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Profitability and Cost Efficiency of Dry Season Leafy Vegetable Production in Ogun State, Nigeria

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Abstract

Dry-season vegetable production plays a vital role in food security, nutrition, and rural livelihoods in Nigeria. This study assessed the profitability and cost efficiency of dry-season leafy vegetable production in Ogun State, Nigeria. A multi-stage sampling technique was used to select 240 vegetable farmers from whom primary data were collected using a structured questionnaire. Budgetary analysis was employed to evaluate the cost and return structure of vegetable farming. A stochastic cost frontier model was used to estimate cost efficiency. The findings revealed that the majority of the respondents were male (63.3%), married (74.2%), with an average age of 42 years and an average farming experience of 15.7 years. Most operated small farm sizes averaging 0.52 hectares. Budgetary analysis showed that total revenue averaged ₦238,506.25 per season, with a net farm income of ₦124,547.95. The benefit-cost ratio was 2.09, rate of return on investment was 109%, and profitability index was 0.52, indicating strong financial viability. However, the stochastic cost frontier analysis revealed that 78.2% of the variation in total production costs was due to inefficiency. Seed cost had the highest impact on total cost, followed by labour cost. Farming experience significantly reduced inefficiency, while household size increased it. Cost efficiency had a mean score of 0.749, suggesting that about 25.1% of resources could be saved if inputs were optimally allocated. In conclusion, dry-season leafy vegetable production is economically viable but constrained by cost inefficiencies driven by high seed and labour costs, household size, and lack of modern farming support. To enhance productivity and profitability, this study recommends the provision of subsidies for seeds and agrochemicals. Additionally, targeted training on efficient resource use and improved access to credit should be prioritized to support smallholder farmers in achieving optimal returns and contributing more effectively to rural development.

Keywords: Budgetary analysis, Cost efficiency, Production, Profitability

1.0 Introduction

1.1 Background Information

The agricultural sector remains a critical component of the Nigerian economy, contributing 26.11% to real GDP in the fourth quarter of 2023, with crop production accounting for 90.03% of the sector's nominal value (NBS, 2023). Beyond its contribution to national output, agriculture provides food, income, and employment for a large proportion of the population, particularly smallholder farmers. It also serves as an important livelihood source for vulnerable groups, including women and persons with disabilities (Fadeyi *et al.*, 2022).

Despite its importance, agricultural production in Nigeria is predominantly rain-fed and highly vulnerable to seasonal variability and climate change, which adversely affect productivity and farmers' livelihoods (Vermeulen *et al.*, 2012). While the rainy season remains central to food production, it is often characterized by glut and low prices, particularly for perishable commodities such as leafy vegetables. In contrast, the dry season presents opportunities for off-season production, when supply is limited and market prices are relatively high (Deshmukh *et al.*, 2019).

Off-season vegetable production is commonly practiced in low-lying, moisture-retentive areas locally referred to as *Fadama* (Hausa) or *Akuro* (Yoruba). These areas support year-round cultivation due to their favorable soil and water retention characteristics. Recognizing their potential, the Nigerian government, in collaboration with development partners, has promoted fadama agriculture to enhance food security and rural incomes. Leafy vegetables, in particular, are widely cultivated during the dry season due to their short growth cycle, low land requirement, and high market demand (Schreinemachers *et al*., 2018; Efretuei *et al*., 2022; Efretuei and Ekwere, 2024).

However, dry-season vegetable production is not without challenges. Farmers face constraints such as high input costs, inadequate irrigation infrastructure, limited access to credit, and climate-induced risks, all of which affect profitability and efficiency (Oladejo and Adetunji, 2022; Olayide *et al.*, 2023). Although several studies have examined vegetable production and profitability in Nigeria, there is limited empirical evidence on the cost efficiency of off-season leafy vegetable production, particularly using stochastic frontier approaches that account for inefficiency effects. Moreover, the relationship between profitability and cost efficiency remains insufficiently explored in the literature.

Existing studies have largely focused on descriptive cost and return analyses, general production constraints and technical efficiency rather than cost efficiency However, there is a notable gap in empirical studies that apply stochastic cost frontier models to estimate cost efficiency in off-season vegetable production and identify determinants of cost inefficiency among farmers. This gap limits the ability of policymakers and stakeholders to design targeted interventions aimed at improving resource use efficiency and farm profitability. The broad objective of this study was to analyze the cost efficiency of off-season leafy vegetable production in the Ilaro Agricultural Zone of Ogun State, Nigeria. Specifically, this study described the socioeconomic characteristics of farmers, estimated the costs and returns of off-season leafy vegetable production, determined the level of cost efficiency among leafy vegetable farmers and identified the determinants of cost inefficiency

1.2 Theoretical Framework

1.2.1 Production Theory

Production theory posits that the output level of a farm is determined by the combination and efficiency of inputs such as land, labour, capital, and management. The theory assumes that farmers aim to maximize output given available resources or minimize inputs for a given level of output. In the context of dry season vegetable farming, key inputs include irrigation water, labor, fertilizer, and seeds.

This theory is useful for explaining the relationship between resource utilization and vegetable yield, particularly under constrained conditions typical of dry season production. Farmers who efficiently combine inputs and adopt optimal practices (e.g., drip irrigation, improved seed use) are more likely to operate close to their production frontier (Ogunmodede and Awotide, 2020; Bolarinwa *et al*., 2024).

1.2.2 Profit Theory

Profit theory in agricultural economics focuses on how producers make decisions to maximize profit under resource and market constraints. Profit is the difference between total revenue and total cost. In dry season farming, revenue is influenced by the scarcity-driven high prices of vegetables, while costs are impacted by irrigation, labor, and input expenses. According to Akinbola (2021), dry season vegetable farmers realize higher profit margins primarily due to favorable market prices, despite higher production costs. However, the level of profit efficiency varies among farmers depending on their managerial capabilities, input access, and risk exposure. Profit theory also supports the notion that cost-minimizing behavior under constraints (e.g., water scarcity, rising input prices) is critical to sustaining farm profitability. Hence, understanding factors affecting both cost and revenue becomes vital to optimizing net income.

1.2.3 Stochastic Frontier Analysis (SFA)

Stochastic Frontier Analysis is an econometric method used to measure efficiency, which refers to a farmer's ability to obtain maximum output from a given set of inputs. The stochastic production frontier model assumes that deviations from the frontier are due to inefficiency and random shocks beyond the farmer's control. The basic form of the Cobb-Douglas SFA model is:

$$Y_i = f\left(X_i;\beta\right).\exp\left(V_i - U_i\right)$$ ……………………………………………Equation 1.0

Where:

Y_i = Output of the ith farmer

X_i = Vector of input variables (e.g., labour, fertilizer, seed, irrigation)

β = Parameter vector to be estimated

V_i = Random error (assumed to be normally distributed)

U_i = Non-negative inefficiency term (reflecting managerial or technical inefficiency)

Empirical studies (Ogunmodede and Awotide, 2020; Bolarinwa *et al.*, 2024) have shown that SFA is effective in identifying the gap between actual and potential output, while also assessing factors contributing to inefficiency (education, extension access, farm size).

2.0 Methodology

2.1 Area of Study

This study was conducted in the Ilaro agricultural zone of the Ogun State Agricultural Department Program (OGADEP). The main type of vegetation in the Ilaro agricultural zone is tropical rainforest and Guinea Savannah. The zone is situated between the latitudes of $6^0$53' N and longitude $3^0$1'E. The rainy season lasts from March/April to October/November. They experience average rainfall of between 1500 mm and 1800 mm. The dry season lasts from October/November to March/April. Temperature ranges from 24^0C to 32^0C and average relative humidity between 80% to 90% is usually experienced. The climatic conditions favour livestock production, especially poultry production. The division is largely characterized by wide distribution of natural grasses/pastures and other herbaceous plants and shrubs (derived savanna) and is considered attractive to pastoralists for grazing or for settlement. Agriculture is the main livelihood for the majority of the residents within the Ilaro agricultural zone. The primary crops cultivated in the region include cassava, maize, various vegetables, and spices, which thrive under the region's seasonal patterns. These crops form the backbone of the local economy and food supply, contributing significantly to both subsistence and commercial farming activities.

2.2 Source of Data

The Primary data were gathered from survey by administering structured copies of questionnaire to vegetable farmers engaged in off-season production within the study area. These questionnaires were designed to capture detailed information about farming practices, challenges, and outcomes. The questionnaire cover information on production costs (e.g., seeds, fertilizers, labour, irrigation), revenue (sales prices, quantities sold), and other relevant economic variables.

2.3 Sampling Techniques

A multi-stage random sampling technique was employed in selecting the sample area for this study, allowing for structured sampling at various levels to ensure a representative and comprehensive data collection process. In the first stage, three blocks (75.0% of the total blocks) were selected from the four blocks in the Ilaro agricultural zone. In the second stage, four (4) cells were randomly selected from each of the selected blocks in the first stage. Thus, twelve cells were sampled in total. In the final stage, twenty (20) vegetable farmers were randomly selected from the identified agricultural cells. This random selection was designed to minimize bias and enhance the reliability of the findings. In total, a sample size of two hundred and forty (240) farmers was established for the study, providing a sufficient data set for the study.

2.4 Method of Data Analysis

Descriptive as well as inferential statistics were used to analyze the sampled data. Descriptive tools such as frequency distribution, percentages and mean were used to describe the socio-economic characteristic of the vegetable farmers in the study area. Budgetary analysis method was employed to estimate the cost and return structure of leafy vegetable production and stochastic frontier analysis was used to estimate the effect of profitability on cost efficiency of leafy vegetable farmers in the study area.

Gross margin

GM = TR – TVC ……………………..Equation 2.1

NFI = TR – TC ………………………………….................................Equation 2.2

Where:
GM (Gross Margin)= the components of the variable cost include cost of seed, labour, fertilizer, pesticides
NFI = Net Farm Income
TR = Total revenue (Price x Quantity of output)
TVC = Total variable cost
TC = Total cost (i.e., Total Variable Cost +Fixed Cost)

Net Income
NI = GM - TFC ………………………………….................................Equation 2.3

Where:
NI = Net income

The financial performance of the farms was determined by the following indices:

Rate of return on investment (RRI) = $\frac{NFI}{TC}$ x 100 ....Equation 2.4

Profitability index = $\frac{NFI}{TR}$ ……………………..Equation 2.5

Benefit-cost ratio = $\frac{TR}{TC}$ ………………………...Equation 2.6

Cobb-Douglas cost function for vegetable production as specified following Ito *et al.* (2023) thus:

$$\ln C_i = \beta_0 + \beta_1 \ln P_i + \beta_2 \ln P_2 + \beta_3 \ln P_3 + \beta_4 \ln P_4 + \beta_5 \ln P_5 + \beta_6 \ln P_6 + \beta_7 \ln P_7 + V_i - \mu_i$$

…………………………………………………………………………….Equation 2.7

Where:

Subscript ij refers to the j^{th} observation of the i^{th} farmer

ln = Logarithm to base e
C_{ij} = Total production cost (N/ha) of the ith farmer
P_1 = Expenses on land (₦/ha)
P_2 = Cost of Family labour (₦/ha)
P_3 = Cost of Hired labour (₦/ha)
P_4 = Cost of agrochemicals (₦/ha)
P_5 = Cost of fertilizer (₦/ha)
P_6 = Cost of seeds (₦/ha)
P_7 = Cost of irrigation (₦/ha).
It is assumed that the cost inefficiency effects are independently distributed and μ; arises by truncation (at zero) of the normal distribution with mean, μ_{ij} and variance, Where i is defined by:

$$\mu_i = \delta_0 + \delta_1 Z_1 + \delta_2 Z_2 + \delta_3 Z_3 + \delta_4 Z_4 + \delta_5 Z_5 + \delta_6 Z_6 + \delta_7 Z_7$$ ……………...Equation 3.8

Where:
μ_{ij} = Cost inefficiency of the i^{th} farmer
Z_1 = Years of farming experience (years)

Z_2 = Years of formal education (years)
Z_3 = Extension contact (number of visits)
Z_4 = Household size (number)
Z_5 = Age (years)
Z_6 = Marital status (1 = married; 0 otherwise)
Z_7 = Credit access (1 = access to credit; 0 otherwise)

3.0 Results

3.1 Socioeconomic Characteristics of Leafy Vegetable Farmers

The socioeconomic profile of respondents indicates that leafy vegetable production is dominated by males (63.3%), with female participation (36.7%). This gender distribution suggests that leafy vegetable farming is not exclusively male-oriented and continues to serve as an important livelihood option for women. Similar gender patterns have been reported in vegetable production studies in Nigeria and other Sub-Saharan African countries, where cultural norms and land access tend to favour male participation, while women remain actively involved in production and marketing (Adeleke *et al.*, 2021; Ogunniyi and Kehinde, 2019).

The mean age of farmers (41.68 years) indicates that respondents are largely within their economically productive age bracket. This finding aligns with earlier studies that report vegetable farming as an enterprise dominated by middle-aged farmers who possess both physical strength and decision-making experience (Idowu *et al.*, 2020). The dominance of married farmers (74.2%) reflects the role of family labour and household responsibility in shaping production decisions.

Average household size was five persons, which is typical of rural farming households in south west Nigeria. However, larger household size may exert pressure on farm resources and negatively influence cost efficiency. Comparable results have been reported by Abdulai and Huffman (2014) as well as Antia-Obong *et al.,* (2021), who contend that bigger families might heighten consumption pressures and lessen the ability to reinvest.

Educational attainment among respondents was generally low, with an average of seven years which indicated that an average vegetable farmer had at least primary education. Low formal education among smallholder vegetable farmers has been widely reported in the literature and is often associated with limited adoption of improved technologies and management practices (Rahman and Umar, 2018). Despite this, farmers reported substantial farming experience, with a mean of 15.73 years, suggesting that experiential knowledge plays a significant role in farm management. Farm sizes were predominantly small, with over 97% of respondents cultivating one hectare or less. This confirms the smallholder nature of leafy vegetable production, consistent with findings by Ojo *et al.* (2020), who noted that vegetable farming in Nigeria is largely characterized by fragmented and intensively cultivated plots.

3.2 Cost and Return Structure of Leafy Vegetable Production

The cost and return analysis reveals that leafy vegetable production is highly profitable. Total revenue substantially exceeded total production cost, resulting in a net farm income of ₦124,547.95 per production cycle. The benefit–cost ratio of 2.09 indicates that for every naira invested, farmers realized more than twice its value in returns. This level of profitability is consistent with previous studies that identify vegetable farming as one of the most lucrative enterprises among smallholder farmers due to its short production cycle and high market demand (Adeoye *et al.*, 2018; Mohammed *et al*., 2021).

Labour accounted for the largest share of total production cost (38.47%), followed by fertilizer and seed costs. The dominance of labour cost reflects the labour-intensive nature of leafy vegetable production, particularly under small-scale systems where mechanization is minimal. Similar cost structures have been reported by Sani *et al.* (2019), who observed that manual land preparation, weeding, and harvesting significantly increased labor expenses in vegetable farming.

Despite high profitability, the cost structure suggests potential inefficiencies, particularly in labour use. This was also observed in the stochastic cost frontier results, which identify labour as a major determinant of production cost.

3.3 Determinants of Cost Inefficiency

In a Cobb–Douglas cost function each coefficient (β) represents the elasticity of total cost with respect to that input. That is a 1% increase in an input cost leads to a β% change in total cost (ceteris paribus). The Constant Term (3.860) is positive and significant at 1%. They also represent the baseline cost when all explanatory variables are at unity (in log terms). The positive and significant coefficient of labour (0.218) implied that 1% increase in labour cost leads to a 0.218% increase in total production cost indicating that labor is a major cost driver , production is labour-intensive and efficient labour management is critical for cost reduction.

The seed (0.498) means that 1% increase in seed cost leads to a 0.498% increase in total cost indicating that seeds are the most influential cost component, nearly half-proportional effect, indicating: high dependence on seed inputs and possibly improved or hybrid seeds with higher costs. This aligns with findings by Battese and Coelli (1995), who emphasized that labour and key variable inputs often dominate cost structures in smallholder agriculture due to labour-intensive production systems. Similarly, studies such as Ogundari and Ojo (2006) found labour cost significantly influences total production cost in Nigerian agriculture, reflecting limited mechanization and reliance on human labour. The high elasticity of seed cost (0.498) supports findings by Amaza *et al*. (2006), who reported that improved seed varieties, although costly, are critical determinants of productivity and cost structure. This suggests that farmers rely heavily on purchased seeds, particularly improved or hybrid varieties. The cost of agrochemicals (0.038) was positive and significant at 1%, that is 1% increase in agrochemical cost increases total cost by 0.038%. This implied that agrochemicals contribute to cost, but their effect is relatively small and Likely used in moderate quantities.

The non-significant coefficients of land and fertilizer costs are consistent with empirical findings in developing countries where land is often inherited or communally owned and fertilizer use is either low or subsidized. For instance, Coelli *et al.* (2005) noted that input variables with low variability or institutional constraints (such as land tenure systems) often appear statistically insignificant in frontier models.

In addition, the sum of significant elasticities: 0.218+0.038+0.498=0.7540 with the total cost of total cost elasticity = 0.75 (< 1). This indicates economies of scale, meaning that total cost increases less than proportionately with input use. The implication is that the production system exhibits economies of scale (cost decreasing with scale), increasing input use leads to less than proportional increase in total cost, and farmers can reduce average cost by expanding production. This finding is consistent with studies by Farrell (1957), who established that efficiency gains are achievable when farms expand operations. Empirical evidence from Ogundari (2010) also confirms that smallholder farmers often operate under increasing returns to scale due to underutilization of fixed inputs.

The negative relationship between experience and inefficiency suggests that experienced farmers are more cost-efficient. This agrees with findings by Abdulai and Huffman (2000), who observed that farming experience enhances managerial ability and resource allocation efficiency. The result that older farmers are more efficient supports studies such as Ajibefun and Daramola (2003), which found that age is positively associated with accumulated knowledge and improved farm decision-making. The positive effect of household size on inefficiency suggests that larger households may lead to labour misallocation or disguised unemployment.

This is consistent with Onyenweaku and Nwaru (2005), who reported that excess family labour can reduce efficiency due to poor coordination and diminishing marginal productivity. The insignificance of education and extension contact contrasts with some studies but aligns with findings by Okoye *et al.* (2008), who argued that extension services in many developing regions are often ineffective due to poor delivery systems, limited coverage, and inadequate training.

Gamma (0.782) implied that 78.2% of total variation in cost is due to inefficiency effects. The high gamma value indicates that a large proportion of variation in cost is due to inefficiency rather than random shocks.This supports the findings of Battese and Corra (1977), who emphasized that high gamma values in agricultural studies reflect substantial inefficiencies among farmers. The sigma-squared (0.094) is significant indicating that the model is well specified.

Similarly, Coelli (1996) noted that in developing countries, inefficiency effects often dominate due to limited access to technology, credit, and information. The findings of this study are largely consistent with existing empirical literature on agricultural efficiency in developing economies. The significant influence of labour and seed costs corroborates earlier studies, while the presence of economies of scale supports the argument that smallholder farmers operate below optimal scale. Furthermore, the role of farming experience and age in reducing inefficiency aligns with established evidence on managerial learning effects, whereas the positive relationship between household size and inefficiency reflects labour misallocation challenges. The high gamma value further confirms that inefficiency remains a critical issue in agricultural production systems.

Table 3.1: Distribution of vegetable farmers by socio-economic characteristics

Characteristics	Frequency	Percentage	Mean±SD
Sex			
Male	152	63.3	
Female	88	36.7	
Age (years)			
< 30	34	14.2	
30 < 40	60	25.0	
40 < 50	94	39.2	41.68±9.07
50 < 60	44	18.3	
60 and above	8	3.3	
Marital status			
Single	38	15.8	
Married	178	74.2	
Divorced	4	1.7	
Widowed	12	5.0	
Separated	8	3.3	
Household size			
≤ 3	50	20.8	
4 < 7	152	63.4	5±1.90
7 and above	38	15.8	
Education Level			
No formal education	68	28.4	
Primary education	64	26.7	
Secondary education	86	35.8	6.83±5.59
OND/NCE	8	3.3	
HND/BSC	14	5.8	
Farm size (Ha)			
≤ 0.50	128	53.3	
0.51 - 1.00	106	44.2	0.52±0.27
Above 1.00	6	2.5	
Farming experience (years)			
< 10	60	25.0	
10 < 20	92	38.3	15.73±9.77
20 < 30	58	24.2	
> 30	30	12.5	

Source: Field Survey, 2025

Table 3.2: Costs and return structure of the leafy vegetable production

Input	Average value (₦)	% of Total Cost
Total Revenue (TR)	238,506.25	
Variables		
Leafy vegetable seeds	13,148.50	11.54
Labour	43,840.83	38.47
Fertilizer (kg/bag)	25,956.67	22.78
Pesticides (litres)	7,232.50	6.35
Transportation	7,054.17	6.19
Other cost	5,150.00	4.52
Total Variable Cost (TVC)	102,382.67	89.84
Rent on land	6,164.17	5.41
Depreciation on farm equipment	5,411.46	4.75
Total Fixed Cost (TFC)	11,575.63	10.16
Total Cost (TC = TVC+TFC)	113,958.30	100.00
Gross margin (GM= TR-TVC)	136,123.58	
Net Farm Income (NFI = TR-TC)	124,547.95	
Benefit-cost ratio (TR/TC)	2.09	
Rate of Return on investment (RRI = NFI/TC)	1.09	
Profitability Index (NFI/TR)	0.52	

Source: Field Survey, 2025

Table 3.3: MLE of the parameters in stochastic cost frontier analysis

Variables	Coefficient	standard-error	t-ratio
Cost factors			
Constant	3.860***	0.959	4.023
Expenses on land	0.007	0.008	0.918
Cost of labour	0.218***	0.018	12.334
Cost of agrochemicals	0.038***	0.008	4.898
Cost of inorganic fertilizer	0.024	0.020	1.200
Cost of seeds	0.498***	0.157	3.171
Inefficiency factors			
Constant	-0.297	0.781	-0.380
Years of farming experience	-0.029**	0.013	-2.222
Years of formal education	-0.007	0.023	-0.291
Extension contact	0.092	0.687	0.134
Household size	0.070***	0.005	13.738
Age	-0.023***	0.002	-10.004
Marital status	-0.095	0.880	-0.108
Credit availability	0.066	0.513	0.129
sigma-squared	0.094***	0.039	2.437
Gamma	0.782***	0.100	7.785
Log likelihood function	3.450		

Source: Field Survey, 2025 ***, **, * sig at 1%, 5% and 10% respectively

Table 3.4: Cost efficiency distribution of leafy vegetable farms

Efficiency range	**Frequency**	**Percentage**
0.41-0.60	36	15.0
0.61-0.80	114	47.5
> 0.80	90	37.5
Total	240	100.0
Minimum	0.411	
Maximum	0.942	
Mean	0.749	

Source: Field Survey, 2025

3.4 Cost Efficiency Distribution

The mean cost efficiency score of 0.749 indicates that farmers could reduce production costs by about 25% without reducing output if they operated at the frontier level. Only 37.5% of farmers achieved efficiency levels above 0.80, while a significant proportion operated below this threshold. These results are consistent with findings by Ojo *et al.* (2020), who reported moderate efficiency levels among vegetable farmers and attributed inefficiency to poor cost management and limited access to labour-saving technologies. The wide dispersion between minimum and maximum efficiency scores highlights heterogeneity in managerial ability and resource utilization among farmers. This reinforces the need for targeted interventions aimed at improving cost efficiency rather than merely increasing output.

3.5 Policy Implications

1. Promote efficient seed use strategies
2. Improve labour productivity: Given labour’s dominant cost share and its strong influence on total cost, policies should promote affordable mechanization, improved tools, and labour efficient production techniques.
3. Strengthen farmer training, experience sharing and reform extension service delivery: The significance of farming experience suggests that peer learning, extension, and mentoring models may be more effective than purely classroom based training.
4. Encourage optimal household labour allocation: Since most farmers are already profitable but inefficient, policies should prioritize cost-reducing and efficiency enhancing interventions rather than merely expanding cultivated area.

4.0 Conclusion

The study concludes that dry season leafy vegetable production is highly profitable and holds strong economic potential for smallholder farmers in Ogun State. However, despite good profit margins, cost inefficiencies exist, largely driven by high labor and seed costs, household size, and limited access to modern farming techniques. The findings imply that policies aimed at expanding vegetable production should move beyond yield enhancement to focus explicitly on cost efficiency. Given the dominance of labor cost, promotion of affordable labor-saving technologies and improved production practices is essential. Furthermore, the significant role of experience suggests that farmer-to-farmer learning and participatory extension approaches may be more effective than conventional top-down extension models in addition vegetable farmers can maximize returns and minimize inefficiencies, contributing significantly to food security and poverty reduction in the study area and the country at large. Based on the findings the following are therefore recommended

1. Since labor is a major driver of production costs (38.47% of total variable cost), farmers should use cooperative labor-sharing schemes to reduce individual burden. Practice better farm planning and scheduling to optimize labor use. Promotion of labor-efficient production systems will encourage the use of simple mechanized tools, improved spacing, and better farm scheduling to reduce labor costs.

2. Seed cost has the highest impact on total production cost (coefficient = 0.498). Farmers should source certified, high-yielding, drought-tolerant seeds from reliable suppliers, and participate in government or NGO-sponsored seed subsidy programs when available. NGOs and Ministry of Agriculture are encouraged to facilitate timely access to improved seeds and agrochemicals at subsidized or negotiated prices to reduce cost variability and improved access to quality inputs.

3. At an average cost efficiency score of 0.749, there's room for improvement, farmers should base input allocation decisions on market prices and economic returns, seek training on resource optimization and input budgeting from agricultural extension officers to strengthen farmer field schools and peer learning by leveraging experienced farmers as local resource persons to disseminate cost-saving practices.

4. Larger households increase cost inefficiency, farmers should ensure family labor is effectively coordinated and assigned meaningful roles, and avoid over-dependence on household labor without optimizing productivity.

5. Government should support farmers by subsidizing improved seeds and agrochemicals, especially during the dry season when input demand is high. Investment in community-based irrigation systems (e.g., solar-powered pumps) can make dry season farming more accessible. Also, formal and informal credit channels should be expanded, with flexible, low-interest loans tailored to smallholder vegetable farmers.

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