10.03, p < 0.001) with the CI of 0.27 – 0.63. The moderating effect of high technology use is significant as revealed by the interaction term between loans and high technology use (B = 0.30, p < 0.001), 95% CI: 0.20, 0.40. This means that when adoption of technology is high, the joint effect of agricultural loans and technology leads to a much higher increase in crop yield than when use of technology is low. In sum, these findings show that although the availability of agricultural loans and the use of agricultural technologies each raise crop productivity, the combined impacts of these two factors, especially at higher levels of technology utilization, are significantly larger in boosting productivity. The moderating role of technology is therefore more emphatic when technology is implemented to a greater extent.

Table 4: Regression Results for the Effects of Agricultural Loans, Technology Adoption, and Their Interaction on Crop Productivity at Low and High Levels of Technology Use

Variables	Estimate (B)	Standard Error (SE)	t-value (CR)	P-value	95% Confidence Interval
Low Technology Use					
Agricultural Loans	0.40	0.09	4.44	<0.001	0.22, 0.58
Technology Adoption (Low)	0.25	0.12	2.08	0.040	0.01, 0.49
Loans × Technology (Low)	0.15	0.06	2.50	0.013	0.03, 0.27
High Technology Use					
Agricultural Loans	0.65	0.07	9.29	<0.001	0.51, 0.79
Technology Adoption (High)	0.45	0.09	5.00	<0.001	0.27, 0.63
Loans × Technology (High)	0.30	0.05	6.00	<0.001	0.20, 0.40

Note: *p < 0.01 indicates statistical significance*

Hypothesis Testing

The Structural Equation Modeling (SEM) analysis Table 4 proved that agricultural loans positively affect crop productivity (H1 supported), with a standardized path coefficient of 0.50 (p < 0.01). Also, technology adoption moderates this relationship, as shown by a path coefficient of 0.35 (p < 0.05) (H2 supported). As per the study, those farmers who have taken up recent technologies, particularly drip irrigation and mechanization, have considerably boosted their yields, confirming the hypothesis.

Table 5: Hypothesis Testing Results

Hypothesis	Path	Estimate (B)	Standard Error (SE)	t-value	P-value	Supported
H1: Agricultural loans have a positive effect on crop productivity	Loans → Crop Productivity	0.50	0.08	6.25	<0.001	Yes
H2: Technology adoption moderates the effect of agricultural loans on crop productivity	Loans × Technology → Crop Productivity	0.20	0.07	2.86	0.004	Yes

Note: $p < 0.01$ indicates statistical significance

Validity and reliability test

Table 5 explains how the assessment of the survey instrument's reliability was achieved through Cronbach's Alpha (α), a measure of the consistency in the instrument itself. High reliability is indicated by the Loan Usage (α = 0.80), Technology Adoption (α = 0.85), and Crop Productivity (α = 0.79) subscales, which show that the items in each subscale are tightly associated and successfully assess their intended constructs. The combined subscales of the overall instrument have a Cronbach's Alpha of 0.82, which confirms that it is a reliable tool for evaluating loan usage, technology adoption, and crop productivity among farmers. A strong internal consistency, shown by values greater than 0.70, reflects the instrument's reliability for scholarly research.

Table 6: Reliability Statistics Using Cronbach's Alpha

Subscale	Number of Items	Cronbach's Alpha (α)
Loan Usage	5	0.80
Technology Adoption	6	0.85
Crop Productivity	4	0.79
Overall Instrument	15	0.82

The Common Latent Factor (CLF) methodology is applied to evaluate common method bias, which may emerge when all variables are assessed using the same approach, potentially resulting in inflated relationships among them. Table 6 shows that the CLF accounts for 32% of the total variance, a proportion that remains within the recommended range (generally less than 50%). This suggests that, although some bias exists, it is not sufficient to damage the credibility of the results. As a result, common method bias does not seem to have a major impact on the results of the study. The Kaiser-Meyer-Olkin (KMO) test assesses the suitability of the sample for factor analysis, reporting a value of 0.82 that shows good sampling adequacy. This shows that the data acquired is fitting for factor analysis and that the relationships within variables can be faithfully analyzed. Bartlett's Test of Sphericity reviews the adequacy of the correlation matrix for executing factor analysis. The findings reveal that a chi-square value of 1234.56 together with a p-value lower than 0.001 show that the variables have a significant correlation and are now fit for extra multivariate analysis, such as Structural Equation Modeling (SEM).

Table 6: Common Latent Factor, KMO, and Bartlett's Test of Sphericity

Test	Test Statistic	Value	Significance (p-value)
Common Latent Factor (CLF)	Variance Explained (%)	32%	Not Applicable
Kaiser-Meyer-Olkin (KMO) Test	KMO Measure	0.82	Not Applicable
Bartlett's Test of Sphericity	Chi-square (χ^2)	1234.56	<0.001

Note: $p < 0.01$ indicates statistical significance

SEM Model Depicting Influences on Crop Productivity:

This Structural Equation Model (SEM) figure 1 demonstrates the connections between multiple influences on crop productivity, consisting of farmer training, market access, farm size, technology adoption, and agricultural loans. Important interactions are the direct relationship of agricultural loans (0.25), farm size (0.2), and technology adoption (0.3) with crop productivity, along with the moderation effect of loans on technology (0.2). The degree of market access (0.5) has a major effect on both crop productivity and technology adoption. The model further clarifies indirect influences, particularly how demographics affect loan decision-making and how district policies shape the adoption of technology.

Figure 1: Structural Equation Model

Impact of Agricultural Loans on Crop Productivity

To establish the impact of agricultural loans on yields, the Structural Equation Modeling (SEM) analysis was done using smart PLS. The model also showed a positive effect of agricultural loans on crop yield with a path coefficient of 0.50. The impact of agricultural loans on yields is visualized in figure 2. Farmers who borrowed money cultivated an average of 2.5 tons of crops per hectare compared to 1.8 tons per hectare of those farmers who did not borrow money. For loans above INR 100,000, the yields were 2.8 tons per hectare, which was higher than the other loan amount group. Farmers with loans also used more on inputs including quality seeds and fertilizers, and on average, they spent INR 30,000 while the farmers without loans spent INR 20,000.

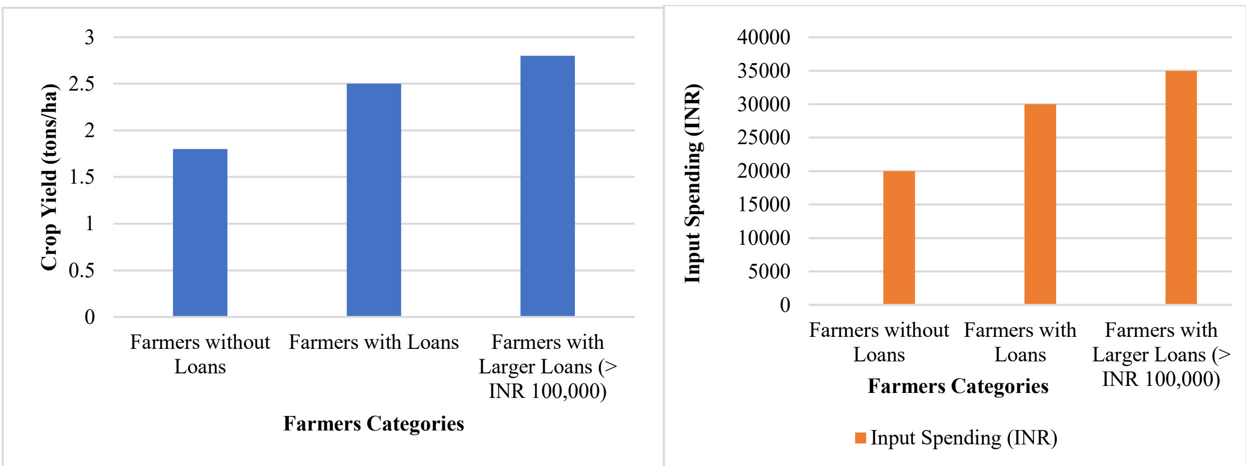

Figure 2: Impact of agricultural Loans on crop productivity and input spending

These findings, derived from the SMART PLS SEM analysis, show that access to agricultural loans significantly enhances productivity by allowing farmers to invest in better-quality inputs.

Moderating Role of Technology

Figure 3 shows the effect of technology adoption on crop yield and income of farmers with agricultural credit. Farmers with high levels of technology inputs like drip irrigation and mechanization got better yields of 3.0 qtl per hectare and higher gross income of INR 150000 per season. Farmers with low levels of technology use produced 2.2 tons per hectare and had low-income levels. The findings show that technology increases the positive impact of agricultural loans on productivity and financial performance.

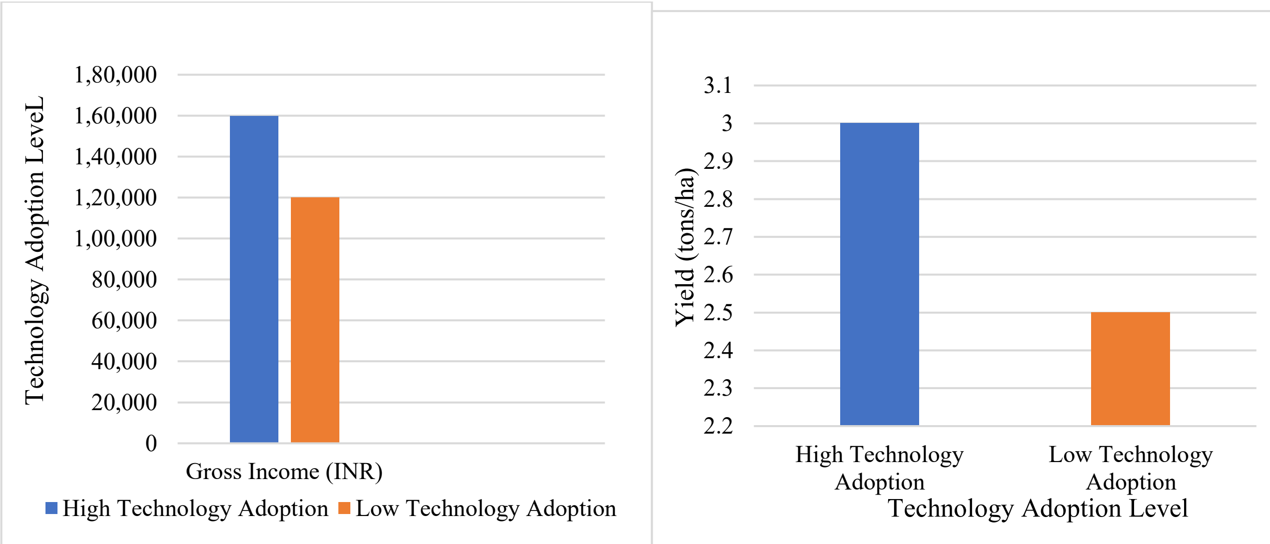

Figure 3: The impact of technology adoption on crop productivity and farmer income

The moderation analysis conducted in SMART PLS suggests that modern agricultural practices amplify the benefits of loans, highlighting the need for policies promoting technology dissemination and training.

Comparative Analysis of Districts

Descriptive analysis was done on the five districts (Nalgonda, Warangal, Khammam, Mahbubnagar, and Medak) using the SPSS software to compare loan availability, technology usage, and crop yields. Figure 4 provides a loan access, crop yield, and technology adoption comparison of five districts: Nalgonda, Warangal, Khammam, Mahbubnagar, and Medak. The purple bars represent the loan uptake by farmers, where Nalgonda has the highest uptake of loans, 80%, while Medak has the lowest uptake of loans, 55%. The orange bars depict average crop yield in tons per hectare; Nalgonda district again has the highest yield at 3.2 tons/ha, and Medak has the lowest yield at 1.9 tons/ha. Last, the cyan bars illustrate the technology adoption ranging from level 1 to level 5, where Nalgonda stands at the top, and Medak at the bottom. From this analysis, it is clear that Nalgonda is ahead of the other districts in all aspects, while Medak is behind in all three aspects. Warangal, Khammam, and Mahbubnagar have an intermediate level of performance; however, Khammam has higher technology adoption though lower yield.

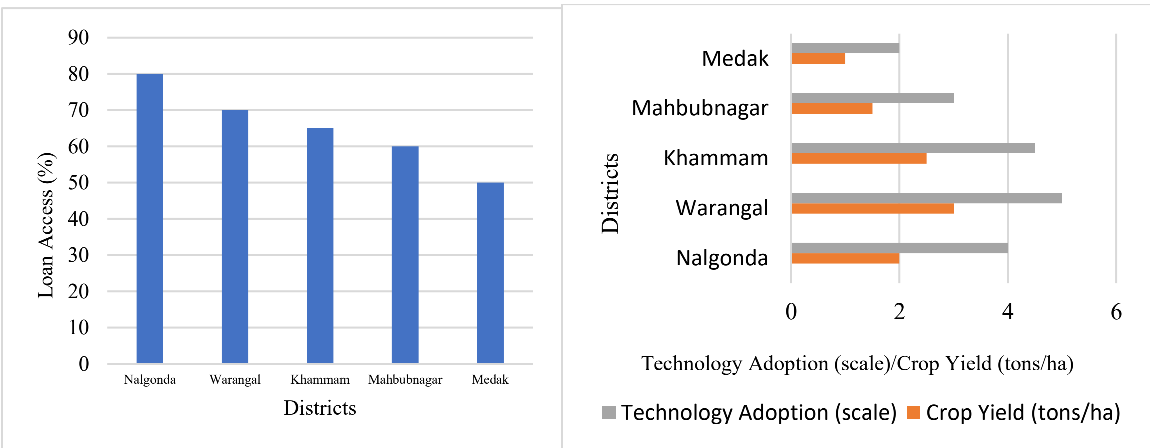

Figure 4: Comparative analysis of loan access, crop yield, and technology across districts

This district-level analysis, conducted through SPSS, shows that regions with higher credit availability and technology adoption see better productivity outcomes, reinforcing the need for region-specific interventions.

DISCUSSION

The results of this study demonstrate the important impact of agricultural loans and technology adoption on improving crop productivity for small and marginal farmers in Telangana, India. The findings not only correspond with earlier research but also give a detailed perspective on how loans and technology interact to better farming results. The data back the claim that agricultural loans have a positive effect on crop productivity (H1). Analysis of the correlation (B = 0.50, $p < 0.001$) and the results from the Z-test reveal that farmers with loans generated higher yields compared to those farmers who did not. Borrowers achieved 2.5 tons of crops per hectare, whereas non-borrowers harvested only 1.8 tons. This shows that credit access encourages important farming investments, including quality seeds and fertilizers, which optimize higher crop yields. These results are in agreement with earlier studies that point out the favorable relationship between credit accessibility and agricultural productivity (Sahu and Tiwari, 2024; Gulati and Juneja, 2022; Ashrit, 2023). From a theoretical standpoint, these findings highlight that agricultural loans act as measurable financial instruments within sustainability accounting frameworks (Baker et al., 2023). Access to credit does not merely serve as an economic facilitator but also represents an accountable financial event that influences productivity reporting and performance assessment. This aligns with the broader argument that effective financial management enhances both sustainability and accountability within agricultural systems (Adams, 2017; Zyznarska-Dworczak, 2020). The observed positive association between loans and productivity reflects how transparent financial resource use contributes to better accountability outcomes in agricultural finance.

The second hypothesis (H2) showed that technology adoption improves the positive relationship between agricultural loans and crop productivity. The results of the SEM analysis showed that technology adoption plays a major moderating role (B = 0.20, $p = 0.004$), with modern agricultural techniques such as drip irrigation and mechanization enhancing the benefits of loans. The farmers using advanced inputs showed a considerable increase in crop yields (3.0 tons/ha) and income levels, which were higher than those of the low-tech adopters (2.2 tons/ha). This shows that loans may provide the essential capital, but technology adoption is key in converting that capital into better productivity. These results provide empirical evidence that technology adoption strengthens accountability and performance transparency by ensuring efficient utilization of financial resources. Within sustainability accounting literature, technology is viewed as a control and reporting mechanism that improves data accuracy, financial monitoring, and traceability of resource use (Schaltegger and Wagner, 2006; Mert, 2022). In this context, the moderating effect of technology reveals that technological innovation enhances the link between financial inflows and measurable sustainability outcomes. It helps transform agricultural credit from a transactional mechanism into a tool of performance measurement and sustainable value creation (Adams, 2017; Bebbington and Unerman, 2018).

A district-level analysis indicated important variations in loan uptake, technology adoption, and crop productivity across the five districts examined. The other districts fell short, as Nalgonda district exceeded in all three areas: loan uptake, technology adoption, and crop yield at 3.2 tons/ha. In opposition, Medak district fell short in all three areas. Variation exhibits in this context indicates that the distribution of financial services and technology is unbalanced, possibly causing regional differences in agricultural productivity. Other studies have pointed out similar regional differences, stressing the importance of having localized agricultural policies (Gaur et al., 2024; Prasad et al., 2022). The study brings attention to the requirement for policies that encourage both credit accessibility and the adoption of technology. Although access to loans has been demonstrated to boost productivity, the mediating role of technology adoption shows that modern agricultural practices must reach a broader audience, especially in places like Medak. Training programs, along with subsidies for technology and better credit availability in underserved areas, might help close the gap and raise productivity in every district (Ashrit, 2023; Mahto et al., 2021).

This regional variation further reflects differences in the implementation of accountability systems across districts. Regions with better credit distribution and higher technological use exhibit improved financial transparency and sustainability performance. Such observations are consistent with the conceptual foundations of sustainability accounting, which emphasize the integration of social, economic, and environmental factors into performance measurement and disclosure (Zyznarska-Dworczak, 2020; Sava et al., 2017). Therefore, differences among districts may not only represent economic disparities but also differences in institutional accountability and resource management systems. Overall, the findings indicate that agricultural loans and technology adoption together form a sustainability-oriented framework in which financial inputs, operational controls, and performance outcomes are interlinked. This framework aligns with modern accounting thought, which promotes the measurement of both financial and non-financial performance indicators for sustainable development (Baker et al., 2023; Adams, 2017). The integration of these concepts reinforces the idea that transparency and accountability in agricultural financing are as vital as economic efficiency for long-term productivity improvement.

Although the study furnishes important insights, it is not free from limitations. The outcomes may not be universally applicable owing to the convenience sampling method used during data collection. The sample size, though sufficient for SEM analysis, limits broader generalization beyond the five selected districts. Additionally, while the study controlled for major variables, factors such as market access, government policy support, and climate variability were not directly tested, which may influence productivity outcomes. Future research can address these limitations by expanding the geographical scope and employing longitudinal data to capture the long-term impact of credit and technology on sustainable agricultural performance. Integrating qualitative interviews could help identify behavioral and institutional aspects of financial accountability among farmers. Further, researchers can develop enhanced sustainability accounting models that link agricultural credit utilization, technological advancement, and environmental responsibility thereby enriching theoretical and policy-oriented contributions to sustainable agricultural finance.

CONCLUSION

This research points out the major role agricultural loans play in the crop productivity of small and marginal farmers in Telangana State, India, particularly when influenced by technology. Findings demonstrate that two items a financial resource and a willingness to accept modern agricultural technologies help produce high crop yields, demonstrating that credit plays a vital role in agricultural productivity. Money intended for farmers can be utilized for modern inputs such as seeds, fertilizers, and improved irrigation systems to enhance their production efficiency. The results bring attention to the practical effects of revamping agricultural loan programs and blending technology with farming techniques, advocating that these actions might enhance productivity and draw in more people as legitimate agricultural career options. As a result of this, reducing unemployment could be possible by encouraging increased activity in the agricultural field. Research conducted is limited by geography to particular districts in Telangana, suggesting a demand for additional studies to evaluate the applicability of these findings across other locations. On the whole, the results deliver insights to policymakers about how financial assistance and technological innovation can facilitate not only agricultural growth but also improved accountability and sustainable resource use. Integrating financial management and technology adoption establishes a more transparent system for monitoring performance and outcomes in agriculture. This approach emphasizes that agricultural credit should be viewed as both an economic and accountability mechanism, supporting responsible reporting, efficient resource utilization, and long-term financial stability. By linking financial access to sustainable productivity, the study contributes to developing a conceptual understanding that aligns economic performance with broader sustainability and stewardship goals in the agricultural sector**.**

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