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Awareness of Precision Agricultural Technologies among Crop Farmers for Rural Livelihoods' Enhancement in Ebonyi State, Nigeria

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Abstract
This study assessed the awareness of Precision Agricultural Techniques (PATs) in Ebonyi State. Specifically, the specific objectives were to: ascertain farmers' awareness of PATs, describe their sources of information on PATs; identify PATs adopted and analyze constraints to adoption of PATs. Four-stage sampling procedure was used for the selection of 120 respondents. Primary data were collected using structured interview schedule, and analyzed with percentages, mean scores and factor analysis. Result showed that awareness of PAT increased for variable rate of fertilizer application ($\bar{X}$ =3.75), studying weed/pest population ($\bar{X}$ =3.58), control and use of farm machineries/equipment ($\bar{X}$ =3.58). Furthermore, radio (63.3%), television (57.5%), extension agents (59.2%) and contact farmers (50.3%) were major sources of information on PAT. Factor analysis results yielded three composite factors that limited adoption decision, all having eigen values above 1; namely: 'socio-economic', financial and 'institutional' factors. It was concluded that several factors were associated with farmers' adoption decision of PATs. A concerted effort focusing on addressing the isolated factors by extension organizations is thereby recommended.
Keywords: Awareness, Precision Agriculture, Rural Livelihoods, Factor analysis

Introduction

Traditional agricultural practices have rarely achieved optimal efficiency, either in terms of optimum yield or minimal cost of production. Under such systems, inputs (e.g. fertilizer and pesticides) are applied, in order to prevent nutritional deficiency or losses in stand or yield, at a uniform rate over an entire farm (Khanna *et al*. 2020). Such decisions which are typically made to avoid more risk, are often not knowledge driven. More specifically, they overlook field variability. Over-application of fertilizers, as an example, results in input losses through leaching and runoff. These practices generate adverse effects on resource quality (e.g. soil and water). There are, in turn, consequential impacts for plants, ecosystems, the economy, and population. Resource misallocation, therefore, has serious implications for sustainability vis-a `-vis food security and enhanced rural livelihoods. Such realizations have focused attention on increasing the efficient use of scarce farm resources. One answer to specific aspects of this problem is the adoption of precision agriculture, which is a production system that involves crop management according to field variability and site-specific conditions (Seelan *et al*. 2013). Precision farming can be defined as a management system, which it depends upon the information and technology or is site-specific management and it uses one or more of the following data sources: soils properties, crop growth parameters, nutrient maps, pests, soil moisture and yield map, for maximization of the economics, sustainability and conservation of the environmental farm (USDA) (2007). It refers to the system that assesses variability in soil and crops through the field. Then, information, which was collected in these assessments, could be then used to develop site-specific management practices for optimizing soil and crop yield production (Baroudy*et al*; 2020 and Paxton *et al*; 2011).

Precision Agriculture (PA) is a whole-farm management approach using information technology, satellite positioning, remote sensing and proximal data gathering. Precision agricultural techniques (PATs) are those technologies which are either used singly or in combination, as the means to realize precision farming and achieve its noble aims. Using PATs, data are collected to assist farmers in making regular and guided sub-field decisions, including applications of fertilizers and pesticides, distribution densities for seeds, irrigation application rates, and tillage regimes (Daberkow and McBride 2015). The ultimate objective is the management of crop and soil variability in a manner which increases profitability and reduces environmental destruction (Fountas *et al*. 2017). According to Folnovic, (2015), the goal of precision farming is to increase agricultural yield production and decrease the environmental risks. These technologies have the goal of optimizing returns on inputs whilst potentially reducing environmental impacts. However, the benefits could include the following points: detecting soil properties and plant physicochemical parameters, real time data collection through remote sensing instruments, saving time and decreasing costs through reducing fertilizer costs and other agrochemicals as well as reducing tillage operation, supplying the farmers with good farm information and databases and integrating farm management software, like Agrivi, to make all farm activities easier and to increase farm productivity. The increased efficiency of the management plan will come about through a good understanding of the interaction between environment, soil, crop and more detailed information using of new advanced and current information technologies such as short and long-term crop growth modeling, soil conservation, climate predictions and agro-economics modeling (A. A Belal *et al*., 2021). The new tools for precision farming are content hardware, software and recommended practices Singh (2004). Others include: Global Position System (GPS), Remote Sensing, Soil and Crop Sensors, Variable Rate Technology (VRT), Yield Monitoring Systems and Mapping, Site-Specific Management Zones (SSMZ) and Crop Modeling. Implementation of this technique to increase soil and crop production, reduce costs, increase farm profitability, reduce environmental risks and desertification processes and as well enhance rural livelihoods is necessary.

Many researchers such as Swinton and Lowerberg DeBoer (2011), Sunding and Zilberman (2011), Tey and Brindal (2012), Filho *et al* (2011) and Pierpaolia *et al*., (2013) have investigated the factors influencing the decision to adopt Precision Farming (PF) technologies. The principal factors influencing the adoption of PF technologies are operator characteristics, farm physical attributes, sources of information, and financial and structural characteristics of the farm business. Examples of operator characteristics include age, formal education, years of farming experience, and computer literacy (Fernandez-Cornejo, Beach, and Huang, 2016). Examples of farm physical attributes include farm size, owned or rented land (Banerjee *et al*. 2018), and sub-field variability in pH, organic matter, soil type and texture, topography, and drainage that influence crop yields (Daberkow and Mcbride, 2017). Extension Agents, contact farmers, Crop consultants, input suppliers, and equipment dealers with expertise in PF services are expected to provide information that can influences PF technology adoption by farmers (Velandia *et al*. 2010; Wolf and Nowak, 2013). The financial position of the farm also influences PF adoption decisions (Daberkow and Mcbride,2017), while profitability and environmental benefits are correlated with the PF technology adoption decision (Batte and Arnholt, 2013).

Despite the quanta of researche conducted in this area of study in developed and developing countries, there seems to exist dearth of knowledge on precision Agricultural techniques (PATs) and its adoption by farmers in Ebonyi State. Till date, no empirical studies have been undertaken to unravel the adoption and utilization of PATs in the study area. This necessitated this study with the aim of addressing the following research questions: Are farmers' aware of available PATs? How do these farmers perceive usage of PATs? What information sources are available to the farmers about PATs? What are the constraints to awareness of precision agriculture in the study area?

The specific objectives were to:

i. ascertain farmers' awareness of precision agricultural techniques;
ii. describe farmers' perception of PATs;
iii. identify sources of information on PATs; and
iv. identify constraints to awareness of PATs in the study area.

Methodology

This study was carried out in Ebonyi State, Nigeria. Farming remains the major economic activities of the people of Ebonyi State, with rice being one of the major crops farmed in the State. The crops produced in this area mainly are Okra (*Abelmoschusesculentus*), yam (*Dioscerаspp*), Cassava (*Manihotesculenta*), Maize (Zea mays) and vegetables.

A four-stage sampling procedure involving both random and purposive sampling were used for the selection of respondents. First, two (2) LGAs were purposively selected from each of the three agricultural zones of the State to give a total of 6 LGAs. Second, random selection of two (2) autonomous communities from each of the six LGAs to make a total of 12 communities was made. Thirdly, there was random selection of two (2) villages from each of the 12 communities to make a total of 24 villages. Lastly, five crop farmers were randomly selected from each of the 24 villages to make a total of 120 respondents. Primary data for this study were sourced using a well-structured questionnaire augmented with interview schedule and analyzed with descriptive and inferential statistics such as frequency count, mean scores, percentages and principal factor analysis respectively.

Model Specification

Mean Score analysis

$\ddot{X} = \sum X/N$

Where:

$\ddot{X}$ = mean score

$\sum$ = summation

X = likert value

N = number of respondents

Decision rule for the five-point likert scale;

5 = Very great extent, 4 = Great extent, 3 = fairly great extent, 2 = Low extent, 1 = Very low extent.

X = 5+4+3+2+1/5 = 15/5 = 3.0

This means that by using 3.0 as decision point, any item with mean score less than 3.0 was rejected whereas those with 3.0 and above were accepted.

Factor-Analysis Model

Mathematically, factor analysis is expressed in a linear equation as;

$Y_i = \beta_{i0} + \beta i1F_1 + \beta_{i2}F_2 + \beta_{i3}F_3 + \ldots\ldots + \beta_{in}F_n + e_i$

Where;

β_{i0} = parameters or loadings hence, $\beta_i - \beta_n$ is the coefficient of loading of variables on F_i to $F_{n.}$

F = the loading factor

ϵ_i = error term

Using Kaiser's criterion, factors with eigen value above 1 were isolated. Based on the rule of thumb as developed by **Kasier**, variable with a minimum loading of **0.4** can be separated and identified as being positive to the attribute in question and vice versa. The extracted factors were named based on underlying similarities reposed in the variables with highest loadings under each factor.

Measurement of Variables

A five-point Likert-type scale was used to evaluate farmers' awareness of Precision Agricultural Technologies in the study area.

Farmers' perception on PATs was measured using frequency counts and percentage values obtained from a list of 10 variables. The numbers of chosen points were calculated to obtain both the frequency and percentage values. Multiple responses were allowed.

Possible sources of information on PATS were listed, categorized into mass media and interpersonal sources and measured using frequency counts and percentages. The farmers were asked to select most important source (s) information on PATs. These were summed and calculated accordingly allowing multiple responses.

As a preliminary check on appropriateness of use of factor analysis for the study, the Kaiser-Meyer-Olkin measure of sampling adequacy of 0.613 reported is adjudged satisfactory being greater than 0.60 minimum required (International Business Machines (IBM) Knowledge Center, 2020), thus indicating that the sample size of the study was adequate to justify the use of factor analysis. Also, Bartlett' test of sphericity yielded chi-square of 423.210, which was significant at $p< 0.01$. Again, the significant chi-square test was necessary for the conduct of factor analytical procedure. IBM-SPSS Statistics (version 23) was used for data analysis.

Results and Discussion

Farmer's Awareness of Precision Agricultural Techniques in Ebonyi State

Result of the analysis on the farmers 'awareness of precision agriculture in the area as shown in Table 1 revealed that farmers were aware of precision agriculture in the area. Their responses were recorded using mean score. Result showed that their awareness increased positively for variable rate of fertilizer application, Studying weed/pest population and control, Use of farm machineries/equipment with mean scores of ($\bar{X}$ =3.75), ($\bar{X}$ =3.58), ($\bar{X}$ =3.58). This could be because the farmers were more aware of those precision technologies that conform to their usual practice and those which are not too expensive to afford. Other precision agricultural technologies such as use of autonomous vehicle ($\bar{X}$ =2.19), remote sensing ($\bar{X}$ =1.34), GPS and mapping ($\bar{X}$ =1.25), use of drone ($\bar{X}$ =1.21), crop yield monitors ($\bar{X}$ =2.69) and use of satellite imagery ($\bar{X}$ =1.14) were not too known to the farmers. This could be due to the fact that the farmers were not computer literate enough and most of them do not have ability to use smart phones.

Table 1: Mean score rating of the respondents according to their awareness of precision agriculture in the area

Precision Agriculture	Weighted mean ($\bar{X}$)
Remote sensing	1.34
Crop yield monitors	2.69
Field/Soil testing	1.82
Variable rate of fertilizer application	3.75
Studying weed/pest population and control	3.58
GPS and mapping systems	1.25
Use of autonomous vehicles	2.19
Use of drones	1.21
Use of satellite imagery	1.14
Use of farm machinery/equipment	3.58

Source: Field Survey, January 2024. *** $\bar{X}$ = 3.45**

Respondents' Perception on Precision Agriculture

Farmer's perception refers to a subjective assessment of attributes and personal innovation. Among the perceived attributes suggested by Rogers (2003), perceived relative advantage is used to evaluate the perception of relative benefits of adopting new technologies and the gain that it brings to overcome other technologies. Farmer's perception was based on decreased field-average, input application, increased farm return (profit), increased field average yield, decreased negative environmental impacts of crop production, and increased farmer's well-being, representing 72.5%, 62.5%, 60.8%, 42.5% and 39.2% respectively. Among other advantages, profitability was a major concern when considering an increase in any capital intensity of agricultural technology, including PAT technologies. Realistically and perceptibly, farmers do not want to get losses in their investments. Therefore, the probability of PAT adoption will be higher if the results of this adoption can be seen. These assumptions were supported by the results of the work of Walton (2008) and Anselmi (2012). Other perceptions include: time saving (34.2%), reduction in post-harvest losses (30.8%), efficient use of farm resources (27.5%), risk reduction (22.5%), and efficient use of equipment (17.5%). The findings of this present study is in conformity with that of Yusuf et al (2020), who reported that farmers who perceived Provitamin A cassava variety to be beneficial would be willing to cultivate it.

Table 2: Distribution of the Respondents According to their Perception on Precision Agriculture

Precision Agricultural techniques (PAT)	Frequency	Percentage
Decreased field-average input application	87	72.5
Increase field-average yield	73	60.8
Increase farm return (profit)	75	62.5
Increase in farmers' well-being	47	39.2
Decrease negative environmental impacts of crop production	51	42.5
Efficient use of equipment	21	17.5
Risk reduction	27	22.5
Reduction in post-harvest losses	37	30.8
Time savings	41	34.2
Efficient uses of farm resources	33	27.5
Average response	**49**	**40.8**

Source: Field Survey, January 2024. *= Multiple responses recorded

Respondents, according to Sources of Information on Precision Agricultural Techniques

Results identified two broad categories of information for precision agricultural technologies by the farmers, namely, mass media and interpersonal channel. The interpersonal channels have higher relative usage by farmers than mass media. Table 3 gives the details of the various sources of information for precision agricultural technologies by the farmers. Extension agents (59.2%) constituted the most regularly used interpersonal channels, followed by opinion leaders (52.5%) and then contact farmers (50.3%). Generally, the majority (63.3%) of the respondents indicated use of radio in obtaining precision agricultural technologies information. Posters/handbills, Newspaper and film show have very low frequency of usage as 26.7%, 22.5%, % and 7.5% of the respondents had respectively indicated their non-use of all the sources of information for precision agricultural technologies dissemination. The low or non-usage of mass media could be due to the low socioeconomic status of the farmers and the lack of facilities such as electricity to operate them. The low or non-usage of print media such as newspapers, extension bulletins/ newsletters can be attributed to low literacy level of the rural farmers. These findings corroborated those of Iwueke (2016) which revealed that television, extension publications (bulletins, newsletters, posters and handbills) were not considered as important sources of agricultural information among the farmers in Nigeria while friends/neighbours/relations, extension agents, and contact farmers were considered important in terms of availability and usage.

Table 3: Distribution of the Respondents according to Sources of Information on Precision Agricultural Techniques in the area

Sources of information	Frequency	Percentage
Mass media		
Radio	76	63.3
Television	69	57.5
Newspapers	27	22.5
News letter	11	9.2
Film show	9	7.5
Posters/handbills	32	26.7
Interpersonal channel		
Extension agents	71	59.2
Contact farmers	61	50.3
Opinion leaders	63	52.5
Friends/neighbours	55	45.8
Faith organization (Church)	43	35.8
Men/Women organization (Age grade)	34	28.3
Cooperative societies	46	38.3
Family members	13	10.8
Average response	**44**	**36.7**

Source: Field Survey, January 2024**. *= Multiple responses recorded**

Constraints to Awareness of Precision Agriculture

Table 4: Varimax Rotated Principal Component factor analysis on the constraints to adoption of Precision Agriculture in the study area

Constraints	Socio-economic constraint	Financial constraint	Institutional constraint
Poor health status of rural farmers	0.100	0.132	0.246
Poor access to a credit facility	0.268	0.096	**0.587**
Natural disasters such as floods or drought	-0.096	0.115	0.168
Untimely dissemination of technologies by extension institutions	0.251	-0.320	**0.552**
Poor understanding of Precision agricultural technologies by farmers	**0.488**	0.258	0.059
Distance to sources of precision agriculture	0.063	-0.029	0.276
Low income to access precision agriculture	0.100	0.383	**0.537**
Low level of education of rural farmers	**0.691**	0.172	0.242
Religious belief	0.052	-0.237	0.106
Poor income realized from farming	0.159	**0.475**	0.214
Lack of technical know-how to operate precision agricultural tools & equipment	**0.783**	0.352	0.275
Poor extension service delivery	0.248	0.176	**0.448**
Irregular use of technologies	**0.580**	0.330	0.260
No observable change in yield	0.007	0.379	0.040
Technologies incompatibility with indigenous practices	**0.844**	0.119	0.055
Climatic factors such as rainfall, temperature and solar radiation	0.048	0.214	0.192
Poor access to information about PAT	**0.419**	0.349	-0.051
Ageing farming population	0.291	0.196	0.177
Lack of youths' interest in agriculture	**0.472**	0.000	0.024
Poor access to farm insurance	0.069	0.175	0.092
Lack of political will to improve agriculture	-0.177	0.204	**0.754**
Land tenure system	-0.077	0.317	0.254
Poor access to weather/climate-related information services	0.327	0.243	0.267
High cost of phones/computer device	0.390	**0.429**	0.379
Inability to use modern ICTs	**0.581**	0.040	0.135
Lack of farmers interest on precision agricultural technologies	**0.477**	0.241	0.248

Source: Field Survey, January 2024.

As presented in Table 4, principal component analysis (PCA) was used as a data reduction technique to achieve this result. From the analysis, three components were extracted. The first component was named as socio-economic constraints. The second component was classified as economic constraints while the third component was named political constraints. All these three components extracted the items in which the loadings were greater than 0.4 and vice versa. Specifically, Technologies incompatibility with indigenous practices (0.844), Lack of technical know-how to operate precision agricultural tools and equipment (0.783) and low level of education of rural farmers (0.691) were the major factors that loaded under socio economic constraints; Poor income realized from farming (0.475) and High cost of phones/computer device (0.429) loaded high under economic constraints while Lack of political will to improve agriculture (0.754), Poor access to credit facility (0.587) and Untimely dissemination of technologies by extension institutions (0.552) were classified under political or institutional constraints. This implies that socio-economic, economic and political constraints limited farmers' awareness of precision agriculture in the study area.

Technologies incompatibility with indigenous practices was a major socio-economic constraint to farmer's awareness of precision agricultural technology in the area. This could be because the farmers lack the knowledge of operating the device and as such could make them rather continue with their normal practices than adopting new ones. This is in tandem with the finding of Umeh (2009) who identified complexity of technology as a constraint to adoption of agro forestry recommendations among farmers in Ebonyi State Nigeria. Consequently, poor income realized from farming and high cost of phones/computer device was also a constraint. This is obvious as the farmers were still low-income earners who are constrained by lack of funds. These findings conform to Chukwu, Eze and Osuafor (2016) who identified funds as a major constraint to continuous adoption of technologies. They further contended that agricultural technologies that are at exorbitant prices are not easily adopted.

Conclusion

The study established that farmers in Ebonyi State were aware of precision agriculture and had positive perception about it; sourcing information from both mass media (radio and television) and interpersonal sources (extension agents and contact farmers). But their awareness was constrained by socio-economic, financial and institutional factors.

Recommendations

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

1. Extension organizations should restructure their extension delivery system to ensure timely dissemination of information on precision agricultural technologies to farmers in the area.
2. Increased and effective utilization of identified channels such as radio, television, extension contacts among others for continuous education of the people on the benefits of precision agriculture could enhance adoption.
3. More advocacy on the benefits of PATs should be carried out to increase its awareness in the area.

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