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Factors affecting the adoption of sawah technology system of rice production in Nigeria

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Abstract

This study examined factors affecting the adoption of sawah technology in Nigeria. A structured interview guide was used to collect data from 124 farmers purposefully selected based on their participation in sawah. The results showed that respondents were predominantly male, married and had Quranic education, with mean age of 42.30 years. The mean household size was 14, farm sizes ranged from 0.03 to10 hectares (mean 0.5 ha), the mean yield was 4.65 tons per hectare. Factors identified affecting farmers' adoption of sawah technology were communication, attributes of the innovation, attitude of farmers toward the innovation and the availability of necessary resources. The regression analysis showed that adoption was positively related to awareness ($\beta = 0.802$; $p<0.01$), attitude of farmers ($\beta = 0.480$; $p<0.01$), attributes of sawah technology ($\beta = 0.328$; $p<0.01$), access to contact farmers ($\beta = 0.51$; $p<0.00$) and household size ($\beta = 0.246$; $p<0.05$). However, adoption was negatively related to constraints faced by farmers ($\beta = -0.32$; $p<0.02$) and the age ($\beta = -0.444$; $p<0.01$). The study revealed that awareness of sawah technology was high among the farmers and influenced their adoption of sawah technology. Attitude of farmers, attributes of sawah technology, access to contact farmers and household size influenced the adoption of sawah technology.

Key words: Sawah, adoption, awareness, constraints, Nigeria.

Introduction

The food sub-sector of Nigerian agriculture parades a large array of staple crops, due to the variations in the climatic conditions in the country. The food crops include rice, sorghum, maize, millet, rice, wheat, yam, cassava, groundnut, cowpeas and vegetables. Among these food crops, rice is most consumed by many households in Nigeria. Thus, rice has become a strategic commodity in the Nigerian economy. Rice is an important source of nutrition and one of the major staples which can provide Nigerian population with the nationally required food security [1]. An average Nigerian consumes 24.8 kg of rice per year, representing 9% of annual calorie intake [2]. Nigeria has experienced rapid growth in per capita rice consumption during the last three decades, from 5 kg in the 1960s to 25 kg in the late 1990s [3]. With this increasing contribution of rice to the per capita calorie consumption of Nigerians, the demand for rice has been increasing at a much faster rate than domestic production and even more than in any other African country since mid 1970s [4].The demand for rice in Nigeria has been soaring. Rising demand was partly the result of increasing population growth, increased income levels, rapid urbanization and associated changes in family occupational structures [5].

Consequently, the Nigerian government has interfered in the rice sector over the past few decades making effort to increase rice production for local consumption. Although rice production in Nigeria has increased during this period, the production increase was insufficient to match the consumption increase with rice imports making up the gap [6]. The need to increase local production necessitated the introduction of sawah technology to enhance domestic production. Sawah-based rice production took off through the establishment of a demonstration farm (1.5 ha) at Ejeti village in Bida, Niger State, in 2001 [7]. Sawah refers to man-made improved rice fields with demarcated, levelled, bunded and puddled rice fields with water inlets and outlets which can be connected to various irrigation facilities such as irrigation canals, ponds, springs or pumps. The term sawah originated from Malayo Indonesia. The English and French terms, paddy or paddi also originated from Malayo Indonesian term padi which means rice plant. Therefore, in order to avoid confusion between upland paddy fields and man-made levelled, bunded and puddled rice field that is typically irrigated rice growing environment the authors propose to use the term "sawah" in Sub Saharan Africa [8]. Sawah-based system of rice production was reported to have contributed to the achievement of green revolution in Asia. The speed and scale with which it solved the food problem was remarkable and unprecedented, and it contributed to a substantial reduction in poverty and the launching of broader economic growth in Asia. With green revolution, per capita production of rice has increased from 200 kg to more than 250 kg in the last 40 years in Asia [8]. Sawah can overcome soil fertility problems through enhancing geological fertilization process, conserves water resources, and

high performance multi-functionality are characteristics of the sawah type wetlands [7]. Therefore, with its inherent potential, there is a need to develop a better understanding of the conditions that encourage its sustained adoption.

Factors affecting adoption: Adoption is the mental process an individual passes through from first hearing about an innovation to final adoption [9]. Technology transfer (or extension in a rural context) involves the movement of technical knowledge, ideas, services, inventions and products from the origin of their development (or other location), to where they can be put into use. Technology adoption is the implementation of this transferred knowledge about an innovation, and is the end product of extension [9].

Farmers may reject or abandon many technologies, that have been proved useful, and adopt others in their place since they consider a variety of factors in deciding whether or not to adopt particular innovation [10].Various factors have been considered in adoption studies. For instance, Clearfield and Osgood [11] considered individual characteristics of farmers (e.g. age, off-farm employment and social participation) and attitude variables, such as risk orientation and non-economic orientation towards farming. Other studies focused on farm characteristics (e.g. farm size), wealth indicators (e.g. livestock numbers) and the availability and profitability of the technology [12]. Sall *et al.* [13] and Wortman and Kirungu [14] reported that not only farm and farmers' characteristics but also farmers' perceptions of technology-specific characteristics significantly influence adoption decisions relating to improved rice varieties.

Focusing primarily on the initial stages of green revolution technology adoption and diffusion, Feder *et al*. [15] concluded that farm size, risk and uncertainty, human capital, labour availability, credit constraints and tenure security were the most important factors determining adoption decisions. Kolawole *et al*. [16] reported on Nigerian farmers who abandoned a technology due to natural hazards and emerging economic constraints. Lapar and Ehui [17] found out that farmers, who are more educated, have higher income and access to credit are more likely to adopt the innovation. Moreover, location of the farm in respect to the availability of innovation also plays a critical role in adoption. Chi [18] in a study to determine the factors affecting technology adoption among rice farmers in the Mekong Delta reported that farmers' perception and education, extension workers' knowledge, ways of organization and management of extension programs and physical conditions of the area influenced adoption among the farmers. Tiamiyu *et al*. [19] also reported that technology adoption and productivity difference among growers of New Rice for Africa in savanna zone of Nigeria was affected significantly by farmers' level of education, extension visits, rice farming experience, tenure status, credit use and level of rice commercialization. Farm size, type of ecosystem, tillage type, education, population pressure on land, farmers' age and non-farm income were found to be positively and significantly related to adoption and use intensity of chemical fertilizer, while field distance to the village, gender, access to credit and labour availability had an indirect relationship with adoption, and use intensity of chemical fertilizer was found to affect fertilizer adoption by rice farmers in Bende local government area of Abia State, Nigeria [20].

Adesina [21] found that the major factors that affect farmers' use of fertilizers in rice fields are cultivation of lowlands, use of mechanization, farm size, type of rice ecosystem, tillage methods, cultivated area, land pressure faced by households, availability of non-farm income, the distance of the field to the village, distance of the village to the major market and gender of the field owner. Family size, membership in social institutions, rate of participation in extension activities and number of extension contacts were also identified as the socio-personal characteristics affecting the adoption of rice-fish culture system in North of Iran [22]. In a study on the factors affecting production, consumption and price of rice and inflation in food sector, Malian *et al.* [23] found that previous paddy harvest, cultivated area, rice import, price of urea-based fertilizer, real exchange value and domestic rice price influence rice production.

Since sawah technology aims at achieving green revolution in Nigeria through the improvement in rice production, a study of the factors affecting the adoption and continued use of the sawah technology is pertinent. This study, therefore, aimed at identifying the factors affecting adoption and continuous use of sawah technology system of rice production in Nigeria. Specifically, the awareness, level of adoption of sawah technology in Nigeria, reasons for the adoption of sawah system of rice production and the factors affecting the adoption of sawah technology were determined.

Methodology

This study was carried out in Nigeria, covering five states and the Federal Capital Territory (FCT) where sawah is being practiced. The states were Niger, Kaduna, Ondo, Kwara, Ebonyi and Abuja (FCT). A list of rice farmers in the villages where sawah technology was disseminated was compiled. One hundred and twenty four farmers in the study locations were interviewed. A structured interview guide was used to elicit information from the farmers. Descriptive statistics was used to analyse the socio-economic and farming characteristics of the farmers, and regression analysis was used to determine the relationships between the variables of the study.

The interview guide was divided into five sections. The first and second sections captured socioeconomic characteristics of the responds and the level of awareness and adoption of sawah technology package among the farmers. A 3-point Likert scale of full adoption, partial adoption and discontinued was used. The third section of the data collection captured farmers' reasons for the adoption of sawah technology rice production system. The forth section addressed the factors affecting the adoption of sawah technology rice production. The last section identified the constraints faced by the farmers.

Results and Discussion

Socio-economic and farming characteristics of the respondents: Table 1 shows the socio-economic and farm characteristics of the respondents. The majority of the respondents were male (98.9%). This shows that male farmers dominated sawah farming in Nigeria. The mean age of the respondents was 42.30 years and 65.40% fell within the productive age of 15-45 years. Most of the respondents were married (98.80%) and 62.70% of the farmers had Quranic education and were Nupes. These findings agree with the findings of Fu *et al.* [24] and Oladele and Wakatsuki [25]. Household size of the farmers ranged between 1 and 40 persons (mean 14). Fifty-five

Table 1. Socio-economic and farming characteristics of the respondents (N = 124).

Characteristics	Percentage	Mean
Sex		
Male	98.90	
Female	1.10	
Age		
15-30	22.00	
31-45	43.40	42.30
46-60	20.10	
Greater than 60	14.50	
Marital status		
Married	98.80	
Single	1.20	
Educational level		
Quranic	62.70	
No formal education	3.60	
Primary	12.00	
Secondary	18.10	
Tertiary	3.60	
Household size (persons)		
1-10	31.10	
11-20	55.60	14
21-30	9.70	
31-40	3.60	
Farm size(ha)		
Less than 0.50	73.90	0.53
0.50-1.00	17.00	
> 1.00	9.10	
Income (₦)		
<100,000	18.10	151,110
100,000-200,000	57.80	
>200,000	24.10	
Yield of sawah rice (tons/ha)		
0-2	77.30	
2.1-4.0	14.70	2.50
4.1-6.0	2.30	
>6.0	8.00	
Access to extension services	33.80	
Access to contact farmer	85.00	
Membership of farmers organization	97.50	
Labour use		
Family	53.80	
Hired	46.20	

percents of the farmers had household size between 11 and 20 persons. The advantage of the relatively large household size of the farmers is that the family members could serve as a viable source of farm labour. The mean size of farm devoted to sawah was 0.5 ha. However, the majority of the farmers had farm size less than 0.5 ha. The mean farmers' income was 151,000 . Mean farmers' years of experience in rice production and sawah production were 32 and 6 years, respectively. This implies that the respondents had considerable experience in rice production and hence were capable of using sawah technology. The mean yield of rice from the sawah field was 2.5 tons with majority of the farmers (77.30%) having yield of less than 2 tons. The yield corresponds with the size of the field. In all, yield of sawah field among the sawah farmers was 4.65 tons per hectare. The average distance covered from the farmers' house to the farm was 0.7 km. Also, 33.80% of the farmers had access to extension services and 85.00% had access to a trained contact farmer in sawah technology. Majority of the farmers (97.50%) were members of farmers' organization and used family members as labour source (53.80%).

Awareness and adoption among the respondents: Table 2 shows the level of awareness and adoption of sawah technology among the farmers. There was a high awareness of puddling (98.80%), bunding of field (100.00%), power tiller use (95.00%), the use of sand bags (92.50%), flooding and flood control (88.80%) and nursery preparation (87.50%). The high level of awareness had influence on the level of adoption among the farmers. Sawah technology package had 56.25% full adoption, 30.55% partial adoption and 13.20% discontinued use of sawah technology. This implies that there was high adoption of sawah technology among the farmers. This may be due to high yield from sawah field, the improvement in the rate of tillering of the rice, efficiency of fertilizer usage and effective weed control [26]. The high level of adoption among the farmers is a direction toward achieving green revolution in Nigeria. There was a high adoption of bunding (100%), canal construction (100%), use of nursery (95%), power tiller use (95%), and puddling (91.20%), use of sand bag (80%), flooding/irrigation (76.2%), levelling (72.5%) and smoothening (67.5%), respectively.

It could be deduced from the results that awareness of innovation has a great influence on the adoption. Adoption process is the mental process an individual passes from first hearing (awareness) about an innovation to final adoption [9]. However, the level of the discontinuity among the farmers based on findings was due to the non availability of the required inputs such as power tiller for puddling. As reported by Ademiluyi *et al.* [27], power tiller is the only power-driven tool that is effectively being used for sawah activities in Nigeria and a set of power tiller cost 5000-7000 USD which an average farmer cannot afford to buy. Difficulty of transplanting of rice seedlings and the required labour for the transplanting, difficulty faced in water management and distribution which sometimes result in flooding of fields, and inability to expand the size of their farm due to land tenure constraint are other factors responsible for the discontinuity. Discussion with the farmers revealed that they are willing to continue the adoption if these problems are solved.

Reason for adoption of sawah technology: Table 3 shows the reasons and motivating characteristics of sawah technology that facilitated adoption among the farmers. All the farmers adopted sawah technology because of the high yield from sawah field (100.00%). Majority of the farmers adopted sawah technology because of the improvement in the rate of tillering of the rice (90.00%) and efficiency of fertilizer usage (75.00%). Adoption of sawah technology among the farmers was also facilitated by the rate at which the weeds were controlled (87.50%). In a well laid out field, with proper water control, throughout the growing season, weeding may not be necessary. Other factors motivating the farmers to adopt sawah were ease of disease and pest management, water management and land preparation. This result agrees with the finding of Fu *et al.* [24], who reported that higher yield and better water and weed control are the major reasons why Nupe farmers adopted sawah technology.

Factors affecting adoption of sawah technology: Table 4 shows the factors affecting the adoption of sawah technology among the farmers. These factors are attributes of the sawah technology, attitude of farmers toward sawah technology, the availability of necessary inputs and communication factor. Majority of the farmers' perceived usefulness (86.20%) and the ease of use of

Table 2. Awareness and level of adoption of sawah technology package (N=124).

Innovation package	Awareness (%)	Full adoption (%)	Partial adoption (%)	Discontinued
Puddling	123(98.80)	71(57.50)	42(33.80)	11(8.80)
flooding/irrigation	110(88.80)	71(45.00)	3931.20)	30(23.80)
Levelling	109(87.50)	30(23.80)	61(48.80)	34(27.50)
Smoothening	104(83.80)	25(20.00)	59(47.50)	40(32.50)
Nursery	109(87.50)	96(77.50)	22(17.50)	6(5.00)
Power tiller use	118(95.00)	40(32.50)	78(62.50)	6(5.00)
Dyke construction	25(20.00)	0(0.00)	19(15.00)	105(85.00)
Bund construction	124(100.00)	105(85.00)	19(15.00)	0(0.00)
Agro forestry and sawah production	0(0.00)	0(0.00)	0(0.00)	124(100.00)
Canal construction	92(73.80)	84(68.00)	40(32.00)	0(0.00)
Use of sand bags	115(92.50)	34(27.50)	65(52.50)	25(20.00)
Total score	-	**1625**	**882**	**381**
Percentage	-	**56.25**	**30.55**	**13.20**

Table 3. Reasons for the adoption of sawah technology rice production (N=124).

Reasons	Percentage
High yield	100.00
Ease of disease management	72.50
Ease of pest management	70.00
Fertilizer management	75.00
Weed control	76.20
Water management	87.50
Land preparation	68.80
Good tillering	90.00

Table 4. Factors affecting the adoption of sawah technology (N=124).

Factors	Percentages
Attitude of respondents	
Perceived usefulness,	86.20
Perceived ease of use	85.00
Fear and anxiety of crop failure	6.50
Perceived risk and uncertainty	2.50
Attributes of sawah technology	
Increased yield	83.80
Weed control ability	68.80
Disease and pest management attribute	63.50
Effective water management	70.50
Fertilizer management efficiency	70.50
Facilities and resources	
Access to credit	12.50
Access to market	38.80
Availability of input	8.80
Communication and extension	
Access to extension agent	18.20
Access to contact farmer	70.00
Feedback problem	2.00

sawah (85.00%) affected their adoption of sawah technology. The fear and anxiety such as crop failure and risk and uncertainty of the technology did not affect the rate of adoption of the technology. The degree of risk associated with a new technology is one of the factors that affect farmers' adoption of an innovation. Technologies which are perceived as relatively risky will be less likely to be adopted by farmers. FAO [4] reported that perceived risk of adopting the technologies may serve as a barrier. Farmers were convinced that sawah technology can help achieve their goal of increase productivity.

The increase in yield (83.80%) of sawah rice made them to adopt the technology. Agricultural innovations that are believed to be profitable to the farmers have an increased likelihood of adoption. On the other hand, if a farmer does not feel that an innovation will be of benefit, there may not be adoption in such instance [28]. The ease of disease and pest control (63.00%) associated with sawah technology as reported by this study made farmers to adopt the technology. Effectiveness of weed control (68.80%) of sawah technology and effective water management (70.50%) of sawah technology as reflected in this study made the farmers to adopt the innovation. In a well laid out and levelled sawah field, with proper water distribution, the farmer may not need to weed throughout the growing season and there will be effective fertilizer distribution and usage. Fertilizer management (70.50%) in sawah technology made the farmers to adopt the sawah technology. Sawah system encouraged the growth of various aquatic algae and other aerobic and anaerobic microbes in addition to rice growth, which increase nitrogen fixation in the sawah system through increase of photosynthesis as functional wetlands. The amounts of nitrogen fixation under the submerged sawah systems are not well evaluated, the amounts could be 20-100 kg/ha/year in Japan and 20-200 kg/ha/year in tropics depending on the level of soil fertility and water management [29,30]. Fu *et al.* [24] also reported that higher yield and better water and weed control have been recognized by participating farmers as the factors affecting the adoption of sawah technology among the Nupe farmers. However, access to credit, extension, market and input availability do not influence the adoption of sawah technology among the farmers. Most of these resources farmers do not have access to and hinder the rate at which farmers increase their level of production. Communication factor identified to be affecting the adoption of sawah technology among the farmers are access to extension (33.00%), access to contact farmers (70.00%) and feedback problem (2.00%). Access to contact farmers at the door step of the farmers has a greater influence on the rate of their adoption.

Constraints faced by sawah farmers: Constraints faced by farmers in the use of sawah technology in order of priority are shown in Table 5. These includes non availability of power tillers (97.00%), fertilizers (81.00%), difficulty in repairing power tillers (76.00%), poor road network (72.00%), marketing of their yield (70.00%), flood (70.00%), credit facilities (66.00%), labour (15.00%), pests, diseases and weeds (15.00%) and drought (15.00%). Lack of social capital needed for agricultural production certainly reduces the capacity of individuals to work and to access resources, knowledge and skills needed. Financial security based on the findings of this study is a necessary condition for adoption of

sawah technology. Labour was identified as a constraint affecting the adoption of sawah technology. Most farmers rely on family labour for their operations which may not be adequate for the size and scale of their production. It was noted that cash and/or labour constraints would likely affect several agrarian systems [31].

Regression analysis between adoption level and other study variables: Table 6 shows the result of regression analysis to determine the relationship between adoption of sawah technology and factors affecting adoption. The results show that adoption of sawah technology is related to awareness ($\beta = 0.80$; $p<0.01$). This implies that the higher the level of awareness, the higher the level of adoption. Also attitude of farmers is significantly related to their level of adoption ($\beta = 0.48$; $p<0.01$). Due to the benefit derived from sawah, farmers have positive attitude towards sawah technology. The yield of sawah farmers has increased from 1.4 tons per hectare [32] to 4.6 tons per hectare as a result of the adoption of sawah technology. Also the attributes of sawah technology ($\beta = 0.33$; $p<0.01$), which include high yield from sawah field, improvement in the rate of tillering of the rice, efficiency of fertilizer usage, weed control, ease of pest management and water management and the relative ease of adoption, had positive effect on adoption. Access to contact farmers ($\beta = -0.51$; $p<0.01$) was also significantly related to adoption. Contact farmers were trained in all the sawah locations in Nigeria to serve as link between the source of technology and the farmers. The results showed that household size of the farmers ($\beta = 0.25$; $p<0.05$) was related to the adoption of sawah technology. This implies that the larger the size of the family, the higher the level of adoption. This may be true because when the size of the family increases, farmers may tend to increase the farm size. In addition, large size of the family could serve as a source of labour hence affecting the level of adoption. This also agrees with the findings of Adesoji *et al.* [33] that large household size increased farmers' participation in farm activities. Also a significant relationship exists between adoption and constraint faced by farmers ($\beta = -0.32$; $p<0.02$). This implies that the higher the constraints faced by farmers the lower the rate of adoption. Adoption of sawah technology depends on the availability of power tillers, fertilizers, improved rice seeds and other farm inputs. Availability of these inputs will influence the level of adoption of sawah technology among the farmers. The more available farm inputs are, the greater the levels of adoption and expansion of sawah technology. The age of the farmers ($\beta = -0.44$; $p<0.01$) was negatively related to level of adoption. This could be because of resistance to change by aged farmers [33, 34]. Older farmers find it difficult to change from their former way of doing for a new method.

Table 5. Constraints faced by the farmers (N=124).

Constraints	Frequency	Percentage
Power tiller availability	120	97.0
Fertilizer	100	81.0
Repairs and spare parts of power tiller	95	76.0
Poor road network	89	72.0
Marketing	86	70.0
Flood	86	70.0
Credit facilities	82	66.0
Labour	18	15.0
Pest, disease and weeds	18	15.0
Drought	18	15.0

Table 6. Regression analysis between adoption level and other study variables (N=124).

Variables	B	SE	Std β	t-ratio	sig
Constant	3.16	3.20	-	0.99	0.33
Awareness	2.71	0.44	0.80	6.10	0.00
Age	-0.13	0.04	-0.44	-3.22	0.00
Experience in sawah	2.69	1.48	0.13	1.82	0.07
Access to contact farmer	3.84	0.55	0.51	6.98	0.00
Attitude of farmer	7.06	1.42	0.48	4.95	0.00
Attributes of the sawah technology	2.89	0.78	0.33	3.70	0.00
Access to extension services	1.07	0.62	-0.13	-1.73	0.09
Constraints faced by farmers	-3.70	1.52	-0.32	-2.44	0.02
Household size	0.14	0.05	0.25	2.86	0.01
Experience in rice production	0.04	0.03	0.16	1.23	0.23
Communication	-1.34	1.35	-0.10	-1.00	0.32

$R = 0.89$, $R^2 = 0.79$, Adjusted $R^2 = 0.76$, $F = 21.36$, Standard Error of Estimate = 2.01.

The younger farmers may be inquisitive, wanting to learn more, hence increase their level of adoption. The results of the regression analysis were also supported by the findings of Feder *et al.* [15] who reported that farm size, risk and uncertainty, human capital, labour availability, credit constraints and tenure security were the most important factors determining adoption decisions.

Conclusions

Awareness of sawah technology was high among the farmers and influenced their adoption of sawah technology. High yield from sawah, good tillering, water management, fertilizer management and weed control and other characteristics of sawah technology were the major reasons why farmers adopted sawah technology. Adoption of sawah technology was influenced positively by awareness, attitude of farmers, attributes of sawah technology, access to contact farmers and household size and negatively influenced by age of farmers and the constraints faced by farmers. The adoption is, however, faced with some constraints. It is recommended that constraints faced by farmers should be addressed urgently to enhance the achievement of green revolution in Nigeria through sawah technology.

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