ESTIMATION OF ECONOMIES OF SCALE FOR WATERLEAF (TALINUM TRIANGULARE) FARMS IN CALABAR METROPOLIS, CROSS RIVER STATE, NIGERIA.

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Abstract
This study examined the economies of scale in waterleaf (Talinum triangulare) farming in Calabar Metropolis, Cross River State, Nigeria. The research aimed to estimate the effects of input costs, farm size, and labour expenses on profitability among smallholder farmers. Primary data were collected from 80 respondents using structured questionnaires and analysed with descriptive statistics, cost structure analysis, and regression modelling. Findings revealed that waterleaf production is mainly undertaken by women (95%) with low levels of formal education (51.3%). Labour (30.9%) and fertiliser (26.6%) represented the largest shares of variable costs, together accounting for over 57% of total production expenses. Regression results indicated that labour and fertiliser costs had significant negative effects on profitability ($p < 0.01$). The estimated optimal farm size was 18.3 hectares, compared to the current average of 0.78 hectares, highlighting notable diseconomies of scale. The study concludes that waterleaf farmers operate below the optimal scale and face constraints from high labour costs and limited land. It recommends policies promoting small-scale mechanisation, cooperative land consolidation, access to affordable inputs, and enhanced extension services to boost productivity and profitability.

Introduction

Waterleaf (*Talinum triangulare*) is a highly valued leafy green vegetable crop widely cultivated in Nigeria, particularly in Cross River State, due to its nutritional, economic, and agricultural significance. Rich in vitamins A and C, iron, calcium, potassium, antioxidants, flavonoids, and phenolic acids, it plays a crucial role in addressing micronutrient deficiencies in rural and semi-urban populations (Agboola, 2020; Eze & Ugochukwu, 2020). As a "poverty crop" requiring minimal investment and management, waterleaf offers quick returns through its short growth cycle and adaptability to diverse climatic and soil conditions, making it a hardy lifeline for smallholder farmers facing crop failures or market volatility (Agboola, 2020; Ekong & Udoh, 2019). In Cross River State, where agriculture drives the economy, it enhances food security by providing year-round, affordable nutrition to low-income households and generates household income, especially for women and youths involved in production and marketing (Olayemi, 2021; Bamire & Ayodele, 2020).

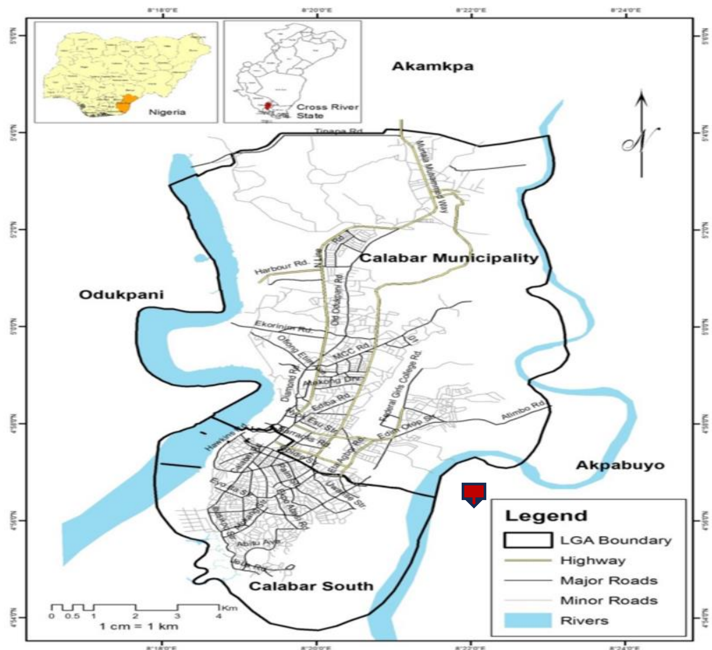
Beyond nutrition, waterleaf holds medicinal value, aiding in the treatment of hypertension, diabetes, inflammation, and oxidative stress-related conditions like cancer and cardiovascular disease through blood pressure regulation and blood glucose moderation (Agboola, 2020; Eze & Ugochukwu, 2020). Cultivation is straightforward, favoring propagation by stem cuttings over seeds for faster growth, well-drained soils with high organic matter, and frequent watering in wet environments; organic manures further boost yields, while its tolerance supports small-scale irrigation (Ekong & Udoh, 2019; Ekanem et al., 2019; Bamire & Ayodele, 2020). In sustainable agriculture, waterleaf promotes soil fertility, erosion control via its canopy, and biodiversity by providing habitats for beneficial insects, positioning it as an ideal organic option for resource-poor farmers (Agboola, 2020; Ekong & Udoh, 2019; Ekanem et al., 2019).

Despite these advantages, waterleaf production is constrained by post-harvest spoilage due to high leaf water content, pest and disease infestations (e.g., aphids and fungi), and limited access to quality seeds, fertilizers, and technical support—challenges amplified in urban settings like Calabar Metropolis with land scarcity, high input costs, and competition for resources (Ekong & Udoh, 2019; Bamire & Ayodele, 2020; Olayemi, 2021). Rapid urbanisation and population growth in Calabar have escalated demand for fresh vegetables, pressuring smallholders to expand efficiently amid these barriers (Adesina & Olanrewaju, 2019). A key research gap persists in analysing cost structures and economic efficiencies, particularly economies of scale, which enable cost benefits from larger production levels to improve resource use, yields, and income in land-constrained urban agriculture. This study addresses this gap by estimating economies of scale for waterleaf farming in Calabar Metropolis. Specific objectives are to: analyse the impact of input cost items on farmers' profitability; determine the effect of farm sizes on profitability; and assess the effect of labour costs on profitability.

Methodology

Study Area

The research was conducted in Calabar Metropolis, comprising Calabar Municipality and Calabar South Local Government Areas of Cross River State. The region lies between latitudes 4°22′ and 5°32′ N and longitudes 7°50′ and 9°28′ E, with coastal plain soils of moderate fertility and favourable rainfall supporting intensive vegetable cultivation.



Source: Office of the Surveyor General of Cross River (2015).

Figure-1. Map of Calabar metropolis showing Calabar Municipality and Calabar South local government areas

Sampling and Data Collection

A multistage sampling technique was employed to select 80 waterleaf farmers from both local government areas. Data were collected using structured questionnaires focusing on socio-economic characteristics, farm size, input use, and output levels.

Analytical Tools

Data were analysed using descriptive statistics, cost structure analysis, and multiple regression models. The profit function model was specified as:

$$\Pi = \beta_0 + \beta_1 C_{fertilizer} + \beta_2 C_{seeds} + \beta_3 C_{labour} + \beta_4 C_{pesticides} + \beta_5 C_{other} + \varepsilon$$

where Π represents farm profit, C_i (i = fertiliser, seeds, labour, pesticides, other) are input costs, and ε is the random error term.

Economies of scale were estimated using the Long-Run Average Cost (LRAC) function derived from the total cost model to identify the optimal farm size.

Results and Discussion

Table 1:Gender distribution of respondents

Gender	Frequency	Percentage (%)
Male	4	5
Female	76	95
Total	80	100

Source: field survey, 2025

The gender distribution of respondents(sampled waterleaf farmers) in Calabar metropolis, as indicated in Table 1 above, indicated a gross gender gap with 95% of the farmers being female and 5% male. The table revealed that Waterleaf Farm is overwhelmingly female-dominated, with 95% of respondents being women. This finding aligns with Akoroda (2012), who noted that women largely sustain vegetable farming in Nigeria. The dominance of women in waterleaf farming highlights both the livelihood importance of the crop for women-headed households and the need for gender-sensitive agricultural interventions.

Table 2: Respondents' Age Distribution

Age Group (Years)	Frequency	Percentage (%)
15–25	5	6.2
26–35	27	33.8
36–45	33	41.3
46 and above	15	18.7
Total	**80**	**100.0**

Source: Field survey, 2025

The age distribution of waterleaf farmers in Calabar metropolis, as shown in Table 2, indicates that the majority (41.3%) falls within the ages of 36–45 years, followed closely by 33.8% in the 26–35 years group. This suggests a predominance of farmers in their productive working ages, with a substantial proportion of younger individuals who represent potential for innovation in farming practices. This aligns with the view of Amafade et al. (2022), who noted that younger farmers are more open to economic principles, research recommendations, new technologies and innovations, and logical decisions, while older farmers often depend on traditional knowledge. This calls for interventions to consider this diversity in age groups.

Table 3: Respondents Marital Status Distribution:

Marital status	Frequency	Percentage (%)
Married	33	41.2
Single	12	15
Widow/divorce	35	43. 8
Total	80	100

Source: field survey, 2025

The result of respondents' marital status distribution was presented in Table 3 which showed that a significant number of farmers are widows/divorced (43.8%). It is very important to take into consideration the diverse marital statuses among waterleaf farmers in the study area. While the 41.2% were married, 15% were widowed/divorced. Marital status is significant in the area of economies of scale intervention as well as decision-making dynamics. From the measurement of waterleaf farm, married has larger space than other respondents. This is in line with the assertion of Otekunrin and Sawicka (2019) that, married farmers may have access to shared resources and joint decision-making, potentially influencing the addressing of problems of limited access to certain resources like land etc.

Table 4: Level of Education Distribution of respondents

Level of Education	Frequency	Percentage (%)
No. Formal education	41	51.3
Primary	23	28.8
Secondary	14	17.5
Tertiary	2	2.3
Total	80	100

Source: field survey, 2025

The result of respondents' education level distribution was presented in 4, which revealed that the majority of waterleaf farmers in Calabar Municipality, representing 51.3%, had no formal education. This is followed by 28.8% representing those who had primary education, indicating a low level of formal education among the sampled waterleaf farmers. This supports the finding of Ojo et al (2019) who opined that education plays a pivotal role in enhancing farmers' capacity to understand and implement innovative farming techniques, such as economies of scale.

Table 5: Respondents' Distribution of Farming Experience

Experience	Frequency	Percentage (%)
1-10	38	47.5
11-20	27	33.8
21 years and above	15	18.7
Total	80	100

Source: field survey, 2025

The distribution of farming experience among respondents, as presented in Table 5, shows that the majority (47.5%) have 1–10 years in waterleaf farming, operating primarily on small scales without achieving economies of scale. This is followed by 33.8% with 11–20 years' experience, who maintain similar land sizes and lack financial records, and 18.7% with over 21 years, indicating limited expansion despite prolonged involvement. This finding aligns with Edet & Akpan (2018), who observed that farming experience improves technical efficiency, but without adequate inputs and institutional support, it alone does not ensure high productivity.

Table 6: Structure of Variable Costs for Waterleaf Farmers

Cost Item	Mean Cost (₦)	Relative Importance (%)	Rank
Labour	29,487.50	30.9	1
Fertilizer	25,389.31	26.6	2
Organic Manure	14,105.19	14.8	3
Pesticides	9,928.51	10.4	4
Transportation	7,943.81	8.3	5
Land Rent	4,815.63	5.0	6
Market Fees	2,634.19	2.8	7
Water	1,165.13	1.2	8
Total Variable Cost	**95,468.28**	**100.0**	

Source: Field Survey, 2025

The analysis of input costs indicated that labour accounted for 30.9% of total variable costs, followed by fertilizer at 26.6%, and organic manure at 14.8%. These results highlight the labour-intensive nature of waterleaf farming and the heavy dependence on purchased fertilizers. Together, labour and fertilizer represented more than half of production expenses, making them the primary determinants of profitability.

Table 7: Regression Analysis for Profitability of Waterleaf Farms

Variable	**Coefficient**	**t-statistic**	**p-value**
Constant	108,450.11	15.22	0.000
Labour Cost	-1.85	-4.91	0.000*
Fertilizer Cost	-1.92	-5.12	0.000*
Manure Cost	-1.01	-1.87	0.066***
Pesticides Cost	-0.88	-1.42	0.160
Transport Cost	-0.21	-0.55	0.582

R^2 0.72

Adjusted R^2 0.70

F-statistic 38.25 (p=0.000)

The multiple linear regression (MLR) model for farm profitability (Π, in ₦) is specified as:
Π = 108,450.11 - 1.85(Labour Cost) - 1.92(Fertilizer Cost) - 1.01(Manure Cost) - 0.88(Pesticides Cost) - 0.21(Transport Cost), where input costs are in ₦1,000 units. The model indicates that labour and fertilizer costs have statistically significant negative impacts on profitability at the 1% level ($p < 0.01$), with manure cost significant at the 10% level ($p < 0.10$); pesticides and transport costs are insignificant. Specifically, every ₦1,000 increase in labour and fertilizer costs reduces profits by approximately ₦1,850 and ₦1,920, respectively. The R^2 value of 0.72 suggests that the independent variables (input costs) collectively explain 72% of the variability in the dependent variable (farm profitability), indicating a good model fit, while the remaining 28% may be attributed to omitted variables or random factors. This finding aligns with Akpan (2020) and Edet & Akpan (2018), who identified labour and fertilizer as key cost constraints in vegetable farming.

Economies of Scale, Optimum Farm Size and Effect of Labour Cost on Productivity

The estimated long-run average cost (LRAC) function revealed an optimum farm size of 18.3 hectares and an optimal output level of 43,566 kg. In contrast, the mean farm size in the study area was only 0.78 hectares, indicating that all sampled farmers operated far below the efficient scale. This sub-optimal scale results in high per-unit production costs and low profitability, consistent with the findings of Noack and Ashley (2019) and Anupama and Thomas (2020) on the benefits of larger-scale operations.

Labour cost elasticity was estimated at +0.31, implying that a 1% increase in labour cost raises total production costs by 0.31%. The high sensitivity of total costs to labour expenditure underscores the need for mechanisation and group labour-sharing schemes to reduce dependency on manual labour.

Conclusion

The findings of this study clearly demonstrate that labour and fertiliser are the most critical cost components negatively affecting the profitability of waterleaf farming in Calabar Metropolis. The results also reveal that individual waterleaf farmers in the area are operating at very small scales (mean farm size of 0.78 hectares), even in prominent cultivation clusters such as New Airport, UniCal, Akim Army Barracks, and Ebritu Barracks, where production occurs on aggregated small plots owned by different smallholder farmers, compared to the economically optimal farm size of 18.3 hectares. This situation has led to significant inefficiencies and diseconomies of scale. Furthermore, the study establishes that labour costs exert a disproportionately high burden on profitability, reflecting the manual and labour-intensive nature of waterleaf farming. Consequently, while waterleaf farming is potentially profitable, the small operational scales and high labour costs continue to limit farmers' ability to achieve optimal economic returns.

Recommendations

Based on the findings, the following recommendations are made:

1. Promote user-friendly small-scale mechanisation (e.g., hand-held tillers, lightweight brush weeders for 10–15 cm waterleaf row spacing, and solar irrigation pumps) designed for low-literacy farmers to reduce manual labour costs, supported by hands-on training from extension agents and NGOs on operation and maintenance.
2. Subsidies on fertiliser should be provided to farmers to reduce input costs. At the same time, farmers should be encouraged and trained to adopt organic alternatives (composting, poultry manure, and green manures) that can enhance soil fertility at lower costs. Research institutions should also develop affordable bio-fertilisers tailored for vegetable production.
3. The government should formulate and implement land consolidation policies to encourage cooperative or cluster farming, where farmers can pool land resources together to achieve scale efficiency. Such policies should also address land tenure insecurity, especially for women, to enable them to expand operations.

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