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# Can ICT Adoption Aid Crop Production in Nigeria? (Smart-Agriculture)

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***Abstract—*** *This paper empirically examines the role of ICT on agriculture by exploring the application of the theoretical prescriptions of the diffusion model to crop production, an agriculture subsector from 1985 - 2014. This research postulates that crop production can be achieved by increasing the availability, reducing the cost of ICT and utilising ICT in the crop production value-chain process. The OLS results showed that internet utilisation has a positive impact on crop production; mobile cell subscription has a negative impact in the short run while the correlation results showed that ICT adoption and crop production have a strong positive association.*

***Keywords— ICT adoption, Crop production, Correlation Analysis, and OLS.***

## I. INTRODUCTION

Goal two of the sustainable development goals (SDG) enacted in 2015 is to end hunger, achieve food security, improved nutrition and promote sustainable agriculture in the world. To achieve this goal, strategies would have to be put in place by countries especially in the developing part of the world to meet up the 2030 deadline. To achieve sustainable agriculture in this modern age, the application of information and communication technology (ICT) cannot be under-utilized. Agriculture plays a significant role in economic and social development in most less-developed and developing countries. Agriculture faces a range of modern and serious challenges, particularly in developing countries exposed to price shocks, climate change, and continued deficiencies in infrastructure in rural areas. Adequate dissemination of detailed information is a necessary condition for improvement of all areas of agriculture (Zhang, Wang & Duan, 2016). Empirical research also suggests that ICT has a positive impact on the development of any nation.

ICTs are being referred to as General Purpose Technologies (GPTs) by economists (Atkinson, 2009). GPTs are technologies that cut across all sectors of the economy and are known to have practical usefulness in those sectors. ICTs have been found to increase productivity and output, reduce cost of transportation and many other benefits. According to World Bank Report (2009), there was a 1.3 percent growth increase with every 10 percent rise in the speed of internet connection. Rational thinkers as human beings would prefer to engage in activities that would yield highest levels of utility. Information and Communication Technology (ICT) found its way into Nigeria territory few decades ago. Its dominance and influence on the economy of the country cannot be overemphasized. Research has shown that ICT has the largest market in Nigeria among other African countries (Ayo *et al*., 2010) capitalizing on her giant population. ICT is widely embraced and acceptable due to the availability and affordability of its infrastructure, which is springing up fast (Seyed & Seyed, 2012).

E-agriculture / Smart Agriculture comprise of the use and development of ICT for agriculture purposes. E-Agriculture started in developed economies, and is now being closely followed by developing economies but is growing at a slow rate (Goyal & González-Velosa, 2012). E – agriculture has been proven to increase agricultural output by improving product quality, providing full information for product pricing, enabling the collection of agricultural data more efficiently, improving soil testing techniques, improving marketing (e-commerce), easy sorting and record keeping, and so on.

Consequently, the immediate research questions include: what role does ICT play in crop production and furthermore agricultural Output? What should be the immediate policy agenda for Nigeria in implementing the use of ICT in agriculture? The main objectives of this paper are to provide

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statistical analysis of ICT and crop production variables in Nigeria, determine the role of ICT on crop production in Nigeria. The specific objectives are to identify the impact of mobile cell phones on agricultural output in Nigeria, to determine the impact of Internet usage on crop production in Nigeria, to know the degree of association between ICT adoption and crop production in Nigeria.

## II. INSIGHTS FROM LITERATURE

The argument for developing countries to globalize is important and is designed to enhance access to foreign capital, improved technology in order to enhance the prospect for larger markets (Alege & Osabuohien, 2013). The continued increase in globalization and integration of food markets has intensified competition and efficacy in the agriculture sector, and has brought unique opportunities to include more smallholders into supply chains. With the rapid development of Information and Communication Technologies (ICTs), data and information can be effectively generated, stored, analysed, disseminated and used to support farmers and farming communities to improve agricultural productivity and sustainability Globalisation has led to several innovations in technology such as the internet (ARPA 1962), mobile phones (1990s), television sets, personal computers, radios and others that have made communication anywhere around the world easier and faster. These modern tools for communication, are now collectively called Information and Communication Technologies - ICTs (Olise, 2010), for which is the main purpose of this study.

Information and communication technology could be used as a very effective medium to harness this potential as applied by many developed & developing countries. Zimbabwe (e-Hurudza phones), India (Reuters Market Light), Zambia (prepaid voucher, MRIAgro), Kenya (M-Pesa, iCow), Ghana (mFarms) have made use of ICT innovations and have had increased agricultural outputs. India for example; the Reuters Market Light (RML) has improved farmers' productivity by 14-16 percent with farmers selling even more profitably (IFPRI, 2002).

Despite the fact that studies have shown e-agriculture increases total agriculture output in developed countries and the fact that Nigeria has the required labour to carry out such great agriculture exploit coupled with one of the highest arable fertile land for growing crops, Nigeria still relies partly on the importation of some agricultural products to combat food insecurity. Many studies in relation to information and communication technology on agricultural productivity have been conducted in Nigeria, but few of them have attempted to provide a comprehensive review and analysis of different information dissemination models and their effects on agricultural productivity in Nigeria using quantitative secondary data. Hence, this study intends to determine the effect of ICT on agricultural productivity (Crop Production) in Nigeria.

ICT adoption is now raising much interest among economists. Literature is starting to witness a large body of theoretical and empirical debate on ICT and economic growth (Ghosh, 2016; Imbert & Papp, 2015; Muralidharan, Niehans & Sukthankar, 2014), inclusive growth (Ejemeyovwi & Osabuohien, 2017). Some researchers investigated ICT penetration and agriculture sector (Vanek *et al*, 2010; Aker, 2011; Armstrong. & Gandhi, 2012; Asenso-Okyere and Mekonnen, 2012; Chavula, 2013; Salampasis & Theodoridis, 2013; Adamides & Stylianou, 2013); Vosough *et al*, 2015; Zhang, *et al*, 2016). Furthermore, the challenges and opportunities in Technological Diffusion and Economic Progress in Africa (Osabuohien & Efobi, 2012); ICT and Productivity (Jorgenson 2003) were explored. The use of ICT in agriculture can bring changes to the poor and needy areas in an economy such as food security (Kumar & Sankarakumar, 2012). ICTs have inclusive advantage accumulation, information storage and dissemination; makes things easier and faster (Chisita, 2010). Mobile technology could be used to overcome problems related to physical distance and mobility of people, allowing them to enlarge areas of practices and maintain connections outside the immediate space of their homes, work, other local areas and increase access to timely and relevant information (Asongu, Boateng and Akamavi, 2016).

ICT could be used to carry out agricultural financial transactions. The e-wallet innovation in Nigeria is a way of using SMS to order and pay for seeds and fertilizers. Financial transactions are even made cheaper with the use of ICT as discount rates are given. This makes agricultural transactions timely, effective and easier. A study carried out revealed that ICT is a veritable tool and requirement for agricultural and rural transformation even though it is not widely accessed by farmers in these communities. It was recommended that information and communication technology facilities be made available in most rural localities in the state such as internet facilities, overhead projector, and the Agricultural extension staff should be properly trained in this area to be able to train farmers using ICT facilities (Ugboh & Tibi, 2008). Labour, as well as capital and technology have a direct relationship with total agricultural output. From the results in the analysis done on the role of ICT on Agriculture in West Africa; labour and capital were elastic. This implies that, for any change in

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Labour and Capital, agricultural output increases more than proportionately. These results were statistically significant (Akimuda, 2014).

Empirical evidence shows that ICT has a positive impact on agricultural output. Most of the works used primary data which involves the use of questionnaires for data collection (Hassan *et al*, 2011; Chukwunonso, Abubakhar & Obidi, 2012; Ramli *et al.*, 2013). Nwabueze and Ozioko (2011) put forward that ICT has been proven to be the engine of growth in the 21st century. It has found its place in many sectors in West African economies and its importance cannot be over emphasized. However, Hallova, *et al*, (2017) noted that there are risks involved in ICT implementation and no ICT resources can guarantee 100 percent protection. In sum, literature gaps have revealed that ICT use in agriculture has shown mixed results (positive and negative). This result of this study contributes by validating one of the views with statistical backing to that debate.

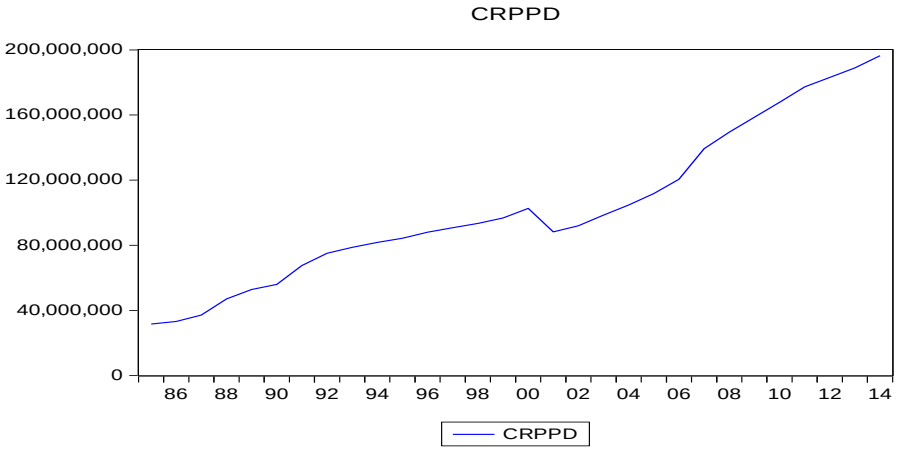
## III. METHODOLOGY

The methodologies used for this research are the Pairwise Correlation method and the Ordinary Least Squares (OLS) to determine the degree of association existing between the two variables involved in the research and to determine the short run relationship between the variables of interest respectively Gujarati (2009)- ICT adoption and Crop Production in Nigeria. The data used for this research is secondary time-series data for Nigeria (1985 – 2014; 30 years). The data was sourced from CBN statistical Bulletin (CBN, 2014) alongside World Bank development indicators (WDI, 2017),

*Table.3.1: Table showing the Variables and their corresponding definitions*

| Variables | Definitions | Data Sources |
|---|---|---|
| Total Crop Production (Y). (dependent variable) | Total number of crops produced (value added) in Nigerian (Tonnes). | Nigerian Bureau of Statistics and Central Bank of Nigeria (CBN) |
| Internet Users (NOIU) ($\beta_1$) | Total number of people that utilise internet in Nigeria | World Development Indicators (WDI) |
| Mobile Cell Phone Users (MCS) ($\beta_2$) | Total number of mobile cell phone Subscription in Nigeria. | World Development Indicators (WDI) |
| Capital (GFCF) ($\beta_3$) | Total amount of investment in the economy in terms of fixed and variable | World Development Indicators (WDI) |

Crop production in Nigeria consists of staples such as maize, millet, sorghum/guinea corn, rice, wheat, acha, beans/cowpea, cassava, potatoes, yam, cocoyam, plantain, vegetables; other crops which comprise of groundnut/peanut, bennis seed / sesame, soya bean, cotton, palm oil, cocoa, rubber, sugarcane, kola nut, ginger, cashew, pineapple, and palm produce. Table 1.0 below shows the trend of Crop production and ICT adoption in Nigeria (1985 to 2014). Crop production capacity (tonnes) in Nigeria has been experiencing increase within the period of 1985 and 2014, although, there was a slight reduction at 2000 and 2001. The maximum crop produced in tonnes was in year 2014 with 196 million tonnes while the minimum was seen in 1985 with 31.6 million tonnes.




*Computed by authors; Data Source: NBS (2016); Software: Eviews9*

*Fig.3.1: The Trend of Crop Production in Nigeria (1985 - 2014).*

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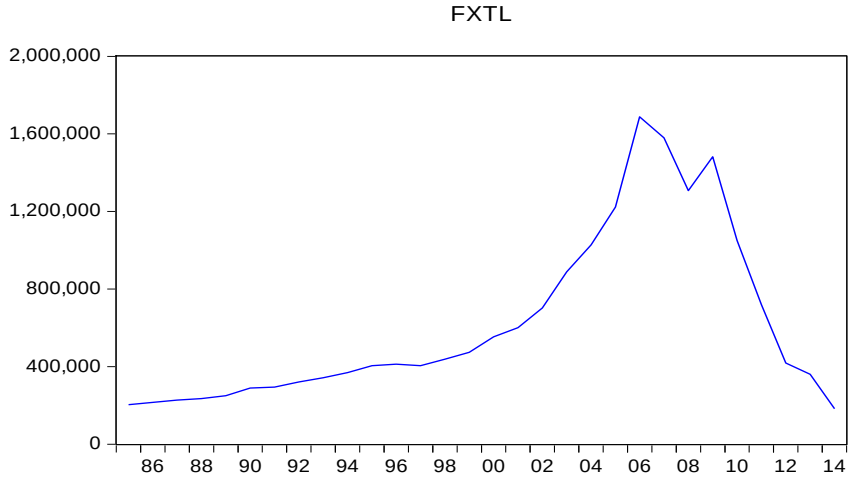
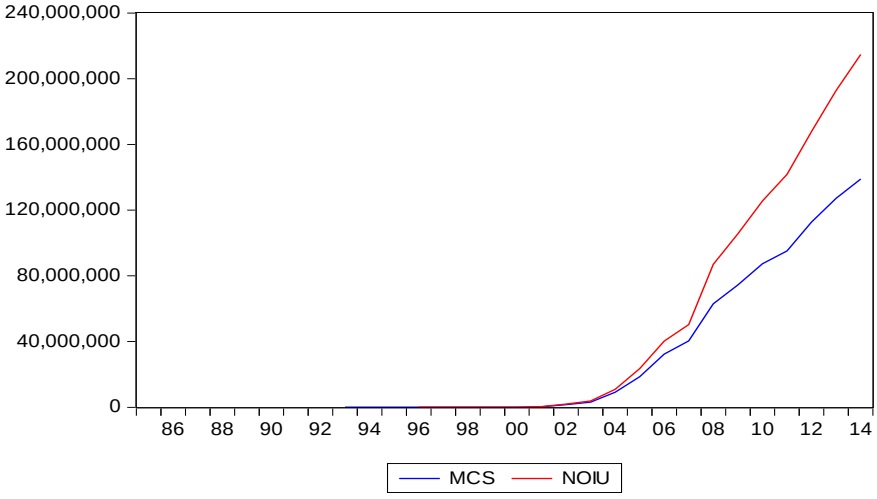
ICT adoption in this paper is measured by fixed telephone lines, Mobile cell phone subscribers (technology), Number of Internet users. During the early period of ICT adoption in Nigeria, Fixed telephone lines were the first to come into Nigeria by 1983/84 (WDI, 2017). Fixed telephone lines had the value of 203,980 by 1985, 342,287 by 1993.




*Computed by authors; Data Source: WDI (2017); Software: Eviews9*

*Fig.4.2: The Trend of Fixed Telephone Lines in Nigeria (1985 - 2014)*

The introduction of mobile cell subscription technology brought about portability and therefore, became attractive. In Nigeria, mobile cell subscription started by 1993 with 9,049 subscribers. Nigeria witnessed internet usage in 1996 with 9,819 internet users. 2006 witnessed the highest amount of fixed telephone lines in Nigeria (1,687,972) which was followed by a fall in fixed telephone lines which was due to the introduction of the likes of mobile cell subscribers. Mobile Cell Subscribers had the highest value of 138 million subscribers at 2014 and its lowest value of 9,049 at 1993. This could be attributed to the fact that some Nigerians have multiple subscription lines from different service providers.




*Computed by authors; Data source: WDI (2017); Software: Eviews9*

*Fig.4.3: Trend of Mobile Cell phone Subscription and Number of Internet Users in Nigeria (1985 - 2014)*

The Theories underpinning this paper are the diffusion theory of innovation (Rogers, 1962) and search theory. The diffusion theory of innovation was proposed by Everett Rogers (1962). The theory proposes that four factors are responsible for the spread of a new idea: the innovation, communication channels, time and a social system. This theory applies to this research on ICT adoption and crop production because innovation has been established as a criterion for increase in productivity overtime as propounded by Schum Peter in the Schumpeterian growth theory. Innovation could be in terms of ICT or non-ICT. Communication channel is also proposed by the diffusion

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theory, which emphasises the importance of ICT in crop production – in bridging the gap between the raw material (seed, fertilizers, and so on) suppliers, producers (farmers), researchers (experts on seed production), distributors, consumer through means like mobile phone applications, real time mobile communication overtime through the internet. The social system being referred to is a receptive environment that is willing to receive and open to new ideas. Search theory is also known as "Matching theory". The theory was propounded by George Stigler. Search theory analyses the search-frictions as a result of the imperfect information that exist between the various components of the value chain such as the demand and supply, producer and supply of raw materials. ICT could help to reduce these search frictions.

Due to the nature of the study, the implicit model for the empirical analysis of this paper is specified thus;

Y= f (LAB, GFCF, MCS, NOIU, FXTL) -- (1)

Where;

Y is total crop production in Nigeria during the years of analysis.

LAB is labour – total number of people in the population included in the production process

GFCF is capital employed in Nigeria

MCS is number of mobile phone users in Nigeria

NOIU is number of internet users in Nigeria

FXTL is the number of fixed telephone lines in Nigeria

The above variables are included in the model so as to examine their individual impacts on total Crop production output in Nigeria.

Given the nature of the data, analysis, the production function adopted is the Cobb Douglas production function which is given as:

$$Y_{(t)} = A_{(t)} K^{\alpha}_{(t)} L^{1-\alpha}_{(t)} \quad - \quad -- \quad - \quad (2)$$

To convert the model to linear form, the explicit form of the model is therefore transformed by taking the log of the values, we have:

$$\mathbf{LY} = \beta_0 + \beta_1 LLab_t + \beta_2 LGfcf_t + \beta_3 LNoiu_t + \beta_4 LMcs_t + \beta_5 LFxtl_t + \mu_t \quad - \quad - \quad (3)$$

Where: $\beta_0$ is the intercept and $\beta_1$, $\beta_2$, $\beta_3$ and $\beta_4$ are the parameters to be estimated; subscript 't' is the time period.

Y in this model is the dependent variable which is the total agricultural output, K is capital, L is labour and we have ICT captured by the variables NCP which is total number of cellular phone users and NIU which is number of internet users. The stochastic term there is represented by μ which covers all variables not included in the model.

The Apriori expectations are the facts which should be a confirmation of the exogenous growth model which propounds that productivity increases with more investment in technology. The Exogenous theory implies that there is a direct relationship between agricultural output and ICT.

Therefore, $\beta_1, \beta_2, \beta_3, \beta_4, > 0$

**Labour**: it has a direct positive relationship with total agricultural output hence; the coefficient carries a positive sign, $\beta_1 > 0$.

**Capital:** Capital has a direct positive relationship with total agricultural output. The coefficient carries a positive sign. $B_2 > 0$

**Number of internet users**: The apriori expected coefficient here has a positive sign meaning an increase in number of internet users brings about an increase in total agricultural output and vice versa. This means that, the coefficient would be $\beta_3 > 0$.

**Number of mobile phone users**: The apriori expected coefficient has a positive sign. Meaning that, an increase in number of phone users brings about an increase in total agricultural output hence, $\beta_4 > 0$.

The **stochastic term**, μ, cannot be estimated because it is expected to be normally distributed with mean of zero and also has a constant variance.

## IV. RESULTS AND DISCUSSION

The research was based upon the diffusion theory of innovation and search theory. This model explained growth and included labour, capital and an exogenous factor, information and communication technology as variables that can affect output. The correlation results are shown below in Table 1.3:

### 4.1 CORRELATION RESULTS

*Table.4.1: Pairwise Correlation Coefficient*

| VARIABLES | LCRPD | FXTL | LMCS | LNOIU |
|---|---|---|---|---|
| LCRPD | 1.00 | | | |
| LFXTL | 0.35 | 1.00 | | |
| LMCS | 0.85 | 0.62 | 1.00 | |
| LNOIU | 0.92 | 0.57 | 0.98 | 1.00 |

*By authors; Package: Eviews9*

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Correlation analysis is used to check for the degree of association that exists between two variables. This implies that if two variables are positively highly correlated, an increase in one of the variables will likely be associated with an increase in the second variable. The correlation results between information and communication technology adoption and crop production show that:

1. Mobile cell phone subscription has a strong positive correlation (0.8501) with Crop production in Nigeria. This implies that an increase in the use of Mobile cell phones is associated with an increase in crop production overtime. The use of mobile cell phone should be encouraged and furthermore, the utilization of mobile cell phones in Agriculture should be encouraged.
2. Number of Internet users also has a strong positive correlation with crop production in Nigeria. This implies that an increase in the number of internet users is associated with an increase in Crop production overtime. Furthermore, the use of the internet for the purpose of agriculture should be encouraged.
3. The Number of Fixed Telephone Lines was seen to have a weak positive correlation exists with crop production in Nigeria. This implies that an increase in the number of fixed telephone lines is associated with a positive but not significant increase in crop production overtime. However, the use of fixed telephones should be encouraged for agricultural use.

## 4.2 ORDINARY LEAST SQUARES (OLS) RESULTS

*Table.1.3: Individual and General Statistics*

| **Dependent var: CRPD** | **Coefficient** | **Robust Standard Error** | **t- statistics** | **p>\|t\|** |
|---|---|---|---|---|
| LNOIU | 0.1563 | 0.04268 | 3.66 | 0.003 |
| LMCS | -0.9770 | 0.01862 | -5.25 | 0.000 |
| LLAB | -0.2262 | 0.7742 | -0.29 | 0.775 |
| LGFCF | 0.1323 | 0.4271 | 3.10 | 0.008 |
| LFXTL | -0.0102 | 0.4779 | -0.21 | 0.834 |
| **Observations** | 30 | | | |
| **F - Statistics** | 453.50 | | | |
| **P value \|F\|** | 0.0000 | | | |
| **$R^2$** | 0.9853 | | | |
| **D- Watson** | 1.5487 | | | |

*Compiled by researcher; Software package: Stata*

In terms of general statistical interpretation of the OLS results, the R-Squared showed that the specified model has an acceptable goodness of fit at 5% level of significance given that it lies between 0.5 and 1 (time series data). The F-Statistics (453) showed that the joint significance of the model is acceptable at 5% level of significance given that it is very high and has a p – value of 0.0000. The D-Watson tests for autocorrelation within the dataset. The Durbin - Watson result is 1.54 which shows that there is no autocorrelation in the data set given that 1.54 is close to 2 (can be approximated to two).

In terms of Individual statistical significance, the t- statistics values are statistically significant at 5% level of significance for 'Number of internet users' and 'Mobile cell phone subscribers' as determinants of 'Crop production' because the t-statistics is greater than 2 according to the rule of thumb while 'Number of fixed telephone' lines is not statistically significant at 5% level of significance because the value of its t-statistics is less than 2 according to the rule of thumb.

The economic interpretation in terms of direction, show that 'mobile cell phone subscribers' has a negative sign (-) which implies that 'mobile cell phone subscribers' has a negative impact on 'Crop production' and a positive sign for 'number of internet users' which shows that 'number of internet users' has a positive (+) impact 'Crop production'. The Negative relationship between Crop production' and 'mobile cell phone subscribers' does not follow the apriori expectation and can be explained by factors such as the high cost of mobile cell phones and subscriptions, the use of this technology for other uses apart from agriculture and crop production. The positive impact of 'number of internet users' on 'crop Production' follows the apriori expectation.

The economic interpretation in terms of magnitude, show that given 'mobile cell phone subscribers' has the value of '0.9770', a unit change in 'mobile cell phone subscribers' will lead to a significant negative but less than proportionate change in crop production (given that it is less than 1). In other words, a unit increase in 'mobile cell phone subscribers' will lead to a less than proportionate decrease in crop production. The coefficient of the 'number of Internet users' has the value of '0.15'. This implies that a unit change in 'number of Internet users' will lead to a significant positive but less than proportionate change in crop production. In other words, a unit increase in 'number of Internet users' will lead to a less than proportionate decrease in crop production. The findings of this study are in line with Akimuda (2014).

ICT helps to provide pricing information, production and agriculture extension and demand information through knowledge availability, (Awuor, *et al*, 2013). Pricing Information here refer to Information on selling such as market availability, retention price, selling price, dealers, ware house; production and agriculture extension information include funding, credit, awareness about crops, pollution control, pest and disease control, new farming techniques, quality enhancement. Demand information consists of crop variety, land use, soil health, soil nutrients, requirement, irrigation, Weather report. Knowledge availability includes dedicated website, emails, SMS, Voice calls/customer care agents, tele-center, E-learning/training. Some other ways in which ICT can help tackle key challenges in agricultural value chain development, are Pricing and weather information systems, applications to help buyers manage transactions with the thousands of small – scale farmers who supply to them, Mobile banking and apps that facilitate quick payments, Initiatives to expand the reach of farm extension services through phones, radio, internet, personal computers, or text messaging (sms) campaign for enabling environment.

## V. CONCLUSION

Wide ICT adoption leads to improved value chain interaction, financial inclusion, increased research and development for increased productivity. The value chain consists of the various users from development/production stage to the distribution stage to the consumption stage. The problem of frictions (imperfect information) between the various components of the value chain will be reduced drastically. ICT serves as a platform for the instantaneous interaction across wide distances without any physical barrier. ICT empowers the value chain members with nearer and safe access to finance, credit facilities, on-the-spot transaction, and so on. ICT assists in delivering research and development by connecting experts on food production, on-the-spot sharing of information of latest world practices on crop production. However, ICT has its limitations in a country like Nigeria. Some of the limitations are high cost of adoption of internet facilities, internet enabled smart phones; high level of illiteracy and language disparity, relatively low ICT Investment and Infrastructure, relatively, inconsistent electricity and energy availability, the creation of room for organised criminal activities such as hacking and cybercrime activities, fear of loss of huge amount of money due to online fraudulent activities.

The results from this research show that ICT adoption has a statistically significant positive role to play in the crop production process. Therefore, as a recommendation based on this study, governments should provide subsidies on the prices of ICT tools such as smart phones, internet subscriptions, and so on, to make them readily available for farmers. Many farmers, especially the small scale ones are living below the international poverty line and would rather not spend their money on ICT equipments. Most of these farmers are traditional in nature, and to convince them to use available ICT tools, these tools must either be given to them freely or prices should be reduced by subsidy considerably. Also, governments and private investors should invest more in capital infrastructure such as ICT with focus on the agricultural sector for improvement to enable the use of ICT tools such as mobile applications, real time connection for sharing information for the development of the agric sector.

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