

International Journal of Agriculture Extension and Social Development

Volume 8; Issue 12; December 2025; Page No. 566-569

Received: 05-09-2025

Accepted: 11-10-2025

Indexed Journal

Peer Reviewed Journal

Analysis of resource use efficiency in the production of *suru* sugarcane in Sindhudurg district of Maharashtra state, India

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DOI: <https://www.doi.org/10.33545/26180723.2025.v8.i12h.2808>

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Abstract

Sugarcane is one of the traditional crops grown extensively in the state of Maharashtra. The present study analysed resource use efficiency in the production of *suru* sugarcane in the Sindhudurg district of Maharashtra state, India. The study was based on primary data. The data were collected by interviewing ninety sugarcane growers. The sampled growers were categorized based on the type of sugarcane they cultivated, i.e., *suru* and *ratoon* sugarcane. However, the present analysis focused exclusively on *suru* sugarcane growers. The relationship between various inputs used in *suru* sugarcane production and output was analysed using the Cobb-Douglas production function. The results revealed that the R^2 value for *suru* sugarcane was 0.79, indicating that the selected input variables explained 79 per cent of the variation in production. Additionally, the return to scale for *suru* sugarcane was found to be 1.05, indicating increasing returns to scale for sugarcane production. The MVP to MFC ratio for *suru* sugarcane exceeded unity for key inputs such as human labour (1.25), bullock labour (2.75), manure (2.56), potassium (2.83) and irrigation (14.25). These findings suggest that these resources were underutilized in *suru* sugarcane cultivation, highlighting the potential for expanding their use to enhance productivity.

Keywords: *Suru* sugarcane, resource use efficiency, Cobb-Douglas production function, marginal value product (MVP) and marginal factor cost (MFC)

1. Introduction

Sugarcane (*Saccharum officinarum* L.) is a natural, renewable agricultural resource that provides a variety of byproducts including biofuel, fiber, fertilizer and sugar, all of which are ecologically sustainable (Singh and Katiyar, 2016) ^[11]. Sugarcane belongs to the Graminae family. Sugarcane has been cultivated in the Indian subcontinent for centuries, with its history tracing back to mentions in the Atharva Veda. Sugarcane plays a crucial role in the agricultural economy of India and other tropical and subtropical regions worldwide. Initially, sugarcane was used for chewing, but in the Indus Valley around three thousand years ago, the preparation of crystallized sugar from cane stalk was reported. However, in the Indian sub-continent, sugarcane was reported to be a vital crop by around 327 B.C. In 647 and 755 A.D., it was introduced to Egypt and Spain, respectively and hence nearly to all tropical and subtropical regions, through traders (Malavolta, 1994) ^[8]. Sugarcane is a perennial tall grass known for its efficiency in photosynthesis and biomass production and it is predominantly cultivated in areas with easy access to irrigation. White sugar, brown sugar (*khandhasari*), jaggery (*gur*) and ethanol are all produced using sugarcane liquid (Mahadik *et al.*, 2023) ^[7]. Sugarcane also provides important byproducts such as bagasse, which serves as a primary energy source in sugar mills, which is essential for

alcohol production (Shukla *et al.*, 2017) ^[10]. Additionally, sugarcane leaves and press mud are valuable as mulch, green manure and sources of plant nutrients. The crop has significant implications for the rural economy, employing millions involved in its cultivation, processing and related industries (Solomon, 2016) ^[13].

Sugarcane is globally an important commercial crops accounting for nearly 70 per cent of the world's sugarcane production (Singh, 2018) ^[12]. Over the last two decades, particularly in South America, Asia and Africa, the sugarcane industry has continued to expand. As per one estimate, the cultivated area under sugarcane throughout the globe increased to 39.2 per cent from 1990 to 2010 (FAOSTAT, 2012) ^[2]. Like the other value-added crops, sugarcane is also a more attractive crop for multi-national companies to invest their capital (Tiwari, 2003) ^[15]. Brazil is the largest producer of sugarcane, contributing 40 per cent of the world's production, followed by India with nearly 20 per cent (FAOSTAT, 2023) ^[3]. In India, sugarcane farming is extensive, particularly in Uttar Pradesh, Maharashtra, Karnataka and Tamil Nadu. In Maharashtra, sugarcane is a significant industry, with rapid growth in recent years. Maharashtra holds the second position in India for both the area under sugarcane cultivation and its production, with Kolhapur being the top district in the state for sugarcane production. The Maharashtra sugar industry plays a

prominent role in the nation's sugar production, contributing significantly to the state's economy and employment (Supriya *et al.*, 2014) [14]. In the last few decades in the Konkan region, Sindhudurg district has been a major producer of sugarcane, with an area of 3294 hectares under the crop (DSA Sindhudurg, 2022) [4]. Therefore, the present study on, "Analysis of resource use efficiency in the production of *suru* sugarcane in Sindhudurg district of Maharashtra state, India" was undertaken with the following objectives-

1. To analyse the resource use efficiency in the production of *suru* sugarcane.
2. To analyse the marginal value productivity of *suru* sugarcane.

2. Materials and Methods

The survey for the specified objective was conducted in the Sindhudurg district of Konkan region. The study employed a four-stage sampling design, selecting districts, tahsils, villages and ultimately sugarcane growers as sampling units. The Sindhudurg district of the Konkan region in Maharashtra, known for its significant sugarcane cultivation, was chosen as the study area. Within this district, three tahsils Vaibhavwadi, Kankavli and Kudal were selected based on their area under sugarcane production. Three villages were randomly selected from each tahsil, resulting in a total of nine villages. Subsequently, 10 sugarcane cultivators were randomly chosen from each village, yielding a total sample size of 90 farmers. The sampled growers were further classified according to the type of sugarcane cultivated, namely *suru* and *ratoon* sugarcane; however, the present analysis focused exclusively on *suru* sugarcane growers. The data and information used in this study pertain to the agricultural year 2022-23.

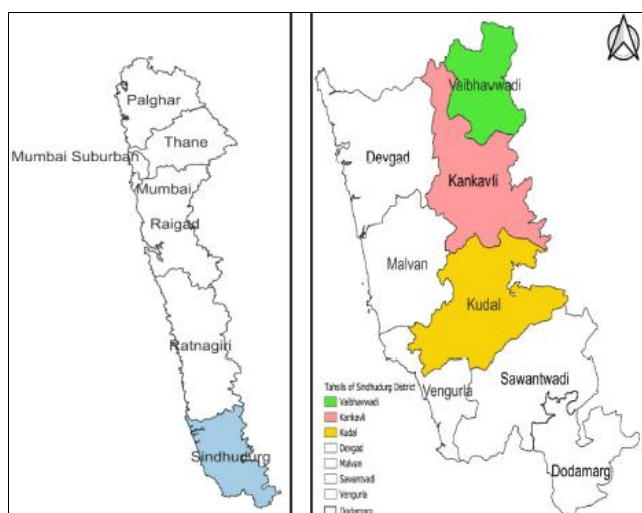


Fig 1: Map showing the study area

2.1 Functional analyses

The objective of resource use efficiency was achieved by the application of functional analysis. Girei and Giroh (2013) [5], Mahadik *et al.*, (2023) [7], Pandey *et al.*, (2020) [9], Singh SP (2018) [12] and Yadav *et al.*, (2021) [16] used the following methods to find out the resource use efficiency in sugarcane cultivation. The Cobb-Douglas production

function was used to determine the regression coefficient. It is specified as

$$Y = a X_1^{b_1} X_2^{b_2} X_3^{b_3} \dots X_n^{b_n} e^u$$

Where,

Y = yield of sugarcane (MT./ ha.)

a = Intercept of the production function

bi = Regression coefficient of the respective variable

X₁ = Human labour (man days)

X₂ = Bullock labour (bullock pair)

X₃ = Machine labour (hrs.)

X₄ = Planting materials (set in no.)

X₅ = Manures (MT.)

X₆ = Nitrogen (kg.)

X₇ = Phosphorus (kg.)

X₈ = Potassium (kg.)

X₉ = Plant protection chemicals (lit.)

X₁₀ = Irrigation (no.)

2.2 Estimation of MVP and MPP

Marginal value product (MVP) is the additional revenue created due to the addition of one unit of the input. Marginal value product was computed by multiplying the unit price of the output by the marginal physical product (MPP). The marginal physical product (MPP) is the change in output produced by the addition of one additional unit of the variable input and was calculated from the estimated regression coefficients and geometric mean values of dependent as well as independent variables.

The following formulas were used for the calculation of marginal physical product and marginal value product.

i) Marginal Physical Product (MPP)

$$MPP_{xi} = b_i \frac{\bar{Y}}{\bar{X}_i}$$

Where,

b_i = Production elasticities of ith input

$\bar{Y}$ = Geometric mean of the dependent variable

$\bar{X}_i$ = Geometric mean of ith independent variable

ii) Marginal Value Product (MVP)

$$MVP_{xi} = MPP_{xi} \times \text{Price per unit of output (P}_y\text{)}$$

2.3 Marginal Factor Cost (MFC)

MFC = Price per unit of the input.

2.4 Resource Use Efficiency (RUE)

After estimating the MVP, the resource use efficiency of different resources will be judged with the help of MVP to MFC ratio as shown below,

MVP/MFC = 1 → Optimum use of resource.

MVP/MFC < 1 → Excess utilization of resources.

MVP/MFC > 1 → Underutilization of resource.

3. Results and Discussion

A functional analysis was conducted to examine the relationship between the resources utilized by growers in

suru sugarcane cultivation. The analysis aimed to assess the efficiency of individual resources in the production process. The findings of this analysis are presented in the following section.

3.1 Resource product relationship in the production of *suru* sugarcane

The relationship between various inputs used in *suru* sugarcane production and the resulting output was analysed

using the Cobb-Douglas production function. In *suru* sugarcane, the independent variables considered in the analysis included human labour (X_1), bullock labour (X_2), machine labour (X_3), planting material (X_4), manure (X_5), nitrogen (X_6), phosphorus (X_7), potassium (X_8), plant protection chemicals (X_9) and number of irrigations (X_{10}). The dependent variable in this analysis was the production of *suru* sugarcane (Y). The regression coefficient of input factors of *suru* sugarcane is represented in Table 1.

Table 1: Coefficient of regression of inputs for the production of *suru* sugarcane

Sr. No.	Variables	Estimated regression coefficient
1	Human labour (days) (X_1)	0.3042** (0.0474)
2	Bullock Labour (pair days) (X_2)	0.0714 (0.0628)
3	Machine Labour (hours) (X_3)	0.0063 (0.1047)
4	Planting materials (no.) (X_4)	0.0469 (0.0317)
5	Manure (MT.) (X_5)	0.2235** (0.0530)
6	Nitrogen (kg.) (X_6)	-0.0138 (0.0467)
7	Phosphorus (kg.) (X_7)	0.0111 (0.0369)
8	Potassium (kg.) (X_8)	0.0635 (0.0465)
9	Plant protection (lit.) (X_9)	-0.0177 (0.0395)
10	Irrigation (no.) (X_{10})	0.3601** (0.0675)
11	Intercept	5.9920 (0.7389)
12	R^2	0.79
13	Sum of elasticities ($\sum b_i$)	1.0555

(Figures in parentheses indicate standard error of coefficient of regression)

** 5 per cent level of significance

The results indicate that, the coefficient of determination (R^2) was 0.79. This means that 79 per cent of the variation in sugarcane yield can be attributed to the variables included in the model. The sum of the elasticity coefficient was 1.05 which was greater than one indicating increasing returns to scale. The regression analysis revealed that human labour (0.3042), manure (0.2235) and irrigation (0.3601) positively and significantly impacted *suru* sugarcane production at the 5 per cent level, indicating their crucial role in boosting yields. Although bullock labour (0.0714), machine hours (0.0063), planting material (0.0469), phosphorus (0.0111) and potassium (0.0635) had positive but non-significant effects, nitrogen (-0.0138) and plant protection (-0.0177)

had negative and non-significant impacts.

3.2 Resource use efficiencies in the production of *suru* sugarcane

The resource use efficiency in sugarcane production was evaluated by analysing the Marginal Value Product (MVP) to Marginal Factor Cost (MFC). This approach was used to assess whether the input resources employed in *suru* sugarcane cultivation were utilized efficiently. The findings of this analysis, detailed in Table 2, provide insights into how effectively the input resources contributed to sugarcane production.

Table 2: Resource use efficiencies in *suru* sugarcane production

Sr. No.	Variables	Units	MPP	MVP	MFC	MVP/ MFC Ratio	Level of resource used
1	Human labour (X_1)	days	135.383	406.150	325	1.250	Under utilization
2	Bullock Labour (X_2)	pair days	871.246	2613.739	950	2.751	Under utilization
3	Machine hours (X_3)	hrs.	24.909	74.726	850	0.088	Excess utilization
4	Planting materials (X_4)	no.	0.579	1.736	3	0.579	Excess utilization
5	Manure (X_5)	MT.	3.420	10.261	4	2.565	Under utilization
6	Nitrogen (X_6)	kg.	-5.685	-17.055	13	-1.312	Excess utilization
7	Phosphorus (X_7)	kg.	9.371	28.112	75	0.375	Excess utilization
8	Potassium (X_8)	kg.	54.830	164.489	58	2.836	Under utilization
9	Plant protection (X_9)	lit.	-697.081	-2091.24	810	-2.582	Excess utilization
10	Irrigation (X_{10})	no.	1901.200	5703.601	400	14.259	Under utilization

(MPP: Marginal Physical Product, MVP: Marginal Value Product, MFC: Marginal Factor Cost)

Table 2 reveals that in *suru* sugarcane production, the MVP to MFC ratio was less than unity for several inputs, specifically machine hours (0.088), planting materials (0.579), nitrogen (-1.312), phosphorus (0.375) and plant protection (-2.582). These ratios indicate that these resources were overutilized, meaning their current levels of use do not contribute proportionally to increases in output,

leading to inefficiencies. To enhance production efficiency, it is recommended to reduce the expenditures on these inputs. Conversely, the MVP to MFC ratio exceeds unity for human labour (1.250), bullock labour (2.751), manure (2.565), potassium (2.836) and irrigation (14.259), suggesting that these resources were underutilized in *suru* sugarcane cultivation which underlines the scope of

expanding the use of these inputs.

4. Conclusion

The resource use efficiency in the production of *suru* sugarcane was analysed by employing the Cobb-Douglas production function. The study concludes that human labour, manure and irrigation play a critical role in enhancing the productivity of *suru* sugarcane. These inputs were found to have a positive and significant impact on yields, emphasizing their importance in optimizing sugarcane production. Overutilization of inputs such as machine hours, planting materials, nitrogen, phosphorus and plant protection were observed, as reflected by their MVP to MFC ratios being less than unity. Reducing the expenditure on these resources can improve overall efficiency and reduce waste. On the other hand, human labour, bullock labour, manure, potassium and irrigation were underutilized in *suru* sugarcane production, with MVP to MFC ratios exceeding unity. This indicates potential for improving productivity by increasing the use of these key inputs. These findings highlight the need for a balanced and rational allocation of resources in *suru* sugarcane cultivation. Farmers should aim to curtail the excessive use of overutilized inputs while enhancing the application of underutilized ones to achieve an optimal input allocation. Such adjustments, supported by improved input quality, better agronomic practices and the adoption of suitable technologies, can substantially improve production efficiency and overall yield performance.

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