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Factors Influencing Use of Mobile-Based ICTs among Cassava Value Chain Operators in Southwest, Nigeria

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Abstract
Heterogeneity in the socioeconomic characteristics of value chain operators is one of the probable determinants of adoption of mobile-based ICTs. The study assessed use and drivers of mobile-based ICTs among cassava value chain operators in Oyo and Ogun States in Southwest, Nigeria. A multi-stage sampling procedure was used to select 327 cassava value chain operators (216 producers, 10 Assemblers, 42 processors, 59 marketers) through a non-random sampling technique. Descriptive and inferential statistics [such as Ordinary Least Square (OLS) regression] were applied to describe the socioeconomic characteristics and assess key factors responsible for adoption of mobile-based ICTs among the selected operators in the study respectively. The study finds that majority of the operators belong to middle age group (49-54years), had at least primary school education, household size of about 6 persons, small land holding category (4.04±2.27ha), 20 years of farming/operating experience, no access to extension services (91-100%), no access to credit (74-88%) with varying levels of income. Mobile phones that have internet connectivity (smartphones) are the most widely used ICT-based device among the value chain operators. The OLS results revealed that the level of formal education, access to extension visits, level of awareness, household size and group membership had significant effects on use of mobile-based ICTs. Major barriers to adoption of mobile-based ICTs include; relatively high prices, limited availability of network signals, low levels of ICT literacy and low awareness of relevant software used in cassava value chain. Policy interventions on awareness creation, reduction in cost of mobile-based ICTs are indispensable for greater uptake of the technology among smallholder cassava value chain operators.

Keywords: Socioeconomics, Smartphone-based app, diffusion, SMS message, social media, specialized software, Mobile technology

Introduction

Information and Communication Technology (ICT) encompasses both the internet-enabled sphere as well as the mobile powered by wireless networks (Ezeanyaeji and Mgbeafulike, 2020). Mobile phone-based ICT is a system of information and communication technology whose major instrument of enabling is the mobile telephone. Text messages and voice calls have traditionally been the only methods of communication available on mobile devices. It does not preclude the use of other technologies to support the functioning of such systems (such as computer servers and database). These technologies have become a major form of communication in the world with the expansion of the mobile phone networks. They have the means of creating a platform (like LinkedIn, Facebook, Twitter YouTube, WhatsApp and Instagram) with farmers, extension workers, and researchers onboard to share valuable information for a rapid response in the marketing of agricultural products, enhancement of efficiency and turnover of farmers through a significant reduction in the cost of marketing agricultural products as well as increased demand for agricultural products.

Mobile-based ICTs are playing an increasingly important role in supporting agricultural value chains in developing countries. They offer opportunities for the creation of timely monitoring systems that support the detection of emerging issues in agriculture, enabling value chain actors to respond to issues promptly (McCole *et al*., 2014), give farmers access to a variety of relevant information sources at an affordable and

effective way (Abdulsalam *et al*., 2016), allow agricultural value chain operators' access to consumers (Minkoua-Nzie *et al*., 2018), acquire improved agronomic technology and access to credit (Mariyono *et al*., 2022). The technology brings about better decision-making and positive changes in the production level of farmers, production cost and postharvest losses across agricultural value chain (Ali and Kumar, 2011).

Studies (such as Mittal and Mehar, 2015; Simtowe *et al*., 2016) have shown that farmers socioeconomic characteristics have featured significantly in explaining ICTs adoption decisions. Identification of the influencing factors and constrains on use of mobile-based ICTs among cassava value chain operators are important for formulation of policies that address those constraints and promote cassava output via mobile-based ICTs. This study therefore profiled the socioeconomic characteristics of cassava value chain operators in the Southwest Nigeria, documents the various mobile-based ICTs currently available and used by cassava value chain operators in the study area, examine socioeconomic drivers on use of mobile-based ICTs and identify constraints facing cassava value chain operators on the use of mobile-based ICTs in the study area. Findings will contribute to scanty literature on the relationship between mobile-based ICTs adoption and socioeconomic characteristics of cassava value chain, relationship between mobile-based ICTs adoption and socioeconomic characteristics of cassava value chain in Southwest Nigeria.

Methodology

Study area

Southwest (SW) of Nigeria comprise six states (Lagos, Oyo, Ogun, Osun, Ondo and Ekiti States) and a major cassava growing region in the country. Oyo and Ogun States were purposively selected for the study because some of cassava related mobile technologies (such as Akilimo, Cassava Seed Tracker, IITA herbicide calculator, IITA NURU, Cassava e-Market) have been launched and disseminated to some selected cassava value chain operators on the use of these apps to assist with the help of African Cassava Agronomy Initiative (ACAI) programme of IITA, Justice, Development and Peace Movement (a Non-Governmental Organisation) in Oyo State and Ogun State Agricultural Development Programme (OGADEP). Oyo State is bounded in the North by Kwara State, in the East by Osun State, in the South by Ogun State and in the West partly by Ogun State and partly by the Republic of Benin. Oyo State is located on the latitude 8°00″N and longitude 4°00″E. It has an inhabitant population estimate of 6,617,720 as at 2006 with a land mass of 28,454km^2. Agriculture is the main occupation of the people of the state with a climate favourable for the cultivation of crops like cassava, maize, yam, millet, rice, plantains, cocoa, palm produce, cashew. Ogun State on the other hand, shares boundaries in the West with Republic of Benin, in the East with Ondo State, in the North, with Oyo State and the South with Lagos State. Ogun State is located on the latitude 7°00″N and longitude 3°35″E. It has an inhabitant population estimate of 4,054,272 as at 2006. The climatic condition of Ogun State is tropical, with about 7-8 months of rainfall occurring between April and October with annual rainfall ranging between 1250mm-1500mm. The state has green vegetation, which favour poultry production and food crops such as maize, cassava, cocoyam, vegetables and major cash crops like cocoa and oil palm.

Sampling procedure and method of data Collection

Multistage sampling procedure was used in selecting the cassava value chain operators (Producers, Assemblers, Processors and Marketers) for the study. In the first stage, Oyo and Ogun were purposively selected from the six states in Southwest Nigeria based on the results of the findings from a reconnaissance survey of SW where cassava operators who use mobile-based ICTs along the value chain are concentrated. The second stage was listing of areas in each of the selected state with the help of staff from Agricultural Development Project (ADP) and other non-profit organisations such as the *Justice, Development and Peace Movement* (*JDPM*), Oyo State where mobile-based ICTs by the African Cassava Agronomy Initiative (ACAI) have been disseminated and cassava operators are using other mobile-based ICTs such as social media for cassava value chain activities. The third stage was arrangement of sensitization meetings with cassava value chain operators in each identified areas (villages) with the motive of identifying cassava operators who make use of their telephone for their value chain activities. In the fourth and final stage, a total number of 340 cassava value chain operators (225 producers, 10 assemblers, 45 processors and 60 marketers) were selected and interviewed through a non-random sampling technique (snowballing) but responses from 327 operators (216 producers, 10 assemblers, 42 processors and 59 marketers) were interviewed across the selected states and used for the analysis, while 13 (9 producers, 3 processors and 1 marketers) were discarded owing to incomplete information. Data were collected from the 327 value chain operators through a single-visit with the assistance of trained enumerators between Nov. 2021 to January 2022 from Oyo and Ogun States Nigeria with the use of a structured questionnaire.

Analytical Model

Both descriptive (such as frequency distribution tables, percentages, mean, and standard deviation) and inferential (regression model) statistics were used in this study. The Ordinary Least Square multiple regression model was used to examine the effects of socioeconomic characteristics of cassava value chain operators on the use of mobile-based ICTs. Four functional forms: Linear, double-log, semi-log and exponential were tried, but the linear functional form based on the a priori expectation, number of significant variables, one with the highest value of coefficient of determination (R-Square value) and significance of F-value was considered and adjudged the best as specified in Equation 1:

$$Y = \beta_0 + \beta_1 X_1 + \beta_2 X_2 + \beta_3 X_3 + \beta_4 X_4 + \beta_5 X_5 + \beta_6 X_6 + \beta_7 X_7 + \beta_8 X_8 + \beta_9 X_9 + \beta_{10} X_{10} + \beta_{11} X_{11} + \beta_{12} X_{12} + \beta_{13} X_{13} + \beta_{14} X_{14} + \beta_{15} \beta_{15} + \varepsilon_i \ldots\ldots\ldots 1$$

Where:
Y = Number of mobile-based ICTs adopted (both specialized and not specialized), X_1 = Age of the respondent (yrs), X_2= Year of experience (yrs), X_3 = Year of formal education (yrs), X_4 = Marital status (1= married, 0 if otherwise), X_5 = Sex of the respondent (1 if male, otherwise 0), X_6 = Value of income from cassava (N), X_7 = Farm size (ha) in production, Firm size in processing and marketing measured by the quantity of products processed or marketed, X_8 = Income from other sources (N), X_9= Access to extension agent (1 if have access to extension agents, 0 if otherwise), X_{10} = Awareness of use of mobile-based ICTs(1 if aware, 0 if otherwise), X_{11}= Household size (number), X_{12} = Access to credit (1 if having access, 0 if otherwise), X_{13} = Group membership (if member = 1, otherwise 0), X_{14} = Geographical location (Ogun State = 1; 0 otherwise), X_{15} = Use of non-mobile-based ICTs (number), ε_i= Error term. Three models (Producers, Processors and Marketers) were modeled, while Assembler was dropped due to small sample size.

Results and Discussion

The socioeconomic data in (Table 1) shows that males dominated cassava production (70.2%), assembling (60%) and marketing (52.8%), while female dominated processing (60.1%). This can be attributed to the belief in the study area that Cassava farming is a masculine occupation, while cassava processing is a feminine occupation. Majority of the operators were married. The mean age of cassava producer is 48.9 yrs (SD =11.4yrs), assemblers, 52.2yrs (SD=12.9yrs), processors, 46.9yrs (SD=7.7) and marketers, 50.9yrs (11.4yrs). This indicates that cassava value chain operators are dominated by middle aged people who are energetic and innovative to carry out the enterprise profitably. Although this variable was not a significant factor in our study in agreement with Akinola (2017) who reported that age is not a significant factor in ICT adoption contrary to Mittal and Mehar (2015), Ezeh *et al*. *(*2015), and Onyeneke (2017) that corroborate findings that age is an important factor that determines ICTs adoption. Majority of the value chain operators had long years of experience with mean years of producer's experience of 24.8 yrs (SD =11.2yrs), Assembler, 25yrs (17.3yrs), Processors, 20.0yrs (SD=8.8yrs), Marketers, 23.1yrs (SD=10.2yrs). About 41.65% have between 0 - 4acres (0-1.62ha) of farm land cultivated with cassava, the mean farm size was 9.96acres ± 4.04ha. Low farm size is an indication that farmers operate in small scaled level, this could be because of the limited availability of farm land due to land fragmentation (Mbam and Edeh, 2011). Results presented in Table 2 revealed that only 29.2%, 20%, 30.9% and 18.0% of the producers, assemblers, processors and marketers had no formal education. This means that cassava value chain operators are fairly educated in the area with majority having at least a taste of primary education. About 80% Assemblers and 61.5% Processors belong to cooperative organization(s) which is a measure of social capital that encouraged them to pool resources such as finance, labour and other essential facilities together for sharing among themselves; most producers (52.3% and Marketers (50.5%) were not members of cooperative group. In addition, only very few operators have accessed credit in form of external finance and loan from friends, cooperative society and banks, while majority (90.9% Producers, 100% Assemblers, 92.3% Processors and 96.7% Marketers) have no access to credit. Most processors and marketers in the study area had at least access to mobile phones. There are high levels of illiteracy among farmers, which limit their use of ICT and information access (Agula *et al*., 2018).

Inventory of mobile-based ICTs developed and disseminated for cassava value chain activities

There are quite a number of emerging mobile-based ICTs and application software that are available to cassava value chain operators in the study area beyond the used of social media that are mobile-based (such as WhatsApp, email, SMS, LinkedIn) in Nigeria for transferring information and new technologies. Other mobile-based apps have also been developed. More than five existing mobile-based applications smart farming tools were identified to be available (Appendix 1) and used by few cassava value chain operators in the study area to disseminate agricultural information by cassava value chain operators. These were: FarmSmarter, Akilimo, Herbicide Calculator, Cassava Seed Tracker, Cassava e-Market, GoSeed Tracker. Most of the value chain operators (80.6%, 60%, 66% by producers, assemblers and marketers respectively) used between 1-3 types of mobile-based ICTs which are social media for their operations, while only few used specialized apps such as Akilimo, Cassava seed tracker, IITA herbicide calculator probably due to the low awareness level by the operators as indicated in Table 3.

Determinants of the use of mobile-based ICTs by cassava value chain operators

Studies (such as Ali and Kumar, 2011; Oluwatayo, 2014; Asfaw and Abate, 2016; Olaniyi and Enwelu, 2021) had shown that individual characteristics (such as educational level, gender, income, age, household size, farming experience, among others) are important indicators for ICTs adoption. Table 4 shows factors influencing mobile-based ICTs adoption. The R^2 (coefficient of determination) shows that the independent variables included in the OLS multiple regression model explained 59.59%, 92.29% and 68.77% of the variations on the use of mobile-based phone ICTs by producers, processors and marketers respectively. F-statistics imply the goodness of fit of the regression; these confirmed adequacy of the model and implies that at least most of the coefficients of the explanatory variables were significant. The variables that are statistically significant include: age, level of education, years of experience, marital status, access to

extension services, level of awareness on use of mobile-based ICTs for cassava value chain activities, household size, access to credit and membership of cooperative groups. Factors that have a positive coefficient and significant effects on adoption of mobile-based ICTs by cassava producers are: producers' years of experience, years of formal education, marital status, extension visits, level of awareness, access to credit and membership of cooperative group, while household size had a negative effect. This indicates that with an increase in farmers' years of experience, more education, more extension visits, access to credit, membership to more associations and movement from single to married increase the level of adoption of mobile-based ICTs in the study area. These findings are consistent with those of Kafura *et al*. (2016); Yu *et al*. (2017) and Kumar *et al*. (2017) who indicated that education is a major factor in adoption and absorption of technology. Educated value chain operators could easily acquire basic ICT operational skills. Factors that have a positive coefficient and significant effects on adoption of mobile-based ICTs by cassava processors are years of formal education, household size, extension visits, level of awareness, while processors years of experience and income from other sources rather than the values of processed cassava negatively affected adoption of these technology. This implied that as the cassava processors improve their formal education, increase their household size, receive more extension services through visits and with more awareness, the level of mobile-based ICTs adopted increases. The level of awareness of mobile-based ICTs had a positive and significantly influence on adoption of mobile based ICTs by cassava marketers, while location (Ogun State) had a negative influence on the adoption probably because the state is not one of the mandate state covered by IITA for dissemination of the mobile-based developed ICTs. This implies that those who have the knowledge of mobile-based ICTs in cassava value chain activities are more likely to use them. These findings are like the result of Verhoeven *et al.* (2020) who found that more exposure to ICT tools should be considered as a factor for someone to think positively towards ICTs. In addition, other sources of income to processor had a negative and significantly explained the use of mobile-based ICTs at 10% level of significance. This implying that a unit increase in off farm income will lead to a corresponding decrease in the use of mobile-based ICTs. The result is contrary to our *a priori* expectation that value chain operators with higher levels of income should be able to afford to own mobile-based ICTs and cover all cost of operations in accessing market information than those with low-income levels. These results disagree with those by Eskia (2019); Li *et al.* (2020) that increased income has a positive impact on decision to use ICT tools. Farmers with more education are more probable to embrace new technologies and increase their productivity. Education boosts the capacity to obtain, decode, and assess helpful information for agricultural production (Nwokoye *et al*., 2019).

Constraints militating against cassava value chain actors in using mobile-based ICTs

The primary objective of agricultural policies is to identify and eliminate the constraints hindering adoption of new technology. Figure 1 presented the results of the constraints facing cassava value chain operators on adoption of mobile-based ICTs in the study area. Major barriers identified to hinder adoption of mobile-based ICTs among cassava value chain operators include: relatively high prices (87%, 90%, 62% and 93% by producers, assemblers, processors and marketers respectively), lack of awareness of availability of mobile-based ICTs (81%, 70%, 60% and 63%), poverty (94%, 80%, 83% and 92%), low levels of ICT literacy (89%, 80%, 67% and 85%), weak network between agriculture institutions and value chain operators (82%, 60%, 88% and 94%), lack of clarifications if any doubt arises (83%, 80%, 57% and 73%) in that order. Some of these findings are in line with studies such as: Luarn and Lin (2005), Aker and Mbiti (2010), Lubua, (2019), Sennuga *et al*. (2020) who observed that lack of awareness, low level of formal education, unavailability of ICT devices, high cost of ICT devices are the most noticeable constraints limiting smallholders' use of ICT devices in sub-Saharan African communities. Muhammad *et al.* (2020) who also found that lack of awareness, poor ICTs infrastructure, inability to use ICTs, and internet coverage are some of the constraints faced by farmer in adopting ICT tools in agriculture. The results show that value chain operators are constrained by different factors, which prevented them from getting access to timelier and better-quality information on products and inputs as well as facilitating technology adoption among them.

Conclusion

The study shows that use of mobile-based ICTs in cassava production is driven by level of education of farmers, training of farmers in ICTs, access to ICT resources and access to extension services. The findings revealed that, cassava producers in value chains are not yet utilizing the mobile phone maximally. This implies the benefits of using mobile phones in cassava value chain, does not guarantee the adoption of mobile-based technologies among the operators. The producers are not well connected with other value chain operators making them liable to exploitation from other chain actors, especially the marketers. They are still ignorant about what takes place in markets. Consequently, they accept any price that the marketers offer them for their produce/commodity. Also, cassava value chain operators' decision to use mobile-based ICTs is associated with the socioeconomic status such as age, education, size of landholdings and farming experience of the farmers. On policy implications, the findings, like previous studies, suggest that socioeconomic characteristics should be put into consideration when promoting adoption of any technology. In addition, our results suggest that raising the level of education is key to overcoming most barriers that cassava value chain operators face with respect to using mobile phone-based ICTs. Nonetheless, the lack of awareness of the

existence of such ICT services points to the need for wider public sensitization to these services. Furthermore, in line with making these services more customizable to enhance adoption, we suggest that mobile-based ICTs applications should have the option of being used in a local language, which enable use by those with low-literacy skills.

Limitation of the study

The current study was limited to the Southwest, Nigeria. Future study can be done in other region of Nigeria for reliability of the results of present study. The use of ICTs in this research does not cover traditional media such as Television, Radio, print media, Compact Disc and so on. Mobile-based ICTs in this research refer to the use of mobile phone, smartphone, software apps, internet, social media (WhatsApp, Facebook, Twitter, etc.).

Suggestions for Further Research

Future studies could offer further insights by analyzing the use of ICTs by youth on specific enterprises. Future research can also focus on analyzing each ICT tool for the different stages of the agricultural value chain so as to better understand how to integrate ICT tools in the various stages of the chain. Also, it is important that future research can consider perceived ease of use and perceived usefulness of mobile-based ICTs.

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Author's contribution**:** Abiodun Elijah **Obayelu**: Conceptualization, Investigation, Supervision, Validation, Methodology, Data Analysis, and draft preparation. Carolyn Afolake **Afolami**: Conceptualization, Investigation, Visualization, Reviewing, and Editing. Olusegun **Folorunso:** Conceptualization, Investigation: Conceptualization, Investigation and data curation. Adebayo **Adebayo**: Conceptualization, Investigation and Literature Review. Olubunmi **Ashimolowo:** Investigation, Reviewing and Editing.

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Table 1: Distribution of Cassava Value Chain Operators by their Socioeconomics Characteristics

Characteristics	Producers^{+} (n= 216)	Assemblers^{+} (n=10)	Processors^{+} (n=42)	Marketers^{+} (n=59)
Sex				
Male	70.19	60	39.92	52.8
Female	29.81	40	60.08	47.2
Marital Status				
Married	92.58	90	81.56	89.84
Single	3.16	0	5.17	3.41
Divorced	1.89	0	13.27	1.14
Widowed/Widower	2.37	10	0	5.61
Age				
<30	2.3	0	6.89	1.14
30 – 40	25.34	20	15.92	14.62
41 – 50	33	30	54.91	38.11
51 – 60	24.21	30	20.56	31.52
>60	15.15	30	1.72	14.62
Mean (SD)	48.86 (11.37)	53.2 (12.89)	46.87 (7.74)	50.91 (11.37)
Household size				
1 – 3	6.8	10	6.89	13.56
4 – 6	50.17	40	60.48	35.59
7 – 9	28.27	30	21.89	33.9
10 – 12	11.54	20	9.02	13.56
13 – 15	3.22	0	1.72	3.39
Mean (SD)	6.53 (2.8)	6.9 (2.92)	6.04 (2.21)	6.64 (2.55)
Type of Household				
Monogamous	69.58	50	83.69	77.42
Polygamous	30.42	50	16.31	22.58
Yrs of Experience				
0 – 5	2.37	0	3.45	1.13
6 – 10	8.35	0	18.04	14.62
11 – 15	11.88	20	12.86	6.74
16 – 20	20.84	40	25.34	22.43
>20	56.56	40	40.31	55.08
Mean (SD)	24.75 (11.17)	25 (17.32)	20.01(8.81)	23.14 (10.23)
Farm Size (acre)				
≤ 1.0	9.41	-	-	-
1.1- 3.0	32.24	-	-	-
3.1-5.0	17.82	-	-	-
5.1-7.0	9.38	-	-	-
7.1-9.0	5.12	-	-	-
> 9	26.03	-	-	-
Mean (SD)	9.96ac ≠ 4.04ha (5.62ac ≠2.27ha)	-	-	-

Note: $^{+}$ ***values in percentage, 1 acre = 0.4047ha***
Source: Data from Field Survey, 2021/2022

Table 2: Distribution of Cassava Value Chain Operators by their Socioeconomics Characteristics

Characteristics	Producers+ (n= 216)	Assemblers+ (n=10)	Processors+ (n=42)	Marketers+ (n=59)
Land ownership				
Inheritance	32.87	-	-	-
Rent	43.06	-	-	-
Lease	18.52	-	-	-
Purchase	4.63	-	-	-
Use as a community member	0.92	-	-	-
Year of Schooling				
0 (no formal education)	29.19	20	30.9	18.03
1 – 6	49.76	70	54.51	48.41
7 – 12	18.16	10	10.74	30.225
13 – 17	2.89	0	0	3.335
> 17	0	0	3.85	0
Mean (SD)	5.1 (4.1)	4.9 (2.70)	5.06 (4.8)	6.57 (4.20)
Access to Extension Services				
No	90.86	100	92.31	96.66
Yes	9.14	0	7.69	3.34
Source of Credit				
No	87.74	80	76.92	74.16
Yes	12.26	20	23.08	25.84
Group Membership				
No	52.3	20	38.46	50.46
Yes	47.7	80	61.54	49.55
Production Income (₦/ha)				
0 – 500000	36.26	100	96.15	90
500001-1000000	28.19	-	3.85	6.66
1000001-1500000	13.84	-	-	3.34
1500001- 2000000	6.94	-	-	-
2000001- 2500000	4.5	-	-	-
2500001-3000000	2.4	-	-	-
>3000001	7.87	-	-	-
Mean (SD)	1,726,147.5 (1,263,151.5)	0 (0)	208,012.6 (57,692.3)	521,056.6 (₦260,000)
Other Income Sources /year				
0 -50000	64.19	100.00	96.15	90
50001 -100000	6.08	-	3.85	6.66
100001- 150000	3.74	-	-	3.34
150001- 200000	8.48	-	-	-
200001- 250000	4.74	-	-	-
250001-300000	1.44	-	-	-
>300001	11.33	-	-	-
Mean (SD)	498,977.20 (172,511.33)	0 (0)	490,923.02 (130,846.2)	646,408.70 (197,266.70)
Use non-mobile based ICTs for general purpose				
No	31.66	40.00	46.82	43.94
Yes	68.34	60.00	53.18	56.06

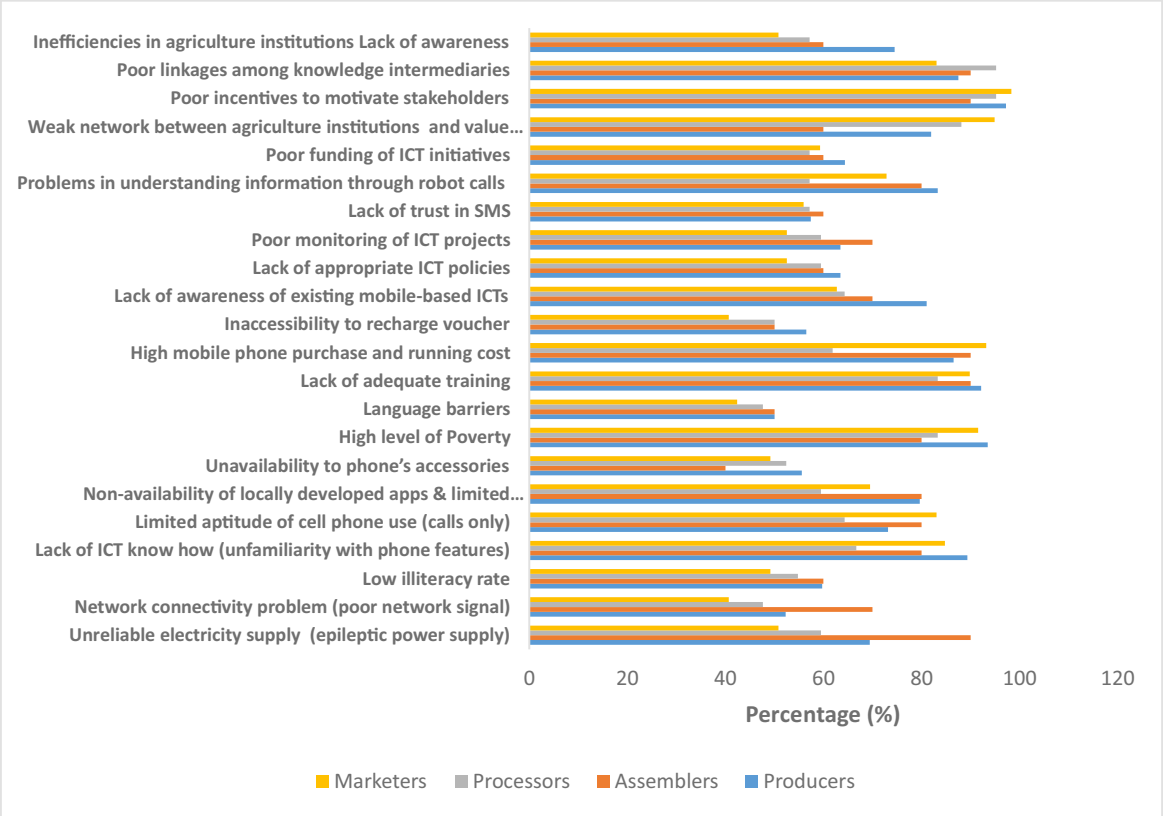
Note: + values in percentage

Source: Data from Field Survey, 2021/2022

Table 3: Distribution of Cassava value chain operators by their level of awareness of mobile-based ICTs

	Producers (n=216)		Assemblers (n=10)		Processors (42)		Marketers (n= 59)	
	Freq.	Perc.	Freq.	Perc.	Freq.	Perc.	Freq.	Perc.
Awareness on specialized mobile-based apps[a] by cassava value chain operators								
Yes	104	48.15	4	40.0	13	30.95	15	25.42
No	112	51.85	5	60.0	29	69.05	44	74.58
Total	216	100	10	100	42	100.00	59	100
Types and perceived condition of mobile telephones used								
Smartphones	77	35.65	3	30.00	13	30.95	15	25.42
Regular Phones	97	44.91	6	60.00	27	64.29	38	64.41
No functional phone	42	19.44	1	10.00	2	4.76	6	10.17
Number of Mobile-based ICTs[a], [aa] used								
1-3	174	80.56	6	60.00	20	47.62	39	66.10
4-6	40	18,52	3	30.00	19	45.24	18	30.51
>6	2	0.92	1	10.00	3	7.14	2	3.39
Mean (SD)	3.43 (2.92)		3.23 (2.0)		4.32 (2.69)		3.80 (2.36)	

Note: [a] are Akilimo, Cassava seed tracker, IITA herbicide calculator, IITA NURU, Cassava e-Market, GoSeed trackers, FarmSmarter, [aa] include: WhatsApp, Facebook, Email, SMS, Calls, YouTube, Mobile radio, Nairaland, Twitter



Source: Data from field survey 2021

Figure 1: Constraints limiting the use of mobile-based ICTs by cassava value chain operators

Table 4: Regression Estimates of determinants of use of mobile-based technologies among cassava value chain operators

Variable	Producers Coefficient	P>t	Processors Coefficient	P>t	Marketers Coefficient	P>t
Age	0.005 (0.008)	0.492	0.004 (0.013)	0.745	-0.012 (0.009)	0.2
Years of experience	-0.006 (0.008)	0.495	-0.026** (0.012)	0.031	0.016 (0.012)	0.194
Years spent in school	0.046*** (0.017)	0.008	0.064*** (0.018)	0.001	0.030 (0.024)	0.211
Marital status (1 = married, 0 if otherwise)	0.488* (0.289)	0.093	-0.161 (0.227)	0.484	0.056 (0.256)	0.829
Sex (Male = 1, 0 if otherwise)	0.226 (0.149)	0.131	0.011 (0.318)	0.973	0.111 (0.200)	0.582
Production Income	-2.10e-08 (4.91e-08)	0.670	1.63E-06 (1.25E-06)	0.203	-2.53E-07 (2.57E-06)	0.922
Farm size (ha)/firm size (volume processed or sales)	-0.003 (0.002)	0.284	2.276 (0.308)	0.000	-0.004 (0.339)	0.990
Income from other sources	3.71e-08 (1.45e-07)	0.799	-1.07E-05* (5.58E-06)	0.065	1.42E-07 (1.64E-06)	0.932
Access to Extension services (1 = Yes, 0 if otherwise)	0.679** (0267)	0.012	3.496*** (0.514)	0.000	-0.896 (0.610)	0.149
Level of Awareness (1 if aware,0 if otherwise	1.573*** (0.161)	0.000	2.088*** (0.208)	0.000	1.564*** (0.215)	0.000
Household size	-0.059** (0.027)	0.028	0.094* (0.047)	0.056	0.003 (0.033)	0.917
Credit source	0.711*** (0.223)	0.002	-0.084 (0.281)	0.768	-0.193 (0.200)	0.34
Group membership	0.528*** (0.191)	0.006	0.001 (0.228)	0.995	-0.085 (0.253)	0.739
State (1 if Ogun, 0 if otherwise)	0.001 (0.258)	0.996	-0.106 (0.405)	0.795	-0.589* (0.321)	0.074
Use of other non-mobile ICTs	0.036 (0.223)	0.873	-	-	-0.281 (0.749)	0.710
Constant	-0.795 (0.436)	0.069	-0.419 (0.529)	0.435	0.336 (0.462)	0.471
Number of observations	216		42		59	
F-statistics	19.66		25.79		6.31	
Prob > F	0.0000		0.0000		0.0000	
R-squared	0.5959		0.9229		0.6877	
Adj R-squared	0.5656		0.8871		0.5788	
Root MSE	0.94035		0.442		0.52201	

Note: Dependent variable = Number of mobile-based ICTs adopted, values in parentheses are the standard errors, cost of mobile phone was dropped due lack of variations in responses, 95% respondents indicated high prices, number of non-mobile ICTs apps was also dropped in processors due to lack of variations in responses

Appendix 1: Profile of Specialized Mobile-Based ICTs Disseminated in the Southwest, Nigeria to Cassava Value Chain Operators

Mobile-based Apps	Description of the apps	Developing Institutions	Source of disseminations	Sources
Specialized Apps				
Akilimo	This is an all-in-one agronomic advisory tool that supports cassava growers with knowledge and recommendations to intensify their cassava-based cropping systems. Akilimo exists in different formats such as paper-based tool, mobile app. It combines this data with weather and soil data in spatial crop models to calculate expected yield increases and revenue gain from investments in improved agronomic interventions. These include customized advice on fertilizer application, tillage regime, best planting practices, cost-effective weed control measures, intercropping practices, and tailored planting and harvest	African Cassava Agronomy Initiative (ACAI) of IITA	Justice, Development and Peace Movement (JDPM) in Oyo State and Ogun State Agricultural Development Programme (OGADEP) trained staff by ACAI in Ogun State.	https://cassavamatters.org/akilimo/ https://www.akilimo.org

	schedules. Akilimo combines the 3-2-1 service of Viamo. By simply dialing 3-2-1 on any mobile phone with an Airtel sim card, a farmer can get information on cassava agronomy free of charge up to 10 times in a month. The service requires no education and no internet.			
Herbicide Calculator	This is a simple mobile application to forestall incidents of under-dosing or overdosing of herbicides. It brings about precision in agriculture, helps farmers to become more efficient and prevents economic losses arising from over dosage of herbicides. The app also prevents environmental pollution and herbicides resistance arising from herbicides abuse.	IITA's Cassava Weed Management Project (CWMP) (now ACAI)	Justice, Development and Peace Movement (JDPM) in Oyo State and Ogun State Agricultural Development Programme (OGADEP) trained staff by ACAI	https://cassavamatters.org/iita_herbicide-calculator/
Cassava Seed Tracker	This is a web-app that provides essential features for quality seed production and access to quality stem cuttings of improved cassava varieties from the accredited seed producers. The Seed Tracker is available on android app in Google Play store, and it enables registration of seed fields for accreditation by National Agricultural Seeds Council (NASC). It also facilitates the buying and selling of quality stem cuttings of improved cassava varieties from accredited seed producers. This app provides details of improved cassava varieties released in Nigeria, the location and availability for ready access.	Developed by a team at IITA-Nigeria led by Dr Lava Kumarm and piloted in Nigeria in collaboration with the National Agricultural Seeds Council (NASC) through Building an Economically Sustainable, Integrated Seed System for Cassava in Nigeria (BASICS) project	Justice, Development and Peace Movement (JDPM) in Oyo State	https://seedtracker.org/cassava/
Cassava e-Market	This is an online market place for cassava and cassava-related commodities on Cassava matters. The platform is a multi-seller/multi-vendor avenue for farmers (especially cassava farmers) to advertise and sell their produce. Related farming and processing equipment, herbicides, fertilizers, farmlands and lots more can also be advertised, sold and bought on the Cassava e-Market.	Developed under the coordination of Godwin Atser, IITA Digital Extension & Advisory Services Specialist	Justice, Development and Peace Movement (JDPM) in Oyo State and Ogun State Agricultural Development Programme (OGADEP) trained staff by ACAI in Ogun State and internet search	https://cassavamatters.org/e-market/
GoSeed Tracker	The GoSeed Tracker is a fully featured program for real-time tracking of cassava seed production, including planting planning, registration of seed fields, crop management, harvesting, quality assessment and quality assertion. The GoSeed tracker also serves as a digital platform for communication and networking of cassava seed producers and service providers.	Developed by the IITA Business Incubation Platform (BIP)	Justice, Development and Peace Movement (JDPM) in Oyo State and internet search	
Cassava Matters	Cassava Matters operates as a collaborative platform between the Cassava Weed Management Project also known as the Sustainable Weed Management Technologies for Cassava Systems in Nigeria, the African Cassava Agronomy Initiative (ACAI) and the Cassava Seed Systems project also known as BASICS. The platform provides information that improves cassava yields, weed management, cassava processing and marketing.	Sustainable Weed Management Technologies for Cassava Systems in Nigeria, ACAI and BASICS in IITA, Ibadan, Nigeria	Justice, Development and Peace Movement (JDPM) in Oyo State and internet search	Cassavamatters.org
FarmSmarter app	FarmSmart, in partnership with London-based technical consultancy Amido, launched an innovative mobile application that shares essential, sustainable and	Tested and use by some farmers in the field by	FarmSmarter platform currently administered by	https://farmsmarter.app

	climate-smart farming knowledge to smallholder farmers. The technology tailored recommendations for farmers based on location, soil-type, season and irrigation access, the app provides a powerful source of knowledge to smallholder farmers online and offline. The mobile application has a range of features that enable farmers to track their finances, connect with other farmers, and eventually support them to sell their produce on the open market. This app includes links to chat groups, allowing the farmers to communicate, share information and eventually sell their produce on the market; and all this is presented through an accessible, simple, intuitive and progressive interface.	Nigerian smallholders in Oyo, Ogun and Nassarawa States, Nigeria	Shola Agoro	
	Social Media mobile-based apps			
Social media such as WhatsApp, Email, SMS, LinkedIn, twitters, YouTube	These provide opportunity to keep in contact with their consumers; getting their feedbacks and complains on a daily basis.	Launched by different bodies	Advisory services provided by the Agricultural Development Programme, personal search through internet and signing in to the platforms by cassava value chain operators	

Source: Field Survey, 2021/2022