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Climate Change

Determinants of extent of adaptation to climate change by female farmers in Enugu State, Nigeria: a hurdle model application

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The influence of gender in climate change adaptation among farm households have emerged as a topical issue in the climate change literature, thus, the study examined the determinants of the extent of adaptation to climate change by female farmers. Primary data was used for the study. 80 female headed households were systematically randomly selected from the list of female farmers provided by the community heads and they were interviewed with the aid of semi-structured questionnaire. Hurdle model which consists of probabilistic and truncated negative binomial regression model was used to analyse the data collected. The results from the hurdle model show that farming experience (0.1027) and membership of cooperative (1.1123) significantly influence the probability of female farmers adapting to climate change, while, farming experience (0.0276), squared farming experience (-0.0005) and farm size (0.0144) significantly influence extent of adaptation to climate change among female farming households. Hence, the study recommends that climate change adaptation among female farming households must take on board these three variables. In this regard, adaptation policies and strategies in the area must be validated against these critical factors. Otherwise, current and future adaptation efforts would be compromised.

INTRODUCTION

Climate change impact has become more threatening not only to the environment but also to the fight against poverty, disease, and hunger. This is due to its direct and indirect impact on agricultural production. While efforts are being made in addressing the causes of climate change through mitigation, building adaptive capacity is particularly important as it will help tackle the current and future impacts of the phenomenon (IPCC, 2007). The IPCC defines adaptation as the "adjustment in natural or human systems to a new or changing environment" (IPCC, 2007, p.3). In other words, climate change adaptation deals with the ability of a system to cushion possible impacts from climate change and to cope with the outcomes.

The impact of climate change in the developing nations, according to John *et al.,* (2013) is mostly felt by the smallholder farmers (Gezu Tadesse and Moges Dereje, 2018). These set of farmers are more dependent on rain water and other resources and inputs that are climate sensitive. The vulnerability of these sets of farmers is expected to be even more severe in Nigeria, where women are more involved in agriculture, yet are highly marginalised and excluded in climate decisions that directly affect them (Osuafor & Nnorom, 2017; Anita H Philip *et al*. 2018). Gender relations in the Nigerian agricultural sector have systematically subordinated women, thereby limiting their access to adaptation information and support (Roehr, 2007). Udry (1994) argues that gender is a social construct that portrays the distinction in roles and opportunities associated with the male and female sexes and the social relations between them. Studies conducted on climate change adaptation in Nigeria have shown that gender relations and women exclusion in climate decisions adversely affect climate change adaptation efforts and agricultural productivity, as women contribute 60% to 80% of food production in the country, mostly for family consumption (Tersoo, 2014; Apata *et al*., 2009; Anselm *et al*., 2010). However, the underlying factors behind these gender issues that constraints female headed farm households in Nigeria have not yet been clarified in literature. This gap in literature is what this study intends to fill. Paying attention to these relations is at the core of framing adaptation strategy that will allow female headed farm households build resilience to the impact of climate change in agriculture (MacGregor, 2010).

In line with climate change adaptation literature, it has been identified that there are three mutually exclusive criteria in vulnerability study based on IPCC (2007) analysis. These three elements are; (i) exposure (extent of susceptibility), (ii) sensitivity (degree of impact), and (iii) adaptive capacity (ability to adjust) to climate change impacts. The World Health Organization (2011) noted that female farmers in developing nations are more exposed to climate variabilities mostly because they make up greater percentage of the world's poor and are mostly charged with daily responsibilities directly linked to the environment such as gathering of firewood for heating and cooking and fetching water for domestic chores. In terms of sensitivity to climate

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impacts, Kalela (2009) noted that 90% of women in many African countries engage in agriculture, Nigeria inclusive and are more reliance for their means of support on natural resources that are vulnerable to climate change impacts. Expounding on this fact, (Liu, 2000) recounted that more than 90% of the fatalities at the 1991 cyclone in Bangladesh were women, and this was due to their social statues, limited skills set and limited mobility.

Consequently, in assessing adaptive capacity of female headed households, the Rio + centre, in partnership with Food, Agriculture and Natural Resources Policy Analysis Network conducted a survey in five southern African countries. The results of the survey showed a strong correlation between gender and adaptation level, with women more likely to have low levels of adaptation. Further analysis from the survey shows that women and men in developing nations do not have equal access to support for climate change adaptation in agriculture, with men more likely to have higher access (Boko et al., 2007). Besides, other studies in various regions in Africa produced similar results (Nakweya, 2012; Ijayi, 2013 and Sunny *et al*., 2018). However, none of these studies has explored the determinants of climate change adaptation among female headed households in these nations. Hence, this study shall fill this gap in literature.

In Nigeria, studies have also shown that women are highly side-lined in climate decision making processes and this in turn affects their access to adaptation information and support (Julia & Okhimamhe, 2009; Anselm *et. al*., 2010; Onwuemele Andrew, 2018; Akintonde *et al*. 2019). Chukwuma (2017) reviewed journal articles on the influence of socioeconomic characteristics on access to adaptation support in Nigeria in order to ascertain its impact on the agricultural sector of the economy and the implications for economic growth. He noted, in line with RIO+ survey, that gender strongly influences access to support for CCA in agriculture in the country. Their work demonstrated the fact that although agriculture employs over 80% of the rural dwellers, Nigeria is the world's 3rd most vulnerable country in terms of the impact of climate change in agriculture. The main conclusion from the reviewed literature was that the adaptation differentials between women and men undermine the capacity of the agricultural sector to absorb climate change, multiple stressors and to maintain function in the face of climate change impacts.

Similarly, Julia *et. al*., (2009) noted that women's lack of adequate access to adaptation support prevents the agricultural sector from evolving into more desirable configurations that build resilience. While most studies in Nigeria emphasize women's lack of access to climate change adaptation support, assessed literature does not really explore the determinants and the underlying institutional factors behind the adaptation disparity between male and female headed farm households in Nigeria. Obviously, a blanket approach of investigating adaptation constraints may not achieve the desired results. There is therefore, a need to systematically and empirically assess the adaptation levels of female headed farm households separately and the underlying socio economic, cultural, policy and institutional dynamics driving their vulnerabilities.

Theoretical and conceptual framework

This study applies the Gender Sensitivity Approach (GSA) to climate change adaptation. In this section, we undertake a brief review of this approach, linking it with the vulnerability theory. These theories are triangulated with relevant empirical literatures regarding gender inclusion and vulnerability assessment in climate change adaptation discourse to provide a conceptual direction for this study.

Gender Sensitivity Approach

According to Calasanti and Slevin (2001), the gender roles of men and women in the society are socially constructed. This implies that in every society, men and women have different needs, play different roles and face different challenges. In most societies especially in developing countries, responsibilities are demarcated between men and women, economic and social activities, authority in decision making, and access to resources (Bastos et al., 2009). Unlike the biological roles which are fixed, gender roles are variable and changes with economic, social and technological changes (Raty & Carlsson-Kanyama, 2009). Gender Sensitivity Approach (GSA) recognises this demarcation and competition between men and women. It thus refers to the application of methodologies and tools that takes into account the differentiated needs, opportunities and capabilities of all gender. It involves both gender analysis and vulnerability assessment (UNFCCC, 2016; Trbovc & Hofman, 2015).

The application GSA in climate change adaptation discourse has become pertinent with the realisation that women are more vulnerable (sensitive) to the devastating impacts of climate change, but unfortunately has lower decision making authority and limited access to resources. According to the Organisation for Economic Co-operation and Development [OECD], (2015), women are disproportionately affected the impacts of climate change, and when it comes to building resilience and adaptive capacity, they are disadvantaged. Several factors have been implicated as being responsible for this situation. They include, limited access to information, poor knowledge of weather warning signals, socio-cultural gender stereotypes, etc (OECD, 2015; Wendy, 2010; World Health Organization; 2005). The application of GSA to climate change adaptation discourse can change these gender inequality narratives where women are perceived as victims of climate change, and empower them as agents of change and innovation (Wendy, 2010). In addition, it will create a win-win situation that would integrate different gender knowledge, vulnerabilities, roles and responsibilities that will improve the resilience and adaptive capacity of all gender. Since women are active actors in agricultural development in most developing, applying GSA to climate change will not only facilitate the acceptance of new adaptation technologies, but will also produce more effective and efficient adaptation policies.

As already highlighted, GSA involves gender analysis and vulnerability assessment. While gender analysis provides the structure for organising the differentiated roles and constraints of men and women, vulnerability assessment provides the framework for measuring gender capacity to anticipate, cope, resist and recover from climate change impacts (Shewmake, 2008). These ideas are summarised in Figure 1 (Conceptual Framework) showing the linkage between gender issues and vulnerability to climate change.

The framework shows the interrelationship between gender issues and vulnerability assessment issues. There are five main domains of gender analysis. Power which pervades all other four domains shows how gender authority can affect the acquisition and use of assets (UNFCCC, 2016). According to Gonda (2016), gender power determines ones capability to take advantage of opportunities in building resilience against climate change. Other gender issues that affect women exposure to, and capacity to cope and recover from climate hazards include the prevailing social beliefs and perceptions on gender roles, and how different institutions, laws and policies treat women (Dossa Armand Makponse *et al*. 2018). Makoni (2015) was of the view that the way in which women are treated creates social marginalisation

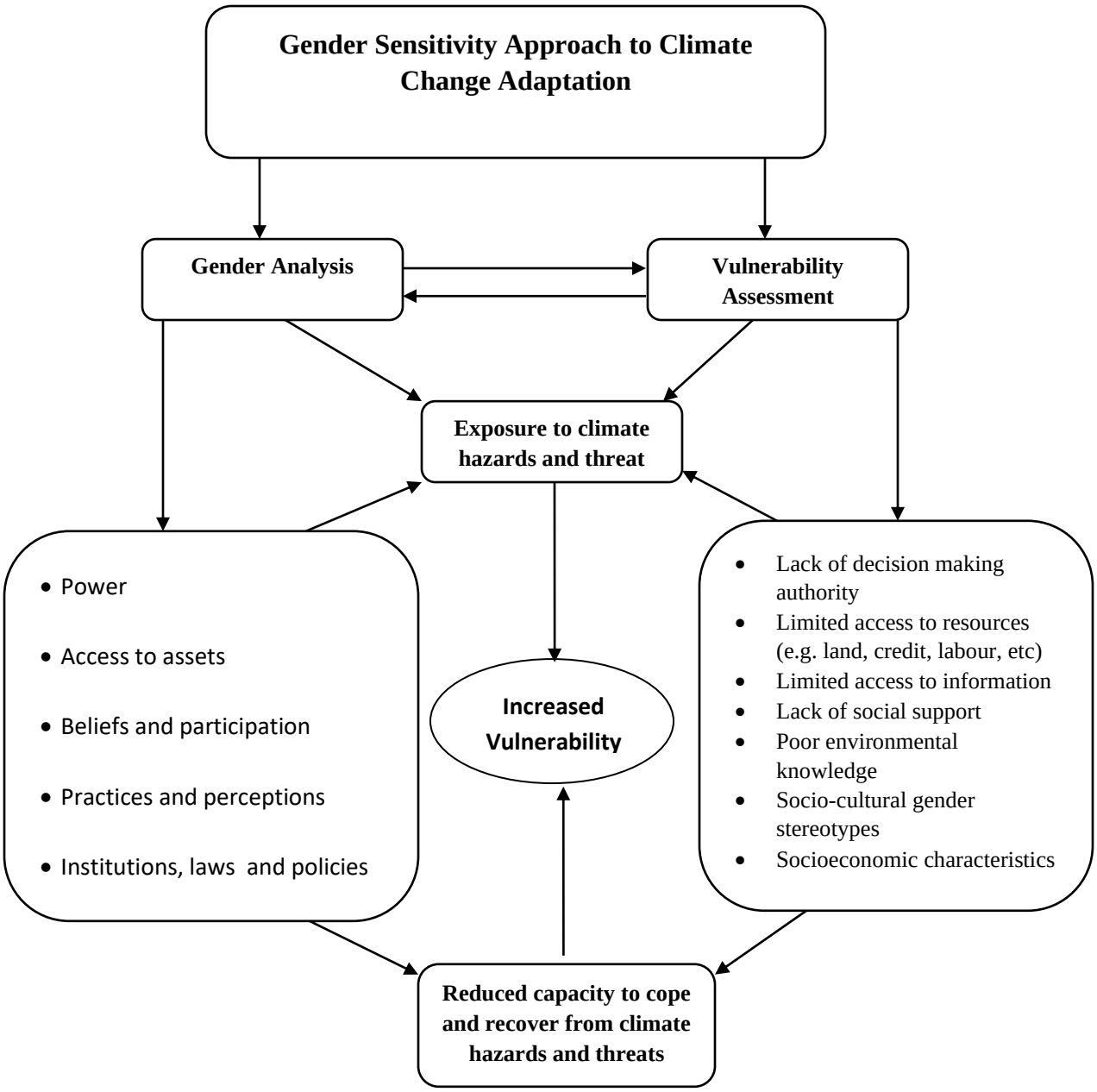

Figure 1 Conceptual Framework

which could dis-empower them adapting to climate threats. In line with this view, Fonjong (2008) noted that gendered hierarchies affect women especially lower-level women who often experience mistreatments and discrimination in accessing both tangible and intangible assets needed for climate change adaptation.

These gender are reflected in the vulnerability assessment which shows how various factors such as lack of decision making authority, limited access to resources, limited access to information, poor environmental knowledge, socio-cultural gender stereotypes increases vulnerability and reduced the capacity to cope and recover from climate hazards.

METHODOLOGY

Study Area

This research was conducted in Enugu state, Nigeria. The state is one of the five states in the South East geopolitical zone of the country. Enugu state was selected purposively because: (1) majority of the rural dwellers in this state engage in small scale farming (2), the state is regarded as the capital and policy making seat of the South-east geopolitical zone (3), the state is reported to have experienced marginalization of women in CCA decision making (Sunny *et al*, 2018). The state is divided into 3 Agricultural Zones [AZs] based on the similarities in soil characteristics and by extension meteorological properties. The zones include Enugu zone, Awgu zone and Nsukka zone. Enugu is located between latitudes

5°61`N and longitudes 6°53`E and 7°55`E (Enugu State Agricultural Development Programme (ADP), 1997). Enugu is made up three agricultural zones namely: Nsukka, Enugu north, Enugu centre. The state has a total land mass of about 8,022.96 km^2. It has a population of about 4,185,509 (National Population Census (NPC), 2006).

Sampling Procedure

A multi stage sampling technique was employed to select 80 female farmers headed households. In the first stage, the two agricultural zones (AZs) of the state were randomly selected. In the second stage, two Local Government Areas (LGAs) within each of the two zones were randomly selected to make 4 LGAs for the study. In the third stage, two communities (Cs) were randomly selected from each of the selected LGAs to make 8 communities. In selecting the respondents a list of female headed households were drafted with the help of community leaders. From this list 10 female farmer's headed households were systematically randomly selected from each selected communities making a total of 80 respondents for the study. Semi-structured questionnaires were administered only to the household heads as their decisions are assumed to affect the entire household.

Data collection

Data used for the study were from primary source. The period of data collection was between June 1st, 2017 to 10th of July 2017. First a pre-test was done to validate the reliability of the questionnaires; however, it was not included in the main data collected. Well trained field assistants helped in the data collection. The primary data obtained include data on the socio-economic characteristics of the farmers such as gender, age, marital status, farm size, education, farming experience, farm income, etc. Besides, data on the farmers' level of awareness of climate change indicators, their level of contribution to decision making in CCA practices, and the climate change coping strategies employed by the farmers.

Data analysis

Model specification

Hurdle model

A hurdle model is a modified count model in which the two processes generating the zeros and the positives are not constrained to be the same. Hurdle model has the characteristics of combining dichotomous model for the choice between zero and positive counts with a count data model for positive integers. The idea underlying the hurdle formulations is that binomial probability model governs the binary outcome of whether a count variate has a zero or a positive realization. If the realization is positive, the hurdle is crossed, and the conditional distribution of the positives is governed by a truncated-at-zero count data model. Let Y be the female farmers that have adapted for climate change and is denote by P(y | x) probability of observing a female farmer with Y = y if she adapted, conditional on a set of covariates x. In a hurdle model, the conditional probability mass function can be expressed as:

$$P(y|x) = \begin{cases} P(0|x) & for\ y = 0 \\ [1 - P(0|x)]P(y|x, y>0) & for\ y = 1,2, \ldots \end{cases} \quad 1$$

where P(0 | x) is the probability of not adapting and P(y | x,y>0) is the probability of observing Y = y, given x and y > 0.

The second hurdle stage uses truncated-at-zero count model called truncated negative binomial regression model.

$$P(y|x, y>0) = \begin{cases} \frac{\theta\pi(1|x)}{1-(1-\theta)\pi(1|x)} & for\ y = 1 \\ \frac{\pi(y|x)}{1-(1-\theta)\pi(1|x)} & for\ y = 2,3 \ldots \end{cases} \quad 2$$

Hurdle count data model allows the two models to run separately without losing any information such that probabilistic model and truncated zero negative binomial model can be analysed separately.

Therefore, the log-likelihood function of the censored hurdle regression model can be written as;

$$logL(\theta i; yi) = \sum_{i=1}^{n} \{(1-di)[Iyi = 0\ logf(0;\theta) + Iyi > 0\ f(yi;\theta)] + dilog(\sum_{j=yi}^{\infty} \Pr(Yi - j))\} \quad 3$$

We now obtain the log-likelihood function for the hurdle negative binomial regression model, we have

$$LL = \sum_{i=1}^{n} \{(1-di)[Iyi = 0\ logwo + Iyi > 0\ \{\log(1-wo) + logg - \log(1-(1+\alpha\mu i) - \alpha - 1)] + dilog(\sum_{j=yi}^{\infty} \Pr(Yi - j)\} \quad 4$$

(McDowell, 2003; Saffani *et al*, 2012)

RESULTS AND DISCUSSION

In table 1, the variables measuring farming experience and membership of cooperative society have significant and positively related to adapting to climate change by female farmers. In the case of farming experience, we observed a positive and significantly measured effect for the probability of adapting to climate change impact and number of adaptation strategies adopted by the female farmers. The result shows that a percentage increase in years of farming experience will increase the probability of adopting any of the adaptation strategies by approximately 0.1% and increase the number of adaptation strategy adopted by the female farmers by approximately the same amount. This result appears to be inconsistent with similar investigation such as Amusa (2010), who reported a negative and insignificant relationship between farming experience and the decision to adapt and extent of adaptation. However, when we used the square of years of farming experience we observed a negative and significant effect. This suggests that as the years of farming experience increases the effect is diminished.

Furthermore, Table 1 shows that a percentage increase in the number of female farmers belonging to cooperative societies will increase probability of adoption by over 1.1%, and will increase the number of strategies adopted by 0.07. This means that female farmers are more likely to decide to adapt if they belong to a cooperative society. Thus, female farmers who adapt to climate change are more likely to employ more adaptation strategies if they belong to cooperative

Table 1 Determinants of extent of adaptation to climate change by female

	Zero count process Probit regression (hurdle)		Positive count process Negative binomial model	
Variable	**Coefficient**	**Standard error**	**Coefficient**	**Standard error**
Household size	.0029568	.0513793	.0043515	.0071519
Marital status	-.1037916	.2404217	-.0182787	.0298809
Farm experience	.1027033**	.0476658	.0276768***	.0064538
Farm experience^2	-.0021459	.0011431	-.0005752***	.0001509
Water	1.360188	.2709024	.0355248	.0398381
Farm size	-.0903617	.0543204	.0144373**	.0073131
Extension service	-.0888289	.1624781	-.0000535	.0148614
Credit access	-.2299339	.2380287	.0268228	.0319606
Previous experience of disaster	.2598641	.2689891	-.0557519	.0474079
Member of cooperative	1.112394***	.3116078	.0783277	.0475196
_cons	-1.726208***	.5280057	2.292183***	.1231116
	Wald chi2(10) = 40.04 Prob> chi2 =0.0000 Log pseudo likelihood = -74.948655 Pseudo R2=0.2219		Wald chi2(10)= 42.56 Prob> chi2=0.0000 Log pseudo likelihood = -272.40652 Pseudo R2=0.0333	

***** and **** denotes significance of parameter estimates corresponding to p-values of 0.01 and 0.05 probability level respectively**.**

societies. According to Ifeanyi-Obi *et al*., (2017), belonging to cooperative societies is one of the most vital tool for encouraging climate change adaptation among farmers. Functional cooperative engenders climate change information sharing, presenting the need for adaptation to the farmers and helping them overcome any challenge in adaptation efforts. Although cooperatives societies may vary in membership size and type, all are structured to help members pool their resources together to help in procurement of credit facilities and farm inputs that can enable them take up more adaptation strategies (Ifeanyi-Obi *et al*., 2017).

Additionally, we found the coefficient of farm size to be statistically significant and positively related to the number of adaptation strategies employed by a farmer. This means that females with larger farm sizes have ahigher likelihood of adopting more adaptation strategies (Selvaraju, 2006; Rockefeller Foundation, 2008). This also corroborates the economic constraint paradigm which argues that economic constraints and resource endowments are the key determinants of adaptation such that inadequate of access to capital or land could significantly constrain both adoption decisions and extent of adoption (Aikens *et al*., 1975; Havens and Flinn, 1976; Yapa and Mayfield, 1978). When we enquired further, we gathered that most of the female farmers do not own their lands and this constrain their ability to employ some adaptation strategies such as the use of irrigation system or water storage. Limited farm size also prevents the farmers from expanding production, which usually translates to lower farm output. The women lamented that they spend most of their income on rent, hence are left with little to access adaptation technology. Furthermore, just like off farm jobs, large farm size will provide female farmers with the wherewithal to withstand shocks and access more adaptation technology when they lease part of their land (Mutabazi, *et al*. 2015; Ifeanyi, 2014).

The remaining variables: household size, access to water and previous experience of natural disaster have positive effects on both the decision to adapt and the number of adaptation strategies adapted, apart from previous experience of natural disaster which has a negative sign for the number of adaptation strategies adapted. These are good performances in terms of a priori expectation (Amusa, 2010). This shows that larger household size, access to water facilities and experience of natural disaster will increase the female farmers' decision to adapt. Those who adapt, these variables will also increase their chances of adopting more strategies. However, these variables were found to statistically insignificant at all the three levels of significance.

CONCLUSION

This study investigated the determinants and extent of adaptation to climate change by female farmers in Enugu State, Nigeria. The results of the study showed that farm size and membership of cooperative society significantly affects the decision to adapt, while farming experience, membership of cooperative and farm size are the factors that affects the extent of adaptation. The positive signs of variables such as farm size and cooperative membership suggests that allowing the female farmers the access to land and belonging to cooperative organizations will not only increase their likelihood of adaptation but their extent of adaptation as well. Based on the findings from this study, it is recommended that efforts in climate change adaptation among female farm households must take on board these three variables. Although there appears to be a narrowing of the gender vulnerability gap among smallholder farmers (Sunny *et al*., 2018), evidence from this study shows that much work still needs to be done in addressing gender issues in climate change adaptation in Nigeria. A novel research direction to explore includes studies on how climate adaptation can be planned to integrate aspects of

gender roles, attributes and stereotypes in resilience building and sustainable development programming. There is also the need to replicate this study in other states of the nation, or possibly, at the geopolitical zones or national level.

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Author's contribution
Ume Chukwuma Otum: developed background, interpretation of results and data collection
Adeosun Kehinde Paul: developed models, analysed data and data collection
Ihemezie Eberechukwu Johnpaul: developed conceptual framework, literature review and data collection

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