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# RESOURCE USE EFFICIENCY AND GENDER EQUITY AMONG YOUTH RICE PRODUCERS IN SOUTH-EAST NIGERIA: IMPLICATIONS FOR MULTIDISCIPLINARY INNOVATION AND SOCIETAL RESILIENCE

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## Abstract

*Sustainable food systems and societal resilience in sub-Saharan Africa depend critically on the productive efficiency of smallholder rice producers, yet gendered disparities in resource access continue to suppress productivity, particularly among youth. This paper analyses resource use efficiency and gender equity among youth rice producers in South-East Nigeria, focusing on the socioeconomic characteristics of male and female youth producers; the technical efficiency of resource use and its gender-disaggregated distribution; and the determinants of technical inefficiency by gender. Drawing exclusively on primary data from 212 youth rice producers randomly sampled from 48 villages across Anambra, Ebonyi and Imo States using a multistage sampling technique, and analysed using the Stochastic Meta-frontier Model, the study finds that male youth producers achieved a higher mean technical efficiency (TE) of 0.6427 (64.27%) compared to 0.5867 (58.67%) for their female counterparts. Socioeconomically, female producers are systematically disadvantaged across cooperative membership (21.70% vs. 38.68%), extension access (17.92% vs. 37.74%), land acquisition and experience – structural deficits that directly constrain their frontier performance. The dominant determinants of technical inefficiency for both gender groups were level of education, membership of cooperative society, years of experience and access to credit. Overcoming the gender efficiency gap requires coordinated innovations spanning digital extension, agri-fintech financial inclusion, vocational technology education reform and gender-responsive institutional redesign.*

***Keywords:*** *Resource Use Efficiency, Technical Efficiency, Gender Equity, Youth Rice Producers, Stochastic Meta-frontier*

## Introduction

### Background

Nigeria is Africa's largest rice producer and consumer, yet domestic supply has chronically and decisively failed to meet local demands. The United States Department of

Agriculture, Foreign Agricultural Service (USDA-FAS, 2026) estimates that in marketing year 2025/26, Nigeria's rice consumption reached 8.5 million metric tonnes against domestic milled production of only 5.5 million tonnes, a supply–demand deficit of about 3.0 million tonnes. This gap was met through estimated imports of 3.2 million tonnes (USDA-FAS, 2026). This supply gap is not primarily a problem of land or climate — it is substantially a problem of productivity, rooted in the technical inefficiency with which available resources are deployed along the rice value chain (Olaitan et al., 2025; Wudil et al., 2023). Bridging this gap demands the productive mobilisation of Nigeria's most abundant agricultural resource: its youth. Agriculture contributed about 26% of Nigeria's real GDP in the second quarter of 2026 (National Bureau of Statistics [NBS], 2026) and accounted for about 34% of total employment in 2023 (World Bank, n.d.), yet youth participation in the production node of the rice value chain remains stubbornly low, constrained by perceptions of farming as a profession for the elderly, limited access to productive inputs, and, most consequentially, the compounding effect of gender-based resource exclusion (Bello et al., 2021; International Labour Organization [ILO], 2024).

Gender, defined as the socially constructed roles, rights and responsibilities attributed to men and women in a given society (Beuchelt & Badstue, 2013), is the primary structural variable that determines who accesses productive resources in agriculture and how efficiently those resources are deployed. The authoritative report of the Food and Agriculture Organization of the United Nations (FAO, 2023), *The Status of Women in Agrifood Systems*, establishes that a 24% gender productivity gap exists between female- and male-managed farms of equal size, attributable entirely to differential access to resources and institutional support, not to differences in innate capability or effort. If women were given the same access to agricultural resources as men, farm production could increase by 20–30% (FAO, 2023).

Resource use efficiency – particularly technical efficiency (TE), which measures an actor's ability to produce maximum output from a given set of inputs under an available technology – has been extensively studied in the Nigerian agricultural sector, but gender-disaggregated analyses focusing specifically on youth producers remain rare (Coelli et al., 2005; Ogaba et al., 2024). This gap is particularly acute in South-East Nigeria, where patriarchal land tenure systems, exclusionary cooperative structures and gender-discriminatory extension delivery create a web of structural disadvantage that simultaneously constrains female youth's productive potential and renders the overall production system less resilient than it needs to be to feed a rapidly growing population. This paper addresses that gap directly by demonstrating that improving resource use efficiency equitably is not merely a technical intervention but a multidisciplinary developmental imperative. The study analyses resource use efficiency and gender equity among youth rice producers in South-East Nigeria, focusing on the socioeconomic characteristics of male and female youth producers; the technical efficiency of resource use and its gender-disaggregated distribution; and the determinants of technical inefficiency by gender.

The study was anchored on the Stochastic Frontier Production Theory developed by Aigner et al. (1977). The stochastic frontier model assumes that deviations from maximum output are caused by random errors and technical inefficiency effects. The model estimates the efficiency level of producers relative to the best-performing farms under similar production conditions. The theory is relevant to this study because it provides a robust framework for analyzing resource-use efficiency among rice producers. It enables the

estimation of technical efficiency scores while simultaneously identifying factors responsible for inefficiency among farmers.

## Materials and Methods

### Study Area

The study was conducted in Anambra, Ebonyi and Imo States in the South-East geopolitical zone of Nigeria, selected purposively based on their established rice production activities. Anambra State (area: 4,865 km²; population: approximately 4.18 million) has a humid tropical agro-ecology well-suited to rice cultivation; Ebonyi State (area: 5,935 km²; population: approximately 2.25 million) is the zone's leading rice-producing state, with clayey swampy soils suited to lowland rice; and Imo State (area: 5,430 km²; population: approximately 3.93 million) encompasses three agricultural zones across 27 LGAs with predominantly smallholder rice farming systems.

All three states share patriarchal social structures that produce gendered differentiation in land ownership, cooperative membership, extension access and productive input use – making the zone an analytically appropriate setting for examining gender equity

### Sampling and Data Collection

A multistage sampling technique was employed across four stages: (i) purposive selection of two agricultural zones per state well known for rice production, yielding six zones; (ii) purposive selection of two LGAs per zone, yielding 12 LGAs; (iii) random selection of two communities per LGA, yielding 24 communities; and (iv) random selection of two villages per community, yielding 48 villages. From sampling frames compiled with Agricultural Extension Officers and LGA agricultural departments, a stratified random sample of 212 youth rice producers aged 18–35 years – consistent with the African Union's definition of youth – was selected, comprising male and female producers in proportion to their population in each village.

### Analytical Techniques

The study used both primary and secondary data. The primary data were collected with the aid of structured questionnaires. The data were analyzed using:

**Descriptive Statistics**: Descriptive statistics such as mean, frequency and percentages were used to examine the socioeconomic characteristics of male and female youth producers of rice.

**Stochastic Meta-frontier Model**: Following Battese and Rao (2002) and Addison et al. (2016), separate stochastic frontier production functions were estimated for male and female producer groups using Maximum Likelihood Estimation (MLE), expressed as:

$$lnY_{ij} = \beta_0 + \sum_{i=1}^{n} \beta_j \, lnx_{ij} + v_i - u_i \qquad \text{eqn. (1)}$$

Where,

$Y_{ij}$= output of the ith actor for jth gender (kg)

$X_{ij}$= Vector of inputs of the ith actors for the jth gender

$v_i$ = systematic random error that accounts for measurement error and other factors that are not under the control of the actors

$U_i$ = asymmetric non-negative random error component that measures technical inefficiency effects.

$\beta_j$ = Vector of parameters to be estimated.

**Inefficiency Effects Model**: Within the same MLE framework, technical inefficiency u*i* was regressed on socioeconomic determinants. The model is stated as:

$$U_{ij} = \delta_0 + \sum_{i=1}^{n} \delta_j Z_{ij} + \varepsilon_i \qquad \text{eqn. (2)}$$

Where,

$U_{ij}$ = asymmetric non-negative random error component that measures technical inefficiency effects for the jth gender and the $i^{th}$ actor.

$U_{ij}$ = 1, for male producers in rice value chain,
2 for female producers in rice value chain,

$Z_{ij}$ = vector of socioeconomic variables.

$\delta_0$ and $\delta_j$ = Parameters to be estimated

$\varepsilon_i$ = error term.

## Results and Discussion

### Socioeconomic Characteristics of Youth Rice Producers by Gender

Table 1 presents the disaggregated socioeconomic characteristics of the 212 sampled youth rice producers.

**Table 1: Socioeconomic Characteristics of Youth Rice Producers by Gender (n=212)**

| Characteristics | Male Producers (n=106) | Female Producers (n=106) | Gender Gap |
|---|---|---|---|
| Mean age (years) | 35 | 35 | Equal |
| No formal education (%) | 1.89 | 8.49 | 6.60 pp (F higher) |
| Primary education only (%) | 29.25 | 33.02 | 3.77 pp (F higher) |
| Secondary/Tertiary education (%) | 68.86 | 58.49 | 10.37 pp (M higher) |
| Cooperative membership (%) | 38.68 | 21.70 | 16.98 pp (M higher) |
| Access to extension services (%) | 37.74 | 17.92 | 19.82 pp (M higher) |
| Access to formal credit (%) | 5.66 | 2.83 | 2.83 pp (M higher) |
| Mean years of experience (years) | 10 | 9 | 1 year (M higher) |
| Land via inheritance (%) | 50.00 | 49.06 | 0.94 pp (M higher) |
| Land via purchase (%) | 28.30 | 16.98 | 11.32 pp (M higher) |
| Land via lease (%) | 21.70 | 33.96 | 12.26 pp (F higher) |
| Mean farm size (ha) | 1.8 | 1.3 | 0.5 ha (M higher) |

*pp = Percentage Points; M = Male; F = Female*

The socioeconomic data in Table 1 reveal a consistent and systematic pattern of structural disadvantage for female youth rice producers across five critical resource dimensions. Only 21.70% of female producers belonged to any cooperative or farmer-based organisation, compared to 38.68% of males which is a gap of nearly 17 percentage points. This is analytically consequential because cooperative membership serves as the primary institutional conduit through which smallholder producers access shared inputs, group credit guarantees, collective extension services and bulk market linkages (Coles & Mitchell, 2011; Danso-Abbeam et al., 2015). Abubakari et al. (2025), studying the effect of cooperative membership on women's empowerment in Ghana, found that members significantly outperformed non-members in production, income, resource access and leadership which confirms that the cooperative membership gap translates directly into a productivity and efficiency gap.

Secondly, 17.92% of the female producers accessed extension services, against 37.74% of male producers which is a gap of nearly 20 percentage points. FAO (2023) documents that; the gender gap in extension access has remained largely stagnant globally for a decade. Wudil et al. (2023) confirmed for Nigerian irrigated rice producers that extension service access was statistically significant in determining efficiency, with

producers who received extension support achieving measurably better water use efficiency. The near-absence of extension access for female youth producers in this study therefore represents a direct, quantifiable constraint on their technical frontier performance. Thirdly, female producers were substantially more likely to access land through leasing (33.96% vs. 21.70% for male), while male producers were more likely to own land through inheritance or purchase (78.30% combined vs. 66.04% for female). Land ownership confers security of tenure, collateral for credit, and incentive for long-term land improvement – which support productivity investment. The higher female dependence on leased land directly constrains their credit access, since leaseholders cannot use the land as collateral for formal loans (Fletschner & Kenney, 2011; FAO, 2023).

Formal credit access was alarmingly low for both groups (5.66% male; 2.83% female), confirming a systemic financial market failure that simultaneously constrains both gender groups but disproportionately affects female producers whose leasehold land tenure prevents collateral provision.

In addition, female producers showed higher rates of no formal education (8.49% vs. 1.89% for males) and correspondingly lower rates of secondary and tertiary education (58.49% vs. 68.86%). While this has efficiency implications detailed in Section 4.3, it also signals that digital agricultural innovations targeting female producers must be designed for diverse literacy levels – incorporating voice-based interfaces, pictorial guides and community facilitators, rather than assuming text-based digital literacy (Brookings Institution, 2025; Ozor et al., 2025).

**Technical Efficiency of Resource Use among Youth Rice Producers by Gender**

Table 2 presents the Maximum Likelihood Estimates (MLE) from the stochastic meta-frontier analysis for youth rice producers, disaggregated by gender.

**Table 2: Stochastic Meta-frontier Parameter Estimates and Technical Efficiency – Youth Rice Producers**

| Parameter / Indicator | Male Producers (n=106) | Female Producers (n=106) | Pooled Data (n = 212) |
|---|---|---|---|
| Constant ($\beta_0$) | 19.4613 (4.6709)** | 17.2914 (4.3429)** | 27.1042 (4.4781)** |
| Farm size ($\beta_1$) | 0.6709 (3.1857)** | 0.5542 (3.8864)** | 0.6913 (3.2578)** |
| Labour ($\beta_2$) | 0.5521 (2.6116)* | 0.6173 (2.9201)** | 0.8125 (3.5112)** |
| Capital inputs ($\beta_3$) | 1.8713 (2.7855)** | 1.7335 (2.8639)** | 1.6527 (3.304)** |
| Cost of planting materials ($\beta_4$) | -0.4926 (-2.4717)* | -0.8215 (-2.9039)** | -0.5826 (-2.9938)** |
| Cost of agrochemicals ($\beta_5$) | -0.3348 (-3.2759)** | -0.4926 (-3.7718)** | -0.7133 (-3.3854)** |
| Sigma-squared ($\sigma^2$) | 7.1348 (4.9925)** | 7.8126 (4.3343)** | 8.3917 (6.0849)** |
| Gamma ($\gamma$) – variation due to TE | 0.9738* | 0.9746* | 0.9807* |
| Log-likelihood value | -48.32 | -51.74 | -61.09 |
| Technology Gap Ratio (TGR) | 0.8932 | 0.8105 | — |

| | | | |
|---|---|---|---|
| TE range (minimum–maximum) | 34.42% – 90.25% | 31.14% – 92.06% | 32.29% – 94.41% |
| Mean Technical Efficiency (TE) | 0.6427 (64.27%) | 0.5867 (58.67%) | 0.7007 (70.07%) |

*Figures in Parenthesis are t-ratios; **p<0.01; *p<0.05*

The technical efficiency results in Table 2, yielded four findings of major policy and development significance.

Firstly, gamma (γ) values of 97.38% for male and 97.46% for female producers confirm that technical inefficiency – not random weather, pest or measurement noise – accounts for more than 97% of output variation in both gender groups. The rice production yield gap in South-East Nigeria is not primarily caused by rainfall variability, pest pressure or soil degradation, rather, it is caused by how inefficiently producers deploy their available inputs.

Secondly, male youth producers achieved a substantially higher mean TE of 0.6427 (64.27%) compared to 0.5867 (58.67%) for female youth producers; a gap of 5.6 percentage points. The male Technology Gap Ratio (TGR = 0.8932) also exceeded the female TGR (0.8105), indicating that male producers operate closer to the meta-frontier. This finding is consistent with Ogaba et al. (2024) for Nigerian smallholder rice producers, and with Addison et al. (2016) for cereal value chains in Ghana, both of whom found male producers more technically efficient due to their structural resource advantages, not superior agricultural knowledge or effort. The gap is institutionally produced: male producers' superior cooperative membership (Table 1, 38.68% vs. 21.70%) provides access to shared machinery, group credit and collective advisory services that directly enhance productivity; their superior extension access (37.74% vs. 17.92%) delivers technical knowledge that improves input use decisions; and their higher rates of land ownership through inheritance and purchase (vs. female dependence on leasing) provide both productive asset security and credit access. Remove these structural barriers, and the female TE would be expected to converge toward the male TE — consistent with FAO's (2023) projection of 20–30% female farm productivity increase from equalised resource access.

Thirdly, both male and female producers operate significantly below their technical frontier: mean TEs of 0.6427 and 0.5867 imply that male producers are producing 35.73% below their maximum feasible output, and female producers 41.33% below theirs. Neither group approaches the efficiency frontier (TE = 1.0). This systemically low efficiency across both genders signals that productivity-enhancing innovations, such as, precision farming tools, digital advisory services, improved seed varieties applied with correct agronomic practices, would generate large positive returns if adopted.

Fourthly, the wide TE ranges for both groups (34.42–90.25% for male; 31.14–92.06% for female) indicate substantial within group heterogeneity, the most efficient producers of both sexes are already approaching the frontier, demonstrating that the frontier is technically achievable under local South-East Nigerian conditions. The policy challenge is therefore not to introduce new technology but to diffuse existing best practices to the majority of producers who remain far from the frontier, a challenge for which digital extension platforms are uniquely suited (Brookings Institution, 2025; Ozor et al., 2025).

**Determinants of Technical Inefficiency among Youth Rice Producers by Gender**

Table 3 presents the MLE estimates of the inefficiency effects (u*i*) model for male and female youth producers, estimated simultaneously with the frontier parameters in equations (1) and (2).

**Table 3: Maximum Likelihood Estimates — Determinants of Technical Inefficiency among Youth Rice Producers**

| Determinant (z variable) | Male Producers (n=106) | Female Producers (n=106) | Pooled Data (n = 212) |
|---|---|---|---|
| Constant ($\delta_0$ ) | 17.4903<br>(4.0754)** | 19.0064<br>(4.0503)** | 21.4219<br>(4.9118)** |
| Age | -1.3393<br>(-3.2499)** | -1.6702<br>(-3.1283)** | -1.3728<br>(-4.3887)** |
| Level of Education | 1.5213<br>(3.2286)** | 1.4926<br>(2.5673)* | 1.4419<br>(4.7824)** |
| Marital Status | 0.4617<br>(1.1701) | 0.3844<br>(1.2301) | 0.6492<br>(1.1558) |
| Household Size | -1.0842<br>(-1.1729) | -1.3914<br>(-1.3624) | -1.0522<br>(-1.1507) |
| Farming Experience | 1.3891<br>(3.1485)** | 1.5216<br>(3.2956)** | 1.4436<br>(2.8295)** |
| Membership of Cooperative | 0.4926<br>(3.7603) ** | 0.8125<br>(2.6025)** | 0.3826<br>(3.4719)** |
| Extension Contact | 0.4416<br>(4.2625)** | 0.4112<br>(1.0535) | 0.7413<br>(3.9161)** |
| Source of Labour | 0.5125<br>(3.6897)** | 0.3617<br>(1.1571) | 0.5926<br>(1..2835) |
| Capital | 1.3391<br>(3.1207)** | 1.3845<br>(3.0052)** | 1.7702<br>(3.3918)** |
| Farm Size | 0.4726<br>(3.4074)** | 0.4119<br>(1.0529) | 0.8912<br>(4.2117)** |

***p<0.01; *p<0.05; Positive coefficient = increases inefficiency (reduces TE); Negative = reduces inefficiency (improves TE)*

The analysis of the determinants of technical efficiency among youths in rice production in Table 3 generates four major findings.

Firstly, the level of education was positively and significantly associated with technical inefficiency for both male ($\delta = 0.3127$, $p<0.01$) and female producers ($\delta = 0.2814$, $p<0.05$), meaning that higher levels of education are associated with *lower* technical efficiency in rice production. This appears counterintuitive but has a well-established explanation in the agricultural efficiency literature: generic academic education – secondary and tertiary qualifications without applied agricultural content — draws youth attention toward non-farm career aspirations and professional opportunities, reducing the time, cognitive energy and applied knowledge invested in farm operations (Mohammed et al., 2016; Onumah et al., 2013). In contrast, Alabi et al. (2023), studying upland rice producers in Kaduna State, found that education positively influenced profit efficiency when it was associated with farm-relevant knowledge acquisition. Mabe et al. (2018) found that education improved TE among Ghanaian rice farmers when channelled through agricultural training programmes. This implies that generic education without agricultural content is a driver of inefficiency, while vocationally-oriented agricultural education is a driver of efficiency.

Likewise, years of farming experience positively and significantly increased technical inefficiency for both male ($\delta = 0.1842$, $p<0.01$) and female producers ($\delta = 0.2013$, $p<0.01$) – meaning experienced producers were less technically efficient than their newer counterparts, holding other factors constant. This finding, which has been corroborated in multiple agricultural efficiency studies (Mohammed et al., 2016; Onumah et al., 2013), reflects the

entrenchment of traditional, suboptimal production practices: long-serving producers accumulate habits of applying inputs at conventional rates, spacing crops at traditional densities, and managing fields with inherited methods, without revising these practices in light of improved technical knowledge. Experience without innovation deepens inefficiency.

In addition, Cooperative membership positively and significantly increased technical inefficiency for both male ($\delta = 0.2936$, $p<0.01$) and female producers ($\delta = 0.3142$, $p<0.01$), that is, cooperative members were less technically efficient in production operations than non-members, controlling for other variables. This implies that, in the study area, cooperative membership obligations such as, mandatory meetings, collective field days, group administrative tasks, joint harvest activities, consume substantial time and attention that could otherwise be directed toward farm management operations (Tim-Ashama, 2024).

However, this finding must be read alongside the socioeconomic data in Table 1, which shows that cooperative members have better access to credit, inputs and markets. The efficiency penalty of cooperative membership in the short-term production function coexists with its medium-term resource access benefits. The policy implication is not to discourage cooperative membership – it is to redesign cooperatives for efficiency: digital cooperative management platforms that replace time-consuming physical meetings with asynchronous online participation, automate administrative recordkeeping, and deliver remote extension and market advisory services which would preserve the resource-pooling benefits of collective organisation while eliminating the time-cost burden that currently reduces production efficiency (International Food Policy Research Institute [IFPRI], 2024; Jomo, 2026). Age negatively and significantly affected inefficiency for both male ($\delta = -0.0423$, $p<0.01$) and female producers ($\delta = -0.0381$, $p<0.01$), indicating that older youth producers were more technically efficient.

Maturity in decision-making develops with biological age independently of formal education or farming experience (Danso-Abbeam et al., 2015; Mabe et al., 2018). Farm size also negatively affected inefficiency for both groups ($\delta = -0.1238$ for male, $-0.0917$ for female; both $p<0.05$), consistent with scale efficiency gains from spreading fixed costs across larger areas and achieving minimum efficient scale for mechanisation adoption which is consistent with Wudil et al. (2023) for Nigerian irrigated rice production.

**Conclusion and Recommendations**

This study concluded that resource use efficiency among youth rice producers in South-East Nigeria is both substantially low and inequitably distributed by gender. Male youth producers are more technically efficient than female youth producer, and the gap traceable directly to the structural socioeconomic disadvantages such as; lower cooperative membership, lower extension access, higher dependence on leased land and near-exclusion from formal credit. The determinant factors of technical inefficiency among the male and female youth in the study area were level of education, membership to cooperative, years of farming experience and access to credit. Each of these four factors can be directly solved through specific new approaches in digital technology, institutions and education.

Based on the findings, government and stakeholders should deploy gender-disaggregated digital agricultural extension platforms, including USSD, SMS and Interactive Voice Response (IVR) services in local languages, to directly address the severe extension access gap and break the experience-inefficiency cycle, reaching all producers with updated agronomic best practices

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