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Determination of adoption stage of precision agriculture technology among extension workers and crops farmers in Benue state, Nigeria

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Abstract

Major causes of food insecurity are the use of inadequate data on agrarian lands, climate change, high cost of inputs and general insecurity etc. Farmers therefore, need to take informed decision based on accurate and timely data. This study determined adoption stage of precision agriculture technology among extension workers and crops farmers in Benue State, Nigeria. The result shows that the respondents were mature and active with a mean age of 39.12 years. Majority (79.00%) were male and married (81.82%) with a mean income of N 553,072,000 per annum. Many (73.35%) were members of one association or the other with 12.33 mean years of formal schooling. The result further shows that, respondents generally have access (1.87) to precision agriculture technology. Content ($\bar{x}$ =2.96) and nature of precision agriculture technology ($\bar{x}$=2.74) were the most important factors that were perceived to determine its adoption. While 53.29% of the respondents were aware of the existence of precision agriculture technology, 48.28% were aware of the existence of precision agriculture technology and had developed interest in the technology. The Chi-square of 34.02 (df=10) for model coefficient indicated that socio-economic characteristics were statistically and significantly related to adoption of precision agriculture technology, hence the null hypothesis was rejected. The study concludes that extension workers and farmers in Benue State were generally at the awareness stage as far as precision agriculture technology was concerned, though a few had shown interest in the technology. It is therefore, recommended that there should be massive enlightenment on the existence of precision agriculture technology and training and demonstration centres should be established across the state to enable extension workers and crops farmers take full advantage of the potentials of the technology.

Keywords: Determination, adoption stage, precision agriculture technology, crops farmers, extension workers

Introduction

Besides increasing population, Africa and the word over is experiencing various negative effects of climate change (Abdulai & Huffman, 2018) [2]. These effects are greatly hampering agricultural production, farm income, and food security. All these culminates to low economic growth.

According to Clapp, food insecurity results mainly from inequitable distribution of resources and information in the agriculture and food production system. One recently adopted sustainable approach is precision agriculture which combines a number of new technologies to collect and transmit a wide range of field data for effective analysis and intuitive decision making (Njoroge, Fei and Thiruchelvam, 2018) [11]. Precision Agriculture (PA) came into existence since the mid-1980s as the process through which the right treatment is given to the agricultural process at the right time.

According to Synergos (2021) [16], Benue State is the leading producer of soybeans, mangoes, citrus fruits, roots and tubers in Nigeria, producing a diverse range of agricultural commodities on a large scale. Farmers in the state can take advantage of precision agriculture technology with the view to improving productivity and ensuring a food secured state. It is for this reason that this research work was carried out to determine the adoption stage of precision agriculture technology among extension workers and crops farmers and in the state.

Problem Statement

In Nigeria, the Federal Ministry of Agriculture and Rural Development (FMARD) reported that an estimated 53 million Nigerians accounting for 30% of the population were hungry in 2010 (FMARD, 2015). Benue State is acknowledged as Nigeria's primary source of food, but the state has been producing well below its potential (Synergos 2021) [16]. However, despite its immense potentials, farmers in Benue State face several challenges. Outdated farming methods, limited access to finance and markets, inadequate infrastructure, unpredictable weather patterns and insecurity all contribute to lower crop yields and inefficiencies in resource management. Empirical studies suggest that new technologies have positive agronomic, economic and environmental and social effects. Several governments of Nigeria have introduced different farming programmes and policies targeted at improving agricultural productivity to meet the growing demand by the population and agro industries (Olaoye, 2014) [14]. The Nigerian government has recognized the need to modernize the agricultural sector by embracing technology-driven solutions. Precision agriculture (PA) appears to be a major asset in making agriculture an innovative and responsible sector.

Precision agriculture is steadily gaining traction as farmers

adopt innovative tools such as satellite imagery, drones, sensors, and data analytics to make informed decisions about planting schedules, irrigation practices, nutrient management and pest control measures (Synergos, 2021) [16].

In spite of this opportunity, agriculture in the state remains insufficiently modernized to meet current challenges (Food security, problems of productivity and competitiveness, general insecurity etc). Experts agree today that technological innovation is an asset to gain time and precision for the benefit of the farmer, the farm and the environment.

In spite of this huge potential provided by precision agriculture, no research is carried out on the adoption of precision agriculture in Benue State. Albeit a lot of research is carried out in other parts of the nation. For instance, Eni (2022) [7] studied '*Precision Agriculture, The Key To Increased Productivity For Smallholder Farmers in South-East Nigeria'.* Similarly, Abdulwaheed (2019) [3] studied "Benefits of Precision Agriculture in Nigeria, a case for National Centre for Agricultural Mechanization (NCAM) situated at Ifelodun Local Government Area (LGA) of Kwara State". It is this research gap that this research intends to fill.

Materials and Methods

The broad objective of this study is to determine adoption stage of precision agriculture technology among extension workers and crops farmers in Benue State, Nigeria.

Specifically, the objectives of this study are to:

1. describe the socio-economic characteristics of extension workers and crops farmers in Benue State,
2. determine the level of access to Precision Agriculture Technology by extension workers and crops farmers in Benue State,
3. to determine perceived adoption determinants of precision agriculture technology
4. ascertain the stage of adoption of Precision Agriculture Technology among extension workers and crops farmers,

Hypothesis

Based on the specific objectives of this study, the following hypothesis was stated and tested empirically:

There is no significant relationship between socio-economic characteristics of extension workers and crops farmers and adoption of precision agriculture technology.

Materials and Methods

Study Area

The study which was carried out in Benue State adopted a qualitative exploratory design as a research methodology.

Benue State has a land mass of 34,059 square kilometers and lies between Longitude 7° 47' and 10° 0' East, Latitude 6° 25' and 8° 8' North; and shares boundaries with five other States namely: Taraba State to the north, Cross-River State to the south, Enugu State to the south-west and Kogi State to the west. The State also shares a common boundary with the Republic of Cameroon on the south-east (Benue State Government, 2012) [6].

The ecology of Benue State supports extensive arable crop and livestock production as well as fruit, palm, grains, legumes, root and tuber production. Hence, the State is acclaimed the '"Food Basket of Nigeria" (Alakali, 2023) [4]. Benue State accounts for over 70% of the country's soybean yield and also produces large quantities of rice and vegetable such as tomatoes, pepper, okra and so on (Benue State Government, 2012) [6]. The State is equally affected by climate change impacts.

Population of the Study

The population of this study consisted of extension workers and crops farmers in Benue State.

Sample Size and Sampling Technique

A total of three hundred and nineteen respondents were selected as sample size using multistage sampling technique, involving purposive, stratified, snowball and simple random sampling techniques. Firstly, Benue state was divided in to three agro-ecological zones namely, Northern, Eastern and Central zones. Ten large commercial crops farmers were purposely selected in each local government area based on level of crop production. Also, three extension staff were randomly selected from each of the divisional offices of Ministry of agriculture in each local government area. Another ten staff, each were randomly selected from the Benue State Ministry of agriculture headquarters, Makurdi and Benue Agriculture and Rural Development Agency respectively.

Table 1: Sample Size Selection Plan

S/N	Source	Number	Total
1	Crops farmers	10 in each LGA	230
2	Agricultural extension staff	3 in each local government agriculture department	69
3	Benue Agriculture and Rural Development Agency Headquarter, Makurdi	10	10
4	Benue State Ministry of Agriculture Headquarter, Makurdi	10	10
Grand total			319

Method of Data Collection

Data were collected mainly from primary source with the use of a structured questionnaire and interview techniques.

Data Presentation and Statistical Analysis

Data for this study were analyzed using descriptive statistics, such as frequency, percentages and mean as well as inferential statistics which is Logistic regression.

Results and Discussion

Socio- economic characteristics of respondents

Age (years)

Table 2 shows that 24.86% of the respondents were aged 36-45 years. This was followed by 19.71% who were aged 26-35 years. Another 17.25% aged 46-55 years. The results further show that 16.24%, 11.78% and 10.16% aged less than 26 years, 56-65 years and above 65 years respectively.

The mean age was 39.12 years. This result implies that extension workers and crops farmers in the study area were mature in age and were in their active years which indicates their ability to adopt precision agriculture technology and can also perform tasks that require energy to perform. The presence of younger farmers on the farm will positively impact on labour availability. Younger people are generally risk takers and thus adopt innovations faster than the older ones who may be aversive to risks (Tijjani, Bakari, Usman and Adebayo, 2016) [17]. By implication, the respondents may be very innovative and could adopt precision agriculture technology.

Onu and Echebiri (2019) [15] reported that 38.80% of cassava farmers in Owerri West LGA of Imo State were 36 - 40 years old. Similarly, Ezeaku, Ani, Adama, Job, Sule, Onwualu, Nwankwojike, Otoijamun, and Ogbobe (2024) [8] in their study of "willingness to adopt precision agriculture: an analysis of Gombe and Bauchi States of Nigeria" reported that 65% of the respondents were between 21 - 40 years, with only 3% being 51 years and above.

Sex

Table 2 also show that 79.00% and 21.00% of the respondents were male and female respectively. This confirms *a priori* expectation that more men are engaged in most farming activities. This is because of the rudimentary nature of most farming activities. The adoption of precision agriculture technology can be achieved among both male and female farmers as both sexes are involved in agriculture.

This result confirms the finding of Aboajah, Ejechi, Adeyongu, Viashima and Muogbo (2018) [1], where the researchers in their analysis of gender roles among cassava producing rural household under Growth Enhancement Support Scheme (GESS) in Benue State, Nigeria, reported that 70.60% were male and 29.40% were female.

Marital status

Result of marital status (Table 2) shows that most (81.82%) extension workers and farmers in Benue State were married, while 11.60% were single. Another 3.14%, 2.19% and 1.23% were divorcee, widow/widower and separated respectively. This result is not unexpected because, marriage is considered important for matured individuals in Benue state. This result implies that, farmers can cultivate a larger farm size if all other resources are available and affordable. Jointly, they can pull resources together for enhanced adoption of precision agriculture technology.

This also connotes a higher level of social responsibility of the farmers (Maurice, Umar, and Zubairu, 2015) [10]. This result is consistent with Kuponiyi and Bamigboye (2014) [9], who reported that 81.00% of the respondents that used indigenous knowledge systems (IKS) in rice production in Ekiti State, Nigeria were married.

Table 2: Distribution of Respondents Based on Socio-Economic Characteristics (n=319)

Variable	F	%	$\bar{x}$
Age (years)			39.12
< 26	52	16.24	
26-35	63	19.71	
36-45	79	24.86	
46-55	55	17.25	
56-65	38	11.78	
> 60	32	10.16	
Sub-total	319	100.00	
Sex			
Male	252	79.00	
Female	67	21.00	
Sub-total	319	100.00	
Marital Status			
Single	37	11.60	
Married	261	81.82	
Separated	4	1.25	
Widower/Widower	7	2.19	
Divorced	10	3.14	
Sub-total	319	100	
Level of Education (Yrs)			12.33
Non- formal (0)	39	2.82	
Primary (6)	56	17.55	
Secondary (12)	132	41.37	
OND/HND/NCE (14)	90	28.22	
First Degree (16)	20	6.28	
Masters Degree/Post Graduate Diploma (17)	5	1.57	
Doctor of Philosophy Degree (20)	7	2.19	
Sub-total	319	100.00	
Membership of Association			
Yes	234	73.35	
No	85	26.65	
Sub-total	319	100.00	
Household Size (No.)			10.46
< 2	4	1.12	

2-6	48	15.24	
7-11	119	37.33	
> 11	148	46.31	
Sub-total	319	100.00	
Farming Experience (years)			14.53
< 5	2	0.63	
5 to 10	80	25.16	
11 to 15	29	9.09	
>15	208	65.12	
Sub-total	319	100.00	
Crop Farm Size (Hect.)			3.4
< 2	97	30.41	
2-5	160	50.16	
6-9	49	15.36	
10-13	8	2.50	
>13	5	1.57	
Sub-Total	319	100.00	
Average Annual Income (N'000.00)			533,072
≤ 300	75	23.51	
301-400	15	4.71	
401-500	10	3.13	
501-600	8	2.51	
> 600	211	66.14	
Sub-Total	319	100.00	
Access to credit			
Yes	70	30.23	
No	160	69.77	

Source: Field Survey, 2024

Level of education

Table 2 shows that 97.18% of the respondents had one form of formal education or the other in Benue State. A breakdown shows that a greater number (41.37%) had secondary education, 28.22% had sub- degree education (Ordinary National Diploma/Higher National Diploma/National Certificate in Education) and 17.55% had primary education. Another 2.19% and 1.57% had Doctor of Philosophy Degree and Masters Degree/Post Graduate Diploma respectively. The mean year of educational level was 12.33 years. This result implies that the training on the use of precision agriculture technology tools such as GPS can be achieved since the respondents were literate enough. This result is similar with the findings of Onu and Echebiri (2019) [15], who reported that more than 80% of their respondents (farmers) in Oweri, Nigeria, were literate.

Membership of association

Table 2 shows that 73.35% of the respondents were members of one form of association or the other in Benue State, while 26.65% of the respondents did not belong to any association. This implies an increased adoption of precision agriculture technology since it will be communicated through a common frame of reference. Many farmers become aware of innovations through their various associations. Similarly, Adekunle (2018), in the study of "Effect of membership of group-farming cooperatives on farmers food production and poverty status in Nigeria" reported that more than half (57.74%) of the respondents belonged to one form of cooperative society or the other.

Household size

Table 2 shows that a greater number (46.31%) of the respondents had a household size greater than 11 persons. Another 37.33% had between 7 and 11 persons in their house hold. Table 2 also shows that, 15.24% and 1.12% had a household size of 2- 6 persons and less than 2 persons respectively. The mean household for the respondents was 10.46. According to Adamu and Bakari (2015), large family size could be viewed as an added advantage in terms of family labour supply, and thus production may be enhanced. This result agrees with the findings of Onu and Echebiri (2019) [15], who reported that about 78% of the farmers had household size of between 1-10.

Farming experience

Table 2 shows that majority (65.12%) of the respondents had farming experience more than 15 years. Another 25.16% had between 5 and 10 years farming experience. Another 9.09% had farming experience between 11 and 15 years. The remaining 0.63% had a farming experience of less than 5 years. The mean farming experience was 14.53 years. This indicates that most of the farmers in the study area have good knowledge of farming, implying that the respondents had adequate experience in farming. Farmers with higher experience may have better access to information and could be in a better position to evaluate new technology for adoption.

Crop farm size

Table 2 shows that 50.16% had a farm size of 2-5 hectares. This is followed by those (30.41%) with a farm size of less than 2 hectares. Another 15.36%, 2.50% and 1.57% had farm sizes of 6-9 hectares, 10-13 hectares and more than 13 hectares respectively. The mean farm size is 3.4 hectares. Although, and this may not encourage mechanization system of farming and thus, production may continue to remain at subsistence level, adoption of precision agriculture technology may not be negatively affected since the farmers have been looking for ways to improve their

productivity hence income. Similarly, Aboajah, Ejechi, Adeyongu, Viashima and Muogbo (2018) [1] in their study of 'Gender Roles among Cassava Producing Rural Households under Growth Enhancement Support Scheme (GESS) in Benue State, Nigeria' reported that Many (55.6%) of the respondents had farm size less than 5 hectares. JAEESJES Vol.4 No. 1 2018, Pages 12.

Average annual income

Data in Table 2 shows that majority (66.14%) of the respondents more than N600,000.00 per annum from their crop farm. Another 23.51% realized less than N300,000.00 per annum. The other 4.71%, 3.13% and 2.51% realized between N301,000.00 to N400,000.00, between N401,000.00 to N500,000.00 and between N501,000.00 to N600,000.00 respectively. The mean income of Benue farmers was N 533,072.The implication of the result to this study is that, given the right orientation, farmers will be willing and able to at least pay for precision agriculture technology, if convinced that the technology will actually lead to an improvement in their productivity. This is not consistent with Odoemenem and Otanwa (2011) [12], where the researchers economically analyzed cassava production in Benue State, Nigeria and reported that majority (41.40%) of their respondents earned between N50,000 and N100,000 in a year. The difference may be as a result of the difference in time of the researches. The prices of farm produce is now generally higher hence income of farmers.

Access to credit

Table 2 shows that only 30.23% of the farmers in Benue State had access to credit, the remaining 69.73% did not have access to credit. This suggests that most of the farmers do not have farm credit for production. Low access to credit adversely affects productivity because it leads to low capital investment.

Level of Respondents' access to Precision Agriculture Technology

Entries in table 3 show that 44.95% of respondents had low level of access to precision agriculture technology, 30.60% had moderate level of access to precision agriculture technology. A smaller 24.45% had low level of access to precision agriculture technology. The mean score of level of access to precision agriculture technology is 1.87. This implies that the respondents generally have access to precision agriculture technology.

Having access to precision agriculture technology by the respondents could be as a result of the high income obtained by respondents.

Table 3: Level of Access to Precision Agriculture Technology n=319)

Level of Access*	Freq.	%	$\bar{x}$
			1.87
High	98	30.60	
Moderate	78	24.45	
Low	148	44.95	
Total	319	100.00	

Source: Field Survey, 2024

*Level of access to precision agriculture technology was measured using the following indicators;

Availability of enough network supply,
Availability of precision agriculture technology tools,
Possession of skill and knowledge for use of precision agriculture technology tools,
Physical access (ability to go to purchase centre) and
Economic access (ability to pay for the tools).

Perceived Adoption Determinants of Precision Agriculture Technology

Table 4 shows that content ($\bar{x}$ =2.96) and Nature of precision agriculture technology ($\bar{x}$=2.74) were the most important factors that were perceived to determine its adoption in Benue State. The nature may have been in terms of accessing precision agriculture technology at low cost and profitability of output. The nature of precision agriculture technology will influence its adoption in Benue state. Farmers and extension workers are always looking for ways to improve their productivity at cheaper labour cost and improve on their job performances respectively. These could be partly responsible for the increased adoption of this technology in some places. This was followed by complexity (ease of understanding the technology) ($\bar{x}$=2.62). Farmers that are exposed to this technology did not find it difficult to use the technology. This may be because of the level of education of the respondents and maybe because they have been previously exposed to similar technologies at home and in their work places. Compatibility (precision agriculture technology fits in to the existing culture and practise) ($\bar{x}$=2.55) will also greatly influence its adoption as the techonology does not violet any existing norm or practice. Income of farmers ($\bar{x}$=1.99) and cost of tools ($\bar{x}$=1.79) are perceived not to determine adoption of precision agriculture technology in Benue State. Observability (the results of precision agriculture technology are easily seen and felt) ($\bar{x}$=1.40) and distance to purchase centre ($\bar{x}$=1.23) are perceived not to determine the adoption of precision agriculture technology.

The implication of this result is that technology attributes are significant determinants of farmers' adoption of an innovation. It also implies that: the farmers will adopt a technology/innovation if there is a comparatively advantageous and profitable. When adoption and non-adoption are discrete, that is, mutually exclusive, farmers would choose to adopt a new technology if the expected profit from such technology is likely to exceed the expected profit without the technology (Asiabaka and Owens, 2002) [5]. Farmers would adopt the technology/innovation if it is simple and farmers would also adopt innovation if it is cheap for them to afford.

Table 4: Rank ordered Distribution of Perceived Adoption Determinants of E-wallet system (n=319)

Factor	$\bar{x}$	Rank
Content	2.96*	1st
Nature of e-wallet	2.74*	2nd
Complexity	2.62*	3rd
Compatibility	2.55*	4th
Income of farmers	1.99	5th
Cost of tools	1.79	6th
Observability	1.40	7th
Distance to redemption centre	1.23	8th

Source: Field Data, 2024

*Very important determinant ($\bar{x} \geq 2$)

Adoption Stage of Precision Agriculture Technology

Table 5 shows that 53.29% of the respondents were aware of the existence precision agriculture technology. Also, 48.28% were aware of the existence precision agriculture technology and had developed interest in the technology. The table also shows that 23.51% had evaluated the technology in terms of its potential benefits, cost, relative advantage, compatibility with existing norms etc. This result shows that farmers and extension workers in Benue State were generally at the awareness stage as far as precision agriculture technology was concerned. The result also implies that as more people are exposed to Precision agriculture technology, more will develop interest in the technology and will therefore evaluate and subsequently adopt the technology.

Table 5: Adoption Stage of Precision Agriculture Technology in Benue State n= 319

Adoption Stage of Precision Agriculture Technology*	F	%
Aware of the existence of precision agriculture technology	170	53.29
Interest in precision agriculture technology	154	48.28
Evaluation of precision agriculture technology	75	23.51
Trial of precision agriculture technology	3	0.94
Adoption of precision agriculture technology	2	0.63

Source: Field Data, 2024
Multiple responses

Influence of Socio - economic Characteristics on Adoption of Precision Agriculture Technology

Hypothesis

There is no significant relationship between socio-economic characteristics of extension workers and crops farmers and adoption of precision agriculture technology.

The chi-Square of 34.02 (df=10) indicated that socio-economic characteristics were significantly related to the rate of adoption hence the null hypothesis was rejected. Specifically, the result shows that membership of cooperative, crop farm size, access to credit and farm experience were significant factors that influence the rate of adoption of precision agriculture technology.

Table 10: Logit Regression of the Influence of Socio - economic Characteristics on Adoption of Precision Agriculture Technology

Socio-economic characteristics	B	S.E.	Wald	Df	Sig.	Exp(B)
Membership of cooperative	-1.223	0.427	6.953*	1	0.008	.324
Household size	0.110	0.052	4.378**	1	0.036	1.116
Farm experience	0.041	0.024	2.923***	1	0.087	1.043
crop farm size	0-.223	0.090	6.099*	1	0.014	.800
Access to credit	1.054	0.467	5.088**	1	0.024	2.870
Constant	1.531	1.084	1.993	1	0.158	4.623
Chi-square	34.02 (df= 10)				0.000	

Source: Computer print out from Field Data, 2024
*Statistically significant at 1% level of significance
**Statistically significant at 5% level of significance
***Statistically significant at 10% level of significance

Conclusion and Recommendations

Conclusion

The study established that the respondents were mature in age and were in their active years which indicates their ability to adopt precision agriculture technology and can also perform tasks that require energy to perform. The result implies that the respondents may be very innovative and could adopt precision agriculture technology. Majority of the respondents were male and married. The marital status connotes a higher level of social responsibility of the farmers as reported by Maurice, Umar, and Zubairu (2015) [10]. The study further established that the training on the use of precision agriculture technology tools such as GPS can be achieved since the respondents were generally literate. Most of the respondents were members of one form of association or the other. This implies an increased adoption of precision agriculture technology since it will be communicated through a common frame of reference. Many farmers become aware of innovations through their various associations. Most of the farmers in the study area have good knowledge of farming, implying that the respondents had adequate experience in farming. This creates room for a better position to evaluate new technology. With the mean income of the respondents been N 533,072, the respondents will be able to purchase precision agriculture technology tools, even when most of them have limited access to credit.

On the level of respondents' access to precision agriculture technology, respondents generally have access to precision agriculture technology. This could be as a result of the high income obtained by respondents. The result shows that that technology attributes are significant determinants of farmers' adoption of an innovation.

The study established that farmers and extension workers in Benue State were generally at the awareness stage as far as precision agriculture technology was concerned.

Finally, it is established that the socio-economic characteristics of the respondents were significantly related to the rate of adoption of precision agriculture technology, hence the null hypothesis was rejected.

Recommendations

Based on the findings of this research, the following recommendations were made:

1. There should be massive enlightenment on the

existence of precision agriculture technology.
2. Training and demonstration centre should be created by the government in partnership with the private sector on the use of precision agriculture technology.
3. Government should step up efforts at ensuring that farm inputs are distributed on time. This is a major problem with precision agriculture technology.

Contribution to Knowledge

1. The study established that extension workers and crops farmers were aware of the existence of precision agriculture technology.
2. The study, against *a priori* also established that extension workers and crops farmers in Benue State can actually afford precision agriculture technology

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