CONSTRAINTS IN UTILIZING DIGITAL AGRICULTURE AMONG VEGETABLE FARMERS IN OBIO/AKPOR LOCAL GOVERNMENT AREA OF RIVERS STATE, NIGERIA

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ABSTRACT

The study examined the constraints in utilizing digital agriculture technologies among vegetable farmers in Obio/Akpor Local Government Area Rivers State, Nigeria. Specific objectives include to identify the socioeconomic characteristics of the vegetable farmers, identify various digital agriculture technologies, and examine the factors influencing utilization of digital agriculture technologies among vegetable farmers. A structured questionnaire in line with the objectives of the study was used to obtain information from seventy (70) vegetable farmers selected using simple random sampling technique. Simple descriptive statistics and logit regression models were used to analyze the data collected. The result shows 43 years as the mean age of the farmers, 11 years as the mean spent to attain the educational level and household size of 6 members as the mean. The result of the logit regression analysis shows that educational level is statistically significant at 0.01 level, while gender, household size, farming experience and ownership of digital tools were statistically significant at 0.05 level of probability respectively. The study concludes that the constraints in utilizing digital agriculture technologies include inadequate capital, ignorance, and lack of access to technologies among others. The study therefore recommends that training programmes should be carried out from time to time to bridge the knowledge gap; farmers should make a deliberate effort to learn digital agriculture technologies and how they can utilize it effectively in the production activities; service providers like MTN, Glo among others should make network accessible and affordable to the farmers among others.

Keywords – Digital agriculture, utilization, ICT, vegetable production, Nigeria

INTRODUCTION

Agriculture serves as the essential underpinning of every society. From the time of ancient, agricultural sector has played a significant role in human history globally. In recent years, the rapid improvement of Information and Communication Technologies (ICT) has impressively transformed and enhanced modern agriculture (Gondchawar and Kawitkar, 2018). The global population is estimated to be about 10 billion by 2050 (Food and Agriculture Organization of the United Nations FAO (2009), while Nigeria population is projected to be about 440 million by 2050, with a population growth rate of about 3.2% yearly according to United Nations as cited in Aroyehun (2023). Subsequently, the world will need to produce 70% more food than current levels to meet the growing demand (FAO, 2009). This necessitates the substantial growth of the smart farming sector, accompanied by the increased use of Internet of Things (IoT) devices for agricultural purposes (Anzum et al., 2021).

To address the global food challenge, agricultural technologies (AgriTech) tools have emerged to make food production more efficient and create data-driven food chains. These technologies, such as Artificial Intelligence (AI), drones, 5G, block chain, IoT, and big data analytics, have revolutionized farming practices. Many regions around the world have already implemented these technologies as part of the Industry 4.0 concept (Scherr, Shames and Friedman, 2019). In the future, the adoption of smart farming techniques is expected to have an even greater impact. Smart farming, also known as precision farming, utilizes modern digital technologies extensively to improve agricultural production by enhancing yield, efficiency, and profitability (Mehta and Patel, 2018). Through smart farming, farmers, corporations, and agricultural institutions gain valuable insights and actionable information regarding their crops or animals, enabling them to enhance the quantity and quality of food production in specific areas (Anzum et al., 2021).

Smart farming enables farmers to closely monitor the individual needs of animals and crops, allowing them to adjust nutrition and farming practices accordingly (Scherr et al., 2019). This ultimately leads to improvements in the food production chain. Manufacturers of farming equipment and agricultural service providers are actively seeking digital advancements in the agriculture sector, recognizing the potential for these developments to greatly impact production methods in the years to come (Anzum et al., 2022). Smart farming is the incorporation of information and communication technologies into machinery, equipment and sensors for use in agricultural production systems (Pivoto et al., 2018). Hence, smart farming is the management of agricultural activities using advanced technology devices that utilize ICT approaches to increase the quantity of farm produce, improves their quality, while minimizing the need for human labour; these could be achieved when farmers embrace smart farming in form of accuracy and timely decision making as well as efficient exploitation operations and management using digital agriculture.

According to Meghan (2018) smart farming technologies (SFTs) is the integration of advanced technologies into existing farming practices to enhance efficiency, productivity, quality and sustainability of agricultural products. SFTs can be grouped into three and they are: farm management information systems (FMIS); precision agriculture (PA) systems; and agricultural automation and robotics. FMIS is the main software systems for collecting, processing, storing, and disseminating data in the form required to carry out a farms operations and functions (Fountas et al., 2015). PA systems are the farming management concept aimed at optimizing input use based on recording technologies to observe and measure inter and intra field spatial and temporal variability in crops, aiming to improve economic returns and reduce environmental impact (Finger et al.,2019). Hence, precision agriculture is able to increase input efficiency for maintaining or increasing production rate using remote sensing technologies for data gathering with either satellite platforms for space imagery or aircrafts/UAVs for aerial applications (Mogili et al., 2018).

Agricultural automation and robotics is closely related ICT sectors. In the case of open-field agriculture, they are interconnected to cover the process of applying automatic control, artificial intelligence techniques, and robotic platforms at all levels of agricultural production (Bechar et al., 2017; Patrício et al., 2018). Hence, agricultural robots of all types can perform specific tasks such as weed control, pest incident identification and application of pesticides as well as harvesting among others, which can be applied to vegetable production as well. Vegetable farmers cultivate various fresh leafy vegetables like fluted pumpkin, water leaves, cabbage, beetroot, tomatoes, okro, cucumber, and chilies among others. The fluted pumpkin is used as a leafy green vegetable and grows in several African countries. Its name, fluted, refers to the shape of the female flower. It is a tropical vine grown mainly for the leaves which constitute an important component of the diet of many people in West African countries and for its edible seed, (Fagbemi et al., 2015). The young shoots and leaves of the plant are the main parts used in soup. The plant is dioecious (that is staminate and pistillate flowers are borne on different parts of the plant), perennial and drought tolerant to a moderate level. It is usually grown trellised. It needs a well-drained soil, some water and some sun. It is grown mainly for the leaves and its edible seed. Fluted pumpkin (Telfairia occidentalis) belongs to the family Cucurbitaceae and it is a crop of commercial importance grown across the low land humid tropics of West Africa with Nigeria, Ghana and Sierra Leone being the major producers (Nkang et al., 2019). It is known for its nutritional values, job creation opportunities and contribute to household income. However, due to institutional constraints vegetable farmers are facing challenges in accessing and utilizing digital agriculture efficiently in their production activities.

Africans including Nigerians are still carrying out agricultural operations using traditional methods. This means that the majority of vegetable farmers continue to rely on their traditional cropping patterns or farming practices. Coupled with rise in temperature, which is expected to increase further; depending on the level of greenhouse gases emission in the future, Sub-Saharan Africa, including Nigeria are likely to suffer the most because of their geographical location, low incomes, and low institutional capacity. Vegetables including fluted pumpkin, is known to be sensitive to environmental conditions, stressed during dry seasons, and other pest infestation which will drastically reduce production. Hence the need for utilizing digital agriculture technologies, as it is a perfect solution to providing real time data on temperature, humidity, solar radiation, irrigation schedule, protective measures during extreme weather events and in optimizing growing conditions is indispensable. Vegetable farmers, are not an exception to these factors, hence, it is important to determine the utilization of these digital technologies in Obio/Akpor Local Government Area Rivers State, Nigeria.

Previous studies on vegetable include Ekong (2016); Ozor (2016); Ifeanyi-Obi et al (2017); Mgbada (2017) among others. While studies on digital agriculture technologies include Akinwumi et al (2017); Singh and Baruah (2018); Shaw (2018); Myeni et al (2020) among others. However, none of these studies examined the constraints in utilizing digital agriculture among vegetable farmers in Obio/Akpor Local Government Area of Rivers State, Nigeria. The specific objectives are to:

i. describe the socioeconomic characteristics of vegetable farmers in the study area,

ii. identify the digital agriculture technologies used by the vegetable farmers in the study area,

iii. evaluate the factors influencing the utilization of digital agriculture technologies among vegetable farmers in the study area, and

iv. identify the constraints in the utilization of digital agriculture technologies by the vegetable farmers in the study area.

MATERIALS AND METHODS

This research was carried out in Obio/Akpor Local Government Area (LGA) Rivers State, Nigeria. The LGA is bounded by Port Harcourt LGA to the South, Oyigbo and Eleme LGAs to the East, Ikwere and Etche LGAs to the North, and Emohua LGA to the West. It is located between latitude 4°45'N and 4°60'N and longitudes 6°50'E and 8°00'E occupying a total land mass of 260km^2 (Niger Delta Regional Development Master Plan NDRDMP, 2006 as cited in Aroyehun and Henri-Ukoha, 2021). The study area lies within the mangrove forest zone. It has an average temperature of 25°C and average humidity level of 73% (Aroyehun and Henri-Ukoha, 2021). The major economic activities of the people in this area is farming of crops like cassava, yam, vegetables, corn, plantain and other food crops as well as rearing of animals. It is also known for fisheries and aquaculture.

This study adopted a simple random sampling method. In the first stage, a sample of seven (7) communities which included Rupokwu, Eneka, Rumuokoro, Rumuodomaya, Rumuomoi, Choba and Rumuola, were selected using a simple random sampling technique. In the secondly, ten (10) vegetable farmers were selected from each community using simple random sampling technique, This gave a total of seventy (70) vegetable farmers for the study. The sampling frame, which is the list of all the vegetable farmers was obtained from the Agricultural Development Programme extension agent resident in the area.

The data for this study were collected from primary and secondary sources. Primary data were gotten through administering of questionnaire and interview schedule, while secondary source of information include textbooks, journals, internet among others. Data collected were analyzed using descriptive statistics and inferential statistics. Objectives (i), (ii), and (iv) were analyzed using descriptive statistics, while objective (iii) was analyzed using binary logit regression model.

Model specification: Binary logit regression model was used to examine the factors influencing the utilization of digital agriculture technologies as used by Henri-Ukoha, et al., (2023) and it is expressed as:

$$Ln\left({}^{y_1}/_{1-y_1}\right) = \beta_0 + \beta_1 X_1 + \beta_2 X_2 + \beta_3 X_3 + \beta_4 X_4 + \beta_5 X_5 + \beta_6 X_6 + \beta_7 X_7 + \beta_8 X_8 + u \quad \text{....1}$$

Where:

y_1 represent farmers that utilize digital agriculture technologies

$1 - y_1$ represent farmers that do not utilize digital agriculture technologies β_0 is the intercept

$\beta_1 - \beta_8$ are the regression coefficients to be estimated:

X_1 = Gender (dummy; 1= Male, 0 = Female)
X_2 = Age of farmers (years)
X_3 = Marital status (D: 1=Married; 0 = Single))
X_4 = Educational level (years)
X_5 = Household size (number)
X_6 = Farming experience (years)
X_7 = Ownership of smart tools (dummy; 1 = yes, 0 otherwise)
X_8 = Cost of using smart farm technologies (Naira)

U = Random error term

RESULTS AND DISCUSSION

The socioeconomic characteristics of vegetable farmers in the study area is presented in Table 1. The result from Table 1 shows that majority (84.3%) of the vegetable farmers were females. This indicates that females had a relatively higher involvement in fluted pumpkin production compared to males. This finding agrees with Ifeanyi-Obi et al (2017) who reported that 51% of fluted pumpkin farmers were females in Ikwere Local Government Area Rivers State, Nigeria. About 34.2% of the vegetable farmers' age ranged between 41-50 years, 32.9% of the vegetable farmers' age ranged between 31-40 years, with mean of 43 years. This implies that vegetable farming is dominated by middle-aged farmers, these groups of farmers are so strong and energetic to enable them explore digital agriculture technologies in vegetable production in the study area.

Table 1 shows that majority (88.6%) of the vegetable farmers were married and 62.8% has household size ranged between 6-10 members, with mean of household size of 6 members. This implies that marriage gives a sense of responsibility. About 58.6% of the vegetable farmers attained secondary education, while about 24.3% of the vegetable farmers had primary education, with mean of 11 years spent in schooling. This implies that the vegetable farmers are educated. Education could expose the vegetable farmers to various digital technologies, thereby enhancing the utilization of digital agriculture technologies in vegetable farming.

The result in Table 1 also shows that about 57.3% and 35.6% of the vegetable farmers has farming experience ranged between 1-10 years and 11-20 years respectively, with mean of 11 years. This implies that the vegetable farmers has good number of years of farming experience that could increase their understanding on how to utilize digital agriculture technologies in vegetable production effectively. About 57.1% of the vegetable farmers cultivated between 0.20-0.50 hectares, with mean of 0.45 hectares of land for vegetable production. This means that most of the vegetable farmers were small-scale farmers.

About 54.3% of the vegetable farmers took farming as their major occupation and source of their livelihood. This finding agrees with Ekong (2016), Ozor (2016) and Mgbada (2017) who reported that farming is the primary livelihood activity among rural dwellers in Nigeria. However, majority (72.9%) of the vegetable farmers do not have access to technologies. This maybe as a result of challenges confronting the rural dwellers in most African countries such as absence or inadequate power supply, network and other social amenities. Majority (80%) of the vegetable farmers do not have access to credit facilities. Similarly, majority (88.6%) of the vegetable farmers do not have access to extension services. Table 1 also shows that about 51.4% of the vegetable farmers were aware of digital agriculture technologies among vegetable farmers in the study area.

Table 2 shows the different digital agriculture technologies awareness among vegetable farmers. It shows mobile devices were mostly aware among the vegetable farmers with 40% aware, 14.29% slightly aware of the digital technologies. However, about 38.57% actually use digital agriculture technologies in there vegetable farming as seen in Table 3. This indicates that despite the fact that more of the farmers in the study area are aware of the use of these technologies, they do not all use it.

Table 4 shows the level of utilization of digital agriculture among vegetable farmers in the study area. This was based on four (4) Point-Likert type scale measuring high utilization, moderate utilization, low utilization, and very low utilization. These were summed up to get 10 and the mean point stands at 2.5. Any point below the midpoint was considered not utilized while any point equal or greater than 2.5 was considered utilized. The result shows that the vegetable farmers in the study area utilized more mobile devices, followed by precision irrigation and vertical farming. Mobile devices ranked first as the most utilized, which could be as a result of the fact that it connect a lot of persons together, farmers and their customers and their target market. This is supported with the findings of Mittal and Mehar (2012) that information through mobile phones has benefited farmers in India to be better connected to markets and attract better market prices.

From the result in Table 5, the Log-likelihood Chi Square is significant indicating that the model is a good fit to the data. Educational level is positive and significant at 0.01 level of probability, which means 1% increase in education level could increase the rate of utilization of digital agriculture by about 20.9%. This implies that the higher the level of education of the vegetable farmers, the more knowledgeable they become and therefore resulting in an increased likelihood of utilizing digital agriculture technologies in the study area. This agrees with the findings of Myeni et al (2020) who reported that knowledge is the main factor in utilizing digital agricultural technologies. Hence, farmers would only adopt the technology if they know its existence and effective utilization. Max (2015), also asserts that education level to be one of the socioeconomic characteristics that determines farmers' behaviour toward the adoption of digital agricultural technology.

Gender is positive and significant at 0.05, which implies that the male vegetable farmers utilized digital agriculture technologies than females. This finding agrees with Obisesan (2014) who reported that male adoption level was higher than females. Household size is positive and significant at 0.05 probability level, which implies that the larger the household size, the higher the probability of utilizing digital agriculture technologies. Large household size could serve as farm hands in the utilization of these technologies in farming operations.

Farming experience also is positive and significant at 0.05, which implies that farmers with more farming experience are more likely to adopt and efficiently utilize digital agriculture technologies. This could be because they have a better understanding of agricultural practices, and as they gain more experience, they become more open to utilizing these technologies. Ownership of digital agriculture tools is positive and significant at 0.05 probability level, which implies that the more farmers own these technologies the more chances of utilizing them.

Table 6 shows the constraints in the utilization of digital technologies among vegetable farmers. The major constraints include inadequate capital (37.14%). Capital is a limiting factor in utilizing digital agriculture technologies among vegetable farmers. This is followed by ignorance (28.57%), This indicates that the vegetable farmers are either not informed about the digital agriculture technologies or do not know how to utilize them. This finding agrees with Edeh et al., (2021) who reported that most farmers do not utilize most digital technologies in agriculture. Others include reliance on traditional farming methods, lack of access to digital tools, unreliable access to electricity and internet, lack of government support and infrastructure, inadequate land, complexity of technology and farm size.

CONCLUSION AND RECOMMENDATIONS

This study focused on constraints of the utilization of digital agriculture technologies among vegetable farmers in Obio/Akpor Local Government Area Rivers State, Nigeria. Based on the findings, it can be drawn to the conclusion that educational level, gender, farming experience, household size and ownership of digital tools were significant factors that increases the probability of utilizing digital agriculture technologies among vegetable farmers in the study area. The constraints limiting vegetable farmers in utilizing digital agriculture technologies include inadequate capital, lack of accessibility of these technologies, their reliance on traditional farming method, unreliable access to electricity and internet, lack of government support and infrastructure, and inadequate land among others. The study therefore, recommends the following:

i. Training programmes should be carried out from time to time to bridge the knowledge gap and enhance farmers' technological skills and digital literacy which can be achieved via collaboration with non-governmental organization and agricultural association as they often have the expertise to support small holder farmers.

ii. Farmers should make a deliberate efforts learn digital agriculture technologies and how they can utilize it effectively in there production activities.

iii. Service providers like MTN, Glo among others should make network accessible and affordable to the farmers.

iv. At the family level, there should be active participation of both spouses in decision making and training to guarantee that the advantages of digital agriculture technologies are fully recognized and practiced within farming households.

REFERENCES

Akinwumi, A.A. & Jonas, C. (2017). Determinant of farmers' adoption & adaptation of alley farming technologies in Nigeria. Agro-forestry systems, 55(2), 9 -112

Anzum, R., & Naeem, J. (2021). Leveraging LoRaWAN technology for smart agricultural monitoring of Malaysian palm oil plantation. IOP Conference Series: Earth and Environmental Science, 756(1), 12052. DOI:10.1088/1755-1315/756/1/012052

Anzum, R., Alawamleh, H., Bokov, D., Al-Attabi, A., Hoi, H., Kamal, W., Nguyen, T., Widjaja, G. & Kurochkin, A. (2022). A review on separation and detection of copper, cadmium, and chromium in food based on cloud point extraction technology. Food Science and Technology (Campinas), 42(2), 1-7. DOI:10.1590/fst.80721

Aroyehun, A.R. & Henri-Ukoha, A. (2021). Barriers to climate change adaptation strategies finance accessibility among gender poultry farmers in Rivers State, Nigeria. Futo Journal Series, 7(1), 47-60

Aroyehun, A.R. (2023). Impacts of climate change and population growth on food security in Nigeria. Black Sea Journal of Agriculture, 6(3), 232-240. Doi:10.47115/bsagriculture.1232578

Bechar, A. & Vigneault, C. (2017). Agricultural robots for field operations. Part 2: Operations and systems. Biosystem. Engineering, 153, 11028

Edeh, M.O., Banjo, O.S., Ugah, J.O., Agubosim, C.C., Oke, O.S., Nwodo, O.O. & Chidi, U.C. (2021). Prospects and challenges of precision agriculture technology in rural areas: A case study of Ubahu Community Enugu, Nigeria. Journal of Computer Science and Its Applications, 28(2), 15-26. DOI:10.4314/jcsia.v28i2.10

Ekong, E.E. (2016) Rural Sociology. An introduction and analysis of rural Nigeria. Dove educational publishers. Uyo, Nigeria.

Fagbemi, T.N.F., Eleyimi, A.F., Atum, H.N. & Akpambang, O. (2015). Nutritional composition of fermented fluted pumpkin (Telfairia occidentalis) seed for production of ogiri ugu fermented foods and beverages: General. 2015 IFT Annual Meeting, New Orleans, Louisiana

Finger, R., Swinton, S.M., El-Benni, N. & Walter, A. (2019). Precision farming at the nexus of agricultural production and the environment. Annual Rev. Resource Economics, 11, 313335

Food and agriculture organization of the United Nation FAO. (2009). Global agriculture towards 2050. Retrieved from: chromeextension://efaidnbmnnnibpcajpcglclefindmkaj/https://www.fao.org/fileadmin/templ ates/wsfs/docs/Issues_papers/HLEF2050_Global_Agriculture.pdf

Fountas, S., Carli, G., Sørensen, C.G., Tsiropoulos, Z., Cavalaris, C., Vatsanidou, A., Liakos, B., Canavari, M., Wiebensohn, J. & Tisserye, B. (2015). Farm management information systems: Current situation and future perspectives. Computer Electronic Agriculture 115, 4050.

Gondchawar, N. & Kawitkar, R.S. (2018). IoT based smart agriculture. International Journal of advanced research in Computer and Communication Engineering, 5(6), 838-842

Henri-Ukoha, A., Ugwuja, V.C., Dominic, D. & Aroyehun, A.R. (2023). Determinants of the usage of cassava smart agricultural practices by cassava based farmers in ObioAkpor Local Government Area, Rivers State, Nigeria. Agricultural Economics and Extension Research Studies, 11(2), 192-201.

Ifeanyi-Obi, C.C., Asiabaka, C.C., Adesope, O.M. & Issa, F.O. (2017). Inhabitants' perception of climate change, effects and adaptation strategies in Etche Local Government Area of Rivers state, Nigeria. Global Journal of Applied Agricultural Research, 1(1), 154-67.

Max, N.A. (2015). Effect of Farmers Socio-economic Toward Adoption Level of Agricultural Technology in Sigi Regency Indonesia. Journal of Applied Sciences, 15(5), 826-830. DOI:10.3923/jas.2015.826.830

Meghan, B. (2018). Smart farming automated and connected agriculture. Retrieved from: https://www.engineering.com/story/smart-farming-automated-and-connectedagriculture

Mehta, A. & Patel, S. (2018). IoT based smart agriculture research opportunities and challenges. International Journal of Research in Engineering & Technology 4, 541543.

Mgbada, J.U. (2017). Agricultural extension; the human development perspective. Computer publishers Enugu.

Mittal, S. & Mehar, M. (2012). How mobile phones contribute to growth of small farmers? Evidence from India. Quarterly Journal of International Agriculture, 51(3), 227-244

Mogili, U.M.R. & Deepak, B.B.V.L. (2018). Review on application of drone systems in precision agriculture. Procedia Computer Science 133, 502–509.

Myeni, L. & Moeletsi, M. (2020). Factors determining the adoption of strategies used by small holder farmers to cope with climate variability in the Eastern free state, South Africa sustainability 10, 410

Nkang, A. Omokaro, D. Egbe, A. & Amanke, G. (2019). Variations in fatty acid proportions during desiccation of Telfairia occidentalis seeds harvested at physiological and agronomic maturity. African Journal of Biotechnology, 2(2), 33-39.

Obisesan, A. (2014). Gender differences in technology adoption and welfare impact among Nigerian farming households. MPRA Working Paper No. 58920 https://mpra.ub.unimuenchen.de/58920/

Ozor, N. (2016). Understanding climate change: Implications for Nigerian agriculture, policy and extension. Paper Presented at the national Conference on Climate Change and the Nigerian Environment, University of Nigeria, Nsukka, 29th June -2nd July.

Patrício, D.I. & Rieder, R. (2018). Computer vision and artificial intelligence in precision agriculture for grain crops: A systematic review. Comput. Electron. Agric. 153, 69–81.

Pivoto, D., Waquil, P.D., Talamini, E., Finocchio, C.P.S., Dalla Corte, V.F. & Mores, G.V. (2018). Scientific development of smart farming technologies and their application in Brazil. Information Processing in Agriculture, 5(1), 21-32.

https://doi.org/10.1016/j.inpa.2017.12.002

Scherr, S. J. Shames, S. & Friedman, R. (2019). From climate-smart agriculture to climatesmart landscapes. Agriculture & Food Security, 1(1), 1-15.

Shaw, C.S. (2018). Agricultural technology adaptation I'm West Africa. Master's thesis, Texas A&M umnesty, college station, Tx,USA

Singha, A.K. & Baruah, M.J. (2018). Farmers' adoption behavior in rice technology: An analysis of adoption behavior of farmers in rice technology under different farming systems in Assam. Journal of human ecology, 35(3), 167-172

Table 1: Socioeconomic characteristics of the vegetable farmers in the study area

Variables	Frequency	Percentage	Mean
Gender			
Male	11	15.7	
Female	59	84.3	
Age (years)			43
21-30	7	10	
31-40	23	32.9	
41-50	24	34.2	
51-60	15	21.3	
61 and above	1	1.4	
Marital status			
Single	8	11.4	
Married	62	88.6	
Educational level (years)			11
No formal education	2	2.9	
Primary education	17	24.3	
Secondary education	41	58.6	
Tertiary education	10	14.3	
House hold size(number)			6
1-5	24	34.3	
6-10	44	62.8	
11-15	2	2.8	
Farming experience (years)			11
1-10	40	57.3	
11-20	25	35.6	
21-30	4	5.7	
31-40	1	1.4	
Farm size (hectare)			0.45
0.01-0.05	6	8.6	
0.06-0.10	10	14.3	
0.20-0.50	40	57.1	
0.60-0.90	8	11.4	
1.0-1.5	4	5.7	
1.6-2.0	1	1.4	
2.1 and above	1	1.4	
Occupation			

Farming as major	38	54.3
Other occupation	32	45.7
Access to technology		
Yes	19	27.1
No	51	72.9
Access to credit		
Yes	14	20.0
No	56	80.0
Access to extension agent		
Yes	8	11.4
No	62	88.6
Awareness of digital agriculture technologies		
Yes	36	51.4
No	34	48.6
Total	70	100

Source: Field survey, 2023

Table 2: Awareness of the digital agriculture technologies among the vegetable farmers in the study area

Variables	**Aware**	**Slightly aware**	**Slightly unaware**	**Not aware**
Drones	5(7.14%)	3(4.29%)	1(1.43%)	2(2.86%)
Global positioning system (GPS)	2(2.86%)	3(4.29%)	1(1.43%)	2(2.86%)
Crop monitoring system(soil moisture sensor, pH meter)	4(5.71%)	1(1.43%)	2(2.86%)	2(2.86%)
Crop disease detector (pest & disease alert)	3(4.29%)	3(4.29%)	1(1.43%)	1(1.43%)
Precision irrigation system (Micro sprinkler, drip tapes)	7(10.0%)	3(4.29%)	1(1.43%)	2(2.86%)
Mobile devices	28(40.0)	10(14.29%)	5(7.14%)	2(2.86%)
Artificial intelligence	1(1.43%)	2(2.86%)	1(1.43%)	1(1.43%)
Vertical farming	4(5.71%)	2(2.86%)	1(1.43%)	1(1.43%)

Source: Field Survey, 2023; * Figures in parentheses indicate the level of technology awareness

Table 3: Utilization of digital agriculture among the vegetable farmers in the study area

Utilization	Frequency	Percentage
Yes	27	38.57
No	43	61.43

Source: Field Survey, 2023

Table 4: Level of utilization of digital agriculture among vegetable farmers in the study area

Variable	Very low utilization	Low utilization	Moderate utilization	High utilization	Mean	Remark
Drones	46(65.71%)	20(28.57%)	3(4.29%)	1(1.43%)	1.41	NU
GPS	43(61.43%)	22(31.43%)	3(4.29%)	2(2.86%)	1.49	NU
Crop monitoring system	38(54.29%)	19(27.14%)	9(12.86%)	4(5.71%)	1.70	NU
Crop disease detectors	40(57.14%)	26(37.14%)	3(4.29%)	1(1.43%)	1.50	NU
Precision irrigation	12(17.14%)	23(32.86%)	21(30.0%)	14(20.0%)	2.53	U
Mobile devices	10(14.29%)	12(17.14%)	20(28.57%)	28(40.0%)	2.94	U
Artificial intelligence	55(78.57%)	15(21.43%)	0	0	1.21	NU
Vertical farming	16(22.86%)	18(25.71%)	21(30.0%)	15(21.43%)	2.50	U

Note: U = Utilized, NU = Not Utilized Source: Field Survey, 2023

Table 5: Factors influencing the utilization of digital agriculture technologies among vegetable farmers in the study area

Variables	Co-efficient	Standard Error	Wald	P-value
Gender	1.795	0.785	2.368	0.012**
Age	-0.026	0.035	0.528	0.468
Marital status	-0.787	1.055	0.557	0.456
Educational level	0.209	0.078	2.679	0.004***
Household size	0.287	0.145	1.979	0.047**
Farming experience	0.069	0.045	2.372	0.024**
Ownership of digital tools	2.037	0.680	2.995	0.036**
Cost of usage	0.000	0.000	0.269	0.604
Constant	-2.429	3.929	0.382	0.536

Note: Log likelihood Chi-square = 86.613; R^2; Cox & Snell R square) = 0.092
Source: Field Survey, 2023; * = Significant P-values

Table 6: Constraints in the utilization of digital agriculture technologies among vegetable vegetable farmers in the study area

Variables	*Frequency	Percentage
Inadequate capital	26	37.14
Ignorance	20	28.57
Lack of access to digital tools	7	10.0
Reliance on traditional farming methods	10	14.29
Unreliable access to electricity and internet	4	5.71
Inability to operate it	2	2.86
Lack of government support and infrastructure	5	7.14
Inadequate land	6	8.58
Complexity of technology	5	7.14
Farm size	7	10.0

Source: Field Survey, 2023; * = Multiple responses recorded.