ADOPTION DYNAMICS OF IFAD-PROMOTED RICE PROCESSING TECHNOLOGIES AMONG SMALLHOLDER FARMERS IN NASARAWA AND NIGER STATES, NIGERIA

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ABSTRACT
This study assessed the adoption dynamics of IFAD-promoted rice processing technologies among smallholder farmers in Nasarawa and Niger States, Nigeria. It specifically examined the stages of adoption of IFAD-promoted smallholder rice processing technologies, assessed the adoption level of IFAD-promoted rice processing technologies, and identified the major constraints faced by smallholder rice processors in adopting the IFAD rice processing technologies in the study areas. Morgan chart for sample size selection was used to randomly select 214 and 217 rice processors from Nasarawa and Niger States, respectively to constitute the sample size (respondents) for the study. Questionnaire was administered to the respondents via an interview schedule to collect data for the study. Data collected were analyzed using descriptive statistics, adoption index, adoption score, and mean from a Likert-type scale. Results showed that 54% of respondents were males, the mean age of beneficiary farmers was 44 years, the majority (86.1%) of the respondents were married, and beneficiary farmers had large family sizes (average 10 and 11, respectively). The result further indicated that while farmers from Niger State had an adoption index of 0.68, those from Nasarawa had an adoption index of 0.65. Technologies like weighing scales, flatbed drying, and false bottoms, have high adoption rates. However, challenges such as high costs, insufficient funds, complex technology, inadequate infrastructure, and weak institutional support hinder the widespread adoption of certain technologies, particularly moisture meters and sorting machines. Addressing these barriers is essential to fully realize the benefits of these technologies and enhance farmers' productivity.

Keywords: Adoption, Farmers, IFAD, Rice processing, Technologies

INTRODUCTION
Rice (*Oryza spp.*), a vital cereal from the Gramineae family, is the staple food for over half the world's population, providing a significant source of calories. Globally, rice ranks third in production after wheat and maize, with annual per capita consumption ranging from 100 to 240 kilograms (FAO, 2019). Among the two major species cultivated—*Oryza sativa* and *Oryza glaberrima*—*Oryza sativa* dominates global production.

In Nigeria, rice consumption has been increasing by approximately 10% annually due to changing dietary preferences (Akande, 2019). Once favouring imported rice for its superior quality, many Nigerians have shifted towards locally produced varieties due to economic realities (Ebuehi & Oyewole, 2017). Rice plays a crucial role in ensuring national food security, reducing rural poverty, and driving economic growth (Mapiye et al., 2017). Despite its significance, the country struggles to achieve self-sufficiency in rice production due to several challenges, including inefficient traditional production practices, limited access to modern agricultural technologies, and inadequate credit facilities (Chadio et al., 2017).

Recognizing these challenges, the Federal Ministry of Agriculture and Rural Development (FMARD, 2016) emphasized that bridging the demand-supply gap in rice production requires strategic interventions and partnerships targeting smallholder farmers. Various initiatives, such as the Anchor Borrowers Program and the Commodity Value Chain Development Program (VCDP), have sought to address these gaps. The IFAD/VCDP initiative in Nasarawa and Niger States exemplifies such efforts, focusing on enhancing rice value addition through smallholder engagement.

Rice processing, which involves husking, milling, and polishing, is pivotal in value addition. Processing technologies can be categorized into traditional, intermediate, and modern methods. While traditional methods like hand pounding are labour-intensive and yield lower quality outputs, modern processing technologies—encompassing mechanized systems such as pre-cleaning, husking, polishing, and grading—improve efficiency and product quality (Tangpinijkul, 2010). However, modern technologies often rely on fossil fuels, contributing to carbon emissions and raising environmental concerns (Goyal et al., 2014). Smallholder farmers' adoption of these technologies is influenced by factors such as accessibility, profitability, and resource availability. Effective extension services play a critical role in promoting adoption by providing education on techniques, market conditions, and resource management (Adika et al., 2018). Smallholder farmers, who dominate Nigeria's crop production sector, face significant challenges in adopting modern agricultural technologies, limiting their productivity and participation in value chain development initiatives.

In Nasarawa and Niger States, smallholder rice farmers have encountered similar constraints, including low awareness, inadequate access to credit and inputs, and limited infrastructure for processing rice efficiently. Although programs such as the IFAD/VCDP have sought to address these issues by promoting modern rice processing technologies, the adoption of these technologies has remained suboptimal. The use of modern machinery, while improving efficiency, comes with challenges such as high costs, reliance on fossil fuels, and environmental concerns, including contributions to climate change (Metcho et al., 2019). Moreover, the socioeconomic circumstances of smallholder farmers, combined with inadequate extension services and financial support, further hinder technology adoption and the realization of value addition.

Given these challenges, it becomes imperative to assess the extent to which IFAD interventions in Niger and Nasarawa States have addressed the barriers to adopting modern rice processing technologies. Specifically, this study seeks to examine the stages of adoption of IFAD-promoted smallholder rice processing technologies, assess the adoption level of IFAD-promoted rice processing technologies, and identify the major constraints faced by smallholder rice processors in adopting the IFAD rice processing technologies in the study areas.

METHODOLOGY

The study was conducted in Nasarawa and Niger States, located in Nigeria's North Central geographical zone. These states are part of the IFAD/FGN Value Chain Development Programme (VCDP), which aims to improve the rice and cassava value chains for smallholder farmers. Nasarawa State lies within the tropical savannah zone and features significant geographical landmarks such as the Benue River Trough and parts of the Jos Plateau. It is bordered by Taraba, Plateau, Kaduna, Kogi, Benue States, and the Federal Capital Territory (FCT), Abuja. Similarly, Niger State, named after the River Niger, is known for its hydroelectric power stations at Kainji and Shiroro Dams and is bordered by Zamfara, Kebbi, Kogi, Kwara, and Kaduna States, as well as the FCT. Subsistence arable farming is the primary economic activity in both states, with opportunities for grazing, fishing, and forestry (Adeola & Abel, 2019).

The study population comprised all 480 registered rice processors participating in the IFAD rice intervention programme in Nasarawa State and 500 in Niger State. Using the standardized sampling table by Krejcie and Morgan (1970), sample sizes of 214 and 217 respondents were selected from Nasarawa and Niger States, respectively. A proportionate sampling model was used at the Local Government Area (LGA) level to ensure fair representation of participants across the selected LGAs. For instance, in Nasarawa State, Lafia LGA contributed 42 respondents, while Wamba LGA contributed 50. Similarly, in Niger State, Bida LGA contributed 38 respondents, and Edati LGA contributed 51. This approach ensured that the sample accurately represented the distribution of participants across the states. Data were collected using a well-structured questionnaire and supplemented with personal interviews. This mixed-methods approach ensured comprehensive data collection to address the research questions effectively. The adoption index and mean score from the Likert-type scale were used to achieve the stated specific objectives. The adoption index model is as specified below:

$$AI = \frac{n_{adptd}}{N_{promtd}}$$

Where n_{adptd} = the number of IFAD-promoted rice processing technologies adopted by a particular farmer, and N_{promtd} the total number of IFAD-promoted rice processing technologies under study (15 technologies). In developing the adoption score, a respondent scores one for each IFAD-promoted technology adopted (Olumba and Rahji, 2014). Following Agwu (2006), the extent of adoption was obtained from the adoption score as given below:

Extent of Adoption	**Adoption Score**
High Adoption	> 9
Medium Adoption	7 – 8
Low Adoption	≤ 6

The mean response from the Likert-type scale was calculated using the following formula:

$$X = \frac{\sum Fx}{n}$$

Where:

$\dot{X}$= Mean response; ∑= Summation; F = number of respondents choosing a particular scale point, x = numerical value of the scale point, n = total number of respondents to the item.

The mean response to each item was interpreted using the concept of real limit of number.

RESULTS AND DISCUSSION

Socioeconomic Characteristics of the Respondents

The distribution of respondents according to socioeconomic characteristics is presented in Table 1. The programme participants were predominantly male (54%). The age distribution of beneficiaries indicates that most participants (58.9%) are in the productive age group of 41–60 years, with a mean age of 44 years. This demographic is well-positioned for active engagement in agricultural activities and technology adoption. The inclusion of younger individuals (36.9%) further supports sustainability through skill transfer and innovation. Such age dynamics are essential for the programme's long-term success. Household size plays a dual role in agricultural productivity. With an average of 10 members per household, families contribute labour, reducing operational costs and ensuring timely farm activities. However, larger households also consume significant portions of farm produce, limiting marketable surplus. The programme's emphasis on education and experience is evident, with most participants possessing secondary or tertiary education and an average of 14 years of rice processing experience. Educational attainment and experience enhance participants' ability to adopt and effectively utilize technologies, resulting in higher productivity and quality control. Furthermore, seamless access to extension services (100%) ensures technical guidance, improving technology adoption and productivity.

Table 1: Selected socio-economic characteristics of the respondents

	Nasarawa State n = 217			**Niger State n = 214**			**Pooled n = 431**		
Socioeconomic Variables	Freq.	%	Mean	Freq.	%	Mean	Freq.	%	Mean
Sex									
Male	119	55		112	52		231	54	
Female	98	45		102	48		200	46	
Age (years)									
20 – 40	81	37.8		81	38.0		162	36.9	
41 – 60	126	58.3	44	123	57.5	45	249	58.9	44
61 – 80	10	3.9		10	4.5		20	4.2	
Marital Status									
Married	193	88.9		178	83.3		371	86.1	
Unmarried	24	11.1		36	16.8		60	13.9	
Household Size (no.)									
1 – 9	108	49.8		95	44.3		203	47.1	
10 – 18	87	40.1	10	89	41.4	11	176	40.9	10
>18	22	10.1		30	14.3		52	12.0	
Educational Qualification									
No formal Education	0	0	11	44	20.6	10	75	17.4	10
Certificate of Primary Education	45	20.7		30	14		67	15.5	
O level Certificate	116	53.5		50	23.3		130	30.2	
ND/NCE	49	22.6		134	31.1		134	31.1	
HND/B.Sc/B.A/B.Ed	7	3.2		25	5.8		25	5.8	
Ext. Services (Agents)									
Access	217	100		214	100		431	100	
No access	0	0.0		0	0.0		0	0.0	

Source: Field survey, 2023

Stage of Adoption of IFAD Promoted Rice Processing Technologies

The adoption of IFAD-promoted rice processing technologies among farmers in Nasarawa and Niger States demonstrates varying levels of uptake across different stages (Table 2). These stages range from awareness (Stage 1), interest (Stage 2), evaluation (Stage 3), trial (Stage 4), to full adoption (Stage 5).

Table 2: State-by-State Stage of Adoption of IFAD-Promoted Rice Processing Technologies

	Stage of Adoption of IFAD Promoted Rice Processing Technologies by Farmers									
	Nasarawa Stage of Adoption					**Niger Stage of Adoption**				
IFAD Promoted Technologies	1	2	3	4	5	1	2	3	4	5
False Bottom	2	22	46	72	75	2	18	56	68	70
De-Stoner	1	19	24	91	82	3	36	43	54	78
Stitching Machine	5	32	70	68	42	5	32	50	65	62
Weighing Scale	0	3	20	72	122	0	5	18	96	95
Packaging Materials	4	5	30	96	82	0	13	30	78	93
Rice Mills	2	29	24	78	84	3	6	58	69	78
Flatbed drying	2	4	21	82	108	6	28	22	72	86
Meter/Smooth Climate Reader	0	27	28	90	72	57	25	24	52	56
Threshers	0	26	70	69	52	1	30	33	92	58
Moisture meter	27	42	60	65	23	44	16	18	66	70
Aluminium Pot	1	29	33	84	70	1	23	26	79	85
Drum	2	12	30	101	72	5	31	47	68	63
Manual Sprayers	1	20	68	76	52	8	36	51	62	57
Par-boilers	0	26	30	86	75	5	22	60	59	68
Sorting Machine/Graders	4	7	18	118	70	10	19	39	76	70

Source: Field Survey Data, 2023

Table 2 reveals a generally high adoption rate (Stage 5) for most technologies, particularly for weighing scales, packaging materials, flatbed drying, and false-bottom equipment, highlighting their perceived usefulness and accessibility. In Nasarawa State, the weighing scale (122 adopters), flatbed drying (108 adopters), and false-bottom (75 adopters) technologies show the highest adoption levels. Similarly, Niger State exhibits strong adoption for false-bottom (70 adopters), de-stoners (78 adopters), and weighing scales (95 adopters). These technologies are likely considered essential for improving efficiency, reducing post-harvest losses, and enhancing product quality. Conversely, the lower adoption rates for moisture meters, manual sprayers, and par-boilers at higher stages suggest potential barriers such as cost, availability, or technical complexity.

The relatively high levels of trial and full adoption in both states indicate a positive response to the IFAD intervention. However, technologies like threshers, stitching machines, and sorting machines/graders show varying adoption rates, reflecting differences in perceived need, operational complexity, and local context. For example, threshers and graders have moderate trial levels (Stage 4), suggesting interest, but limited progression to full adoption (Stage 5) points to barriers such as cost or labour requirements.

The findings suggest that the adoption of rice processing technologies is influenced by factors such as perceived benefits, ease of use, and resource availability. To enhance adoption rates, particularly for less-utilized technologies, targeted interventions should address specific barriers, such as cost reduction, provision of technical training, and increased access to extension services. By doing so, IFAD can further promote sustainable practices and productivity in rice processing across Nasarawa and Niger States.

Adoption Index of IFAD-Promoted Rice Processing Technologies

The adoption of IFAD-promoted rice processing technologies among farmers in Nasarawa and Niger States reveals notable differences in adoption rates across specific technologies and between the two States as presented in Table 3.

Table 4.3a: Adoption of IFAD Promoted Rice Processing Technologies

IFAD promoted rice processing technologies	Nasarawa		Niger	
	%	Z	%	Z
1. False bottom	34.6	0.84	32.7	0.83
2. De-stoner	37.8	0.55	36.4	0.6
3. Stitching machine	19.4	0.13	29	0.2
4. Weighing scale	56.2	1	44.4	1
5.Packaging materials	37.8	0.87	43.5	1
6. Rice mill	38.7	0.88	36.4	0.89
7. Flatbed drying	49.8	0.96	40.2	0.92
8.Meter/smooth climate reader	33.2	0.61	26.2	0.24
9. Threshers	24	0.46	27.1	0.59
10. Moisture meter	10.6	0	32.7	0
11. Aluminum pot	32.3	1	39.7	1
12. Drum	33.2	0.52	29.4	1
13. Manual sprayers	24	1	26.6	1
14. Parboilers	34.6	0.84	31.8	0.81
15.Sorting machine/graders	32.3	0	32.7	0.12
∑Normalized score		9.68		10.2
Adoption Index		0.65		0.68

Source: Field survey, 2023 %: Percentage of adopters, Z: Normalized value of adoption scores.

The adoption index, calculated at 0.65 for Nasarawa and 0.68 for Niger, suggests a slightly higher overall adoption level in Niger. This indicates that while the IFAD interventions are effective, there is room for improvement in driving higher adoption rates across both states. Weighing scales stand out as the most widely adopted technology, with 56.2% adoption in Nasarawa and 44.4% in Niger, both normalized at the maximum value of 1. This reflects the importance of weighing scales in ensuring fair trade practices and accurate measurements in rice processing. Similarly, flatbed drying has a high adoption rate of 49.8% in Nasarawa and 40.2% in Niger, underlining its effectiveness in reducing post-harvest losses.

Technologies such as false bottoms, de-stoners, and packaging materials also have substantial adoption rates, with normalized values ranging from 0.6 to 0.87 in both states. Conversely, moisture meters and sorting machines/graders exhibit low adoption levels, with percentages as low as 10.6% and normalized values of 0 or near zero. This suggests challenges such as high cost, lack of technical know-how, or limited perceived benefits, which hinder widespread adoption. Niger generally scores slightly higher than Nasarawa in the adoption index, reflecting a marginally better uptake of IFAD-promoted technologies. This could be attributed to differences in extension service delivery, resource availability, or farmer perceptions of technology utility. However, both states show consistent trends in the adoption of widely accepted technologies like weighing scales and flatbed drying. Low rates of adoption are documented in SSA (Gaya et al., 2016; Alwang et al., 2005), especially in SSA, where zero uptake of conservation agriculture is observed in most countries.

Constraints to the Adoption of IFAD-Promoted Rice Processing Technologies

The adoption of IFAD-promoted rice processing technologies faces several constraints categorized into production/input-related, economic/technological, and institutional barriers as presented in Table 4. These constraints vary in severity but collectively highlight the challenges farmers encounter, limiting the full adoption of these technologies. The respondents reported production and input-related challenges as the most severe constraints. Key issues include the extra cost in production (mean = 4.07), insufficient funds (mean = 4.05), and inadequate equipment (mean = 4.00). These constraints reflect financial and resource limitations that hinder the capacity of farmers to procure and utilize advanced rice processing technologies. The lack of high-quality paddy (mean = 3.90) and high labour costs (mean = 3.72) further compound these challenges, pointing to systemic issues in the agricultural supply chain and labour market. The finding of this study agrees with Adika et al. (2018), who reported insufficient funds as a major constraint among rice processors in Niger State, Nigeria.

Economic and technological constraints, though somewhat less severe than production/input-related issues, remain significant. Complexity of technology (mean = 3.60) and inadequate rural infrastructure (mean = 3.59) are critical barriers, suggesting that technology accessibility and ease of use are not well-aligned with the capabilities of local farmers.

Table 4.6: Constraints to Adoption of the IFAD Rice Processing Technologies

S/N	Constraint Type	VHC (5)	HC (4)	IND (3)	LC (2)	VLC (1)	SS	MEAN
Production/Input Related Constraints								
1	Extra Cost in Production.	176	146	82	17	10	1754	4.07*
2	Insufficient Fund	189	162	26	24	30	1749	4.05*
3	Insufficient Equipment	172	158	48	36	17	1725	4.00*
4	Lack of High Quality Paddy	166	128	92	20	25	1683	3.90*
5	High Labour Cost	150	118	96	30	37	1607	3.72*
Economic/Technological Constraints								
6	Lack of Good Market	106	38	19	201	67	1208	2.80
7	No Difference in Selling Price	101	42	22	66	200	1071	2.48
8	Complexity of Technology	168	99	42	68	54	1552	3.60*
9	Inadequate Rural Infrastructure	156	101	68	56	50	1550	3.59*
Institutional Constraints								
10	Poor Extension Services	180	104	64	55	28	1646	3.81*
11	Poor Group Leadership	120	86	95	70	60	1429	3.31
12	No Frequent Monitoring of Group	111	43	56	101	120	1217	2.82
13	Lack of Insurance	68	92	106	43	122	1234	2.86
14	Untimely Supply of Inputs	186	106	88	31	20	1700	3.94*

Source: Field Survey Data, 2023. VHC implies Very High Constraint, HC implies High Constraint, IND implies Indifference, LC implies Low Constraint while VLC implies Very Low Constraint.

Conversely, lack of good market access (mean = 2.80) and no difference in selling price for processed rice (mean = 2.48) indicates that economic incentives for adopting these technologies are weak, reducing farmer motivation. Institutional barriers include poor extension services (mean = 3.81) and untimely supply of inputs (mean = 3.94), which highlight inefficiencies in support systems that are crucial for technology adoption. Poor group leadership (mean = 3.31) and lack of frequent monitoring (mean = 2.82) suggest that cooperative and group dynamics also play a role in the slow uptake of these technologies. Additionally, the lack of insurance options (mean = 2.86) exposes farmers to risks that deter investments in new technologies.

CONCLUSION AND RECOMMENDATIONS

The adoption of IFAD-promoted rice processing technologies in Nasarawa and Niger States shows promising progress, especially for technologies like weighing scales, flatbed drying, and false bottoms, which have high adoption rates due to their effectiveness in improving efficiency and reducing post-harvest losses. However, challenges such as high costs, insufficient funds, complex technology, inadequate infrastructure, and weak institutional support hinder the widespread adoption of certain technologies, particularly moisture meters and sorting machines. Addressing these barriers is essential to fully realize the benefits of these technologies and enhance farmers' productivity. Based on findings from the study, the following policy recommendations are made:

1. The government should introduce subsidies, affordable loans, and cost-sharing schemes to help farmers acquire high-cost technologies.
2. Technology manufacturers should simplify the design of complex technologies and offer regular training programs to build farmers' confidence in using them.
3. The government should enhance extension services to ensure farmers receive timely advice, training, and ongoing support for technology adoption.
4. The government and relevant stakeholders should ensure the timely delivery of inputs and invest in rural infrastructure, such as roads and storage facilities, to support efficient rice processing and market access.
5. The government and development partners should support farmer cooperatives for shared resources and introduce affordable insurance schemes to reduce risks and encourage investment in new technologies.

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