2026 SCIENCELINE

Online Journal of Animal and Feed Research

Volume 16, Issue 1: 16-23; January 30, 2026

ISSN 2228-7701

DOI: https://dx.doi.org/10.51227/ojafr.2026.3

ANALYSIS OF DEMAND FOR WATER AND ITS IMPACT ON BROILER PRODUCTION IN IMO STATE OF NIGERIA

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Supporting Information

RESEARCH ARTICLE
PII: S222877012600003-16
Received: September 05, 2025
Revised: January 19, 2026
Accepted: January 15, 2026

ABSTRACT: This study analyzed the demand for water and its effect on the productivity of broiler production in Imo State, Nigeria. Specifically, the objectives were to A) estimating the determinants of water demand in broiler farms, B) examining the level of water consumption relative to recommended standards, C) evaluating the productivity of broiler farmers, and D) identifying constraints to water access. Primary data were collected from 120 broiler farmers using a structured questionnaire and analyzed with descriptive statistics, the broiler water consumption ratio (BWCR), productivity index, and multiple regression models. Results showed that the exponential functional form was the best fit, with an R^2 of 0.684, indicating that 68.4% of the variation in water demand was explained by farm and bird characteristics. Age of birds ($P < 0.05$), stock size ($P < 0.01$), and bird weight ($P < 0.10$) significantly influenced water demand. Based on the BWCR, 43.3% of broilers consumed water below optimal levels, 25.0% consumed excessively, and only 31.7% were within the recommended range. Farmers demonstrated high productivity with a ratio of 3.30, suggesting efficient input use; however, sustainability is threatened by persistent water constraints. The most pressing challenges were limited access to water distributors (18.5%), scarcity (15.0%), contamination (13.0%), high fuel costs (13.0%), and climate change (13.0%). The findings underscore the need for policy interventions to strengthen rural water infrastructure, promote solar-powered pumping systems, and improve extension services on water-use efficiency. Addressing these issues will enhance both the productivity and resilience of broiler production in water-scarce environments.

Keywords: Broiler productivity, Poultry requirements, Water consumption ratio, Water demand, Nigeria

INTRODUCTION

Water is the most critical nutrient for animal survival and productivity, yet it remains one of the least examined inputs in livestock systems. Broilers have particularly high water requirements relative to feed intake; a bird reaching 2.3 kg typically consumes about 8.2 kg of water compared to 4.6 kg of feed (Tabler, 2023). Because water underpins thermoregulation, digestion, metabolism, and waste elimination, any disruption in supply directly affects growth performance and carcass quality (Jacquie, 2020). However, climate variability, rising temperatures, and infrastructural limitations have intensified water scarcity globally, creating significant bottlenecks for poultry production (Leal Filho et al., 2022; El-Sabry et al., 2023).

In sub-Saharan Africa, water scarcity is both an environmental and livelihood concern, as many rural households depend on smallholder poultry systems for income and food security. High levels of water poverty, driven by inadequate infrastructure and reliance on seasonal rainfall, exacerbate vulnerability among rural livestock farmers (Umunakwe et al., 2021). For broiler production, insufficient or contaminated water increases mortality rates, reduces feed conversion efficiency, and lowers profitability (Ogbonna et al., 2020).

Nigeria hosts one of the largest poultry industries in Africa, contributing significantly to rural employment and national protein supply (Adeyonu et al., 2021). Nonetheless, farmers face persistent water-related challenges, including unstable electricity for pumping, high fuel costs, and rising expenses associated with water storage and distribution (Onuwa, 2022). These constraints are more severe in southeastern Nigeria, where climatic variability and uneven rainfall further widen the supply–demand gap (Emeka-Chris et al., 2022). In Imo State, most broiler farmers rely on commercial

Citation: Anyiam KH, Igwe KC, Amusa TA, Obinna-Nwandikom CO, Enoch OC, Isaiah IG, Obasi AC, Okoro FN, Iwezor-Magnus DN, Anene HU, Nnorom EI, Olumba UM, Igwenagu MO, Onu DO, Ozor MU (2026). Analysis of demand for water and its impact on broiler production in Imo state of Nigeria. *Online J. Anim. Feed Res.*, 16(1): 16-23. DOI: https://dx.doi.org/10.51227/ojafr.2026.3

water vendors or costly boreholes, increasing production costs and reducing margins. Disease outbreaks linked to contaminated water have also been reported, heightening production risks (Sanusi and Dries, 2025). Despite the centrality of water to poultry performance, empirical research in Nigeria has largely prioritized feed and disease management, with limited attention to water demand and its direct relationship with broiler productivity.

Although previous studies have highlighted the physiological role of water in poultry production (Barbosa et al., 2014; Jacquie, 2020; Tabler, 2023) and the influence of environmental factors on livestock water use (Leal Filho et al., 2022), empirical evidence linking water demand to broiler productivity in Nigeria remains sparse. Existing research has focused on water contamination (Ogbonna et al., 2020) and the impact of production inputs on farm performance (Onuwa, 2022), but few studies have investigated how water availability shapes growth outcomes and economic returns. This is a critical omission, as water affects feed conversion ratios, market weights, survival rates, and overall profitability, while the rising cost of accessing water through pumping, storage, and borehole systems has not been fully incorporated into productivity assessments.

This study addresses these gaps by examining the determinants of water demand and its effect on broiler productivity in Imo State, Nigeria. The specific objectives are to identify the determinants of water demand in broiler production, assess the level of water consumption relative to established standards, evaluate the productivity of broiler farmers, and identify the key constraints limiting access to adequate water supply. By integrating water demand analysis with productivity assessment, the study provides empirical evidence to support the formulation of sustainable water-use policies and strengthen the resilience of poultry production systems under conditions of increasing water scarcity.

MATERIALS AND METHODS

Study area

The study was carried out in Imo State, Nigeria. Imo State is located in the Southeastern zone of Nigeria. It is divided into three agricultural zones, viz-a-viz Orlu, Okigwe and Owerri. These divisions are for administrative and extension services and not for any agro-ecological difference. It is delineated into 27 Local Government Areas. The state lies between latitudes 4° 45'N and 7° 15'N of the equator and longitudes 6° 50'E and 7° 25'E of the Greenwich Meridian. It occupies the area between the lower River Niger and the upper and middle Imo River. It is bounded on the East by Abia State, on the West by the River Niger and Delta State; and on the North by Anambra State, while Rivers State lies to the South. Imo State covers an area of about 5,135 km^2, with an estimated population of 5,459,300 and a population density of about 1,063 km^2 (National Population Commission, 2023). The State has an average annual temperature of 24.1°C which can rise up to 32.6°C during the dry season, an average annual relative humidity of 64.2% which can rise to up to 77.9% during the rainy season, average annual rainfall of 1800mm to 2738mm and an altitude of about 100m above sea level (NBS, 2016). Agriculture is practiced by a good number of the population in the state. Crop farming is mainly regulated by the seasonal distribution of rainfall, although there are a few farmers involved in dry season farming of some food crops and vegetables. Also, livestock like cattle, sheep, goats, pigs, poultry, rabbits, and snails are reared through subsistence and commercial farming in the state (Imo Agricultural Development Programme (ADP), 2014).

Sample technique

A multistage sampling technique was used in the selection of respondents. Firstly, the 3 agricultural zones of the state were selected to enable the survey to cover the entire state. Orlu, Okigwe and Owerri zones are made up of 10, 6 and 11 Local Government Areas respectively. In the second stage, a proportionate sampling technique was used to select 4 LGAs from Orlu zone, 2 LGAs from Okigwe zone and 4 LGAs from Owerri zone bringing it to a total of 10 LGAs from the 3 Agricultural zones. This was done due to the unequal numbers of LGAs in each agricultural zone. In the third stage, four Communities each were randomly selected from the 10 LGA giving a total number of 40 communities.

In the fourth stage, 3 broiler farmers each were selected randomly from the list of registered poultry farmers in the communities selected making a total of 120 broiler farmers. These lists were obtained from Agricultural Development Programme and from the opinion leaders such as community leaders, and presidents' generals of the communities. A total sample size of 120 was used for this study. The study population consisted of registered small- and medium-scale broiler farmers. Industrial poultry operations and backyard keepers were excluded. All respondents operated commercial broiler units using deep-litter housing systems and had completed at least one production cycle within the study period. The dominant strains raised were Arbor Acres, Ross 308, and Marshall standard commercial broiler breeds in southeastern Nigeria. These strains were documented during data collection to account for potential breed-based differences in water consumption.

Methods of data collection

Primary data were obtained through a structured questionnaire administered directly to farmers. The instrument collected information on water sources, water use, production practices, flock characteristics, and productivity indicators. Data were collected on the following traits: farmer characteristics such as age, education, farming experience, flock characteristics such as breed, flock size, age of birds, water-use traits such as daily water intake, water source, water cost, supply frequency, and productivity indicators such as mortality, feed intake, live weight, feed conversion ratio, production cost, and revenue. Water quality parameters were not assessed in this study.

The questionnaire was pre-tested with 15 farmers outside the study area to ensure clarity. A Cronbach's alpha value of 0.81 indicated strong internal consistency. Among the four functional forms tested (linear, exponential, double-log, semi-log), the exponential function was selected as the lead equation because it provided the highest explanatory power (R^2 = 0.684) and statistically significant coefficients for key variables such as age of birds, stock size, and weight. This implies the model better captured the nonlinear relationship between water demand and the explanatory variables.

This study relied on cross-sectional data collected within one production cycle. Seasonal variations in water availability and long-term productivity effects were not fully captured. In addition, self-reported measures of water consumption may be subject to recall bias. These limitations suggest caution in generalizing results beyond the study area.

Method of data analysis and model specification

Data collected were analyzed using descriptive statistics (mean, frequency count, and percentage), multiple regression technique, Likert scale, and demand function and productivity model. The water demand was determined and was estimated using the model as specified. The model was developed for this study considering the aim of the study.

$$D_w = b_0 + b_1AGB + b_3WB + b_4SS + b_5FI + b_6P_w + e$$

Which D_w = Quantity of water used by the broiler (Litre); AGB = Age of the broiler (weeks); WB = Weight of the broiler (kg); SS = Stock Size (Number of broilers kept); FI = Feed Intake (kg); P_w = Price of water (₦); e = error term; $b_0 - b_6$ = Parameters to be estimated.

Then, the Broiler water consumption ratio (BWC) was used to categorize the water usage level into optimal consumption level, excessive consumption level, and low consumption level. The model is specified as follows;

$$\text{BWCR} = \frac{Total\ Volume\ of\ water\ consumed\ (kg)}{Total\ Stock\ weight\ (Kg)}$$

Decision rule

If BWCR = 1.50 – 3.0, an Optimal Consumption level; If BWCR = 3.50 - Above, an Excessive consumption level; If BWCR = 0.5 – 1.50, a Low consumption level.

The productivity of broiler farmers in the study area was achieved using a total productivity ratio. The model as used by Anyiam et al. (2019) was adapted and remodeled to suit the study. The model is specified as:

$$P = \frac{Value\ of\ Output\ \ from\ broiler\ farm (naira)}{Value\ of\ Input\ used\ in\ broiler\ farm\ \ (naira)}$$

The output from the broiler farm consisted of the value of the broiler at maturity plus the value of the waste generated from the broiler farm. If P = 0.5, productive, If P > 0.5, highly productive, If P < 0.5, not productive.

RESULTS

Demand for water and level of water usage

The results for the demand for water for broiler production were achieved using the four functional forms of linear, exponential, double log and semi-log. The result is presented in Table 1.

Table 1 - The demand for water for broiler production.

Explanatory variable	Linear function	+Exponential function	Double-Log function	Semi-Log function
Constant	62.967 (1.102)	3.475 (4.854)	4.009 (2.045)	24.342 (0.813)
Age of the bird	-0.419 (-0.917)	-0.002 (-2.412)**	-0.196 (-0.518)	-20.475 (-0.966)
Weight of the bird	-43.608 (-0.564)	-0.864 (-1.891)*	-0.252 (-0.736)	-8.921 (-0.446)
Stock size	-0.059 (-1.576)*	-0.002 (-5.125)***	-0.394 (-4.445)***	-2.844 (-1.279)
Feed intake	1.378 (1.134)	0.010 (0.664)	0.168 (0.798)	10.358 (0.995)
Price of water	-0.045 (-0.075)	-0.004 (-0.550)	0.243 (0.927)	2.561 (0.125)
	Functional parameters			
R^2	0.473	0.684	0.637	0.456
Adj R^2	0.411	0.636	0.585	0.408
F-Statistics	2.169	5.884	4.593	1.877

*Source: Field Survey Data Analysis, 2025. + = Lead equation *** = significant at 1%, ** = significant at 5%, * = significant at 1% values in parenthesis are the t-values

The regression results for the demand for water in broiler production are presented in Table 1. The exponential functional form was selected as the lead equation because it yielded the highest explanatory power ($R^2 = 0.684$) and statistically significant coefficients for bird age, stock size, and weight. This indicates that 68.4% of the variation in water demand was explained by the model. The negative coefficient for bird age suggests that younger birds consume less water than older birds, while the negative relationship with stock size implies that larger flocks may experience rationing behavior, whereby water per bird is reduced as stock size increases (El-Sabry et al., 2023). The relationship between bird age and water demand is illustrated in Figure 3, which shows a declining trend as birds mature.

These findings corroborate Tabler (2023), who observed that water intake in broilers changes over time and is sensitive to environmental and management conditions. Similarly, Parker and Brown (2003) reported that water demand in poultry is non-linear and influenced by both biological and management factors.

Level of water consumption

The level of water consumption for broiler production was estimated using the Broiler Water Consumption Ratio (BWCR). The results are presented in Table 2.

The Broiler Water Consumption Ratio (BWCR) revealed that 31.7% of birds consumed water at optimal levels, 25.0% consumed excessively, while 43.3% had suboptimal consumption (Table 2; Figure 1). The high proportion of suboptimal consumption suggests that many farms do not provide adequate water for their broilers, which could reduce feed intake and growth performance. This is consistent with findings by Ebrahimi et al. (2024), who demonstrated that both inadequate and excessive water supply negatively affect feed conversion efficiency and carcass quality in broilers.

Statistical analysis further supports these observations. The chi-square test ($\chi^2 = 6.20$, $p = 0.045$) shows a significant difference in water consumption levels across farms. The Standard Error of the Mean (SEM = 6.43) shows the variability in consumption frequencies, showing inconsistencies in water provision across different operations. Pairwise comparisons reveal that low water consumption differs significantly from excessive consumption ($p = 0.012$) and marginally from optimal consumption ($p = 0.038$), while no significant difference was observed between optimal and excessive consumption ($p = 0.471$). These results indicate that inadequate water supply is a more critical issue than excessive provision in the study area. The variation across farms underscores knowledge and infrastructure gaps in water management. Farmers with better access to storage and distribution facilities were more likely to achieve optimal water consumption, emphasizing the need for targeted interventions to improve water provision and management practices in broiler production.

Table 2 - Level of water consumption

Water consumption level (Litre)	Frequency	Percent	P-value
Optimal consumption	38	31.70	0.038
Excessive consumption	30	25.00	0.012
Low consumption	52	43.30	0.471
Total	120	100	
chi-square (χ^2)	6.20		
SEM	6.43		

Source: Field Survey Data, 2025, 0.5L – 1.0L (Low consumption), 1.5L – 2.0L (Optimal consumption 2.5L – above (Excessive consumption).

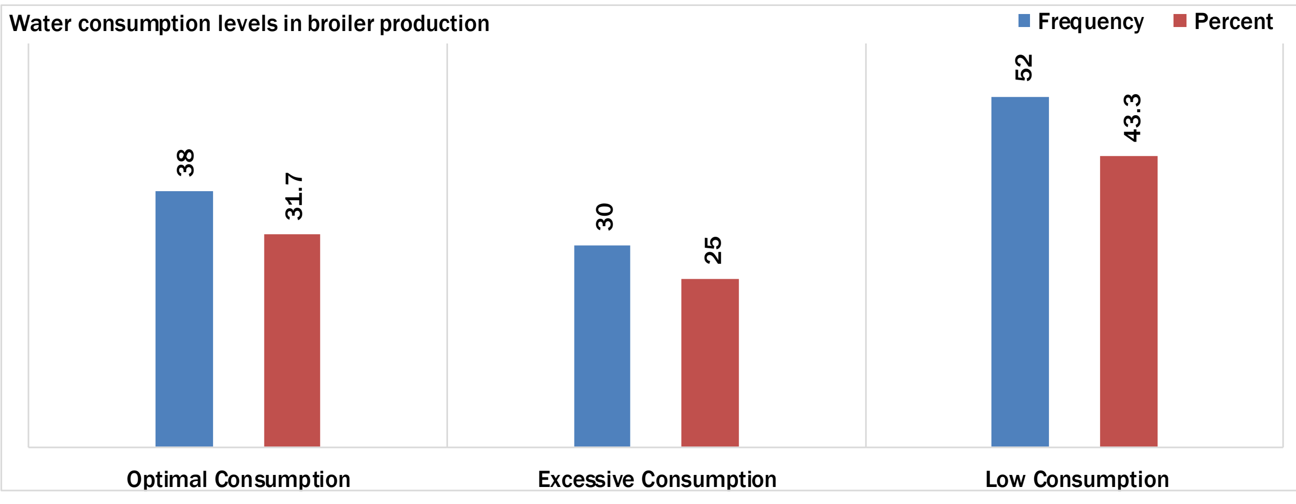

Figure 1 - Water Consumption level in Broiler Production

Productivity of broiler farmers

The productivity of the broiler farmers was determined by the productivity ratio. The result of the productivity of broiler farmers is shown in Table 3. The productivity analysis (Table 3) shows a ratio of 3.30, indicating that broiler farmers in the study area are highly productive. This suggests efficient conversion of inputs such as feed and water into outputs (mature birds and by-products). These findings align with Onuwa (2022), who emphasized that efficient input use strongly contributes to profitability in broiler production. However, sustaining this level of productivity may be challenged by persistent water-related constraints, as discussed below.

Table 3 - Productivity of broiler farmers.

Output (Naira)	($)	Input (Naira)	($)	Productivity	Decision
₦1306878	$871	₦396200	$271.34	3.299	Highly productive

*Source: Field Survey Data, 2025

Constraints faced by the farmers

The results of the constraints faced by the farmers for water is presented in Table 4. The constraints reported by farmers are summarized in Table 4 and Figure 2. Limited access to water distributors (18.5%) emerged as the most critical issue, followed by scarcity (15.0%) and contamination, high fuel costs, and climate change (13.0% each). These findings highlight systemic challenges beyond individual farm practices. Similar issues were reported by Adeoti et al. (2023), who noted that rural farmers in Nigeria face high costs of water procurement and limited infrastructure. Furthermore, Ogbonna et al. (2020) highlighted that water contamination, particularly with heavy metals and pathogens, compromises poultry health and productivity. The reported influence of climate change also reflects the findings of Leal Filho et al. (2022), who showed that rainfall variability exacerbates livestock water insecurity in Africa.

Table 4 - Distribution according to constraints faced by farmers in accessing water in Imo State.

Constraint ***	Frequency	Percentage
Scarcity	30	15
Contamination	26	13
Cost of borehole	15	7.5
Unstable electricity supply	6	3
High cost of fuel	26	13
Limited access to water distributors	37	18.5
Climate change	26	13
High cost of water storage tank	20	10
Water pollution	14	7

Source: Field Survey Data, 2025; *** = Multiple responses

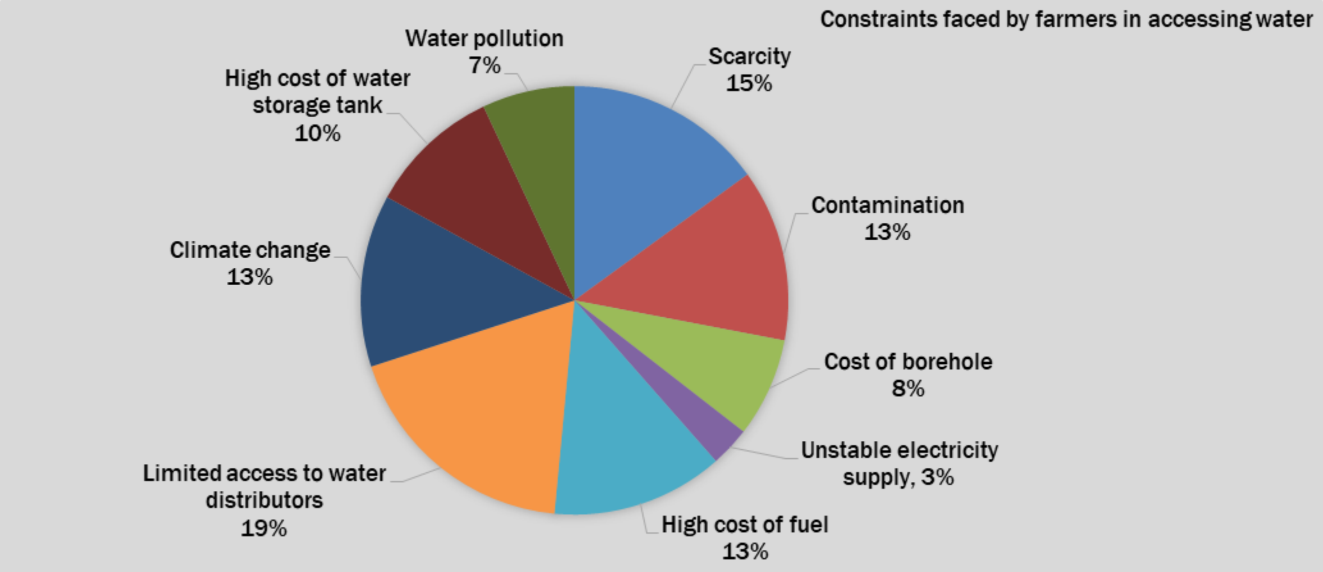

Figure 2 - Constraints faced by farmers in accessing water.

DISCUSSION

The regression analysis revealed that stock size, age, and live weight significantly influenced water demand among broiler farms. However, the negative relationship between stock size and water consumption deviates from the conventional expectation that larger flocks require proportionately more water. This counterintuitive finding suggests adaptive rationing behavior by farmers operating under conditions of water scarcity and rising production costs. Similar patterns have been documented in recent studies across water-stressed poultry systems. For instance, El-Sabry et al. (2023) reported that broiler farmers in semi-arid regions deliberately reduce per-bird water allocation as flock size increases in order to minimize pumping and storage costs, often at the expense of optimal bird performance. Likewise, FAO (2023) highlighted that water rationing has become a coping strategy among small-scale poultry producers in developing countries facing unstable water supply and high energy prices.

The observed distribution of water use levels, where 43.3% of farms operated below recommended water intake and 25% exceeded optimal levels, points to widespread inefficiencies and limited technical knowledge regarding water management. Recent empirical evidence supports this finding. Ebrahimi et al. (2024) demonstrated that suboptimal water provision, whether insufficient or excessive, adversely affects feed conversion ratios and growth performance in broiler production. Similarly, Umar et al. (2022) found that poor understanding of water quality requirements and inappropriate drinker systems contributed significantly to productivity losses among poultry farmers in sub-Saharan Africa. These findings reinforce the need for targeted extension services focusing on water-use efficiency, water quality management, and appropriate delivery systems.

The estimated productivity ratio of 3.299 suggests relatively high efficiency among broiler farmers in the study area, indicating that producers are able to generate substantial output from available inputs. This result aligns with recent studies by Onuwa (2022) and Nwadiolu & Akpodiete (2023), who reported that efficient input allocation and managerial experience significantly enhance profitability in small- and medium-scale broiler enterprises. However, despite this apparent efficiency, the long-term sustainability of productivity remains uncertain due to persistent water-related constraints. According to World Bank (2021), escalating costs of water storage infrastructure and energy for pumping increasingly erode profit margins in intensive livestock systems, particularly in regions with unreliable public water supply.

Furthermore, the ranking of constraints, particularly limited access to reliable water distributors and contamination risks, suggests that challenges extend beyond farm-level management to systemic supply-chain and institutional failures. Recent policy reports corroborate this observation. The International Water Management Institute (IWMI, 2023) emphasized that weak water distribution networks and inadequate quality control mechanisms disproportionately affect livestock producers, leading to inconsistent supply and heightened disease risks. This implies that improving broiler water productivity requires not only farmer-level interventions but also broader investments in water infrastructure, regulation, and private-sector participation.

CONCLUSION AND RECOMMENDATIONS

This study analyzed the demand for water and its effect on the productivity of broiler production in Imo State, Nigeria. The findings revealed that water demand is significantly influenced by bird age, stock size, and weight, with the exponential functional form providing the best fit for explaining variations. Despite high productivity levels (productivity ratio of 3.30), a large proportion of farms operate with suboptimal water consumption. Furthermore, systemic challenges such as limited access to water distributors, scarcity, contamination, high energy costs, and climate variability remain persistent constraints. These results highlight the paradox of poultry production in the study area: while farmers demonstrate efficiency in resource use, structural water-related barriers undermine sustainability. If these issues remain unresolved, the long-term viability of broiler farming, a major contributor to Nigeria's food security and rural income, could be compromised.

The following recommendations were made:

1. Government and development partners should expand rural water infrastructure, including community boreholes and small-scale water schemes, to reduce dependence on costly private distributors.
2. Farmers should be supported through subsidies or credit schemes to acquire solar-powered pumps, thereby reducing reliance on expensive fuel and unstable electricity supply.
3. Targeted training on water-use efficiency, quality monitoring, and proper delivery systems should be provided to ensure birds receive water at optimal levels.
4. Strengthening monitoring of water contamination and pollution will reduce risks of disease outbreaks and improve flock health.
5. Future studies should adopt longitudinal designs to capture seasonal variations in water demand, as well as explore the interactions between water quality, disease incidence, and productivity outcomes.

By implementing these measures, policymakers and stakeholders can enhance water accessibility, lower production risks, and secure the long-term sustainability of broiler farming in southeastern Nigeria.

DECLARATIONS

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Acknowledgements

The authors gratefully acknowledge the broiler farmers of Imo State who generously provided the data for this study. We also appreciate the village heads and agricultural extension officers for their support during fieldwork. The authors Special thank Dr. K.H. Anyiam from the Department of Agricultural Economics, Federal University of Technology Owerri for the improvement of this manuscript.

Author contributions

K.H. Anyiam = Conceptualization, methodology, supervision, manuscript drafting, data analysis, interpretation. K.C. Igwe = Data analysis, interpretation, manuscript review. T.A. Amusa = Field survey coordination, data curation, results validation. C.O. Obinna-Nwandikom and D.O. Onu = Statistical modelling, literature review. O.C. Enoch = Methodology development, editing. A.C. Obasi = Data collection, preparation of tables and figures. F.N. Okoro, M.U. Ozor = Review of related literature, referencing. Doris N. Iwezor-Magnus = Manuscript editing, formatting. I.G. Isaiah, E.I. Nnorom and H.U. Anene, M.O. Igwenagu = Data collection, critical revisions. Ujunwa Miriam Olumba = Policy recommendations, conclusion drafting. All authors read and approved the final manuscript.

Data availability

The datasets generated and analyzed during this study are available from the corresponding author upon reasonable request. Due to the sensitivity of respondents' personal and farm-level information, raw survey data cannot be publicly shared but may be accessed in anonymized form for academic and policy research purposes.

Ethics approval

The authors compiled with the ARRIVE guidelines and or the Interdisciplinary Principles and Guidelines for the Use of Animal Research, Testing, and Education by the New York Academy of Sciences, Ad Hoc Animal Research Committee.

Funding

There is no funding or grant from any organization. The funding is done by the financial contributions of the authors.

Competing interests

The authors declare that there is no competing interest regarding the publication of this paper.

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