ASSESSING THE APPLICATION OF GEOGRAPHIC INFORMATION SYSTEM (GIS) AMONG AGRICULTURAL-BASED RESEARCHERS IN SOUTHWESTERN NIGERIA

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ABSTRACT

This study assessed the application of Geographic Information System (GIS) tools among agricultural-based researchers in southwestern Nigeria. It specifically described the personal and socio-economic characteristics of agricultural-based researchers, determined their level of awareness in the use of GIS, examined their perception about GIS and assessed the application of GIS by agricultural-based researchers. A two-stage sampling procedure was used to select 150 respondents from six public universities with faculties of Agriculture using proportionate sampling technique which translated into 36, 22, 24, 22, 25 and 23 respondents from OAU, OOU, FUTA, UniOsun, FUNNAB and LAUTECH respectively. Data were gathered through structured questionnaire and analyzed using descriptive statistics such as frequency count, percentages and mean while correlation and chi-square analyses were used to make inferential deductions. The results show that the respondents had a mean age of 42.9 ± 9.8 years and 56.0% had obtained Ph.D. degree. The mean year of experience as researchers was 14.5 ± 6.8 years. Majority (86.9%) of them has heard about GIS. There were significant associations between respondents' application of GIS and their sources of fund for research *($\chi 2= 33.483$; $\rho \leq 0.01$) and researchers' academic qualification ($\chi 2= 29.502$; $\rho \leq 0.01$). There was a negative and significant relationship between respondents' application of GIS and their years of experience ($r=-0.130$; $\rho \leq 0.01$). The study concluded that many of the respondents have heard about GIS but have not been applying it in their research endeavour and need to be trained on how to explore the potentials of GIS in their research for better results.*

Keywords: Assessment, Application, Geographic Information System, Agricultural-based Researchers.

INTRODUCTION

Geographical Information System (GIS), according to Bill (1999), is a computer-supported system consisting of hardware, software, data and corresponding applications. Like a powerful set of tools, GIS is used for storing and retrieving at will, transforming and displaying spatial data from the real world for a particular set of purpose (Burrough, 1986). GIS devices like remote sensing technology play an important role in precision agriculture and its application in precision agriculture introduces new opportunities for improving agricultural

practices. According to Environmental Systems Research Institute (ESRI), (2013) GIS technology is applicable in various sectors of agriculture to manage resources, increase yield, decrease input cost, predict outcomes and improve business practices. The capability of GIS to visualize agricultural environments and progress in work being done has proved to be very beneficial to those involved in farming and other farm related activities. Anon (2015) explained that the uses of GIS, GPS, and RS technologies, either individually or in combination, span a broad range of applications and degrees of complexity. Simple applications might involve determining the location of sampling sites, plotting maps for use in the field, or examining the distribution of soil types in relation to yields and productivity. More complex applications take advantage of the analytical capabilities of GIS and RS software. These might include vegetation classification for predicting crop yield or environmental impacts, modelling of surface water drainage patterns, or tracking animal migration patterns (Anon, 2015). The powerful analytical capabilities of the technology, according to ESRI (2013), are used to examine farm management practices including crop yield estimates, soil amendment analyses and erosion identification. Furthermore, GIS can also be used to reduce farm input costs such as fertilizer, fuel, seed, labour, and transportation expenses (ESRI, 2013). In addition, farm managers can use GIS to submit government programme applications, simplifying what used to be a time-consuming process. From collecting of field data such as slope, aspect, nutrients, and yield with mobile GIS devices like global positioning system (GPS) to the analysis of remote-sensing data at the farm manager's office, GIS is playing an increasing role in modern agriculture production throughout the world by helping farmers expand production, reduce costs and manage their land more efficiently. It has the capability to determine and record the correct position continuously; therefore, it can create a large database for its users (Anil, 2006; Anon, 2015; Goodchild, 1988). The functionalities of GIS include, among other things, the following:

1. Data capture: data input by the user employing scanner, digitizer tablet, keyboard etc., or data import from digital sources.
2. Data check: plausibility, revision and completion.
3. Data integration: the transfer of data sets into a consistent geographic data structure by generalisation, co-ordinates transformation resp. translation etc.
4. Data storage: spatial data are stored as a grid or vector data. Advanced GIS can process both types of data in hybrid systems. Normally, the data are stored in intra-system databases.
5. Data retrieval: basic functions for a user-defined query of databases.
6. Data analysis: GIS provides a broad range of tools to analyse the database. In this respect, all GIS functionalities can be used, in particular, the visualisation methods.
7. Data display: the most important display formats of GIS are maps. But also table sand graphics are possible formats for the presentation of results (Kistemann, *et al.*, 2002).

The evolution of GIS, the Global Positioning System (GPS), and Remote Sensing (RS)

technologies has enabled the collection and analysis of field data in ways that were not possible before the arrival of computers. Nowadays, with improved access to computers and modern technologies, GIS is becoming increasingly popular for resource management (Sonti, 2015).The application of GIS does by no means overcome two major concerns of any empirical research, viz: data availability and data quality. Data collecting is both time-consuming and expensive, and GIS offers some helpful tools for integration and matching of data that are already available. An increasing amount of datasets is becoming available as public domain (Clarke *et al.*, 1996). Researchers in Agriculture can use GIS images as models, making precise measurements, gathering data, testing ideas with the help of the computer and adding to the body of knowledge in a constant adjustment to changing environmental developments (Kenneth and Burrough, 2000; Ketherine *et al.*, 2005). Despite the plethora of usage to which GIS can be put into in agricultural research, many agricultural-based researchers have not availed themselves of this technology in their research. More information is needed to shed light on the limited use of GIS, especially among researchers in developing countries, hence this study.

OBJECTIVE

The main objective of this study is to assess the application of GIS among agricultural-based researchers in south-western Nigeria. The specific objectives are to:

i. describe the personal and socio-economic characteristics of agricultural-based researchers in the study area;
ii. determine the level of awareness of agricultural researchers in the use of GIS;
iii. examine the perception of agricultural researchers about GIS; and
iv. assess the application of GIS by agricultural-based researchers.

HYPOTHESES

The following null hypotheses were set for the study

i. There is no significant relationship between the personal and socio-economic characteristics of the agricultural researchers and application of GIS;
ii. There is no significant relationship between agricultural researchers' perception of GIS and its application

METHODOLOGY FOR THE STUDY

The study was conducted in southwestern, Nigeria. The respondents for the study were agricultural-based researchers in the study area. The descriptive survey research design was adopted for the study. A two-stage sampling procedure was used to select the respondents. At the first stage, six out of ten public universities with faculty/college of Agriculture were randomly selected in Southwestern Nigeria. The selected universities were the Obafemi Awolowo University (OAU) Ile-Ife, Olabisi Onabanjo University (OOU) Ago-Iwoye, Federal University of Technology (FUTA) Akure, Osun State University (UNIOSUN) Ejigbo Campus, Federal University of Agriculture Abeokuta (FUNAAB) and Ladoke Akintola University of Technology (LAUTECH) Ogbomoso. Finally, forty percent of the respondent were proportionately selected across the selected

universities which include 36 agricultural-based researchers from Obafemi Awolowo University, 22 from Olabisi Onabanjo University, 24 from Federal University of Technology, 22 from Osun State University, 25 from Federal University of Agriculture Abeokuta and 23 from Ladoke Akintola University of Technology to make a total of 150 respondents interviewed for this study. Duly validated and pretested structured interview schedule was used to elicit information from the respondents. Data were summarized with percentages, means and standard deviation, while Chi-square and Pearson Product Moment Correlation (PPMC) were deployed to draw inferences from the hypotheses. Perception in this study was measured by asking the respondents to indicate their response to eight perception statements which were rated on a five point Likert scale and were scored as 5points for Strongly Agree (SA), 4points for Agree (A), 3point for Neutral (N), 2 point for Disagree (D) and 1point for Strongly Disagree Agree (SD) while awareness was measured by asking the respondents to indicate whether they are aware of listed GIS tools and positive response was scored 1 point while was scored zero point.

RESULTS AND DISCUSSION

Results in Table 1 reveal that the mean age of the agricultural-based researchers in the study area was 42.89 ± 9.82 years. This indicates that a larger proportion of the respondents were still in their active years of life which could positively influence their application of GIS. Majority (70.0%) of the respondents were male. This implies that the employment process into agricultural based research work in Nigeria universities is gender sensitive and relatively fair to female; while 92.0 percent were married, indicating that majority of the respondents were people with responsibilities. Furthermore, the results also reveal that many (56.0%) had obtained Doctor of Philosophy (Ph.D.) degree in various disciplines of agriculture. This finding implies that majority of Nigerian University researchers were highly educated. In addition, 49.2 percent had less than 10 years of experience as researchers, 39.2 percent had between 10 and 19 years' experience as researchers while 11.7 percent had above 20 years' experience as researchers. The mean year of experience of the respondents as researchers was 15.4 ± 7.7 years.

The majority (96.0%) of the respondents got their funds for conducting research from their personal savings. Finally, 14.7 percent, 19.3 percent, 26.0 percent, 18.7 per cent, 16.0 percent and 5.3 per cent of the respondents were from the Department of Agricultural Extension, Soil Science, Crop Production and Protection, Animal Sciences, Agricultural Economics and Family Nutrition/Consumer Science, respectively. This indicates that more of these researchers were specialists in life sciences which actually need more of GIS application in the course of their research work. The overall results indicate that majority of the respondents in the Universities had relatively long years of experience as researchers which could afford them ample opportunities to apply GIS tools in their research activities. However, conducting research in agriculture with personal savings could contribute a setback to the application of GIS for agricultural research because of the high cost of procuring GIS devices and remote sensing data.

Table 1: Distribution of respondents by their personal and socio-economic characteristics (n=150)

Variables	Frequency	Percentage	Mean	Standard deviation
Sex of respondents				
Male	105	70.0		
Female	45	30.0		
Marital status				
Married	138	92.0		
Single	12	8.0		
Sources of the fund for research				
Personal savings	114	76.0		
Relatives	2 5	16.7		
NGO's	11	7.3		
Experience as researchers (years)				
<10	69	46.0		
10-19	57	38.0		
20 and above	24	16.0	15.4	7.7
Age in years				
<30	27	18.0		
30-59	108	72.0		
60 and above	15	10	42.9	9.8
Researchers' academic qualification				
Ph.D. holders	83	56.0		
M, Sc. holders	58	38.7		
B. Agric. or B.Sc. holders	9	6.0		
Researcher' Department/unit				
Agricultural Extension	22	14.7		
Soil Science	29	19.3		
Crop Protection/Production	39	26.0		
Animal Science	28	18.7		
Agricultural Economics	24	16.0		
Family Nutrition and Consumer Science	8	5.3		

Source: Field survey, 2016

Awareness of GIS amongst agricultural researchers

The results in Figure 1 reveal that 14.0 per cent of the respondents have not heard about GIS while 86.0 percent of them have heard about GIS. Amongst the 86.0 per cent of the respondents that have heard about GIS, 31.0 percent have undergone training(s) on it. The inference is that though majority of the respondents have heard about GIS only a few had undergone training(s) on the use of GIS for carrying out agricultural research activities. This might not be unconnected with the fact that majority of agricultural-based researchers conduct researches from funds sourced from personal savings as a result of little or no external funding. This implies that although level of awareness creation or advocacy for the use of GIS for carrying out agricultural research activities was very high among agricultural-based researcher in southwestern, Nigeria but they need to be trained in order to explore its potentials.

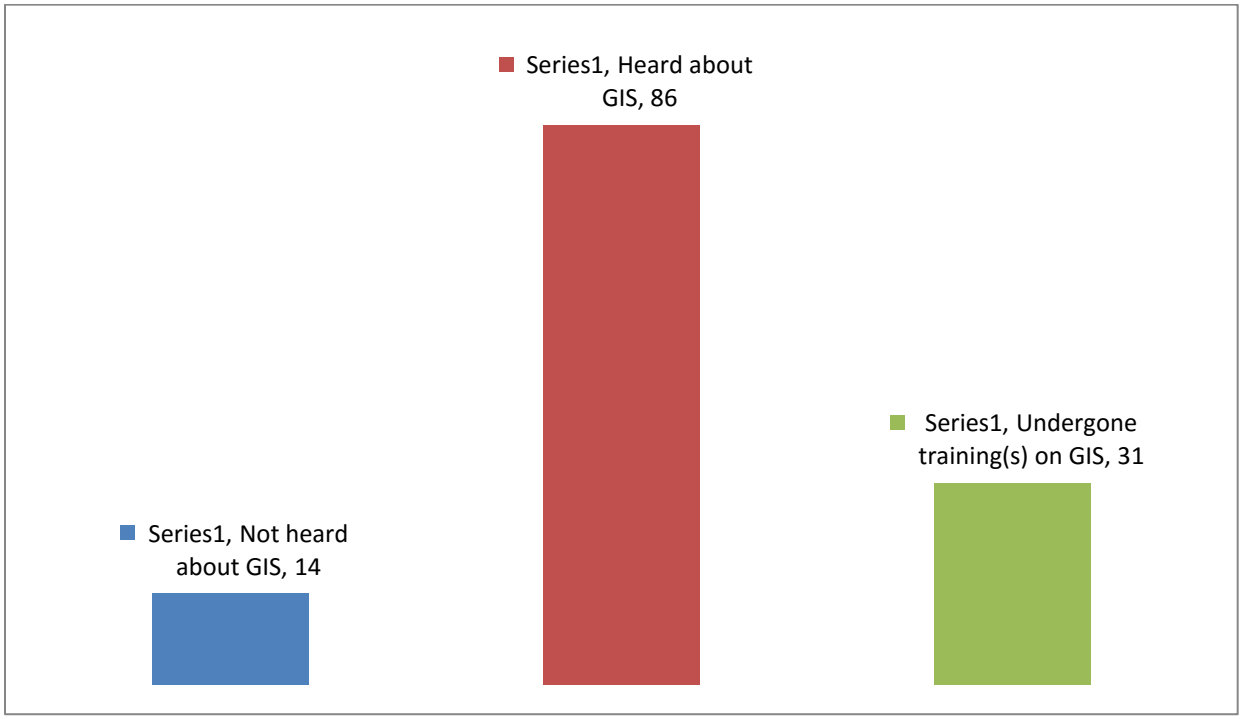

Figure 1: Distribution of respondents based on their awareness of GIS
Multiple responses
Source: Field survey, 2016

Respondents' familiarity with GIS devices
Results from Table 2 reveal that the Global Position System (GPS) ranked highest (63.3%) among GIS tools the respondents were familiarity with. This was followed by Remote Sensing (52.7%), Based maps (47.3%), Plotter (33.3%), Scanner (31.7%), Pen and puck (31.7%), Workstation (31.7%), Total station (24.0 %), Digitizer (17.7 %) in descending order. It is obvious that higher proportion of the respondents were more familiar with GPS and Remote sensing devices compared with other GIS tools. This might be as a result of the likelihood of the respondents having more training in the areas of the use of GPS and Remote sensing than in other GIS devises.

Table 2: Distribution of respondents by their level of familiarity with GIS devices
(n=150)

*GIS devices	Frequency	% familiarity	Ranking
Global positioning system	74	63.3	1st
Remote Sensing	55	52.7	2nd
Based maps	43.3	47.3	3rd
Plotter	40	33.3	4th
Scanner	64	31.7	5th
Pen and puck	38	31.7	6th
Workstation	39	31.7	7th
Total station	26	24.0	8th
Digitizer	22	17.7	9th

*Multiple responses

Source: Field survey, 2016

Perception of Agricultural-based researchers towards the application of GIS

Results in Table 3 reveal that respondents had more favourable perception in the following statements: Introduction of GIS into agricultural-based research is a welcome development ($\overline{x}$ = 4.52) came first and it was followed by the complexities, technicalities and cost of GIS devices discourage the interest of researchers outside the study of Geography ($\overline{x}$ = 4.42). Others include regardless of the way people embrace GIS they still need to continue the use of conventional way of data acquisition ($\overline{x}$ = 4.34), sustainable resource management can only be enhanced if GIS is incorporated into agricultural research ($\overline{x}$ = 3.98), and GIS helps agricultural researchers to have a better spatial understanding of their environment ($\overline{x}$ = 3.91). On the other hand, respondents had a less favourable perception in the following statements: Conventional agricultural research method is not sufficient to meet with emerging challenges of present-day world ($\overline{x}$ = 3.77), and I esteem my conventional research method than other disciplines method like GIS ($\overline{x}$ = 3.51). It can be inferred from these results that though the introduction of GIS into agricultural-based research is a welcome development, the complexities, technicalities and cost of GIS devices discourages the interest of researchers outside the study of Geography. This finding is in agreement with the submission of Briggs and Elliot (1995) that access to spatial data (which are fundamental to any GIS application) continues to be difficult and expensive.

Table 3: Distribution of respondents by perception towards the application of GIS

(n=150)

Statement	SA %	A %	U %	D %	SD %	Mean	Rank mean
Introduction of GIS into agricultural-based research is a welcome development.	54.5	37.5	5	3.0	0	4.52	1st
The complexities, technicalities and cost of GIS devices discourage the interest of researchers outside the study of Geography.	49.2	33.3	17.5	10	0	4.42	2nd
Regardless of the way people embrace GIS they still need to continue the use of conventional way of data acquisition.	68.5	16.7	5	5	4.8	4.34	3rd
Sustainable resource management can only be enhanced if GIS is incorporated into agricultural research.	39.3	33.3	17.5	6.6	3.3	3.98	4th
A GIS helps agricultural researchers to have a better spatial understanding of their environment	2.0	3.0	16.7	10	68.3	3.91	5th
Introduction of GIS into agriculture will not strengthen interdisciplinary research.	3.3	3.3	37.5	3.4	52.5	3.81	6th
The conventional agricultural research method is not sufficient to meet with emerging challenges of present-day world	6.6	6.6	10	37.5	39.3	3.77	7th
I esteem my conventional research method than other disciplines method like GIS.	0	3.3	16.7	54.5	25.5	3.51	8th

SA= Strongly Agree, A= Agree, U= Undecided, D= Disagree, SD= Strongly Disagree

Grand mean = 3.90

Standard deviation = 1.8

Source: Field survey, 2016

Application of GIS in Agriculture

Results in Table 4 reveal that the highest applied GIS device in Agriculture among the respondents was the global positioning system ($\overline{x}$ = 3.74). This was followed by remote sensing (3.43), based maps (3.35), plotters (3.22), scanners ($\overline{x}$ = 3.10), pen and puck ($\overline{x}$ = 2.63) in that order. The least applied GIS device was digitizer ($\overline{x}$ = 2.50). Since the grand mean of application of GIS devices was 3.23, there is a low level of application of GIS devices among the respondents in the study area. The overall result indicates that only the global positioning system, remote sensing and based maps were the most common GIS device applied by the respondents for their research activities. This could be as a result of little or no exposure to training opportunities that would have to increase the respondents' level of awareness and utilization of GIS as a tool for agricultural research. The finding is in agreement with the submission of Tanser and le Sueur (2002) that training creates capacity and leads to an increase in terms of data needs and usage.

Table 4: Distribution of respondents by application of GIS devices (n=150)

GIS devices	FA F (%)	OA F (%)	RA F (%)	NA F (%)	Mean	Rank
Global positioning system	111(74.2)	39 (25.8)	0 (0.0)	0 (0.0)	3.74	1st
Remote Sensing	83 (55.0)	50 (33.3)	17 (11.7)	0 (0.0)	3.43	2nd
Based maps	77 (51.7)	47 (31.7)	26 (16.6)	0 (0.0)	3.35	3rd
Plotter	72 (48.3)	37 (25.0)	41 (26.7)	0 (0.0)	3.22	4th
Scanner	65 (43.3)	35 (23.3)	50 (33.4)	0 (0.0)	3.10	5th
Pen and puck	50 (33.3)	26 (16.6)	44 (29.2)	30 (20.8)	2.63	6th
Work station	51 (34.0)	23 (15.0)	40 (26.7)	36 (24.2)	2.59	7th
Total station	50 (33.3)	20 (13.3)	37 (25.0)	43 (28.3)	2.53	8th
Digitizer	48 (32)	23 (15.3)	37 (24.7)	42 (28.0)	2.50	9th

FA= Frequently Applied, OA= Occasionally Applied, RA= Rarely Applied, NA= Not Applied

Percentage in the parenthesis

Grand mean = 3.23

Source: Field survey, 2016

Hypotheses testing

Results in Table 5 reveal that at 0.01 level of significance, sources of fund for research (χ^2 = 33.483) and researchers' academic qualification (χ^2 = 29.502) of the respondents had a significant association with the application of GIS tools for agricultural-based researches. Furthermore, at 0.05 level of significance, the respondents' sex (χ^2 = 29.502) had a significant association with the respondents' application of GIS tools for agricultural-based researches. Whereas marital status (χ^2 = 4.370; $p \geq 0.05$) had no significant association with the respondents' application of GIS. Thus, respondents' source of fund for research, researchers' academic qualification and their sex could influence researchers' application of GIS tools for agricultural-based researches. This implies that if the researcher has better access to fund their research work, it could enhance their ability to undergo training on GIS. Moreover, researchers' academic qualification could spur them into seeking for more knowledge and skills in the application of GIS tools in carrying out their day to day research activities to achieved better research output.

Table 5: Results of Chi-square analysis of the relationship between socioeconomic characteristics of respondents and application of GIS

Variables	χ^2 -value	Df	P-Value	Decision
Sources of fund for research	33.483	4	0.847**	S
Sex	32.851	2	0.741*	S
Marital status	4.370	3	0.021	NS
Researchers' academic qualification	29.502	7	0.635**	S

*Significant at 0.05 level of significant S- Significant NS- Not significant
** Significant at 0.01 level of significant DF- Degree of Freedom
Source: Field survey, 2016

Results in Table 6 reveal that at 0.01 level of significance, respondents' age (r = -0.414) and years of experience as researchers (r = -0.434) had a significant relationship with the application of GIS tools for agricultural-based researches. Both of them were negative. Thus, an increase in the respondents' age and years of experience as the researcher would decrease their application of GIS tools for agricultural-based researches. This might not be unconnected with fact that as the age of the agricultural-based researcher's increases, they tend to be risk adverse and resist change.

Table 6: Correlation analysis showing the relationship between socio-economic characteristics of respondents and their application of GIS (n=150)

Variables	Correlation coefficient (r)	Coefficient of determination (r^2)	Decision
Age	-0.414**	0.099	S
Years of experience as researcher	-0.434**	0.111	S

**Significant at the 0.01 level
Source: Field survey, 2016

Results in Table 7 show that there was a positive and significant relationship (r= 0.578; $p \leq 0.01$) between respondents' application of GIS and their perception about it. The contribution of respondents' perception towards the application of GIS was 33.4 per cent (r^2=0.3341). This implies that the more favourable the respondents' perception towards GIS, the higher the application of GIS tools for agricultural-based researches.

Table 7: Correlation analysis showing the relationship between perception of respondents towards GIS and their application of GIS. (n=150)

Variables	Correlation coefficient (r)	Coefficient of determination (r^2)
Perception	0.578**	0.3341

**Significant at the 0.01 level

Source: Field survey, 2016

CONCLUSION AND RECOMMENDATIONS

Based on the findings of this study, it was concluded that the application GIS still remains unpopular despite its acclaimed values and importance among agricultural-based researchers. Although many of agricultural-based researchers have heard about GIS, only a few had undergone training(s) on its utilization for agricultural research which led to a low level of its application. It is recommended that agricultural-based researchers in the study area should be encouraged not only on the need to explore the potentials of GIS but provided the access to facilities and skill on its application. Such provisions and skill acquisition will boost their research outputs and facilitate precision agriculture.

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