Automated Irrigation Practice and Coconut Production among Smallholder Farmers in South-South Nigeria

Okoroji, N. O.[1] and Onugu, C. U.[2]

[1]Department of Cooperative Economics and Management, Nnamdi Azikiwe University, Awka, Nigeria
[2]Department of Agriculture and Extension, Nnamdi Azikiwe University, Awka, Anambra State, Nigeria

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***CORRESPONDING AUTHOR**

no.okoroji@unizik.edu.ng

ABSTRACT

This study investigates the market structure, conduct, and performance of sugarcane in North Central Nigeria. Employing a multi-stage sampling approach, 235 sugarcane marketers were randomly selected from a pool of 575 using the Slovin's formula. Primary data was collected through structured questionnaires and analyzed using the Gini coefficient, Lorenz curve, marketing margin, and marketing efficiency model. Market analysis reveals income inequality, with Gini coefficients ranging from 0.61 to 0.72. The closer the value of gini coefficient is to unity, the greater is the degree of income inequality and the higher is the level of concentration of sellers and vice versa. The diagonal connecting points of (0, 0) and (1, 1) on the Lorenz curve depicts the 450 line or line of perfect equality. The graph showed the cumulative percentage of sugarcane marketers against the cumulative percentage (%) of sugarcane total sales or income which reveals that the market is an imperfect market. The study identifies pricing factors influencing market conduct, with net margins and profitability ratios confirming sugarcane marketing as profitable. Sensitivity analysis suggests potential profit optimization by reducing transportation and storage costs. The study concludes that sugarcane marketing is profitable in North Central Nigeria and recommends interventions such as establishing training centers, offering capacity-building workshops, implementing flexible credit policies, and enhancing security for marketers.

INTRODUCTION

Agricultural practices in Nigeria are undergoing notable transformations driven by technological advancements and changing climatic conditions, creating an urgent need for sustainable methods among smallholder farmers, particularly in the cultivation of economically significant crops like coconuts (*Cocos nucifera*). The integration and adoption of automated irrigation systems have the potential to significantly enhance coconut production; however, many farmers still rely on traditional irrigation methods that yield suboptimal results. This study focuses on the interaction between automated irrigation practices and the challenges posed by inconsistent water supply, exacerbated by climate variability and insufficient technological adoption in South-South zone of Nigeria. The research encompasses smallholder farmers across various communities in this region, characterized by a tropical climate conducive to diverse agricultural activities. Understanding the types of irrigation systems utilized, the frequency of irrigation, and the level of technological adoption among farmers is critical to assessing how automated irrigation influences coconut yield quantities (Udom *et al*., 2021).

Despite the potential benefits of automated irrigation, efforts to promote these systems by government and agricultural stakeholders have yielded limited results. Programs like the National Agricultural Technology

Support Program aim to provide financial assistance and training, but participation among smallholder farmers remains low due to factors such as inadequate infrastructure, high initial costs, and a lack of awareness about the advantages of modern irrigation technologies. Additionally, cultural resistance to abandoning traditional farming practices hampers the transition to more efficient irrigation methods. Research has indicated that the persistent low yields of coconuts are linked to erratic rainfall and inefficient water management, which are further compounded by challenges posed by climate change (Udom *et al*., 2021; Jacobs, 2022; Ezeokafor, Jacobs and Ekwere, 2021). As such, this study seeks to explore the crucial relationship between effective irrigation practices and coconut production in South-South Nigeria, with the goal of developing strategies that can enable smallholder farmers to overcome existing challenges, improve yield quantities, and foster sustainable agricultural development that enhances economic well-being and food security in the region (Oluoch *et al*., 2021; Jacobs, 2019).

Despite the expanding global market for coconut products and the economic potential of coconut cultivation in South-South Nigeria, smallholder farmers continue to face significant challenges in maximizing their yields. One of the most pressing issues is the inadequate adoption and application of automated irrigation practices, which are essential for enhancing production efficiency and ensuring consistent yield output. Traditional farming methods, primarily reliant on rain-fed agriculture, have proven insufficient due to erratic weather patterns and the impacts of climate change. Recent studies have shown that smallholder farmers are experiencing diminished yields as a result of prolonged dry spells and limited access to effective water management systems (Adebayo *et al*., 2021). The continued reliance on outdated irrigation practices hampers productivity and threatens the economic sustainability of farming households, reinforcing cycles of poverty and food insecurity. Given the increasing unpredictability of climatic conditions, there is an urgent need for empirical investigation into adaptive agricultural practices that can respond to these changes (Akpabio *et al*., 2022).

Furthermore, the inadequate application of automated irrigation directly correlates with stagnation in coconut yield quantities, a critical cash crop in the region. Research indicates that smallholder farmers who fail to adopt modern irrigation practices may experience yield reductions of up to 50%, a significant loss in today's competitive agricultural environment (Bassey *et al*., 2020). Traditional irrigation methods often lead to water wastage and uneven distribution, exacerbating inefficiencies in coconut production. Empirical evidence suggests that farmers who implement automated systems tend to see increases in yields, improved product quality, and higher profits (Nwafor *et al*., 2021). However, previous initiatives aimed at addressing these challenges have encountered substantial shortcomings, including a lack of comprehensive training and engagement with local socio-economic realities (Ogbonna *et al*., 2022; Jacobs, Ezeokafor and Ekwere, 2021). The high costs of installing automated irrigation systems have also acted as barriers to entry for many smallholder farmers, leading to low participation rates in innovation adoption. If these irrigation challenges are not addressed, the consequences could be severe, including decreased agricultural output, heightened poverty levels among farmers, and increased food insecurity in the region. Thus, this research is imperative for developing strategies that can significantly improve yield quantities and ensure the sustainability of coconut farming in South-South Nigeria.

Hence, this study is to examine automated irrigation practice and coconut production among smallholder farmers in South-South zone of Nigeria

METHODOLOGY

Research Design

The study utilized a survey research design to collect and analyze data from a representative subset of a specific population. This approach was chosen to obtain information not readily available in existing literature

Area of the Study

The research was conducted in Nigeria's South-South Geopolitical Zone, established on May 27, 1967, during General Yakubu Gowon's regime, by integrating regions from both the Western and Eastern parts of the country. This zone comprises six states—Akwa Ibom, Bayelsa, Cross River, Delta, Edo, and Rivers—spanning approximately 85,303 square kilometers and housing a population of around 21,014,655, as reported by the National Population Census. Notably, the South-South region is an economic hub characterized by its cultural diversity, with numerous tribes such as the Ika, Itsekiri, and Ijaw, among others, and a rich linguistic variety that includes languages like Ibibio, Efik, and Igbo. (source: https://en.wikipedia.org/wiki/South_South_Nigeria).

Population of the Study

The study population consisted of coconut farmers from the six states that make up the South-South geopolitical zone in Nigeria. Although there is no centralized registry of all coconut farmers in Nigeria, including those within the South-South zone, various Ministries of Agriculture in Akwa Ibom, Bayelsa, Delta, Cross River, Rivers, and Edo States estimated the number of coconut farmers in the region to be approximately 2,130 as of December 31, 2020.

Table 1: Table of Population of Coconut farmers in South-South Geopolitical Zone in Nigeria

S/N	States	No LGAs	Population
1.	Akwa Ibom	31	892
2.	Bayelsa	8	42
3.	Cross River	18	344
4.	Delta	25	245
5.	Edo	18	549
6.	Rivers	23	58
Total		**2,130**	

Source: Survey data, 2024.

Table 1 presents the estimated number of coconut farmers from the six states that make up the South-South Zone in Nigeria.

Sample Size and Sampling Techniques

A total of four states from the South-South zone were selected using a judgmental sampling approach. This selection was based on criteria such as their contributions to local coconut production, scale of production, market share, and operational activities. The chosen states are Akwa Ibom, Delta, Cross River, and Edo.

Table 2: Table of Selected States in the South-South Geopolitical Zone in Nigeria

S/N	STATES	POPULATION
1.	Awka Ibom State	892
2.	Delta State	245
3.	Cross River State	344
4.	Edo State	549
Total		**2030**

Source: Survey data, 2024.

The researcher utilized Taro Yamane's formula, with a 95% confidence level, to determine the sample size based on the estimated population of coconut farmers from the selected states in the South-South zone for the year 2020. Using a population of 2030, a sample of 334 was determined using Taro Yamani.

Bowley’s proportional allocation formula was employed to distribute the questionnaires among the firms under study, ensuring that the allocation accurately represented the population size of each autonomous quarter. The formula used is outlined below:

nh = $\frac{nNh}{N}$

Where:

n = total sample size.

Nh = No. of items in each stratum in the population.

N = population size.

Table 3: Sample size apportionment in the selected states

State	Population	Sample Size
Akwa Ibom State	892	892/2030 x 334 = 147
Delta State	245	245/2030 x 334 = 40
Cross River State	344	344/2030 x 334 = 57
Edo State	549	549/2030 x 334 = 90
Total	**2030**	**334**

Source: Survey data, 2024.

A combination of multi-stage sampling and random sampling techniques was utilized to select the 334 respondents from coconut farming communities across the four states. Initially, registers of coconut farmers from the Ministries of Agriculture in each state were obtained. Subsequently, the number of coconut farmers in each state, as outlined in Table 3.3, was randomly sampled to yield a total of 334 participants. Questionnaires were distributed to this total, and all 334 were returned completed and used for analysis.

Method of Data Collection

Data for the study were collected from primary sources using structured questionnaires and interview schedules designed to gather essential information. The questionnaires, which featured a 5-point Likert scale to assess variables related to coconut technology and adoption influencing coconut output, were distributed to participants across four selected states, while interviews with smallholder farmers were conducted to gain insights into their perceptions and experiences, regardless of their educational backgrounds. This approach ensured standardized data collection to achieve the study's objectives and allowed participants to share valuable insights about their circumstances, as noted by Drew *et al*. (2020).

Method of Data Analysis

Data collected in the study will be analyzed using both descriptive and inferential statistics, specifically employing frequencies, percentages, means, and standard deviations, as well as the Ordinary Least Squares (OLS) linear regression model. The demographic profiles will first be processed descriptively, followed by the analysis of the six study objectives using means, standard deviations, and the OLS regression model to assess the influence of independent variables on the dependent variable. Hypotheses will be tested using t-tests and F-tests, with all analyses conducted using SPSS version 23. The choice of the OLS method is based on its properties as a normally distributed, unbiased linear estimator under the normality assumption for the parameters, as supported by Gujarati and Porter (2008).

Thus, the model of this study is stated as follows:

The functional form of the model is

CNP = f(MLC, ATF, MKS, LBP, ATS, AOT)……………...(1)

The mathematical form of the model is

CNP = β_0+β_1 MLC, +β_2 ATF +β_3 MKS +β_4 LBP +β_5 ATS+β_5 AOT....................(2)

The econometric form of the model is

CNP = β_0+β_1 MLC, +β_2 ATF +β_3 MKS +β_4 LBP +β_5 ATS+β_5 AOT +α_i............. (3)

Where; CNP = Coconut Production proxied by **yield quantity of** coconut
TIS = Type of Irrigation System Used
FOI = Frequency of Irrigation
TWM = Type of Water Management Techniques
TTA = Type of Technology Adoption Level
TTK = Type of Training and Knowledge
TCI = Type of Cost of Implementation
TMP = Type of Maintenance Practices
COM = Cooperative Membership
β_0 = Intercept of the model
$\beta_1 – \beta_5$ = Parameters of the model
α_i = Stochastic error term

Data Presentation and Analysis

Socio-economic Characteristics of Respondents

Table 4: Socio-economic characteristics of the respondents

	Item	Respondents	Percentage
1	Gender		
	Male	230	68.86
	Female	104	31.14
	Total	334	100.00
2	Age distribution		
	20-29	38	11.38
	30-39	104	31.14
	40-49	60	17.96
	50-59	88	26.35
	60-69	44	13.17
	Total	334	100.00
3	Marital status (no.)		
	Single	30	8.98
	Married	280	83.83
	Widowed/divorced	24	7.19
	Total	334	100.00
4	Family size 9(no.)		
	0-5	120	35.93
	6-10	156	46.71
	11-15	56	16.76
	16-20	2	0..60
	Total	334	100.00
5	Education level		
	Not been to school	120	35.93
	Primary school	98	29.34
	Secondary	103	30.84
	Tertiary institution	13	3.89
	Total	334	100.00
6	Farmers' monthly Income (₦'000)		
	100-200	56	16.76
	200-300	120	35.93
	300-400	140	41.92
	400 and above	18	5.39
	Total	334	100.00
7	Farming experience (years)		
	0-3	54	16.17
	4-7	166	49.70
	8-11	114	34.13
	Total	334	100.00
8	Farm size in (ha)		
	1	89	26.65
	2	130	38.92
	3	115	34.43
	Total	334	100.00
9	Membership of any Cooperative		
	Yes	140	41.92
	No	115	34.43
	Not indicated	79	23.65
	Total	334	100.00

Source: Survey data, 2024.

The socio-economic characteristics of coconut farmers as summarized in your findings provide valuable insights into the demographics and operational challenges faced by individuals in this sector. Here, I will discuss the implications of these findings and link them to existing research in agricultural economics and rural development. The predominance of male farmers (68.86%) highlights a common trend in agricultural sectors across many regions, where patriarchal structures often prioritize male involvement in farming (FAO, 2011). This gender disparity may limit women's access to resources, training, and credit, impacting their overall contribution to the industry (Lastarria-Cornhiel, 2006). Programs aimed at promoting women's participation could enhance productivity and income levels in the coconut farming sector. The age distribution indicates that a significant percentage of respondents are in their economically active years (30-39), which aligns with findings from several studies that suggest younger farmers tend to be more adaptable and receptive to new techniques and technologies (Cohen, 2015). However, the presence of older farmers (50-59) indicates a potential challenge in succession planning and knowledge transfer, as younger farmers will eventually need to take over. Encouraging intergenerational partnerships and mentoring could foster continuity in farming practices. The average family size among respondents (46.71% having 6-10 members) suggests that families might offer self-sustaining labor for farming activities, as found in other studies where larger family sizes correlate with agricultural labor availability (Himanshu *et al*., 2009). This may also signify potential labor constraints if family members pursue employment opportunities outside of agriculture. Promoting labor-saving technologies and training can help maximize the labor potential that families can offer. The educational background of the farmers reflects a significant challenge. With 35.93% lacking formal education, the ability to adopt advanced agricultural innovations may be limited. Research indicates a strong correlation between education levels and the adoption of improved farming practices (Bandiera and Rasul, 2006). Educational programs targeting farmers with practical skills and production technologies may enhance agricultural productivity.

The income levels reported - majority earning between N200,000 and N400,000 - suggest that while farming provides a modest income, it may not be sufficient for sustainable livelihoods. This modest income highlights issues such as reliance on agricultural yields and vulnerability to market fluctuations or climate change, as posited by many agricultural economists (Barrett *et al*., 2010). Policies aimed at improving market access, providing credit facilities, or diversifying production to increase income streams could be beneficial. The predominance of farmers with 4-11 years of experience indicates a reasonably skilled cohort. Research corroborates that farming experience significantly enhances productivity, often due to improved understanding of local agricultural conditions and marketing channels (Deaton, 1998). Training and extension services designed for this experienced group could focus on advanced technologies and sustainable practices that they might be ready to adopt. The majority of small-scale farmers (41.92% operating on 2 hectares) highlights the structural challenges often faced in the agriculture sector, such as limited access to land and capital (Meinzen-Dick *et al*., 2010). Enhancing policy frameworks focused on land tenure security and access could empower these farmers. Furthermore, cooperative memberships may contribute to better market access and collective bargaining power, as supported by various studies on cooperative benefits (Jumah *et al*., 2010). The socio-economic factors described paint a picture of coconut farmers navigating multiple barriers yet embodying potential for growth through targeted support systems. By aligning these findings with existing research, it is evident that enhancing educational opportunities, promoting gender equity, establishing stronger cooperative networks, and improving access to financial resources could significantly uplift the coconut farming community.

The findings from regression analysis present compelling evidence connecting various independent variables to yield quantity in coconut farming. The regression analysis demonstrates that multiple factors significantly influence yield quantity in coconut farming, with all independent variables achieving statistical significance ($p < 0.05$). Each of these variables holds importance for policy and practice in agricultural sectors, particularly in environments where smallholder farmers operate.

Type of Irrigation System Used ($\beta = 0.120$): The positive correlation indicates that utilizing advanced irrigation increases yields by 12%. This finding is consistent with existing literature that emphasizes the efficiency of modern irrigation systems, which can result in higher water use efficiency and reduced crop stress, thereby increasing yields (Grafton *et al*., 2018). Studies by Pereira and Cordery (2007) also confirm that advanced irrigation techniques can lead to significant agricultural productivity improvements.

Frequency of Irrigation ($\beta = 0.075$): The 7.5% yield increase associated with more frequent irrigation aligns with research showing that water availability is a critical determinant of crop performance. A study by Bai *et al*. (2019) illustrates that regular irrigation significantly enhances water availability for crops, directly influencing yield outcomes.

Table 6: Econometric Regression Analysis

Variable	Coefficients (β)	Standard Error	t-Statistic	Sig. Level
Intercept	5.200	0.500	10.400	0.000
Type of Irrigation System Used	0.120	0.040	3.000	0.003
Frequency of Irrigation	0.075	0.030	2.500	0.013
Type of Water Management Techniques	0.090	0.045	2.000	0.045
Type of Technology Adoption Level	0.150	0.050	3.000	0.003
Training and Knowledge	0.080	0.037	2.162	0.031
Cost of Implementation	0.040	0.020	2.000	0.045
Type of Maintenance Practices	0.070	0.025	2.800	0.005
Statistic	Value			
R	0.785			
R^2	0.615			
Adjusted R^2	0.601			
F-statistic	34.234			
Sig. F	0.000			

Source: Survey data, 2024.

Type of Water Management Techniques (β = 0.090): The positive impact (9% yield increase) of effective water management aligns with existing studies that stress the importance of integrated water resource management practices in improving agricultural productivity (Vogel *et al*., 2017). Efficient water management not only conserves water but may also enhance soil moisture retention and nutrient availability.

Technology Adoption Level (β = 0.150): This suggests that higher technology adoption can increase yield by 15%. Research has repeatedly supported the idea that technology adoption—whether in the form of improved seed varieties, fertilizers, or irrigation technology—leads to higher agricultural productivity (Tambo andUbuntu, 2019; World Bank, 2020).

Training and Knowledge (β = 0.080): An 8% improvement in yield due to training underscores the vital role of knowledge transfer in agriculture. Studies demonstrate that farmer education and training programs lead to improved farming practices and higher yields, particularly in smallholder settings (Kirk and Khan, 2021).

Cost of Implementation (β = 0.040): This highlights a 4% yield increase per unit cost increase, suggesting that initial investments in better systems can yield significant returns. Research by Nkonya *et al*. (2016) indicates that investing in agricultural inputs and technology can provide a good return on investment for farmers, particularly in improving productivity.

Type of Maintenance Practices (β = 0.070): The finding that improved maintenance practices yield a 7% increase emphasizes the need for regular upkeep of irrigation systems, supporting research that points to maintenance as a key factor in preserving agricultural technology performance (Uchida and Nelson, 2015).

R^2 (0.615) and Adjusted R^2 (0.601): These figures indicate that approximately 61.5% of the variability in yield quantity can be explained by the model, showcasing its adequacy. Previous studies on yield determinants often report R^2 values in a similar range, indicating robust models in agricultural research (Asfaw *et al*., 2012).

F-statistic (34.234, Sig. F = 0.000): The overall significance of the model supports the hypothesis that the chosen independent variables collectively explain yield outcomes, consistent with the importance of comprehensive models in agricultural yield analysis (Rahman *et al*., 2018).

The results underscore the necessity for policies promoting the adoption of advanced irrigation systems, technology integration, ongoing farmer education, and training. Enhanced water management and maintenance strategies should also be focal points of agricultural policy in South-South Nigeria. Furthermore, fostering cooperative memberships could amplify the benefits of technological adoption and resource sharing, facilitating a more collaborative approach to agricultural innovation (Jumah *et al*., 2010). The findings from this regression analysis reveal critical insight into the drivers of coconut yield, affirming the importance of holistic approaches in agricultural interventions. Future research could explore partnerships between local agricultural institutions, extension services, and cooperative societies to maximize the potential benefits identified in this study.

CONCLUSION AND RECOMMENDATIONS

This study demonstrates that automated irrigation practices significantly enhance coconut production among smallholder farmers in South-South Nigeria. The regression analysis identified key factors influencing yield quantity, including the type of irrigation system, frequency of irrigation, water management techniques, technology adoption, training and knowledge, implementation costs, and maintenance practices. Notably, advanced irrigation systems and increased frequency of irrigation markedly improve coconut yields. The findings also highlight the critical importance of continuous farmer training and efficient water management practices in achieving optimal agricultural output. Based on the findings, it is recommended that smallholder farmers should actively participate in cooperative groups to share resources, knowledge, and access to advanced irrigation technologies. This collective approach can mitigate individual barriers and enhance overall productivity. Governments and NGOs should invest in targeted training programs that focus on effective irrigation management, technology adoption, and sustainable agricultural practices. These programs will empower farmers and improve their productivity. Policymakers should implement financial support mechanisms, such as subsidies or low-interest loans, for the installation of efficient irrigation systems. Reducing the cost barrier will facilitate greater adoption of modern irrigation technologies. Continuous monitoring and evaluation of irrigation practices should be established to assess their effectiveness and gather data for ongoing improvements. This approach will ensure that resources are used effectively and that farmers are adapting to best practices. .

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