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A Comparative Economic Analysis of Resource Use Efficiency between Insured and Non-Insured Sugarcane Farms in Tamil Nadu, India

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Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

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ABSTRACT

This study analysed the resource use efficiency among the insured and non-insured sugarcane farms in Kallakurichi district in Tamil Nadu, India. The research aimed to inform policy decisions and extension programs for improving productivity and sustainability in the sugarcane sector. Multistage Purposive sampling method was used by which 120 farmers (60 insured and 60 non-insured) were

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selected from Rishivandiyam and Thirukovillur block. Cobb-Douglas Production function was used to calculate the resource use efficiency using the ratio of Marginal Value Product (MVP) to Marginal Factor Cost (MFC) for various inputs. Results showed that for insured farmers variables such as Nitrogen fertiliser, human labour and machine labour significantly and positively influenced the yield. For non-insured farmers, human labour, nitrogen and phosphorus had significant positive effects on yield. The R^2 values were 0.70 and 0.75 for insured and non insured farmers respectively. Resource use efficiency analysis revealed differences between insured and non insured farmers. Insured farmers underutilised farm yard manure and machine labour while over utilizing other inputs. Non-insured farmers only underutilised machine labour and over utilising all other inputs. The study concludes that crop insurance influences the input allocation decisions highlighting inefficiencies in resource use among both groups. These findings specify the need for targeted interventions to enhance the resource use efficiency in sugarcane cultivation. Optimizing input utilization could improve the sector's resilience, sustainability, and competitiveness that supports the India's food security and sustainable agricultural development goals. The research also provides a foundation for further studies into factors influencing resource use efficiency and the potential role of precision agriculture in promoting sustainable farming practices.

Keywords: Resource; efficiency; sugarcane; insured; non insured.

1. INTRODUCTION

Sugarcane (*Saccharum officinarum L.)* is one of the most important crops cultivated globally and is grown in more than 90 countries [1]. Sugarcane plays an important role in India's agriculture landscape, occupying about 2.57 per cent of the total cropped area. It is a vital cash crop with significant global and economic importance. Sugarcane is the leading source of sugar and biofuel in the world and plays an important role in both food security and renewable energy production [2]. It is a strategic crop for coping with climate change mitigation and being used as a raw material for ethanol and biomass production from which energy is produced [3,4]. Sugarcane is a widely cultivated cash crop in tropical and sub-tropical regions of the world [5]. India is the world's 2nd largest producer after Brazil followed by China,Thailand and Pakistan. In India sugarcane has been cultivated in an area of 5.8 mha with the production of 4905.3 lt [6]. According to the season and crop report of Tamil Nadu 2022-23, Sugarcane is grown in an area of 158.9 thousand hectares with production of 176.5 Million tonnes. Resource use efficiency in sugarcane cultivation varies across different regions and farm types. Sugarcane crop production is a complex process which depends on the use and combination of different inputs that determines the yield of the sugarcane. Studies on resource use efficiency are important as that may lead to Economic stability, Environmental conservation, Soil health protection and so on. To improve resource use efficiency and profitability, researchers recommend ensuring the availability and affordability of inputs, implementing modern agro-machinery, and providing subsidies [7,8]. Research on crop insurance and resource use efficiency shows the complex relationship between the crop insurance, input allocation and productivity. Some studies suggest that insurance leads to increased use of risk increasing inputs like feed in salmon farming [9] or more use of synthetic inputs in wheat farming [10]. whereas some studies show contradictory results where the findings states that insured wheat farmers used less amount of chemical inputs, supporting conventional view of moral hazard [10]. Specifically for sugarcane crop, optimal planting dates, irrigation regimes and nitrogen levels can improve resource use efficiency, including water use and nitrogen use efficiency [11]. Research on agricultural insurance reveals its significant impact on farming practices and resource use efficiency. Insurance participation can increase farmer's enthusiasm for crop production, particularly in sugarcane farming [12]. However, the relationship between insurance and efficiency is complex. While some studies found no significant difference in input allocation efficiency between insured and non insured rice farmers [13]. But others reported a negative relationship between insurance and technical efficiency in rice production [14]. Conversely, research on Italian grape growers showed that insurance enhanced production and efficiency while reducing intermediate input use [15]. These mixed findings highlight the need for context-specific analyses.Insurance can potentially mitigate risk-averse behaviours, leading farmers towards profit maximizing decisions [15]. Overall, the impact agricultural insurance varies across crops and regions, emphasizing the importance tailored policies and further research to optimise its benefits. These mixed findings highlight the complexity of the relationship between insurance and resource use efficiency, emphasizing the need for crop specific and context dependent research that helps in policy formulations. This study analyses the resource use efficiency between insured and non-insured sugarcane farmers. This helps in making policy decisions and extension programs aimed at boosting productivity and sustainability in India's sugarcane sector.

1.1 Selection of Study Area

In the selection of the study area, a multistage purposive sampling method was followed. Fig. 1 represents the comprehensive flowchart of Multistage purposive sampling method. The study was purposively conducted in the Kallakurichi district of Tamil Nadu which has the largest area under Sugarcane crop. Kallakurichi district has a total Sugarcane area of 25.7 thousand ha with production and productivity of 2.88 Million tonnes and 112.15 tonne/ha. [16]. 756 hectares of land has been covered under sugarcane crop insurance in the district in the year 2022-23 which is the largest among all other districts in Tamil Nadu. The survey was conducted in the Rishivandiyam Block and Thirukovillur Block of Kallakurichi district. Fig. 2 represents the map of Kallakurichi district. A total of 120 samples were collected consisting of 60 insured and 60 non-insured sugarcane farmers.

2. MATERIALS AND METHODS

The data collected from the sample farmers were analyzed and estimated with certain statistical technique

2.1 Cobb-Douglas Production Function

Production functions show a technical relationship between input and output in a production process. Cobb-Douglas production function was used to assess resource use efficiency [17].

The Cobb-Douglas function generally can be presented as

$$Q = AX^{b}$$

Where A is a positive constant term and b is a positive fraction.

Q and X are the variables, the relationship between which are examined by the equation. However, in order to specify the equation, the above implicit equation must be explicitly expressed by taking the log transformation of both sides as shown below

$$LnQ=ln\beta_0+\beta_1 lnX_1+\beta_2 lnX_2+\beta_3 lnX_3+\beta_4 lnX_4+\beta_5 ln X_5+\beta_6 lnX_6 +u$$

Where,

Y- Yield (Rs/ha) from a production activities as an output
X_1= Quantity of Seed material (Kgs/ha)
X_2 = Quantity of Farm Yard Manure (tonnes/ha)
X_3= Human labour (Man days/ha)
X_4 = Machine labour (Hrs /ha)
X_3 = Quantity of Nitrogen (Kgs/ha)
X_4 = Quantity of Phosphorous (Kgs/ha)
X_5 = Quantity of Potassium (Kgs/ha)
X_6= Cost of Plant Protection chemicals (Rs/ha)
β_0 = regression constant
$\beta_1 - \beta_6$ are the parameters (coefficients) to be estimated
u is the error term which is assumed to be normally distributed with mean zeros and constant variance. In this equation, the natural logarithm of the respective variables was included.

The level of resource use efficiency was calculated using following formula

$$RUE=MVP/MFC$$

Where,

r = Efficiency ratio

MVP = Marginal Value Product; which is the value of incremental unit of output resulting from the additional unit of inputs added.

MFC = Marginal Factor Cost which is equal to one since both dependent and explanatory variables are converted to monetary value; and is defined as the increase in the cost of inputs due to purchase of additional unit of inputs.

$$\text{Now, } MVP=b_i*Y_i / X_i$$

b_i= Estimated regression coefficient of input Xi
Y_i= Geometric mean value of output.
X_i= Geometric mean value of i^{th} resources used.

Decision rule

r= 1; Efficient use of resource
r>1; Underused of the resource
r<1; Overused of the resource

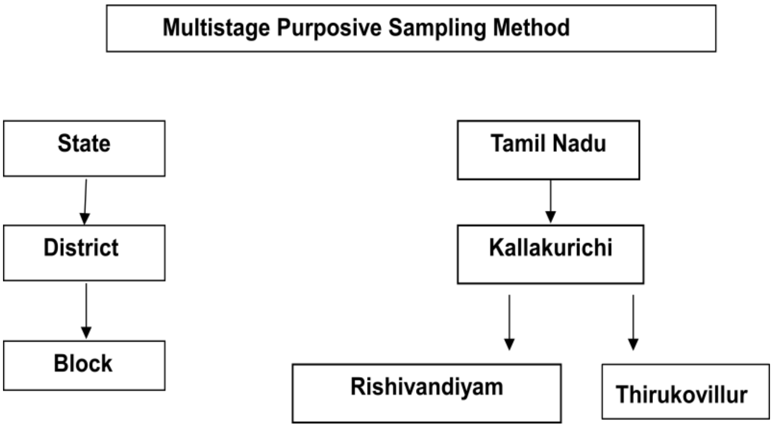

Fig. 1. Flowchart of multistage purposive sampling method

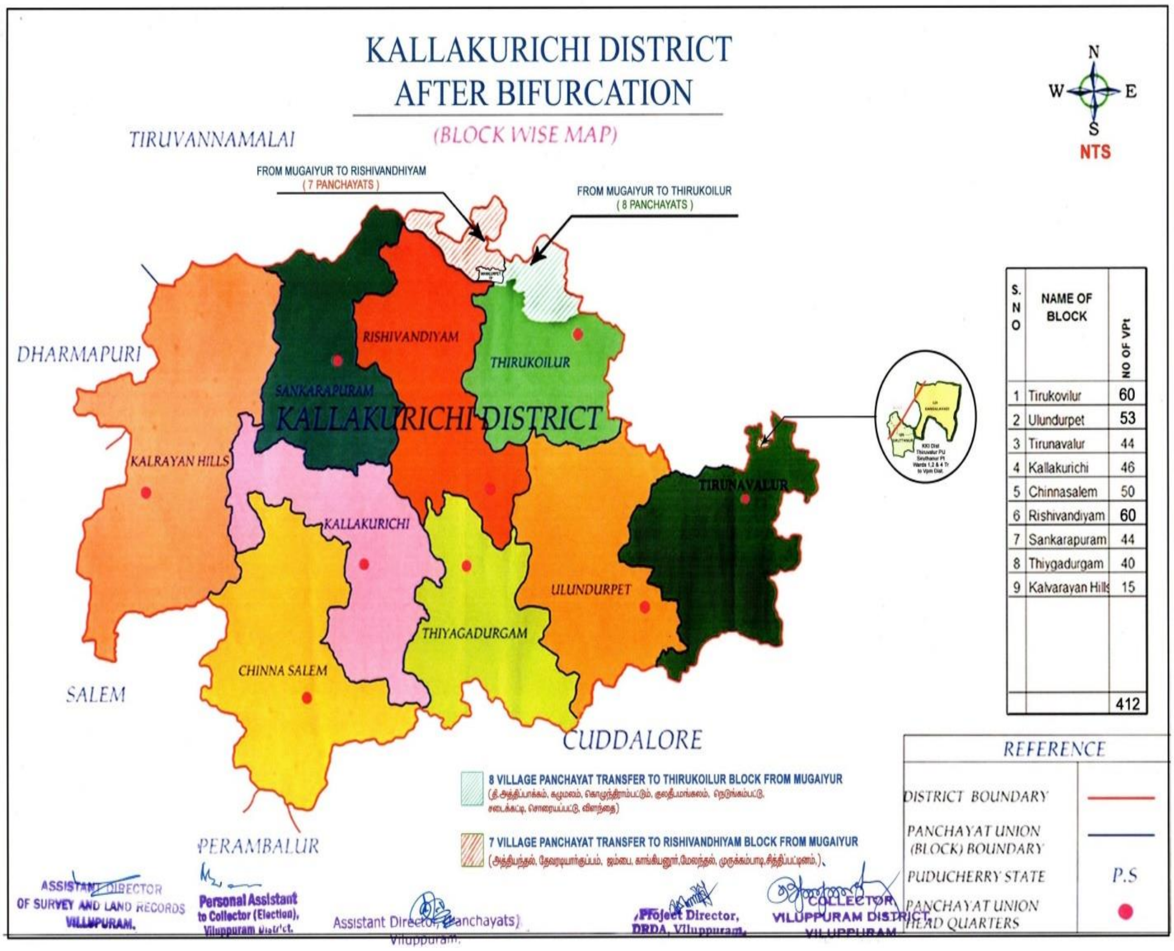

Fig. 2. Map showing kallakurichi district

3. RESULTS AND DISCUSSION

The results of the regression estimates of Cobb Douglas Production function for sugarcane cultivation in the study area is presented in the Table 1.The results showed that in case of the Insured farmers, Nitrogen fertiliser, human labour used in the production process were found to have a significant and positive influence on yield at 5 per cent level where as the Machine Labour used in cultivation as bund former and rotavator and harvester was found to be positive and significant at 1 per cent level of significance. Thus, the regression coefficients implied that one per cent increase in Nitrogen fertiliser from its mean level would increase the yield of Sugarcane by 0.30 percent. Similarly, if there is 1 per cent increase in variables namely, machine power, human labour would increase the yield of sugarcane by 0.25 and 0.20 per cent respectively. The sum of elasticity of regression coefficient was worked out to be 1.43 which indicated an increasing return to scale for insured farmers. This implies that one per cent increase in all the inputs for Sugarcane cultivation simultaneously would increase the paddy yield by 1.43 per cent.

Similarly, in case of non insured Sugarcane farmers, the coefficients of human labour, nitrogen, phosphorus were found to influence the sugarcane yield significantly at 5 % level and found positive. It could be inferred from the results that one per cent increase in the human labour, nitrogen, phosphorus, would increase the yield from its mean level by 0.30, 0.40, 0.12, per cent, respectively. The sum of elasticity of regression coefficients was worked out to 1.16 which implied an increasing return to scale for non- insured farmers.

From the Table 1, It could be inferred that the coefficient of multiple determination (R) of insured and non-insured farmers were found to be 0.70, 0.75, indicating that 70 & 75 per cent of the variation in the model was explained by the chosen independent variables, respectively. A study found a decreasing return to scale and R^2 for marginal, small and medium farms was estimated to be 0.923, 0.928 and 0.930 respectively [18].

Resource use efficiency of Sugarcane farms in the study area was estimated by using the marginal value product and marginal input cost of the output and inputs used in the production process. The regression co efficient was required for the estimation are derived from the Cobb Douglas Production function using OLS estimates. Decision rule for resource use efficiency states that if the ratio of MVP and MFC is more than 1 then the resource is being underutilised by the farmers for the Production process, if the ratio is equal to 1 then the resources are properly utilised and if the ratio is more than 1 then it states that the resources are underutilised by the farmers in the production process.

From the Table 2, it could be inferred that among the insured farmers resource use efficiency of inputs like Farm yard manure, Machine labour are more than 1 that states that these resources were underutilised by the sugarcane farmers in the study area in the crop production. Seed rate, Human Labour, Nitrogen, Phosphorus, Potassium and Plant Protection Chemicals are less than 1 which means that these inputs were over utilised by the farmers.

Table 1. Regression estimates of production function for sugarcane cultivation in the study area

S.No	Variables	Insured Farmers		Non Insured Farmers	
		Coefficient value	**t- value**	**Coefficient value**	**t- value**
1	Constant	0.19	0.42	0.15	-1.51
2	Seed rate (kg/ha)	0.08	1.08	0.03	0.77
3	Farmyard Manure (tonnes/ha)	0.25	2.03	0.03	1.04
4	Human Labour (Mandays/ha)	0.25**	2.80	0.30**	2.77
5	Machine Labour (hrs/ha)	0.20***	3.92	0.15*	2.29
6	N (Kgs/ha)	0.30**	2.68	0.40**	3.73
7	P (Kgs/ha)	0.15	1.47	0.12**	2.02
8	K (Kgs/ha)	0.08	1.48	0.07	1.47
9	Plant Protection chemicals (Rs/ha)	0.03	1.72	0.06	1.14
10	R2	70		75	
11	Adjusted R2	69		72	
12	F- Value	32		36	
	N	60		60	

*(*** Significant at 1 percent level, ** Significant at 5 percent,*significant at 10 percent level)*

Table 2. Estimates of resource use efficiency of sugarcane farms in the study area

Variable	Insured		Non Insured	
	Regression Co efficient	MVP/MFC	Regression Co efficient	MVP/MFC
Seed rate	0.08	0.38	0.03	0.12
Farmyard Manure	0.25	2.70	0.03	0.16
Human Labour	0.25**	0.8	0.30**	0.95
Machine Labour	0.20***	21.5	0.15*	18.5
Nitrogen	0.30**	0.15	0.40**	0.92
Phosphorus	0.15	0.28	0.12**	0.13
Potassium	0.08	0.05	0.07	0.03
Plant Protection chemicals	0.03	0.00	0.06	0.000

*(*** Significant at 1 percent level, ** Significant at 5 percent,*significant at 10 percent level)*

Among the non insured farmers, it is found that ratio of MVP/MFC of the variable Machine Labour is more than 1 which means that this input was underutilised and the inputs such as Seed rate, Farm Yard Manure, Human Labour, Nitrogen, Potassium, Phosphorus are less than 1 which states that these resources were over utilised in the production process of sugarcane in the study area. There exists a significant difference in resource use efficiency of inputs between the insured and non insured farmer. Inputs such as farm yard manure and machine labour show resource use efficiency ratio more than 1 among the insured farmers, which states that underutilization of these resources. Conversely, other inputs such as seed rate, human labour, nitrogen, phosphorus, potassium and plant protection chemicals have ratios less than 1 indicating overutilization of these resources Among non insured farmers, only machine labour appears underutilized with a ratio more than 1,while seed rate, farm yard manure, human labour ,Nitrogen, Phosphorus, Potassium shows ratio less than 1,indicating overutilization of resources .Similar findings were found in a study conducted on Resource use efficiency in sugarcane production in Tirunelveli district of Tamil Nadu that shows that MVP to MIC ratio is less than unity for Setts (0.764), Machine labour (0.1658), Human labour (0.1794), potash (-1.392), Irrigation (-4.733) indicates the over utilization of these resources. MVP to MIC ratio was more than unity for Nitrogen (22.749) and Phosphorus (7.433) indicates that the resources are underutilized [19]. Their study also shows a differences in resource use patterns that followed but they didn't compare between insured and non insured farmers. Their study emphasized the need for better resource management practices and targeted interventions to improve overall efficiency in sugarcane cultivation, echoing the implications of the current analysis. Similar results were found in a study on An Economic analysis of sugarcane farms in western Maharashtra. They didn't compare between insured and non insured farmers but calculated the resource use efficiency for sugarcane farms in Western Maharashtra. The findings state that the ratio of marginal value product to factor cost (MVP/MC) exceeds unity for phosphorus, irrigation and working capital indicating these resources are underutilized and could be increased to boost output. Conversely, human labour manure, nitrogen and potassium show MVP/MC ratios below unity, suggesting overutilization. To optimize production efficiency, farmers should consider reallocating resources by increasing the use of phosphorus, irrigation, and working capital while potentially reducing or maintaining current levels of human labour, manure, nitrogen, and potassium inputs. This strategic adjustment in resource allocation could lead to improved overall productivity and more efficient farming practices [20].

In contrast to our findings,the study conducted on resource use efficiency in sugarcane farming between tenant and owner farms states that the tenant farmers underutilise the resources such as setts material ,human labour, fertiliser and machine labour but owner farmers underutilised human labour, fertiliser and machine labour but over utilised sett material .The study revealed the difference in resource use efficiency between tenant and owner farmers [21].

4. CONCLUSION

This study on the resource use efficiency in sugarcane farming provides valuable insights into input utilization patterns among the farmers. The results shows that there is a need for both efficient practices and improvement across various inputs such as fertilizers, water, machinery and labour. There is a notable difference in resource use efficiency between insured and non insured farmers which suggests that risk management strategies influence input allocation decisions. The findings highlight the overutilization of certain inputs, particularly chemical fertilizers and Labour, while others like farm yard manure and mechanization are underutilised. These inefficiencies impact farm profitability as well as environmental sustainability. These results help farmers maximise their input use, policymakers develop focused initiatives and agricultural agencies provide specialize advice. The study also laid a foundation for further research into factors influencing resource use efficiency and the role of precision agriculture in promoting sustainable farming practices. Enhancing resource use efficiency in sugarcane cultivation is important for improving the sector's resilience, sustainability and competitiveness. By optimizing input utilization, the sugarcane industry can better support India's food security and sustainable agricultural development goals.

DISCLAIMER (ARTIFICIAL INTELLIGENCE)

Author(s) hereby declare that NO generative AI technologies such as Large Language Models (ChatGPT, COPILOT, etc) and text-to-image generators have been used during writing or editing of manuscripts.

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COMPETING INTERESTS

Authors have declared that no competing interests exist.

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