The determinants for climate change adaptive capacity and resilience of rural communities in Nigeria

ABSTRACT

This study investigated the relationships between the different sources of climate change vulnerability in rural communities, the interplay between factors of social vulnerability and structural vulnerability, and their influences on climate change adaptive capacity and resilience. The study took place in rural farming communities in Egbema district of Ohaji/Egbema local government area of Imo State, Nigeria between the month of March 21, 2021 to February 6, 2024. Three communities from the district of Egbema were purposively selected based on their social, cultural, and biophysical characteristics that expose them to climate change impacts. Semi-structured questionnaires were used to collect data from 240 household heads selected using simple random sampling technique. The study considered ten social vulnerability indicators from social, economic, and demographic characteristics of the respondents. The data were analyzed using descriptive statistics with the help of SPSS version 27. The data on social vulnerability indicators were used to calculate Social Vulnerability Index (SoVI) values. The result of the study shows that education had low influence on social vulnerability given that above 60% of the household heads attained at least secondary education level and the SoVI value of 0.18 is considerably low. However, other factors such as sex (0.90), age (0.66), disability (0.90), income (0.88), alternative housing (0.90), and mode of transport (0.40) increased social vulnerability. The finding shows that demographic and economic factors with SoVI values of 0.66 and 0.59 respectively contributed 87.4% of social vulnerability in the study area. The study therefore concludes that social vulnerability is exacerbated by political, socioeconomic and cultural factors. Government needs to improve infrastructure to increase community resilience whilst also facilitating household adaptive capacity on local and regional-scales to reduce climate disaster risk rather than just relying on household actions alone.

Keywords: Adaptive capacity; Climate change impacts; Resilience; Rural communities; Social

vulnerability

1. INTRODUCTION

Social vulnerability refers to the propensity of individuals or communities to be affected by natural and anthropogenic disasters [80, 34, 41]. The attributes of sex, age, income, education, disability, health and other sociocultural factors are the major determinants of levels of vulnerability (e.g., [7, 51]). However, these elements are not fixed but changes over time and space with circumstance, meaning that social vulnerability is a dynamic phenomenon [80]. Social vulnerability also influences the adaptive capacity and resulting resilience of individuals and households to weather and climate events, particularly in the developing world and under agricultural economies where household socioeconomic success is closely linked to favourable weather conditions for crop growth [49, 8, 40, 9]. Thus, the degree to which individuals, households and wider communities are affected by climate change is largely determined by their collective vulnerability. In the developing world, climate change vulnerability also reflects the interplay of historical and present-day marginalization of some communities for political, socioeconomic, culture, ethnic/language and other reasons [43, 67]. This can mean that, even in the same area, different individuals and households may exhibit different levels of vulnerability that are influenced by different factors.

Vulnerability also arises as a result of weaknesses in infrastructural and governance systems that serve local communities, here termed structural vulnerability. Elements of structural vulnerability include: the presence and quality of road/transportation networks; the presence and cost of public transport systems, healthcare systems (hospitals/clinics, doctors, pharmacies), reliable electricity; the infrastructure, water and sanitation systems to households; the presence and quality of schools, education and training in the area; the quality of housing and the built environment; food production, supply and security systems in the area; and the nature and diversity of economic systems and employment options in an area, including industry, markets and business opportunities. Structural vulnerability therefore refers to the presence and adequacy of built infrastructure that can support community socioeconomic success [1], but also

refers to the effectiveness of governance systems at all levels in decision-making and disaster risk management [67, 73]. Structural vulnerability is important because it has implications for societal adaptive capacity and achieving the Sustainable Development Goals [72, 18, 65, 1].

The nature of the interactions between different social and structural factors that can give rise to vulnerability has been evaluated in several studies [80, 16, 40]. For example, a lack of adequate infrastructure in an area can amplify any existing social vulnerabilities, as where a lack of sanitation, clean water or access to healthcare can impact on household resilience, especially of children, the elderly, or sick people [32, 40]. Likewise, poorly-regulated environmental pollution can decrease community resilience and increase vulnerability to pests, infectious diseases and food insecurity [74]. By contrast, supportive and integrated governance and societal structures can reduce household vulnerability and increase adaptive capacity [79]. These interconnected issues give rise to a more nuanced representation of vulnerability, and the role of different actors or processes in modifying vulnerability risks [23, 7, 17, 53]. Based on this previous work, this study aims to explore the interplay between social and structural vulnerability factors that influence the capacity of rural households in Imo State, Nigeria, to respond to, withstand, and recover from extreme weather and climate events. Calculated Social Vulnerability Index (SoVI) values are used to evaluate which are the most significant factors that influence vulnerability.

2. MATERIALS AND METHODS

2.1 Study Area

The study area is Egbema, a rural agricultural region in Imo State, Nigeria (Figure 1). This area has a humid tropical climate with average annual rainfall of 2000–2250 mm and average annual temperature of 26 to 32^{o}C. Rainfall is seasonal with the rainy season extending from March until October/early November [75]. Flooding is the most common hazard in the study area, and this takes place along the Orashi River, part of the Niger River system [59]. The rivers and soils in the area are also strongly polluted from metal mining, poor waste management, and oil/gas plants [22]. The three communities sampled in this study are all located 2–3 km from the river

and are periodically affected by flooding. Subsistence agriculture is the main economic activity [63] with fishing, hunting, palm oil production and animal husbandry all commonly practised [21]. The total population of Egbema according to the 2020 population projection is 69,695 (National Population Commission, 2020).

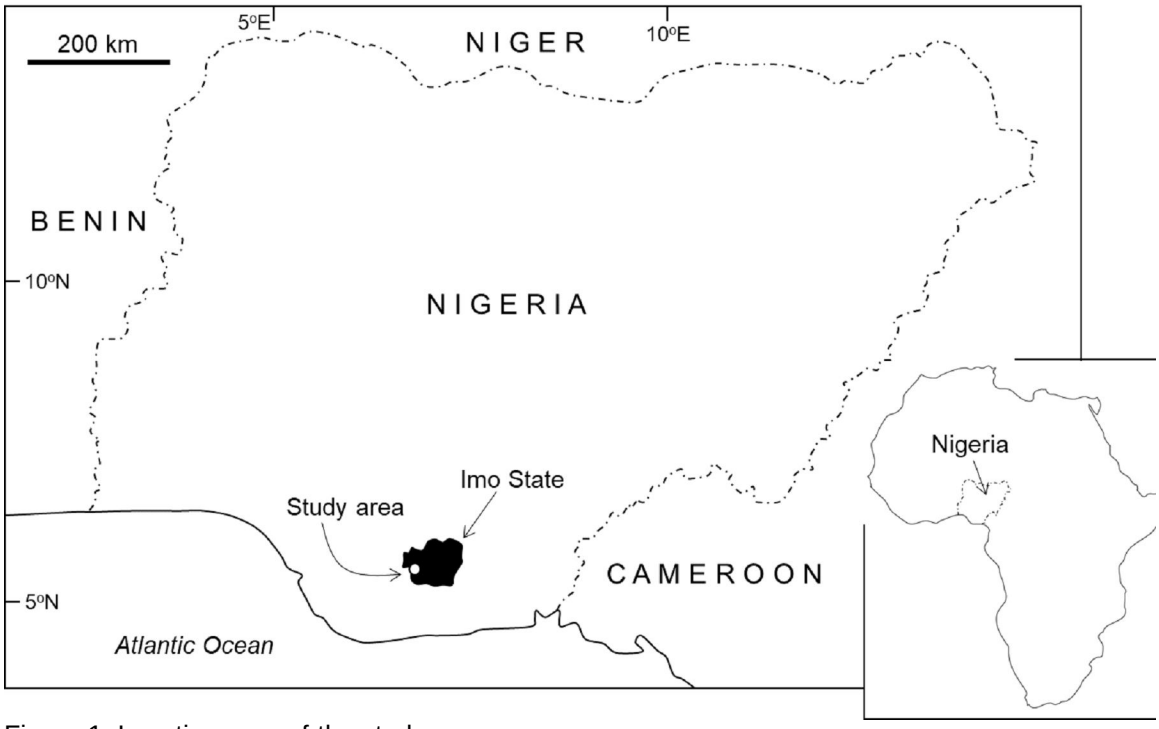

Figure 1. Location map of the study area.

2.2 Data collection methods

The wider literature on social and structural vulnerabilities, especially in a rural African context, identifies many factors affecting vulnerability that are mentioned time and again in different studies (e.g., [5, 39, 42, 8, 9]. This study selected ten of the most common factors, including both societal and structural elements, in order to evaluate which of these are the most significant determinants of vulnerability amongst the study population. Using simple random sampling technique, 240 rural household heads above 18 years old (both male and female) were selected in total from three communities in the study area (Etekwuru, Mmahu, and Opuoma). The sample size was determined using the Andrew Fisher's formula:

$$\text{Sample size} = \frac{(\text{z-score})^2 \times \text{std} \times (1 - \text{std})}{(\text{confidence interval})^2}$$

Where confidence level = 95%

Confidence interval = +/-5

Standard deviation (std) = 0.5

The selected household heads completed interview schedule with both closed and open-ended questions on demographic and socioeconomic characteristics of the household; climate risks and perceptions; and individual and societal adaptation strategies. The questions were completed in the local language of Igbo and participants gave informed consent before data collection took place.

Data analysis was undertaken using descriptive statistics and quantitative analysis using SPSS v27. This provided an overview of the dataset as well as identifying patterns and relationships within the data related to social and structural vulnerability factors. The indicator technique utilized by Dumenu and Obeng [19] and Dumenu and Tiamgne [20] was employed in order to measure social vulnerability to weather and climate events. The indicator technique calculates various indices. This method was chosen because it may be applied at any level (household or community) and helps to identify the most important factors that influence vulnerability. Ten indicators were used to determine the communities' social vulnerability, based on an examination of the literature. The indicators were: sex, age, education, household size, source(s) of income, total income, disability, access to transport, access to healthcare, and alternative shelter or refuge when there are floods. The indicators made up the subcomponents of the social vulnerability index, whereas the vulnerability factors made up the primary (major) components [20]. Indicators for the vulnerability categories (demographic, economic and social factors) were evaluated to ascertain the social vulnerability of the study communities. Then, in order to make the measured indications comparable as an index, they were standardized [20]. The functional correlations between the chosen variables and vulnerability were taken into account while standardizing the units (Table 1). An upward functional relationship is found when an indicator's

value rises together with vulnerability. As a result, greater vulnerability is indicated by higher indicator values. A downward functional relationship is found when vulnerability diminishes as the indicator's value rises. The index values of each indicator (subcomponent) of the factors (major components) were added together, and the average was calculated. This was calculated using the formula [19, 20]:

where M_v is the averaged index value of one of the factors (major components) of social vulnerability, X_i is the actual value of the indicator for the communities (j), and n is the number of indicators for each social vulnerability factor (major components). To determine the overall social vulnerability of the study communities, the following formula was used formula [19, 20]:

where M_{DF} is the index value of the demographic factors, M_{EF} is the index value of the economic factors, M_{SF} is the index value of the social factor, and n is the number of social vulnerability factors (major components).

3. RESULTS

3.1 Social Vulnerability Factors

The results are presented in Table 1. The sex makeup of participants is relatively balanced, and 60.8% of participants were aged between 18 and 47 years. Younger household heads were mainly males whilst older household heads were mainly females. Most of the participants had attained secondary education level or above.

The average number of household is six and the number of persons per household also varied by age of the householder. For example, in 70% of households with 2–4 members, the householder was aged 18–37 years; in 50% of households with 5–7 members and 51% of households with 8–10 members, the householder was aged 38–57 years. In households with 8–10 members, the householder was aged 58–67 years. This suggests multigenerational

households consistent with the time of life of the householder. These demographic factors are now interpreted with reference to their implications for social vulnerability.

Table 1 Household heads' socioeconomic and demographic characteristics (n=240).

Variable	Total	Percentage (%)
Sex		
Male	117	48.8
Female	123	51.2
Age (10years range)		
18–27	43	17.9
28–37	52	21.7
38–47	51	21.2
48–57	46	19.2
58–67	30	12.5
68–77	11	4.6
78 and above	7	2.9
Education		
No formal education	20	8.3
Primary education (class 1 - 6)	48	20.0
Secondary (Jss1 – SS3)	145	60.4
Tertiary (Diploma and above)	27	11.3
Number of people in household		
2–4	65	27.1
5–7	103	42.9
8–10	46	19.2
>11	26	10.8
Sources of livelihood		
Farming	160	66.7
Hunting	18	7.5
Fishing	33	13.7
Others such as government jobs, and trading	29	12.1
Household heads' income per month in Naira		
Less than 10,000	10	4.2
10,000–20,000	56	23.3
20,000–30,000	28	11.7
30,000–40,000	27	11.3
40,000–50,000	50	20.8
50,000–60,000	41	17.1
60,000–70,000	6	2.5
70,000–80,000	2	0.8
80,000–90,000	2	0.8
90,000–100,000	1	0.4
100,000 and above	17	7.0
Disability in household		
Yes	31	12.9
No	209	87.1
Access to healthcare		
Hospital	83	34.6
Clinic	14	5.8
Chemist shop (Patent medicine dealers)	124	51.7
Herbalist (Traditional medication)	19	7.9
Means of transportation		

Personal vehicle	28	11.6
Bicycle	93	38.8
Motorcycle	46	19.2
On foot	42	17.5
Others (e.g., taxi, canoes/boats)	31	12.9
Do you have any alternative place to live if your home gets affected by weather/climate events?		
My friends and relatives can accommodate me if such a thing happens	123	51.3
I do not have any other place to live outside this home	117	48.7

Male and female respondents exhibit different types of vulnerabilities, and to differing degrees (Table 1). For example, the results show that 67% of household heads with the highest education attainment are males. Over 60% of farmers are females, and 70% of the lowest income earners are also female. This may reflect the gendered societal, cultural and socioeconomic roles in the household and in wider (patriarchal and traditional) societies. Female household heads may be more vulnerable to climate change or weather events than males because they may have lower access to capacity-building programs and credit facilities, and they may engage with social networks that are more centered on children/healthcare rather than training/building adaptive capacity [26, 33, 27]. Studies have shown that during climate-related disasters, women in rural areas have higher mortality rates than men [24]. This can be attributed to poorer socioeconomic conditions of women in rural areas, protracted psychological stress, poverty, mobility challenges, lack of education, unemployment, hunger, and limited access to healthcare [28, 27, 24].

Given the wide age range of household heads in this study (Table 1), their ages may have implications for their farming experience, knowledge of weather/climate events, and may influence their education status and climate change adaptation practices [69, 26]. Since 67% of household heads between the ages of 18–39 years attained tertiary education (Table 1), it implies that younger household heads may have less farming experience but greater education, climate change awareness and adaptive capacity than older household heads. However, more experienced (older) farmers may be able to make better climate change adaptation decisions than less experienced ones. The ages of household members may also have implications for different vulnerabilities: older adults may have certain medical needs or rely on caregivers and a

robust healthcare system, but healthcare facilities in rural areas of Africa may not even be present, or may be poorly-resourced or unable to cope with societal demands [15, 44]. Larger households, with adults of different ages, may lead to increased overall adaptive capacity [51]. These may correspond to multigenerational households of the same extended family, or may include non-kin household members such as farm workers [48, 52]. Larger households may benefit from a greater agricultural labour force or wider skill-sets, but the trade-off is that they need more food or other resources. Participant 15 from Mmahu community said: “Having many children is a common practice that helps us cultivate, harvest, and process our farm produces from the numerous farmlands we possess”. This study shows that 80% of participants with 2–4 household members have at least secondary education. Given that less educated households earn lower incomes, having large household sizes may exacerbate their vulnerability. Several studies have also highlighted the complex family and social units that make up larger rural farming households, and their implications for climate change adaptive capacity and resilience [48, 31].

Education status has implications for climate change awareness, adaptive capacity and resilience [35, 25]. There are also relationships between education status, age, social capital, and income [11, 6]. The higher the level of education, the more likely it is that household heads will be able to receive, process, and comprehend climate change information [51]; 72% of household heads in this study have at least secondary education level (Table 1). By contrast, the least well educated or illiterate are most likely to engage in climate-sensitive occupations such as farming or fishing; may have reduced access to information; and lowest adaptive capacity [64, 35, 51]; 28% of household heads in this study belong to this category. Climate change knowledge through education does not necessarily translate to increased adaptive capacity but can help to lower vulnerability through its relationship to income and healthcare [25].

Of the 240 respondents, 67% are farmers (Table 1). The majority of these (67%) are aged 38–57 years, whereas only 14% are aged 18–37 years and 19% aged 58 years or above. Participant 9

from Etekwuru community said: Majority of us are farmers since it is the one thing that feed our families transferred from our ancestors to us". Household heads who engage in hunting only constitute 8% of the respondents but these are mainly young males with 44% of them having no formal education and an additional 22% having only primary education. Out of the 29 participants who claimed other sources of livelihood, most (66%) were between 18 and 39 years. Diversification of household income is a way of spreading risk and reducing reliance of climate-sensitive activities [11, 31]. Climate- and environment-linked occupations such as farming, fishing and hunting are undertaken by 88% of households in the study area (Table 1). When climate disasters such as floods occur, the majority of the rural population is unable to make a living when agricultural land is flooded, and animals and communities displaced. For example, during the series of previous flood events in the area (especially in 2012 and 2022), it took several months for fishing settlements to return to their base for business [41].

In Table 1, household heads reported their monthly income from their various economic activities. In total, 4% have a household income of less than 10,000 Naira (NGN) per month. This compares to the household Living Income found in rural Nigeria (2020 values) of NGN 138,678 per year (NGN 11,556 per month) [18]; and to the annual National Minimum Wage, agreed at federal level in Nigeria in 2017, of NGN 360,000 (NGN 30,000 per month) [3]. None of the householders in this study reported a household income of more than the annual National Minimum Wage, thus this indicates a situation of extreme rural poverty. For example, participant 17 from Opuoma community said: 'There are times in a month we do not have money to buy food or other items because we earn is not usually enough.' Of the lowest earners, 20% were aged 18–37, 60% were 38–57 and 20% were above 58 years. In total, 20% of this group have no formal education, 20% have only primary and 60% have secondary education. In total, 30% of the lowest-earning household heads were male while 70% were females. In detail, younger household heads (18–37 years) have a higher income than older ones (Figure 2a), and those that are more educated earn more than less educated ones (Figure 2b). Household heads with more members earn less than those with fewer household members (Figure 2c) and those that

engage in other external economic activities earn more than those in primary economic activities like farming, hunting, and fishing (Figure 2d).

Figure 2a: Distribution of income according to age of household heads

Figure 2b: Distribution of income according to educational background of household heads

Figure 2c: Distribution of income according to household sizes

Figure 2d: Distribution of income according to sources of livelihoods

[45] argued that education rather than age is the most significant influence on income, because education has an impact on the source of livelihood undertaken by an individual or household. Peichi et al. [66] reported that changes in household structures in Germany can increase income disparities at the household level, suggesting that household size and demographic make-up can influence total household income and thus financial resilience.

Disability (people with poliomyelitis, mental illness, or autism) in the household is a measure of social vulnerability because disabled people commonly require extra care, medicines or food, and may contribute less to the finances of the household [36]. The burden created by disability in such households may increase vulnerability where disabled people depend on other household members for support [62]. For example, participant 25 from Mmahu community said: 'Having a disabled family member slows the progress of the family since resources will be committed to assisting the individual. Those with disabilities may also be older adults who may have additional

health needs. Thus, any household with a disabled person is more likely to be vulnerable to the impacts of climate change [36]. In total, 13% of households have disabled members, which is slightly higher than 10% for Nigeria as a whole [54]. Further, participant 18 from Opuoma community said: 'I do not go to hospitals because I feel traditional medicines are more potent and cheaper.' Because of the high levels of poverty in the study area, only 35% of household heads go to hospital for medical treatment, with the majority (52%) patronizing chemists (patent medicine dealers) and 8% traditional herbalists (Table 1). Male household heads (54%) have greater access to hospitals than female household heads of which 59% patronize patent medicine dealers (chemists). This compares with findings by Smits et al. [70] that show that females in Suriname use healthcare facilities more than males because they fall sick more often and may require more medical attention.

The most common means of transportation used by households is bicycles (39%, Table 1) of which most users (53%) are aged 50 or above. Participant 8 from Etekwuru community said: 'One can hardly find a family without bicycle but those who own motorcycles and cars are the very rich ones among us.' People in this category are among the lowest earners as 57% of them earn between NGN 10,000–30,000 monthly. Householders aged 18–47 are the most common demographic that uses personal vehicles (57%) and motorbikes (74%). The majority of people who travel by foot (74%) are aged 38–47. The majority of personal vehicle users (73%) are male household heads, whereas 68% of those who use bicycles are female. Most of those who use motorcycles (53%) are male household heads while 58% of those who travel by foot are female. Canoes are used by a significant minority of people, for transport over floodwaters. Transport within and outside the community is necessary for accessing markets, healthcare and education, and for access/evacuation during climate-related emergencies [2, 10]. This is also limited by the available road network and the built infrastructure of roads. These rural communities may become isolated for response teams and health workers when climate emergencies occur. When floods take place, around half of the households (52%) can access alternative accommodation or shelter. Participant 12 from Opuoma community said: 'When flood disasters occur, people who

have friends or relatives outside the community whose houses were not affected always assist to accommodate others.' Having alternative accommodation or shelter during these events can reduce household vulnerability. Around half of the households surveyed (Table 1) do not have access to such shelters.

The built infrastructure of healthcare facilities and schools is a crucial factor in social vulnerability due to its role in improving the resilience and the adaptive capacity of rural communities [43, 29]. However, the absence of such infrastructure in the study area – either not present at all, or being inadequate or not fit for purpose – means that there is a lack of government-provided service provision of all different types. This is known to increase social vulnerability especially when aggravated by climate changes such as extreme heat waves and flooding [15], and to increase any pre-existing social inequalities [4]. Access to healthcare may be a function of income, age, and education [74] because people who have higher incomes tend to have greater mobility and access to healthcare. The high proportion of female respondents in this study who use local chemists and herbalists (63%), in addition to their lower mobility and with issues of maternal and infant healthcare [68], results in significant female vulnerability that may be amplified by domestic, familial, cultural and religious constraints.

3.2 Structural Vulnerability Factors

The household heads described structural vulnerability factors preventing them from adapting to climate change (Table 2). For example, participant 1 from Opuoma community said: 'There is no or little government presence in terms of basic and social amenities in the community.' Most male respondents (53%) pointed to lack of electricity as their major concern whereas 56% of female respondents were most concerned with poverty. Participant 30 from Mmahu community said: 'I cannot remember the last time our community had electricity supply, and due to high cost of petrol, it is difficult to run electric power generator sets.' Most (60%) of those who said their biggest challenge is lack of basic infrastructure were male respondents; 55% of those who reported food shortage were male while 63% of those who said insecurity of lives and property

were female respondents. Participant 4 from Opuoma community said: 'We have poor road networks and the existing ones are bad due to lack of maintenance.' Participant 13 from Etekwuru community said: 'People no longer go about their normal economic activities especially early morning and evening/night hours for the fear of being attacked by armed men.'

Table 2. Barriers to climate change adaptive capacity (n=240).

What are your challenges in coping with weather/climate events?	**Total**	**Percentage (%)**
Our community does not have electricity	38	15.8
We are very poor in this community	108	45.0
This community lacks basic infrastructure	30	12.5
Food shortage is a challenge here	40	16.7
Insecurity of lives and property is a big problem in this place	24	10.0

3.3 Social Vulnerability Index (SoVI)

In order to better understand the social aspects of climate change vulnerability and to plan and create interventions to increase social groups' resilience and adaptive capacity, the Social Vulnerability Index (SoVI) can be used as a bridge between science and policy. SoVI is suitable for this study because it can be used at the scale of communities, districts or social groups [19, 20]. Similar parameters to those examined in this study have been previously used to conduct assessment of SoVI at the national and household levels in different locations (e.g., [67]. Based on calculation of SoVI, sources of livelihood (0.18), income (0.88), and access to healthcare (0.18) were among the economic and social factors that influenced the degree of vulnerability of rural populations in the study area. Sex, disability, and alternative housing/shelter had the highest scores (0.90) among these demographic factors, followed by age (0.66) and mode of transportation (0.40); education had the lowest index score (0.18), as did household size (0.18), indicating a declining or decreasing contribution of these factors to calculated vulnerability. The low contribution of education as a factor here is because over 60% of the population in the study area has at least secondary level education (Table 1). Of the three social vulnerability categories, social factor had the lowest index score (0.18) (Table 3). SoVI values are considered to be low where 0–0.30, high where 0.40–0.60; and very high where 0.70–0.1) [20]. Thus, the very highest variables contributing to vulnerability in this study are sex, disability status,

alternative housing/shelter, and income (Table 3). These span social and structural vulnerability factors. Dumenu and Tiamgne [20] examined the social vulnerability of smallholder farmers to climate change in Zambia and reported that social and economic factors contributed more and demographic factors contributed less to farmer vulnerability. Lottering et al. [39] found that social factors contributed more and demographic factors contributed least to the vulnerability of small-scale farmers in South Africa. Similarly, [19] reported index values of 0.52 and 0.50 for demographic factors in Sudan and Guinea Savanna zones of Ghana, respectively.

Table 3. Calculated Social Vulnerability Index values for the study area

Social vulnerability factors	**Indicators (subcomponents)**	**Sub-component index and percentage contribution**		**Major component index (MCI)**	**Overall index**
Demographic	Sex	0.90	16.7%		
	Age	0.66	12.2%		
	Household size	0.18	3.3%		
	Disability	0.90	16.7%	**MCI for Demographic factors = 0.66**	
Social	Education	0.18	3.3%		
	Access to healthcare	0.18	3.3%	**MCI for social factors = 0.18**	
Economic	Sources of livelihood	0.18	3.3%		
	Income	0.88	16.3%		
	Mode of transport	0.40	7.4%		
	Alternative housing/shelter	0.90	16.7%	**MCI for economic factors = 0.59**	
Total social vulnerability index					**0.48**

Aggregate social vulnerability index for the study area is MCI_E (0.66) + MCI_S (0.18) + MCI_E (0.59) =0.48

4. Discussion

Rural communities in West Africa are sensitive to the effects of ongoing climate and environmental change (e.g., [61, 78, 71]). This is particularly the case in the study area of Egbema in Nigeria where there is a close dependence on subsistence agriculture (66% of householders) for household socioeconomic success (Table 1). Several previous studies have identified the major societal and structural factors that have the greatest influence on

vulnerability of African rural communities to climate and environmental change (e.g., [7, 49, 11, 6, 32, 51]). This previous work highlights the multidimensional factors that give rise to vulnerability, linking together social and structural factors. This study builds upon this previous work by exploring the detailed interplay between these vulnerability factors. This is achieved through use of the Social Vulnerability Index (SoVI) and by examining the co-relationships between different variables as described in free-text comments from participants captured in questionnaire responses.

The main results show that communities in the study area had an aggregate social vulnerability index value of 0.48 (Table 3) which is considered as high [20] and moderately high [39] in comparison to other studies. Other factors not explicitly considered, however, may include infrastructural deficit, poverty, food shortages, lack of electricity supply, and insecurity of lives and property (Table 2). These can also reduce the climate change adaptive capacity of rural households thereby raising their vulnerability.

Regarding the major drivers of social vulnerability, demographic factors were identified as the most important (0.66) contributing 46.2% of the social vulnerability in the study area, followed by economic (0.59) contributing 41.2% of the study area's vulnerability, and then social factors (0.18) contributing the least (12.6%). Rural farming areas in Africa that are most vulnerable to climate change variability do not necessarily correspond with the populations that are most at risk from such variability. Our findings suggest that demographic factors are the major contributor to climate change sensitivity. However, the social vulnerability of rural households may be exacerbated by existing structural vulnerability within their communities. This has implications for vulnerability and adaptive capacity of rural residents to climate change. The presence of structural vulnerability evident as the challenges of climate change adaptation in rural communities may lower adaptive capacity and resilience of rural households during climate-related disasters. This is supported by Generalized Resistance Resources (GRRs) theory explains that communities with higher resources will have better resistance to climate change

impacts. Similarly, households with higher GRRs levels will likely withstand and recover faster from the impacts of climate change.

4.1 The interplay of social and structural vulnerability factors

In this study, social vulnerability factors were not considered in isolation but in the context of how they contribute to overall vulnerability through their connections to demographic and economic characteristics of households and the wider community. This follows approaches that adopted in some previous studies in different parts of Africa (e.g., [34, 43, 58, 9]. Results of this study show that a significant proportion of households have lower incomes than the Nigerian national average either do not make enough money to meet their basic needs or do not get enough money after meeting their basic needs. Despite the low-income (economic factor) rural residents earn in the study area (Table 1), they have large households (demographic factor) and among them may be persons with disabilities (demographic factor) who require special care and needs. Such households are likely to exhibit less resilience and low adaptive capacity, making them vulnerable to extreme weather/climate events (e.g., [48, 46, 31].

Compared to other studies (e.g., [19, 20, 39], sources of livelihood showed a limited contribution to overall vulnerability in the study area, with a SoVI value of 0.18 (Table 3). This may be due to the similarity in occupation for over 65% of the households. Most (67%) of the household heads are farmers who practice crop diversity that reduces vulnerability to climate change [38]. Even though larger fraction (88%) of surveyed households rely on climate-sensitive economic activities such as farming and hunting, other rural households have members with a range of other jobs (Table 1). This may help provide an economic buffer during periods of extreme weather/climate events, in particular related to food security, and can also influence other factors that contribute to resilience such as education and health [66]. The interplay and trade-offs between these factors that are founded on the economic livelihoods of households has not been fully explored [80, 31]. The sensitivity of rain-fed agriculture to climate variations means that households in the study area are highly climate-dependent, expressed through variability of

agricultural production and therefore household-level food security and income. It is likely that cyclic variations in climate, such as El Niño events and changes in strength of the West African monsoon that affect this part of Nigeria [56], are linked to variations in agricultural success and therefore household resilience [31].

An important element to note is that stated SoVI values (Table 3) may not reveal their true significance for the lived experiences of households in how they navigate their livelihoods, vulnerabilities and household demands on a day-to-day basis. Thus, the interplay between different social and structural factors may vary with circumstance and from one household to another. It also means that making generalisations about the vulnerability/resilience of whole communities may be problematic. A critical element contributing to the development of household resilience is the ability of household members to access markets, schools, hospitals and workplaces outside of the region through adequate transport networks and transportation modes (e.g., [10]). However, transport within and outside of these communities was not considered adequate by householders (Table 2), leading to increased exposure to weather and climate events such as floods. Lack of transport capacity or transport routes has implications for the ability of vulnerable or hazard-affected populations to evacuate an area, or emergency responders to enter and move within an area [42, 29, 15, 4]. The dominance of bicycles and foot-transport in the study area (Table 1) implies relatively low mobility, covering short transport distances, and relatively slowly. This may also limit householders' capacity to transport goods and access services in the wider region (e.g., markets, schools, hospitals). This may mean that those with greater mobility are likely to have greater resilience, regardless of their household socioeconomic status. Mobility is also related to the quality, density and integration of the road network and its associated services (e.g., presence of gas stations, road safety, road lighting, maintenance, vehicle quality and safety) and these reflect the structural vulnerability and resilience of the transport network. The relative inaccessibility of markets, schools, hospitals and workplaces in the study area as a result of householders' low mobility may increase their social vulnerability related to education, healthcare, income and other factors. Of note is the low SoVI

score (0.18), which indicates that access to healthcare is not a prominent factor to social vulnerability among rural households in the study area. However, the value arises as a result of the varied factors influencing access to healthcare in the first place, including structural vulnerability factors related to transport, travel distance, income, and insurance [14]. Thus, this SoVI value does not capture the interplay of social and structural vulnerability factors that underlie it.

Although education has a low SoVI score (0.18), its varied and diverse interactions with gender (0.90), age (0.66) and income (0.88) lead to an increase in vulnerability. In the study communities, female household heads exhibit higher vulnerability related to their general lower education status (Table 1) which has implications for income, access to weather/climate information, climate risk awareness and preparedness strategies, and effective adaptation behaviours (e.g., [24, 27, 60]). Education status therefore closely relates to individual and household demographic and social factors. It also has implications for the ability of individuals to make the most of training opportunities for increasing agricultural adaption, or to develop alternative income streams to increase climate change resilience [66].

Transport, education and other infrastructural elements such as water and electricity supply and sanitation systems, and the robustness of the built environment such as housing quality, provide the basis of the structural vulnerability and resilience of the study communities (e.g., [72,1, 79]). In addition, unequal resource distributions between more urbanized and rural areas, the political and socioeconomic marginalization of many rural communities, and poor institutional governance frameworks are very commonly found in the developing world [72]. These factors contributing to structural vulnerability can impact on social vulnerability and thus the capacity of rural households to adapt to weather and climate events. In addition, elements of structural vulnerability such as poor electricity supply, poverty, inadequate infrastructure and food insecurity can affect individuals disproportionately during extreme weather and climate events (e.g., [16, 48, 7, 40]).

4.2 Dealing with vulnerability and resilience

Agricultural systems in rural areas of Africa exhibit vulnerabilities to climate change and increased weather/climate variability and extreme events through both agricultural ecological processes (crop yield, pests, soil erosion, carbon storage), and through the social and demographic properties of agriculturally-dependent communities [39, 9, 31]. As such, increased hazard risks associated with climate change impacts represent a considerable source of future uncertainly for rural African communities [74, 28, 65]. This means that strategies to reduce social and structural vulnerability are an important aspect of risk mitigation and sustainable development [49, 18, 46].

In the study area, both social and structural vulnerabilities and properties act as challenges or barriers to climate change adaptation (e.g., [23]). For instance, land tenure systems may hamper the acquisition of land for farming where land is split up between family members, while the inability of the government to provide rural farmers with credit facilities, incentives, and access to loans may reduce farmers' production capacity, thereby weakening their adaptive capacity. The root causes of vulnerability identified here are the combination of individual characteristics of rural residents (socioeconomic and demographic) and the elements of structural vulnerability. This can result in an unequal distribution of resources, engagement in climate-sensitive occupations like farming and hunting, and financial inability to invest in more climate-resilient infrastructure or resources. Since the interplay of social and structural vulnerability likely results in a disproportionate resource allocation amongst rural people and can increase household inequalities, those households with access to greater income or other resources will likely have higher adaptive capacity and greater resilience than others during extreme weather and climate events (e.g., [50, 9]).

Governmental inefficiency and corruption, poor policy planning and implementation, lack of strategic oversight and expertise are factors that contribute to weak or ineffective infrastructure

development in Africa [72, 18]. This in turn fails to support the development of climate-resilient communities or to build social resilience through education, training, healthcare and economic growth [65, 58]. This means that low-earning and large households, as in this study, experience greater vulnerability and are less able to establish the foundations upon which they can develop social resilience. Although better-educated rural residents have higher incomes (Fig. 2), the structural vulnerability created by the weak implementation of government policies, programs, and frameworks for rural development negatively impacts on household resilience irrespective of educational background.

This study highlights that household resilience in rural Nigeria is linked to both social and structural vulnerability of the rural communities and their built infrastructure. The interplay between these different vulnerability sources shows how one affects the other, but that these are strongly mediated by household composition, including the number of household members, their ages/disabilities, education status and other demographic factors (Table 3). Of note is that these vulnerabilities exist irrespective of agricultural practices. This contrasts with many previous studies that have considered agricultural adaptation and resilience alone as the most important way of dealing with weather and climate risks in rural Africa (e.g. [13, 26, 47]. Based on the results of this study, it is argued that agricultural adaptation cannot take place successfully without first addressing underlying social and structural vulnerabilities. This argument is similar to approaches now adopted in biodiversity conservation that state that effective conservation cannot take place without 'transformative change' of existing socioeconomic and political systems, that have hitherto failed to deliver conservation outcomes (e.g., [37, 77, 12]). This study therefore argues that underlying social and structural vulnerabilities need to be addressed in order to make any agricultural adaptations quicker, more effective, cheaper and more sustainable. Household vulnerability is influenced by both internal (household) and external political, economic, cultural and social factors. However, investment in more effective and climate-resilient infrastructure can increase household and community resilience and adaptive capacity. This is also a more equitable, regional and long-term plan for reducing climate risk

rather than just relying on household actions alone.

5. Conclusions

Based on household-level questionnaires in a rural area of Imo State, Nigeria, this study identified and discussed the major economic, social and structural vulnerabilities that impact on household resilience and adaptive capacity to cope with extreme weather and climate events. These were evaluated through consideration of ten key social and structural vulnerability indicators, used for calculation of Social Vulnerability Index (SoVI) values. The results show that demographic (0.66) and economic factors (0.59) are the major elements contributing to 87.4% of vulnerability in the study area, but that there is a close interplay between these factors that belies their SoVI values. Social and structural vulnerability are related to each other through the presence of different infrastructural elements in the study area that can provide resilience, such as through the provision of education, healthcare, housing, water/electricity services, roads and economic support structures such as markets. These can support the wellbeing of individuals and communities and their socioeconomic uplift. Conversely, poor government frameworks and weak infrastructure can exacerbate social vulnerability. Increasing community resilience to weather and climate events in the study area, as in rural agricultural areas of Africa more generally, requires an integrated approach to addressing social and structural vulnerability. At present, this is largely not the case. Further work is also needed in understanding community and household resilience, and identifying the most important elements that are required in different contexts to develop such resilience. This requires a more integrated research and risk-management approach than has been achieved hitherto.

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Conflicts of Interest

The authors declare no conflicts of interest regarding the publication of this paper.

Consent

As per international standards or university standards, Participants' written consent has been

collected and preserved by the author(s).

Ethical Approval

The study received ethics clearance (H22/01/24) from the University of Witwatersrand, Johannesburg South Africa.

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