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WILLINGNESS TO ADOPT PRECISION AGRICULTURE: AN ANALYSIS OF GOMBE AND BAUCHI STATES OF NIGERIA

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Abstract

Adoption of Precision Agriculture (PA) technologies has apparent benefits for agricultural production management, cost savings, and environmental sustainability. However, these technologies are also extremely complicated and influenced by various social and economic forces, which impact their adoption rate, particularly in developing nations. Demographic and agricultural characteristics also play an important role in determining willingness to adopt PA. This study is a survey aimed at establishing the willingness indices of farmers and other relevant personnel to embrace precision farming technologies in Gombe and Bauchi states of Nigeria. The survey included individuals of varied ages; but an average age of 28.5 years for Gombe and 36.5 years for Bauchi, educational levels, and employment statuses, as well as agricultural and operational features. The willingness to adopt PA is high in both states, with 92% in Gombe and 96% in Bauchi. The findings suggest that, while high costs and a lack of technical know-how had a negative impact on readiness to adopt PA in both states, the level of complexity was rated higher by the older generation in Bauchi state, which had a comparatively high mean farmer age. The size of the farm and the number of employees had no direct influence on the adoption of PA technology. Other criteria, such as age and number of years of operation, indicate overlap between the various stages of internet and digital technology adoption, mechanization, and PA. The high willingness rating indicates that farmers are willing to adopt PA technologies if made accessible. It is therefore advised that legislative tools, training programs, and necessary access to financing facilities be employed to make these technologies available and cheap for farmers.

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1.0 INTRODUCTION

One of the problems of sustainable agriculture is optimizing production and maximizing farm income while using less resources and financing [1]. Precision agriculture is the evolution of core cultural practices across time, beginning with small-scale family farms. Traditional farmers observed spatial and temporal field variables and monitored their effects on crop yield [2]. This knowledge is utilized to make site-specific decisions about farm management in order to maximize production. While farmers' aspirations of increased production, higher income, and a healthier environment have remained constant, the technologies used to achieve these goals have changed dramatically [1].

These small-scale farmers achieved their goal by making the same site-specific management decisions,

such as observing differences in soil compaction, weed density, field topography, and so on. The implementation of site-specific management results in increased profitability, improved crop quality, cost savings, and reduced environmental impact [3, 4, 5, 6]. However, the spatial and temporal heterogeneity seen by smallholders, as well as the treatments, were not quantified, preventing the entire process from being replicated. While farmers in developing countries have been reaping the benefits and possibilities of PA technology for more than two decades [7, 8], its adoption in Sub-Saharan Africa is limited [9]. Aside from a few yield monitors in South Africa and some variable rate application (VRA) fertilization in remote plantations, the deployment of PA in African countries remained mostly unknown [10]. With the rapid increase in technological application to agricultural development, new and relevant agricultural practices are being widely implemented in various countries around the world where food production is the primary source of income and livelihood to meet increasing constraints on land use and the environment [11, 12]. However, these methods and cutting-edge information are getting more complex and harder to incorporate into existing frameworks [13, 14].

As [15] put it, PA is an agricultural system approach that demands a high level of expertise. Agricultural practices are fast transitioning to a more information-based and complex in considerations of the recent economic and environmental impacts. The use of data obtained from unmanned aerial vehicles (UAVs) and satellites through remote sensing is becoming an increasing requirement for farm management and PA [16, 17, 18, 19]. Despite the promised impact and accrued positive features of precision agriculture technology, they are still not widely adopted even in developed countries [20]. Previous studies on the adoption of precision agriculture have shown economic factors as a major contribution to the employment of various smart devices and precision agriculture technology [21, 8]. The major economic precursors of the deployment of smart devices and precision agriculture technologies are cost reduction through efficiency and productivity, environmental consideration and sustainable farming practices, potential for increased profits and higher yields, and access to data-driven insights for better decision-making. Perceptions of net benefit, farm size and farmer educational levels have also shown a positive influence on to willingness to adopt precision agriculture technology [22]. Other studies indicate that larger operations are more likely to adopt precision agriculture technologies, suggesting that economies of scale exist among farmers [23]. In all these, very little if any, has been reported on the willingness of Nigerian farmers to adopt this system of farming. The objective of this study therefore, was to determine the willingness indices of Nigerian farmers to adopt PA technologies, using Gombe and Bauchi States as case studies.

2.0 METHODOLOGY

2.1 Study Area

The study area comprises agricultural zones in Gombe (Latitude: 10.2500 Longitude: 11.1667) and Bauchi (Latitude: 10.5000 Longitude: 10.0000) States in Nigeria; both States in the northeastern region of Nigeria. Majority of the people in both States work in agriculture, with primary crops grown being maize, sorghum, groundnuts, millet, beans, rice, and tomatoes. The farmers in these states equally engage in livestock farming. Several agricultural development initiatives including some supported by the World Bank have been implemented in the states. The agricultural sectors in these states hold great economic potential [24]. The survey sample population was determined using the Taro Yamani Sampling technique [25].

2.2 Survey Questionnaire

A field survey was carried out to determine the willingness and adoption indices respectively of the Nigerian farmers on precision agriculture. The main instrument used in the survey was questionnaire . The survey included a characterization of the farm/enterprise feature within the region. It also covered the technology-related features used in the farms, including willingness indices to accept and adopt Precision Agriculture (PA). The sample population included agricultural stake holders such as students, researchers, marketers, fabricators and farmers, and questions cut across willingness to adopt, receive training, acquire equipment, invest and disseminate precision agriculture. Other types of data collected included background of the farmers, crop enterprise, size of farm, level of mechanization and application of digital devices, benefits of PA, etc. The questionnaire were in open-ended format for ease of completion and administered to Nigerian farmers, relevant research institutes and researchers. Data gathered were analyzed using descriptive statistics to determine the percentage, mean, and standard deviation. This was done to derive various indices and variables indicating the willingness to adopt PA of the respondents across the population distribution in the study area.

3.0 RESULTS AND DISCUSSION

3.1 Sample Description and Technology Features

The study area as indicated, comprises agricultural zones within local government areas in Gombe and Bauchi States, Nigeria. The total number of respondents, N = 749, with 343 from Gombe State and 406 from Bauchi State. Tables 1 and 2 show the distribution of those respondents across local government in the States.

Table 1: Population distribution of respondents in Gombe State

Agricultural Zones							Total
Northern Zone Local Govt. Area			Central Zone Local Govt. Area		Southern Zone Local Govt. Area		
Kwami	Funakaye	Dukku	Akko	Yamaltu Deba	Billiri	Balanga	
53	50	48	51	49	48	44	**343**

Table 2: Population distribution of respondents in Bauchi State

Agricultural Zones										Total
Northern Zone Local Govt. Area				Central Zone Local Govt. Area		Western Zone Local Govt. Area				
Kata-gum	Shira	Jama'are	Misau	Ningi	Ganguwa	Bauchi	Alkaleri	Bogoro	T/Balewa	
41	49	39	46	47	45	50	47	29	13	**406**

The total number of responses from the survey questionnaire was 749. In Gombe State, as shown in Table 3 below, an overwhelming majority of them are male, 86%. 94% of the respondents were farmers with the next in size being extension service workers 5%. The largest share of age was between 21 – 40, which makes up 65% of the total, with only 3% being 51 years and above. This shows that the farming population across the states is relatively young. Respondents from Bauchi State were made up of a larger percentage of females than Gombe, that is, 20%. 87% of the respondents were exclusively involved in farming activity, 7% were extension service workers, while 6% were engaged with other related activities. There is also a difference in the age demographic characteristics of the Bauchi respondents, respondents between age bracket 51 – 60 years is 11% while that of Gombe is 2%.

Furthermore, the percentage age bracket between 41 – 50 years in Bauchi is 24% while Gombe is 16%. This reveals a relatively older farming population in Bauchi State. The majority of the overall population were farmers by profession, with over two-thirds of the total respondents being fulltime farm workers, with only about 15% of them without any formal education. Primary and secondary educational levels amongst the population were 21% and 14% respectively for Gombe, with 50% having tertiary educational degrees, with Bachelor's and Master's degrees making 13% and 0.3% respectively. None indicated as having a Doctorate. This indicates that about half of the population should be conversant with internet technology. In Bauchi State, a relatively lower percentage of the respondents, 64%, are fulltime farmers, compared to Gombe. Primary and secondary educational levels amongst the population are 15% and 27% respectively with 42% having tertiary education degrees, with no Master's or Doctorate.

This indicates a lower educational profile among the Bauchi state/State respondents. Table 3 shows the mean and standard deviation value of various demographic and farm variables for both states. The survey participants included farmers, extension service workers, and supervisors of Ministries, Departments and Agencies (MDA), manufacturers/dealers and other agricultural professionals.

Table 3: Descriptive statistics and correlation between study variable (respondents) from the states; Gombe and Bauchi States: N = 749)

	Variable	Mean		Standard Deviation	
		Gombe	Bauchi	Gombe	Bauchi
1	Age[a]	28.5	36.5	15.04	2.91
2	Sex[b]	1.86	1.8	.35	.4
3	Educational Level[c]	4.39	3.66	1.36	1.20
4	Employment Status[d]	1.69	1.58	.46	.65
5	Farm size[e]	1.74	1.81	.78	.95
6	Work experience (years)[f]	2.39	2.47	1.11	1.56
7	Number of employees[g]	1.44	1.73	.74	.98

Note: Reliability of scales where appropriate are presented in the diagonal (Cronbachs alphas)

[a] 15.5 = < 20 years, 25.5 = 21 – 30 years, 35.5 = 31 – 40 years, 45.5 = 41 – 50 years, 55.5 = 51 – 60 years, 65.5 = > 61 years

[b] 1 = female, 2 = male

[c] 1 = No formal education, 2 = Primary / elementary school, 3 = Middle / secondary school, 4 = National Diploma (ND), 5 = National Certificate in Education (NCE), 6 = Higher National Diploma, 7 = Bachelor's Degree, 8 = Master's Degree, 9 = Doctorate Degree

[d] 1 = part time, 2 = fulltime

[e] 1 = ≤ 2 ha, 2 = 3-9 ha, 3 = 10-20 ha, 4 = 21-30 ha, 5 = ≥ 31 ha

[f] 1 = <5, 2 = 5-14, 3 = 15-24, 4 = 25-34, 5 = 35-44, 6 = > 45
[g] 1 = 1-5, 2 = 6-10, 3 = 10-20, 4 = 21-35, 5 = 36-50, 6 = over 50

Majority of the farm produce from these farms are sold within the state as shown in Figure 2, with others sold within the farmstead, few transported to other states, especially for Bauchi; and close to nothing has been packaged and exported. This indicates a general small-scale agricultural engagement across the two states. As shown in other surveys, farm size affects willingness to adopt Precision Agriculture thus, these are potential factors for low adoption of Precision Agriculture. Precision Agriculture could also facilitate other tertiary agricultural activity like marketing, therefore the lack of adoption of these technologies also pose an impedance to the medium for translating farm proceeds to the market.

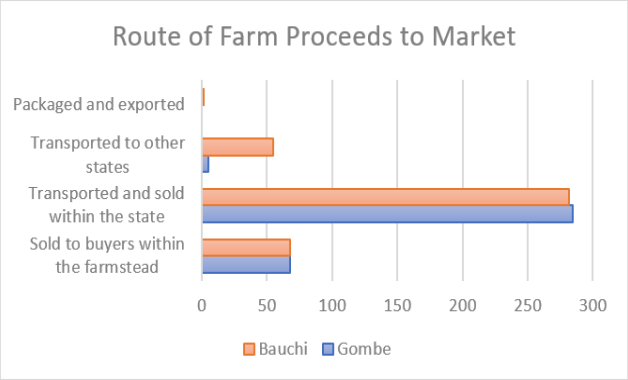

Figure 2: Channel of farm product access to the market

Figure 3: Planting season characteristics across Gombe and Bauchi States

The use of irrigation systems is also very low, constituting only 3% of mechanized operation in Gombe, and 1% in Bauchi states. Therefore, most of the farmers operate rain-fed agriculture. Figure 3 shows that only 2% plant during the dry season, using irrigation. This affects productivity as all-year plant cultivation is not implemented across the states. Most of the seeds used are also from previous harvests with only 9% being genetically modified as shown in Tables 4 and Figure 4. This could either be a result of a lack of exposure to advanced seed materials and research proceedings, or a reluctance and stigmatization to the use of genetically modified seed. This might indicate a willingness or otherwise considering other factors to the adoption of the proceeds of recent or non-traditional technology and resources.

Table 4: Planting season and seed type characteristics across Gombe and Bauchi States

Planting seasons	**Both States (%)**
a. Rainy season only	78
b. Dry season (irrigation/fadama) only	2
c. Rainy and dry seasons	20
Type of seeds planted	
a. Genetically modified (GMO) seeds	9
b. Selected from previous harvest	91
c. Others	0

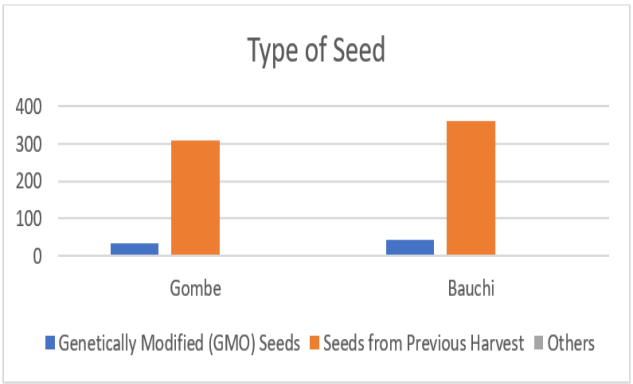

Figure 4: Indication to type of seed used in crop plantation

The level of mechanization is a potential index to show exposure to recent technological farming procedures. This also might indicate inclinations towards relevant internet and computer technology. The survey as indicated in Table 5, shows that none of the participants had any degree of exposure to solar-powered technology, or any other form of mechanization aside from manual, animal and engine technology. Over two-thirds of the farmers in Bauchi make use of human labour/manual operations with 30% making use of animal-powered technology, none of them makes use of engine-powered technology. On the other hand, in Gombe State, there is a faint application of engine-powered technology, but a majority still apply human labour/manual operations. Most of the applications of animal technology used are either as supplements to tractors or because they are cheaper to use. This demonstrates a financial impedance to the adoption of engine-powered technology since only about 8% indicated the

unavailability of tractors as a hindrance to mechanization.

Table 5: Level of mechanization in Gombe and Bauchi States

1	**Level of mechanization in farm operations**	**Gombe (%)**	**Bauchi (%)**
	a. Human labour/manual	57	70
	b. Animal technology	40	30
	c. Engine-powered technology	3	0
	d. Solar powered technology	0	0
	e. Others. Specify	0	0
2	**Tillage operations engaged in animal technology**		
	a. As a supplement to tractors	45	38
	b. Animal technology cheaper than tractors	39	45
	c. Animal technology more suitable for the nature of soil and type of crop	9	7
	d. Tractors not easily available	7	10

Tractors and Ploughs are the major equipment and machines used on the farm, with spraying equipment having a significantly large application among Gombe State farmers. Harrows are also in little application among Bauchi State respondents as Threshers is to Gombe State respondents. As shown in Table 6, ridging is by far the most engaged tillage practice used in farm operations amongst the survey population, with hallowing either alone or alongside other farming operations being the next significant tillage practice this can be seen in Figure 5.

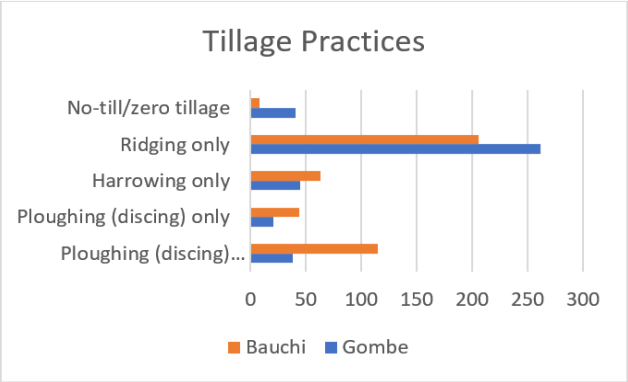

Figure 5: Tillage practices in Gombe and Bauchi States

Table 6: Tools and machinery used in tillage operation in Gombe and Bauchi States

1	**Tools/machines currently used in the farm**	**Gombe (%)**	**Bauchi (%)**
	a. Tractors	24	23
	b. Ploughs	30	39
	c. Harrows	3	12
	d. Threshers	11	6
	e. Planters	1	3
	f. Harvesters	0	3
	g. Spraying equipment	28	13
	h. Irrigation system	3	1
	i. Others. Specify	0	0
2	**Tillage practices used in operations**		
	a. Ploughing (discing) followed by harrowing	9	26
	b. Ploughing (discing) only	5	11
	c. Harrowing only	11	15
	d. Ridging only	64	47
	e. No-till/zero tillage	10	2
	TOTAL		

The exposure to the practical application of Precision Agricultural technology is even much lower as shown in Table 7, with less than one-tenth having seen the operation of the PA technology they are conversant with. The greatest practical exposure to PA is in Tillage, Planting, Fertilizer application, and Herbicide and Insecticide application, with Gombe state showing a relatively higher percentage exposure in the overall application of PA technology.

Table 7: Farming operations with application in the area of knowledge or conversance with PA technologies (percentage of the total; N = 749)

Operations where the PA technologies you have seen or conversant with are being used	**Gombe**	**Bauchi**
Tillage	5%	7%
Planting	3%	4%
Fertilizer application	5%	3%
Herbicide application	4%	1%
Insecticide application	4%	2%
Harvesting	3%	1%
Transportation	3%	1%
Processing	1%	2%
Animal husbandry	1%	2%
Soil sampling and mapping	0.3%	1%
Yield mapping	0.3%	0.2%
Data storage and transfer	0%	0.5%
Others	0%	0%

The use of Information and Communication Technology (ICT) is a vital component of the Precision Agriculture architecture. However, the major application of ICT among the survey population is in official record keeping, data report and planning (farmer logbook), soil nutrition plan, land utilization, with a minimal application in farm management. There is generally little or no application of ICT in other areas relevant to Precision Agriculture. Table 8 shows that even such application of ICT in farm operation formally stated is relatively low with not more than 17% application in any ICT activity. Table 12 shows the distribution of these across the states.

Table 8: Application of information and communication technology (ICT) across farming activities

Which activities do you use information and communication technology (ICT) for?	**Gombe**	**Bauchi**
Official record keeping, data report and planning (farmer logbook), soil nutrition plan, land utilization, etc).	17%	13%
Farm management	7%	8%
Food traceability, processing and safety	0.6%	1%
Forecast (weather, plant protection, pests), risk mitigation.	0.6%	2%

Precision farming, cultivation, production technologies	3%	0%
Market access, e-commerce, input purchase, sale of product	0.3%	0.5%
Others	0%	0.2%

There seems to be an overlap across stages of adoption of Internet and Communication Technology (ICT) and mechanization, illustrated in Table 9. While characteristically, Gombe state/State has a relatively smaller farm size and the number of workers, they indicate employing mechanization more, while Bauchi state/State has a larger number of their enterprises in the online space (having a website). This can be understood by considering that the proportion of farm size and the number of workers in Bauchi is disproportional such that the lack of mechanization constitutes some amount of increased workforce. Gombe State also exhausts all its products in the local market with only a minimal amount transported to other states with none packed and exported, this might explain the lack of online presence among the farmers. Thus size of the farm and the number of workers don't seem to have a direct impact on the adoption of PA technology. Positive influence of farm size and farm income, affordability and profitability of equipment and characteristics of technologies; complexity and compatibility, on the probability of technological adoption have been shown in other works [26, 13] also indicated that the adoption of PA, which is usually not an immediate activity is affected by a wide variety of variables including farmer's characteristics, farm structure, location, organization and institutional factors and information-related factors.

Table 9: Respondent's indication to questions on ICT and mechanization; knowledge and use

Questions	Gombe	Bauchi
Does your enterprise have a website?		
a. Yes, please provide the URL	10%	17%
b. No	90%	83%
Have you heard of the term mechanization?		
a. Yes	93%	70%
b. No	7%	30%
Have you used any mechanization devices in your agricultural operations?		
a. Yes	81%	63%
b. No	19%	37%
If yes to the question above, which operations have you applied to the mechanization system?		
a. Bush clearing	7%	12%
b. Tillage	31%	25%
c. Fertilizer application	16%	11%
d. Weeding	7%	7%
e. Spraying	30%	31%
f. Harvesting	3%	8%
g. Trailing	0%	1%
h. Product processing	8%	4%

3.2 Willingness of Respondents to Adopt Precision Agriculture

The willingness to adopt Precision Agriculture in the study area is very high despite a low knowledge about it. In Gombe State, the percentage willingness to adopt increased by 92 – 95% with the possibility of potential benefit over the application of PA technology and digital devices. In Bauchi State, there is a percentage drop in the application of PA over benefit accrued with usage, this might be a result of the relatively lower knowledge or conversant to PA, making participants more likely to respond positively to a question with detached relevance to them, but more considerate when it deals with the actual and practical engagement with the object of the question as illustrated in Table 10.

Table 10: Willingness of respondents in percentage across Gombe and Bauchi States

Willingness Status of The Respondent	Gombe	Bauchi
Will you be willing to adopt precision agriculture technologies in your farm business?		
a. Yes	92%	95%
b. No	8%	5%
Would you adopt precision agriculture technologies and digital devices if you tried them long enough to see the benefits?		
a. Yes	95%	88%
b. No	5%	12%
If no to question 14 above, what is/are your reasons?		
a. High cost	64%	53%
b. Lack of technical know-how	34%	38%
c. Too complex for older generation	2%	10%
d. Others. Specify		

Willingness to adopt PA is high in both states; 92% and 96% in Gombe and Bauchi respectively. The difference in exposure to PA across the states can be accounted for by the age and educational demography of the respondents in the states. The greatest impedance to the adoption of PA technology is finance, with two-thirds of Gombe respondents indicating high cost as a reason for lack of willingness to the adoption of Precision Agriculture despite having greater access to credit facilities compared to Bauchi State respondents as shown in Figure 6. Among Bauchi farmers, there is a greater reluctance due to lack of technical know-how, this is expected since there is a lower educational profile among the respondents. The age demography of Bauchi is also reluctant as a barrier to the adoption of PA since they have a greater population of farmers that are 41 years or above. Thus there is a fivefold indication of percentage unwillingness to adopt PA due to the complexity to the older generation than in Gombe State. The overall willingness to engage in other PA-related activities like training, research, attending seminal, form co-operative, market and disseminating information were very high. There were also positive

indications to owning, renting, investing and funding PA technologies.

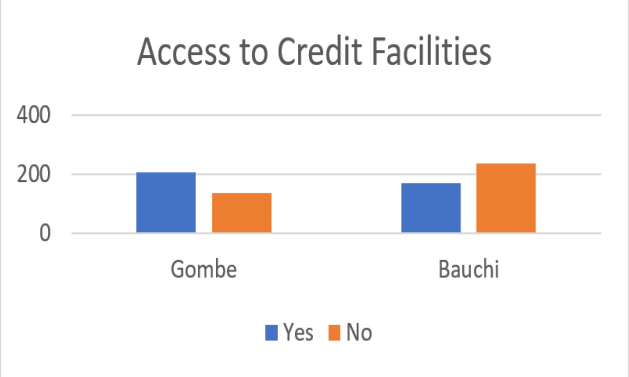

Figure 6: Access to credit facilities across Gombe and Bauchi States

Global positioning system (GPS) receivers are the most conversant among the respondents with 37% in Gombe and 17% in Bauchi State, knowledge about any other PA technology is below 10% (Source: field survey data processed by the authors.). Aside a considerable knowledge or conversance with Differential Global Positioning System (DGPS), Geographic Information System (GIS), Smart Farming and Mobile Phone Applications, there is little to no knowledge or conversance with other Precision Agriculture Technology. Table 11 shows the percentage application of any of these PA technology across the states. Comparing the demographic data with the level of adoption of digital devices, ICT, mechanization and PA across the states, the population's mean age and work experience is rather a considerable factor in the adoption of PA technology. Older farmers who are more conversant with their traditional farming methods would be more reluctant to change and accommodate new and complex technology than younger farmers who are still early in their farming enterprise.

Table 11: Response to the use of any PA technology in farming operation

In your farming operations, do you use any of the PA technologies?	Gombe	Bauchi
a. Yes	32%	17%
b. No	68%	83%

Most of these technologies require the acquisition and transfer of specific information, high technical skills, and practical exposure. This requires that a learning process like seminars, workshop and extension services usually precedes the adoption decision, in which the farmer assimilates information or engage in experimentation over a given time. The survey participants showed high interest and willingness to engage in the learning process for PA adoption as shown in Table 12 below. There is also a high estimation of capacity to use PA, as respondents showed high anticipation of benefits from its application, evident from the survey findings.

Table 12: Survey responses to a willingness to learn and engage in PA technology

Have you attended any seminars or workshops on precision agriculture?	Gombe	Bauchi
a. Yes	44%	31%
b. No	56%	69%
Will you be willing to attend seminars and workshops on precision agriculture?		
a. Yes	93%	95%
b. No	7%	5%
Did you easily understand precision agriculture practices?		
a. Yes	56%	41%
b. No	44%	59%
Can you easily practice precision agriculture?		
a. Yes	69%	64%
b. No	31%	36%

3.3 Problems of Precision Agriculture

The problems with the adoption and application of precision agriculture in Nigeria include many factors such as the land tenure system, financing, climate change, government policies and management issues. Table 13 below shows the responses to the influences of these factors on the adoption of precision agriculture technology. The percentage indication of a problem with PA from the outlined factors was high, with Bauchi State respondents indicating relatively more challenges to the adoption of PA technology. This shows the wide range of factors to be mitigated in order to effectuate the adoption and application of PA technologies.

Table 13: Respondent's indication of problems with Precision Agriculture across various factors

1	Which of the following is or could be the problem(s) of precision agriculture in Nigeria?	Gombe	Bauchi
	a. Land tenure		
	Yes	85%	93%
	No	15%	7%
	b. High cost of acquiring the systems		
	Yes	86%	93%
	No	14%	7%
	c. Climate change effects		
	Yes	86%	91%
	No	14%	9%
	d. Lack of personnel to manage the equipment		
	Yes	86%	94%
	No	14%	6%
	e. Poverty level of the end-users		
	Yes	85%	94%
	No	15%	6%
	f. Lack of extension officers for on-farm demonstration		
	Yes	86%	94%
	No	14%	6%
	g. Unfavorable government policies		
	Yes	86%	93%

	No h. High running cost	14%	7%
	Yes No i. Low soil fertility for large-scale production	86% 14%	94% 6%
	Yes No j. High rate of postharvest losses	86% 14%	90% 10%
	Yes No k. Bad weather	86% 14%	91% 9%
	Yes No l. Lack of information and data	86% 14%	90% 10%
	Yes No m. High cost of bio inputs (fertilizer, agrochemicals, seeds and seedlings, etc.)	85% 15%	93% 7%
	Yes No	85% 15%	95% 5%
2	**How do you think the culture of the land tenure system will affect precision agriculture adoption in Nigeria?**		
	a. Positively b. Negatively c. No effect	61% 38% 1%	74% 22% 4%

4.0 CONCLUSION

The result of the study while showing a high level of willingness to the adoption of precision agriculture among respondents indicated a low rate of actual application and adoption. Some of the main indicators can be summarized thus;

1. The high willingness rating in both Gombe and Bauchi States indicate that farmers are willing to adopt PA technologies if made accessible.
2. Mechanization levels are proportionate to farm size and worker count, therefore larger farms do not necessarily mean more mechanization. Despite previous research indicating a link between increased farm size and PA adoption, the number of work years and age of farmers in this study indicate a stronger link between mechanization and PA technology adoption.
3. The survey found that while economic considerations are the main impediment to adopting PA technology, other social-cultural and individual factors also play a role. For example, Bauchi State has a lower rate of adoption of PA technology compared to other states with larger farm sizes, higher productivity, better access to credit, and more farm workers.
4. Other criteria, such as age and number of years of operation, indicate overlap between the various stages of internet and digital technology adoption, mechanization, and PA.
5. To promote willingness of farmers to adopt PA technology in the states, efforts should focus on sensitization, information distribution, favorable government regulations, manufacturer and dealer availability, and technical support.

5.0 RECOMMENDATIONS

The following recommendations are made:

1. Government should support the adoption and use of relevant PA technologies through favourable policies, enabling environment and provision of requisite funding
2. More research should be carried out on development, adaptation, extension and use of different PA technologies for specific applications
3. The socio-economic impact of PA technologies on the farmers and agricultural productivity/enterprise in the States and other parts of Nigeria should be investigated further

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7.0 CONFLICT OF INTEREST

The authors declare no conflict of interest

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