



Research Article

Assessment of Resource Use Efficiency and Its Determinants in Maize Production Among Smallholder Farmers in Uasin Gishu and Transzoia Counties, Kenya

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Abstract

Maize remains a cornerstone crop for food security and livelihoods in Kenya, particularly in the high-producing counties of Uasin Gishu and Transzoia. Although these regions have the potential to yield 900,000 and 1,000,000 metric tons respectively, actual production lags considerably at approximately 400,000 and 600,000 metric tons. This productivity gap underscores inefficiencies in how resources are utilized by smallholder farmers. This study evaluated resource use efficiency and explored key determinants impacting maize production among a sample of 274 farmers drawn from a population of 16,300 using stratified random sampling guided by Cochran's formula. Primary data were collected through a structured, self-administered questionnaire designed on a 5-point Likert scale, and the analysis was grounded in production theory and efficiency analysis using a stochastic frontier model estimated by maximum likelihood. Utilizing descriptive statistics alongside Stochastic Frontier Analysis, the findings revealed an average technical efficiency of 82%, with scores ranging between 75% and 91%. Major contributors to inefficiency included limited education, smaller farm sizes, and inadequate access to extension services. The input-output analysis further showed that seed was the most efficiently utilized resource, with an input-output ratio of 66.67, whereas fertilizer and labor recorded lower ratios of 13.33 and 6.67, respectively. Farmers with more than two acres of land, college-level education or above, and access to credit reported higher resource efficiency ratings. The research highlights that optimizing resource use could increase maize yields by up to 25%, advocating for policies that improve farmer training, expand extension outreach, and enhance access to modern inputs to drive sustainable productivity gains.

Keywords

Resource Use Efficiency, Maize Farming, Smallholder Agriculture, Technical Efficiency, Stochastic Frontier Analysis, Kenya

1. Introduction

Maize is a staple crop worldwide, crucial for food security, especially in Sub-Saharan Africa. In 2022, global maize production topped 1.2 billion metric tons, with the United States,

China, and Brazil leading the pack [8]. Africa's share is modest, contributing about 7% of that total, with Kenya emerging as a notable producer in the region [8]. Despite its importance,

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maize farming faces plenty of challenges. Smallholder farmers in key maize-growing areas like Uasin Gishu and Transzoia Counties deal with climate change, pest outbreaks, and unstable input costs—all of which limit their yields [32]. On top of that, lack of access to modern farming tech and quality inputs continues to hold back productivity in these regions.

In Kenya, maize farming forms the backbone of rural livelihoods and food security, with smallholder farmers responsible for roughly 80% of national maize output [7]. Still, average yields fall far short of what's possible. Across the country, farmers harvest between 6.5 and 8.1 bags per acre, even though the potential yield is about 38 bags per acre [12, 13]. This gap is even more pronounced in Uasin Gishu and Transzoia. Uasin Gishu produces around 400,000 metric tons annually, though it could produce up to 900,000 metric tons [15, 17]. Transzoia's production sits near 600,000 metric tons against a potential of 1,000,000 metric tons [18]. These shortfalls highlight inefficiencies in how resources are used and show why boosting productivity is a challenge.

Getting the most out of available resources—what experts call technical efficiency—is key to closing this yield gap. Research suggests that technical efficiency in Uasin Gishu is about 80%, meaning output could rise by 20% simply through better resource management. Transzoia is a bit lower at 75%, leaving even more room for improvement [13]. The main obstacles include limited access to modern inputs, climate stress, pest problems, rising fertilizer prices, land fragmentation, and poor storage facilities [14]. Although the government has introduced subsidies and extension services, inefficiencies still persist and hamper progress [2, 19].

Improving technical efficiency is essential for sustainable maize production. This means raising productivity without needing big new investments or harming the environment [6]. To do that, localized studies are needed to dig into what affects resource use efficiency in counties like Uasin Gishu and Transzoia. Understanding these factors will help craft better policies and targeted interventions that make the best use of available resources. This study aims to assess resource use efficiency and pinpoint its drivers among smallholder maize farmers in these counties. The goal is to offer practical recommendations that boost agricultural productivity and strengthen national food security.

1.1. Statement of the Problem

Maize production is a cornerstone of Kenya's food security and rural economy, with smallholder farmers contributing approximately 80% of national output [7]. However, in critical maize-producing regions such as Uasin Gishu and Transzoia Counties, actual maize yields remain significantly below their agronomic potential. Uasin Gishu produces around 400,000 metric tons annually, falling short of its potential 900,000 metric tons, while Transzoia produces about 600,000 metric tons against a potential of 1,000,000 metric tons [16, 20]. This substantial productivity gap is largely attributed to inefficiencies

in resource utilization and technical inefficiency among smallholder farmers [21]. Factors such as limited access to modern inputs, inadequate extension services, climate variability, rising input costs, and land fragmentation exacerbate this challenge [14]. Despite governmental initiatives like input subsidies and agricultural training programs, these inefficiencies persist, hindering the full realization of maize production potential and threatening regional food security and livelihoods [2, 14]. This study seeks to systematically investigate the determinants of resource use efficiency in maize production within these counties to identify actionable pathways for improving productivity and sustainability.

1.2. Objective of the Study

To assess the level of resource use efficiency and identify the key determinants influencing resource use among smallholder maize farmers in Uasin Gishu and Transzoia Counties, Kenya.

1.3. Research Question

What is the level of resource use efficiency among smallholder maize farmers in Uasin Gishu and Transzoia Counties, and which factors significantly determine this efficiency?

1.4. Significance of Study

This study provides critical insights into the resource use efficiency and its determinants in maize production among smallholder farmers in Uasin Gishu and Transzoia Counties. By identifying key factors that influence efficient resource utilization, the findings offer valuable guidance to policymakers in formulating targeted agricultural policies and strategies that enhance productivity and sustainability. For farmers, the study empowers them with practical knowledge to optimize input use, reduce wastage, and improve overall farm performance. Agricultural extension officers and development agencies can leverage the results to design more effective training programs and resource allocation initiatives. Ultimately, this research contributes to strengthening food security, promoting economic resilience, and fostering sustainable agricultural development within the region.

2. Theoretical Framework

Production theory offers a fundamental framework for understanding the agricultural production process by explaining how various inputs such as land, labor, capital, seeds, and fertilizers are transformed into outputs like maize yield [31]. This theory places strong emphasis on efficiency, defined as the optimal use of scarce resources to maximize output without wastage [22]. Farrell's seminal work categorizes efficiency into three types: Technical Efficiency (TE), Allocative Effi-

ciency (AE), and Economic Efficiency (EE) [3]. Technical efficiency pertains to a farm's ability to produce the maximum output from a given set of inputs, while allocative efficiency involves using inputs in cost-minimizing proportions, and economic efficiency combines both to reflect overall cost-effective production [22].

Analyzing technical efficiency typically involves two main approaches: input-oriented and output-oriented methods [11]. The input-oriented approach focuses on reducing the quantity of inputs used while maintaining the current output levels, emphasizing resource conservation [3]. In contrast, the output-oriented approach examines the potential increase in output achievable without additional inputs, highlighting opportunities for productivity gains [22]. Both approaches utilize efficiency frontiers or isoquants to graphically depict the optimal input-output combinations, where farms operating below this frontier demonstrate technical inefficiency and scope for improvement [11].

Importantly, production theory recognizes that inefficiencies in agricultural production are influenced not only by internal management decisions but also by external environmental and institutional factors [4]. Market access challenges, climate variability, limited credit availability, and inadequate extension services can all constrain a farmer's ability to use resources efficiently, causing deviations from the production frontier even when inputs are sufficient [30]. Consequently, a comprehensive assessment of technical efficiency must consider both the technical production process and these external factors, which affect farmers' capacity to optimize resource allocation [10].

Further, production theory's application in smallholder

farming contexts offers a structured methodology for identifying and addressing inefficiencies by evaluating resource utilization patterns [3]. It facilitates the diagnosis of where input use deviates from optimal levels and helps pinpoint factors limiting productivity [22]. Integrating socio-economic and environmental variables into the analysis enhances the ability to design targeted interventions aimed at improving efficiency, particularly in resource-constrained regions such as Uasin Gishu and Transzoia [4]. This theoretical grounding provides a strong basis for understanding the dynamics of maize production inefficiencies and guides policy formulation to enhance agricultural productivity.

Finally, production theory forms a critical theoretical underpinning for this study, offering essential insights into maximizing output through efficient input use and highlighting the multifaceted influences on farm efficiency [22]. Its ability to distinguish between technical, allocative, and economic efficiency is particularly useful for identifying determinants of resource use efficiency among smallholder maize farmers [14]. By incorporating both technical and socio-economic factors, production theory supports the study's aim of revealing specific influences on technical efficiency in Kenya's maize sector, thus informing sustainable productivity improvement strategies [10].

2.1. The Conceptual Framework

The study was guided by a conceptual framework (Figure 1), with Resource Use Efficiency and Its Determinants as the independent variable and maize production as the dependent variable.

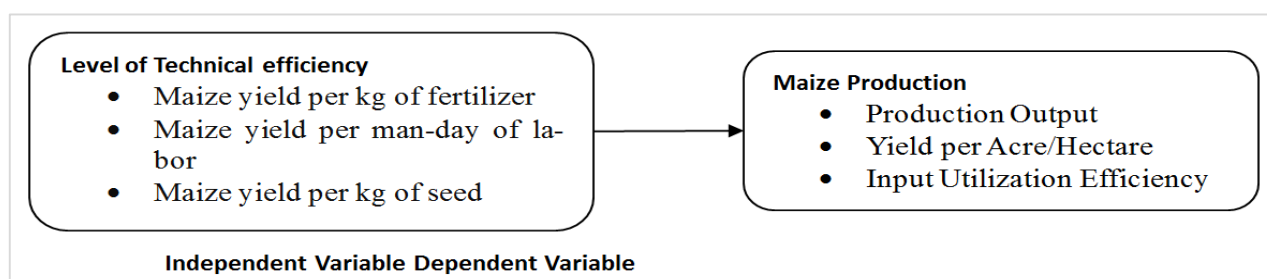


Figure 1. The Conceptual Framework.

2.2. Empirical Review: Resource Use Efficiency and Its Determinants in Maize Production Among Smallholder Farmers

Globally outside Africa, [5] used a stochastic frontier production model analyzing data from 200 smallholder maize farmers in Sri Lanka's Moneragala District. The study examined how access to credit, improved seeds, and extension ser-

vices affected resource use efficiency. Findings revealed inefficiencies caused by poor input allocation and knowledge gaps despite government interventions. However, the study's focus on South Asia means it does not capture the socio-economic and agroecological differences found in African smallholder maize farming. This underscores the need for context-specific studies in Africa that address local farming conditions and constraints.

In the United States, [9], applied panel data econometric models to 500 maize farms across the Midwest, focusing on nitrogen fertilizer use efficiency and input optimization. The

study found that adoption of modern management practices and technological innovations significantly improved resource efficiency and environmental sustainability. It highlighted that policy incentives can further encourage efficient input use among farmers. Nonetheless, the large-scale mechanized farming context differs substantially from African smallholder systems. This creates a gap for research on resource use efficiency in less industrialized and climate-challenged farming environments such as those in Africa.

Regionally in Africa, [10], used a stochastic frontier production function to analyze resource use efficiency among 350 smallholder maize farmers in Southern Ethiopia. The research identified underuse of fertilizers, poor soil management, and limited extension service access as primary contributors to inefficiency. Their recommendation focused on improving input access and farmer education to boost productivity. However, the study was geographically limited to Ethiopia and did not include Kenya's leading maize-producing regions. This highlights a clear gap for comparative studies across Eastern Africa, particularly involving Kenya's major maize zones.

Similarly, [2], applied a stochastic frontier model to data from 250 maize farmers in Northern Ghana to understand efficiency determinants. Their results showed that credit constraints, labor shortages, and inadequate market access significantly hindered efficient resource use. The study advocated for strengthened institutional support and improved infrastructure. Yet, it did not explore how these factors vary in East African countries, especially Kenya. This regional gap signals the need for tailored research that accounts for East Africa's unique agricultural and socio-economic challenges.

In Kenya, [27], conducted a quantitative survey and efficiency analysis involving 180 smallholder maize farmers in Nyando. The study underscored soil organic carbon and sound farm management as critical to enhancing resource efficiency. Despite this, persistent challenges remained in accessing inputs and credit facilities. However, their focus excluded major maize-producing counties such as Uasin Gishu and Transzoia. This omission creates a vital research gap, emphasizing the necessity of comparative efficiency studies in Kenya's primary maize production areas for effective policy formulation.

A production frontier analysis was performed on 200 smallholder farmers, including maize growers in Kenya's central

highlands [21]. They identified significant inefficiencies caused mainly by limited access to improved seeds and fertilizers. The findings suggested policy interventions to improve input delivery and extension services. However, the study did not specifically analyze Uasin Gishu and Transzoia counties, Kenya's largest maize producers. This limitation indicates a gap in localized knowledge, which is essential for designing region-specific strategies to enhance resource use efficiency among smallholder maize farmers in these critical regions.

3. Research Methodology

This study employed a descriptive survey research design to evaluate technical efficiency among smallholder maize farmers in Uasin Gishu and Transzoia counties, Kenya [24, 25]. The target population comprised approximately 16,300 small-scale maize farmers, with a sample size of 274 determined using Cochran's formula [4], and selected through proportional allocation and systematic random sampling [14]. Primary data were collected via a structured, self-administered questionnaire designed on a 5-point Likert scale, following procedures validated by prior research [26]. Data analysis involved descriptive statistics including means, frequencies, and percentages to summarize socio-economic and institutional characteristics [29]. Production Theory and Efficiency Analysis were applied using a stochastic frontier model estimated by maximum likelihood to assess technical efficiency and inefficiency effects, with model validity tested through likelihood ratio tests [3].

4. Data Analysis, Results and Discussion

This section explores the relationship between inputs and outputs, analyzing how efficiently farmers use their resources, including farm size, education, and access to resources such as extension services and credit.

4.1. Input-Output Analysis

In this subsection, we analyze the relationship between inputs (fertilizer, water, labor) and output (maize yield) based on the survey data. The results are summarized in Table 1.

Table 1. Input-Output Analysis.

Input	Average Input per Acre	Average Output per Acre (kg)	Input-Output Ratio
Fertilizer	150 kg	2,000	13.33
Labor	300 man-days	2,000	6.67
Seed	30 kg	2,000	66.67

Source: Field Data, 2025

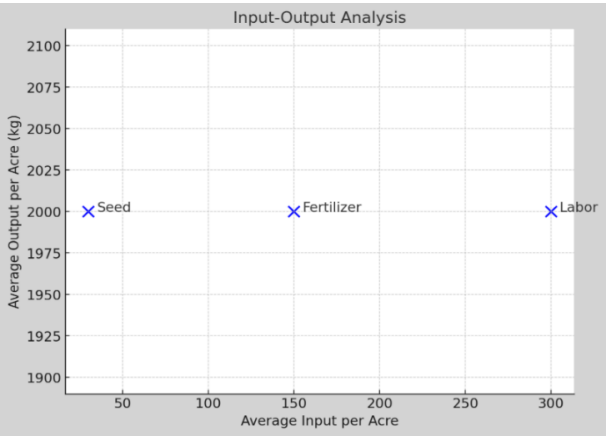


Figure 2. Input-Output Analysis.

Based on Table 1 and Figure 2, the input-output ratios show that seed is the most efficient resource in terms of output per unit of input (66.67). Fertilizer and labor, however, have much lower ratios of 13.33 and 6.67, respectively, indicating less ef-

ficient use of these resources. While farmers are achieving decent maize yields, improving the efficiency of fertilizer and labor use could significantly enhance productivity. [8], argue that improving input-output efficiency in smallholder farming is crucial for enhancing agricultural productivity. Similarly, a study by [23], supports this, suggesting that improving the efficiency of input use, particularly fertilizer and labor, could lead to higher yields and reduce costs. Furthermore, [18], highlighted that optimizing input use, especially in resource-limited environments, is essential to boosting farm productivity. On the other hand, [28], suggest that inefficiency in input use often stems from limited access to technology and information, which may restrict farmers' ability to optimize resource allocation. This points to the need for enhanced access to agricultural innovations to improve resource use efficiency.

4.2. Factors Influencing Resource Efficiency

This subsection explores how factors such as farm size, education, and access to resources (e.g., extension services, credit) affect the efficiency of resource utilization. The analysis is summarized in Table 2.

Table 2. Factors Influencing Resource Efficiency.

Factor	Efficiency Rating	Frequency	Percentage
Farm Size (>2 acres)	4.0	120	43.7%
Education (College/Above)	4.2	150	54.8%
Access to Credit	3.9	100	36.4%

Source: Field Data, 2025

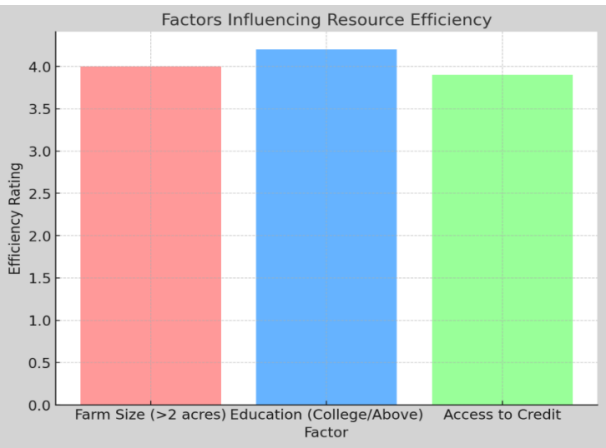


Figure 3. Factors Influencing Resource Efficiency.

Based on Table 2 and Figure 3, the findings suggest that larger farm sizes, higher education levels, and access to credit positively influence resource efficiency. Farmers with more

than 2 acres of land and those with college-level education or above report higher efficiency ratings. This underscores the importance of farm size and education in enabling farmers to manage their resources more effectively. [9], argue that larger farms benefit from better economies of scale, allowing for more efficient use of resources. Similarly, [1], show that education improves farmers' ability to apply efficient agricultural practices and make informed decisions. However, [11], suggests that access to extension services and technology is just as crucial as farm size and education for improving resource efficiency, highlighting the need for a comprehensive approach to enhancing productivity. Thus, while farm size and education are important, supporting farmers with technology and knowledge is essential for achieving optimal resource efficiency.

5. Conclusion and Recommendation

This study clearly demonstrates that resource use efficiency

significantly affects maize production among smallholder farmers in Uasin Gishu and Transzoia counties, Kenya. Inefficient use of inputs, especially fertilizer and labor, limits productivity despite available resources. Key factors such as farm size, education level, and access to credit were found to positively influence how efficiently farmers utilize their resources. These findings highlight the critical need for focused interventions aimed at improving farmers' knowledge and access to inputs. Addressing these inefficiencies is essential for closing the yield gap and enhancing overall maize productivity in these regions.

Based on the findings, several recommendations are proposed to improve resource use efficiency. Governments should enhance affordable access to inputs and credit while strengthening agricultural extension services to promote best farming practices. Policies that encourage consolidation or better management of fragmented farms could improve input utilization. Additionally, collaboration among research institutions, development agencies, and farmer groups is vital to delivering education and training programs. Implementing these strategies will support sustainable maize production, boost food security, and foster economic growth in Kenya's maize-producing counties.

Abbreviations

SFA	Stochastic Frontier Analysis
TE	Technical Efficiency
AE	Allocative Efficiency
EE	Economic Efficiency
FAO	Food and Agriculture Organization
MALF	Ministry of Agriculture, Livestock, and Fisheries
KALRO-KCEP	Kenya Agricultural and Livestock Research Organization - Kenya Climate-smart Agriculture Project
CIMMYT	International Maize and Wheat Improvement Center
DEA	Data Envelopment Analysis
ORCID	Open Researcher and Contributor ID
GDP	Gross Domestic Product

Conflicts of Interest

The author declares no conflicts of interest.

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