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CLIMATE CHANGE VULNERABILITY IN GHANA: A SPATIAL DISAGGREGATION ANALYSIS OF HOUSEHOLD SENSITIVITY

Robert Darko Osei, Nkechi S. Owoo,

Monica P. Lambon-Quayefio, Abena D. Oduro

TSITICA Transforming Social Inequalities Through Inclusive Climate Action
ARUA-CD Centre of Excellence Climate and Development
UK Research and Innovation
ACDI African Climate & Development Initiative
University of East Anglia
ACEIR African Centre of Excellence for Inequality Research

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DISCLAIMER

All opinions, interpretations and conclusions expressed in this Transforming Social Inequalities through Inclusive Climate Action (TSITICA) Working Paper are entirely those of the authors and do not reflect the views of the research funder UK Research and Innovation (UKRI).

ACKNOWLEDGEMENTS

The Transforming Social Inequalities Through Inclusive Climate Action (TSITICA) project investigates how climate change action can be socially transformative in three contrasting African countries: Ghana, Kenya and South Africa. The research agenda addresses the nexus between climate change, sustainable livelihoods and multidimensional poverty and inequality to tackle the overall question: how can climate actions be deliberately targeted to improve livelihoods and lead to equitable benefits for the most vulnerable and poor – especially for women and youth? With the goal of inspiring climate actions that also reduce poverty and inequality, based on evidence and insights from the research, TSITICA aims to contribute the Agenda 2030 ambition of leaving no one behind.

The full project team comprises researchers from two African Research Universities Alliance (ARUA) Centres of Excellence hosted by the University of Cape Town (UCT); researchers from the centres' regional nodes at universities in Ghana and Kenya; and collaborators from four universities in the United Kingdom:

• African Centre of Excellence for Inequality Research, hosted by UCT's Southern Africa Labour and Development Research Unit, School of Economics

• ARUA Centre of Excellence in Climate and Development, hosted by UCT's African Climate and Development Institute

• ARUA-CD and ACEIR nodes convened respectively by the Institute for Environment and Sanitation Studies and the Institute of Statistical, Social and Economic Research, University of Ghana

• ARUA-CD and ACEIR nodes convened respectively by the Institute for Climate Change and Adaptation and the School of Economics, University of Nairobi

• Grantham Research Institute on the Environment and Climate Change, London School of Economics and Political Science

• Townsend Centre for International Poverty Research, University of Bristol

• International Inequalities Institute, London School of Economics and Political Science

• Tyndall Centre for Climate Change Research, University of East Anglia

• Tyndall Manchester, University of Manchester

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Abstract

Climate change adaptation strategies are becoming an important priority in many developing countries, and it is important to assess the degree to which individuals within a country are susceptible to the effects of climate change. Using the three waves of the Ghana Socioeconomic Panel Survey (GSEPS) (i.e., 2009, 2014 and 2019) and two (2) sets of climate change vulnerability indices, patterns of climate change sensitivity across various population groups are presented. Results of the analyses show that climate change vulnerabilities have been declining in Ghana over time. Economic factors and poor living conditions are stronger contributors to households' climate change sensitivities, while nutrition and demographic characteristics are less prominent factors. Using the 2019 wave of the GSEPS data, it is observed that vulnerabilities remain higher in rural, compared to urban areas; in male-headed, compared to female-headed households; and are more prominent in poorer, compared to richer households. Regional analyses also show that compared to regions in southern Ghana, the three northern regions are particularly vulnerable to climate change, although within-region nuances are noted. Spatial analyses of climate change vulnerability indicate that the intensity of climate change vulnerabilities is lowest in the regional capitals in the country, including those in northern Ghana. This suggests some inequality in the distribution of social amenities such as water and sanitation, among others, between northern and southern Ghana, rural and urban Ghana, and between major regional cities and other communities. Development programmes can play a critical role in reducing the sensitivity to climate change by programmes specific interventions.

Keywords: climate change, vulnerability index, subgroup decomposition, spatial analyses, Ghana

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Introduction and Background

Climate change adaptation strategies are becoming an important priority in many developing countries, largely due to the acknowledged adverse effects of climate change on lives and livelihoods (Asante and Amuakwa-Mensah, 2015). According to WHO (2021), between 2030 and 2050, climate change is expected to cause approximately 250,000 additional deaths per year from malnutrition, malaria, diarrhoea, and heat stress; the climate crisis threatens to undo the last fifty years of progress in development, global health, and poverty reduction. In Ghana, the situation is no less dire. Desertification is on the increase (EPA, 2008); rainfall patterns have become highly variable, with implications for agricultural productivity; and temperatures in the country are expected to rise by 2050, particularly in the northern regions of Ghana (World Bank, 2010). These environmental effects have been found to have negative implications for households' poverty status, as poor households who depend directly on their immediate environment for livelihood are likely to be greatly affected (Nelson and Agbey, 2005; Arndt et al., 2014). Women, given their disproportionate engagement in domestic work such as firewood and water collection, are expected to experience the worst impacts through the distances travelled to fetch these resources. Additionally, the use of firewood for cooking also has noted negative health implications as the exposure to wood smoke may lead to acute respiratory infections, lung problems, cataract, cardiovascular diseases, and bronchitis (Piabuo and Puatwoe, 2019).

Climate vulnerability indices are useful for ascertaining the degree to which individuals and households are likely to suffer from climate change. It also provides some direction on effective means of addressing detrimental effects of climate change on the affected people. The Intergovernmental Panel on Climate Change (IPCC, 2007) defines vulnerability to climate change as "the degree to which a system is susceptible to, and unable to cope with, adverse effects of climate change, including climate variability and extremes". Although climate vulnerabilities are not directly observable, a set or composite of proxy indicators are often used by researchers to quantify them.

Climate Vulnerability Indices (CVI) have been developed for specific climatic disasters such as droughts or floods and for specific communities (e.g., Sathyan et al., 2018); other general climate vulnerability indices have been developed at the national level. Country-level indicators such as temperature rise, heavy rains, drought, land use, industrial structure, institutional capacity, among others have typically been used to construct representations of a country's vulnerability to climate change (e.g., Closset et al., 2018). These national-scale indices have, however, been criticised as being inadequate as climate change vulnerabilities are more often experienced at a more localized level (Fussel, 2010; Ludena and Yoon, 2015). National-level indicators also typically suffer from aggregation problems, challenges with data quality, adequacy of indicators used, and unrealistic assumptions for aggregating variables (Eakin and Luers, 2006).

The use of more disaggregated vulnerability assessments is useful given that most adaptive responses to climate change are made at the local level by resource managers, municipal planners, and individuals (Ludena et al., 2015). Additionally, socio-economic contextual differences, which likely contribute to coping and adaptive responses, may exist and be easier to capture at the local level. For this reason, country-level indicators such as rainfall, temperature, among others, are not employed in this study; rather, vulnerability assessments are conducted at the household level using household-level indicators.

In the 2007 IPCC report, important elements of a country's vulnerability typically related to exposure, sensitivity, and adaptive capacity. More recently, in the IPCC 2014 report, exposure is no longer a driver of climate change vulnerability, but characterized separated from vulnerability as more of a spatial attribute- it is defined as the presence of people, livelihoods, species or ecosystems, environmental functions, services, and resources, infrastructure, or economic, social, or cultural assets in places and settings that could be adversely affected.

Vulnerability is therefore determined by a system's sensitivity and adaptive capacity. *Sensitivity* can encompass geographical conditions, land use, demographic characteristics, and industrial structure such as dependency on agriculture and extent of industrial diversification. *Adaptive capacity* describes the ability of systems, institutions, humans, and other organisms to adjust to potential damage by taking advantage of opportunities. This depends on physical resources, access to technology and information, varieties of infrastructure, institutional capability, and the distribution of resources (Yohe and Tol, 2002). Functionally, vulnerability is related directly with sensitivity and inversely with adaptive capacity (Sharma & Ravindranath, 2019). The characteristics that make a system weak are recognized as sensitivity indicators, for instance, the marginalization of households within a community. Therefore, while innate strengths enhance the adaptive capacity of a system, inherent disadvantages increase its sensitivity.

In this paper, focus is on households' sensitivities to climate vulnerability using a series of demographic, economic, housing and nutrition indicators. Quantification and profiling of climate change vulnerability is vital to aiding vulnerable households in the prioritisation and planning of activities to tackle the impacts of climate change. Heterogenous effects associated with climate vulnerability are also examined by gender of the household head, rural/urban residence, household wealth status, and regional location. Available GIS information on households' longitudes and latitudes will also be used to provide a spatial mapping of climate sensitivity across the country.

The rest of the paper is organised as follows: Section II describes the data and the construction of the various household-level climate vulnerability indices; Section III presents results of the distribution of climate vulnerability by various sub-groups in the country (i.e., by gender of the household head, rural/urban residence, household wealth status, and regional location). It also includes a presentation of the spatial distribution of different forms of climate change vulnerability across households in Ghana. Section IV provides concluding remarks and policy applications of the results.

Data and Methods

a. Data

Data used for the analyses is from the three waves of the Ghana Socioeconomic Panel Survey (GSEPS) (2009, 2014, 2019), with a focus on the third and most recent wave. The first round of the GSEPS was collected in 2009/10 (Wave 1), consisting of a nationally representative sample of 5,010 households in 334 enumeration areas containing 18,889 household members. Follow-up rounds were conducted in 2013/14 (Wave 2), and 2018/19 (Wave 3). A two-stage stratified sample design was used for the survey and stratification was based on the then ten (10) regions of Ghana. The first stage involved selecting geographical precincts or clusters from an updated master sampling frame constructed from the 2000 Ghana Population and Housing Census. A total of 334 clusters (census enumeration areas) were randomly selected from the master sampling frame. The number of clusters in each administrative region was arrived at using Probability Proportional to Size (PPS), ensuring representativeness at the regional level. A complete household listing was conducted in 2009 in all the selected clusters to provide a sampling frame for the second stage selection of households. The second stage of selection involved a simple random sampling of 15 of the listed households from each selected cluster. The primary objective of the second stage of selection was to ensure adequate numbers of completed individual interviews to provide estimates for key indicators with acceptable precision at the regional level.

The dataset is ideal for the analyses as it has information on all the indicators that are critical to the derivation of household-level climate vulnerability indices. The GIS information also facilitates a spatial mapping of climate vulnerabilities across the country, exposing areas of high and low concentrations for ease of policy focus and targeted interventions.

b. Indicators of Climate Change Sensitivity at the Household Level

This section describes the demographic, economic, housing and nutrition indicators that are used to construct a household's climate change sensitivity status.

i. *Demographic Indicators*

These refer to the set of demographic factors that increase households' vulnerabilities to climate change. Four variables are used- Children under 10 years of age, presence of elderly members who are sixty years of age and above in the household, pregnant women, and household members with disabilities.

Children below ten (10) years of age are likely to increase a household's vulnerability. In situations of floods, for example, children are more vulnerable to harm as they are relatively short, light, and may not be strong enough swimmers to escape harm (Mort et al., 2016). Babies (under 12 months) are also at risk of heat stress as they have more limited temperature regulation, compared to older children and adults. Currently *pregnant women* also increase a households' vulnerability to climate change given the higher risk of spontaneous abortion, low birthweight, neonatal deaths, congenital anomalies, and maternal mortality due to flooding (Mallett and Etzel, 2017). *Elderly* household members who are sixty (60) years and above also increase a household's vulnerability as they are more sensitive to heatwaves. Approximately 80-90% of excess mortality from heat stress has been found to occur in this age group - particularly among those suffering from obesity, cardiovascular disease, respiratory disease, and diabetes (Kenny et al., 2010). Finally, *disabled* household members are also at a greater risk of harm during extreme climate events (Gutnik and Roth, 2018).

Dummy variables with values of 1 are constructed for households with at least one member who is elderly, a child, pregnant or disabled. Household are assigned values of 0 where none of these conditions are present.

ii. Economic Indicators

Certain *jobs/livelihoods* are vulnerable to climate change – particularly those require working outdoors. This is because individuals working in outdoor occupations may be exposed to increases in temperature, poor air quality, and extreme weather. Extreme heat may result in more cases of heat-related illnesses, like heat stroke, heat exhaustion, and fatigue (EPA, 2016). Dummy variables are constructed for households in which at least one household member works in the following occupations: Subsistence Farmers, Fishers, Hunters and Gatherers; Building and Related Trades Workers (excluding Electricians); Agricultural, Forestry and Fishery Labourers; and Street and Related Sales and Service Workers.

iii. Household Living Conditions

Households' housing conditions are assessed from floor, walls, and roof construction materials used for the home; adequacy of water supply and sanitation; in addition to access to information.

Natural materials such as mud/earth used to construct floors, walls and roofs are vulnerable to storms and indicate *poor housing conditions*. *Surface water* also increases households' vulnerability to both drought and floods. *Open defecation and unimproved sanitation* make households vulnerable to sewerage contamination during floods. With respect to *information*, a lack of access to a radio, TV, mobile or landline telephone or internet access reduces the likelihood of receiving disaster warnings and other relevant and potentially life-saving information.

Households are categorised as having poor housing if at least one of constructed walls, roof, or floors are constructed from mud/natural materials. Sanitation is inadequate if household uses pit latrine, KVIP, or pan/bucket. It is adequate if household uses any type of flush toilet (inside or outside the household). Water supply is inadequate if household uses open sources like borehole[1], unprotected wells, river/stream, rainwater/spring, or a dugout pond. Water is safe if household uses standpipe, water tanker[2], water vendor, sachet/bottled water. Information is inadequate if household possess neither a TV, a radio, nor internet access. Information is adequate if households possess at least one of these resources.

iv. Nutrition

This is measured by household food insecurity and anthropometric failure among children. Using data on per capita food expenditures and an adult equivalence scale and following Canagarajah and Thomas (2001) and Omonona and Adetokunbo (2007), this study uses the weighted two-thirds of the mean of per capita expenditure as a threshold so that a household is referred to as food insecure when the observed per capita food expenditure is or less than the threshold.

Anthropometric failure is measured by the presence of a stunted child below five (5) years of age in the households.

c. Construction of the Climate Vulnerability Indices

Climate change vulnerability indices are constructed from the eleven (11) indicators discussed above. Two different vulnerability indices are constructed- the first, a weighted sum of vulnerability scores for each household, with each indicator being equally weighed. The use of equal weights assigns identical importance to each indicator, in the absence of an empirical justification of why one indicator may be weighted higher than another. The constructed index takes a value between 0 and 1 with higher scores indicative of greater household sensitivity to climate change. Each household's vulnerability index is calculated as:

$$Average\ Vulnerability\ index_h = \frac{1}{n}\sum_{i=1}^{n} Indicator_i \qquad (1)$$

Where $Indicator_i$ refers to a dummy variable with a value of 1 for each indicator that household *h* is vulnerable in; it has a value of 0 for indicators that households are not vulnerable in. *n* refers to the total number of different indicators, i.e., 11. Average vulnerability scores are also constructed for each sub-set of the four (4) categories of

[1] Although boreholes are deep, narrow holes drilled into the ground from which water is drawn, poor seals around them can lead to contamination from nearby toilets, in addition to fertilizers from farms. Climate change worsens the problem when floods overwhelm vulnerable sanitation systems and contaminate the water supply- https://washmatters.wateraid.org/sites/g/files/jkxoof256/files/2022-03/Groundwater%20The%20world's%20neglected%20defence%20against%20climate%20change.pdf

[2] The assumption here is that water is sourced from public standpipes. 0.3% of households use this source.

indicators (i.e., demography, economic, housing and nutrition) to examine if households are more vulnerable in certain sub-categories, compared to others.

The second vulnerability indicator sums up the number of different vulnerability indicators for each household in an attempt to measure the intensity of households' vulnerability. The index takes a value from 0 (vulnerable in none of the indicators) to 11 (vulnerable in all of the indicators). Each household's intensity is calculated as:

$$Vulnerability\ Intensity_h = \sum_{i=1}^{n} Indicator_i \qquad (2)$$

Where variables are as defined above.

Results

In this section, statistics are presented on each of the 11 indicators for all three waves of data, in addition to the constructed climate vulnerability indices. This helps to show how sensitivities have evolved over time. Following this, other data description uses the most recent wave to show current sensitivity statuses in Ghanaian households. The presentation of all statistics is disaggregated by the gender of the household head, rural/urban residence, household wealth status and regional location. Household wealth is constructed using a series of household assets and a principal component analysis (PCA) technique[3]. Spatial mappings of the distribution of the climate change vulnerabilities in Ghana are also presented.

a. Summary Statistics

In Figure 1 below, statistics of each of the 11 indicators of climate sensitivity are shown for years 2009, 2014 and 2019.[4] Job vulnerability appears to be increasing over time, as well as elderly members within various households. There have been some improvements in access to amenities like sanitation and water between 2009 and 2019, and food insecurity, despite rising in 2014, has decreased within the period. The percentage of stunted children follows a similar pattern- peaking in 2014 and falling by 2019. Housing conditions have also improved over time- while 46% of households had poor housing, this percentage fell to 40% by 2019. Access to information has also increased slightly between the period. The number of pregnant women and young children in households has also fallen between 2009 and 2019. Disability however appears to be on a steady rise from 2009 to 2019.

[3] See Appendix 1 for list of variables

[4] Sample is balanced and includes the same 4,016 households from 2009 to 2019.

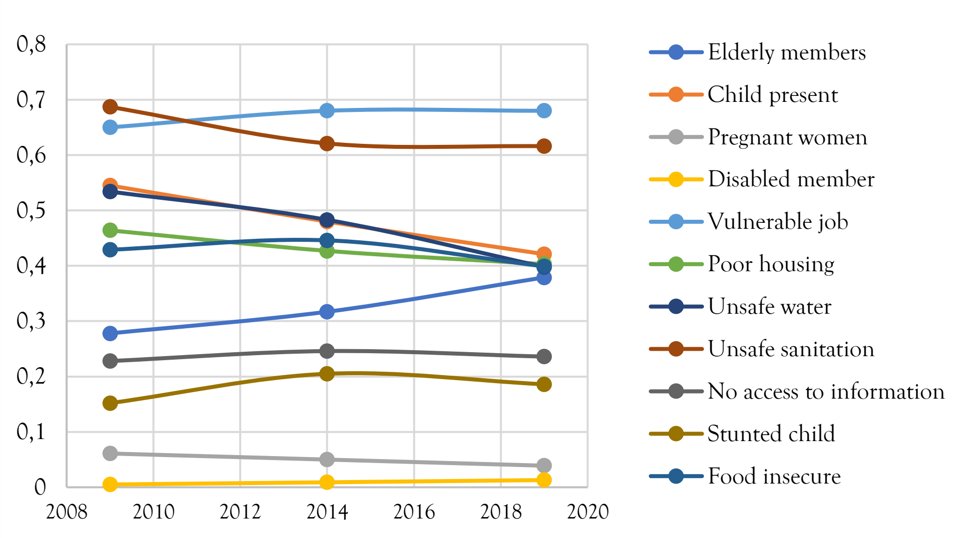


Figure 1: Annual Trends in Climate Vulnerability Indicators, 2009- 2019

Author Construction, GSEPS 2009- 2019

Figure 2 shows trends in climate vulnerability sub-categories from 2009 to 2019. With the exception of the Economic category, measured as job vulnerabilities, other vulnerabilities appear to be declining over time. The Economic sub-category has the greatest proportion of vulnerable households, compared to other vulnerability sub-categories. The least vulnerability is observed in the Demography sub-category; it is also the category that has shown the least variation over time between 2009 and 2019.

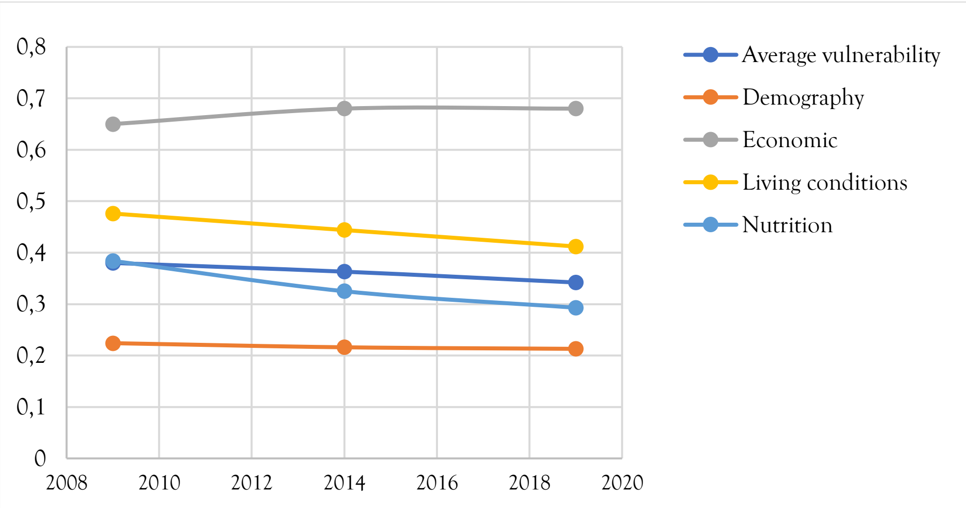


Figure 2: Annual Trends in Climate Vulnerability Sub-Groups, 2009- 2019

Author Construction, GSEPS 2009- 2019

The remaining description of the data will focus on the most recent wave of the Ghana Socioeconomic Panel Survey, collected in 2018/19. Table 1 below provides descriptive statistics of the eleven (11) indicators used in the construction of the household-level climate vulnerability indices.

About a third of all households in the sample have members who are at least 60 years of age, with a higher proportion observed in rural (39%), compared to urban (30%) areas. A higher proportion of elderly members are also present in female-headed (37%), compared to male-headed (29%) households. With respect to wealth, the presence of elderly members appears to decline with increasing wealth status of the household. Forty percent of the poorest households have elderly members, compared to only 20% of the richest ones.

About 40% of households in the sample report the presence of a child under the age of ten (10), with a disproportionate amount of such households found in rural areas (47%) compared to urban (34%) and among male-headed (43%), compared to female headed households (39%). The presence of children is highest in both the poorest and richest households in Ghana and appears to follow a U-shaped pattern with household wealth. Only about 4% of household reported the presence of a pregnant woman at the time of the survey, with higher proportions observed in rural (5%) and male-headed (4.9%) households, compared to urban (3.2%) and female-headed (3.1%) households. Only 1.2% of households have a disabled member. Disability appears to be higher in urban (1.4%), compared to rural (1.1%) areas, and in female-headed (1.8%), compared to male-headed (1.1%) households.

In the sample, 64% of households have members in vulnerable jobs that are performed outdoors and where members are exposed to the heat and other elements. This includes jobs in agriculture, forestry and fisheries (skilled and unskilled), building and related trades, street and related sales and service work. This percentage is higher in rural (84.5%) compared to urban areas (41.6%), and in male-headed (72.9%), compared to female-headed households (50.8%). The percentage of households with members engaged in vulnerable occupations decreases markedly with wealth status of the household, with the 85% of the poorest households having members involved in vulnerable occupations, compared to only 45% of the richest households.

Table 1: Summary Statistics of Climate Change Vulnerability Indicators, by Subgroups, 2019

	All	**Urban**	**Rural**	**Female head**	**Male head**	**Poorest**	**Poorer**	**Middle**	**Richer**	**Richest**
Demographic										
Elderly members	0.320	0.303	0.390	0.373	0.286	0.396	0.397	0.303	0.280	0.219
Child present	0.413	0.341	0.467	0.387	0.431	0.453	0.421	0.391	0.394	0.407

Pregnant women	0.042	0.032	0.051	0.031	0.049	0.044	0.049	0.036	0.044	0.040
Disabled member	0.012	0.014	0.011	0.018	0.008	0.010	0.017	0.013	0.011	0.009
Economic										
Vulnerable job	0.642	0.416	0.845	0.508	0.729	0.847	0.733	0.618	0.569	0.448
Living Conditions										
Poor housing	0.393	0.152	0.594	0.317	0.441	0.915	0.507	0.289	0.173	0.071
Unsafe water	0.376	0.100	0.609	0.281	0.437	0.878	0.467	0.253	0.193	0.085
Unsafe sanitation	0.614	0.375	0.804	0.552	0.655	0.890	0.713	0.600	0.545	0.323
Poor information	0.235	0.118	0.333	0.312	0.185	0.681	0.344	0.138	0.011	0.001
Nutrition										
Stunted child	0.170	0.147	0.205	0.140	0.189	0.227	0.181	0.167	0.159	0.114
Food insecure	0.385	0.289	0.486	0.330	0.421	0.668	0.454	0.359	0.282	0.166

Author Construction, GSEPS 2019

With respect to household living conditions, about 40% of the total sample have their floors, walls or roofs made from natural material that would be vulnerable to events like flooding. Thirty eight percent of households have unsafe water while 61% have unsafe sanitation. Only about a quarter of households have poor access to information. Generally, living conditions are worse in rural, compared to urban areas. Female-headed households appear to have better living conditions than male-headed households across almost all dimensions, with the exception of access to information, where male-headed household are more endowed. Living conditions show a noticeable downward trend with lower household wealth status.

Seventeen percent of households have at least one stunted child. This is more prevalent in rural (20.5%), compared to urban (14.7%) households, and also more prevalent in male-headed (18.9%), compared to female-headed (14%) households. The incidence of stunting decreases with increased wealth status of the household- 23% of the poorest households have stunted children, compared to only 11% of households in the richest household.

Approximately 39% of households in the sample are food insecure. Food insecurity is higher in rural (49%), compared to urban (29%) households; and higher in male-headed (42%), compared to female-headed (33%) households. About 67% of households in the lowest wealth quintile are food insecure, compared to only 16% of households in the highest wealth quintile, suggesting that food security is directly related with the wealth status of households.

Figure 3 below summarises climate change vulnerability indicators by each of the ten (10) administrative regions of Ghana. There is a noticeable north-south divide with respect to access to amenities. For example, a larger percentage of households in regions in northern Ghana (e.g., Northern Region, Upper East Region, and Upper West Region) have unsafe water, sanitation, poor housing conditions, and lower access to information, compared to regions in the south such as the Ashanti Region, Greater Accra Region, and Central Region.

Households in northern Ghana have a larger proportion of stunted children, compared to those in southern Ghana, with the exception of the Greater Accra region. Children in the Greater Accra region, however, have the 3rd highest stunting incidence in the country, after the Northern and Upper West Regions. Food insecurity is lowest in the Western region, and highest in the three northern regions.

Figure 3: Climate Change Vulnerability Indicators, by Administrative Region, 2019

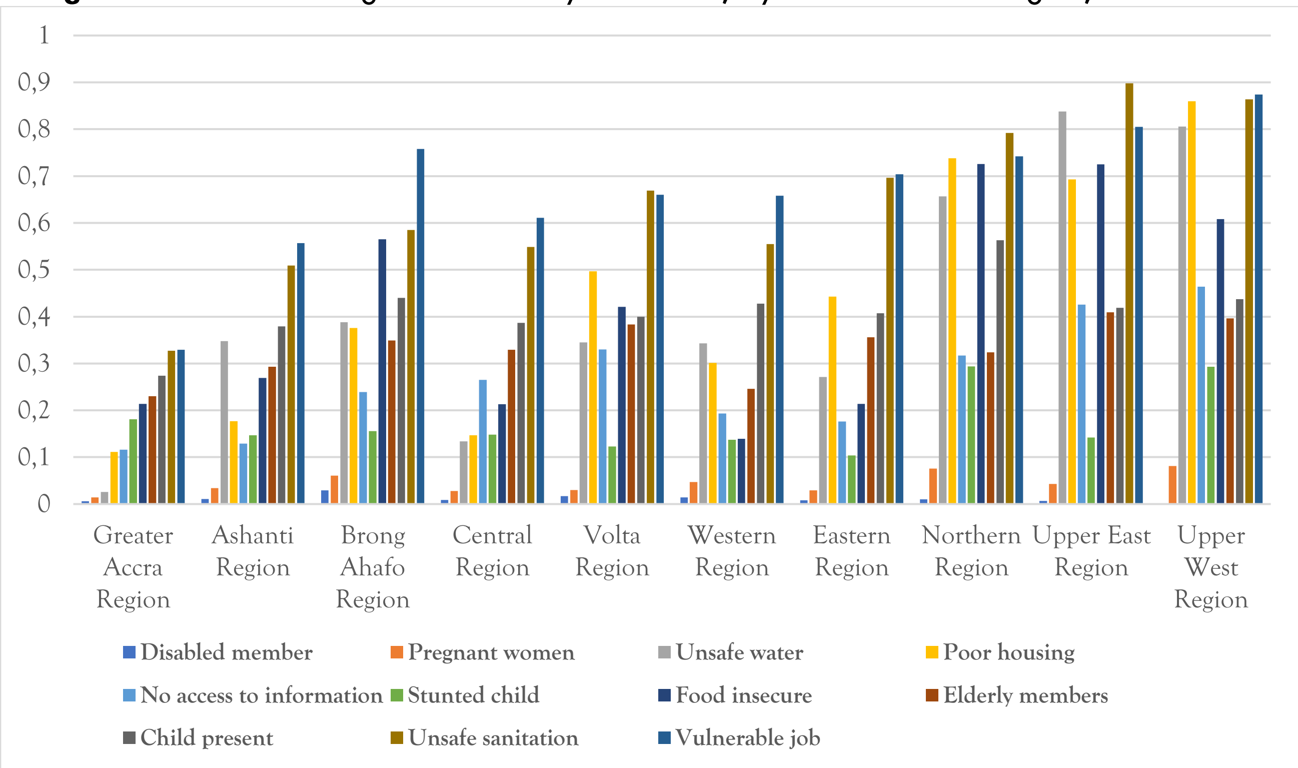


Figure 3: Climate Change Vulnerability Indicators, by Administrative Region, 2019
Source: Author Construction, GSEPS 2019

Some regional differences in demographic conditions are also observed- With the exception of the Greater Accra Region and Western Region, where about a quarter of households have elderly members, about a third of households in other regions have elderly members present. The Brong Ahafo Region stands out as having more disabled people, compared to other regions, although general cases of disability appear to be low in the sample. This could be as a result of underreporting. More pregnant women are observed in the Brong Ahafo Region, Northern Region, and Upper West Region. With the exception of the Greater Accra Region, all other regions have relatively high incidences of household members being involved in vulnerable occupations, with the highest proportion observed in the Upper West Region.

Despite the important regional differences in climate change sensitivity indicators shown in Figure 3 above, these statistics may mask important intra-regional variations among households. Figure 4 summarizes the indicators separately for rural and urban areas in each of the ten (10) regions. Important results are observed. Although Figure 1 suggests that regions in southern Ghana are better endowed in social amenities and resources, compared to regions in the north, figure 2 shows that this access and endowment varies by rural and urban areas. For example, urban areas in a given region are better off than their rural counterparts, and rural households in the south, in some cases, are more disadvantaged than urban households in the north.

In the Greater Accra, only 1-in-4 of all rural households have access to safe sanitation, compared to 3-in-4 households in urban households in the region. Stunting is also higher among urban children in the Greater Accra region, compared to children who live in rural areas of the region. Food insecurity is also prominent, with about 40 percent of rural households in the Greater Accra region being food secure, compared to 20% of urban households. With the exception of the Volta region, food insecurity in urban Greater Accra is higher than in other urban regions in southern Ghana.

In the Ashanti region, 14% of urban households have poor access to safe water, compared to 73% of rural households. The Ashanti region has the worst access to safe water in rural households, compared to all other regions in southern Ghana. There are also large variations in housing/living conditions between households in rural and urban areas within the region. Only 6% of urban households are characterised by poor housing conditions, compared to 36% of rural households. Other noticeable differences are with respect to job vulnerabilities and safe sanitation, where rural households are more disadvantaged than urban households. The proportion of disabled members in urban households is higher than what is reported for rural households, however.

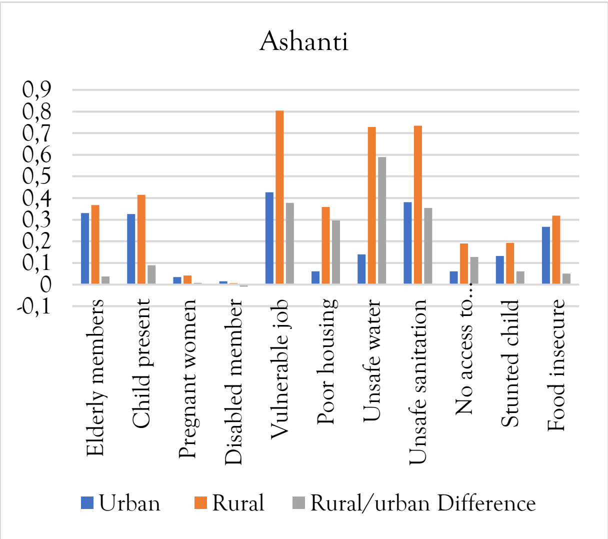
The largest differences between rural and urban areas in the Central region are with respect to job vulnerabilities and unsafe sanitation. While majority of vulnerable conditions are higher in the rural, compared to urban, households, urban households exhibit greater vulnerabilities with respect to pregnancies, disability status of members and child stunting in the Central region.

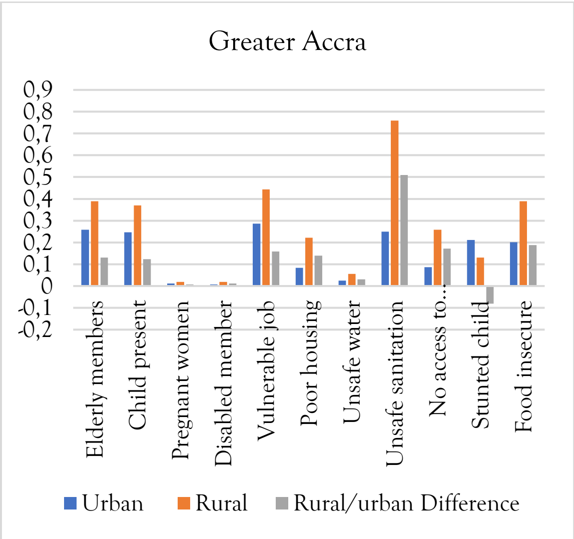
In the Eastern region, the largest rural/urban gaps are observed in the areas of housing, unsafe water, and job vulnerabilities, with poorer outcomes observed in rural areas. Both urban and rural households are characterised by poor access to safe sanitation, with 64% and 83% of the respective households showing vulnerabilities. It is the only region, after the Upper West region, with the lowest access to safe sanitation in urban households.

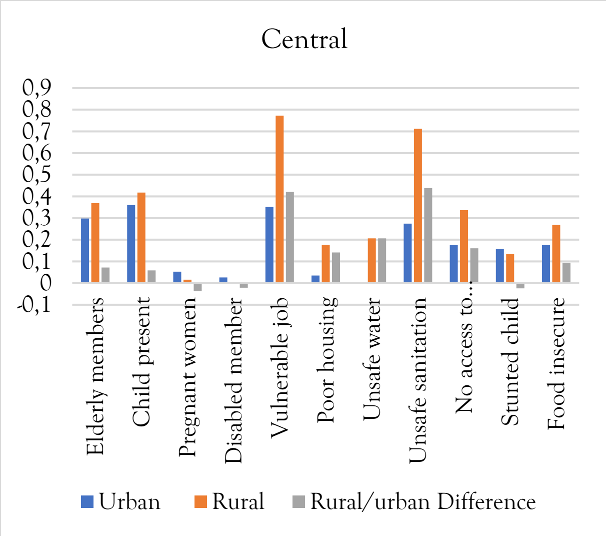
Similar to other regions, urban households in the Volta and Western regions generally appear to fare better than their rural counterparts. Urban households in the Volta region however exhibit greater vulnerabilities with respect to demographic factors such as children present in the household, pregnancies, and disability condition of members. Urban households in the Western region are also more vulnerable with respect to the disability status of members. It should be noted that lower reported disability in rural households may be as a result of lower access to health facilities and less frequent diagnoses within these communities. The Western region has the some of the lowest stunting rates in the country among children in urban households.

The Brong Ahafo region has the highest vulnerabilities with respect to jobs, with close to 90% of rural households involved in vulnerable jobs, compared to 65% of urban households. It also has the highest food insecurity among all regions in southern Ghana.

The Northern region has less than 1% of urban households having access to unsafe water, compared to close to 90% of rural households. Large rural/urban differences are also observed with respect to job vulnerabilities, housing, sanitation, and food security. Urban households consistently have better outcomes, compared to rural counterparts. The other two regions found in northern Ghana have similar challenges.



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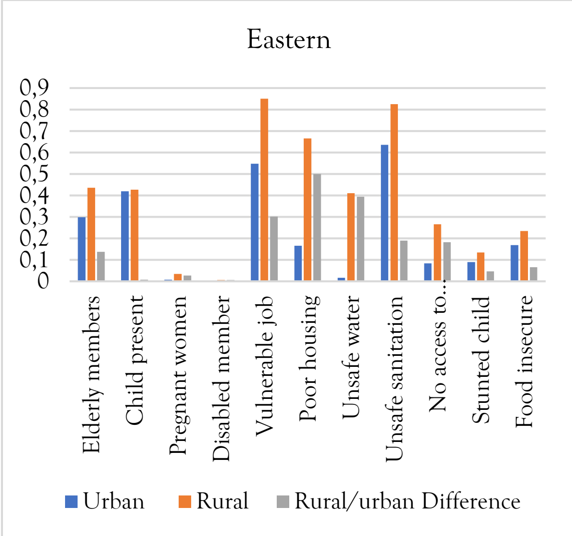
Elderly members
Child present
Pregnant women
Disabled member
Vulnerable job
Poor housing
Unsafe water
Unsafe sanitation
No access to...
Stunted child
Food insecure
Urban
Rural
Rural/urban Difference


Eastern
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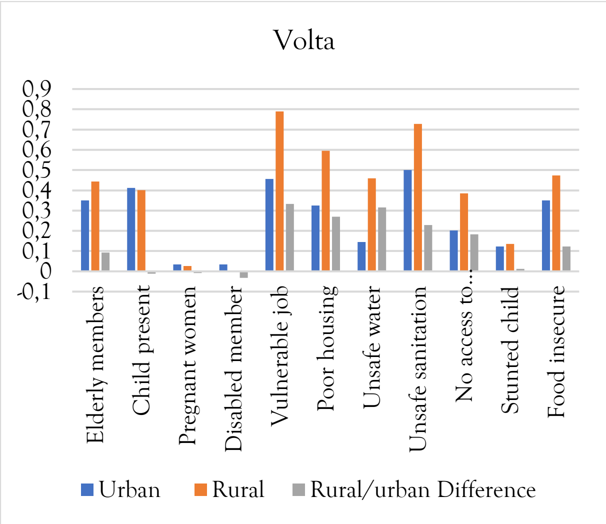
0
Elderly members
Child present
Pregnant women
Disabled member
Vulnerable job
Poor housing
Unsafe water
Unsafe sanitation
No access to...
Stunted child
Food insecure
Urban
Rural
Rural/urban Difference


Volta
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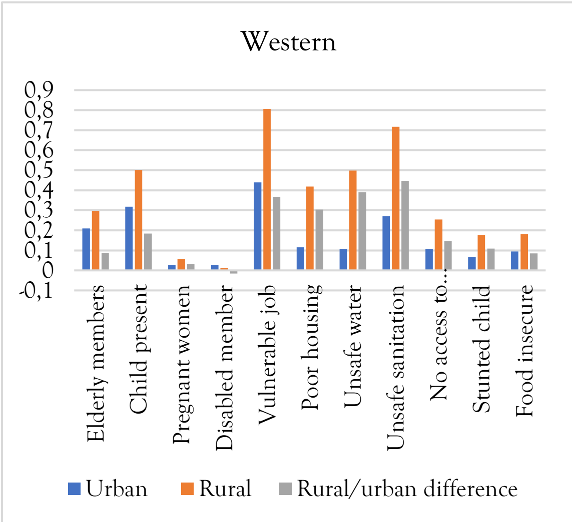
Elderly members
Child present
Pregnant women
Disabled member
Vulnerable job
Poor housing
Unsafe water
Unsafe sanitation
No access to...
Stunted child
Food insecure
Urban
Rural
Rural/urban Difference


Western
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0,1
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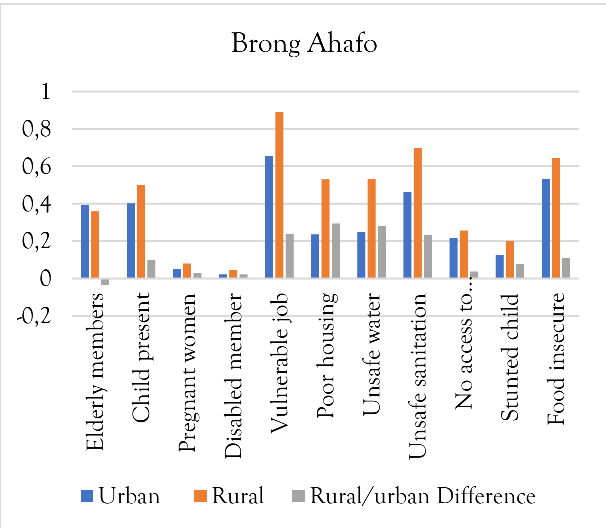
-0,1
Elderly members
Child present
Pregnant women
Disabled member
Vulnerable job
Poor housing
Unsafe water
Unsafe sanitation
No access to...
Stunted child
Food insecure
Urban
Rural
Rural/urban difference


Brong Ahafo
1
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0,4
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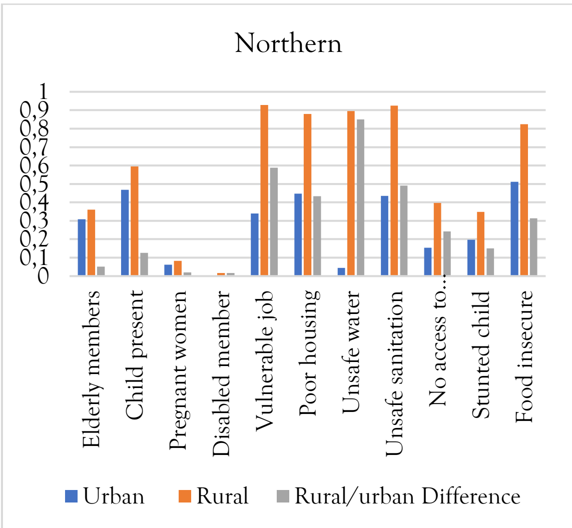
-0,2
Elderly members
Child present
Pregnant women
Disabled member
Vulnerable job
Poor housing
Unsafe water
Unsafe sanitation
No access to...
Stunted child
Food insecure
Urban
Rural
Rural/urban Difference


Northern
1
0,9
0,8
0,7
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0,5
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0,3
0,2
0,1
0
Elderly members
Child present
Pregnant women
Disabled member
Vulnerable job
Poor housing
Unsafe water
Unsafe sanitation
No access to...
Stunted child
Food insecure
Urban
Rural
Rural/urban Difference

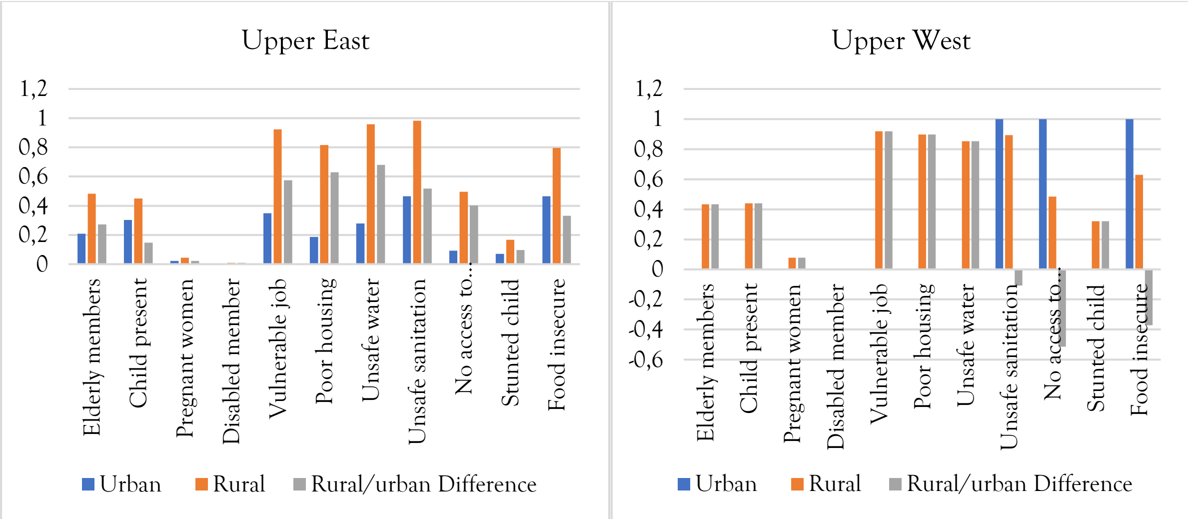

Figure 4: Climate Change Vulnerability Indicators, by Rural Urban residence and Administrative Regions, 2019
Source: Author Construction, GSEPS 2019

b. Climate Change Average Vulnerability Indices

As discussed above two indices of households' climate change vulnerability are constructed from the eleven (11) household-level indicators described above. The first, the average climate change vulnerability index, ranges between 0 (indicating low vulnerability to climate change) and 1 (indicating high vulnerability to climate change). The second indicator is the climate change intensity, which sums up the total number of indicators that households are vulnerable in. This measure ranges from 0 to 11, with vulnerability in a higher number of indicators suggestive of greater climate change vulnerability of the household.

From the intensity index in Figure 5 below, most households are vulnerable in two indicators. Six percent of households are not vulnerable in any indicator, while 0.1% of all households in the sample are vulnerable in ten indicators. No household is vulnerable in all 11 indicators.

On average, households in the sample have an overall vulnerability index of 0.327. Vulnerable occupations contribute the most to households' average climate vulnerabilities; the vulnerability score for vulnerable occupations in the sample is 0.642. Households' living conditions are also prominent contributors to average vulnerabilities in Ghana. Living conditions are determined by construction materials for floors, roofs and walls, availability of safe water and sanitation, and adequate access to information. The average vulnerability score for living conditions is 0.404. Household nutritional status (0.277) and demographic backgrounds (0.197) contribute the least to average climate change vulnerabilities in the sample.

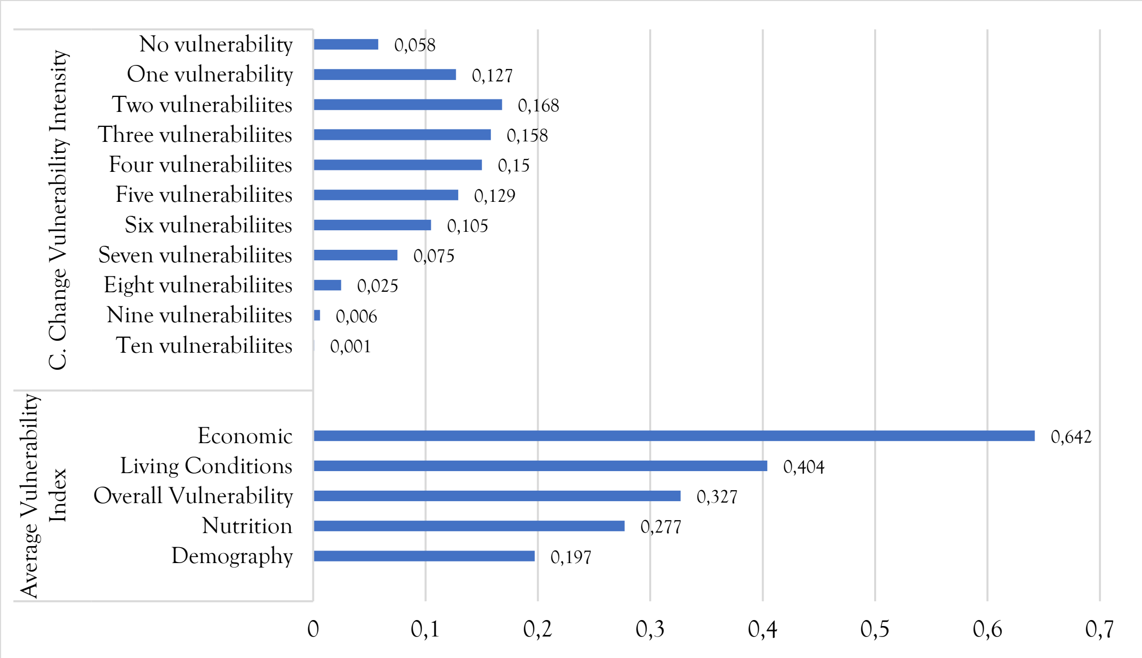

Figure 5: Climate Change Vulnerability Indices, Ghana, 2019
Source: *Author Construction, GSEPS 2019*

The study also explores climate change vulnerabilities by different sub-groups- i.e., gender of the household head, rural/urban residence, household wealth status and regions.

In Figure 6 below, differences in both measures of climate change vulnerabilities are shown for male- and female-headed households. Female-headed households appear to be vulnerable in a smaller number of indicators, compared to male-headed households. 0.1% of male headed households are vulnerable in ten (10) indicators while no female-headed household is vulnerable in that many indicators. Additionally, while male-headed households are more vulnerable in nutrition, living conditions and occupation choices, female-headed households are slightly more vulnerable in the demography category. As was shown in Table 1 above, female headed households have higher proportions of the elderly, pregnant women and disabled members within their households, compared to their male counterparts.

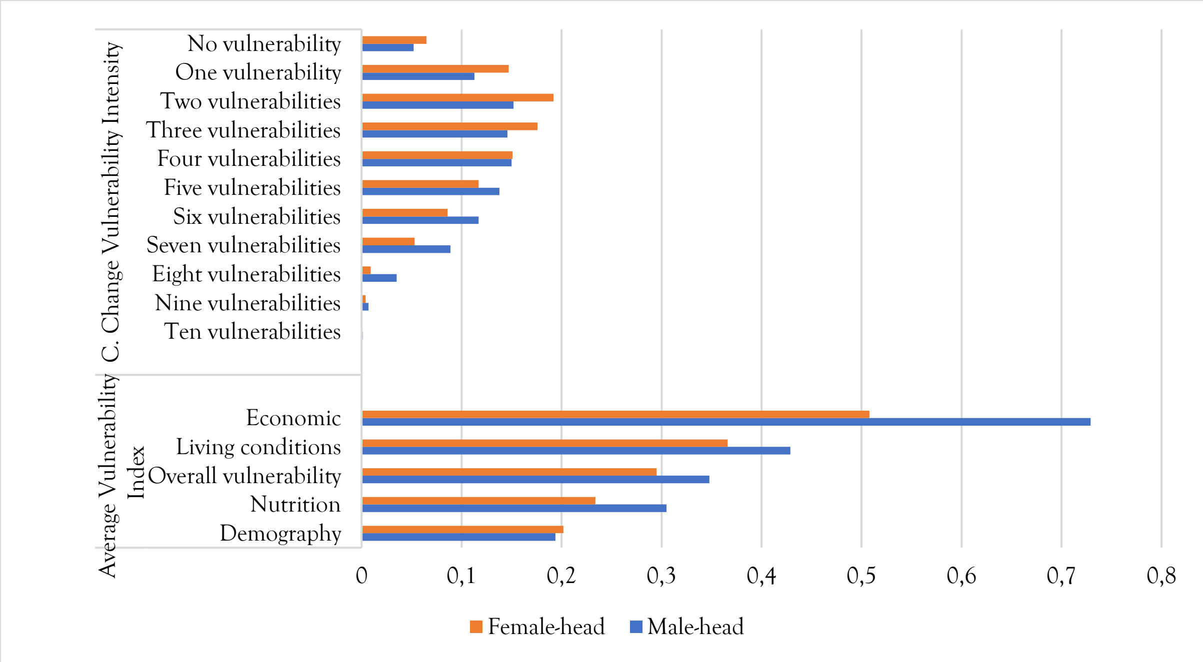

Figure 6: Climate Change Vulnerability, by Gender of Household head, 2019
Source: *Author Construction, GSEPS 2019*

In Figure 7 below, rural households are vulnerable in many more indicators, compared to urban households. While 11% of urban households are not vulnerable in a single indicator, less than 1% of rural households are similarly not vulnerable in any indicator. Urban households are not vulnerable in more than seven vulnerabilities, while rural households are vulnerable in as many as ten vulnerabilities. Additionally, average climate change vulnerabilities, across all sub-categories, are higher in rural, compared to urban areas.

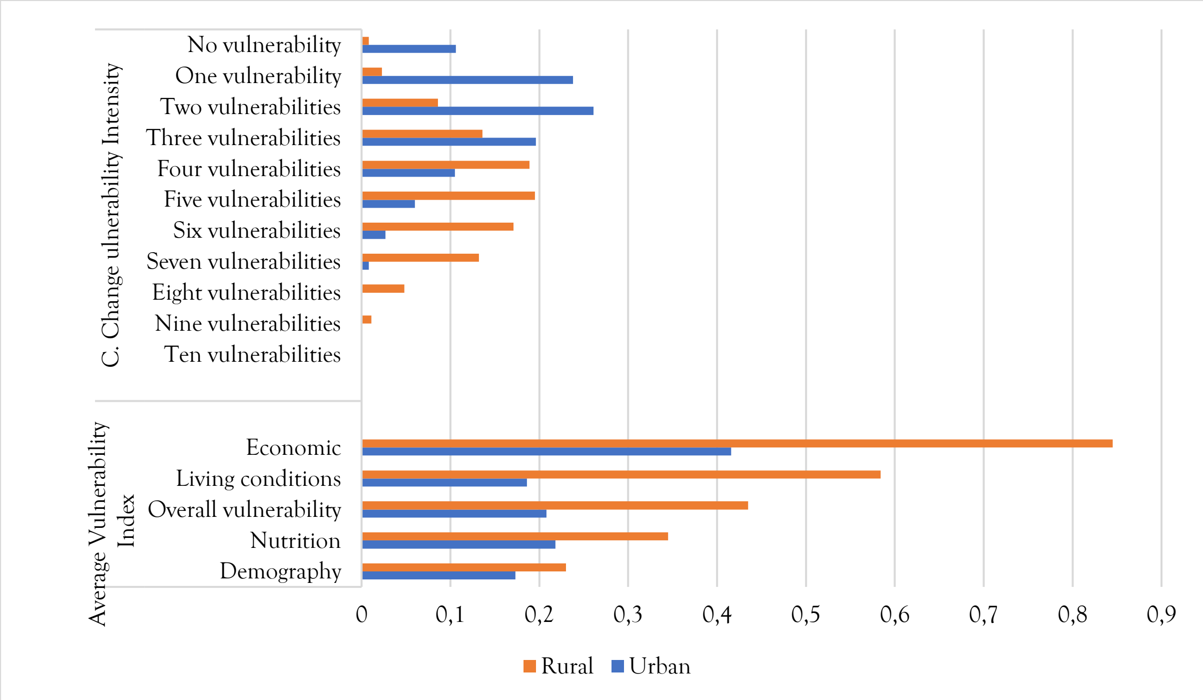

Figure 7: Climate Change Vulnerability, by Rural/urban location, 2019
Source: *Author Construction, GSEPS 2019*

Figure 8 below summarizes climate change vulnerabilities for households of different wealth status. Climate vulnerability intensity is highest in the poorest households where they report being vulnerable in many more indicators than richer households. For instance, no households in the middle, richer and richest wealth categories are vulnerable in all ten (10) indicators, while households in the poorest wealth quintiles are. Additionally, the poorest households are vulnerable in at least two (2) indicators, while 4%, 8% and 15% of the middle, richer, and richest households are not vulnerable in any indicators. Average vulnerabilities, across all sub-categories, are also higher in poorer, compared to richer, households.

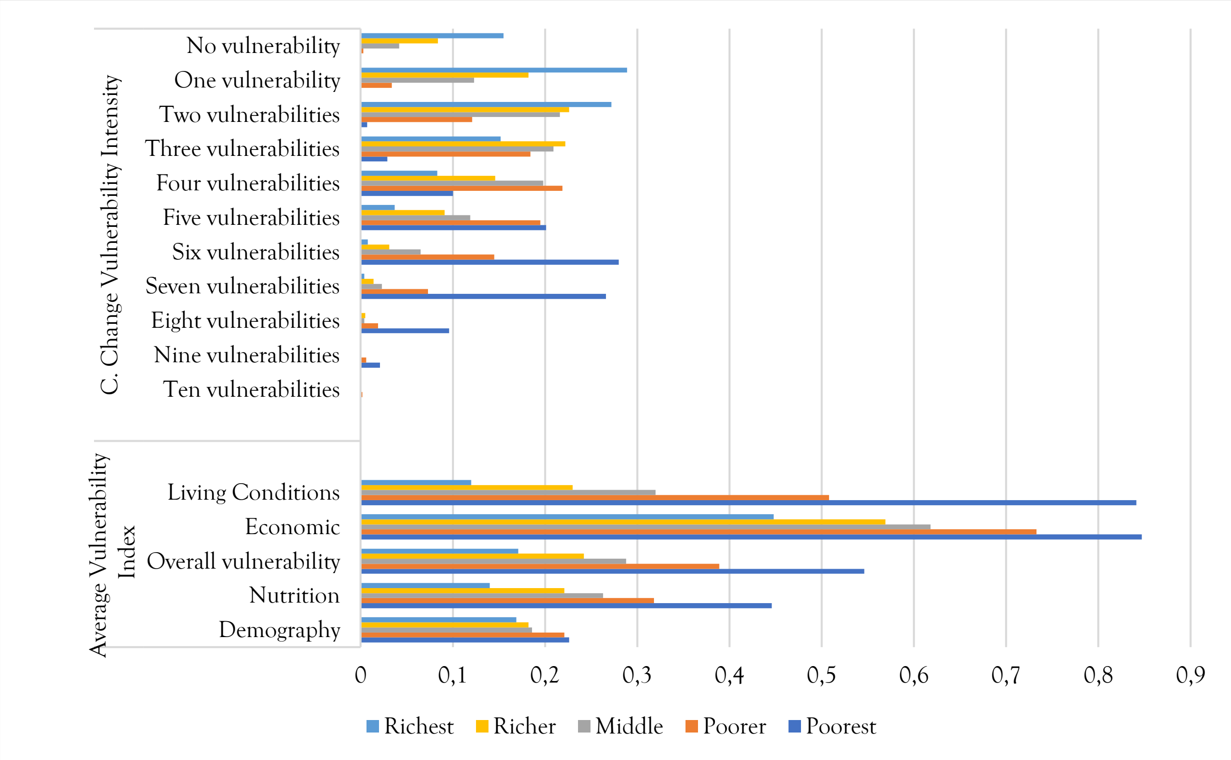

Figure 8: Climate Change Vulnerability, by Household Wealth Status, 2019
Source: *Author Construction, GSEPS 2019*

Climate change vulnerabilities in Ghana are also presented by region. Appendix 2 shows a map of Ghana's administrative regions and its agroecological zones. While administrative regions in the southern parts of the country are generally found in coastal and forest zones, regions in the northern sections of the country are found in the drier, savannah zones. The Brong Ahafo Region is found in the transitional zone between the forest and savannah zones.

In Figure 9, a number of patterns emerge. Regions are generally most vulnerable in the economic category, with regions in northern Ghana showing the highest vulnerabilities. This is followed by vulnerabilities in housing, again led by the three regions in the northern part of the country. Majority of regions are least vulnerable in demographic factors, with the exception of the Eastern and Western regions (these regions are rather least vulnerable in the Nutrition category). The Greater Accra Region, found in the coastal zone, compared to all other regions, has the least vulnerability to climate change in almost all categories, with the exception of nutrition, where other regions like Western, Central, Eastern fare better.

The Western Region, found in the Wet Evergreen and Moist Evergreen zones has the lowest vulnerability to nutrition. The highest vulnerabilities in the nutrition category are observed in regions found in the Savannah zone, i.e., Northern, Upper East and Upper

West. Households in the Brong Ahafo Region, found in the transitional zone, are also vulnerable to climate change across all categories.

It is important to point out, however, as was observed in Figure 4 above, that the experience between rural and urban households can differ. Rural households in southern regions often face deprivations similar to households in northern parts of the country, and urban households in northern regions are often less deprived that rural households in southern Ghana.

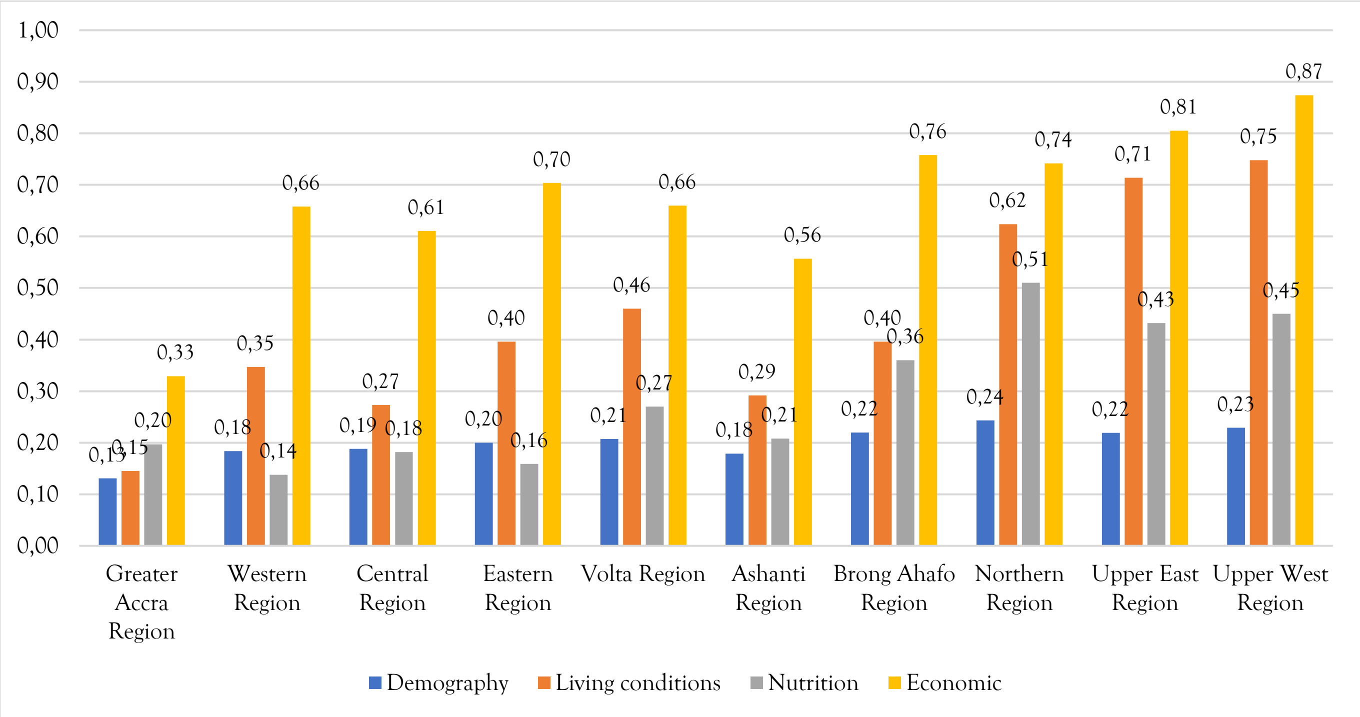

Figure 9: Climate Change Average Vulnerability, by regions, 2019
Source: *Author Construction, GSEPS 2019*

Figure 10 also summarizes statistics for climate sensitivity by each of the ten regions, using the second sensitivity measure i.e., intensity of vulnerability. Below, in the Greater Accra Region, 50% of households are vulnerable in at most two (2) indicators. In regions like the Ashanti, Central, Eastern and Western, 50% of households are vulnerable in at most three (3) indicators. In the Brong Ahafo Region and Volta Region, 50% of households are vulnerable in about four (4) indicators, while in the three northern regions- i.e., Northern, Upper East and Upper West, 50% of households in these regions are vulnerable in about 6 indicators. These patterns, again, show a clear north-south divide in households' vulnerabilities to climate change in Ghana.

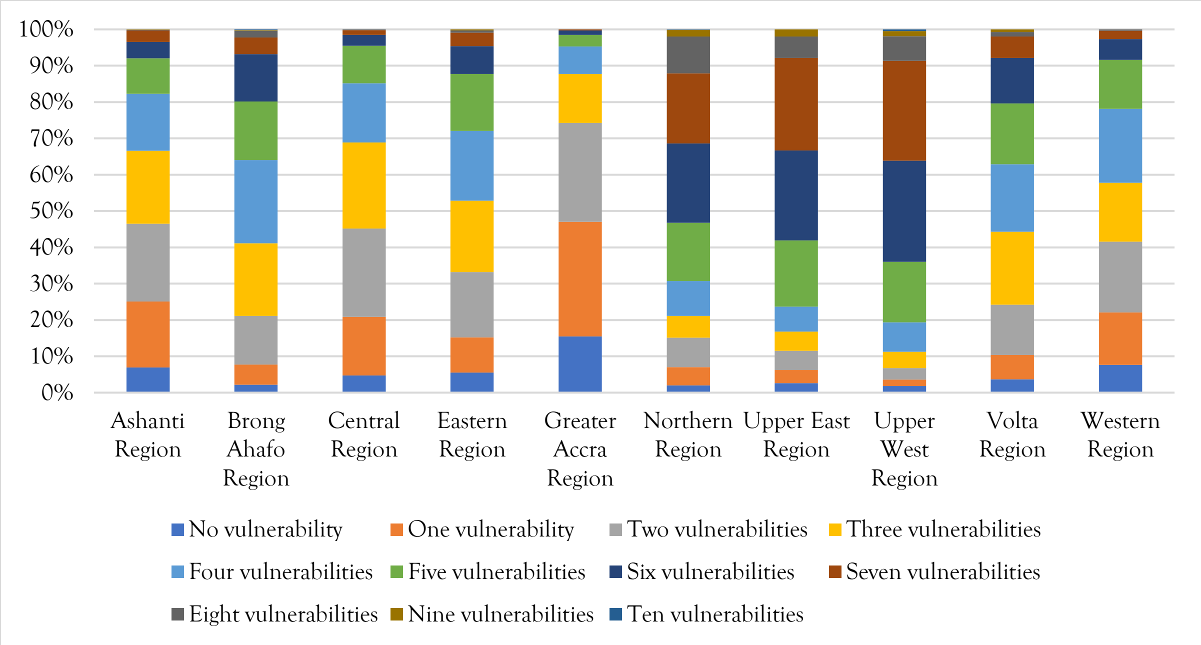

Figure 10: Climate Change Vulnerability Intensity, by regions, 2019
Source: *Author Construction, GSEPS 2019*

Despite the findings in Figure 9 and 10 that least vulnerabilities are observed in the southern regions of Ghana, particularly the Greater Accra region, it is important to note, again, that results are more nuanced. In Figure 4, for example, within-region patterns varied among rural and urban households. Figure 11 describes household vulnerabilities in different regions also by their wealth status.

While it was observed in Figure 9 that households in the Greater Accra region have the lowest vulnerabilities, a disaggregation by wealth status tells a more nuanced story. Some of the poorest households in the Greater Accra region exhibit high climate change vulnerabilities. In some cases, these vulnerabilities are comparable to the situation observed in northern regions of the country. Again, while it initially appeared that households in northern Ghana are more vulnerable to climate change (see Figure 9), Figure 9 below shows that this is not the case across all households in northern Ghana. Relatively rich households in the Northern, Upper East and Upper West regions have low vulnerabilities to climate change, comparable to levels observed in southern Ghana.

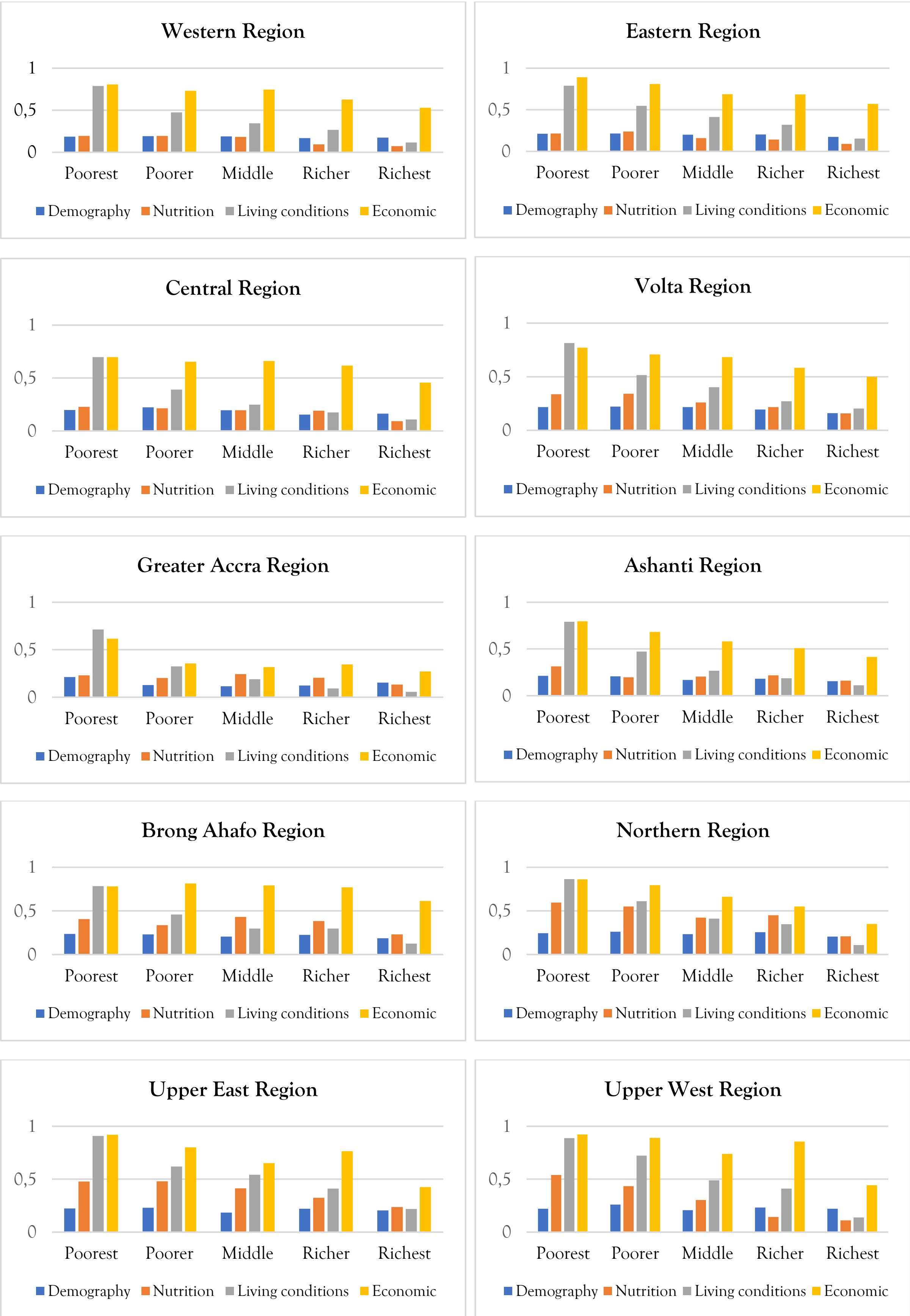

Figure 11 Climate Change Vulnerability by Region and Household Wealth Status, 2019
Source: *Author Construction, GSEPS 2019*

c. Spatial Distribution of Climate Change Vulnerability in Ghana

Figure 12 below shows a standard deviation map of the distribution of average climate vulnerability in households across Ghana. Each category in the figure represents a natural breaks distribution where classes are based on natural groupings inherent in the data. Class breaks are created in a way that best groups similar values together and maximizes the differences between classes. In the data, the average climate change vulnerability is 0.327, with a standard deviation of 0.19. Light brown dots represent households that have low average vulnerabilities to climate change. A lot of these households are found in the southern parts of the country. Dark brown dots represent households that have higher average vulnerabilities. While these are found all over the country, large clusters are found predominantly in households in the northern part of the country.

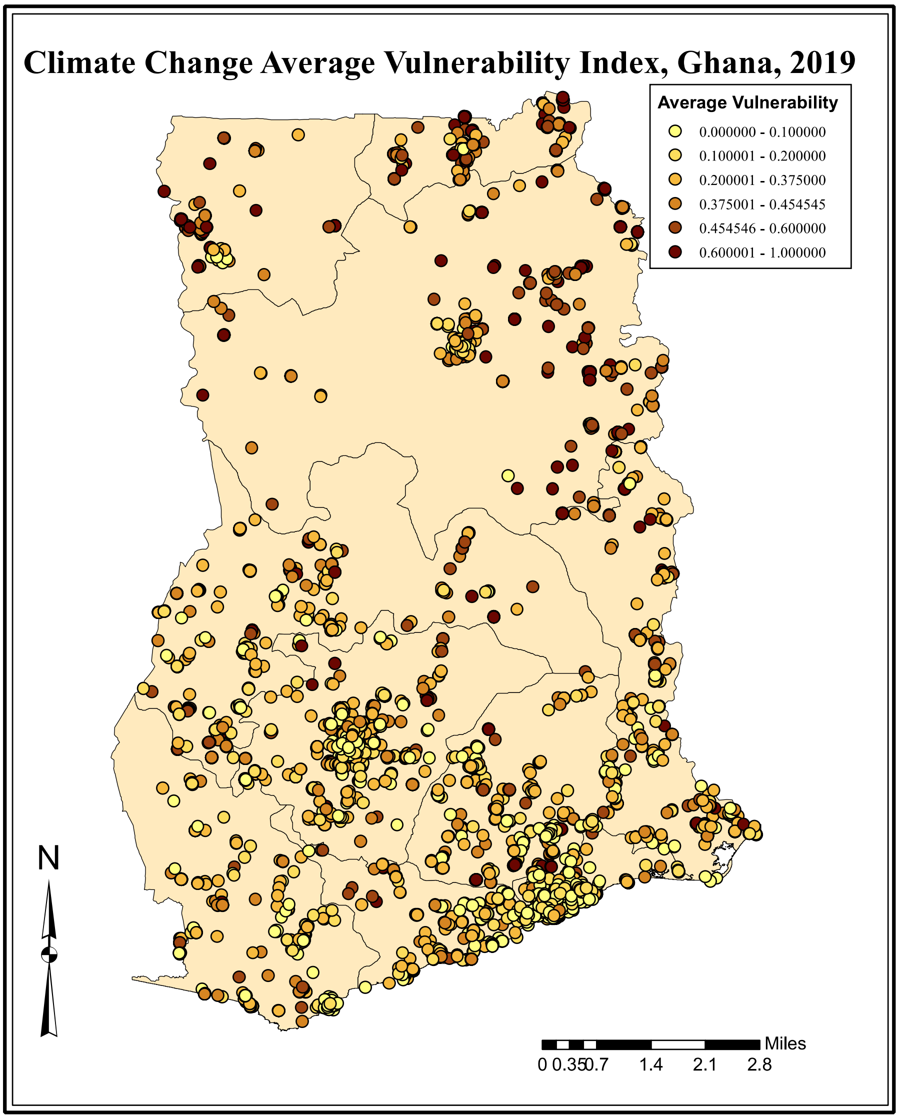

Figure 12 Climate Change Average Vulnerability Index, 2019
Source: *Author Construction, GSEPS 2019*

Figure 13 shows the distribution of climate change vulnerability intensities across the country. A very interesting pattern emerges from the map. Households that are not vulnerable in any conditions (see red dots) are clustered in the major/regional capital cities in Ghana such as Accra in the Greater Accra Region, Kumasi in the Ashanti Region, Sekondi in the Western Region, Ho in the Volta Region, Koforidua in the Eastern Region, Tamale in the Northern Region, Wa in the Upper West Region, and Bolgatanga in the Upper East Region. A lot of households that are vulnerable in four, five, six and above indicators, illustrated in shades of green, are found in the northern, savannah parts of the country. These areas have fewer households, compared to southern Ghana, who are not vulnerable in any indicators. This suggests that major cities in the different regions are sensitive to fewer climate change vulnerability conditions in the country. Additionally, northern households appear to be more disadvantaged than their southern counterparts, although earlier caveats regarding within-region nuanced must not be disregarded in presenting a fuller picture of household vulnerabilities.

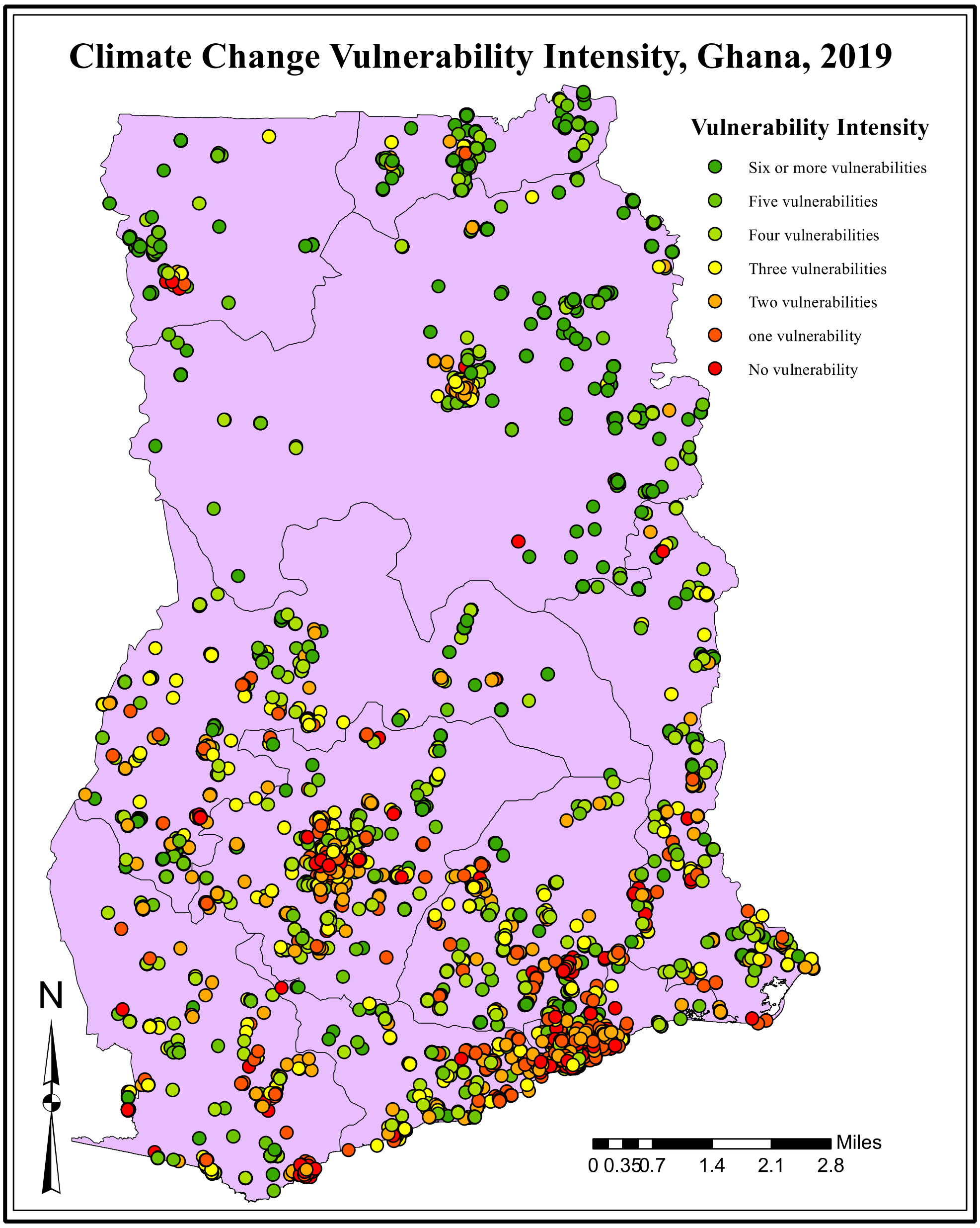

Figure 13: Climate Change Vulnerability Intensity, 2019
Source: *Author Construction, GSEPS 2019*

d. Bivariate relationship between Climate Shocks and Climate Sensitivity (District-level analyses)

This sub-section explores the spatial bivariate correlation between climate shocks and vulnerabilities at the district level in Ghana for the three years preceding and including survey years 2009, 2014 and 2019. Data on climate shocks was obtained from the Geocoded Disasters (GDIS) dataset from the International Disasters Database (EM-DAT). This contains essential core data on the occurrence and effects of over 22,000 mass disasters in the world from the 1900s to the present day. The database is compiled from various sources, including UN agencies, nongovernmental organizations, insurance companies, research institutes and press agencies. For a disaster to be entered into the database at least one of the following criteria must be fulfilled: Ten (10) or more people reported killed; hundred (100) or more people reported affected; there must have been a declaration of a state of emergency; or a call for international assistance. In Ghana, there has been a total of about 80 events that meet the above criteria between 1968 and 2019. The climate shocks variable used in this paper is constructed as the number of events that occurred in various districts in Ghana in the three years preceding, and including, the years of data collection.

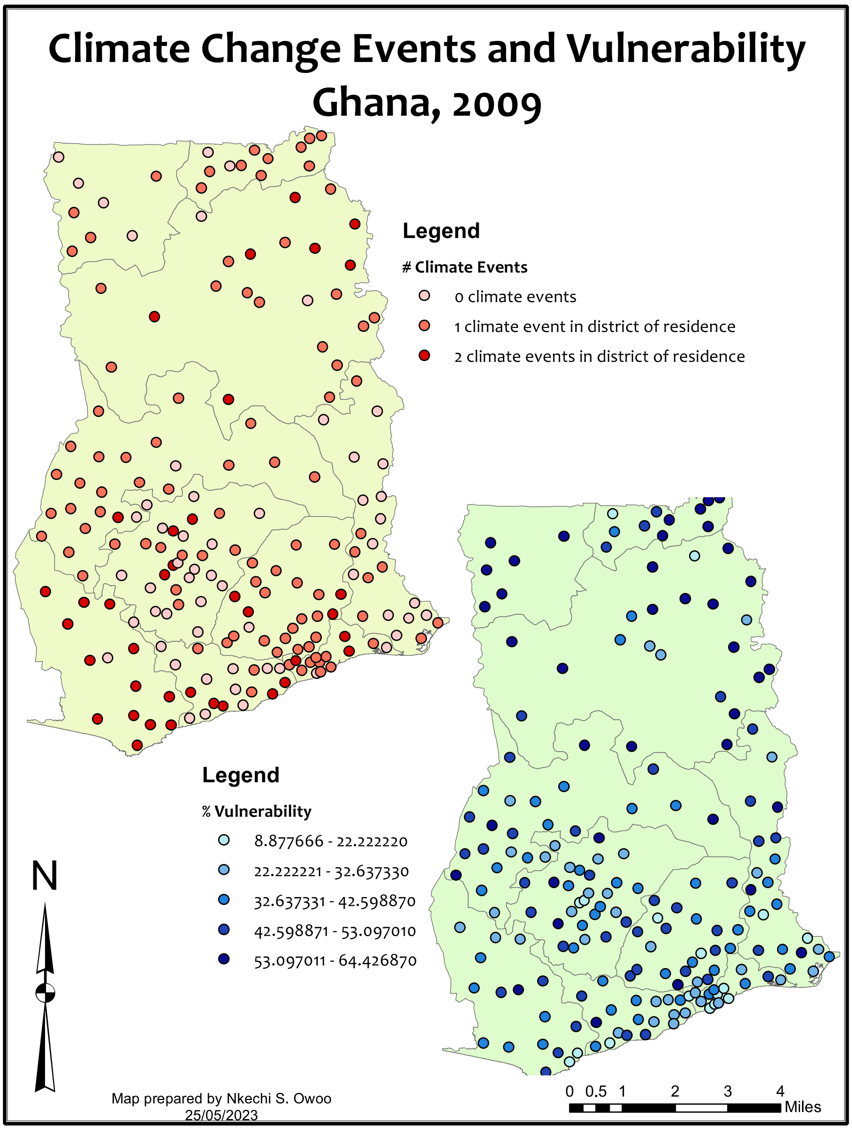

Figure 14: Climate Change Shocks and Vulnerability Intensity, Ghana Districts, 2009

In Figure 14, there are strong overlaps in shocks and vulnerabilities in districts in the Upper East region of Ghana, as well as the Western and Northern regions. Although flooding events are also observed along the Coast, districts in the Greater Accra and Central regions show lower sensitivies to these shocks.

Similar patterns of vulnerability are found in Figure 15 below using 2014 survey data and corresponding climate shocks information, with stronger sensitivities observed in the north, compared to southern Ghana. Flooding events are observed mostly in districts in the Volta and Northern regions of the country.

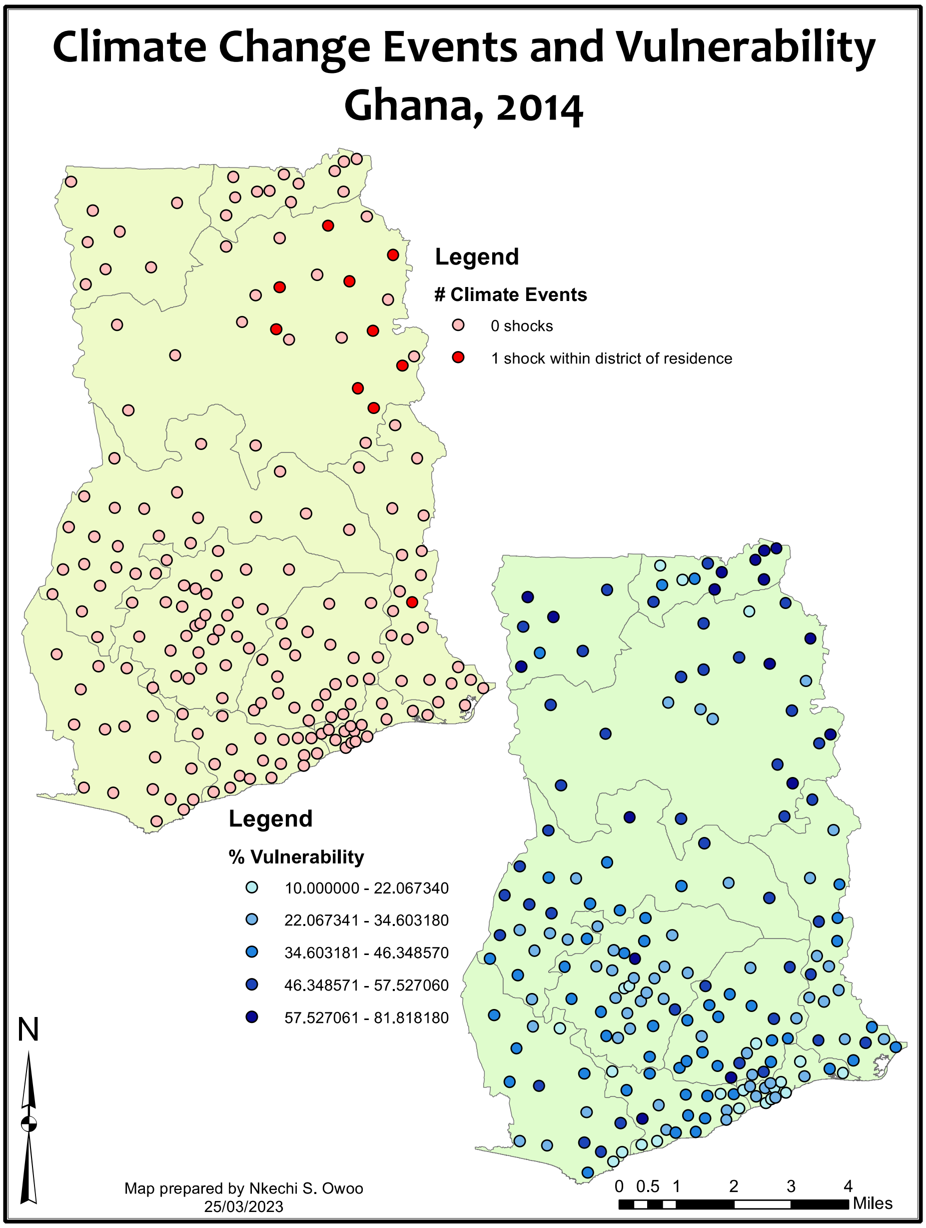

Figure 15 Climate Change Shocks and Vulnerability Intensity, Ghana Districts, 2014

In Figure 16, flooding events occur in districts in the Upper East, Western, Greater Accra and Central regions. It is important to know that greater sensitivities to climate events in the Upper East region suggest that households in these districts will require additional attention and interventions in order to mitigate the effects of climate events on these households.

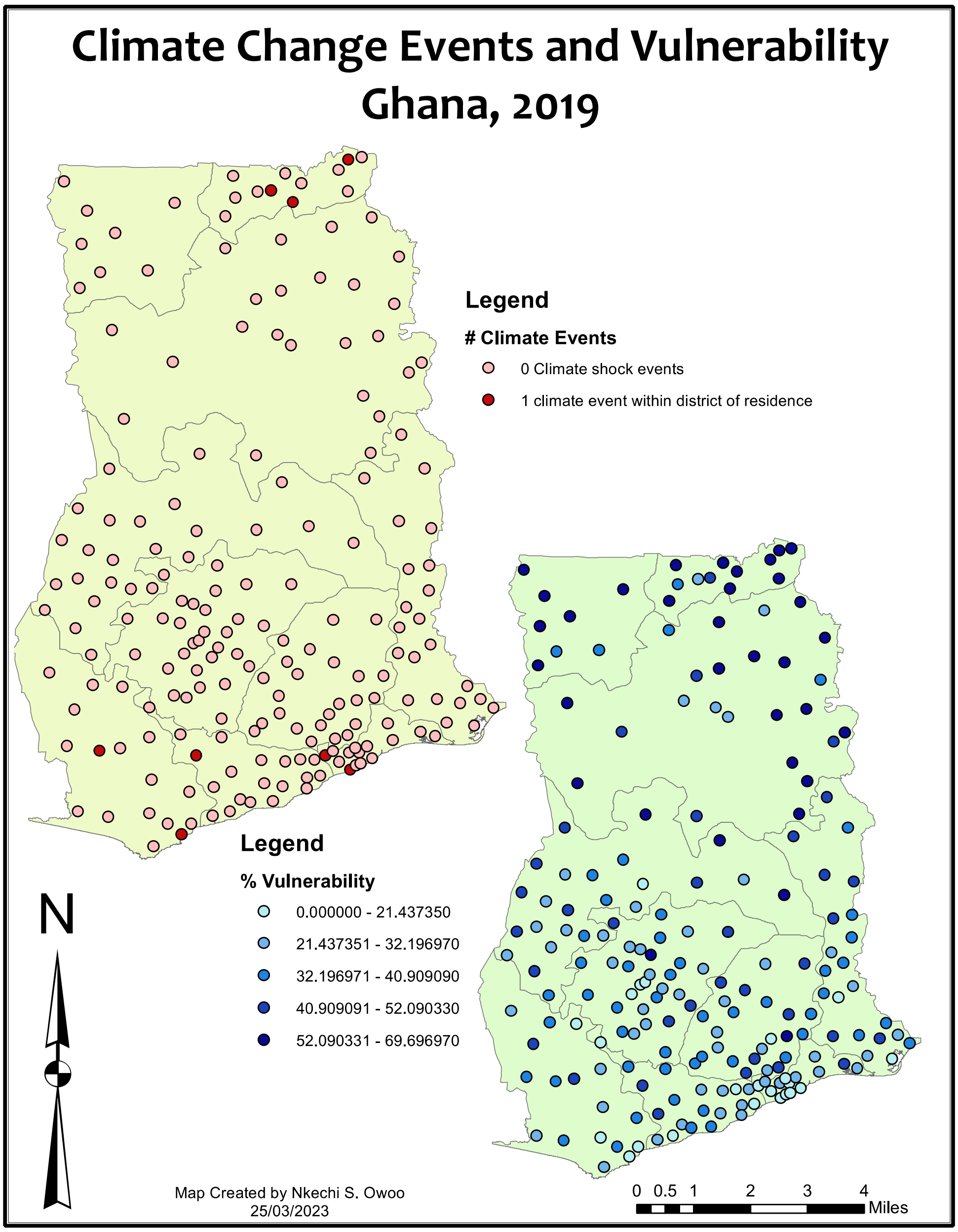

Figure 16 Climate Change Shocks and Vulnerability Intensity, Ghana Districts, 2019

Concluding remarks

Climate change vulnerabilities in Ghanaian households are assessed in this paper. Using all waves of the Ghana Socioeconomic Panel Survey (2009- 2019), household-level indices of climate change vulnerabilities are constructed. Analyses show that climate vulnerabilities across the country have changed over time and vary by different subgroups. For example, while Economic vulnerabilities have increased over time, others have fallen, with the least change relating to Demography vulnerabilities. In 2019, it was observed that vulnerabilities are higher in rural, compared to urban areas, and in male-headed, compared to female-headed households. Climate vulnerabilities are also more prevalent in poorer, compared to richer households. A north-south divide in vulnerabilities was also observed, with greater vulnerabilities observed in households located in the northern, savannah regions, compared to southern coastal and forest areas of the country. Finally, it was observed that major/regional cities in both north and south Ghana had the lowest climate vulnerability intensities (i.e., were not vulnerable to any indicators), suggesting some inequalities in the provision of public goods and utilities between cities and other communities.

The strongest contributors to climate change vulnerabilities were the nature of occupations that individuals were engaged in. Outdoor jobs that increase exposures to heat and the elements were an important contributor of overall vulnerabilities. The second contributor was households' living conditions. The use of natural materials like mud and thatch to construct walls, floors, and roofs, served to increase households'' vulnerabilities. Households' nutritional status and demographic compositions did not contribute as much to average vulnerabilities, although importance varied across regions.

A number of policy recommendations result from these findings: First, policies and programme interventions should be targeted to those locations that demonstrate the highest vulnerabilities such as rural areas and parts of northern Ghana. Secondly, with over 60% of Ghanaians lacking adequate access to sanitation and access to safe water also an identified problem, efforts should be made to increase access to these amenities and social infrastructure. There are also observed inequalities in access to underlying resources between regional cities and other communities and these imbalances need to be addressed. These are inequalities relating to the provision of utilities like electricity, pipe-borne water, sanitation services, among others.

The contribution of vulnerable occupations to households' climate vulnerabilities has already been highlighted. Workers (and employers) in outdoor occupations should be well informed about emerging issues and dangers associated with climate change in order to better develop plans that address worker's safety and health. Although food insecurity does not present a challenge to regions in southern Ghana, close to 50% of households in Northern, Upper East and Upper West regions demonstrate vulnerabilities in this area, with added concerns of child stunting. Given the dry, savannah zone that these regions are located in, efforts should be made to boost agricultural productivity in order to alleviate food shortages.

We observe strong spatial bivariate correlations between shocks and sensitivities at the district level. In regions with greater experiences of shocks, combined with higher sensitivities, it is important to note that these households will require greater programs and interventions to ensure that the effects of shocks are mitigated within these households.

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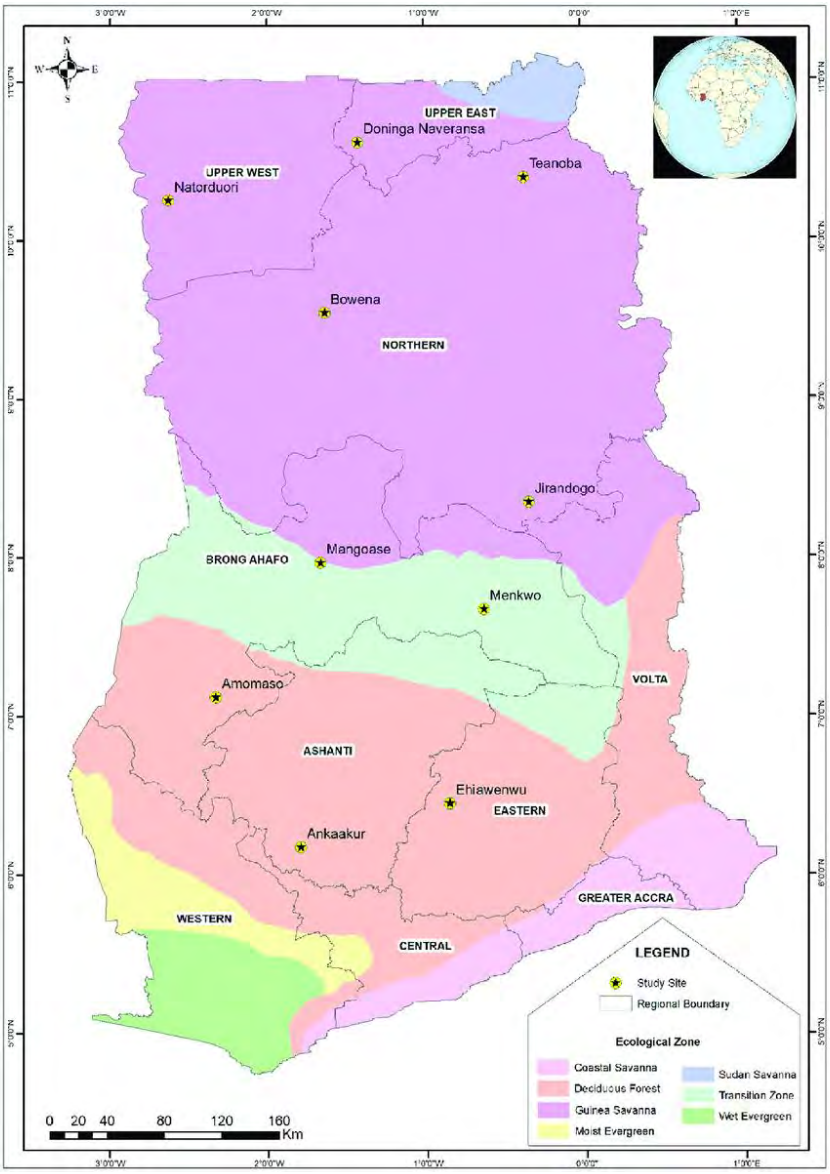
Appendix A

List of variables used to calculate the wealth indices

Toilet	Stove	Satellite dish
Water	Washing machine	Vehicle
Floor materials	Phone (land line)	DVD player
Roof materials	Furniture	Air conditioner
Internet	Computer	Generator
Camera	Sewing machine	Land

Appendix B

Ghana's regions and ecological zones



Source: Nimo-Paintsil et al. (2019)