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Research Article

Profitability and Technical Efficiency of Irrigated Tomato Production in Some Selected Local Government Areas of Niger State-Nigeria

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Abstract

The study assessed the profitability and technical efficiency of irrigated tomato production in Katcha, Bosso, and Wushishi Local Government Areas of Niger State, Nigeria. A sample of 122 tomato producers was selected through a multi-stage sampling method. Data were collected using structured questionnaires and analyzed using gross margin analysis, stochastic frontier function, and descriptive statistics employing a 4-point Likert scale. The total cost of production and total revenue in the study area was N226280.78 per hectare and N1053192.89 per hectare respectively. While the gross margin was 6.5%. Also, the mean technical efficiency of tomato farmers was 0.21 in the study area. Further findings revealed that the coefficient of education, farm size and extension visit had a significant relationship with tomato output. Tomato farmers in the study area encountered significant challenges, primarily the absence of storage facilities and the prohibitive cost of labor. Recommendations include providing training to farmers on post-harvest handling techniques to minimize losses and exploring alternative, cost-effective irrigation sources. Government intervention is crucial in facilitating access to such irrigation alternatives to alleviate financial burdens on farmers.

Keywords: *Gross margin, Irrigation, production, profitability and Tomato*

Introduction

Tomato (Lycopersicon esculentum) is one of the most widely cultivated crops in the world. It is an important source of vitamins and an important cash crop for small and medium-scale farmers (ShankaraNaika et al, 2005). As an important source of Minerals, Vitamins and health acids, tomato is one of the most important vegetable crops of Solanaceae grown universally with the production of 124.75 million tonnes per annum (FAO 2007). Tomatoes is commonly grown in the Northern part of Nigeria, but largely consumed in the south western states, Some places in the southern part such as Oyo State also produce some amount of tomatoes but the urban centres mostly in the south constitute the major consumption areas and market in those areas are the common outlets for all the production zones (Sanusi and Dada, 2016) It is pertinent to note that, in spite of the existence of favourable tropical climate for its production in South Western Nigeria, the scarcity and exorbitant price

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of the product necessitate an in – depth investigation into its profitability and production efficiency in the study area. Crude technology has made farming unattractive and tedious. Excess production through finished products such as tomato “puree”, “paste”, and “ketch up” could be exported to the foreign countries and thus gives Nigeria a good foreign exchange (Salau and Salman 2017; Amao, 2010).

Technical efficiency is gauged using the stochastic frontier production function (Ogaji, 2012), essential for enhancing productivity amidst increasing demands and resource constraints in tomato cultivation. Despite the critical importance of technical efficiency in optimizing irrigated tomato production and addressing resource gaps among farmers, insufficient efforts have been directed towards enhancing production efficiency. There exists a pressing need to bolster tomato output to meet the demands of producers and improve their technical efficiency. Information collection and dissemination are pivotal in this endeavor, facilitating a comprehensive understanding of factors influencing farm-level efficiency. Efficiency studies present opportunities for enhancing productivity without necessitating resource expansion, particularly in economies lacking advanced technologies. Thus, proper analysis of efficiency factors holds promise for advancing the tomato industry and elevating farmers' productive capacity in the study area.

Irrigation is the watering of land by artificial means to foster plant growth. In Nigeria, irrigation plays a pivotal role beyond merely ensuring food security; it also serves as a means of income generation and employment, especially during distinct seasons: the rainy season spanning from April to October and the dry season from November to March. During the dry season, when farmers are less occupied with field activities, irrigation farming emerges as a lucrative alternative, offering employment opportunities and supplementary income (Kolawole, 2010). The relationship between tomato cultivation and irrigation underscores the multifaceted significance of both practices in agricultural sustainability and economic development. Not only do tomatoes contribute to dietary diversity and nutritional well-being, but they also offer economic opportunities for farmers. Likewise, irrigation farming not only extends the growing season but also provides employment and income stability, particularly during periods of agricultural downtime (Sekumade, 2014). The integration of irrigation into tomato cultivation reflects the adaptive strategies of farmers to harness water resources efficiently and maximize agricultural productivity. Furthermore, it underscores the importance of diversified livelihood strategies in mitigating the impacts of seasonal fluctuations and enhancing rural livelihoods. As such, understanding the interplay between tomato cultivation and irrigation is essential for developing effective agricultural policies and interventions that promote food security, economic resilience, and sustainable livelihoods in Nigeria.

The objectives of the study were analysed using budgetary techniques analysis such as gross margin and Net farm Income was used to estimate the costs and returns of tomato production in the study area. (Kingsley, 2018), and stochastic frontier (Cobb – Douglas frontier production function.

Materials and Methods

Niger State comprises of three agricultural zones: Zone i, Zone ii, and Zone iii. Multistage sampling technique was used the study and a purposive sampling approach were adopted in the first stage to select one Local Government Area (LGA) from each of the agricultural zone known for high tomato production: Katcha, Bosso, and Wushishi. In the second stage, two villages were randomly selected from each chosen LGA, resulting in a total of six villages populated by tomato producers. Finally, the third stage involved the selection of 122 tomato producers from the study area, which were determined using the Taro Yamane equation for sample size determination, as utilized by Abdullahi et al. (2018). Data collection was conducted through structured questionnaires administered by selected tomato farmers.

The first objective entailed the application of budgetary techniques like gross margin and net farm income analysis to assess the costs and returns of tomato production in the study area (Kingsley, 2018). These techniques allowed for a comprehensive evaluation of the financial aspects of tomato cultivation, facilitating insights into profitability and economic viability. The gross margin analysis provided insights into the profitability of tomato production by comparing total revenue against variable costs, while net farm income estimation further elucidated the overall financial performance of tomato farming operations;

Gross Margin = Total revenue (₦) - Total variable cost

Total Cost = Fixed Cost + Variable Cost

Net Farm Income = Gross Margin – Fixed Cost

$$\textbf{EE} = \frac{\text{Net Farm Income}}{\text{Total Cost}} \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\textbf{(1)}$$

Where:

EE=Economic Efficiency,

$$\text{BCR} = \frac{\text{Total revenue}}{\text{Total Cost}}, \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\textbf{(2)}$$

Where;

BCR=Benefit Cost Ratio.

This function relates the logarithm of tomato output (Y) to the natural logarithms of various input factors (X1, X2, X3, X4, X5), each representing farm size, seed quantity, labor input, agro-chemical usage, and fertilizer quantity, respectively. The model also incorporates random error (Vi) and technical inefficiency effect (Ui), representing factors beyond farmers' control and behavior-driven inefficiencies, respectively.

Technical efficiency (TE) for individual farmers is expressed as the ratio of observed output (Yi) to frontier output (Yi*), where TE values range between 0 and 1. A TE value of 1 indicates alignment with the production frontier, signifying maximum efficiency, while a value less than 1 suggests inefficiency. The disparity between observed output (Y) and frontier output (Y*) is captured by U, where U = 0 indicates technical efficiency, and U > 1signifies inefficiency. Understanding these metrics is crucial for optimizing agricultural practices and maximizing productivity.

Identifying and addressing inefficiencies are essential steps towards enhancing agricultural performance and sustainability. By pinpointing areas where production falls short of its potential, farmers can implement targeted strategies to improve efficiency and output. Moreover, insights gained from the stochastic frontier analysis provide valuable information for policymakers and agricultural stakeholders to design interventions aimed at enhancing productivity and promoting sustainable agricultural practices. Ultimately, optimizing technical efficiency in tomato production contributes to food security, income generation, and overall economic development in the study area and beyond.

The technical inefficiency effect Ui, is defined as:

$$U_i = a + \delta_1 Z_1 + \delta_2 Z_2 + \delta_3 Z_3 + \delta_4 Z_4 + \delta_5 Z_5 + \delta_6 Z_6 + W \ldots.(3)$$

Where:

U_i = Technical inefficiency of the i^{th} farmer,

Z_1 = Age (yr),

Z_2 = Educational level (Years spend in school)

Z_3= Marital status

Z_4 = HH size (number),

Z_5 Farming experience (years),

Z_6 = Gender (male = 1, female = 0),

W = error term

Results and Discussion

The cost and return analysis of tomato production in the study area, as depicted in Table 1, unveils crucial insights into the financial dynamics of this agricultural endeavor. Notably, variable costs per hectare amounted to N22,031.05, constituting 9.74% of the production cost. Expenses attributed to transportation, seed, labor, agrochemicals, and fertilizer individually accounted for 1.55%, 0.44%, 5.96%, 1.39%, and 0.37%, respectively. Fixed costs totaled N204,249.73, representing 90.2% of the total cost. The aggregate production cost and revenue stood at N226,280.78 per hectare and N1,053,192.89 per hectare, respectively. Profitability indicators, including gross margin and net farm income, depicted figures of N103,161.84 per hectare and N970,500 per hectare, respectively.

The profitability of tomato production in the study area was highlighted by a gross ratio of 0.21, signifying that 21% of total revenue covered the total cost. This outcome aligns with Olukosi's (2008) perspective, which advocates for a gross ratio below one as desirable for farm businesses. A lower ratio indicates higher returns per unit of investment, reflecting the profitability observed in tomato production.

The analysis of technical efficiency among tomato farmers in the study area unveiled insightful findings. The average technical efficiency of the of the respondent was found to be <1, indicating that, on average, farmers were operating below the maximum efficiency frontier. The most technically efficient farmer achieved an efficiency score of 0.9596, equivalent to 95.96%, while the least efficient farmer recorded a technical efficiency of 0.5530, representing 55.30%. The overall mean technical efficiency stood at 0.8827, signifying that, on average, farmers attained 88.27% of potential technical efficiency from the given mix of production inputs and corresponding output. This suggests a substantial scope for enhancing technical efficiency in tomato production within the study area. Specifically, there is a potential for a 4.04% increase in technical efficiency through the adoption of best practices observed in tomato farming. By leveraging proven technologies and management strategies employed by the most efficient farmers, others can significantly enhance their productivity and optimize resource utilization.

Furthermore, the identification of efficiency differentials among farmers underscores the importance of disseminating knowledge and promoting capacity-building initiatives. Efforts aimed at facilitating the adoption of innovative techniques and efficient farming practices could yield notable improvements in overall productivity and agricultural sustainability within the tomato sector.

The estimated coefficients of farm size, seed, labor, and fertilizer in the technical function were found to be positive and statistically significant at various levels of significance. Specifically, at $p<0.01$, $p<0.01$, $p<0.10$, and $p<0.05$ respectively, indicating that these variables significantly influence the farm-level technical efficiency of tomato farmers in Niger State. A unit increase in farm size, seed, labor, and fertilizer is associated with an increase in technical efficiency by 0.52524, 0.00480, 0.00778, and 0.00308 respectively.

The study also revealed the existence of technical inefficiency effects in tomato production within the study area. The estimate of sigma-square (0.32746) was significantly different from zero at $p<0.05$, indicating a good fit of the model. Furthermore, the estimated gamma (0.94673) was significant at $p<0.01$, suggesting that 94.67% of the variation in tomato output can be attributed to the technical inefficiencies of farmers in the area.
Moreover, household size, years of farming experience, and extension contact were found to be negatively signed and significant at $p<0.05$, $p<0.050$, and $p<0.05$ respectively, in influencing the technical inefficiency of tomato farmers. An increase in these variables is likely to reduce technical inefficiency among farmers. Specifically, a larger household size may result in access to more cheap labor, while increased years of farming experience may enhance the application of skills and allocation of scarce resources. Additionally, greater extension contact implies more exposure to best farming practices, collectively contributing to improved technical efficiency among farmers in the area.

The findings in Table 4 reveal the constraints reported by respondents and their respective severity rankings. Inadequate storage facilities emerged as the most severe constraint, ranking 1st with a mean value of 3.90. This was closely followed by high labor costs, ranked 2nd with a mean value of 3.70, which could be attributed to the insufficient labor supply resulting from limited engagement in tomato production by farmers.
Furthermore, high costs associated with irrigation facilities ranked 3rd with a mean value of 3.65, indicating its significant impact on tomato production in the study area. Inadequate access to credit facilities also posed a considerable challenge, ranking 4th with a mean score of 3.04. Interestingly, the high cost of inputs was identified as one of the least constraints, with a mean score of 3.04, suggesting that while input costs are a concern, they are relatively less pressing compared to other constraints.

Conclusion

The study findings revealed that the technical efficiency of tomato farmers in the study area fell below optimal levels, indicating a need for interventions to enhance productivity and efficiency in tomato production. To address this, it is recommended that farmers receive training on post-harvest handling techniques to minimize losses and maximize the quality of produce.

Furthermore, access to credit facilities should be improved to enable farmers to invest in inputs, equipment, and technology that can enhance their production capacity. Subsidizing inputs and providing other incentives can also help alleviate the financial burden on farmers and encourage increased investment in tomato cultivation. Additionally, efforts should be made to explore alternative and cost-effective irrigation methods to mitigate the challenges posed by high irrigation costs. Government intervention in this regard can play a crucial role in supporting tomato farmers and promoting sustainable agriculture in the study area.

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Table 1: Cost and Returns Analysis of Tomato Production

Variables	Cost/Hectares (N)	% of total cost
Variable Cost (VC)		
Transportation	3517.77	1.55
Seed	1014.34	0.44
Labour	13490.8	5.96
Agro-chemical	3164.2	1.39
Fertilizer	843.94	0.37
Total Variable Cost (TVC)	22031.05	9.74
Fixed Cost (FC)		
Depreciation	200 899.48	88.8
Interest on credit	3350.25	1.48
Total Fixed Cost (TFC)	204249.73	90.2
Total Cost (TC)	226280.78	100.
Total Output (TO)	1053192.89	
Gross Margin (GM)	103161.84	
Net farm Income (NI)	9705000	
Gross Ratio (GR)	0.21	

Source: Field survey Data, (2022)

Table 2: Technical Efficiency Scores Obtained with Stochastic Frontier Model for Tomato Farmers in Selected LGAs of Niger State

Efficiency class index	No of farmers	Frequency
0.51 - 0.60	3	2.45
0.61 - 0.70	1	0.82
0.71 - 0.80	11	9.02
0.81 - 0.90	40	32.79
0.91 – 1.00	67	54.92
Total	122	100.00
Mean	0.8827	
Minimum	0.5530	
Maximum	0.9596	

Source: Field Survey Data, (2022)

Table 3: Maximum-Likelihood Estimates of the Stochastic Production Function for Tomato Farmers in Selected LGAs of Niger State

Variable	Parameter	Coefficient	t-ratio
Efficiency model			
Constant	β_0	12.75868	18.96***
Farm Size	β_1	0.52524	5.00***
Seed	β_2	0.00480	4.98***
Labour	β_3	0.00778	1.89*
Fertilizer	β_4	0.00308	2.48**
Agro-chemical	β_5	-0.00064	-0.92
Inefficiency model			
Constant	δ_0	-3.74799	-0.21
Age	δ_1	0.03403	0.23
Gender	δ_2	0.43140	0.21
Marital Status	δ_3	-0.74617	-0.22
Household Size	δ_4	-0.00556	-2.08**
Educational level	δ_5	0.10907	0.22
Years of farming Experience	δ_6	-0.12369	-2.11**
Extension Contact	δ_7	-0.15054	-2.47**
Sigma-squared	σ^2	0.32746	2.40**
Gamma	Γ	0.94673	4.42***

Log likelihood function = 37.21372***
*** = p<0.01, ** = p<0.05 and * = p<0.10 level of probability

Table 4: Constraints faced by tomato farmers in the study area

Variables	Very severe	Severe	Slightly severe	Not severe	Sum	Mean	Remarks
Lack of storage facilities	114 (93.4%)	4 (3.3%)	4 (3.3%)	-	476	3.90	Severe
High labour cost	94 (77.0%)	20 (16.4%)	8 (6.6%)	-	452	3.70	Severe
High cost of irrigation facilities	94 (77.0%)	16 (13.1%)	10 (8.2%)	2 (1.6%)	446	3.65	Severe
Inadequate credit facilities	33 (27.0%)	73 (59.8%)	5 (4.1%)	11 (9.0%)	372	3.04	Severe
High cost of input	7 (5.7%)	114 (93.4%)	1 (0.8%)	-	372	3.04	Severe
Insufficient water	15 (12.3%)	8 (6.6%)	92 (75.4%)	7 (5.7%)	275	2.25	Not severe
High cost of fuel	3 (2.5%)	109 (89.3%)	10 (8.2%)	-	250	204	Not severe
Pest and diseases infestation	5 (4.1%)	5 (4.1%)	83 (68.0%)	29 (23.8%)	230	1.88	Not severe
Poor road	6 (4.6%)	9 (7.4%)	15 (12.3%)	92 (75.4%)	173	1.41	Not severe
Poor soil fertility	6 (4.9%)	6 (4.9%)	3 (2.5%)	107 (87.7%)	155	1.27	Not severe
Poor marketing channel	-	6 (4.9%)	12 (9.8%)	104 (85.2%)	146	1.19	Not severe

Source: Field survey Data(2022