Rice Farming in Ghana: Exploring Varietal Choices, Perceptions, and Production Constraints in Ejura-Sekyeredumase, Atwima Nwabiegya, and Kedjebi Districts.

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DOI: https://dx.doi.org/10.47772/IJRISS.2025.915EC0036

Received: 06 April 2025; Accepted: 14 April 2025; Published: 19 May 2025

ABSTRACT

This paper examined farmers' perceptions, constraints and preferences for improved rice varieties among smallholders in Ghana. Using data from 411 randomly selected farmers from the Ejura-Sekyeredumase, Atwima Nwabiegya, and Kedjebi Districts, a 5-point Likert was used to examine farmers' perception on improved rice varieties. The Kendall's Coefficient of concordance was used to rank key constraints To estimate the factors influencing farmers' choice of rice varieties among available alternatives, the multinomial logistic regression (MNL) model was used. The result revealed a favorable attitude toward improved rice varieties among Ghanaian farmers generally, particularly regarding yield, market demand, and cooking quality. The MNL results revealed that age has a consistent negative effect across all varieties, with older farmers favoring landrace, likely due to familiarity and lower risk tolerance. Education significantly influenced varietal selection, reflecting informed decision-making shaped by agronomic or market factors. Distance positively affected the adoption of AGRA Rice, indicating that logistical challenges encourage its selection over Landrace. Farming experience and extension visits ewere positively associated with Amankwatia, highlighting its appeal to experienced farmers as well as the critical role of advisory services in promoting its adoption. Additionally, male farmers exhibited a slight preference for Jasmine over Landrace. Beyond varietal choice, the study also explored constraints in rice production. , Results revealed that, limited access to capital and low commodity prices are the most pressing issues, while infrastructural and mechanization challenges also featuredd prominently. These findings provided valuable insights into the interplay of demographic, logistical, and advisory factors in shaping adoption of varieties. Policymakers and stakeholders must adopt a holistic approach, integrating financial, technical, and infrastructural solutions to address these constraints comprehensively.

Keywords: Farmers' perceptions, Improved rice varieties, Multinomial logistic regression, Prodcution constraints, and Adoption decision

INTRODUCTION

The significance of rice as a fundamental staple crop and its pivotal role in poverty alleviation, food security, and economic growth in many countries, including Ghana, cannot be overstated. Climate change and continuous global population expansion make ensuring food security increasingly complex (Soullier et al., 2020). This challenge calls for the development and adoption of enhanced crop varieties tailored to address diverse agronomic, ecological, and consumer demands. In Ghana, rice holds particular significance, emerging as the fastest-growing staple food, with per capita consumption currently at 40 kilograms per person per year and increasing steadily (USDA, 2018; MOFA, 2020; Sedem-Ehiakpor et al., 2017). Despite this growing demand, domestic production remains insufficient, leading to significant rice imports (MOFA, 2020). This growing demand underscores the dual challenge of increasing production to meet domestic consumption and reducing the country's heavy reliance on rice imports, which carry significant economic implications.

The Ghanaian government, working with international agricultural organizations, has prioritized investments in rice production to address this gap. Over the years, substantial resources have been channeled towards developing improved rice varieties (IRVs) tailored to the unique ecological and agronomic conditions of Ghana. In 2019, six new commercial rice varieties were introduced through a collaboration between the Council for Scientific and Industrial Research-Crops Research Institute (CSIR-CRI) and the Alliance for a Green Revolution in Africa (AGRA), bringing the total number of available rice genotypes in the country to nineteen (19) between the period of 2009-2019 (CSIR-CRI, 2020; National Variety Released Catalogue (NVRC), 2019). However, , Ghana continues to experience production deficits attributed to challenges such as low adoption of modern agricultural technologies and suboptimal farm yields (MOFA, 2020).

The Adoption Challenge

The adoption of improved rice varieties is imperative for augmenting rice yields and fostering socio-economic development. Research indicates that incorporating advanced technologies into farming practices not only boosts productivity but also yields positive economic outcomes (Kariyasa and Dewi, 2013). Diverse factors, such as technological attributes, farmer characteristics, and farm-level characteristics, shape farmers' adoption decisions. Factors such as age, gender, sex, extension services, knowledge of varieties, educational background, household size, farming experience, farm size, membership in farmer-based organisations, location, access to research, training, credit, and non-governmental organisations and development programs all affect farmers' decisions to select improved crop varieties (Bruce, 2014; Chandio and Yunsheng, 2018; Ghimire et al., 2015; Onyeneke, 2017; Aidoo et al., 2014; Farid et al., 2015; Donkoh et al., 2019; Asante et al., 2021).

The Role of Varietal Preferences in Rice Production

Understanding farmer preferences and their impact on adoption rates is critical to designing interventions that promote sustainable agricultural systems. Agroecological factors, market demands, variety-specific traits, and socio-cultural influences shape varietal preferences, according to recent studies (Wongnaa et al., 2018; Donkoh et al., 2019; Asante et al., 2023; Abebrese et al., 2019; Danso-Abbeam et al., 2014). Research suggests that attributes such as grain quality, early maturity, and yield potential are primary considerations for farmers selecting rice varieties (Timu et al., 2014; Asante et al., 2013; Nonvide et al., 2018; Musila et al., 2018; Abebrese et al., 2019). However, these preferences are not uniform across the regions. In southern Ghana, for example, farmers in lowland areas may prioritize traits that improve resilience to flooding or poor soil conditions, while upland farmers may focus on drought tolerance and shorter growth cycles (Ragasa et al., 2013; Takeshima et al., 2013). These nuanced preferences underscore the need for localised research to inform varietal development and dissemination strategies.

Production Constraints in Ghana’s Rice Sector

Beyond varietal preferences, rice production in Ghana faces a myriad of challenges that constrain productivity and profitability for farmers. These constraints include limited access to improved seed varieties, inadequate irrigation infrastructure, and low adoption of modern farming practices (Denkyira et al., 2016; Ragassa and Chapoto, 2017; Anang et al., 2016; Bissah et al., 2022; MOFA, 2020). Additionally, farmers often contend with poor soil fertility, pests and diseases, and high post-harvest losses, all of which undermine efforts to increase rice yields (Bruce, 2014; MOFA, 2020). Economic and institutional barriers further exacerbate these challenges. Limited access to credit and agricultural inputs, coupled with fluctuating market prices, reduces the capacity of farmers to invest in high-quality seeds and technologies (Denkyira et al., 2016; Ragassa and Chapoto, 2017; Anang et al., 2016; Bissah et al., 2022). Moreover, weak extension services mean that many farmers lack the technical knowledge required to adopt and maximize the benefits of IRVs (Ragassa & Chapoto, 2017; Anang et al., 2016; Bissah et al., 2022). Addressing these barriers requires a comprehensive approach that integrates technological, economic, and policy interventions to support farmers at every stage of the production cycle.

This study seeks to explore the interplay between varietal preferences, production constraints, and perception of IRVs in three key districts of Ghana: Ejura-Sekyeredumase, Atwima Nwabiagya, and Kedjebi. These districts were selected for their strategic importance in rice production and their diverse agroecological conditions, which provide a representative overview of the challenges and opportunities within Ghana's rice sector. The research is guided by three key objectives: understanding farmer choice of rice variety, assessing production ponstraints, and evaluating perception on IRVs

METHODOLOGY

Study Area

The study was conducted in three administrative municipalities from two major rice growing regions in Ghana. Notably, the Kadjebi Municipality in the Oti Region and Atwima Nwabiegya and Ejura-Sekyedumase Districts in the Ashanti Region. These municipalities and regions were chosen based on their strategic importance in rice production and their diverse agroecological conditions, which offer a representative overview of the challenges and opportunities within Ghana's rice sector. In each municipality, four major rice growing communities were selected (Table 1).

A multi-stage sampling method was employed to obtain the data for this study. The first stage involved the purposive selection of the two major rice growing regions, - the Ashanti and Oti regions to reflect rice production and distribution patterns in southern Ghana. This was followed by a purposive sampling of three major rice growing municipalities from both sampled regions. From each district/municipality, four communities were randomly selected resulting in twelve communities from both regions. Finally, from each community, an average

of 33 rice producing households were randomly selected. In all, a total of only 411 rice farmers were involved in the study. The data was then collected using structured questionnaires comprising both closed and open-ended questions through face-to-face individual interviews. The collected data comprised demographic data, farm level characteristics, perceptions of IRVs, factors related to farmers' variety choice decisions, agricultural extension, markets and incomes, constraints associated with rice production, and participation in rice development activities.

Table 1: Number of farmers interviewed in household survey in the three administrative municipalities

Districts	**Communities**	**Sex**		**Pool**
		Female	**Male**	
Ejura-Sekyedumase	Aframso	15	25	40
	Dromankoma	14	18	32
	Hiawoanwu	15	17	32
	Teacherkrom	19	20	39
	Sub-Total	**63**	**80**	**143**
Atwima Nwabiegya	Akwaboa	7	13	20
	Mfensi	16	26	42
	Sokwai	22	20	42
	Ntensere	18	17	35
	Sub-Total	***63***	***76***	***139***
Kadjebi	Dodi Papase	14	18	32
	Dodo Amanfrom	10	18	28
	Kadjebi	25	17	42

	Poase Cement	13	14	27
	Sub-Total	***62***	***67***	***119***
Total		**188**	**223**	**411**

Analytical procedure

The study employed both descriptive and inferential statistical analysis. Descriptive statistics (e.g., mean, standard deviation) were used to summarize and describe the survey results. Inferential statistics were used to arrive at conclusions based on probability. The data was analyzed using the STATA 16 and SPSS version 20. The socio-economic characteristics of the rice farmers in the study area were summarized with the use descriptive statistics such as frequencies, mean score and percentages and then presented in tables.

Examining perceptions on improved rice varieties

To examine the perceptions on improved rice varieties, a five-point Likert scale (5=strongly agree, 4=agree, 3=neutral, 2=disagree, 1=strongly disagree) was employed. This scale was used to assess farmers' perception on various statements relating to improved rice varieties. The mean scores of all the farmers with regards to each of the perception statements was then calculated. The mean score of each perception statement was computed with the use of the mathematical formula.

Formula: $$\frac{[(fsa\times1)+(fa\times2)+(fn\times3)+(fd\times4)+(fsd\times5)]}{x} \quad (1)$$

Where;

fsa = frequency of strongly agree,

fa = frequency of agree,

fn = frequency of neutral,

fd = frequency of disagree,

fsd = frequency of strongly disagree

x = number of rice farmers who responded to the perception statements.

The overall perception index was finally computed as the average of all the mean scores for all the perception statements ranked by the respondent. The results of this analysis obtained by using simple arithmetic mean were also presented in tables. The averages of the mean scores of the perception statements was calculated. The perception index was calculated as:

$$P.I = \frac{\sum W.M}{N_{ps}}, but\ W.M = \frac{1*n_{sd} + 2*n_d + 3*n_e + 4*n_a + 5*n_{sa}}{N} \quad (2)$$

Where;

P.I = overall perception index

W.M = weighted mean

n_i = number of respondents for each agreement level (Strongly disagree to Strongly agree)

N = total number of respondents

N_{ps} = number of perception statements

Ranking of Production constraints

Following Mattson (1986), the Kendall's coefficient of concordance (W) was used to rank production constraint. The Kendall's W is computed as:

$$W = \frac{12\sum Ri^{-2} - 3N(N-1)^2}{N(N-1)} \quad (3)$$

Where: W = Kendall's value

N= total sample size

R = mean of the rank

A lower mean rank indicates that the constraint is more important. The Kendall's W indicates the level of agreement among the farmers of the rankings obtained Subsequently, a higher Kendall's W^a denotes high level of agreement on the rankings.

Estimating the Choice of Rice Variety

To estimate the factors influencing farmers' choice of rice varieties among the available alternatives, the multinomial logistic regression (MNL) model is used. The framework is based on the premise that a farmer chooses a rice variety that maximizes their utility, subject to individual, household, and contextual characteristics. The choice model assumes the following:

Farmers derive utility (U_{ij}) from choosing a specific rice variety (*j*), which depends on the attributes of the rice variety and the socio-economic and environmental characteristics of the farmer and their farming context. The utility function can be expressed as:

$$U_{ij} = \beta_j X_{ij} + ei \quad (4)$$

where:

U_{ij} = Utility derived by farmer *(i)* from choosing rice variety *(j)*. where J can take values

1, 2, 3 .... n, which represents the choice of rice variety (1=Landrace, 2= AGRA Rice, 3=Amankwatia, 4=Jasmine).

X_{ij} = Vector of observed explanatory variables affecting the choice.

β_j = Coefficients associated with the explanatory variables for variety *(j)*.

ε_{ij} = Random error term capturing unobserved factors.

Choice Probability: The farmer selects the rice variety *j* that provides the highest utility. The probability (P_{ij}) of farmer *i* choosing variety *j* over a base category (Landrace) is given by:

$$P_{ij} = \frac{exp(\beta_\kappa X_{\iota\kappa})}{\sum_{K=1}^{J} exp(\beta_\kappa X_{\iota\kappa})} \quad (5)$$

where *J* represents the total number of rice varieties, and the base category's β_κ is normalized to zero.

The MNL model is specified as follows: $In\left(\frac{p_{ij}}{p_{ibase}}\right) = \beta_j X_{\iota j}$ (6)

Where

P_{ij} = probability of choosing variety j.

P_{ibase} = Probability of choosing the base category (landrace).

In = Natural logarithm of the oods ratio

RESULTS AND DISCUSSION

Demographic Characteristics of Respondents

The results of the descriptive analysis are summarised and presented in Table 2. The results show that, the mean age of sampled farmer is 45 years across the municipalities. This infers that generally, the rice farmers in the districts belong to a young generation, which presents a great future for the rice industry in Ghana. This result confirms the findings of Tasila et al. (2019), who reported 45 years as the average age of a typical Ghanaian rice farmer. The percentage of male respondents was slightly higher compared to the female respondents (52% males and 48% females) across municipalities. A typical rice famer attained an average of five years of schooling with the highest recorded in the Kadjebi District (7 years), and Atwima Nwabiegya Municipal and Ejura Sekyedumase Municipal recoding the least (4 years). This indicates that most farmers have at least a basic level of formal education.

Table 2: Demographic Characteristics of Respondents

	District								
Variables	Ejiro-Sekyere (*N*=141)		Atwima Nwabiegye (N=139)		Kadjebi (N=119)		Total (N=411)		F-stat.
	Mean	SD	Mean	SD	Mean	SD	Mean	SD	
Age	46	14.48	44	10.33	47	10.63	45	12.02	1.83*
Sex *(Male=1)*	0.66	0.48	0.42	0.49	0.47	0.50	0.52	0.50	7.91***
Education (*year*)	4	5.15	4	4.83	7	4.63	5	5.10	17.70***
Farm size *(acres)*	2.81	1.61	3.95	1.92	1.95	1.79	2.89	1.95	37.36***
Farming experience	11	10.06	14	10.68	10	7.80	12	9.84	3.37**
Extension visits	4	4.47	2	2.32	3	2.13	3	3.19	10.04***
FBO membership *(Yes=1)*	0.50	0.50	0.42	0.49	0.83	0.37	0.58	0.49	27.74***
Credit access *(Yes=1)*	0.11	0.30	0.15	0.36	0.07	0.225	0.11	0.30	2.23**
Off-farm income *(Yes=1)*	0.27	0.44	0.32	0.47	0.33	0.47	0.31	0.46	0.74
Household size	8	4.15	7	3.46	6	2.62	7	3.56	8.35***
Economic Active in HH	4	2.03	3	1.56	3	1.40	3	1.73	10.83***
Household Dependency	4	3.06	4	2.46	3	2.21	4	2.63	4.82***

Source: Survey result, 2021. Note: SD denote Standard Deviation; the asterisks * ** denote 1%significance level, exp denote experience and HH denote Household Field Survey, 2021

Rice Varieties Adopted by Farmers

Table 3 presents the results of rice variety adoption among farmers in the study area. The findings reveal six main rice varieties: AGRA rice, Amankwatia, Jasmine 85/Lapez, Mr. More, Sikamo, and Togo Marshall. Among these, three varieties; AGRA rice, Amankwatia, and Jasmine 85/Lapez are classified as improved varieties, while the remaining three; Mr. More, Sikamo, and Togo Marshall, are landrace varieties. Togo Marshall is primarily cultivated in the Kadjebi district within the Oti region, while Sikamo is commonly grown by farmers in the Ejura-Sekyeredumase and Antwima Nwabiegya districts in the Ashanti region.

The study reveals that the majority of surveyed farmers (47.7%) have adopted AGRA rice exclusively. This is followed by Jasmine 85/Lapez, with an adoption rate of 22.6%, and Amankwatia, adopted exclusively by 9.5% of the farmers. Additionally, 3.6% of farmers grow both AGRA rice and Amankwatia, while 3.4% cultivate both Jasmine 85/Lapez and Mr. More. About 6.1% of the sampled farmers grow only Mr. More, 3.2% adopt only Sikamo, and 3.9% grow only Togo Marshall.

Table 3: Tabulation of Rice Varieties Grown by District

Variety	**Districts**							
	Ejura Sekyedumase		**Atwima Ngwabeagya**		**Kadjebi**		**Total**	
	Freq.	**(%)**	**Freq.**	**(%)**	**Freq.**	**(%)**	**Freq.**	**(%)**
AGRA Rice	79	(54.5)	65	(44.2)	52	(43.7)	196	(47.7)
Amankwatia	12	(8.3)	23	(15.7)	4	(3.4)	39	(9.5)
Jasmine/Lapez	28	(19.3)	29	(19.7)	36	(30.3)	93	(22.6)
AGRA and Amankwatia	5	(3.5)	10	(6.8)	0	(0.0)	15	(3.7)
Jasmine and Mr More	5	(3.5)	9	(6.1)	0	(0.0)	14	(3.4)
Mr More	11	(7.6)	3	(2.0)	11	(9.2)	25	(6.1)
Sikamo	5	(3.5)	7	(4.8)	1	(0.8)	13	(3.2)
Togo Marshall	0	(0)	1	(0.7)	15	(12.6)	16	(3.9)
Total		145	147		119		411	

First row has frequencies and second row has column percentages

Farmer perceptions of Improved Rice Varieties in the study area

Table 4 presents the perceptions of farmers on improved rice varieties across the three districts. The overall perception index for improved rice varieties was 3.51 on a five-point Likert scale, where 3 indicates a neutral response. This suggests that respondents held a moderately positive view, leaning slightly toward agreement with favorable statements about the improved varieties. Farmers generally agree that improved rice varieties offer high yields, with the majority (43.07%) agreeing and 28.71% strongly agreeing. also perception index of 3.84 indicates that farmers believe improved rice varieties show good resistance to pests and diseases. Again, The perception index for drought tolerance is 3.28, showing moderate agreement. Most respondents (54.5%) agree, suggesting that while farmers recognize some drought tolerance, the confidence in this trait may be less than for yield or pest resistance. With an index of 3.11, farmers have mixed perceptions of improved varieties' resistance to lodging (plants falling over), with 46.96% agreeing and a notable 22.38% strongly disagreeing, indicating a split opinion. Over half (54.5%) agreeing that improved rice varieties are not labor-intensive, suggesting that labor demands are viewed as manageable. The statement, Fertilization Needs recorded an index of 3.72, farmers seem to believe that improve varieties require optimal fertilization, reflected in 45.01% agreeing and 21.41% strongly agreeing, indicating that these rice types might need specific nutrient management. Although 59.61% agree that seeds are accessible, a significant 26.28% strongly disagree, suggesting that accessibility is a concern for some farmers. Many farmers (54.26% agreeing and 27.98% strongly agreeing) appreciate the cooking qualities of these varieties, indicating a favorable perception. The statement Tolerance to

Poor Soil recorded the lowest index at 2.92, indicating uncertainty about the adaptability of improved rice varieties to poor soil conditions, with 29.44% strongly disagreeing. The highest perception index (4.08) indicates a strong belief in the high market demand for improved rice varieties, with a large portion of farmers (35.52% strongly agreeing and 44.04% agreeing) expressing confidence in marketability. Finally, with an index of 3.15, farmers report moderate agreement that improved varieties are common among rice farmers, with a majority (56.69%) agreeing, though there is some ambivalence.

Table 4: Farmer perceptions of Improved Rice Varieties in the study area

Statement	**SD (1)**	**D (2)**	**N (3)**	**A (4)**	**SA(5)**	**Perception Index**
The improved varieties are high yielding	0.97	0.73	26.52	43.07	28.71	3.98
The improved varieties are tolerant to pest and disease	2.68	0.24	25.3	53.53	18.25	3.84
The improved varieties are tolerant to drought	16.06	0.24	26.28	54.5	2.92	3.28
The improved varieties are tolerance to lodging	22.38	0.24	26.03	46.96	4.38	3.11
The improved varieties are not labour intensive	11.44	4.14	23.6	54.5	6.33	3.4
The improved varieties require optimal fertilization	6.08	3.41	24.09	45.01	21.41	3.72
The improved varieties seeds are easily accessible	26.28	0.24	12.65	59.61	1.22	3.09
The improved varieties have good cooking qualities	2.43	1.46	13.87	54.26	27.98	4.03
The improved varieties are tolerant to poor soil condition	29.44	1.95	17.03	49.88	1.7	2.92
The improved varieties have high market demand	2.92	0.49	17.03	44.04	35.52	4.08
The use of Improve rice varieties is common among rice farmers in Ghana	22.38	3.16	14.36	56.69	3.41	3.15
Overall Perception Index						**3.51**

#SA, A, N, D and SD denotes strongly agree, agree, neutral, disagree, and strongly disagree respectively. Results are in percentile

Factors influencing farmers' choice of rice varieties

The multinomial logit regression was used to estimate the factors influencing farmers' choice of rice varieties among the available alternatives, these categorised varieties are Landrace, AGRA Rice, Amankwatia, and Jasmine. Landrace was used as a base category in the analysis. Results are presented in Table 5

In comparing AGRA Rice, Amankwatia, and Jasmine varieties to Landrace, the variable *Age* showed a negative and highly significant effect ($p<0.01$), indicating that older farmers are less likely to adopt AGRA Rice compared to Landrace. Conversely, *Education* had a positive and significant influence ($p<0.05$), suggesting that farmers with higher levels of education are more inclined to choose AGRA Rice over Landrace. Additionally, the positive and significant ($p<0.05$) coefficient for *Distance to Market* implies that farmers located farther from markets or resources are more likely to prefer AGRA Rice over Landrace.

For Amankwatia, the variable *Age* was negative and highly significant ($p<0.01$), indicating that older farmers prefer Landrace over Amankwatia. For Amankwatia, *Education* was positive and significant ($p<0.05$), suggesting that farmers with higher levels of education are more likely to adopt Amankwatia compared to Landrace. Additionally, farmers with more years of farming experience showed a positive and marginally significant preference ($p<0.1$) for Amankwatia over Landrace. The positive and significant ($p<0.05$) effect of *Extension Services* indicates that farmers receiving extension support are more inclined to choose Amankwatia over Landrace.

For Jasmine, *Sex* was positive and marginally significant ($p<0.1$), implying that male farmers are more likely to prefer Jasmine over Landrace. However, *Age* remained negative and highly significant ($p<0.01$), reinforcing that older farmers tend to prefer Landrace over Jasmine.

Table 5: Multinomial logistic regression of factors influencing farmers' choice of rice varieties

	AGRA Rice		**Amankwatia**		**Jasmine**	
Variable	Coef. (S.E)	ME (S.E)	Coef. (S.E)	ME (S.E)	Coef. (S.E)	ME (S.E)
Sex	0.364	-0.014	0.432	0.003	0.619*	0.058
	(0.333)	(0.050)	(0.453)	(0.029)	(0.363)	(0.045)
Age	-0.04***	-0.001	-0.064***	-0.002	-0.045***	-0.002
	(0.015)	(0.002)	(0.021)	(0.001)	(0.016)	(0.002)
Education	0.087**	0.007	0.119**	0.004	0.060	0.003
	(0.036)	(0.005)	(0.050)	(0.003)	(0.039)	(0.005)
Off-farm income	0.389	0.083	-0.470	-0.062	0.239	0.006
	(.363)	(0.054)	(0.545)	(0.037)	(0.392)	(0.047)
Credit	0.198	0.143	-0.382	-0.025	-0.604	-0.13
	(0.495)	(0.081)	(0.763)	(0.052)	(0.598)	(0.081)
Farming Experience	0.027	0.001	0.051*	0.002	0.025	-0.000
	(0.020)	(0.003)	(0.027)	(0.002)	(0.022)	(0.003)
Farmer Association	-0.058	0.045	-0.507	-0.032	-0.277	-0.032
	(0.350)	(0.051)	(0.464)	(0.029)	(0.377)	(0.045)
Extension Visit	0.028	-0.005	0.141**	0.009	0.044	0.001
	(0.059)	(0.008)	(0.067)	(0.003)	(0.063)	(0.007)
Distance	0.051**	0.008	-0.014	-0.004	0.037	0.001
	(0.024)	(0.003)	(0.039)	(0.003)	(0.025)	(0.002)
Yield potential	-0.389	-0.013	-0.455	-0.008	-0.451	-0.023
	(0.325)	(0.051)	(0.457)	(0.030)	(0.355)	(0.045)
Constant	2.902***		2.69**		2.549***	
	(0.803)		(1.074)		(0.863)	
Mean dependent var		1.484		SD dependent var		1.018
Pseudo r-squared		0.550		Number of obs		411
Chi-square		53.385		Prob > chi2		0.005
Akaike crit. (AIC)		984.861		Bayesian crit. (BIC)		1117.474

SE denote the standard error of the estimates. ME represents marginal effects. *** p<.01, ** p<.05, * p<.1

Constraints Affecting Rice Production

The major constraints in rice production within the study districts are presented in Table 6. The analysis employs Kendall's coefficient of concordance (W^a) to evaluate the level of agreement among farmers regarding constraints. High W^a value of (0.685) indicate significant consensus among farmers. The chi-square tests is statistically significant ($p < 0.05$), affirming the reliability of these rankings. From the table, limited access to capital remains a pervasive challenge for smallholder farmers, as it restricts their ability to invest in essential inputs like seeds, fertilizers, and machinery. It is ranked first across all districts with a total mean of 1.51, underscoring its universality as a primary bottleneck. This finding aligns with prior studies that emphasize how financial constraints hinder agricultural modernization in sub-Saharan Africa (Adjognon et al., 2017).

Low market price for rice was ranked second overall with a mean of 2.58. This constraint reflects market inefficiencies and poor price incentives, which discourage farmers from investing in increased production. Addressing this requires not only improving value chains but also enhancing market linkages and price stabilization mechanisms to protect farmers from volatile market conditions. The availability of quality milling infrastructure is vital to ensuring that harvested rice meets market standards. Milling infrasture inadequancies ranks third with a combined mean of 4.02, highlighting its significance as a post-harvest challenge. Storage inadequacies rank fourth overall with a mean of 4.76. Poor storage facilities often lead to significant post-harvest losses, further compounding financial challenges for farmers.

Labor costs rank fifth overall with a mean of 5.61, reflecting the increasing challenge of agricultural labor availability and affordability. While mechanization could alleviate this issue, its impact is contingent on accessibility and affordability. The rising cost of labor is consistent with trends in rural-urban migration, which reduces labor supply in agriculture (Jedwab et al., 2017). Post-harvest losses rank sixth with an average mean of 5.64. These losses not only reduce effective yields but also waste labor and resources invested in production.

Access to power tillers ranks seventh with a mean of 6.65. Mechanization, particularly for land preparation, is crucial for enhancing productivity and reducing labor demands. This constraint's ranking suggests that farmers perceive mechanization gaps as a barrier to efficiency, though not as critical as financial constraints. Inadequate Drying Floors ranks eighth with a mean of 7.07. Proper drying facilities are essential to maintaining rice quality, particularly in humid conditions where improper drying leads to spoilage. Labor shortages rank ninth with a mean of 8.74, further emphasizing the importance of addressing labor supply challenges.

Lack of Technical Know-How and Difficulty in Accessing Improved Varieties were ranked tenth and eleventh, with means of 9.54 and 9.76, respectively. This low ranking of technical know-how may reflect improvements in extension services or better access to information through digital tools. Access to improved seeds has long been recognized as a key driver of agricultural productivity (Langyintuo et al., 2010). Although ranked lower, its inclusion suggests that seed distribution networks still require attention, particularly in remote areas.

Table 6: Constraints in rice production

Constraints	Mean	Rank
Limited access to capital	1.51	1st
Lack of technical know how	9.71	11th
Limited access to power tillers for land preparation	6.65	7th
Difficulty in accessing improved varieties	9.69	10th
High post-harvest losses	5.64	6th
Low commodity price	2.58	2nd
Inadequate drying floors	7.07	8th
Inadequate storage warehouses	4.76	4th

Inadequate rice milling machines	4.02	3rd
High cost of labour	5.61	5th
Difficulty in accessing Labour	8.74	9th
Kendall's W[a]:	0.685	
Chi Sq.:	2816.407	
P-value:	0.000	

DISCUSSION

Farmers' perception of Improved Rice Variety in Ghana

The perception index for yield is notably high at 3.98, reflecting strong farmer belief in the high yield potentialof improved rice varieties. This positive perception aligns with established research indicating that yield improvements are a primary factor influencing adoption rates of new agricultural technologies, particularly in regions where productivity constraints limit food security (Kijima et al., 2012; Minten et al., 2013). Also a considerable percentage of the farmers agree that improved varieties are resilient against pest and disease. The literature supports the necessity of disease resistance as a key motivator for adoption, especially in tropical environments where pest pressures are high (Abebrese et al., 2019). However, the mixed response, with 2.68% strongly disagreeing, indicates that some farmers may have observed inconsistencies in this trait, possibly due to regional variability in pest populations or limitations in the expression of genetic resistance under field conditions.

Again, the mean index for drought tolerance is relatively moderate at 3.28, with 54.5% of farmers agreeing. This perception suggests cautious optimism among farmers regarding the drought resilience of improved varieties. However, the reduced percentage of strong agreement (2.92%) indicates that while some drought resilience is present, it may not be sufficient under severe conditions. This insight is supported by studies such as those by Fischer et al. (2015), which emphasize the need for more robust drought-resistant varieties to mitigate the impacts of increasingly variable rainfall patterns associated with climate change. Given that drought tolerance is essential for adaptation to climate variability, breeding programs may benefit from intensifying efforts to enhance this trait.

Another important genetic trait, lodging tolerance scored a low perception index of 3.11, with 22.38% of farmers strongly disagreeing. Lodging can lead to significant yield loss, particularly under high-yield conditions where plant stature and architecture may predispose rice varieties to this issue (Sarkar et al., 2018, ; Danso-Abbeam et al., 2014). The high disagreement rate suggests that current improved varieties may not sufficiently address this challenge, possibly affecting their desirability in regions prone to heavy rains or wind. Further genetic improvement in lodging resistance, potentially through modification of plant architecture or stem strength, could be pivotal in enhancing the appeal of these varieties. With an index of 3.4, there is general agreement (54.5%) that improved rice varieties are not labor-intensive. This trait is particularly valued in farming systems where labor scarcity or cost is a limiting factor (Musila et al, 2018). However, the moderate index also reflects that improved varieties might still require specific management practices or input applications that some farmers perceive as demanding.

Again, the perception index for fertilization requirements stands at 3.72, indicating that while improved varieties are perceived as requiring optimal fertilization, this is accepted by most farmers. Studies in similar agronomic contexts have shown that adoption can be hindered if high fertilization requirements increase input costs disproportionately to yield gains (Falconnier et al., 2017). This finding highlights a potential barrier for resource-constrained farmers who may struggle to afford fertilizers, underscoring the importance of ensuring that improved varieties are responsive to both high and low-input systems. While 59.61% of farmers agree that seeds are accessible, 26.28% strongly disagree, suggesting variability in seed distribution channels or availability. This issue is crucial, as access to seeds is fundamental for the adoption and widespread use of improved varieties (Langyintuo et al., 2010). Addressing this concern requires robust seed systems that ensure timely and affordable access, potentially involving both public and private sector interventions to reach remote farmers more effectively.

The high perception index of 4.03 for cooking quality indicates that improved rice varieties meet consumer preferences in terms of cooking and taste characteristics. Consumer preferences strongly influence market demand, and cooking quality is a significant determinant for adoption among farmers aiming to cater to local market tastes (Custodio et al., 2019). This positive perception reinforces the notion that breeding programs should prioritize consumer-relevant traits, as they can directly impact farmers' income by aligning production with market demands. Soil fertility management is a central concern in sub-Saharan Africa, where nutrient-poor soils are common (Tittonell & Giller, 2013). The relatively low rating for soil adaptability suggests that current improved varieties may not perform optimally on marginal lands, potentially limiting their adoption in resource-poor areas. Future breeding efforts should consider soil adaptability to increase the resilience and scalability of these varieties.

With the highest perception index of 4.08, farmers show a strong belief in the high market demand for improved rice varieties, which aligns with observed trends of increasing rice consumption in Ghana and across West Africa (Adjao & Staatz, 2015). A high perception of market demand can drive adoption by ensuring farmers have a reliable outlet for their produce. Finally, the perception index of 3.15 for the statement that improved varieties are common among farmers shows moderate agreement, suggesting that while adoption is spreading, it may still be in nascent stages or constrained by factors such as accessibility, costs, and environmental adaptability. This insight aligns with Rogers' Diffusion of Innovations theory, which posits that early adoption is often limited by perceived compatibility with existing practices (Rogers, 2003).

Factors Influencing Farmers’ Choice of Rice Varieties

A consistent, negative coefficients of age across all varieties, suggesting that older farmers show a strong preference for Landrace, highlighting their familiarity and lower risk tolerance toward newer or hybrid varieties. This result is consistent with Ogada et al. (2014) and Uduji and Okolo-Obasi, (2018) found that younger farmers were more likely to adopt improved varieties due to greater openness to innovation and risk-taking. The intuition is that as farmers grow older, they tend to be more risk-averse and this decreases their interests in long term farm investments, which include technology adoption while younger farmers are typically risk-loving and are more willing to try new technologies.

Education significantly influences varietal adoption, as better-educated farmers often possess more knowledge about the benefits of improved varieties and market trends. This is consistent with Asante et al. (2021) who observed that education level was a major determinant in farmers’ decisions to adopt improved technologies. Mariano et al. (2012) reported similar trends, emphasizing that educated farmers were more adept at evaluating the profitability and agronomic advantages of hybrid crops, suggesting they could navigate input and output markets more effectively.

The positive association between distance to the nearest market and AGRA Rice adoption could reflect logistical challenges that favor improved varieties recognized for their higher productivity. This finding aligns with studies by Addai et al. (2023) and Oyinbo et al. (2019), which identified market distance as a positive predictor of agricultural technology adoption, likely due to the perceived efficiency gains of such technologies in overcoming logistical barriers. However, this result contrasts with Mulwa et al. (2017), who argued that increased market distance typically raises transaction costs and transportation difficulties, thereby discouraging the adoption of agricultural innovations.

Farming experince positively associated with Amankwatia, suggesting experienced farmers might perceive it as a practical and reliable alternative to Landrace. This indicate that farming experience enhances farmers’ capacity to assess varietal performance over time, leading to more informed choices. Azumah et al. (2017), found experience to significantly and positively influence farmers’ adoption of climate smart coping strategies in Northern Ghana.

Extension visit’s positive association with Amankwatia variety, underscores the role of agricultural advisory services in promoting adoption. This finding is consistent with Asante et al. (2021) who found access to extension services to be a key factor in the intensification of technology adoption by farmers in Ghana. Likewise, Ragasa et al. (2013) found that consistent extension support was instrumental in increasing adoption rates of improved varieties, as it provided farmers with the necessary knowledge and confidence to transition from traditional practices.

Male farmers' preference for Jasmine over Landrace aligns with gendered roles in agriculture. This result is consistent with Doss et al. (2018) and Quisumbing et al. (2019) who observed that male farmers are more likely to engage with market-oriented and high-value crops due to their control over household resources and decision-making processes. Similarly, Quisumbing et al. (2019) noted similar trends, where gender dynamics influenced varietal choices, with men often prioritizing varieties with higher market value.

CONCLUSION

An overall perception index of 3.51 indicates that respondents generally viewed improved rice varieties in a positive light. While not a strong endorsement, the score reflects a mild level of agreement, suggesting that the varieties are accepted but that further efforts may be needed to strengthen trust and satisfaction among farmers. The study highlights several factors influencing farmers' choice of rice varieties. Age consistently exhibits a negative influence, with older farmers showing a strong preference for Landrace varieties, likely due to familiarity and lower risk tolerance. Education plays a pivotal role, as better-educated farmers demonstrate distinct preferences, potentially reflecting informed decisions shaped by agronomic or market considerations. Distance positively affects the choice of AGRA Rice, indicating that logistical challenges make it a favorable option for farmers farther from critical resources. Farming experience is positively associated with Amankwatia, suggesting that experienced farmers perceive it as a reliable alternative to Landrace, while extension visits further promote its adoption, underscoring the importance of agricultural advisory services. Also, gender dynamics reveal that male farmers exhibit a slight preference for Jasmine over Landrace. Limited access to capital and low commodity prices are the most pressing issues, while infrastructural and mechanization challenges also feature prominently. These findings offer valuable insights into how demographic, logistical, and institutional factors shape varietal adoption. The study provides both practical and policy implications. On a practical level, given the moderately positive perception index (3.51) toward improved rice varieties, efforts should focus on strengthening awareness and addressing any lingering skepticism. Extension services should prioritize targeted outreach and practical demonstrations to build farmer confidence. Policies should also support access to inputs and training, helping farmers see clear benefits in yield, resilience, or income. With the baseline perception already leaning positive, strategic engagement can shift attitudes further toward strong adoption. At the broader policy level, a coordinated approach is needed—combining financial support, rural infrastructure investment, and targeted subsidies—to remove adoption barriers and enhance farmer decision-making. These strategies will be critical to accelerating the uptake of improved rice varieties and supporting sustainable agricultural development.

Abreviation

MNL - Multinomial logistic regression
IRV – Improved rice varietie
USDA – United State Department of Agriculture
MOFA – Ministry of Food and Agriculture
AGRA - Alliance for Green Revolution in Africa
NVRC - National Variety Released Catalogue

ACKNOWLEDGEMENTS

The authors express their profound gratitude to the Directors and Extension Agents of the Atwima Nwabiagya, Kadjebi, and Ejura-Sekyedumase Districts' Departments of Agriculture for their exceptional support in implementing the survey. We extend our heartfelt appreciation to the enumerators for their diligent efforts in collecting data from the farmers. Lastly, we are deeply thankful to the respondent farmers for their time and patience in answering all the survey questions.

Author Contributions: Conceptualization, S.J.A, B.O.A., and J.A.B.; methodology, S.J.A and B.O.A; software, S.J.A.; validation, E.K.T., M.D.A., B.S. and J.A.B.; formal analysis, S.J.A. and B.O.A.; investigation, S.J.A., B.S., B.O.A.; curation, E.N.N and S.J.A.; writing—original draft preparation, S.J.A., and E.N.N., writing—review and editing, E.K.T., B.S., and S.J.A.; supervision, B.O.A., J.A.B. and M.D.A.; All authors have read and agreed to the published version of the manuscript.

Funding

No funding was avainlable this work.

Availability of data and materials

Data will be made available on request.

Declarations

Ethics approval and consent to participate

Participation in the survey was made completely voluntary and informed consent was taken from all the participant respondents, however, ethics approval for the study was not required in accordance with local/national legislation in Ghana particularly concerning survey data collection.

Informed Consent Statement: Informed consent was obtained from all subjects involved in the study. All the primary data have been anonymized.

Competing interests

The authors declare that they have no competing interests

REFERENCE

1. Abebrese, S. O., Martey, E., Dartey, P. K. A., Akromah, R., Gracen, V. E., Offei, S. K., & Danquah, E. Y. (2019). Farmer preferred traits and potential for adoption of hybrid rice in Ghana. Sustainable Agriculture Research, 8(3), 38-48.
2. Addai, K. N., Temoso, O., & Ng'ombe, J. N. (2023). Heterogeneous effects of agricultural technology adoption on smallholder household welfare in Ghana. Journal of Agricultural and Applied Economics, 55(2), 283-303.
3. Adjao, R. T., & Staatz, J. M. (2015). Asian rice economy changes and implications for sub-Saharan Africa. Global Food Security, 5, 50-55.
4. Adjognon, S. G., Liverpool-Tasie, L. S. O., & Reardon, T. A. (2017). Agricultural input credit in Sub-Saharan Africa: Telling myth from facts. Food policy, 67, 93-105.
5. Aidoo, R., Mensah, J.O.B., Omono, F. and Abankwah, V., 2014. Factors determining the use of certified maize seeds by farmers in Ejura-Sekyedumasi Municipality in Ghana. World Journal of Agricultural Sciences, 2(5), pp.084-090.
6. Anang, B. T., Bäckman, S., & Sipiläinen, T. (2016). Technical efficiency and its determinants in smallholder rice production in northern Ghana. The Journal of Developing Areas, 311-328.
7. Asante, B. O., Frimpong, B. N., Asante, M. D., Prah, S., Ayeh, S. J., Sakyiamah, B., ... & Tufan, H. A. (2023). Exploring gender differences in the role of trait preferences among stakeholders in the rice value chain in Ghana. Sustainability, 15(7), 6026.
8. Asante, B. O., Koomson, I., Villano, R. A., & Wiredu, A. N. (2021). Adoption of integrated crop-livestock management practices (ICLMPs) among men and women smallholder farmers in Ghana. Gender, Technology and Development, 25(2), 163-192.
9. Asante, B. O., Villano, R. A., & Battese, G. E. (2014). The effect of the adoption of yam minisett technology on the technical efficiency of yam farmers in the forest-savanna transition zone of Ghana. African Journal of Agricultural and Resource Economics, 9(2), 75-90.
10. Asante, B.O., Adabah, R., Agyeman, K., Ayeh, S.J., Aidoo, R. and Afona, D., 2021. Preference for

improved varietal attributes of Bambara groundnut among smallholder farmers in Ghana. African Journal of Agricultural and Resource Economics Volume, 16(2), pp.155-168.

11. Asante, B.O., Koomson, I., Villano, R.A. and Wiredu, A.N., 2021. Adoption of integrated crop-livestock management practices (ICLMPs) among men and women smallholder farmers in Ghana. Gender, Technology and Development, pp.1-30.
12. Asante, M.D., Asante, B.O., Acheampong, G.K., Wiredu, A.N., Offei, S.K., Gracen, V., Adu-Dapaah, H. and Danquah, E.Y., 2013. Grain quality and determinants of farmers preference for rice varietal traits in three districts of Ghana: Implications for research and policy. Journal of Development and Agricultural Economics, 5(7), pp.284-294.
13. Azumah, S.B., Donkoh, S.A. and Ansah I.G.K. (2017). Contract farming and the adoption of climate change coping and adaptation strategies in the northern region of Ghana. Environment, Development and Sustainability, 19 (6), pp. 2275- 2295.
14. Bissah, M. N., Kotey, D. A., Tongoona, P., Egbadzor, K. F., Gracen, V., & Danquah, E. Y. (2022). Factors influencing rice production in the south-eastern belt of Ghana. Heliyon, 8(12).
15. Bruce AKK, Donkoh SA & Ayamga M, 2014. Improved rice variety adoption and its effects on farmers' output in Ghana. Journal of Development and Agricultural Economics
16. Chandio, A.A. and Yuansheng, J.I.A.N.G., 2018. Determinants of adoption of improved rice varieties in northern Sindh, Pakistan. Rice Science, 25(2), pp.103-110.
17. Custodio, M. C., Cuevas, R. P., Ynion, J., Laborte, A. G., Velasco, M. L., & Demont, M. (2019). Rice quality: How is it defined by consumers, industry, food scientists, and geneticists?. Trends in food science & technology, 92, 122-137.
25. Danso-Abbeam, G.; Armed, M.; Baidoo, F. Determinants of consumer preference for local rice in Tamale Metropolis, Ghana. Int. J. Educ. Soc. Sci. **2014**, 1, 13–34.
18. Denkyirah, E. K., Aziz, A. A., Denkyirah, E. K., Nketiah, O. O., & Okoffo, E. D. (2016). Access to credit and constraint analysis: the case of smallholder rice farmers in Ghana. Journal of Agricultural Studies, 4(2), 53-72.
19. Donkoh, S.A., Azumah, S.B. and Awuni, J.A., 2019. Adoption of improved agricultural technologies among rice farmers in Ghana: A Multivariate probit approach. Ghana Journal of Development Studies, 16(1), pp.46-67.
20. Doss, C. R. 2018. Women and agricultural productivity: Reframing the issues. Development Policy Review, 36(1): 35–50. https://doi.org/10.1111/dpr.12243
21. Falconnier, G. N., Descheemaeker, K., Traore, B., Bayoko, A., & Giller, K. E. (2018). Agricultural intensification and policy interventions: Exploring plausible futures for smallholder farmers in Southern Mali. Land use policy, 70, 623-634.
22. Farid, K.S., Tanny, N.Z. and Sarma, P.K., 2015. Factors affecting adoption of improved farm practices by the farmers of Northern Bangladesh. Journal of the Bangladesh Agricultural University, 13(452-2016-35870), pp.291-298.
23. Fisher, M., Abate, T., Lunduka, R. W., Asnake, W., Alemayehu, Y., & Madulu, R. B. (2015). Drought tolerant maize for farmer adaptation to drought in sub-Saharan Africa: Determinants of adoption in eastern and southern Africa. Climatic Change, 133, 283-299.
24. Ghimire, R., Wen-Chi, H.U.A.N.G. and Shrestha, R.B., 2015. Factors affecting adoption of improved rice varieties among rural farm households in Central Nepal. Rice Science, 22(1), pp.35-43.
25. Jedwab, R., Christiaensen, L., & Gindelsky, M. (2017). Demography, urbanization and development: Rural push, urban pull and… urban push?. Journal of Urban Economics, 98, 6-16.
26. Kariyasa, K., & Dewi, Y. A. (2013). Analysis of factors affecting adoption of integrated crop management farmer field school (ICM-FFS) in swampy areas. International Journal of Food and Agricultural Economics (IJFAEC), 1(2), 29-38.
27. Kijima, Y., Ito, Y., & Otsuka, K. (2012). Assessing the impact of training on lowland rice productivity in an African setting: Evidence from Uganda. World Development, 40(8), 1610-1618.
28. Langyintuo, A. S., Mwangi, W., Diallo, A. O., MacRobert, J., Dixon, J., & Bänziger, M. (2010). Challenges of the maize seed industry in eastern and southern Africa: A compelling case for private–public intervention to promote growth. Food Policy, 35(4), 323-331.
29. Mariano, M. J., Villano, R., & Fleming, E. (2012). Factors influencing farmer's adoption of modern rice technologies and good management practices in the Philippines. Agricultural systems, 110(2012) 41–53.

https://doi.org/10.1016/j.agsy.2012.03.010
30. Ministry of Food and Agriculture (2020). Agriculture in Ghana. Facts and Figures,Statistics, Research and Information Directorate (SRID), Accra, Ghana
31. Minten, B., Murshid, K. A. S., & Reardon, T. (2013). Food quality changes and implications: evidence from the rice value chain of Bangladesh. World Development, 42, 100-113.
32. Mulwa, C., Marenya, P., & Kassie, M. (2017). Response to climate risks among smallholder farmers in Malawi: A multivariate probit assessment of the role of information, household demographics, and farm characteristics. Climate risk management, 16, 208-221.
33. Musila, R. N., Sibiya, J., Derera, J., Kimani, J. M., Tongoona, P., & Danda, K. (2018). Farmers' perceptions of, and preferred traits in, rice varieties in the Coastal Region of Kenya and their implications for breeding. Journal of International Cooperation for Agricultural Development, 16, 20-30.
34. Nonvide, G.M.A., Sarpong, D.B., Kwadzo, G.T., Anim-Somuah, H. and Amoussouga Gero, F., 2018. Farmers' perceptions of irrigation and constraints on rice production in Benin: A stakeholder-consultation approach. International Journal of Water Resources Development, 34(6), pp.1001-1021.
35. Ogada, M. J., Mwabu, G., & Muchai, D. (2014). Farm technology adoption in Kenya: a simultan- eous estimation of inorganic fertilizer and improved maize variety adoption decisions. Agricultural and Food Economics, 2(1), 1–18. https://doi.org/10.1186/s40100-014-0012-3
36. Onyeneke, R.U., 2017. Determinants of adoption of improved technologies in rice production in Imo State, Nigeria. African Journal of Agricultural Research, 12(11), pp.888-896.
37. Orr, G. (2003). Diffusion of innovations, by Everett Rogers (1995). Retrieved January, 21, 2005.
38. Oyinbo, O., Chamberlin, J., Vanlauwe, B., Vranken, L., Kamara, Y. A., Craufurd, P., & Maertens, M. (2019). Farmers' preferences for high-input agriculture supported by site-specific extension services: Evidence from a choice experiment in Nigeria. Agricultural systems, 173, 12-26.
39. Quisumbing, Agnes R. & Meinzen-Dick, Ruth Suseela & Malapit, Hazel J., 2019. "Gender equality: Women's empowerment for rural revitalization," IFPRI book chapters, in: 2019 Global food policy report, chapter 5, pages 44-51, International Food Policy Research Institute (IFPRI).
40. Ragasa, C., & Chapoto, A. (2017). Limits to Green Revolution in rice in Africa: The case of Ghana. Land use policy, 66, 304-321.
41. Ragasa, C., Dankyi, A., Acheampong, P., Wiredu, A.N., Chapoto, A., Asamoah, M. and Tripp, R. (2013). Patterns of adoption of improved rice technologies in Ghana. International Food Policy Research Institute Working Paper, 35, pp. 6-8.
42. Sarkar, R. K., Chakraborty, K., Chattopadhyay, K., Ray, S., Panda, D., & Ismail, A. M. (2019). Responses of rice to individual and combined stresses of flooding and salinity. In Advances in rice research for abiotic stress tolerance (pp. 281-297). Woodhead Publishing.
25. Sedem Ehiakpor, D.; Apumbora, J.; Danso-Abbeam, G.; Adzawla, W. Households' preference for local rice in the upper east region, Ghana. Adv. Agric. **2017**, 2017, 1812975. Available online: https://www.hindawi.com/journals/aag/2017/1812975/
26. Soullier, G.; Demont, M.; Arouna, A.; Lançon, F.; Del Villar, P.M. The state of rice value chain upgrading in West Africa. Glob. Food Secur. **2020**, 25, 100365.
43. Takeshima, H., Jimah, K., Kolavalli, S., & Diao, X. (2013). Dynamics of transformation insights from rice farming in Kpong Irrigation System (KIS).
44. Tasila Konja, D., Mabe, F. N., & Alhassan, H. (2019). Technical and resource-use-efficiency among smallholder rice farmers in Northern Ghana. Cogent Food & Agriculture, 5(1), 1651473
45. Taylor, J., Ghana Grain and Feed Annual 2019 Annual Report.
46. Timu, A.G., Mulwa, R., Okello, J. and Kamau, M., 2014. The role of varietal Attributes on adoption of improved seed varieties: the case of sorghum in Kenya. Agriculture & Food Security, 3(1), pp.1-
47. Tittonell, P., & Giller, K. E. (2013). When yield gaps are poverty traps: The paradigm of ecological intensification in African smallholder agriculture. Field Crops Research, 143, 76-90.
48. Uduji, J. I., & Okolo-Obasi, E. N. (2018). Adoption of improved crop varieties by involving farmers in the e-wallet program in Nigeria. Journal of Crop Improvement, 32(5), 717–737. https://doi.org/10.1080/15427528.2018.1496216
49. Wongnaa, C. A., Awunyo-Vitor, D., & Bakang, J. E. A. (2018). Factors affecting Adoption of Maize Production Technologies: A study in Ghana. Journal of Agricultural Sciences (Sri Lanka), 13(1).