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An economic evaluation of resource use efficiency of small tea growers in Assam

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Abstract

The tea industry in Assam, a vital component of India's agricultural landscape, has undergone a significant transformation with the growing prominence of small tea growers. The study, entitled *"An Economic Evaluation of the Resource Use Efficiency of Small Tea Growers of Assam,"* aims to assess the efficiency of resource utilization in green tea leaf production by small-tea growers. Focusing on Tinsukia and Dibrugarh districts—two districts with major concentration of small tea grower, the study employed a multi-stage random sampling technique to select a representative sample of 197 growers. Primary and secondary sources of data were utilized in the research. The Cobb-Douglas production function was applied to evaluate how effectively resources are used by the small-tea growers in the sample. The study analysed patterns of input use and identifies resource gaps that impact productivity. The sum of the output elasticities (Σb_i) for each category exceeded 1, indicating that all groups experienced increasing returns to scale. The results of the investigation highlighted that there was positive correlation between inputs and the yield which was indicated by the coefficient of multiple determination (R^2) across all categories of growers.

Keywords: Resource-use efficiency, multi-stage random sampling, cobb-doughlas production function, output elasticities, coefficient of multiple determination

1. Introduction

Tea holds a prominent place in global agriculture and trade, being one of the most consumed beverages worldwide. India is a major player in the tea industry, ranking among the top producers and exporters. Assam is the leading tea-producing state in India, contributing more than half of the nation's total output (Tea Board of India, 2021) [11]. Historically, tea cultivation in Assam was dominated by large plantations, but over the past few decades, there has been a significant rise in the number of small tea growers (STGs) thereby reshaping the structure of the industry.

Small tea growers, defined as those cultivating tea on land less than 10.12 hectares, have become crucial contributors to the rural economy of Assam. They are particularly concentrated in districts *viz*. Tinsukia, Dibrugarh, Golaghat, Jorhat, and Sivasagar. These growers often rely on family labour and face various challenges such as limited access to credit, lack of technical support, fluctuating prices, and inefficient use of available resources (Baruah & Hazarika, 2015; Deka & Sarma, 2020) [2, 6]. Despite their growing importance, there remains a noticeable gap in research and policy support focused specifically on improving their production efficiency.

Evaluating how efficiently small tea growers use their resources is essential for improving both productivity and sustainability. Resource use efficiency reflects how well inputs such as land, labour, fertilizers, and capital are transformed into output. Efficient resource use leads to cost savings, higher yields, and better livelihoods for smallholder farmers. One common and effective method for analyzing input-output relationships is the Cobb-Douglas production function, which helps quantify the contribution of individual resources to overall production and assess where improvements are needed (Coelli *et al.*, 2005) [5].

This study aims to explore the efficiency of resource use among small tea growers in Assam, focusing specifically on the districts of Tinsukia and Dibrugarh. Using data collected from a sample of 197 growers through a structured multi-stage random sampling method, the study applies the Cobb-Douglas production function to evaluate how inputs are utilized in tea leaf production. The insights drawn from this research are expected to inform policymakers and development agencies about strategies to support small growers in optimizing resource use and improving their economic outcomes.

1.1. Objective

The objective of the current investigation is to assess the resource use efficiency in green leaf production by the small tea growers.

1.2. Literature review

Han *et al.* (2016) [7] stated that excessive nitrogen application is common in Chinese tea gardens, often leading to environmental degradation such as nutrient leaching and soil acidification, without corresponding increases in yield. They observed that applying nitrogen at levels above 300 kg/ha per year did not significantly boost productivity.

In their study, Bera *et al.* (2018) [3] observed that incentivized plucking systems in the Dooars region of India led to better leaf quality and higher yields. They concluded that labour productivity could be significantly enhanced by combining training with performance-based rewards.

Barua *et al.* (2019) [1] stated that smallholder tea farmers often struggle with resource inefficiency due to limited access to inputs, knowledge, and technology. Their study in Assam emphasized the need for training and support programs to empower these farmers.

Jayasinghe and Kumarasinghe (2019) [8] stated that partial mechanization using hand-held plucking machines in Sri Lanka resulted in 30-40% improvement in labour efficiency. They reported only a marginal compromise in leaf quality, which suggests potential for wider adoption, especially in regions facing labour shortages.

In their study, Muraleedharan and Radhakrishnan (2020) [10] highlighted that integrated nutrient management, combining balanced NPK fertilizers with organic manures, improved tea yield and enhanced soil health in South India. They suggested that such practices are essential for achieving long-term nutrient efficiency.

Koshal *et al.* (2020) [9], in their study, observed that sustainability certification programs such as Rainforest Alliance and Fair Trade encourage efficient resource use through compliance with environmental standards. They noted that such certifications not only improve farming practices but also enhance market access and premiums.

2. Methodology

2.1. Sampling Procedure

The current study utilized a multistage random sampling method. In Assam, small tea farms are primarily found in Upper Brahmaputra valley and the North bank plain areas. The Upper Brahmaputra valley represents 97 percent of Assam's overall small tea output. Therefore, at the first stage, Upper Brahmaputra Valley Zone was selected as this zone forms the major tea belt of the state with maximum concentration of tea growing areas.

Two districts were purposively selected at the second stage having the highest number of-small-tea growers. At the third stage, two blocks from Tinsukia and two blocks from Dibrugarh districts were purposively selected for the investigation. At the fourth stage, small tea growers were selected randomly constituting the final sampling unit from the selected blocks from both the districts.

2.2. Selection of blocks

Tinsukia district comprises seven development blocks: Guijan, Hapjan, Itakhuli, Kakopathar, Margherita, Sadiya, and Saikhowa. Among these, the Guijan and Itakhuli blocks were purposively selected for the present study due to the relatively high concentration of small tea growers. Similarly, Dibrugarh district also consists of seven blocks, *viz*. Barbaruah, Joypur, Khowang, Lahoal, Panitola, Tengakhat, and Tingkhong. For the purpose of this research, the Panitola and Lahoal blocks were purposively chosen, as they represent significant areas of small tea cultivation.

2.3. Selection of respondents

Small tea growers were selected randomly constituting the final sampling unit from the selected blocks from both the districts. The growers were classified into three different size group based on their tea plantation holdings.

- Marginal-small growers: 0-2.5 hectares
- Small-scale growers: 2.5-5.00 hectares
- Medium small growers: 5.0 hectares and above.

The sample size of small tea growers from Guijan and Itakhuli blocks of Tinsukia district was 92. Consequently, 105 small-tea growers were selected from Panitola and Lahoal blocks of Dibrugarh district randomly. The sample size was constituted of 197 respondents.

2.4. Data collection

Data for the study were collected from both primary and secondary sources. Primary data were obtained directly from respondents through personal interviews. Secondary data were sourced from a range of published materials and official documents, including reports from the Tea Board of India, the Indian Tea Association, and the Department of Industry and Commerce, Government of Assam. Additional sources included publications from the All Assam Small Tea Growers' Association and the *Statistical Handbook of Assam (2023)*. Relevant literature such as Ph.D. theses, research reports, books, and journal articles were also consulted to gather comprehensive secondary information.

2.5. Period of study

The information pertaining to the present study was collected and gathered during the year 2023-24.

2.6. Analytical Framework

a. Tabular analysis

To provide information related to the objectives under study, the primary and secondar data gathered was presented in simple tabular form to analyse and infer conclusions from it.

b. Descriptive statistics

The collected information was summarized through descriptive statistical techniques like averages, means, and percentages to produce significant findings.

c. Cobb-Doughlas Production function

A production function (Cobb-Douglas type) was utilized to evaluate how effectively resources are used by the small-tea growers in the sample. To identify what influences the production of green leaves by small tea growers, a Cobb-Douglas production function was applied. Cobb-Doughlas function instrumented for the study is given as under:

$$\ln Y = \ln a + b_1 \ln X_1 + b_2 \ln X_2 + b_3 \ln X_3 + b_4 \ln X_4$$

where,
Y= Yield (kgs)
X_1= Quantity of hired-labour (mandays)
X_2= Quantity of family-labour (mandays)
$X_{.3}$ = Quantity of manures and fertilizers (kgs)
X_4= Quantity of plant protection chemicals (kgs)
a = Intercept
$b_1...b_4$= Regression coefficients of independent variables

3. Results and Discussion

Resource-use efficiency was estimated using Cobb-Douglas production function. The estimation was carried out for marginal, small-scale and medium small tea growers. The coefficient of multiple determination (R^2) tries to explain the variation in the dependent variable due to the independent variables associated with the production function. The elasticity of production was given by the estimated regression coefficients (b_i) of the considered inputs (X_i). The regression coefficient (b_i) indicates the percentage change in yield (Y) with a unit change in the inputs (X_i) while other factors remain constant.

A. Resource- use efficiency of marginal small growers

The estimated Cobb- Douglas production function for marginal small tea growers can be found in Table 3.1. The co-efficient of multiple determination (R^2) for these growers was 0.90, showing that the independent variables explained 90 percent of the yield variation. These variables included the amount of hired labour, family labour, fertilizers, manures, and plant protection formulations. Among them, the amount of hired labour and the use of manures and fertilizers had a significant effect on yield at a five percent significance level. Specifically, an increase of one percent in hired labour and manures and fertilizers led to a rise in yield by 0. 43 and 0. 34 percent, respectively. The impact of plant protection chemicals was also positive and significantly affected yield; a one percent increase in their usage resulted in a 0. 14 percent yield increase. Furthermore, the coefficient for family labour, which was 0. 13, was positive and significant. The Σbi value indicates returns to scale, which was calculated at 1. 04. This suggests that if all independent variables were increased simultaneously by one percent, the yield would rise by 1. 04 percent, demonstrating increasing returns to scale.

Table 3.1: Resource-use efficiency of Marginal small tea growers

Sl. No.	Particulars	Coefficient
1	Intercept	2.18
2	Quantity of hired labour (man days)	0.43*
3	Quantity of family labour (man days)	0.13
4	Quantity of manures and fertilizers (kg)	0.34*
5	Quantity of plant protection chemicals (kg)	0.14
6	R^2	0.9
7	$\sum b_i$	1.04

* Significant at 5% level of significance

B. Resource- use efficiency of small-scale growers

The Cobb-Douglas production function was estimated for the small-scale tea growers and is presented in Table 3.2. The coefficient of multiple determination (R^2) for small-scale growers was 0.91 which indicated that 91 percent of variation in yield was explained by the independent variables in the production function. Among the different independent variables, the quantity of hired-labour and quantity of manures and fertilizers significantly influenced yield of the small-scale growers. A one per cent increase in the use of hired-labour and manures and fertilizers were found to increase the yield by 0.64 and 0.38 percent respectively. The coefficient of plant protection chemicals was found to be positive and it significantly influenced the yield. The coefficient of family labour (0.17) was estimated to be positive and found to be significant. The Σb_i value was estimated to be 1.58 which indicated that a simultaneous increase in all the independent variables by one per cent would increase the yield by 1.58 percent which shows increasing return to scale.

Table 3.2: Resource-use efficiency of small-scale growers

Sl. No.	Particulars	Coefficient
1	Intercept	2.25
2	Quantity of hired labour (man days)	0.64
3	Quantity of family labour (man days)	0.17
4	Quantity of manures and fertilizers (kg)	0.38
5	Quantity of plant protection chemicals (kg)	0.39
6	R^2	0.91
7	$\sum b_i$	1.58

C. Resource-use efficiency of Medium-small tea growers

The Cobb-Douglas production function has been analyzed for medium small tea farmers and the findings are shown in Table 3.3. For medium tea growers, the coefficient of_ multiple determination, or R^2; was_0. 90. This means that 90 percent of the yield variation can be attributed to the factors included in the production function, such as hired labor, family labor, fertilizers, manures, and plant protection chemicals. Among these independent variables, hired labor and the use of manures and fertilizers had a significant impact on yield. Specifically, a one percent rise in hired labor and in manures and fertilizers leads to increases in yield of 0. 71 and 0. 42 percent, respectively. Furthermore, the effect of plant protection chemicals was positive and also significantly affected the yield, with a one percent increase resulting in a 0. 41 percent rise in yield. The coefficient for family labor was 0. 19, showing a positive and significant contribution. The combined Σbi value was determined to be 1. 73, suggesting that if independent variables are increased by one percent at the same time, the yield would rise by 1. 73 percent, indicating increasing returns to scale.

Table 3.3: Resource-use efficiency of medium-small tea growers

Sl. No.	Particulars	Coefficient
1	Intercept	2.86
2	Quantity of hired labour (man days)	0.71
3	Quantity of family labour (man days)	0.19
4	Quantity of manures and fertilizers (kg)	0.42
5	Quantity of plant protection chemicals (kg)	0.41
6	R^2	0.9
7	$\sum b_i$	1.73

4. Conclusion

The present study provides an empirical assessment of resource use efficiency among small tea growers (STGs) in the Tinsukia and Dibrugarh districts of Assam, employing the Cobb-Douglas production function framework. The findings highlighted that, inputs such as hired labour, family labour, fertilizers, manures, and plant protection chemicals collectively explain a substantial proportion of yield variation across all categories of growers, with the R^2 values ranging from 0.90 to 0.91. Among these, hired labour and the application of manures and fertilizers emerged as the most influential factors in determining output. The positive and statistically significant coefficients across all size groups suggest that increased investment in these inputs correlates with higher productivity.

Moreover, the estimated sum of the input elasticities (Σbi) for marginal (1.04), small-scale (1.58), and medium-small growers (1.73) consistently indicate increasing returns to scale. This implies that proportional increases in all input resources would lead to more than proportional increases in output, underscoring the potential for enhanced productivity through optimized resource utilization.

In conclusion, the study underscores the critical need for targeted policy interventions and institutional support such as access to affordable credit, training on best agronomic practices, and input subsidies in order to help small tea growers optimize input use and achieve sustainable productivity gains. Given their growing contribution to the tea economy, empowering STGs with the necessary knowledge, resources, and market linkages is vital for enhancing rural livelihoods and maintaining Assam's leading position in India's tea sector.

5. Policy Recommendations

Based on the observed patterns of input utilization and the potential for increasing returns to scale among small tea growers (STGs) in Assam, the following policy recommendations have been proposed to enhance resource-use efficiency and promote sustainable green leaf production:

1. **Strengthen Access to Affordable Inputs and Credit:** Many small growers operate with constrained financial resources, limiting their ability to invest in essential inputs. The government and financial institutions should facilitate easy access to subsidized credit schemes and input supply chains.
2. **Capacity Building through Targeted Training and Extension Services:** Given the positive impact of labour and fertilizer use on productivity, it is essential to improve growers' knowledge of input optimization. Structured training programs should be delivered through local agricultural extension services focusing on labour management, efficient fertilizer application, integrated pest management, and sustainable cultivation techniques.
3. **Encourage Mechanization and Labour Efficiency:** Labour remains a significant input, and with rising labour costs and seasonal shortages, partial mechanization should be encouraged. Government-backed subsidies or cost-sharing models for small-scale machinery acquisition can help STGs adopt appropriate technology and improve labour productivity.
4. **Introduce Resource-Use Benchmarking and Monitoring Tools:** Development of digital tools and mobile applications to track input use, yields, and costs can empower growers to make data-informed decisions. Government and NGOs should invest in the development and dissemination of such tools, tailored to the literacy and digital capabilities of rural farmers.
5. **Link Resource-Efficient Practices with Certification and Market Incentives:** Linking resource efficiency with sustainability certification can offer growers better market access and price premiums. Policymakers should support growers in meeting certification requirements through training, documentation assistance, and connecting them with certified buyers.

These recommendations if implemented in a coordinated and participatory manner, could significantly improve the efficiency and resilience of small tea growers in Assam.

Competing Interests

Authors have declared that no competing interests exist.

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