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Vulnerability to Livelihood-shocks Among Agrarian Households in Oyo State, Nigeria

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ABSTRACT

The impacts of livelihood shocks on agrarian population especially the natural resource-dependent smallholder farmers in Nigeria cannot be over-emphasized, as this devastating event renders many farmers vulnerable because of limited adaptive capacity. Therefore, this study examined the vulnerability of agrarian households to livelihood shocks using a sample size of 368 farmers selected from Oyo State, Nigeria, through a multistage sampling technique, and from whom relevant data were elicited. This study applied the livelihood vulnerability index approach, and composite score technique to decipher the vulnerability space of the respondents, and for the ordinal categorization of the respondents into different vulnerability categories, respectively. The study also used proportional odds model to investigate the determinants of livelihood vulnerability from the perspective of adaptive capacity vis-à-vis the livelihood capital assets of the farmers. Findings from the study indicated that farmers suffered heavily from crime and economic related shocks due to the farmers-herdsmen conflict, while covariate and idiosyncratic related stressors were also reported by the farmers. Findings also indicated a high level of farmers' exposure to shocks, with a moderate sensitivity to shocks, and a low adaptive capacity, which apparently pre-dispose the farmers to a serious vulnerable position. The farmers' adaptive capacity linkage of the livelihood capital assets were also found to contribute significantly to farmers' vulnerability status in the study area. The study recommended strengthening of physical, human, natural, social, and financial capital assets in building a sustained adaptive capacity of the farming population.

***Key words**: Livelihood-shocks, Agrarian households, Vulnerability index, Composite score, Proportional odds model, Nigeria*

Introduction

The increasingly pronounced occurrence of climate extreme events, shocks and stressors are putting pressure on the agrarian livelihoods in worse ways due to the sensitivity, fragility, and susceptibility of agri-food ecosystems and these events leave the farmers in a vulnerable condition, with little or no buffers to deal with it (Okon *et al.*, 2018). Vulnerability represents a dynamic concept and manifestation of the joint interactions of shocks and stressors, individual conditions, and the person's actions. In fact, vulnerability is an anticipatory measure of household's well-being, and the severity of this vulnerability is determined by confluence of many factors, including the characteristics of the shocks and

the ability of individuals or households to respond to such (Chaudhuri, 2003). Apparently, vulnerability effect mirrors people's exposure to future losses as a result of shocks which can hitherto cause significant decline in the well-being of individuals below a given socially acceptable threshold (Okon *et al.* 2018).

Most notably, smallholder farmers in the developing economies, such as Nigeria, are faced with avalanche of challenges, and are more susceptible, exposed and vulnerable to livelihood-shocks which disrupt their economic life; sadly, these farmers lack the necessary buffers to build resilience towards ensuring livelihood sustenance (Nguyen *et al.,* 2018). The need is urgent for development policies to advance creation of enabling environment for vulnerable individual, people and communities to thrive, and to break the cycle between conflict and hunger, instability and forced migration caused by these unpleasant events (Donnati *et al.,* 2019).

Smallholder farmers and farm families cultivate on small and scattered landholdings, and they account for about two-third of the global farms (UNEP 2013). They are also important actors in the food chain processes, because they are important actors in the food production chain across many developing countries (Lowder *et al.,* 2016; Donnati *et al.,* 2019). However, despite the contribution and importance of the farm families to the agri-food sector in the developing economies, they are often constrained by limited resources, usually neglected and often marginalized politically from governments' social investment and development programmes, and they also lack buffers to expand their operations and build resilience against unpredictable livelihood shocks and unpleasant events (Harvey *et al.,* 2014). In addition to the problems associated with land fragmentation, smallholder farmers are also faced with numerous forms of shocks and stressors leading to output decline, price shock and income volatility. The consequential impact of these events is immeasurable, and remains a serious threat that further exposes the vulnerability precarious life situation of the smallholder farmers in many of the global south countries (Donnati *et al.,* 2019).

The vulnerability of farmers is more pronounced as a result of the increased and over-stretched dependence on the fragile ecosystem for goods and services associated with their livelihood (Fischlin *et al.,* 2007), low capacity to adapt to shocks and climatic hazards as well as cultivation system and lack of irrigation facilities which predisposes them to rely on rainfed cultivations. The interactions of all these factors, coupled with the marginalization from government trap the farmers into geographical pocket of poverty. Meanwhile, farmers usually resort to various forms of survival strategies, such as, debt, adjustment in food intake, distress sale of precious assets, and discontinuing children's enrolment in school (Olawuyi *et al.,* 2011) further worsen farmers' vulnerability situation now, and in the future. Consequently, this research investigated various forms of livelihood-shocks commonly experienced by the farmers, the farmers' vulnerability space, as well as the determinants of vulnerability to livelihood-shocks from the perspective of adaptive capacity vis-à-vis the livelihood capital assets of the respondents in the study area, with a view to underscore how and the extent to which the respondents' adaptive capacity is able to respond to the impact of livelihood-shock exposure and the sensitivity of the exposure. Apparently from this, policy relevant instruments and baseline can also be highlighted for the development and implementation of programmes to assist the resource-poor and vulnerable rural farmers, and the general populace.

Theoretical and Conceptual Underpinning of Livelihood Vulnerability

The sustainable livelihoods theory practically applies to this study, and it is a holistic and multidimensional approach that captures, and provides a path to comprehend the fundamental drivers and forms of poverty and vulnerability without narrowing the scope of engagements to just a few factors (for instance, economic issues, food security) (Masud *et al.,* 2016). Households around the world face various shocks, including climatic, economic, environmental, and conflict-related stresses and shocks, and such shocks disproportionately impact households' livelihoods across numerous domains such as natural, physical, human, financial, and social capital assets (Masud *et al.,* 2016). The agrarian sectors in the developing countries are most impacted by shocks and stressors, which are mostly climate related owing to farmers' weak adaptive capacity and lack of buffers to cushion the impacts which disproportionately affect different people (Nguyen *et al.,* 2018). As a result, livelihood outcomes (reduced vulnerability, increased income, improved food security status, well-being and resilience, and more sustainable use of natural resource

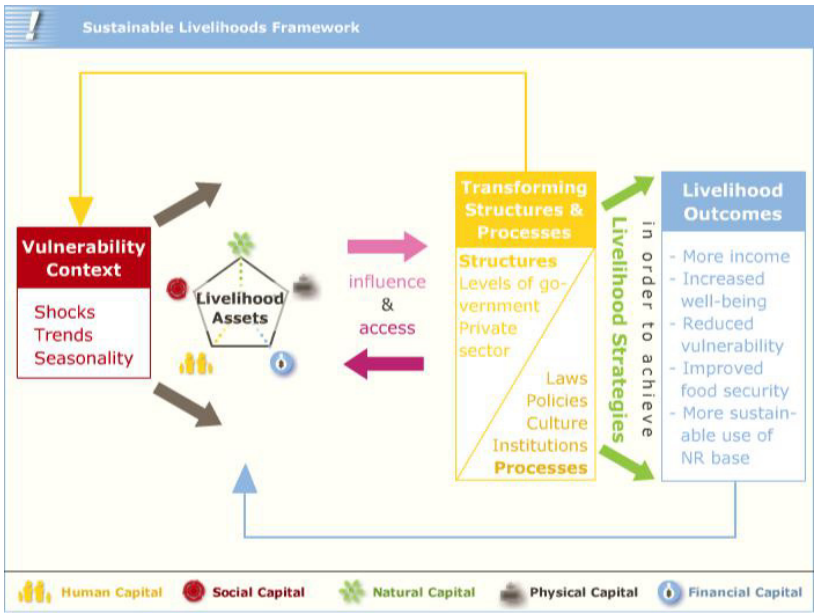

Fig. 1. The Sustainable Livelihoods Framework
Source: DFID (2000)

base) are badly impacted.

In addition to the climate change effect, the interactions and convergence of many other shocks and stresses significantly impact the African economies (Hahn *et al.*, 2009), and the manifestation of this including the current health challenges is obvious and causing economic turbulence both in the developed and developing nations. The impact on the developing economies such as Nigeria, which is highly dependent on petroleum resources, with little attention on agri-food sector, could be enormous and severe. As expressed by Hahn *et al.* (2009), the resultant effect of these stresses and shocks could present critical challenges such as food and nutrition insecurity, civil conflicts and social unrest, owing to poor adequate planning, mismanagement and lack of resources for adaptation. In the light of this, there is a need to understudy livelihood-shocks in terms of vulnerability assessment projections, and what can be referred to as broad-spectrum impacts on human societies, social hierarchies, adaptive capacity and resilience, and to properly understand the interactions and complexity of network of issues that may interact to affect the vulnerability level of different individuals, especially in the agrarian sector.

The study site

The study area is Oyo State, South-West, Nigeria, with its capital located at Ibadan. The state is bounded in the south by Ogun State and in the north by Kwara State, bounded partly in the west by Ogun State and partly by the Republic of Benin while in the east it is bounded by Osun State. The state enjoys both wet and dry seasons, which favours the cultivation of arable crops by farmers, who are mostly smallholders. Other livelihood activities commonly practiced in the study area include trading, and vocational activities such as carpentry, bricklaying, amongst many others. The State is mostly inhabited by the Yoruba ethnic group and is homogenous in nature, with few other minority ethnic groups who are spread across the state.

Materials and Methods

Research design

Cross-sectional research design was used for this study. Cross-sectional information (primary data) such as the socio-demographic features and farm-level information were collected from the sampled respondents. Information on the livelihood capital assets, and vulnerability space components and indicators were also elicited from the respondents through the use of a well-structured interview schedule designed in line with the objectives of this research.

Sampling procedure and sample size

A multistage sampling procedure involving random proportionate to size sampling technique was applied to select 385 farmers used as sample size for this research. Oyo State has four Agricultural Development Program (ADP) zones which are differentiated into blocks based on geographical location, and these blocks are: Ibadan/Ibarapa having nine blocks, Ogbomoso having nine blocks, Oyo zone having five blocks, while Saki zone have nine blocks.

The first stage involved selection of one-third of the blocks in each of the zones to arrive at a total of ten blocks selected across the area of study. In the second stage, three villages were selected from chosen blocks through a random sampling technique to arrive at a total of thirty selected villages. Owing to the variations that exist in the population of individuals across the selected villages in the area of study, the third and the last stage applied a random proportionate to size sampling technique in the selection of the representative sample for this study.

It is important to emphasis that there are three main caveats required for determining a suitable sample size for an observational study of this nature, and these are: the level of precision, confidence level and the degree of variability (Miaoulis and Michener, 1976). Given the caveats, this study determined the representative sample for this study through a validated sample size determination procedure for an infinite population (when the population is unknown). In line with Shete *et al.* (2020), using 99% confidence level with ±5% precision, the minimum required sample size as estimated for this study is:

$$n_0 = \frac{z^2 \times p(q)}{e^2} \quad .. (1)$$

where:

n_0 = Proposed sample size

z^2 = Critical value (Z-score value)

p = Maximum variability of the population

$q = 1–p$

e = error margin

Therefore at 5% (0.05) error margin (95% confidence interval), the sample size is calculated as:

$$n_0 = \frac{(1.96)^2 \times 0.5(1-0.5)}{(0.05)^2} = 384.16 \cong 385 \; respondents$$

But, due to few attritions and lack of consistency in the information provided by some of the respondents, responses from 368 respondents (almost 96% success in the response rate) entered into the final data analyses, while the rest were discarded.

Data analysis

For this study, farmers are the unit of analysis. In the analysis of the dataset, frequency counts, percent, and cross-tabulation were used to describe and profile the respondents' socio-demographic features, farm-level characteristic, typology of livelihood shocks, and the coping strategies employed by the respondents, while a construct of livelihood vulnerability index was developed in line with the approach described in Sujakhu *et al.* (2018) and this was used to explain the vulnerability space of the respondents. The study also applied composite score technique as described in Adepoju *et al.* (2011) for the ordinal categorization of the respondents into different vulnerability categories. Proportional odds model (otherwise known as the ordered logit regression model) was applied to interrogate the determinants of livelihood vulnerability (in categories) from the perspective of adaptive capacity vis-à-vis the livelihood capital assets of the respondents, while goodness of fit test statistics (Long and Freese, 2014) were obtained to ascertain that the model fits well. The likelihood-ratio tests of proportionality of odds across response categories, as well as omnibus-brant diagnostic test of parallel regression (Brant, 1990) were also carried out as post-hoc estimations to test the proportional odds assumption as required in ordered discrete outcomes model, so as to further ensure that the model has no outliers and the fitted variables explain the model well.

Empirical Approach: Livelihood Vulnerability Index

The IPCC livelihood vulnerability index (IPCC-LVI) is a construct which frames all the livelihood vulnerability parameters into three contributory factors pushing individuals to a vulnerable condition (Hahn *et al.*, 2009; Shah *et al.*, 2013); these are: exposure, sensitivity, and adaptive capacity (Hahn *et al.* 2009; Shah *et al.*, 2013; Sujakhu *et al.*, 2018). In general term, exposure mirrors the nature and extent to which agrarian livelihood economies and systems are susceptible to extreme weather conditions, and sensitivity is the extent to which agrarian livelihood systems or agriculture-based livelihood systems is distressed by the impact of extreme weather condi-

tions, while adaptive capacity mirrors the farmers' capability to respond and/or adjust to livelihood shocks and stresses (Sujakhu *et al.,* 2018). Individual or household's adaptive capacity is conceptualized as a configuration of resilience propensity, and emergent expression of the five forms of livelihood capital assets, which are: physical, human, natural, financial and social capital assets. Following Hahn *et al.* (2009), as well as Nguyen *et al.* (2018), the indicators and sub-indicators of the IPCC-LVI components as considered in this study are defined as follow:

Exposure: This measures the degree to which people and the things they value could be exposed to shocks and stresses. For instance, past experience on the occurrence of climate extreme events, natural hazards and disasters: For instance, occurrence of fluctuating temperature, excessive rainfall and flood, high humidity, epidemic/pandemic, droughts and famine.

Sensitivity: This measures the degree to which people and the things they value could be harmed by the exposure to shocks and stresses. Conceptually, sensitivity is measured through the assessment of the current situation of commune's food and water security, health status, and housing and land tenure. Suffice it to say that sensitivity revolves around food, water, health status, tenural (ownership) of farmland by individuals, cost of crop/animal loss, time spent on water collection during off season, occurrence of dispute on the use of water resources in the village, perception on crop productivity trend in the past.

Adaptive capacity: This is conceptualized from the perspective of economic resources, technological advancement, infrastructural assets, access to useful information, possession of skills and managerial ability, institutional functionality, and social network accumulation, kinship ties, neighborhood effect, reciprocity and trust, demographic features, and livelihood diversification strategies. All these are broadly grouped into the following indicators and sub-indicators, as highlighted:

Physical capital: This could include access to irrigation facilities, ownership of household assets, such as radio, TV, and mobile phone, provision of potable water, and rural electrification, excellent road network, provision of good storage infrastructure, and access to safe energy for cooking.

Human capital: This involves access to good extension delivery system for information sharing and capacity building, literacy status, early warning on climate extreme events, access to modern farm inputs, dependency ratio, adoption of agricultural technologies

Natural capital: Ownership of crop farmland, ownership of tree plantation, accessibility to other peoples' lands.

Financial capital: Engagement in alternative source of income, access to credits and/or micro finance or traditional saving methods

Social capital: Membership of farmers/community based organizations, access to loan, access to remittance, and access to social safety net or social protection program.

Drawing from Hahn *et al.* (2009), Shah *et al.* (2013), and Sujakhu *et al.* (2018), a composite livelihood vulnerability index is useful to assess relative exposure, sensitivity and adaptive capacity of a population. The technique permits to identify relevant and important indicators to guide in developing appropriate policy interventions (Sujakhu *et al.* 2018). In practical terms, this approach computes a vulnerability index through aggregation of the sub-indices data under each of the three indicators (exposure, sensitivity and adaptive capacity, as defined earlier), and each of the three main indicators were normalized, that is, rescaled from 0 to 1 (Hahn *et al.* 2009; Shah *et al.,* 2013; Sujakhu *et al.,* 2018).

$$\text{Index}_{si} = \frac{S_i - S_{min}}{S_{max} - S_{min}} \quad .. (2)$$

where:

Following the technique described in Sujakhu *et al.* (2018), the normalized sub-indices under each of the three indicators were aggregated to create a composite vulnerability index, as given by:

$$\text{LVI} = \frac{E + S + (1 - AC)}{K} \quad .. (3)$$

where:

LVI = livelihood-shocks vulnerability index, E = sub-indices of exposure aggregate, S = sub indices of sensitivity aggregate, AC = sub-indices of individuals' adaptive capacity aggregate, K = Number of indicators (which is, 3).

The livelihood vulnerability index was also subjected to composite score analysis as applied by Adepoju *et al.* (2011) to achieve the ordinal categorization of the respondents into low, moderate, and

high livelihood vulnerability categories. Arising from this, the study used proportional odds model to investigate the determinants of livelihood-shocks vulnerability (in ordinal categories) from the perspective of adaptive capacity vis-à-vis the livelihood capital assets of the respondents. This is designed is to see how the vulnerability categories (as a response variable) can perfectly predict the responses to other questions bothering on adaptive capacity as represented by the livelihood capital assets.

Model Specification: Proportional Odds Model

Proportional odds model is a regression model that is built on logit regression, which permits multiple discrete outcomes in an ordered or ranked form (Greene and Hensher, 2010). The proportional odds model is used for modeling relationships between multiple ordered discrete outcome variables and set of regressors. Computation of the ranked outcome response is through the categorization of an underlying composite index variable (Hosmer and Lomeshow, 2000).

For this study, the response (dependent) variable is categorized, and according to Sujakhu *et al.* (2018), the model can be expressed as:

$$\Pr(Y \leq j) = \ln\left(\frac{\Sigma pr\left(Y \leq \frac{j}{X}\right)}{1-\Sigma pr\left(Y \leq \frac{j}{X}\right)}\right) = \alpha_j + \beta_i X_i \ldots + \beta_n X_n \quad ..(4)$$

where:

Y = vulnerability to livelihood-shocks, conceptualized as: (high = 2, moderate = 1, and low = 0).

i = 1, 2, 3……..n (hypothesized explanatory factors), while *j* = 1, 2, 3, and α = the threshold,

β_i - β_n = estimated parameters, and X_i - X_n = the sub-indicators/indicators of adaptive capacity (the livelihood capital assets - human, physical, natural, financial and social capital assets).

Results and Discussion

Respondents' socio-demographic characteristics, livelihood shocks, and vulnerability components

The summary statistics of the respondents' socio-demographic characteristics, type of livelihood shocks, and vulnerability components is presented in Table 1. With respect to gender, the results indicated that approximately 7 out of 10 respondents are male, which pointed to a persisting unequal involvement of both male and female gender in agricultural activities despite the promotion of gender equality in agricultural activities and policy interventions by development experts.

The results also revealed that on the average, respondents are about 52 years of age, with family size of approximately 7 members in each of the households, and about 4 members of each household actively involved in income generating activities. The result also showed that respondents have approximately 20 years of farming experience which is a good sign of human capital development. Apparently, this finding indicated that quite a fairly old population group with large family size engages in agricultural activities in the study area. The form of livelihood shocks suffered by the respondents as revealed from the findings in Table 1 indicated that 9 out 10 farmers suffered from crime and economic related shocks, and about 2 out of 10 farmers suffered from covariate related shocks, and approximately 6 out of 10 farmers suffered from idiosyncratic related shocks. As expected, most of the respondents suffered heavily from the crime shocks due to the persisting farmers-herdsmen crisis in most of the agrarian settlements in Nigeria, and consequently resulted to economic shocks. This is technically an indirect declaration of war on the global food security because the farmers-herdsmen crisis can potentially bring a large population to the brink of starvation. The results in Table 1 also indicated a high level of exposure to shocks by the respondents, and a moderate sensitivity to shocks, which also justify the farmers' low adaptive capacity to mitigate all forms of shocks and stressors.

Respondents' coping strategies

As revealed in Table 3, nearly three-quarter (72.3%)

Table 1. Summary Statistics

Variables	Mean	Std. dev.	Min.	Max.
Gender	0.68	0.46	0	1
Age	51.50	6.90	32	69
Family size	6.73	1.42	5	11
Number of working members	3.51	1.07	2	4
Years of farming experience	19.55	5.63	14	38
Index of idiosyncratic shocks	0.69	0.45	0	1
Index of covariates shocks	0.72	0.44	0	1
Index of economic shocks	0.89	0.32	0	1
Index of crime shocks	0.94	0.47	0	1
Index of exposure	0.78	0.41	0	1
Index of sensitivity	0.46	0.32	0	1
Index of adaptive capacity	0.34	0.47	0	1

Source: Data analysis, 2022

Table 2. Distribution of Respondents by Typology of Livelihood-Shocks

Livelihood-Shocks	*Frequency	Percentage
Idiosyncratic shocks		
- Death of household working member	21	5.70
- Illness	35	9.51
- Job loss	14	3.80
Covariates shocks		
- Drought/Famine	73	19.84
- Flood/Excessive rainfall	47	12.77
- Epidemic/Pandemic	142	38.60
Economic shocks		
- Loss of crops and animals	286	77.72
- Price fluctuation	164	44.57
- Income volatility	119	32.34
- Reduced production output	239	64.95
Crime shocks		
- Theft	87	23.64
- Attack from herdsmen	343	93.20

* Multiple responses suggesting simultaneous incidence of two or more of the typology of livelihood shocks reported by the respondents.
Source: Data analysis, 2022

of the respondents of the respondents take to debt as a coping strategy against shocks, while about 50% made use of indigenous knowledge to mitigate shocks or stressors. This is actually a good statistics owing to the recent promotion of indigenous knowledge among the smallholder farmers. As revealed, 29.1% and 20.7% of the respondents engaged in distress sales of assets and adjustment in food intake as coping strategy respectively, while only about 14% reportedly removed their children from formal school to cope with the impact created by shocks. Apparently, this shows that the farmers have limited capacity to effectively respond to any shock.

Table 3. Distribution of Respondents by Coping Strategies

Coping Strategies	*Frequency	*Percentage
Debt	266	72.3
Adjustment in food intake	76	20.7
Distress sales of assets	107	29.1
Removing children from formal school	51	13.9
Use of indigenous knowledge	183	49.7

*Multiple responses indicating simultaneous use of two or more coping strategies by the respondents.
Source: Data analysis, 2022

Respondents' Vulnerability space

The results shown in Table 4 revealed the vulnerability space of the respondents. In line with Matemilola and Elegbede (2017), the farmers displayed high level of exposure to shocks in terms of their experience with, and perception on extreme weather events, while they were also marginally sensitive to shocks in terms of food security status, water security, health status. Conversely, farmers lacked sufficient adaptive capacity and buffers in terms of access and control of the livelihood capital assets, to mitigate all forms of shocks and stressors, as evidently shown in the results; hence the likelihood is high for the farmers to be vulnerable because they lack the required supports in terms of incentives, as well as poor agri-food policy.

Table 4. Respondents' Vulnerability Space

Vulnerability Space	Mean
Exposure	0.78
Sensitivity	0.46
Adaptive capacity	0.34
LVI = (E+S+(1-AC))/3	0.63

Source: Data analysis, 2022

In all, the mean value of livelihood vulnerability index of the farmers was estimated at 0.63 points value, which suggests that most of the respondents fall within the high category of vulnerability space.

Cross-tabulation analysis of livelihood-shocks and Vulnerability space

The results in Table 5 revealed the cross-tabulation of farmers' composite vulnerability categories against the type of livelihood shocks they experienced. It is necessary to stress that since multiple responses are attached to almost all the typologies of livelihood shocks (as shown in Table 2), a respondent is then said to suffer from a type of livelihood shock and categorized therein, if and only if he/she reported at least one of the forms of livelihood shocks, which is thus used for the classification of livelihood shocks as shown in Table 5.

The findings in Table 5 indicated that one-quarter (25.3%) of the farmers are within the low categories of vulnerability, and this suggests that one in every 4 people are within the low vulnerability category. In a similar manner, one-fifth (20.7%) of the respondents are within the moderate vulnerability cat-

Table 5. Cross-tabulation of Livelihood shocks and Vulnerability categories

	*Livelihood shocks				
Vulnerability categories	Idiosyncratic	Covariates	Economic	Crime	Total
Low	7 (30.40)	17 (21.30)	32 (25.40)	37 (26.62)	93 (25.3)
Moderate	4 (17.40)	15 (18.70)	24 (19.0)	33 (23.74)	76 (20.7)
High	12 (52.20)	48 (60.0)	70 (55.60)	69 (49.64)	199 (54.0)
Total	23	80	126	139	368

* Multiple responses suggesting simultaneous incidence of two or more of the typology of livelihood shocks reported by the respondents. Figures in parentheses are percentage values
Source: Data analysis, 2022

egory, while more than half of the respondents (54%) are within the high vulnerability category. This finding suggests that majority of the farmers are highly vulnerable to livelihood shocks and stressors. Furthermore, and as expected, the cross-tabulation results also revealed the trend showing that the farmers who suffered from all forms of livelihood shocks are skewed towards the high vulnerability category, while those within the moderate vulnerability category mostly suffered from the crime and economic related shocks. On the other hand, given the proportion of the farmers found in each of the types of livelihood shocks, those within the low vulnerability category suffered majorly from idiosyncratic related shocks, while others within the same category also suffered from covariate, economic and crime related shocks but not as much as their experience with idiosyncratic related shocks.

A notable implication of this result is that most farmers are haplessly facing the challenges of crime related shock (for instance, farmers-herdsmen conflict) which metamorphosis into economic shocks. But those farmers who are in the high vulnerability categories are significantly affected by economic and crime related shocks. In tandem with Mngumi (2021), these set of individuals are highly vulnerable to episodes of shocks and stressors without any sustainable buffer options, which apparently can be attributed to their limited capacity across all the livelihood capitals.

Proportional odds model for the determinants of vulnerability to livelihood-shocks

The findings as shown in Table 6 revealed the model's log-likelihood value of -331.162, and a LR-chi^2 value of 67.24 at a *df* of 23, with a significant *p-value*, suggesting that the full model was statistically significant as against the null model with no predictors, and this is also an indication that the model provides a good description of the data. The model's two cut-points with the estimated values of -0.4032 and -2.8395 respectively as shown in Table 6 are the threshold parameters which explain that, there are indeed two differentiated equations in the proportional odds model, but the output reflect a single equation model because of the categorization of the response variable (Ender, 2005).

Given the estimates from the proportional odd model computation in Table 6, the findings suggest that, for every unit increase in the respondents being a male gender, the odds of being in the high vulnerability category versus the combined moderate and low categories were 0.05 times lesser, holding other variables in the model constant. Then, the odds of the combined moderate and high vulnerability categories versus low vulnerability category were 0.05 times lesser in the same case, given that other variables in the model were also held constant.

In the same vein, the odds of being in the high vulnerability category versus the combined moderate and low categories were 0.53, 0.46, and 0.01 times lesser for a unit increase in access to irrigation, potable water, as well as ownership of television/radio/mobile phone respectively, going from 0 to 1, and holding other variables constant. The same explanation holds for the odds of the combined moderate and high vulnerability categories versus low vulnerability category. As expected, the implication of this result is that these identified sub-indices of physical capital asset (component of the adaptive capacity indicator of livelihood vulnerability) significantly increase the chances of the farmers to be in the moderate and the low categories of vulnerability.

The proportional odds model results also indicated that, for every unit increase in the respon-

dents' access to affordable health care, access to electricity, and access to storage infrastructure respectively, the odds of being in the high vulnerability category versus the combined moderate and low categories were approximately 0.03, 0.17, 0.1 times higher, holding other variables in the model constant. Then, the same explanation holds for the odds of the combined moderate and high vulnerability categories versus low vulnerability category, given that other variables in the model were also held constant. By implication, these identified sub-indices of physical capital asset (component of the adaptive capacity indicator of livelihood vulnerability) significantly decrease the chances of the farmers to be in the moderate and the low categories of vulnerability. This result contradicts a-priori expectations because access to affordable health care, access to electricity, and access to storage infrastructure are expected to increase the farmers' adaptive capacity to shocks, all else equal. A plausible explanation for this deviation is that farmers perhaps do not have access to functional health care system in their domains which invariably affects their health and productivity status. Also, lack of electricity supply and storage infrastructure can lead to production glut, and loss of perishable agricultural produce is imminent; this evidently reduces farmers' income, and by extension increases farmers' vulnerability to livelihood shocks.

The findings also revealed that, for every unit in-

Table 6. Proportional Odds Model - Determinants of Vulnerability to Livelihood-Shocks

Vulnerability (categories)	odds ratio	*z- statistics*	$p > \|z\|$
Age	0.3076	1.64	0.100
Gender	-0.0507	-1.90*	0.058
Physical capital			
Access to irrigation/ dry season gardening	-0.5351	-3.17***	0.002
Ownership of television/radio/mobile phone	-0.0133	-2.06**	0.039
Access to potable water	-0.4663	-1.89*	0.058
Access to affordable health care	0.0269	1.95*	0.051
Access to electricity	0.1676	5.16***	0.000
Access to good roads	-0.9813	-1.48	0.139
Access to storage infrastructure	0.1117	2.31**	0.021
Access to safe energy use (LPG gas)	-0.1630	-0.70	0.485
Human capital			
Extension services delivery/Information sharing	-0.2171	-1.85*	0.065
Literacy status	0.032	1.54	0.124
Early warning on weather-related issues	0.0127	0.93	0.351
Access to modern farm implements/inputs	-0.0141	-0.71	0.479
Dependency ratio	-0.3834	-2.74***	0.006
Adoption of agricultural technologies	-0.0056	-1.44	0.149
Natural capital			
Ownership of crop farmland	-0.1730	-2.16**	0.031
Ownership of tree plantation	-0.0047	-0.43	0.665
Financial capital			
Engagement in alternative livelihood	0.4242	2.10**	0.036
Access to credits/traditional saving methods	-0.0873	-3.64***	0.000
Social capital			
Membership of farmers-based organizations	-0.1893	-2.43**	0.015
Access to remittance	0.1973	0.73	0.472
Participation in community collective action	-0.2189	-1.06	0.290
cut1 (α_1)	- 0.4032		
cut2 (a_2)	- 2.8395		
LR chi^2 (23) = 67.24			
Log likelihood = -331.162			

*** - $p<0.01$; ** - $p<0.05$; * - $p<0.1$ probability levels respectively.
Prob > chi^2 = 0.0000; Pseudo R^2 = 0.1274, Number of observations = 368.
Source: Data analysis, 2022

crease in the respondents' access to extension service delivery by farmers and their household's dependency ratio, the odds of being in the high vulnerability category versus the combined moderate and low categories were approximately 0.22 and 0.38 times lesser, holding other variables in the model constant; the same explanation holds for the odds of the combined moderate and high vulnerability categories versus low vulnerability category, given that other variables in the model were also held constant. This result agrees with a-priori expectation on the relationship of human capital assets with vulnerability condition. The implication is that, access to extension service delivery service comes with relevant agricultural information dissemination benefits which assist the farmers to increase productivity and income, with the potential to reduce the chance of being vulnerable to livelihood shocks.

Further, the results revealed that for every unit increase in the farmers' ownership of farmland holdings (a natural capital asset), the odds of being in the high vulnerability category versus the combined moderate and low categories was approximately 0.17 times lesser, holding other variables in the model constant. The same explanation also holds for the odds of the combined moderate and high vulnerability categories versus low vulnerability category, given that other variables in the model were also held constant. This result is as expected because personal ownership of farmland does not have any restriction on the extent of use to which the land can be put.

In terms of every unit increase engagement in alternative livelihood activities (an indicator of financial capital assets), the results indicated that the odds of being in the high vulnerability category versus the combined moderate and low categories was approximately 0.42 times higher, while for every unit increase in access to credit (an indicator of financial capital assets), the odds of being in the high vulnerability category versus the combined moderate and low categories was approximately 0.09 times lesser, holding other variables in the model constant. Meanwhile, the same explanation holds for the odds of the combined moderate and high vulnerability categories versus low vulnerability category, given that other variables in the model were also held constant. The estimate of engagement in alternative livelihood activities which contradicts a-priori expectation appears so perhaps because the income from such activities is not sustainable, however, the estimate of credit access seems to be in tandem with a-priori expectation because credit obtained can be used to expand the farming operations, expand the production curve, and generate more income; this can potentially reduce the chance of being vulnerable to livelihood shocks at a higher level.

Considering the social capital asset, the findings revealed that for every unit increase in the membership of farmers-based organization, the odds of being in the high vulnerability category versus the combined moderate and low categories was approximately 0.19 times lesser, holding other variables in the model constant. The same explanation holds for the odds of the combined moderate and high vulnerability categories versus low vulnerability category, given that other variables in the model were also held constant. This is as expected because such occupational based organization is characterized by information sharing in terms of exchange of ideas and experience on livelihood activities, as well as credit assistance through their traditional savings method.

In conclusion, the study underscores the contributions of farmers' adaptive capacity through the components of the livelihood capital assets, in reducing farmers' vulnerability to livelihood shocks in the study area. This will be helpful in formulating policy target interventions.

Goodness of Fit Tests for the Determinants of Vulnerability to Livelihood-Shocks

Information measures (AIC and BIC): The Bayesian Information Criterion (BIC), Akaike's Information Criterion (AIC) and McFadden's R^2 represent the basic focus in the fit statistics for ordered response models (Williams, 2018a). The information measures are usually applied to compare non-nested models and the relative plausibility of two models (2018b). It is important to stress that, the best model is usually designated with the one the smaller value of the test statistics and/or a more negative value generated (Williams, 2018a). Suffice it to say that, the model having a smaller AIC is regarded as the best fit model, while the BIC assesses the model with a high likelihood to have generated the observed data, all else equal. On these premises, the information measures provide an indication that the decision favors the full model as against the null model having no predictors; hence, the model fits well.

Measures of fit tests

Log-Lik Intercept Only:	-360.347	Log-Lik Full Model:	-331.162
D (343):	641.204	LR (23):	67.241
		Prob > LR:	0.000
McFadden's R^2:	0.127	McFadden's Adj. R^2:	0.056
ML (Cox-Snell) R^2:	0.218	Cragg-UhlerR^2: (Nagelkerke)	0.260
McKelvey and Zavoina's R^2:	0.238	Variance of error:	4.512
Variance of y*:	5.631	Adj Count R^2:	0.375
Count R^2:	0.599	AIC*n:	690.762
AIC:	1.991	BIC':	13.209
AIC used by Stata:	690.762		
BIC:	-1321.028		
BIC used by Stata:	756.348		

***Omnibus Brant test of parallel regression assumption*:** The parallel assumption of probability curves was further investigated with the brant diagnostic test as suggested by Brant (1990), as well as Long and Freese (2014). In line with these literatures, a non-significant statistic value suggests that the parallel regression assumption is not violated and that the estimation is reasonable; and this is also vice-versa. Since the omnibus brant test result shown in Table 7 indicated an overall non-significant statistics, and that no fitted variables presents any estimation issue, the fitted model is appropriate, and the parallel regression assumption is not violated.

Conclusion and Recommendations

Farmers' vulnerability to livelihood shocks was investigated in Oyo State, Nigeria through livelihood vulnerability composite index, and proportional odds model. Most notable among the livelihood shocks reported by the farmers are crime and economic related shocks due to the farmers-herdsmen conflict ravaging the country. Other farmers also reported covariate related shocks, while very few farmers experienced idiosyncratic related shocks. The findings also revealed a high level of farmers' exposure to shocks, and they are also moderately sensitive to shocks. This justifies the farmers' low adaptive capacity to mitigate shocks and stressors, as shown in this study. Regardless of the farmers' differentiated socio-demographic characteristics and coping mechanisms, proportional odds model revealed that farmers' adaptive capacity (expressed by the sub-indices and indicators of livelihood capital

Table 7. Brant test of parallel regression assumption for the determinants of vulnerability to livelihood-shocks

Variable	*chi*^{2}	*p>chi*^{2}	*df*
All	27.21	0.293	23
Age	0.03	0.859	1
Gender	2.30	0.129	1
Access to irrigation/ dry season gardening	1.99	0.158	1
Ownership of television/radio/mobile phone	0.00	0.996	1
Access to potable water	1.82	0.177	1
Access to affordable health care	0.00	0.991	1
Access to electricity	2.40	0.122	1
Access to good roads	1.90	0.168	1
Access to storage infrastructure	0.80	0.372	1
Access to safe energy use (LPG gas)	2.91	0.088	1
Extension services delivery/Information sharing	2.61	0.106	1
Illiteracy	0.11	0.740	1
Early warning on weather-related issues	0.18	0.672	1
Access to modern farm implements/inputs	0.13	0.715	1
Dependency ratio	1.27	0.531	1
Adoption of agricultural technologies	0.41	0.526	1
Ownership of crop farmland	0.08	0.771	1
Ownership of tree plantation	0.24	0.622	1
Engagement in alternative livelihood	2.53	0.283	1
Access to credits/traditional saving methods	1.99	0.369	1
Membership of farmers-based organizations	2.15	0.142	1
Access to remittance	1.53	0.224	1
Participation in collective action	0.620	0.431	1

Source: Data analysis, 2022

assets) contribute significantly to the farmers' vulnerability status in the study area. Based on the findings, the following recommendations are important for the development of policy interventions by the government, non-governmental organizations, and development experts:

- Promotion of gender just society to bridge the gender gap in the participation of women in agriculture.
- Adequate of water supply for drinking and irrigation purposes.
- Provision of affordable rural health care facilities to promote functional health care system that can have positive implication on farmers' health and productivity status.
- Lack of electricity supply and storage infrastructure challenge the vulnerability status of the farmers in the study area. Therefore, the need is necessary for relevant stakeholders to ensure adequate rural electrification, and provision of facilities for storage of perishable farm produce.
- Functional extension delivery system should be promoted to facilitate timely information sharing and adoption of improved agricultural technologies by the agrarian population.
- Livelihood diversification in high value activities should also be promoted through appropriate social intervention programme, to boost farmers' adaptive capacity to shocks.
- Kinship networks should also be strengthened among the agrarian population since membership of farmers-based organization contributes to farmers' vulnerability status.
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- The authors declare no competing interests.
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