IMPACT OF ICTS USAGE ON SMALLHOLDER FARMER'S ADAPTATION STRATEGIES: A STRUCTURAL EQUATION MODELING STUDY IN NIGER STATE

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Abstract

The study was conducted in Kontagora Local Government Area of Niger State between June and August 2021. The objective of this study was to find out the impact of ICTs on adaptation strategies of the smallholder farmers. The study used a multiple-stage random sampling technique to randomly select 240 respondents. The levels were determined using frequency and percentages of summated scores by categorization into high moderate and low using range. The impacts of ICTs on adaptation strategies were determined using structural equation modeling (IBM SPSS Amos 20). The study revealed high-level adaptation strategies (M=3.69) and a moderate level of ICTs (M=3.51). The study also revealed the impact of ICTs on adaptation strategies. The impact of radio (β= 0.355, CR = 4.145, P =.001), mobile (β=.322, CR= 4.111, P=.000), television, (β=.211, CR=3.717, P=.000) on adaptation strategies were positive and statistically significant. The study recommended planned interventions should be undertaken to bring those responsible for adaptation policy and planning (particularly National Adaptation Plans) together with ICT/telecommunications agencies for more effective planning and implementation.

Keywords: Adaptation, Farmers, ICTs, Smallholders, Structural equation modeling.

INTRODUCTION

The application of Information and Communication Technology (ICT) across different sectors of the global economy has become a game changer in boosting work efficiency and productivity. The agriculture sector in the global economy is one of the industries experiencing tremendous ICT application in all spheres of its operations. ICT is an umbrella term that includes radio, television, mobile phone, internet, etc. The ICTs increase productivity, access to markets, and adaptability to weather conditions in agriculture (Salampasis and Theodoridis, 2013). More effective interventions are needed in agriculture because rising food prices pushed over 40 million people worldwide into poverty since 2010 (Stein, 2011). The growing global population which is expected to reach 9 billion by 2050, has heightened the demand for food and placed pressure on already- resources (Ghose, 2014). Even after years of industrialization and growth in services, agriculture still accounts for one-third of the gross domestic product and three-quarters of employment in Nigeria (Obasan and Adediran, 2011).

Over 60 percent of the labour force in countries with per capita incomes in the range of US$ 400 to 1,800 range works in agriculture (World Bank, 2019). The arid-north region of Nigeria is already experiencing extreme heat and reduced rainfall as a result of climate change, while the Sahel region receives less than 10 inches of rain per year, which is 25% less than thirty years ago (Chukwuezie et al., 2016). According to the intergovernmental panel on climate change (IPCC) the situation might worsen by 2100, when worldwide rainfall will have decreased below 10%. The agriculture sector has experienced a new technological revolution for the past ten years (Ali et al., 2016). Compared to a decade earlier, this new technological revolution, has the potentials to respond to farmers' needs accurately and swiftly.

Daum (2020) observed that in recent years, ICTs had become one of the main driving tools used by farmers to manage the essential factors of production in agriculture. ICT applications have the potential to identify and find solutions to some of the numerous problems faced in the field of agriculture, which includes prolonged droughts, pest and disease outbreaks, seasonality and spatial dispersion of farming; high transaction costs and information asymmetry (Anh et al., 2019).

Information and communication technologies have had an increasing impact on economic and social development over the past two decades, resulting from their capacity to generate and disseminate information, to facilitate the coordination of different actors in and beyond government, and to make government, business, and development processes are more efficient (Ali et al., 2016). These three capacities are as relevant to climate change adaptation as they are to other fields.

However, the extent of experience in deploying ICTs for adapting to climate change is currently less than in other development fields, such as health and education (Creech & Parry, 2014). ICTs also have a complex relationship with sustainability and with the underlying cause of climate change (Papa et al., 2015). This relationship can be described in terms of the effects of ICTs. The ICTs can play an important role in increasing productivity through intensive agriculture (Rengaraj & Shibu, 2022). Conducting impact studies and sharing pilot project information is critical to success with ICTs as more specific lessons and impacts are learned (Wroński, 2019). The pace at which ICT application is growing in every sector of the world has triggered the development of different ICT applications in agro climatology to aid the rapid access to information by farmers.

The specific objectives of this study are to: determine the level of ICTs usage (mobile, radio, and television) and adaptation strategies; examine the impact of ICTs usage on smallholder farmers' adaptation strategies.

Research Framework

This study is based on the proposed framework shown in Figure 1. The framework considers the impact of ICTs (radio, mobile phone, and television) on adaptation strategies of smallholder farmers toward reducing and managing risks related to climate change which provide information to help farmers in confronting the physical impacts of climate (Adaptation strategies)

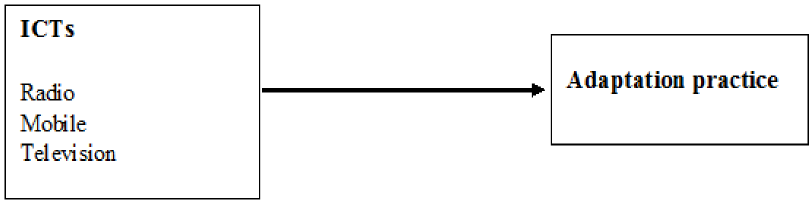

Fig 2. Research Framework

METHODOLOGY

Study Area

Fig. 2 Map of Niger State Showing Kontagora LGA

This study was carried out in Kontagora area of Niger State from June to August 2021 for the agricultural season. The study used a multi-stage sampling technique. In the first stage Zone iii was selected out of the 3 Agricultural Development Programe (ADP) zones in Niger state. In the second stage, Kontagora was selected out of eight (8) Local Governments in Zone iii.
The third stage, 4 wards were selected. In the fourth stage, 240 farmers were selected purposively who were using ICTs in farming activities as shown in Table 1 below:

Table 1. Showing Disproportionate Sampling

Zone	District	Wards	Population	Sample
Zone III	Kontagora	Madara	921	90
		Usubu	277	35
		Masuga	485	45
		Nagwamatse	711	70
			2, 394	**240**

The data were collected through questionnaires and interview method. Firstly, the level of adaptation strategies was determined using frequency and percentages of summated scores by categorization into high moderate, and low range. The level of ICTs as perceived by individual farmers was to provide a true picture of what is on the ground at the time of conducting this study. In addition, the impact of predictor variables on the outcome variables (ICTs on adaptation strategies) was determined using structural equation modeling (IBM SPSS Amos 20). The first step was to evaluate the measurement model's validity, followed by a test of the structural model. Confirmatory factor analysis (CFA) was used in the first stage. Its purpose is to see if the measurement model is correct. The measuring model's validity must meet two criteria: acceptable degrees of Goodness-of-Fit (GOF) and construct validity (Hair et al., 2010). Some of the commonly used goodness-of-fit indices include normed Chi-square x^2=d f, comparative fit index (CFI), adjusted goodness-of-fit index (AGFI), non-normed fit index (NNFI), goodness-of-fit index (GFI), normed fit index (NFI), parsimonious goodness-of-fit index (PGFI), the root mean square error of approximation (RMSEA), and. Standardized factor loadings, average variance extracted (AVE), and construct reliability are three construct validity metrics to consider (CR).

The structural model was estimated once the measurement model was validated. Running SEM and collecting the GOF indices using the same assessment criteria as CFA was the second stage. The path coefficients, as well as structural equation fit, were then interpreted (R^2). The goodness-of-fit indices for the model are X^2 = 1258.541, df = 624, p = 0.000, CFI = 0.915, RMSEA = 0.053 (90 percent confidence for RMSEA = 0.041–0.048) and normed x^2 = 2.13. CFI values of 0.9 are generally regarded as acceptable (Hair and Patel, 2014). The RMSEA should be between 0.03 and 0.08, and a normed Chi-square of 3 or less is associated with better fit (Hair et al., 2010).

Variable Measurement and Estimation Procedures

Structural equation modeling (SEM) was used to estimate the interrelationships among constructs in the conceptual model. Even though the focus was on the fundamental features of ICTs radio, mobile phone, and adaptation strategies. The goal of the estimation was to figure out the ICTs usage of farmers to gauge the impacts on adaptation strategies. Respondents were asked how they agreed or disagreed on a five-point Likert scale as indicated in Table 2.

Table 2. Indicator Variables in the Model Observed.

Item	Description	Measurement
RD1 RD2 RD3 MP1 MP2 MP3 TV1 TV2 TV3	ICTs usage (Radio, Mobile phone, Television)	5-point Likert scale (disagree to agree)
AD1 AD2 AD3	Adaptation strategies	5-point Likert scale (disagree to agree)

RD= Radio, MP=Mobile phone, TV= Television, AD= Adaptation

RESULTS AND DISCUSSION

Level of Adaptation Strategies

Table 1 indicates that the majority of the respondents were given more priority to irrigation as an adaptation practice towards climate change (M = 4.65), followed by cover coping (M = 4.50), drought-resistant varieties, and Organic matter all at moderate levels. Therefore, this can be attested that smallholder farmers had played a significant role in the use of adaptation practices towards climate change impact in the study area as the overall mean score signified a high level of adaptation strategies (M=3.96). This result is consistent with the previous findings of Jha et al. (2018) on the use of adaptation practices to cope with climate change impacts.

Table 1: Level of Adaptation Strategies of Respondents

Adaptation practice	Mean	Level
Irrigation	4.65	High
Drought-resistant varieties	3.10	Moderate
Cover crops	4.50	High
Organic matter	3.60	Moderate
Total Mean	**3.96**	

Level of ICTs Usage

Data relating to respondents' ICTs usage levels are presented in Table 2. The table shows the highest proportion of the respondents uses the Mobile phone (M=410). However, a moderate level was shown on Radio (M=3.33) and television (M=3.11). Therefore the overall mean score on ICTs (M= 3.80) signifies a moderate level on the usage of ICTs. The usage ICTs increase farm productivity, and adaptability to weather conditions in agriculture (Gangopadhyay et al., 2019). The use of ICTs helps one to acquire necessary technical skills and knowledge towards a logical and progressive attitudinal change which may result in improved performance of farmers' productivity (Sima et al., 2020).

Mobile phones reduced the gap between farmers and extension research centers as he communicates directly with the extension agent on the issue of adaptation and other related agricultural practices. Chhachhar et al. (2014) revealed that the internet, mobile phones, radio, and television were the most important tools of communication providing knowledge and information to farmers about agriculture.

Table 2: Level of ICTs usage

ICTs usage	Mean	Level
Mobile	4.10	High
Radio	3.32	Moderate
Television	3.11	Moderate
Total Mean	**3.51**	

Impact of ICTs on Adaptation Strategies

- Measurement model

The findings of the measurement model frequently in Table 3 show a good fit. All standardized factor loadings that are statistically significant should be at least 0.5 (Hair et al., 2010). This level of loading suggests that the observed indicators are strongly linked to the structures with which they are associated. It also contributes to construct validity (Hair et al., 2010). In our model, all standardized factor loadings are significant. The bulk of factor loadings are more than 0.5, CR stands for convergent validity. Strong reliability is indicated by a CR of 0.7 or higher. Most of the constructs in our model have CR values larger than 0.7. A CR of less than 0.7 is acceptable if the research is exploratory in nature (Hair & Patel, 2014). Average Variance Extracted **(**AVE) is another convergent validity indicator, and convergence is good when the AVE is 0.5 or more (Hair et al., 2010). The AVE values for all constructs in our model are greater than 0.5, as shown in Table 3, which is acceptable.

Table 3: Factor loadings, Average Variance Extracted and Construct Reliability

Constructs	Items	Factor Loading	CR (Above 0.6)	AVE (Above 0.5)
Radio	RD1	0.66	.76	.63
	RD2	0.81		
	RD3	0.74		
Mobile phone	MP1	0.81	.80	.62
	MP2	0.77		
	MP3	0.86		
Television	TV1	0.65	.82	.61
	TV2	0.76		
	TV3	0.85		
Adaptation strategies	AD1	0.74	.85	.60
	AD2	0.86		
	AD3	0.77		

CR=Construct reliability, AVE= Average Variance Extracted

The other relevant indicators (factor loadings) are within acceptable bounds, meaning that convergent validity is acceptable. Discriminant validity of the construct is achieved when the square root of the AVE is greater than the correlation between the constructs (Afthanorhan, 2014). The degree to which a test or measure diverges from (i.e., does not correlate with) another measure whose underlying construct is conceptually unrelated to it (Hair et al., 2010). As depicted in Table.

Table 4. Discriminant Validity of the Constructs

Construct	RD	MP	TV	AD
RD	**0.822**			
MP	-0.188	**0.779**		
TV	0.497	0.046	**0.784**	
AD	0.403	- 0.220	0.164	**0.809**

Note: on the diagonal (bold) represent AVE while off-diagonal represent correlation coefficients

The structural model's results show that it fits well. The relative x^2 (Chisq/df) is 2.444 (achieved), which is below the acceptance level of 5.0; other fit indices include AGFI = 0.834 (not achieved), GFI = 0.834 (not achieved), CFI = 0.919 (achieved), IFI = 0.916 (achieved), TLI = 0.933 (achieved), and RMSEA = 0.638 (achieved). As previously stated (Hair et al. 2010). The goodness-of-fit indices of the correlation output structural model are shown in Table 5 below.

Table 5 Goodness-of-fit Indices of Correlation Output Structural Model

Name of category	Name of Index	Recommended Value	Value (Results)
Absolute Fit	Chi- square	> 0.05	0.000*
	RMSEA	< 0.08	0.638
	GFI	> 0.9	0.811**
Incremental Fit	AGFI	> 0.9	0.721**
	CFI	> 0.9	0.919
	TLI	> 0.9	0.933
	IFI	> 0.9	0.916
Parsimonious Fit	Chisq/df	< 5.0	2.444

Note: *Not applicable for large sample (more than 200). **Not achieve the accepted level

Table 6 summarizes the results of the structural model with a structural path estimate of a significant effect of ICTs on adaptation strategies. The standardized coefficients are (β= 0.355, CR = 4.145, P =.001; β=.322, CR= 4.111, P=.000; β=.211, CR=3.717, P=.000). The findings reliably support the conceptual model, with all estimated path coefficients being statistically significant. For our primary construct, adaptation strategies, the squared multiple correlations (R^2) is 56.1%. That signifies the important factors in our model can account for over 56.1% of the variation in adaptation strategies. In other words, the influence of the predictor variable on the outcome variable in this study has been confirmed. This revealed that radio was a favorite tool of communication which broadcasts many adaptation programs while television also contributed much in disseminating information about climate change adaptation as well in the area. Mobile phones reduced the gap between farmers and Extension Agents. Farmers got the latest information from the metrological department for weather conditions before taking any adaptation measures in their farms.

According to the findings of this study, the predictor variable has contributed to the outcome variable in a relative sense as shown in Table 6 below.

Table 6: Regression Results

Regression path			β	C.R.	P
ADP	<---	Radio	.355	4.145	.001
ADP	<---	Mobile	.322	4.111	***
ADP	<---	Television	.211	3.717	***

Significant at 5% level of significance **R^2=56.1%**

Conclusions and Recommendations

In this respect, the current study concludes that smallholder's adaptation strategies towards climate change in Kontagora were encouraged due to exposure to ICTs which positively contributed towards smallholder adaptation practice. The ICTs created awareness to smallholder farmers on various adaptation practices towards climate change impact on farming activities. The identification of the importance of ICTs can enable the policymakers in creating climate change adaptation options. Therefore the following recommendation were made

(i) Build capacity for integrating ICTs into national strategic adaptation plans: Planned interventions should be undertaken to bring those responsible for adaptation policy and planning (particularly National Adaptation Plans) together with ICT/telecommunications government staff to work together for more effective planning and implementation.

(ii) Involve the private sector more extensively in planning and implementation: With Public-Private Partnership (PPP) ICT infrastructure should be developed across the country to ensure access to ICT technologies. Accessible telecoms and power infrastructure in rural areas should be developed to use ICTs in agriculture.

More work is needed to engage strategically with the private ICT sector, to review where privately motivated interests in applications could directly or serendipitously enhance adaptation while also delivering commercial value.

(iii) The Government and NGOs should sensitize the farmers on the benefits of using ICTs and ICT education in the schools and colleges/universities should be made compulsory to address the shortage of ICT skills. Adaptation Plans should be seen as a window of opportunity for the inclusion of ICT-relevant interventions. Preparation for these should include a capacity-building programme to review where and how investments in ICTs might be best integrated.

REFERENCES

Afthanorhan, W. M. A. W. (2014). Modeling the multiple indirect effect among latent constructs by using structural equation modeling: volunteerism program. *International Journal of Advances in Applied Sciences*, *3*(1), 25-32.

Ali, S., Jabeen, U. A., Nikhitha, M., & India, Z. (2016). Impact of ICT on agricultural productivity. *European Journal of Business, Economics, and Accountancy*, *4*(5), 82-92.

Creech, H., Akoh, B., & Parry, J. E. (2014). ICTs for climate change adaptation in Africa.

Chhachhar, A. R., Qureshi, B., Khushk, G. M., & Ahmed, S. (2014). Impact of information and communication technologies in agriculture development. *Journal of Basic and Applied scientific research*, *4*(1), 281-288.

Chukwuezie, O. C., Nwakuba, N. R., Nwigwe, K. N., & Asoegwu, S. N. (2016). The impact of climate change on Nigerian agricultural sector and economy. In *The 37 National conference and annual general meeting of the Nigerian Institution of Agricultural Engineers (NIAE)* (Vol. 37, pp. 498-502).

Gangopadhyay, P. K., Khatri-Chhetri, A., Shirsath, P. B., & Aggarwal, P. K. (2019). Spatial targeting of ICT-based weather and agro-advisory services for climate risk management in agriculture. *Climatic change*, *154*(1), 241-256.

Ghose, B. (2014). Food security and food self-sufficiency in China: from past to 2050. *Food and Energy Security*, *3*(2), 86-95.

Hair, J. F., Gabriel, M., & Patel, V. (2014). AMOS covariance-based structural equation modeling (CB-SEM): Guidelines on its application as a marketing research tool. *Brazilian Journal of Marketing*, *13*(2).

Hair, J. F., Ortinau, D. J., & Harrison, D. E. (2010). *Essentials of marketing research* (Vol. 2). New York, NY: McGraw-Hill/Irwin.

Hanjra, M. A., & Qureshi, M. E. (2010). Global water crisis and future food security in an era of climate change. *Food policy*, *35*(5), 365-377.

Jha, C. K., Gupta, V., Chattopadhyay, U., & Sreeraman, B. A. (2018). Migration as adaptation strategy to cope with climate change: A study of farmers' migration in rural India. *International Journal of Climate Change Strategies and Management*.

McNamara, K., Belden, C., Kelly, T., Pehu, E., & Donovan, K. (2017). Introduction: ICT in agricultural development.

Obasan, K. A., & Adediran, O. A. (2011). Small and medium scale enterprises and economic growth in Nigeria. *International Journal of Research in Social Sciences*, *1*(2), 25.

Papa, R., Galderisi, A., Vigo Majello, M. C., & Saretta, E. (2015). Smart and resilient cities. A systemic approach for developing cross-sectoral strategies in the face of climate change. *TeMA Journal of Land Use, Mobility and Environment*, *8*(1), 19-49.

Rengaraj, D., & Shibu, N. S. (2022). Impact of Icts on agricultural productivity in Perambalur district.

Salampasis, M., & Theodoridis, A. (2013). Information and communication technology in agricultural development. *Procedia Technology*, *8*, 1-3.

Sima, V., Gheorghe, I. G., Subić, J., & Nancu, D. (2020). Influences of the industry 4.0 revolution on the human capital development and consumer behavior: A systematic review. *Sustainability*, *12*(10), 4035.

Stein, H. (2011). World Bank agricultural policies, poverty and income inequality in sub-Saharan Africa. *Cambridge Journal of Regions, Economy and Society*, *4*(1), 79-90.

Tserendorj, G., Marinova, E., Lechterbeck, J., Behling, H., Wick, L., Fischer, E. ... & Rösch, M. (2021). Intensification of agriculture in southwestern Germany between the Bronze Age and Medieval period, based on archaeobotanical data from Baden-Württemberg. *Vegetation History and Archaeobotany*, *30*(1), 35-46.

Ujházy, N., Molnár, Z., Bede-Fazekas, Á. & Biró, M. (2020). Do farmers and conservationists perceive landscape changes differently? *Ecology and Society*, *25*(3).

World Bank. (2019). *Global financial development report 2019/2020: Bank regulation and supervision a decade after the global financial crisis*. The World Bank.

Wroński, M. (2019). The productivity growth slowdown in advanced economies: causes and policy recommendations. *International Journal of Management and Economics*, *55*(4), 391-406.