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Knowledge and Adoption of Precision Agriculture among Oil Palm Smallholder Farmers in Akwa Ibom State, Nigeria

Obot Akaninyene P.[1], Okechukwu Frances O.[2], Eze MaryAnn O.[3], Obot Elizabeth A.[4] & Udoh Mfon[5]
[1]Depart. of Agricultural Economics and Extension, Nnamdi Azikiwe University, Awka, P.M. B 5025, Anambra State, Nigeria
[2,3]Federal College of Education (Technical), Asaba, Delta State, Nigeria
[4]Department of Engineering, TopFaith University, Mkpatak, Akwa Ibom State, Nigeria
[5]General Studies, TopFaith University, Mkpatak, Akwa Ibom State, Nigeria

Corresponding author: ap.obot@unizik.edu.ng Ph. +2348063662407

ABSTRACT

Precision Agriculture (PA) deals with the fine-tuned management of crop inputs including seeds, fertilizers, water, pesticides and energy in order to create savings on these inputs, increase yield, augment profitability and protect the environment. This study was carried out with the aim of knowing the level of awareness of precision agriculture and the various factors affecting the adoption of precision agriculture by oil palm smallholder farmers in Essien Udim rural communities. Eighty respondents were interviewed. The data was analyzed using descriptive analysis such as frequency, percentage, mean and likert scale. The outcome of the study showed that most of the farmers were aware of precision agriculture because most of them had formal education. This means that the level of education of oil palm smallholder farmers could result to a high rate of agricultural technology adoption.

On the constraints to the adoption of precision agriculture, the study revealed that lack of capital, information, facilities and low technical knowhow were the major constraints identified by the farmers.

Since capital, information, facilities and technical knowhow were the major constraints, the availability of capital and agricultural information devices such as radio and mobile phones would help farmers to make informed decisions about what crops to sow or transplant and where to purchase affordable crop inputs and the market to sell their produce.

KEYWORDS:

Technologies, knowledge, adoption, precision agriculture, oil palm, smallholder farmers, constraints

INTRODUCTION

Oil palm has been a major source of foreign exchange to Nigeria and income generating venture to most segment of the rural population in the Southern Nigeria (Onoh and Peter-Onoh, 2012). Its importance outside to the economy of Nigeria, ranges from production of food, employment, income to farmers and raw materials for industries. Omonona and Agbaje, 2018; Tiku and Bullem, 2015; Kehinde, 2020; Partnership Initiatives in The Niger Delta (PIND, 2019) Foundation further buttress on the economic importance of oil palm tree as outside the palm oil gotten from it, the by products like the palm kernel can be used for palm kernel oil, palm kernel cake which serves as animal feed while the fonds can be used to make broom, fire word and sometimes to make thatch house and the slurry can be used for the production of soap and fertilizer. In the course of these processes, the oil palm business create job for the people mostly the rural people. Despite the important of oil palm business is dominated predominantly by the smallholder farmers who uses outdated production methods. Agriculture is the most important economic sector in many Sub-Saharan Africa (SSA) countries and it employs more than two third of its labor force and also contribute to one third of the Gross National Product (GNP) (FAO, 2017). Despite the central role played by agriculture in the SSA economy, there is still low improvement in the agricultural practices and productivity as a result of low inherent soil fertility combined with increased population pressure that has led to soil degradation and nutrient depletion (Fuglie, 2013). In Nigeria, agriculture contributes to its GDP and the employment of the youths but farmers in the rural area are still faced with numerous challenges like low adoption of technologies, lack of capital, land etc. This can be done by increasing agricultural productivity through mechanization and precision farming. Nigeria food security has assumed an alarming proportion largely because of the poor growth in the agricultural sector combine with the ever-increasing population growth. The ever-increasing population and the percentage of young persons making up its population is supposed to be an advantage in the adoption of technologies and increase agricultural productivity but the opposite is the situation as most of the young people rather migrate to the urban area in search of white-collar jobs.

Food insecurity remains a major challenge for African countries because the number of African people who need food and poor still surpasses quality food supply. Subsequently, several African countries still require and rely on food donations and support from other continents (www.intechopen.com,2021). Such persistent food insecurity is substantially due to unsustainable farming methodologies, limited mechanisation efforts, limited skills capacity, and ineffective farming innovative technologies. Consequently, subsistence and smallholder farming persists, and most farming activities in Africa are executed for a small community or family consumption only. Additionally, climate change has resulted in unpredictable weather patterns such as floods and progressive desertification due to droughts. This has further exacerbated the already delicate farming conditions in Africa. Thus, this negatively affects Africa's resources base, more especially in communities liable to soil degradation, water shortages, and increasing desertification. In addition, about 90 percent of the world’s farmers are smallholders, owning less than two hectares of land. Farming is often the primary (and only) source of revenue for smallholder farmers, making them vulnerable to price fluctuations and extreme weather events. Smallholder farmers not only suffer from a lack of access to resources (e.g., financing, land, water) but also from various asymmetries in markets, including in power structures and information access. Improving the productivity and livelihoods of smallholder farmers is thus vital for achieving United Nations Sustainable Development Goals (SDGs). Yet, small farm size poses several challenges for farmers. It makes technological investments to enhance productivity and yields infeasible and acts as a barrier to benefiting from economies of scale.

For agriculture to fulfill the ever-increasing food demand, productivity must be increased through the adoption and application of improved technologies. Agriculture is now on the cusp of another revolution the digital revolution which could help address several issues faced by the sector. This digital revolution is a key foundation for precision agriculture with farm management approach that uses data and technology to make farming simpler, more efficient and more productive. It enables agricultural inputs like water, fertilisers and pesticides to be applied in precise amounts to get increased average yields compared to traditional cultivation techniques. Precision agriculture solutions powered by digital technologies can improve productivity and crop yields, help protect the environment by reducing chemical inputs, foster gender inclusion and help make farming profitable for smallholders. Increased efficiency in management systems is a key aspect of precision farming, especially in smallholder systems where funds to buy large amounts of external inputs are often in short supply. The approach carries many clear messages with emphasis on efficient fertilizer usage. Smallholders should also try to determine the type of system required and manage it as specifically as possible. It is worth stressing the fact that smallholders often do not need equipment. They know the variability of their soil very well, they observe crop variability and they can manage their fields on a site-specific basis even if they rely on manual labour and do not make major investments. However, advances in various technologies (particularly digital technologies) and their growing affordability are now making precision agriculture available to smallholder farmers in developing countries.

There is little or no research on knowledge, adoption and constraints to precision agriculture in Akwa Ibom State, Nigeria. This study intended to fill the gap and try to provide an original contribution by putting forward an articulated steps of knowledge and constraint to innovation uptake by smallholder farmers in the study area.Given this background, it therefore becomes imperative to carry out this research with a view to producing answers to the following research questions:

Research questions

a. What are the socio-economic characteristics of the farmers?
b. What is the level of awareness of the farmers on precision?
c. What is the level of adoption of the precision agriculture?
d. What are the factors affecting the adoption of precision agriculture among the farmers?

Objectives of study

The general objective of the research was to analyze the knowledge and adoption of precision agriculture among selected oil palm smallholder farmers in Essien Udim LGA, Akwa Ibom State.
The specific objectives were;

a. to examine the socio-economic characteristics of the respondents;
b. to examine the respondents level of awareness on precision agriculture;
c. to examine the respondents level of adoption of the technology;
d. to determine factors influencing the adoption of precision agriculture.

LITERATURE REVIEW

The adoption of technologies by smallholder farmers which is one of the resources for crop production is vital to increasing agricultural productivity. The adoption of technology or new innovation is a mental process that consist of stages that is the awareness stage, the interest stage, the evaluation stage, trial stage and finally, the adoption stage (Rogers, 2013; Cheteni et al., 2014; Sennuga et al., 2020). At the awareness stage, an individual becomes aware of the idea but lacks detailed information about it. At the interest stage, an individual gets more information about it and wants to know more about how it works, what it is and its affordability. At the third mental stage the

user has obtained more information from the previous stages. At the fourth mental stage, the individual makes a small-scale trial of the ideas and requests for more specific information to answer questions. The last mental stage, adoption, is characterized by a large-scale adoption of the ideas and most importantly its continued use.

Conceptual Framework

In order to achieve the objectives outlined previously, it is important to provide an economic framework that justifies the methods used. Discrete choice experiments utilized here are rooted in random utility theory (McFadden, 1974; Scarpa et al., 2013). That is, as rational agents decision makers are assumed to make choices that maximize utility. Although the actual utility of a given choice is latent, the choice itself can be observed, and the utility derived from that choice can be decomposed into two parts: systematic utility, which is a function of observable attributes or characteristics, and a random component that is composed of the imperfect knowledge associated with unobservables. It is important to note that maximizing utility may not directly correspond with maximizing profit.

This point is especially important for this study where respondents are asked to make choices about precision agriculture technologies and services that do not necessarily correspond with profit maximization (i.e., increased convenience).

The foundations of random utility theory are well established and for this reason are not discussed in detail here. Interested readers should consult Train (2003) for a more detailed treatment of random utility theory.

Technology adoption and the determinants

Adoption of technology is defined as the decision to make full use of a new idea as the best course of action available (Akubuilo, 1982). It involves a change in the orientation and behaviour of the users from the time he/she becomes aware of the technology to its use. Rogers (2005) in his own word defined adoption of technologies as a decision to apply innovation/new technology, method, practice by a firm, a farmer or a consumer and continue to use it. Rate of adoption is the relative speed with which an innovation is adopted by members of a social system. A number of theories have been propounded to explain technology adoption. These include the theory of reasoned action, theory of planned behaviour, unified theory of acceptance and use of technology, diffusion innovation theory and technology-organisation-environment framework (Hassen, 2014). Others are: rational expectation theory of technology adoption and agricultural household models. Adopters are divided into five categories, each with its own characteristics. These are: i) innovators, ii) early adopters, iii) early majority, iv) late majority, and v) laggards. Theoretical models of adoption behaviour looked into variables that may explain the decision to adopt or the intensity of adoption (Toborn, 2011). The adoption decision of farmers and intensity of use of improved technologies are determined by many factors. The most often cited factors that have been used to explain the variability in agricultural technology adoption and its patterns of diffusion are those described by Feder (1985).

Traditionally, the factors include farming household specific characteristics, farm size, risk exposure and capacity to bear risk, human capital, labour availability, credit constraints, tenure, and access to input and commodity markets. These factors are considered important at the early stages of adoption but may become less significant in later stages.

Empirical studies on agricultural technology adoption in Nigeria for example suggest that factors such as socio-economic characteristics of farmers, access to credit or cash resources and information from extension and other media influence adoption rate of new agricultural technology among farmers (Ayinde et al., 2010;Idrisa et al., 2012).The wide variety of empirical results, interpreted in the

context of the theoretical literature, suggests that size of holding is a surrogate for a large number of potentially important factors such as access to credit, capacity to bear risk access to scarce inputs (water, seeds, fertilizers, insecticides), wealth, access to information, to mention just a few.

METHODOLOGY

Study Area

Akwa Ibom State is located in South of Nigeria and lies between latitude 4°31 and 5°31 North and longitude 7°35 and 8°35 East; occupying a total land area of 7,254,935 sq.kmand has an estimated population of 3,920,208 (NPC, 2006). Located at an elevation of 42.58metre above the sea level, Akwa Ibom has a Tropical monsoon climate (Classification: Am). The city's yearly temperature is 28.47ºC and it is -0.99% lower than Nigeria's averages. Akwa Ibom typically receives about 342.56 mm of precipitation and has 294.37 rainy days (80.65% of the time) yearly.Essien Udim is one of the Annang speaking Local Government Areas in Akwa Ibom State, Nigeria. It was created out of the former Ikot Ekpene division and includes the following clans in Annang land: Ukana, Adiasim, Akon, Afaha, Odoro Ikot, Ekpenyong Atai and Ikpe. Essien Udim LGA has an estimated population of 79,444 occupants with most of the area's general population being individuals from the Annang ethnic sub-division. The major occupation of the people in the study area is agricultural practices.

Data collection

The method of data collection of the study was the administration of a semi-structured questionnaire. Information gathered was basically on socio-economic characteristics, level of awareness of precision agriculture, level of adoption and constraints to adoption of precision agriculture.

Sampling procedure and sample size

A two-stage sampling procedure was used in selecting the respondents that were used for the study. The first stage was the purposive selection of Essien Udim Local Government Area in the State, based on their predominance in oil palm farming activities. Purposive selection of four communities – Mkpatak, Adaisim, Ukana and Ikpe based of prior knowledge of their active engagement in oil palm farming.

The second stage was a random selection of (20) of the oil palm farmers from each of the (4) selected communities to get a total of (80) respondents was used for the study. Each member of defined population has an equal chance on being selected and the selection of all members is independent of one another. The self-administered questionnaires that were provided to participants by the researcher were utilized in gathering main data for the study.

Data Analysis

The information was analyzed through descriptive analytics and inferential statistics. Based on the survey questions, the data were examined using statistical software for applied sciences. The replies were summarized and the degree of parallels and disparities will be demonstrated using various statistics, including mean scores, standard deviations, percentages, and frequency distribution The data obtained were subjected to descriptive analysis. Objectives 1, 2, 3 and 4 were achieved using descriptive statistics such as frequency, percentage, mean and likert scale. For objective 3, a 3-point scale is described as follow: Low Adoption (LA) = 1; Adopted but Discontinue (AD) = 2; High Adoption (HA) = 3. The mean score of the respondents based on 3-point scale was computed in this way: 3 + 2 + 1 = 6. Hence, 6/3 = 2 cut off point, which determine whether there was a high level of adoption or not. For objective 4, a five point likert scale was used, where: 1-1.8 is Strongly disagree; 1.9-2.6 Disagree; 2.7-3.4 Neither; 3.5-4.2 Agree; 4.3-5.0 Strongly agree.

RESULTS AND DISCUSSION

Socio-economic Characteristics of the respondents

Socio-economic characteristics of the respondents were considered in this section of the study which included gender, age, educational qualification, marital status, household size, years of experience, major occupation, monthly income, extension contact, membership of cooperative and access to credit.

Table 1. Socioeconomic characteristics of respondents

Variables	Frequency (n = 80)	Percentage (100%)	Mean
Gender			
Male	22	27.5	
Female	58	72.5	
Age			
18-25	15	18.8	
26-33	23	28.7	34.3
34-41	21	26.3	
42-49	21	26.3	
Education qualification			
Non formal education	9	11.3	
Primary	38	47.5	
Polytechnic	18	22.5	
University	15	18.8	
Marital status			
Married	61	76.3	
Single	3	3.8	
Divorced	3	3.8	
Widowed	13	16.3	
Household size			
1-2	33	41.3	
3-4	46	57.5	2.7
5-6	1	1.3	
Farming experience			
1-3	12	15.0	
4-6	26	32.5	7.3
7-9	11	13.8	
10-12	31	38.8	
Major occupation			
Farming only	16	20.0	
Farming with business	64	80.0	
Farm size			
0.1-0.5	73	91.25	0.36
0.6-1.0	4	5.0	
1.0-1.5	3	3.75	
Monthly income			
₦1, 000- ₦50,000	67	83.8	33,125.5
₦50,001-₦100,000	13	16.3	
Extension contacts			
Yes	14	17.5	

No	66	82.5
Membership of cooperative		
Yes	53	66.25
No	27	33.75
Access to credit		
Yes	11	13.75
No	69	86.25

Field survey 2023

4.1.1 Gender

The study shows that 72.5% of the respondents are females while only 27.5% are males. This can be attributed to the fact that women in the rural communities of Essien Udim do more of the farm activities than their male counterparts. Men do other businesses to support their farming activities while most of the women might do solely farming activities. The result agrees Obot et al. (2022) that more women were involved oil palm farming than the male counterpart in the study area.

4.1.2 Age

Age is very important in agricultural production as it determines the physical strength of the individual, and young people tend to withstand stress, put more time in various agricultural operations which can result to increased output (Adeola, 2010). The results presented in Table 1 shows that majority (28.7%) of the respondents fall between 26-33 years, 26.3% were between 34-41 years and 42-49 years while 18.8% were between 18-25 years. The mean age of the respondents was 34.3 years. The result supports Obot et al. (2022) that majority of the respondents are between the ages of 31-40 years in the study area. The finding that the majority of farmers are young and middle-aged is in line with a study conducted by Mogues and Benin (2012) in Nigeria, which found that younger farmers are more likely to adopt modern agricultural practices.

4.1.3 Educational level

The educational level of respondents plays an important role in oil palm farming. According to Oladejo (2010), education is important in achieving high level of management capabilities. The result shows that 47.5% had primary education which is good for the adoption of innovation. 22.5% had polytechnic education, 18.8% had university education and only 11.3 % had no formal education. Given this level of literacy, it is expected that information can be disseminated with ease among the respondents. Inference has been made that farmer education has a beneficial impact on farmers' decisions to use modern technology. A farmer's ability to acquire, analyze, and apply information pertinent to the acceptance of a modern innovation is impacted by his educational attainment (Mignouna et al., 2011). The result Obot et al. (2022) that the respondents in the study area had one form of education or the other.

4.1.4 Marital Status

The marital status indicates that 76.3% of the respondents were married, 16.3% were widowed, 3.8% were single and divorced. The implication is that family labor can substitute for paid labor. It also revealed that 77.3% of the farmers were married, while the rest of the respondents were single, widowed or divorced. This suggests that married individuals focus their efforts on farming activities inorder to feed their families. The result corresponds with Obot et al. (2022) that most of the farmers were married.

4.1.5 Household Size

The result as shown in table 1 indicates that 57.5% of the respondents have family size 3-4 persons, 41.3% have family size of 1-2 persons and 1.0% have family size of 5-6 persons. Family members are also a source of labour in the farms. Greater family size would mean that the cost of paid labour provided by hired labour would be less. The mean household size was 2.7. The result agrees with Obot et al. (2022) that noted that the majority of respondents had house hold size of 1-5 persons.

4.1.6 Farming experience

It is of general opinion that experienced farmers would be more efficient, have a better knowledge of the market situations and are expected to run a more efficient and profitable enterprise (Oluwatayo et al.2008). The result shows that 38.8% of the respondents have 10-12 years farming experience, 32.5% of the respondents have 4-6 years of farming experience, 15.0% of the respondents have 1-3 years farming experience and 13.8% of the respondents have 7-9 years of farming experience. This indicates that most of the respondents have been involved in agricultural activities for quite a long time. The mean value for farming experience was 7.3years. This implies that oil palm farming is done by well experienced farmers. The more years of farming experience, the more knowledge and profits the farmers tends to get, as he/she will use his/her understanding of marketing, market condition as well as product price.

A farmer with extensive farming expertise has a higher tendency to possess the capacity to wisely allocate resource. This result confirms the study of Komolafe et al. (2014); Obot et al. (2022) who showed that greater experience of a farmer will also lead to better knowledge of spatial variability of the field and more accurate assessment of the benefits that comes from adoption of technologies.

4.1.7 Major occupation

A higher percent of the farmers (64.0%) did not take farming activities only as their occupation because of the risk associated with agriculture. Therefore, farming is combined with other businesses. Only 20.0% of the respondents did farming as their only occupation. This poses a problem to the state government agenda to achieve food security.

4.1.8 Farm size

Table 1 went ahead in revealing that 91.25% of the respondents have 0.1-1.0 ha of farmland, 5.0% have 1.1-2.0 haand 3.75% have 2.1-3.0 ha. The mean farmland is 0.68 ha which shows that the farmers are operating on a small scale. The study support Mwangi and Kariuki (2015) who reported a positive relation between farm size and adoption of agricultural technology and stated that small farm size provides an incentive to adopt a technology especially in the case of an input-intensive innovation such as a labor-intensive or land-saving technology. Smallholder farmers who own small plot of land adopt land-saving technologies such as greenhouse technology, zero grazing among others as an alternative to increased agricultural production (Diro, 2013). The result corresponds Obot et al. (2022) that farm size was also relatively low as majority of the respondents (95.00%) operated a small-scale farming. Hence, the finding that the majority of farmers operate on a small scale is consistent with previous research. For example, a study by Afolayan et al. (2017) found that small-scale farming is prevalent in Nigeria due to limited access to credit and other resources.

4.1.9 Monthly farm income

83.8% of the respondents stated that their monthly farm income is N1, 000-N50, 000 while 16.3% of the respondents stated that their monthly farm income is N50, 000 - N100, 000. The mean value of monthly income is N33,125 which shows that the farmers do not really have much from their business and discourages most young people from venturing into the business as a full-time occupation. Since

they have the financial means to take advantage of agricultural advances in order to maximize profit, respondents with access to credit facilities are more likely to use enhanced technology to increase their farm output. Jamilu et al.(2014) stated that if credit is offered under the right circumstances, properly handled production credit may speed up the adoption of better technology by farmers who would rather be unable to use it, hence fostering rapid agricultural development.

4.1.10 Extension contacts

A high percent (82.5%) of the respondents do not have access to extension contacts and it becomes difficult for the transfer/dissemination of innovation and subsequently, the adoption of new technologies. Only 17.5% of the respondents have contact with extension agents.

4.1.11 Membership of cooperative

66.25% of the respondents in the study area belong to cooperative society. This is a welcome development as the cooperative will help its members to secure loans and subsidies as well as relate information to members. 33.75% of the respondents were not members of any cooperative.

4.1.12 Access to credit

Access to credit is important for the development of small and medium enterprise. Credit is required by farmers for the purchase of farm input and financing other range of activities required by the enterprise. Lack of access to financial services is a critical constraint to the establishment or expansion of viable agricultural enterprises. Table 1 indicates that 86.25% of the respondents do not have access to institutional credit while only 13.75% respondents had access to institutional credit. Hence, they resort to personal savings. The low access to credit could be attributed to high interest rate charged by lending institutions which discourages the borrowers. The inadequate capital is a major constraint to small-scale enterprises including farmers in Nigeria (Osondu et al. 2014). This shows that there is very little assistance from the financial institution to farmers in the study area.

Table 2. Respondents according to level of awareness

Variables	Frequency (n = 80)	Percentage (100%)
Aware	47	58.75
Unaware	33	41.25

Field survey 2023

The result in table 2 shows that 58.75% of the respondents were aware of precision agriculture in the study area. This can be attributed to the fact that most of the respondents had formal education which made it easy to get information. Since most of the respondents had formal education, they were receptive to new technologies. 41.25% of the respondents were not aware of precision agriculture. This group finds it difficult to adopt or try new technologies. This agrees with Obayelu et al. (2015) that crop production technologies such tractor pulled implement, herbicide, knapsack sprayer, improved seed and inorganic fertilizer were perceived as effective (0.74), appropriate (0.81), readily available in the localities (0.70), affordable (0.70), durable (0.80), user friendly (0.74) and gender friendly (0.70) and the farmers also had the requisite skills to use them (0.72).

Table 3. Respondents according to stages of adoption

Variables	Mean score	Decision Rule
Awareness stage	2.85	Accepted
Trial stage	2.10	Accepted
Adoption stage	1.47	Rejected

Field survey 2023

Mean scores less than 2 = low level of adoption; mean scores higher than 2 and above = high level of adoption

Table 3 shows the level of adoption of precision agriculture among the rural farmers in the study area. Awareness (2.85) and trial (2.10) stages was the stages where most the respondents in the study area have the highest mean scores. The result shows that the technology with least level of adoption among the rural farmers in the study area was the adoption stage with a mean score of 1.47. The high percent having knowledge of precision agriculture is not surprising as most of the respondents can read and write.

Table 4. Constraints to adoption of precision agriculture

Variables	Mean	Standard deviation	Rank
Lack of land	3.03	1.11	5
Lack of facilities	4.05	1.12	3
Lack of extension contacts	2.86	0.92	6
Lack of information	4.88	0.33	2
Lack of capital	4.94	0.24	1
Low technical knowhow	3.91	0.86	4
Less returns	1.75	0.93	7

Field survey 2023

Table 4 shows the constraints to the adoption of precision agriculture in the study area. Lack of capital is the major constraint that farmers agreed on. The mean value was 4.94 which indicates that the farmers strongly agreed that it was the major one in the study area. Lack of information was the second issue indicated by the respondents as a constraint. The mean value of lack of information was 4.88 which indicates that the respondents strongly agreed on it as a constraint. This result supports Sennuga et al. (2023) who found that 98% of the respondents indicated that "Insufficient information on improved technologies for maize production", "inadequate resources and technical knowledge to implement the recommendations of agronomic research", "inadequate finance", "high cost of labour", "transportation problems", "high cost of inputs", "incidence of droughts" among others were major constraints they are faced when adopting improved maize production technologies. This also agrees with Amaechi and Ossai-Onah (2015) study that proved that unrestricted access to relevant, accurate and timely agricultural information through the proper channels will enable farmers to make appropriate decisions that will lead to agricultural development. Lack of facilities was also another constraint with a mean value of 4.05 which indicates that farmers agreed on it as a constraint. Low technical knowhow has a mean value of 3.91 which indicates that the respondents agreed on it as a constraint. Lack of land was the fifth constraint in the study area. The mean value for this was 3.30 which indicates that the respondents neither agree nor disagree on the issue as a constraint. Lack of extension contacts was a constraint with a mean value of 2.86 which shows that the farmers neither

agree nor disagree on it as a constraint. The last constraint was the less profit with a mean value of 1.75 which shows that the farmers strongly disagree on it as a constraint to the adoption of precision agriculture in the study area.

The result is supported by Amungwa (2018) who identified that inadequate farmers' participation in innovative farming programme and development have been linked to high cost of implication and poor funding, social and cultural misfit technologies/innovations for indigenous farmers. According to Achukwu et al. (2023); Obot et al. (2022) the result showed that the major limiting factors to the adoption of innovation were cost of innovation (mean = 3.74), lack of training on adoption for farmers (mean = 3.53), limited access to credit facilities (mean = 3.48), and inadequate extension service (mean = 3.25). The findings on challenges revealed the participant's agreement to the presented items as limiting factors to the acceptance of agricultural innovations and strategies.

CONCLUSION

Despite agriculture's importance, it has performed below its potential for generations in sub-Saharan Africa, neglected by government policies and held back by low farm productivity. Following age-old practices, African smallholder farmers have long survived by growing crops on reclaimed forest and grazing land or by recycling plots without replenishing their nutrients. Production increases have come from expanding cultivated land area, not from making farming more efficient. The scope for further area expansion is diminishing, and farmers now need to produce more food for each unit of land, with the help of modern technology.

Adoption of precision agriculture by smallholder farmers is still at a nascent stage and is limited by several factors. In addition to high costs of some of the above solutions, other key barriers include the lack of digital infrastructure like Internet and electricity, lack of awareness and digital skills among farmers, and societal barriers like gender. Overcoming these challenges requires cross-sector collaboration among the public and private sectors, civil society, and the academia. Solutions should be user-centred and designed considering the local context such as language, social and political barriers and inclusion challenges. An open approach (e.g., open source, open standards) to designing digital solutions will increase collaboration among stakeholders, ensure interoperability between solutions, and prevent duplication of efforts.

Precision agriculture will allow for the targeting of inputs to specific areas of fields, thus making inputs to be effectively use. Wastage of those inputs will also be prevented thus resulting in reduction of farm expenses and prevention of environmental pollution. High crop yield would be achieved and farmers will have high profit.

This study was carried with the aim of knowing the level of awareness of precision agriculture and the various factors affecting the adoption of improved agricultural technologies by smallholder farmers in Essien Udim rural communities. The outcome of the study showed that most of the farmers were aware of precision agriculture because most of them had formal education. This means that the level of education of smallholder farmers could result to higher rate of agricultural technology adoption.

The constraints to the adoption of precision agriculture, the study also revealed that lack of capital, information, facilities and low technical knowhow were the major constraints identified by the farmers. The availability of agricultural information devices such as radio and mobile phones and adoption of agricultural technology would help farmers to make informed decisions about what crops to plant, where to purchase affordable inputs and which market to sell the produce. Capital should also be made available for farmers to access with ease and at a low interest rate. Facilities that make the adoption and application of PA effective should be made available, accessible and affordable to the farmers.

Finally, lack of digital skills and literacy among smallholder farmers remains a major barrier in leveraging the potential of digital technologies. The public and private sectors can partner with civil society organisations (CSOs) and leverage their on-ground presence (e.g., agricultural extension workers) for delivering hands-on trainings and building digital capacities of farmers. In Nigeria, all these technologies are available and they can be implemented through agricultural training centres by giving training to agriculture officers in these technologies.

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