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Spatial pattern of climate change and farmer–herder conflict vulnerabilities in Nigeria

Ignatius A. Madu · Cletus Famous Nwankwo

Abstract Climate change is recognised among the drivers of conflicts in developing regions but the growing studies on climate change–violent conflict nexus in Africa have paid little attention to the spatial dimension of the farmer–herder conflict in Nigeria. Existing studies have not explored the issue of climate change vulnerability regarding the farmer–herder conflict. Therefore, this paper contributes to the literature by examining the spatial dimension of the relationship between climate change and farmer–herder conflict vulnerabilities in Nigeria. Data were obtained from various secondary sources and the analyses were based on climate security vulnerability model. The study shows that the farmer–herder conflict is widespread across Nigeria but with significant spatial clustering and the hotspot is in the Middle Belt, especially in Benue State. The result of the regression model indicates that climate change vulnerability is the best predictor of the farmer–herder conflict in Nigeria but the effect is negative. This result implies that regions more vulnerability to climate change experience lesser farmer–herder conflict. The paper demonstrates that climate change could influence herders' migration pattern as the herders now move southward due to deteriorating environmental conditions partly caused by changing climate in the northern regions. Thus, it argues climate change is not necessarily the cause of the conflict because the change in the pattern of herder's migration does not automatically lead to climate change causing conflict. Migration is important but the mechanism establishing the migration–conflict nexus has to be explained by taking cognisance of identity differentials between herding groups and local communities.

Keywords Climate change and security · Climate security vulnerability model · Farmers–herders conflicts · Climate change and conflict · Environmental security · Spatial analysis

Introduction

This study is about the relationship between climate change vulnerability and farmer–herder conflict vulnerability. Specifically, it examines the spatial dimension of the relationship between climate change-related hazards and the farmer–herder conflict in Nigeria. It conducts this study to contribute to the debate about whether climate change induces conflict particularly in developing regions. The nexus of climate change and conflict has gained increased scholarly attention in the last decade and vulnerability

I. A. Madu · C. F. Nwankwo (✉)
Department of Geography, University of Nigeria, Nsukka, Nigeria
e-mail: cletus.nwankwo@unn.edu.ng

I. A. Madu
e-mail: ignatius.madu@unn.edu.ng

to climate change has been seen as pivotal to conflict. Although Africa's contribution to global climate change is minor, it is argued that Africa is most vulnerable to its impacts (IPCC 2007). The IPCC defines vulnerability as the level of susceptibility to and coping ability of systems with the harsh impacts of climate change (IPCC 2007). Three factors determine vulnerability: exposure to the threat, sensitivity and adaptive capacity (IPCC 2007). Africa has weaknesses in all three parameters and hence climate change would probably have severe impacts on both natural and social systems (IPCC 2007). Although there is a strong claim that climate change can heighten the risk of conflict, there is no consensus on that. Thus, while the issue of climate change as a security risk has not only lately been given increasing attention, it has also created two opposing views of enthusiasts and sceptics (Olaniyan and Okeke-Uzodike 2015).

Despite the debate about climate change and cosnflict nexus in Africa, it is argued that the overall effects of climate change in Sub-Saharan Africa have not been fully understood (Serdeczny et al. 2017). Also, it is important to know how and under what conditions climate change may lead to violent strife as this may offer direction regarding what real actions add to decreasing the possibility of conflict (SIDA 2018). Despite the growing studies on the nexus of climate change and violent conflict in Africa, only a few studies have considered this issue regarding the farmer–herder conflict in Nigeria using a spatial analysis framework. Besides, existing studies on the nexus of climate change and farmer–herder conflict have not explored the issue of vulnerability from a spatial dimension. It has been stressed that the spatial dimension is necessary for analysing the connexions between climate-related environmental change and violent battles (Madu 2018). Therefore, this paper contributes to the literature by examining the spatial dimension of the relationship between climate change and farmer–herder conflict vulnerability in Nigeria.

The study shows that the farmer–herder conflict is rife across Nigeria but with significant spatial clustering in the Middle Belt, especially in Benue State. The paper shows that climate change vulnerability is the best predictor of the farmer–herder conflict in Nigeria but the effect is the opposite of what most studies championing the environmental security thesis found. The effect of climate change is negative implying that vulnerability to climate change does not automatically lead to conflict between herders and farmers. The regions that are more vulnerability to climate change experience lesser farmer–herder conflict. This result demonstrates that climate change could influence herder's migration pattern as the herders now move southward due to deteriorating environmental conditions partly caused by changing climate in the northern regions. However, climate change is not necessarily the cause of the conflict because the change in the pattern of herder's migration does not automatically translate to climate change causing conflict. Migration is important but the mechanism establishing the migration–conflict nexus has to be explained by taking cognisance of identity differentials between herding groups and local communities. The paper is structured as follows: the next section reviews the literature and after that is the theoretical orientation. Following the theoretical section is the methods of the study and after that are the results, discussion and conclusion respectively.

Review of the literature

Many studies have argued that climate change is a part of the factors of violent conflicts (Nordås and Gleditsch 2007; Hendrix and Glaser 2007; Hendrix and Salehyan 2012; Hsiang et al. 2013). Other studies have been skeptical about such interpretations (Raleigh and Urdal 2007; Gleditsch 2012; Wischnath and Buhaug 2014). Those that argue in support of the impact of climate change are of the view that even though climate change has a no direct and linear relationship with violent conflicts, climate-related change can stimulate factors that intensify conflicts. In this regard, IPCC (2014) observes that climate change can inversely amplify violent strife such as civil war and inter-group hostilities by intensifying known factors (e.g., economic shocks and poverty) of these crises.

Climate change can worsen competition for resources, impact livelihoods, and upsurge the possibility of conflicts and insecurity, particularly in locations experiencing political, economic and social strain (OCHA 2016). Ubelejit (2016) argues that climate change is a driver of strife at the community level and its impetus is substantially shaped by migration and other elements such as immigrants' behaviours on the one hand and the other hand, host communities' perception. Levy et al. (2017) observe that raised temperatures and precipitation extremes with their related concerns, plus subsequent dearth of cropland and other critical environmental resources, are chief conduits by which climate change influences collective violence.

As Adams et al. (2018) noted, climate change sceptics suspect the conclusions that climate change is triggering violent conflicts as generalised and that it is hard to substantiate in individual cases. It was easy to dismiss the findings of earlier proponents of climate change-conflict thesis because they provided less than satisfactory critical analysis and nuance evidence to support their claim. For example, most of the evidence is derived from grey and second–hand literature that has not undergone rigorous systematic analysis (e.g., Sachs 2005). Rigorous systematic analysis has been used based on climatic and conflict data from different countries (e.g. Hendrix and Salehyan 2012; Hsiang et al. 2013). O'Loughlin et al. (2012) indicated that the relationship between climate variables (such as temperature) and conflict shows that much warmer than usual temperatures increase the possibility of violence. Average and cooler temperatures have no effect, although there are large spatial variations in the climate–conflict relationships. These temperature and precipitation effects are statistically significant but have a diffident impact regarding predictive power in a model with political, economic, and physical geographic predictors (O'Loughlin et al. 2012).

SIDA (2018) emphasises that decline in access to water and dangerous weathers may harmfully impact food security and weaken the livelihoods of susceptible households and communities, upsurge the possibility of poverty, hunger, forced migration and crises and human rights abuses. Hendrix and Salehyan (2012) demonstrate a robust relationship between environmental shocks showing that rainfall variability has a substantial impact on both large-scale and smaller-scale occurrences of political conflict though wetter years are expected to suffer more from violent events. Great rainfall abnormalities particularly dry and wet years—are associated positively with all forms of political conflict, though the correlation is robust regarding violent events, which are more reactive to profuse than limited rainfall (Hendrix and Salehyan 2012). Theisen et al. (2012) show no evidence for drought-conflict connection and indicate that the local risk of civil war can be explicated by sociopolitical and geographic factors: proximity to international borders, a politically marginalised population, high local population density and high infant mortality. Raleigh and Urdal (2007) and Wischnath and Buhaug (2014) argued that the influence of social, political and economic factors on violent conflicts far outweighs environmental cum climatic factors. Despite the two opposing views, there is a growing consensus among researchers that climate change can upsurge the possibility of violent strife under specific scenarios.

It has been argued that the context in which climate change results in conflict is pertinent to our understanding of climate-conflict nexus. Fjelde and von Uexkull (2012) contend that the effect of climate change on conflict is positively heightened in the presence of marginalisation of some ethnopolitical groups. It could boil down to the argument that the conflict emanates from the way actors and groups respond to resource scarcity caused by climate change or other environmental factors. However, the response would depend on the capacity to do so as it has been argued that some regions, e.g., Africa cannot mitigate or adapt to climate change (Cabot 2017). Thus, there also is a general agreement that autonomously, climate change does not lead to violence. Rather, it is the cross-linkage of vulnerability to climate change and wider socio-economic strain that energies the likelihood for violent strife (OCHA 2016; SIDA 2018). Thus, several factors bring about outbreaks of violence and as a result, it is usually not possible to identify single determining factors (Theisen et al. 2012). There is a need for a better understanding of why, how and when climate change can upsurge the danger of violent crises and if done properly, climate–conflict research is indeed prized. Such studies require a systematic analysis into how climate change shapes—and possibly violently upset—societies at large is very essential.

The farmer–herder conflict in Africa is one of such conflict scenarios that has been linked with climate change, especially in dryland parts of the Sahel belt and requires systematic analysis. Studies have advanced the notion that climate change influences the farmer–herder conflict (Herrero 2006; Obioha 2008; Ajaero et al. 2015). For example, Ajaero et al. (2015) argue that there is a strong link between climate change and herdsmen–indigenes conflicts. The herder-farmer crisis has been conceived as a reality of the climate change and resource control interface, and its embedded security challenges. Cabot (2017) argues that the farmer–herder conflict in West Africa is a struggle over shared natural renewable resources, namely freshwater and land but the conflict is climate-change-induced or—aggravated. Other studies especially those conducted in Nigeria show that climate change is one of its causes particularly as herdsmen move southward as a means of adaptation to the drying climate in the north (Onuoha and Ezirim 2010; Odo and Chilaka 2012; Folami and Folami 2013; Abugu and Onuba 2015; Ubelejit 2016). Equally, studies have rejected the view that climate changes cause herder-farmer conflict although they recognise that climate change can lead to resources scarcity but it does not by itself cause violent conflicts (see, e.g., Schilling et al. 2012; Turner 2004).

In spite of the debate about climate change and conflict nexus in Africa, it is argued that the general effects of climate change in Sub-Saharan Africa have not been totally understood (Serdeczny et al. 2017). Besides, it is essential to know how and under what circumstances climate change may lead to violent strife as this may suggest direction concerning what real actions add to lessening the likelihood of conflict (SIDA 2018). Despite the increasing studies on the nexus of climate change and violent conflict in Africa, only a few studies have explored this issue concerning the farmer–herder conflict in Nigeria using a spatial analysis framework. Besides, existing studies on the nexus of climate change and farmer–herder conflict have not explored the issue of vulnerability from a spatial dimension. It has been indicated that the spatial dimension is crucial for analysing the connexions between climate-related environmental change and violent conflicts (Madu 2018). Therefore, this paper examines the spatial dimension of the relationship between climate change and farmer–herder conflict vulnerabilities in Nigeria.

Climate change and farmer–herder conflict: a theoretical explanation

Varied theoretical approaches have been applied to the study of the farmer–herder conflict in Africa, but the common property resource theory (CPT), political economy, political ecology and environmental security approaches have been influential. There is an emerging critical tradition that argues for a discursive treatment of the conflict via constructivist and post-structuralists lenses (Nonye and Iwuoha 2015; Nwankwo 2018a; Nwankwo et al. 2020) including the advancement of critical geopolitics of the conflict (Nwankwo 2018b, 2019a). The political ecology approach has gained a footing in the analysis of the conflict even though previously, the common property theory and environmental security were leading lenses to understanding the crisis. The CPT is a tradition that focuses on the conflict as a product for the struggle for common-pool resources such as land and waterholes and argues that it is institutional letdown that engenders the lack of regulation of the use of common resources which makes resources' users engage in violent, competitive struggle (Hoffmann 2004). The environmental security tradition argues that it is the scarcity of resources (not necessarily as "commons") which is produced by environmental degradation, drought and climate change that engenders the conflict.

The political ecology approach emerged to critique both the CPT and environmental security and argues that it is the struggle for access to and control over resources mixed with the historical, political and social settings of the relation between pastoralists and farmers that produce the conflict (Turner 2004; Benjaminsen and Ba 2009, 2019). Political ecology emphasises that resource scarcity or depletion does not necessarily lead to conflict because there are places of resources abundance but having conflict and places of resources scarcity with no conflict. Political ecologists draw attention to the issue of local and national land policies and legislation that favour farming interests and neglect nomadic pastoralism as part of the stratagem for pursuing modernisation (e.g. Turner 2004; Moritz 2006a; Benjaminsen and Ba 2009; Benjaminsen et al. 2009). Some authors have disapproved such policies arguing that the conflicts often have a political basis (Bassett 1988; Turner 2004; Moritz 2006a, b), which is linked with a current process of pastoral marginalisation (Benjaminsen and Ba 2009, 2019; Benjaminsen et al. 2009). Critical studies have drawn our attention to factors beyond local and national policy–that of discourse, identity, subjectivity and issues of national identity and belonging in which the pastoralists especially nomadic Fulani herders are considered as aliens, intruders in the sense of not a "Nigerian" or not "Ghanaian" for example which encourages the discrimination and marginalisation of the pastoralists in local communities (e.g., Nwankwo 2018a, 2019a; Nwankwo et al. 2020).

Despite the critiques, the environmental security approach has been the framework for studies exploring the nexus of climate change and conflict, and this paper draws upon it to examine the relationship between climate change vulnerability and farmer–herder conflict vulnerability in Nigeria. There has been an increased level of experts' confidence regarding the current and projected impacts of climate change on human society. It is argued that snowballing temperatures, more irregular rainfall, sea-level rise and more recurrent and severe natural hazards are expected to afflict the African continent progressively. There is a prevailing argument that significant parts of Africa will witness larger climatic variability and drought in the nearest future. The impact of climate change in Africa is argued to be not only ecological but also severe societal consequences because most African countries depend on rain-fed agriculture. There are projections that climate change will impact freshwater resources and it is dreaded that this could lead to global water wars. Even though the feared wars remain imaginary, there are grim apprehensions about the impact of climate change on security as indicated in the Intergovernmental Panel on Climate Change (IPCC) and the Human Development Reports (IPCC 2014). The IPCC also reported that climate change already impacts freshwater and land resources in Africa and it is increasingly observable (IPCC 2007: 10, 2014: 1202).

These ecological impacts of climate change embody unparalleled tests for the African societies, and can potentially threaten social and human security systems. A growing issue is the linkage of increasing scarcity of natural resources to conflicts and violence. It is argued that climate change can result in environmental decay and resources scarcity which exacerbate armed conflicts in Africa what is termed "climate wars" (Nordås and Gleditsch 2013). Although there is no consensus on the relationship between climate change and violent conflict, several empirical studies submit that the environment at best has an insignificant influence on the risk of systematised violence (e.g. Raleigh and Urdal 2007; Buhaug 2010). Nonetheless, some studies do find support for the connection between climate change and conflict, whereas others find that climate variability and socio-political factors both influence conflict. In this sense, Fjelde and von Uexkull (2012) show that large negative variation in rainfall pattern from the historical norm is associated with a higher risk of communal conflict but the effect of rainfall shortages on the risk of communal conflict is intensified in regions occupied by politically excluded ethnopolitical groups. This suggests that the effect of climate change on conflict could be heavier in the presence of socio-economic and political forces.

Drawing on environmental security thesis societies with growing populations that rely greatly on natural resources are particularly susceptible and expected to experience a rise in conflicts and violence in relation to climate change. In parts of sub-Sahara, every day livelihood strategies such as herding and farming rely on natural resources' productive abilities. It is argued that farmers and pastoralists struggle for land and freshwater resources since both heavily rely on them for survival. Thus, they are traditionally likely to have conflicts with each other about the distribution of these resources, which are severely impacted by climate change (Mjøs 2007 cited in Nordås and Gleditsch 2013). There is a contention that social, political and economic factors shape environmental changes and define if the societal test posed by climate change will be conflictive or be peacefully handled. Likewise, it has been shown that economic, social and political factors play vital roles in the farmer–herder conflicts (Bassett 1988; Turner 2004; Moritz 2006a, b).

Nonetheless, the issue of vulnerability is pertinent to explicating the impact of climate change on violent conflict. Vulnerability defines the level of physical exposure and resilience, i.e. the ability of societies to forestall, cope and recover from climate change and other environmental shocks (Sabates-Wheeler et al. 2008). Existing explanations of the environmental scarcity–conflict nexus have been critiqued for not adequately accounting for local configurations of socio-economic vulnerabilities of households and communities (Raleigh 2010). Violence is a high-cost rejoinder to climate-induced adversities and will pivot on the lack of substitute surviving schemes. Thus, it is vital to incorporate socio-economic vulnerability in the analysis of the relationship between climate change vulnerability and violent conflict.

In Sub-Saharan Africa, households and local communities socio-economic vulnerability interact with physical vulnerability, since the population with low socio-economic level frequently reside in degraded land that is susceptible to natural catastrophes such as flooding. The socio-economic level is probable to exact a substantial impact on the group's choice of using violence when faced with environmentally-induced adversities. Spirits of lack both in absolute and relative terms create frustration and aggression, which expedite enrolment for violence against other communities (Gurr 1993; Kahl 1998; Fjelde and Østby 2010). Also, populations with low socioeconomic status have lower opportunity costs for partaking in violence, since the revenue lost when fighting instead of regular economic activity is lower for the poorest (Collier et al. 2003). Essentially, socio-economic status also powerfully shapes the capacities of local communities to weather destructive environmental conditions because it restricts options open to communities when challenging the economic costs of climatic variances.

Literacy level, school enrolment, access to improved health care and improved drinking water sources are all indictors of socio-economic level. Literacy level and school enrolment are important indicators of education level in communities. Education is a good predictor of income and wealth level and by extension, poverty. Income and wealth status could determine the level of access to and control over resources, including lands and water. Poverty, therefore, constricts the series of alternatives open to groups when challenging hostile effects of climate anomalies, signifying that socio-economic vulnerability is vital for understanding the conflict potential of climate change. It has been shown that the economic vulnerability level of the low socio-economic level group is worsened in environmental hardships times. At times of environmental hazards that can result from climate change such as floods and drought, poor households are compelled to sell properties that safeguard their income at misery prices, lowering their economic levels (Sabates-Wheeler et al. 2008).

Regarding climate–conflict linkage, unequal socioeconomic levels between and among farmers and herders can lead to unequal access to and control over property at the local level which might reinforce feelings of marginalisation and deprivation in the face of environmental hardships, thus growing the possibility of violent mobilisation by farmers and herders (Fjelde and Østby 2010). Since climate change limits available resources to farming and herding groups, population pressure can also contribute to the possibility of violent mobilisation in the face of climate anomalies. Growing population in the face of limited resources means that there are limited resources which are contested for between and among farming and herding interest and since there is inequality in economic levels, only the highest bidders have access to scarce resources. This situation leaves many poor groups frustrated and feelings of marginalisation which can sway them into violent mobilisations to secure access to resources. In this paper, we test the relationship between household/community vulnerability, climate change vulnerability and farmer–herder conflict vulnerability.

Methodology

The data for the study were collected from the Nigeria Watch database (2018), which records conflict events in the country plus the number of violent deaths occurring from these events, National Bureau of Statistics Annual Abstract of Statistics (2017), Federal Ministry of Agriculture and Rural Development Collaborative Survey on National Agriculture Sample Survey (NASS) reports (2012). The data generated were normalised by converting them to natural logarithms before analysing them in stages. This was done to combine the variables denominated in different units. Also, the variables were weighted using Principal Component Analysis (PCA) in line with an earlier work by Madu (2016). The research employed Climate Security Vulnerability Model (CSVM) version 3.0, developed by Busby et al. (2013) for the Climate Change and African Political Stability (CCAPS). The model is used to produce maps with an explicit security focus that emphasise situations where large numbers of people could be at risk of death from exposure to climate-related hazards. The CSVM was very useful in this work because apart from climate change, there are other intervening variables for the incessant farmers–herders clashes in Nigeria. As has been earlier stated, climate change alone seldom results in conflict until combined with other variables. The CCAPS vulnerability model identified four main sources, or "baskets," of vulnerability*:* (1) climate-related hazard exposure, (2) population density, (3) household and community resilience, and (4) governance and political violence. The variables and indicators used are presented in

Table 1 Variables and indicators used for the study

Variables	Indicators
Climate-related hazard exposure	Rainfall variability
	Annual temperature range
	Incidence of droughts
	Incidence of desertification
	Water scarcity
Population pressure	Population density
	Household size
	Dependency ratio
Farmer–herder conflicts exposure	Herdsmen–farmers conflict fatality
	Herdsmen–farmers conflict occurrence
Household and community resilience	Adult literacy rate
	Primary school enrolment
	Percentage of population with access to improved drinking water sources
	Percentage of population with health facility access

Table 1. Since we are not concerned with political stability in this study, the three baskets that relate more to the association between climate change and farmer–herder conflict are used: climate-related hazard exposure, population pressure and household and community resilience (Table 1).

The variables within a given basket of vulnerability were summed and mapped using GIS to create a basket map for climate-related hazard exposure, population pressure, farmers-herdsmen violence and household and community resilience. The data were re-normalized on a scale from 0 to 1 using min–max normalisation as shown in Eq. 1 (Busby et al. 2013; Federal Ministry for Economic Cooperation and Development 2014).

$$X_{i,\,0\text{ to }1} = (X_1 - X_{Min})/(X_{Max} - X_{Min}) \qquad (1)$$

where X_i represents the individual data point to be transformed, X_{Min} the lowest value for that indicator, X_{Max} the highest value for that indicator, and $X_{i,0\text{ to}1}$ the new value you wish to calculate, i.e. the normalised data point within the range of 0 to 1. A score approaching zero represents high vulnerability, while a score approaching one represents low vulnerability. The reason is that a low score means that the area has minimal resilience and thus represents a high level of volatility and risk. On the other hand, a high score implies more resilience and therefore represent lower levels of risk and volatility (Busby et al. 2013; OCHA 2016).

Moran's Index enables the analysis of the spatial pattern of climate change vulnerability and farmer–herder conflict vulnerability. Moran statistic is useful for detecting spatial autocorrelation in area data (Getis 2007), and it is given as:

$$I = \frac{\mathrm{n}\sum_{\mathrm{i}}^{\mathrm{n}}\sum_{\mathrm{j}}^{\mathrm{n}} w_{ij(x_i-\bar{x})(x_j-\bar{x})}}{\left(\sum_i^n\sum_j^n w_{ij}\right)\sum_i^m (x_i-\bar{x})^2}$$

where n is the numbers of observation, x is the variable of interest, $\bar{x}$ is the mean of the variable of interest x_j is the value of that variable at a neighbouring location. w_{ij} is the measure of the spatial proximity between sates i and j. w_{ij} is defined as the binary connectivity requiring states to share a common boundary of nonzero length termed as rook's case contiguity. $w_{ij} = 1$ if states i and j are contiguous and $w_{ij} = 0$ if otherwise (Nwankwo 2019b: 149).

A statistically significant positive Moran's value indicates spatial dependence, and a significant negative value shows a pattern of variation. The statistics test the hypothesis of random distribution of values of x (Shin and Agnew 2007). Moran's *I* values closer to -1 shows negative spatial autocorrelation (except for small n), while values closer to 1 indicate a positive spatial autocorrelation (Nwankwo 2019b: 149–150). A Moran's I of zero suggests the absence of spatial autocorrelation; however, the value for no spatial autocorrelation is not zero but is instead given by the expected value E[I] of Moran's I, which is contingent upon n observations (Kinsella et al. 2015):

$$E[I] = \frac{-1}{\mathrm{n}-1}$$

If the value is close to zero or instances where the value approximates its expected value, then it shows the lack of a spatial pattern, i.e. a random pattern. Values greater than the expected value shows a clustered pattern which implies that neighbouring states have similar climate change vulnerability or farmer–herder conflict vulnerability levels. However, values less than the expected value signify a dispersed pattern that is, neighbouring states have different levels of climate change vulnerability or farmer–herder conflict vulnerability.

Geographically weighted regression (GWR) enables the analysis of the relationship between farmer–herder conflict vulnerability (dependent variable) and climate change vulnerability, population pressure basket vulnerability and household/community resilience (covariates). The primary principle of GWR is that parameters may be predictable anywhere in the study area given a dependent variable and a set of covariates with a known location (Fotheringham et al. 2003). In each of the observations in the dataset, a measurement of its position is developed in a suitable coordinate system (Fotheringham et al. 2003). Since the data has autocorrelation, a spatial lag model was used for the GWR which includes a spatial lag variable in the model to sieve out the possibly puzzling influence of spatial autocorrelation in the variables to get the appropriate inference on the coefficients of the other covariates in the model. The Geoda program was used for GWR analysis.

Results

Spatial patterns of the baskets

The baskets vulnerabilities are shown in Table 2. The results of climate change exposure show a significantly clustered pattern (Table 3). Generally, the northern states are more vulnerable than the southern states. However, the most vulnerable parts of the country are the North East and North West (Fig. 1). The 13 most vulnerable states are all located in the north. They include; Sokoto, Kano, Yobe, Zamfara, Jigawa, Kebbi and Borno with vulnerability indices of 0.00, 0.03, 0.04, 0.04, 0.06, 0.14 and 0.18 respectively. Others are Gombe (0.39), Bauchi (0.31) and Katsina (0.39). The least vulnerable states are mostly located in the south-west and south-east although there are low vulnerable states in the north-central and south-south geopolitical zones of the country. The low vulnerability areas in terms of climate change exposure are Anambra (1.00), Kogi (0.90), FCT (0.90), Taraba (0.89), Ogun (0.85), and Nassarawa (0.85). It is interesting to note that the states that are mostly affected by farmers–herder's clashes experience low vulnerability to climate change exposure. The implication is that herders rather than adapt to the changing climate move downward from the north that experiences a severe threat to climate change to the south particularly to the middle belt.

In terms of population pressure, the southern states are generally more vulnerable because of the high concentration of people and socioeconomic activities in relatively smaller land areas. The twelve most vulnerable states in this regard are all located in the southern part of the country. They include Lagos (0.00), Anambra (0.26), Imo (0.29), Oyo (0.33) and Akwa Ibom (0.39). The low vulnerability states in this basket include Taraba (1.00), Yobe (0.95). Borno (0.92), Niger (0.92) Kwara (0.88), Adamawa (0.83), Kebbi (0.82), Zamfara (0.82) and Bauchi (0.79) and all located in the north where there are large landmasses with relatively low population concentration (Fig. 2).

The basket on farmers–herders conflict show a significantly clustered pattern (Table 3) with Benue (0.00), Plateau (0.26), Taraba (0.26) Adamawa (0.33), Nasarawa (0.30), Kaduna (0.35), Kogi (0.42) and Zamfara (0.53) and Niger (0.55) being the most vulnerable states. Five of these high vulnerability states namely; Benue, Plateau, Nassarawa, Kogi and Niger are in the North Central geopolitical zone while Taraba and Adamawa are in the North Eastern Zone and Kaduna and Zamfara are in the North West. These are the hot spot states in terms of farmers–herders conflict. The southern states generally have low to very low vulnerability. They include Enugu (0.68) Imo (0.73), Delta (0.81) Anambra (0.85) and Ogun (0.85) (Fig. 3). The pattern shows that the hotspots are

Table 2 Vulnerability baskets

S/N	States and the Federal Capital Territory (FCT)	Climate-related hazard exposure vulnerability	Population pressure basket vulnerability	Farmer–herder conflict vulnerability	Household and community resilience
1	Abia	0.74	0.36	1.00	0.22
2	Adamawa	0.46	0.83	0.33	0.15
3	Akwa-Ibom	0.70	0.36	1.00	0.23
4	Anambra	1.00	0.26	0.85	0.21
5	Bauchi	0.31	0.79	1.00	0.15
6	Bayelsa	0.83	0. 48	1.00	0.24
7	Benue	0.83	0.71	0.00	0.15
8	Borno	0.18	0.92	1.00	0.11
9	Cross River	0.64	0.71	1.00	0.22
10	Delta	0.76	0.57	0.81	0.21
11	Ebonyi	0.79	0.48	1.00	0.18
12	Edo	0.75	0.58	1.00	0.23
13	Ekiti	0.69	0.42	1.00	0.20
14	Enugu	0.75	0.42	0.68	0.20
15	Gombe	0.39	0.71	1.00	0.15
16	Imo	0.68	0.29	0.73	0.19
17	Jigawa	0.06	0.63	1.00	0.14
18	Kaduna	0.84	0.49	0.35	0.19
19	Kano	0.03	0.41	1.00	0.19
20	Katsina	0.39	0.56	0.72	0.11
21	Kebbi	0.14	0.82	0.59	0.14
22	Kogi	0.90	0.74	0.42	0.14
23	Kwara	0.76	0.88	0.78	0.16
24	Lagos	0.80	0.00	1.00	0.38
25	Nassarawa	0.85	0.89	0.34	0.15
26	Niger	0.58	0.92	0.55	0.15
27	Ogun	0.85	0.58	0.85	0.24
28	Ondo	0.78	0.59	1.00	0.22
29	Osun	0.80	0.46	1.00	0.22
30	Oyo	0.81	0.33	1.00	0.26
31	Plateau	0.77	0.74	0.26	0.17
32	Rivers	0.69	0.39	1.00	0.25
33	Sokoto	0.00	0.71	1.00	0.13
34	Taraba	0.89	1.00	0.33	0.12
35	Yobe	0.04	0.95	1.00	0.13
36	Zamfara	0.04	0.82	0.53	0.16
37	FCT	0.87	0.45	1.00	0.18

in the Middle Belt. It also shows that the conflicts are extending southward, and that explains why vulnerability is high in the two southeastern states of Enugu and Imo.

Table 3 Moran's *I* estimates of climate change and farmer–herder conflict baskets

Item	I	E[I]	*p* value	Mean	SD	z-value	Pattern
Climate related hazard exposure vulnerability	0.679	− 0.028	0.001	− 0.028	0.106	6.691	Clustered
Farmer–herder conflict vulnerability	0.294	− 0.028	0.005	− 0.035	0.103	3.177	Clustered

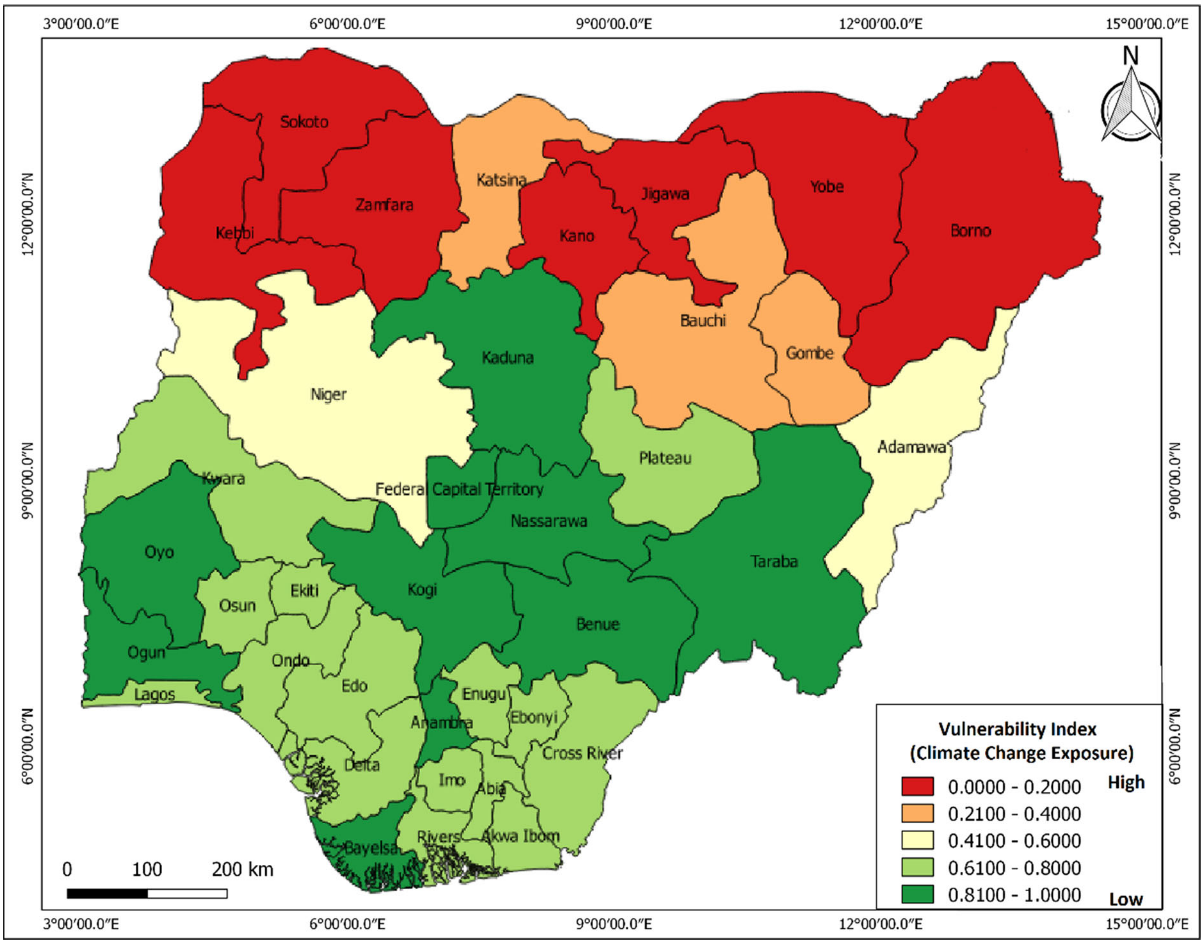

Fig. 1 Climate-related hazard exposure vulnerability

The fourth basket is on the household and community resilience. Again, there is a general increase of vulnerability towards the northern part of the country from the south. Table one shows that the first 19 states among the most vulnerable states are located in the north with Borno, Katsina, Taraba, Sokoto, Yobe and Jigawa leading. Lagos, on the other hand, is the least vulnerable, followed by Oyo, Rivers and Ogun (Fig. 4). This can be explained by the higher level of socio-economic development in the south (Fig. 4).

Correlates of the farmer–herder conflict

To specify the appropriate model for the relationship between farmer–herder conflict and climate change, we explored the ordinary least square (OLS) regression diagnostics. The Jarque–Bera test (3.6506) is not significant at 95% level of confidence. Thus, there are non-normal errors. In other words, there is heteroskedasticity—the random regression errors does not have constant variance in overall observations. In

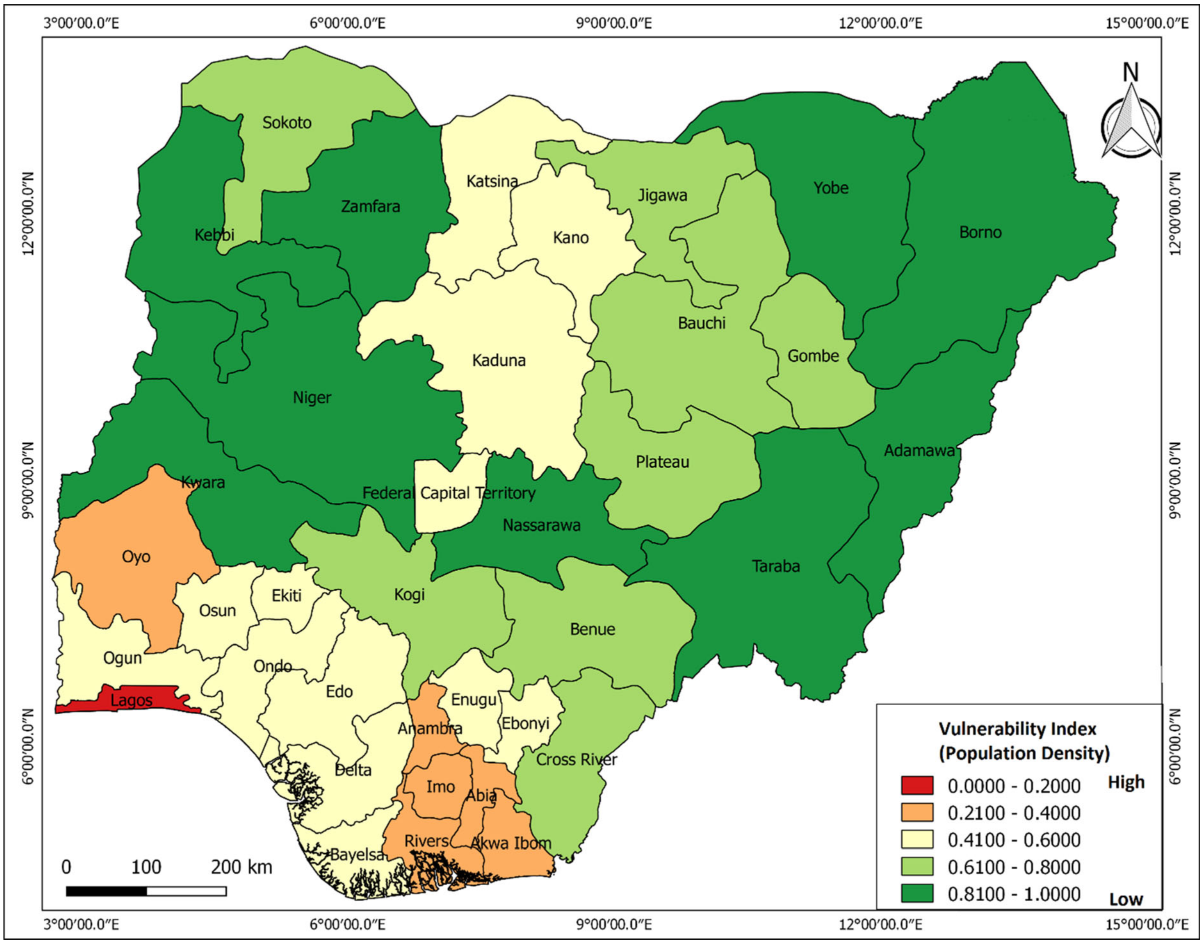

Fig. 2 Population pressure basket vulnerability

this case, it is expected that the model is unbiased and predicted the pattern of farmer–herder conflict appropriately. Even though the Jarque–Bera statistic is not significant ($p > 0.05$), indicating that the model predictions are unbiased, the OLS estimates are still not the most efficient because the results of the Breusch–Pagan test (0.874) and Koenker–Bassett (1.0755) test are not significant ($p > 0.05$). This is an indication of systematic regional differences in the relationship between farmer–herder conflict and climate change, (see the regional clustering of farmers–herder conflict in Fig. 3), and because of this spatial effect, the OLS model misspecified. Hence, we rely on the Lagrange Multipliers to specify an alternative model to the OLS. The simple rule is that if none of the Lagrange Multiplier (lag) and Lagrange Multiplier (error) reject the null hypothesis, i.e., if the p values of both are not higher than 0.05, we stick with the OLS.

Since the Lagrange Multiplier (lag) [2.2587] and Lagrange Multiplier (error) [0.6813] have p values higher than 0.05, we cannot use the OLS. We then focused on the robust forms of the test statistics. The more significant statistic is selected in this case. Here, the robust Lagrange Multiplier (lag) is more significant (p = 0.09894) that the robust Lagrange Multiplier (error) (p = 0.28456). Thus, the most appropriate model is the spatial lag model. We confirm this by looking at the test value of the Lagrange Multiplier (SARMA) (3.4039) which is insignificant ($p > 0.05$). If the Lagrange Multiplier (SARMA) is significant, it implies that either Lagrange Multiplier (lag) or Lagrange Multiplier (error) is appropriate. The spatial lag model estimates are presented in Table 4.

From Table 4, the best predictor of farmer–herder conflict is climate change. Climate change has a negative effect on farmer–herder conflict. A unit

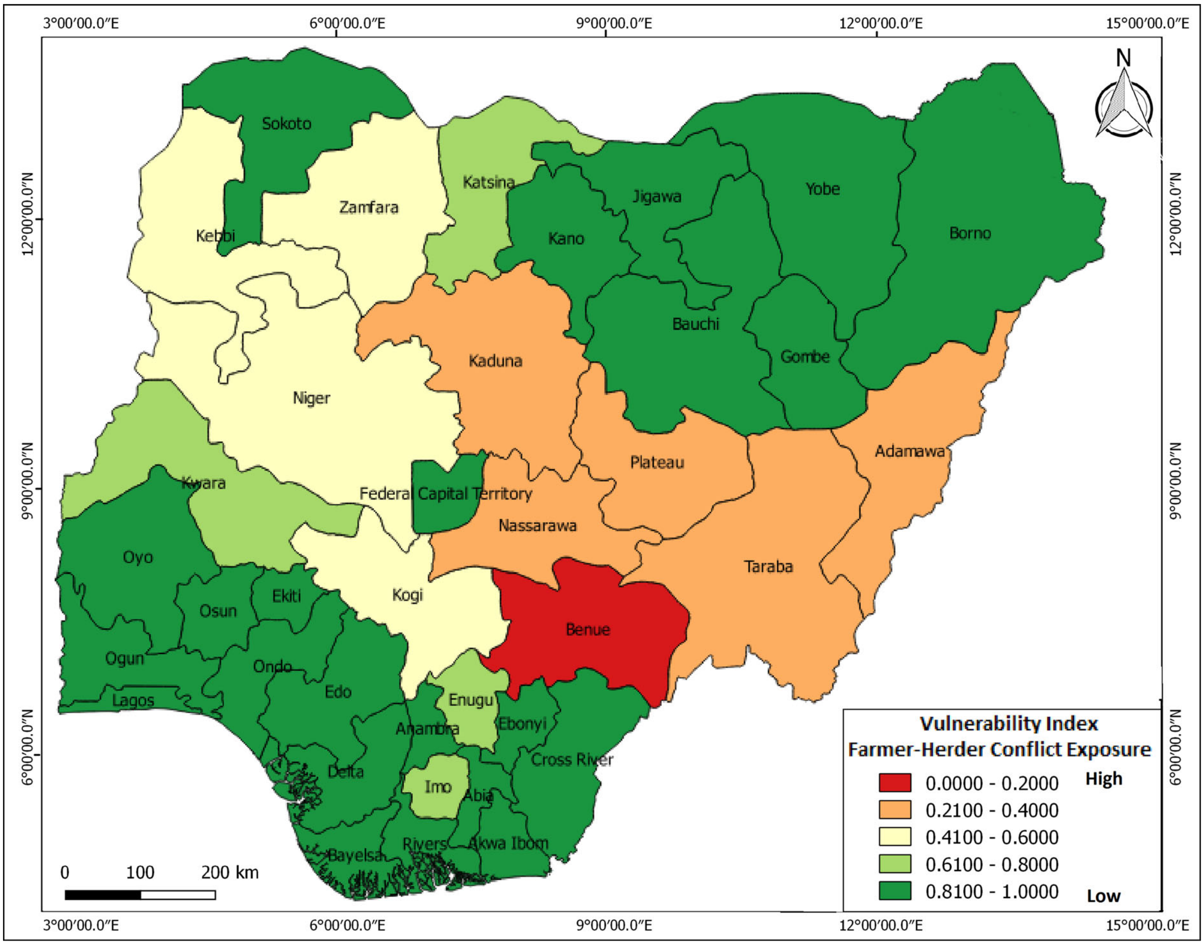

Fig. 3 Farmer–herder conflicts vulnerability in Nigeria

increase in climate change is associated with 0.415 decreases in farmer–herder conflict. This effect is significant at a 99% confidence level. Population pressure has a similar effect on farmer–herder conflict as a unit increase leads to 0.365 decreases in farmer–herder conflict. However, the effect of population pressure is not significant. Household and community resilience has a positive effect on the farmer–herder conflict as unit increase leads to 1.542 increase in the farmer–herder conflict, although this effect is not significant.

Discussion

The result of the regression model has shown that climate change vulnerability is the best predictor of the farmer–herder conflict in Nigeria but the effect is the opposite of what most studies championing the environmental security thesis found. The effect of climate change is negative implying that vulnerability to climate change does not automatically lead to conflict between herders and farmers. Instead, vulnerability to climate change decreases the conflict. This result confirms the previous argument that the effect on climate change on conflict is indirect (Raleigh and Urdal 2007; Buhaug 2010; Schilling et al. 2012). The finding does not support the studies that argue that conflict change causes farmer–herder conflict (Herrero 2006; Obioha 2008; Folami and Folami 2013; Cabot 2017) and that those that specifically argue that climate change-induced herders' migration which engenders conflict as herders come in contact with farmer (e.g., Ajaero et al. 2015; Onuoha and Ezirim 2010; Odo and Chilaka 2012; Abugu and Onuba 2015). Southward migration of herders does not

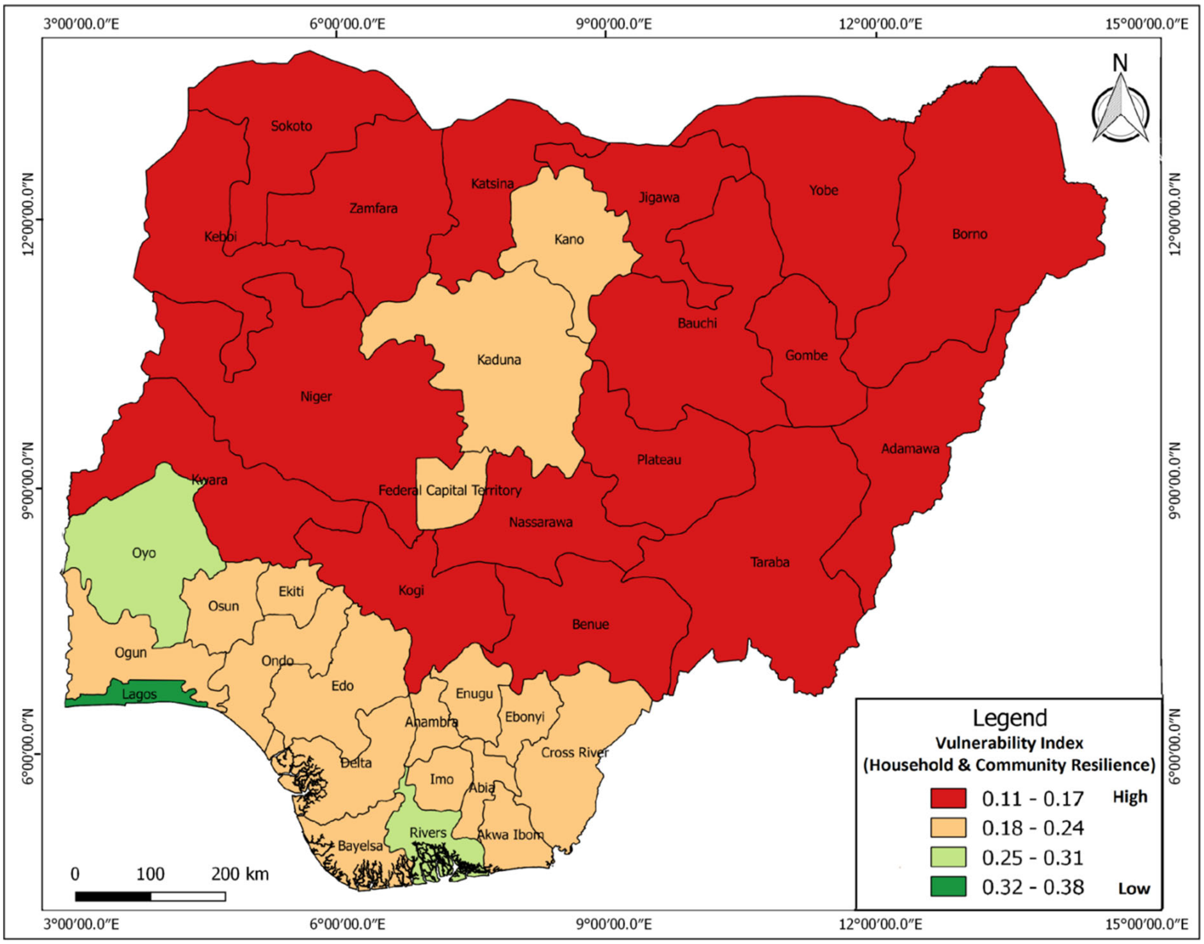

Fig. 4 Household and community resilience

Table 4 GWR estimates of the relationship between farmer–herder conflict and climate change

Variable	Coefficient	SE	z value	Probability
W_farmer–herder conflict	0.327991	0.184353	1.77915	0.07522
Constant	0.722718	0.371612	1.94482	0.05180
Climate change	− 0.414532	0.137207	− 3.02121	0.00252*
Population pressure	− 0.365015	0.248054	− 1.47152	0.14115
Household and community	1.54172	1.12561	1.36968	0.17079

*Significant at 0.05

properly explain while conflict develops when the herders come in contact with farming groups.

Although historically herders in Nigeria moved southward and back in search of grasses and water for their cattle depending on the season. This method is no longer sustainable given increasing population density, large-scale urbanisation, expansion of public infrastructure and acquisition of land by large-scale farmers and other private commercial interests. Therefore, the regression coefficient for climate change will be negative because the conflict now occurs in regions (Central and Southern Nigeria), where climate change-related disasters, e.g., desertification, drought, are not intense. While we could argue that climate change has influenced the change in the pattern of herders' migration pushing them to dwell in Southern Nigeria more leading to competitive struggles for resources, the effect of population pressure on the conflict says the contrary. The influence of population pressure is negative and also insignificant. Thus, while herders' migration pattern may have been impacted by climate change, it might not necessarily lead to conflict in their host communities in Central and Southern Nigeria because migration alone cannot explain the mechanism that produces the conflict. Thus, the notion that herdsmen migration towards southern regions of Nigeria because of changing climate and the resultant loss of grazing lands and scarcity of water leads to clashes with the host crop farming communities needs scrutiny.

The issues of identity and belonging can be vital to understanding how the migration of herders engenders conflict with their host communities in Central and Southern Nigeria. Some studies have pointed out that because herders are most times of different ethnicity and perhaps religion, the idea of autochthonous and allochthonous communities becomes heightened when herder comes in contact with communities of different ethnicity and religion to theirs (Nwankwo 2019a; Nwankwo et al. 2020). Nwankwo (2018a) argues that the constitution of herders' identity as "aliens" and not belonging in central and southern parts of Nigeria produces a binary of "self" and "other" between indigenous landowners and alien herders. The construction of a self and other identity encourages practices of segregation between herders and farmers not only in Nigeria but also in many parts of West Africa such as in Ghana (Bukari and Schareika 2015). Thus, the conflict can become inter-ethnic groups' hostilities in which an ethnic group would highlight its own identity but victimise others (Akov 2017). However, there are indications that the discrimination of herders is partly influenced by herders' destructive behaviours such as taking herds to feed on crops and trampling on farmlands and pollution of community water sources, raping of women (Kuusaana and Bukari 2015; Maiangwa 2017).

Conclusions

The purpose of this paper was to examine the spatial pattern and relationship between climate change vulnerability and farmer–herder conflict vulnerability in Nigeria. The study has shown that the farmer–herder conflict is widespread across Nigeria but with significant spatial autocorrelation and the hotspots is in the Middle Belt, especially in Benue State. The hotspots states are the major food-producing areas of the country. The clashes, therefore, portend serious danger to food production in Nigeria. The study shows that the relationship between climate change vulnerability and the farmer–herder conflict is negative implying that climate change does not directly cause the conflict. The paper demonstrates that climate change could influence herder's migration pattern but not necessarily the cause of the conflict. Also, the change in the pattern of herder's migration does not automatically translate to lead to conflict. Migration is important but the mechanism establishing the migration–conflict nexus has to be explained by taking cognisance of identity differentials between herding groups and local communities. The paper also shows that while the increase in the population of the country may have put pressure on land and water resources in many parts of the country, it does not automatically lead to conflict between herders and farmers.

The paper argues that climate change may matter to the farmer–herder conflict but in indirect ways. It could influence changes in herders' migration pattern but not necessarily causing them or farmers to take up arms. Issues of identity and belonging can be salient in bringing farmers and herders into conflicting positions. Nevertheless, the current practice of herders moving cattle in search of pastures perhaps in an attempt to evade drought and desertification in Nigeria is evidence of non-adaptation to climate change. This is unsustainable and requires a sound policy towards sustainable adaptation strategies. Adequate policing of the rural communities, the establishment of grazing reserves, ranches, provision of basic education and combating desertification are essential to tackling the conflict**.** Combating desertification may require the implementation of programs under the Great Green Wall Initiative for the Sahara and the Sahel, a trans-African project designed to restore drought-and-desert degraded environments and livelihoods in the Sahara and the Sahel including Nigeria's far northern belt.

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Compliance with ethical standards

Conflict of interest The author(s) declare no conflict of interest.

Code availability No codes were used for the analysis.

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