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CLIMATE CHANGE VULNERABILITY IN KENYA: A SPATIAL AND SOCIOECONOMIC ANALYSES OF HOUSEHOLD SENSITIVITY

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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

UEA University of East Anglia

ACEIR African Centre of Excellence for Inequality Research

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Climate Change Vulnerability in Kenya: a Spatial and Socioeconomic Analysis of Household Sensitivity

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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).

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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

This paper presents spatial and socioeconomic analyses of climate change vulnerability of households in Kenya. The paper first examines trends in climate change vulnerability indicators in the period 2005 to 2019 using the 2005/2006 and 2015/2016 Kenya Integrated Household Budget Surveys, and the 2019 Kenya Population and Housing Census. Secondly, the paper constructs climate change vulnerability indices using the KIHBS 2015/2016 because that is the only survey containing all the required vulnerability indicators. Finally, that paper looks at a bivariate relationship between climate change hazards and household climate change vulnerability. A set of indicators of a household's climate change sensitivity categorized as; housing living conditions, demographic structure, economic conditions, and nutrition are aggregated to generate two indices (an overall household climate change vulnerability index and a household climate change vulnerability intensity index). The spatial and social economic analysis of household climate change vulnerability is based on the two indices with the spatial analysis extended to counties - which are the sub-national units created by the Kenya Constitution passed in 2010 as the focal points for devolution. The results show that measures (indices) of climate change variability highlight heterogeneity in household climate change sensitivity across space (counties and location) and socio-economic characteristics. At the national level, 26.3% of households are vulnerable to climate change. Poor nutrition (food insecurity and child stunting) is the main contributor to vulnerability while economic activities (substance, pastoralism and open-air activities ('jua kali')) contribute the least. The results also, show that: overall, rural households are more vulnerable than urban households, poor households are more vulnerable than non-poor ones, female headed households are more vulnerable than their male counterparts, wealthier households are less vulnerable than those with less asset wealth, and climate change sensitivity appears to decrease with the level of education attainment of the household head. Furthermore, there are remarkable differences in climate change sensitivities across counties. Finally, there is a strong spatial correlation between climate change shocks and household climate change sensitivities at the county level. Our analysis highlights the need for policies and interventions to help counties adapt to climate change shocks.

Keywords: Climate change, vulnerability, sensitivity, spatial and socio-economic analysis, Kenya

JEL Codes: R10, R10, Y91, I10, I20, Q10, J68

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Introduction and Background

Climate change is among the global challenges facing humanity today and manifests itself as long-term increase in temperatures and shifts in weather patterns. The shifts may be natural, for instance, through variations in the solar cycle, or due to human activities primarily arising from the burning of fossil fuels, like coal, oil, and gas (CIA, 2021). Burning fossil fuels generates greenhouse gas emissions that act like a blanket wrapped around the earth, trapping the sun's heat and raising temperatures on earth (Government of Kenya, 2018). As carbon dioxide and other greenhouse gases build up in the atmosphere, they trap heat and as a result, average global temperatures and sea levels are rising, causing significant environmental and economic disruption (World Bank, 2018). According to Intergovernmental Panel on Climate Change, IPCC (2022), Africa is one of the lowest contributors to greenhouse gas emissions causing climate change, yet African populations are the most affected and have experienced widespread losses and damages attributable to human-induced climate change, including biodiversity damage, water shortages, reduced food production, loss of lives and reduced economic growth.

Kenya, like other developing countries, has been adversely affected by climate change and has experienced a general warming trend since 1960s.This, for instance, has resulted in change in rainfall patterns, with the long rainy season becoming shorter and dryer and the short rainy season longer and wetter. Overall annual rainfall remains low, the long rains have been continuously declining in recent decades (Chaudhury, Summerlin, and Ginoya, 2020). Droughts have intensified in terms of frequency, severity, and spread over the past few decades. Also, sea level is rising along Kenya's Indian Ocean coast due to increased melting of land-based ice such as mountain glaciers and ice sheets. The sea level rise is projected to be greater than the global average of 26 to 82 cm by the 2080s (Transparency International, 2022). Many Kenyans are vulnerable to the impacts of climate change, which is a contributor to poverty, which stood at 33.4% before the Covid19 pandemic (World Bank, 2022).

As a country, Kenya is most vulnerable to climate change as the key drivers of its economy (agriculture, livestock, tourism, forestry, and fisheries) are climate-sensitive (IPCC, 2022). Climate change threatens to adversely affect economic growth in Kenya hindering it from achieving high quality life for all its citizens. The cumulative impacts of climate change over the next two or three decades have the potential to reverse much of the progress made towards the attainment of the Sustainable Development Goals and Vision 2030 (Government of Kenya, 2018). There is increasing evidence that climate change directly affects countries' social, economic, and human development at regional, national, and local levels. Taking urgent action to combat climate change, therefore, has become one of the

key global development priorities and prompted the construction of climate vulnerability indices (WBG Climate Change Knowledge Portal, 2020).

Analysis of climate change vulnerability indices is vital in establishing the extent to which people, sectors, and places are affected by climate change and can help reduce these adverse impacts and promote climate-resilient development (Mwangi and Mutua, 2015). The IPCC (2022) defines climate change vulnerability 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. A country's vulnerability to climate change is a function of the character, magnitude, and rate of climate change. Climate change vulnerability typically relates to exposure, sensitivity, and adaptive capacity of a country. However, in the IPCC 2014 report, exposure is no longer a driver of climate change vulnerability, and is more of a spatial attribute. Climate change vulnerability is driven by types of livelihoods, species or ecosystems, environmental services, resources, infrastructure, and cultural assets. Thus, vulnerability is determined by a system's sensitivity to climate change and its capacity to adapt to the change. The extent of a system's sensitivity to climate change is determined by geographical conditions, land use, demographic characteristics, and industrial structure, such as dependency on agriculture and extent of industrial diversification. A country's adaptive capacity is dependent on abilities of national systems, institutions, population groups and other organisms to adjust to potential damage associated with climate change. Functionally, vulnerability is related directly to a country's sensitivity, and inversely to a country's adaptive capacity (Sharma and Ravindranath, 2019). The characteristics that make a system weak or strong (relative to climate change) are recognized as sensitivity indicators, for instance, the extent of a group's marginalization within a community or region.

Several studies worldwide have sought to identify where, how, and why human systems are vulnerable to climate change, with such works growing rapidly over the last decade (see, Abbass et al., 2022; Dilling et. al., 2015; Ford et.al., 2015; Jurgilevich et.al.,2017; Nelson et.al.,2016; Preston et.al., 2017; McDowell et al. 2016; and Räsänen et al. 2016). However, few of these studies have been done in Africa (see e.g., Leibrandt, Shifa & Machemedze, 2022, for South Africa; Mwangi and Mutua, 2015; Marigi, 2017, for Kenya, among others). Most of the studies on climate change vulnerability however have been largely done at the national or sometimes regional level. Such studies tend to hide the intra-country and household heterogeneity of the extent to which countries or national systems are sensitive to climate change. Thus, this study carries out a spatial and socioeconomic analysis of climate change sensitivity in Kenya using household level indicators and indices. The aim is to identify areas and households that are most sensitive to climate change.

Whereas studies using household level climate change vulnerability indicators and indices have been done in some countries (see e.g., Ludena, 2015 for Latin America; Pandey and Jha, 2012 for India; and Qin Zhang and Haiping Tang, 2018 for China), none has been done in Kenya. Some of the variables used to measure a household's sensitivity to climate change include: adequacy of water and sanitation, undernourishment, children's underweight, child mortality, and GDP per capita, household dependency ratio, literacy of the household head, household with members who have migrated out, whether a household collects fodder and/or firewood, crop varieties, agricultural work as primary job, household debt, receipt of government or social support, infant and adult mortality, food insecurity, fertilizer and pesticide use, water availability and source, amount of land owned, education level of household members, housing conditions, number of relatives, among others. In this paper, focus is on households' sensitivities to climate sensitivity using a series of demographic, economic, housing and nutrition indicators. We use some of these indicators in our study based on their availability in our datasets. To be specific, we construct climate change vulnerability indices using household level demographic, economic, housing conditions and nutrition indicators and analyse the extent to which the sensitivities are related to climate chocks.

This study contributes to existing literature in several ways. First, this study uses household level climate sensitivity indicators to carry out spatial and socioeconomic analysis of climate change vulnerability. Second, in carrying out this analysis, we identify the main contributors to climate change vulnerability and its intensity. Finally on the policy front, by identifying areas where households are most vulnerable to climate change, this study should inform decision makers and other actors as to policy instruments that can be used to make households resilient to climate change shocks.

The remaining parts of the paper is organised as follows. Section 2 outlines the dataset used in the analysis and discusses the climate change indicators and the construction of the climate change vulnerability indices. Section 3 provides trends in climate change indicators and the spatial and social-economic analysis of the indices and analyse the extent to which the sensitivities are related to climate chocks. Section 4 is the summary and conclusion.

Methodology

This section discusses the dataset used in the analysis. This is followed by a discussion on the climate change sensitivity indicators and the construction of the climate change vulnerability indices used in the study.

Data

Three datasets are used in the analysis. The three are two Kenya Integrated Household Budget Surveys (KIHBS) 2005/06 and 2015/2016and the Kenya Population and Household Census (KPHC 2019). The 2005/06 and 2015/16 Kenya Integrated Household Budget Surveys (KIHBS) are population-based surveys designed to provide estimates for various indicators representative at the national level, urban and rural areas and at the county level. The data from the surveys can be used to: compute poverty and inequality indicators; construct monetary, non-monetary and multi-dimensional indicators and the socio-economic profiles of living standards; compute labour force indicators; identify consumption baskets that can be used to construct new consumer price index (CPI) series; and to construct the agriculture and livestock input-output structure of the Kenyan System of National Accounts (SNA).The 2005/06 KIHBS Sample Survey is drawn from the fourth National Sample Survey and Evaluation Programme (NASSEP IV) household sampling frame, while the 2015/16 KIHBS sample is drawn from NASSEP V frame, both of which are used by the Kenya National Bureau of Statistics (KNBS) to conduct the surveys. The sample size for KIHBS 2005/06 is 13,430 households in 1,343 Clusters, and for KIHBS 2015/16 survey is 24,000 households in 2,400 Clusters. The two surveys collected information on household members, demographics, education, labour, health, fertility and mortality, child health and nutrition, information and communication technology (ICT) services, and domestic tourism at individual level. At the household level, information is collected relating to housing, water, sanitation and energy use, agricultural holdings, activities and outputs, livestock, household economic enterprises, transfers, income, credit, and recent shocks to household welfare, food security, justice, credit and ICT at the household level. Further information is collected on household consumption expenditure, including information relating to purchases and consumption of food, non-food and services in the household. Such information included expenses incurred by households on foods, house rent, healthcare, education, household goods, insurance, among others.

The 2019 Kenya Population and Housing Census (KPHC) was the eighth to be conducted in Kenya since 1948 and was conducted from the night of 24th/25th to 31st August 2019. It was implemented under the provisions of the Constitution of Kenya, 2010 and the Statistics (Amendment) Act, 2019. It also followed the United Nations Principles and Recommendations for conducting the 2020 round of censuses, including adoption of technology. Indeed, the country leveraged on technology to capture data during cartographic mapping, enumeration and data transmission, making the 2019 KPHC the first paperless census to be conducted in Kenya. The information contained herein responds to the ever-increasing demand for official statistics and provides benchmark information for other statistical development and infrastructure, particularly for the devolved units of governance. The 2019

KPHC generates a wealth of data including information on the size, composition, distribution and socio-economic characteristics of the population. The census provides the much-needed comprehensive data at lower levels to inform development planning and programming to facilitate delivery of quality services to citizens. In addition, KPHC is used to monitor progress in achieving internationally agreed milestones of programs such as the Sustainable Development Goals (SDGs). The Census collected data on size composition and spatial distribution of the population; levels of fertility, mortality and migration rates; levels of educational attained by the population; rate and pattern of urbanization; size and deployment of labour force; housing conditions and availability of household amenities and agricultural indicators. Only 10% of the 2019 KPHC is available for use in the analysis which constitutes 1,204,066 households both in urban and rural areas and in all the 47 counties.

Table 1 shows the comparison of various household climate change vulnerability indicators for Kenya between the two surveys and the Population Census.

Table 1: Household climate change vulnerability indicators for Kenya (2005-2019)

	KIHBS 2005/06	KIHBS 2015/16	KPHC 2019
Demographic Indicators			
Younger children (under 10)	66.7	56.5	53.1
Older people (aged 60 and above)	22.1	18.7	18.4
Disabled people	5.7	9.2	10.1
Economic Indicators			
Subsistence Farmers (i.e. household involves in agriculture)	-	30.1	34.2
Pastoralists	-	4.0	4.1
Informal sector workers	-	31.9	18.6
Household Indicators			
Inadequate Housing Construction (Mud/earth floor, natural materials for walls and roof)	63.1	48.3	46.9
Inadequate Sanitation (open defecation & unimproved sanitation)	51.5	34.5	17.5
Inadequate water supply (household depend on surface water for it need)	27.7	17.8	21.7
Not having a radio, TV, mobile or internet	21.0	13.1	3.0
Nutrition			
Food insecure if a household report yes to at least one of the FIES indicators	-	64.6	-
Stunted child under 5 years	-	9.6	-

Source: Estimates based on KIHBS 2005/06 and 2015/16 and 10% of the Kenya Population and Housing Census 2019.

To construct the climate change vulnerability indices (household level quantities that are adversely affected by climate change), we use demographic, economic, living conditions and nutrition indicators to construct these outcome variables. All the three data sets have information on only three of the demographic indicators, with no information on pregnant women while KIHBS 2005/06 does not have information on economic indicators in the format and categories available in KIHBS 2015/16 and KPHC 2019. All the three datasets have the required information on household living conditions indicators but only 2015/16 have information on nutrition indicators of climate change sensitivity. Due to missing information on some of the climate change vulnerability indicators in KIHBS 2005/06 and KPHC 2019, we use the three datasets to display and discuss trends in the indicators available in three datasets and then use KIHBS 2015/16 that has all the indicators to construct the climate change vulnerability indices for use in the analysis.

Household Level Climate Change Sensitivity Indicators

This subsection discusses household level climate change sensitive indicators. The indicators can be categorized into demographic, economic, housing living conditions and nutrition indicators. There are several indicators under each of the categories, but we use those that can be constructed using the data sets that we have. The indicators are used to construct climate change vulnerability indices as explained in the next subsection. Below we discuss the indicators used under each category and then Table 2 summarizes the indicators under each category and how they are measured.

Demographic Indicators

These are a set of demographic indicators that increase households' vulnerabilities to climate change shocks. Based on information available in our datasets, three indicators are used. These are children under 10 years of age, presence of elderly members who are sixty years of age and above in the household and presence of a disabled person in a household. For instance, younger children (under 10) are more likely to be vulnerable to harm during flooding as they are relatively short, light, cannot swim very well or flee quickly from harm (Mort et al., 2016). Furthermore, infants are at risk of heat stress as they have limited temperature regulation, compared to older children and adults. Elderly members (60 years plus) of a household are more vulnerable especially to heat waves with approximately 80-90% of this age group likely to die due to heat stress - particularly among those suffering from obesity, cardiovascular disease, respiratory disease, and diabetes (Kenny et al., 2010). Disabled members of a household are more likely to be harmed during extreme climate events (Gutnik and Roth, 2018). Thus, the presence of children less than ten years, elderly and disabled people in a household increases the likelihood of the household being vulnerable to climate change hazards. We could have included the presence of pregnant women in household as an indicator under this category they are susceptible to climate

change hazards in various ways, but this information is not available in our datasets. The indicators are measured as shown in Table 2.

Economic Indicators

Certain livelihoods/jobs particularly those that require working outdoors are sensitive to climate change shocks due to the fact that individuals working in outdoor occupations are more likely to 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). Based on our data sets, three indicators are generated in this category. These includes households that are involved in subsistence farming, households that are pastoralists and household at least one member employed in the informal ('jua kali') sector. All the three require working outdoors and thereby susceptible to climate change hazards. The indicators are measured as shown in Table 2.

Household Living Conditions

Household living conditions include four indicators and whose information is available in our datasets. These are poor housing, poor sanitation, unsafe water and inadequate information. Poor housing is ascertained based on the materials used to construct the wall, roof and floor of the house. Poor housing is any house whose floor, wall, or roof are constructed using natural materials such as mud/earth and grass. Such natural materials are vulnerable to climate change shocks such as storms and flooding. Households living in such in houses with such conditions are more susceptible to climate change shocks. Also, households may face poor sanitation condition and rely on open defecation and unimproved sanitation facilities. Such households are vulnerable to sewerage contamination during floods. Furthermore, households whose main source of drinking water is surface water are more vulnerable to climate change hazards such as drought and floods. On inadequate information, 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 that do not have access to any of this communication equipment are more vulnerable to climate change hazards. The four indicators are defined as shown in Table 2

Nutrition

We use two indicators of climate change vulnerability under this category, and these are household whose any of its member is faced by food insecurity and those with children who are under five years and stunted. Climate change hazards are likely to diminish progress on food security through production disruptions that lead to local availability limitations and price increases, interrupted transport conduits, and diminished food safety, among other

causes. Therefore, households facing food insecurity and also have stunted children are more vulnerable to climate change hazards.

Table 2: Household climate change sensitivity indicators for Kenya

Category and indicators	**Definition**
Demographic Indicators	
Younger children (under 10)	A dummy variable taking the value of 1 if a household has at least a child less than 10 years old, 0 otherwise.
Older people (aged 60 and above)	A dummy variable taking the value 1 if a household has at least one member aged 60 and above, 0 otherwise
Persons living with Disability	A dummy variable taking the value 1 if a household has at least one member living with disability, 0 otherwise.
Economic Indicators	
Subsistence Farmers (i.e. household involved in agriculture)	A dummy variable taking the value 1 if household is involved in subsistence farming, 0 otherwise.
Pastoralists	A dummy variable taking the value 1 if household is practising pastoralism, 0 otherwise
Informal sector workers	A dummy variable taking the value 1 if household is an employee in the informal ('jua kali') sector, 0 otherwise
Household Living Conditions Indicators	
Poor housing	A dummy variable taking the value 1 if a household lives in a house with mud/earth floor, natural materials for walls/roofs, 0 otherwise.
Poor Sanitation	A dummy variable taking the value 1 if a household uses open defecation & unimproved toilet, 0 otherwise
Unsafe water	A dummy variable taking the value 1 if a household main source of water is surface water, 0 otherwise
Not having a radio, TV, mobile or internet	A dummy variable taking the value 1 if a household has no access to radio, TV and mobile phone, 0 otherwise
Nutrition	
Food insecure	A dummy variable taking the value 1 if a household report that a least a member of their households was uncertain about their ability to obtain food, forced to compromise on the quality and quantity of the food they eat or have typically run out of food or gone a day (days) without eating, 0 otherwise
Stunted child under 5 years	A dummy variable taking the value 1 if a household has a child under five who is stunted, 0 otherwise

Construction of the climate change vulnerability indices

The analysis of climate change vulnerability in this paper is based on climate change vulnerability index and intensity of households' vulnerability which are constructed using several household climate change sensitivity indicators. The climate change vulnerability index is the overall index while the intensity of households' sensitivity shows the proportion of households that are not vulnerable and those that are vulnerable to 1, 2, 3,…N indicators. This section discusses the construction of the index and the household's intensity to vulnerability, followed by a discussion of the climate change vulnerability indicators and finally the datasets used in the analysis.

In our case, 12 climate change indicators equally weighted are used to construct a weighted vulnerability index for each household as shown in equation (1). Each of the 12 indicators are assigned a weight of unit which gives identical importance to each indicator, due to the fact that we do not have an empirical justification of why one indicator may be weighted higher than another.

$$\textit{Household climate change vulnerability index} = \frac{1}{N}\sum_{i=1}^{N} indicator_i \quad (1)$$

Where $indicator_i$ refers to a dummy variable for each indicator that a household is vulnerable in. N is the total number of different indicators used in the analysis, in our case, 12. The constructed index takes a value between 0 and 1 with higher scores indicative of greater household sensitivity to climate change. In addition to constructing the overall household index, we also construct a vulnerability score for each sub-set of the four (4) categories of indicators (i.e., demography, economic, housing and nutrition) to examine if households are more vulnerable in certain sub-categories, compared to others.

Another vulnerability indicator which measures intensity of households' vulnerability to climate change shocks is estimated by summing up the number of different vulnerability indicators for each household. The index takes a value from 0 (vulnerable in none of the indicators) to 12 (vulnerable in all of the indicators).

Each household's intensity to vulnerability is calculated using equation (2) as shown below.

$$\text{Household vulnerability Intensity} = \sum_{i=1}^{N} indicator_i \quad (2)$$

Where the indicators are as defined earlier.

Results

This section presents trends on indicators that are available in all, or two of the three datasets and descriptive statistics based on KIHBS 2015/15 which has data all the indicators used in the analysis. The section starts by looking at trends in climate change vulnerability indicators if data on the indicators is available in two or three datasets. This is then followed by descriptive statistics and indices analysis based on KIHBS 2015/16 data which has all the twelve indicators used in the construction of the indices.

Trends and statistics of climate change vulnerability indicators over the period 2005-2019

Three demographic indicators and all four household living condition indicators are available in all the three datasets while three economic indicators of climate change vulnerability are available for KIHBS 2015/16 and KPHC 2019. Indicators for nutrition are only available in KIHBS 2015/16. The ten indicators that are available in two or three of the datasets are displayed on Figure 1, which generally shows how the indicators have evolved over time in the period 2005 to 2019. Before discussing the trends in climate change indicators, it is important to mention that we converted some indicators from individual data to household level measures and this resulted in differences in measure when using individual data compared to when household data. The indicator converted from individual level to household level data include children less than 10 years old, old people aged 60 years and above and disabled people. Table 1 in the appendix shows that the proportion of the indicators measured at household level are higher than those measured using individual level data.

As shown in Figure 1, five of the indicators appear to have declined over time. The proportion of households with children below 10 years have declined over time from 68.9% in 2005/06 to 56.5% in 2015/16 and the final to 53.1% in 2019. Likewise, the proportion of poor household living conditions declined from 61.3% in 2005/06 to 48.3% in 2015/16 and then to 46.9% in 2019. In addition, poor sanitation seems to have steeply declined over the same period from 51% in 2005/06 to 17.5% in 2019. The proportion of households receiving inadequate information also declined over the period from 17.1% in 2005/06 to about 3% in 2019 while proportion of households with at least one of its members working in informal sector ('jua kali') declined from 12.8% in 2015/16 to 6.2% in 2019. The proportion of household practising pastoralism and those with at least an elderly person seem to have remained fairly the same in 2015/16 and 2019 at about 4% and about 18% respectively. Households practising subsistence farming increased from 30.7% in 2015/16 to 34.2 % in 2019. Similarly, household with at least a disabled person increased over time from 5.3% in 2005/06 to 10.2% in 2019. Finally, the proportion of household using unsafe water declined between 2005/06 and 2015/16 and then increased between 2015/16 and 2019.

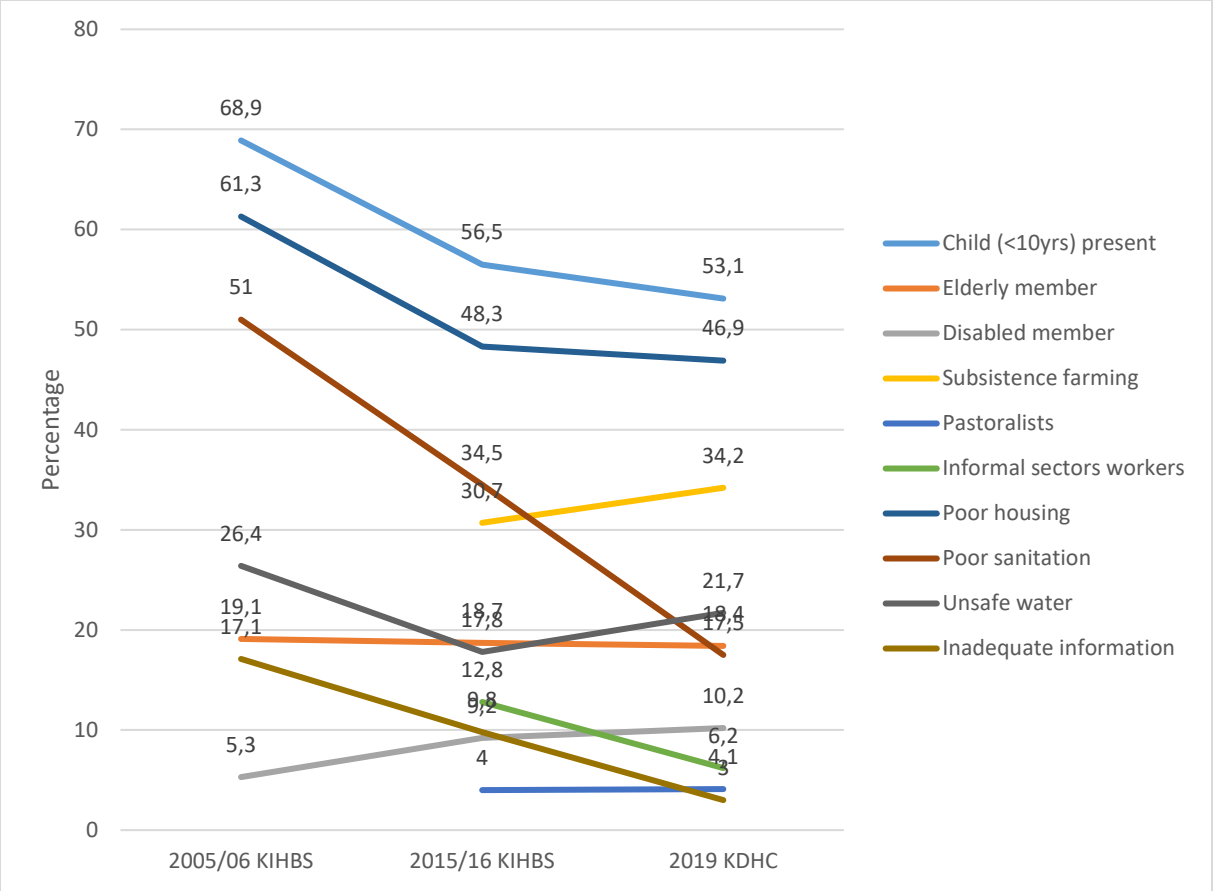


Figure 1: Annual Trends in Climate Vulnerability Indicators, 2005 - 2019

Source: Own estimates based on KIHBS 2005/06 and 2015/16 and KPHC 2019

As mentioned earlier, given that KIHBS 2005/06 and KPHC 2019 do not have data on all the climate change vulnerability indicators that are required to construct climate change vulnerability indices, the construction and analysis of the indices is based on KIHBS 2015/16 data which has data on all the required indicators. Henceforth, the analysis below was based on KIHBS 2015/16 and is disaggregated by the region (rural/urban areas and counties), gender of the head of household, household poverty status and wealth quintiles and by education level of head of household. This analysis begins by looking at the descriptive statistics of the indicators followed by a discussion on the climate change vulnerability indices.

Table 3 shows the descriptive statistics for the 12 climate change vulnerability indicators used in the construction of the household-level climate vulnerability indices. The proportion of households with at least one child under the age of 10 years is 56.6%, with the proportion of such households found in rural areas being 63.6% compared to 47.3% for urban areas. The proportion of the households with at least one child less than 10 years is higher among the poor than non-poor households, in male headed than in female headed households, in

the least wealthy than in the richest households and in households with no education of lower education compared to those with higher education. About 19% of all households in the sample have members who are at least 60 years of age, with a higher proportion observed in rural (25.6%) than in urban areas (9.7%). The proportion of the elderly is also higher in female headed households (24.9%) than in male headed households (15.7%). The presence of elderly members appears to decline with increasing wealth status of the household and with the higher level of education of head of the household. About 9% of households have a member living with disability. Disability appears to be higher in rural areas (12.1%), compared to (5.5%) in urban areas, and in female-headed and poor households compared to male-headed and non-poor households, respectively. The proportion of persons living with disability declines with the level of wealth of the household and with the level of education of the household head.

Table 3: Summary Statistics for Climate Change Sensitive Indicators at Household Level, by Subgroups, 2015/16

Indicators at household level	All	Urban	Rural	Male HH	Female HH	Poor	Non-poor	Q1	Q2	Q3	Q4	Q5	None
Demographic													
Child (<10yrs) present	56.5	47.3	63.6	57.6	54.1	70.4	52.2	60.9	62.0	61.3	56.7	47.6	53.8
Elderly member	18.7	9.7	25.6	15.7	24.9	25.4	16.1	28.2	21.2	24.2	17.8	9.4	50.5
Disabled member	9.2	5.5	12.1	8.2	11.4	13.7	7.5	12.4	11.6	10.9	9.7	4.7	17.0
Economic													
Subsistence farming	30.7	9.1	47.4	29.2	33.8	36.4	28.6	34.6	42.6	44.9	34.2	9.5	38.6
Pastoralists	4.0	0.5	6.7	3.7	4.6	8.5	2.3	16.0	3.1	2.7	2.4	0.6	17.6
Informal sectors workers	11.3	14.8	8.5	13.6	8.5	12.3	10.9	7.6	11.6	9.8	12.7	10.7	4..8
Living Conditions													
Poor housing	48.3	19.4	70.7	46.2	52.6	72.7	39.0	87.4	73.4	63.4	40.0	9.5	81.3
Poor sanitation	34.5	12.6	51.5	32.4	38.9	52.3	27.8	70.9	51.7	44.5	27.2	4.9	64.9
Unsafe water	17.8	5.5	27.4	16.0	21.6	26.1	14.7	34.2	29.7	21.1	13.7	3.2	33.8
Inadequate information	9.8	4.1	14.1	7.1	15.3	18.5	6.5	45.5	8.4	6.6	2.0	0.8	35.3
Nutrition													

Food insecurity	64.6	58.2	69.5	61.7	70.5	82.9	57.7	83.6	74.9	71.0	60.3	47.8	82.7
Stunted child present	9.6	6.9	12.7	10.3	8.3	14.5	7.8	16.7	12.5	11.8	7.2	4.9	12.1

Source: own calculation based on KIHBS 2015/16

In terms of economic activities, job/livelihood activities performed outdoors, subsistence farming constitutes 30.7% while pastoralism constitutes 4% and as expected these are much more of rural activities than urban areas and are practised more by female headed households, poor households and household heads with lower education level. Those employed in informal sector constitutes 12.6% of the households with higher proportions in the urban areas, male headed household, poor household and households whose heads have lower education level.

With respect to household living conditions, 48.3% of the households live in poor housing conditions particularly houses with floors, walls or roofs made from natural material including mud/earth. A higher proportion of households living in poor housing conditions are in the rural areas, female headed households, a mong the poor households and among those households whose heads have with no or have lower education level. Another important observation is that poor housing conditions decline as wealth increases. A similar picture can be observed with respect to household with poor sanitation and unsafe water. About 34.5% and 17.8% of the households have access to poor sanitation and unsafe water, respectively, with a higher proportion of households in rural areas, female headed and poor households. They also decline with the level of wealth of households and level of education of household head. With respect to access to information, 9.8% of the households have access to inadequate information. Again, the proportion of households accessing inadequate information is higher for rural, female headed, poor households and households whose heads have no education or have lower education levels.

About 64.6 % of households in the sample are food insecure. Again, food insecurity is higher in rural (70%), compared 58.2% to urban areas, and higher in female-headed (70.2%), compared to 61.7% in male-headed households. The poor households are most affected by food insecurity at 82.9%. Again, households faced with food insecurity decline with the level of wealth and the level of education of the household heads. About 84% of households in the lowest wealth quintile are food insecure, compared to only 47.8% of households in the highest wealth quintile, suggesting that food security is directly related with the wealth status of households with a similar picture based on education level of the household head. On anthropometric measures, about 9.6% of households have at least one stunted child. This is more prevalent in rural (13%), compared to urban (7%) households, male-headed (10%) compared to female-headed (8.3%), poor households (14.5%) households and non-poor

households (7.8%) respectively. The incidence of stunted children decreases with increased wealth status of the household- ranging from 17% of the poorest households having stunted children to 5% of households in the richest household and also with the education level. The incidence also declines with the level of education of the household head.

Climate Change Vulnerability Indices

Two indices of households' climate change vulnerability are constructed from 12 household-level climate change sensitive indicators discussed earlier. The first is the overall and has sub-indices based on four categories, that is, demographic, economic, households living conditions and nutrition. The climate change vulnerability indices range from 0 (indicating low vulnerability to climate change) and 1 (indicating high vulnerability to climate change). The sub-indices are also constructed in a similar way. The second indicator is the intensity of the households' climate change intensity, which sums up the total number of indicators that households are vulnerable in. This measure ranges from 0 to 12, with households' intensity to climate change vulnerability being greater the high the number of indicators a household is vulnerable in.

Climate Change Sensitivity at the National Level

Figure 2 shows estimates of these indices at the national level. As shown in the figure most households are vulnerable in one and two indicators and 8.2% of households are not vulnerable in any of the indicators while 0.2% of all households in the sample are vulnerable to 9 or more indicators. However, no household is vulnerable to all 12 indicators. The overall climate change vulnerability index shows that 26.3% of households in the sample are vulnerable to climate change shocks. Sensitivity due to poor nutrition contribute the most to households' overall climate change vulnerability with a score of 37.1%. This is followed by vulnerability due to demographic structure (28.1%), vulnerability due to household living conditions (27.6%) and due to household economic livelihood/job contributes the least (15.3%) to average climate change vulnerabilities in the sample.

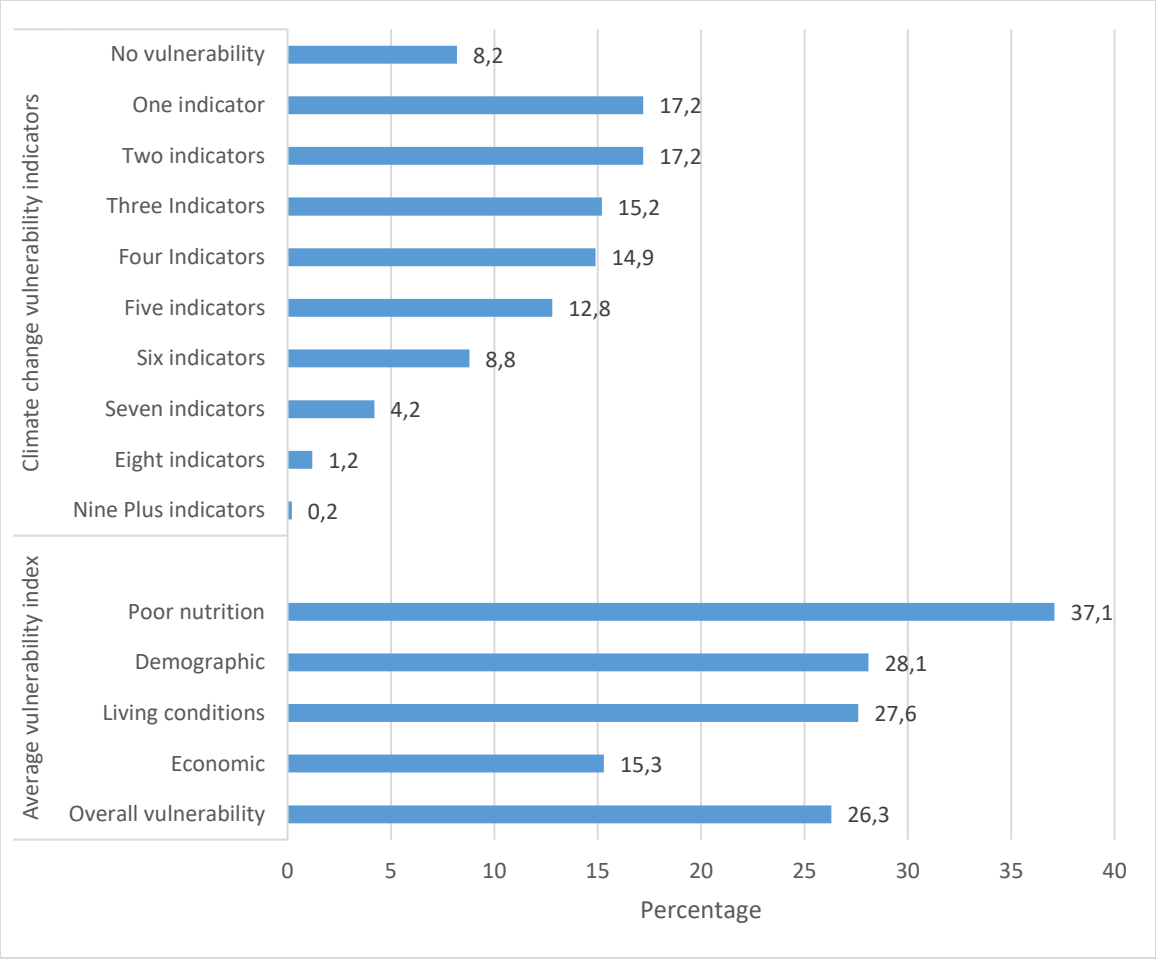


Figure 2: Climate Change Vulnerability in Kenya, 2015/16

Source: own calculation based on KIHBS 2015/16

Climate Change Vulnerability by Region

In terms of regions, Figure 3 shows differences in measures of climate change vulnerabilities for rural and urban areas. Most (30.9%) urban households seem to be vulnerable in one climate change vulnerability indicators while most (25%) rural households are vulnerable in four climate change vulnerability indicators. While 15.5% of the urban households are not vulnerable in any of the indicators only 2.6% the rural households are not vulnerable in any of the indicators. The proportion of urban households vulnerable to climate change in two or less indicators is higher than that for rural households while the proportion of rural households vulnerable to climate change in three or more indicators is higher than that for urban households. Additionally, the overall climate change vulnerabilities, across all sub-categories, are higher in rural compared to urban areas. In the rural areas, poor nutrition and household living conditions contribute more to climate change sensitivity at about 41% while for urban areas poor nutrition contributes more to climate change sensitivity at 32.1%.

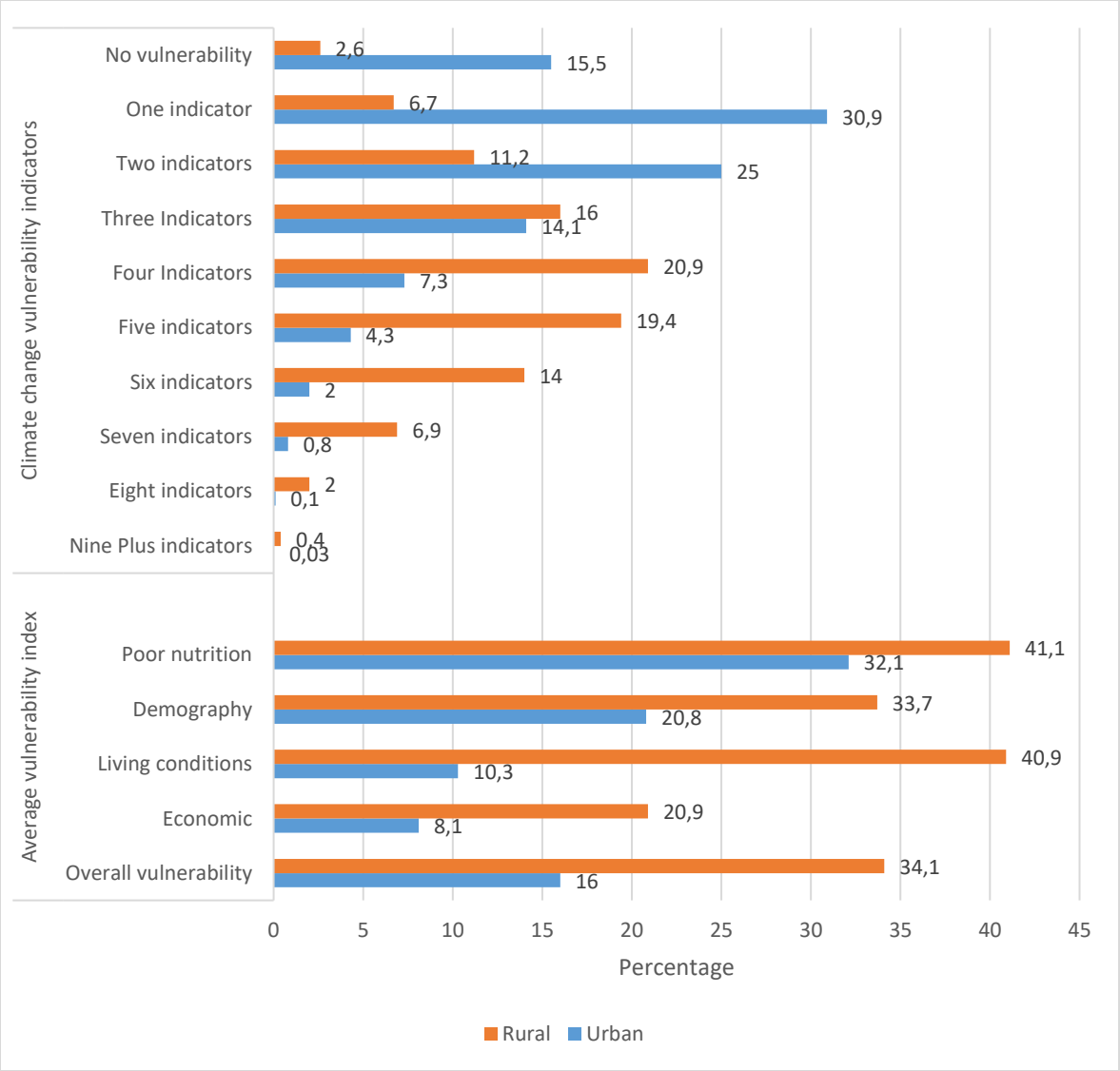


Figure 3: Climate Change Vulnerability by Rural/urban location, 2015/16

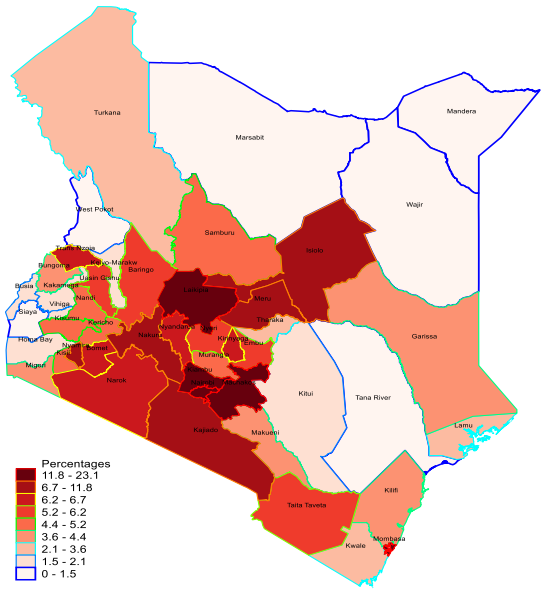
Source: own calculation based on KIHBS 2015/16

There is variation in climate change vulnerability indices and intensity across the counties as shown in Figures 4, 5 and 6 below and in Appendix Tables 1 and 2. Figure 4, panels A and B are maps showing households that are not vulnerable to any of the climate change vulnerability indicators and vulnerable to 1-3 vulnerability indicators respectively. As shown in the two maps, most of the households in counties in the central, southern, Nairobi and parts of the Rift Valley are not vulnerable to any of the indicators or 1-3 climate change vulnerability indicators. Relatively low proportions of households in these categories are in counties in Western, Northern, Eastern and Coastal part of the country. Figure 4 panels C and D shows maps for households that are vulnerable to 4-6 vulnerability indicators and 7 or more indicators respectively. The two show that households that that are vulnerable to 4

and more vulnerability indicators are concentrated in counties in western, northern, eastern and coastal parts of Kenya with a small proportion of households in the Rift Valley, Central, Nairobi and Southern parts of the country. From this presentation and discussion, it one can identify counties where households are more vulnerable to climate change shocks.

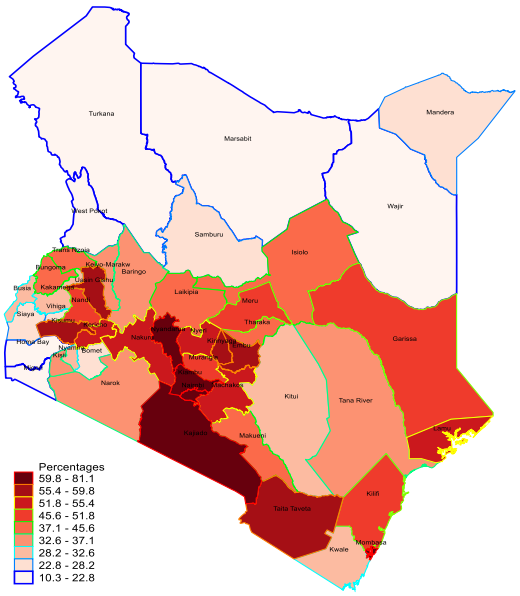
A

Not Vulnerable to any Climate Change vulnerability indicator



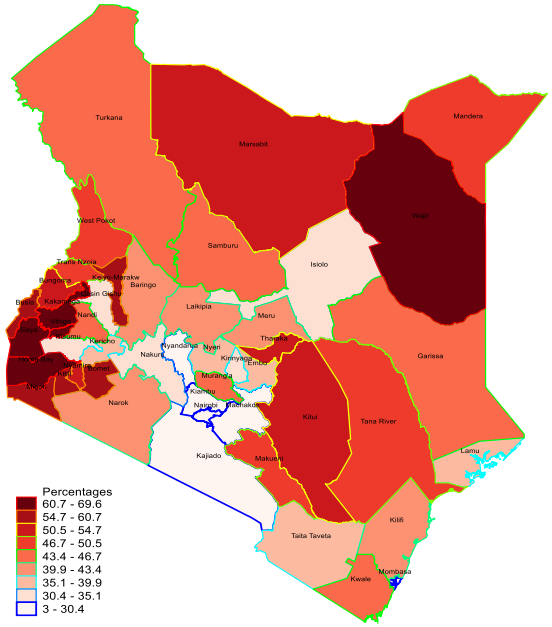
B

Vulnerable to 1-3 Climate Change Vulnerability Indicators



C

Vulnerable to 4-6 Climate Change Vulnerability Indicators



D

Vulnerable to 7 or more Climate Change Vulnerability Indicators

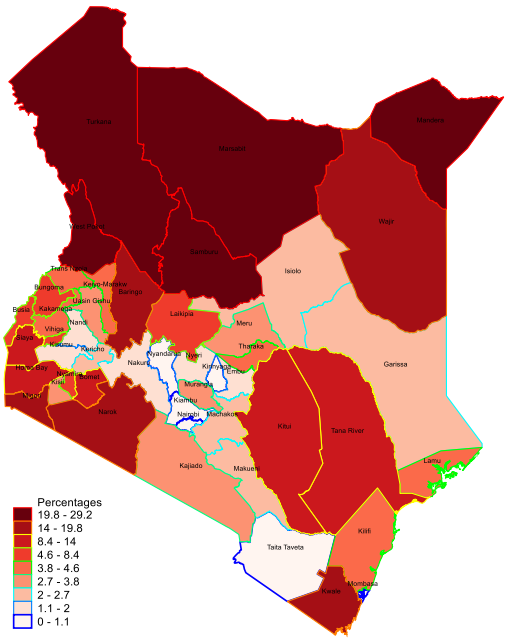


Figure 4: Maps for Household's intensity of climate change vulnerability by county

Source: own calculation based on KIHBS 2015/16

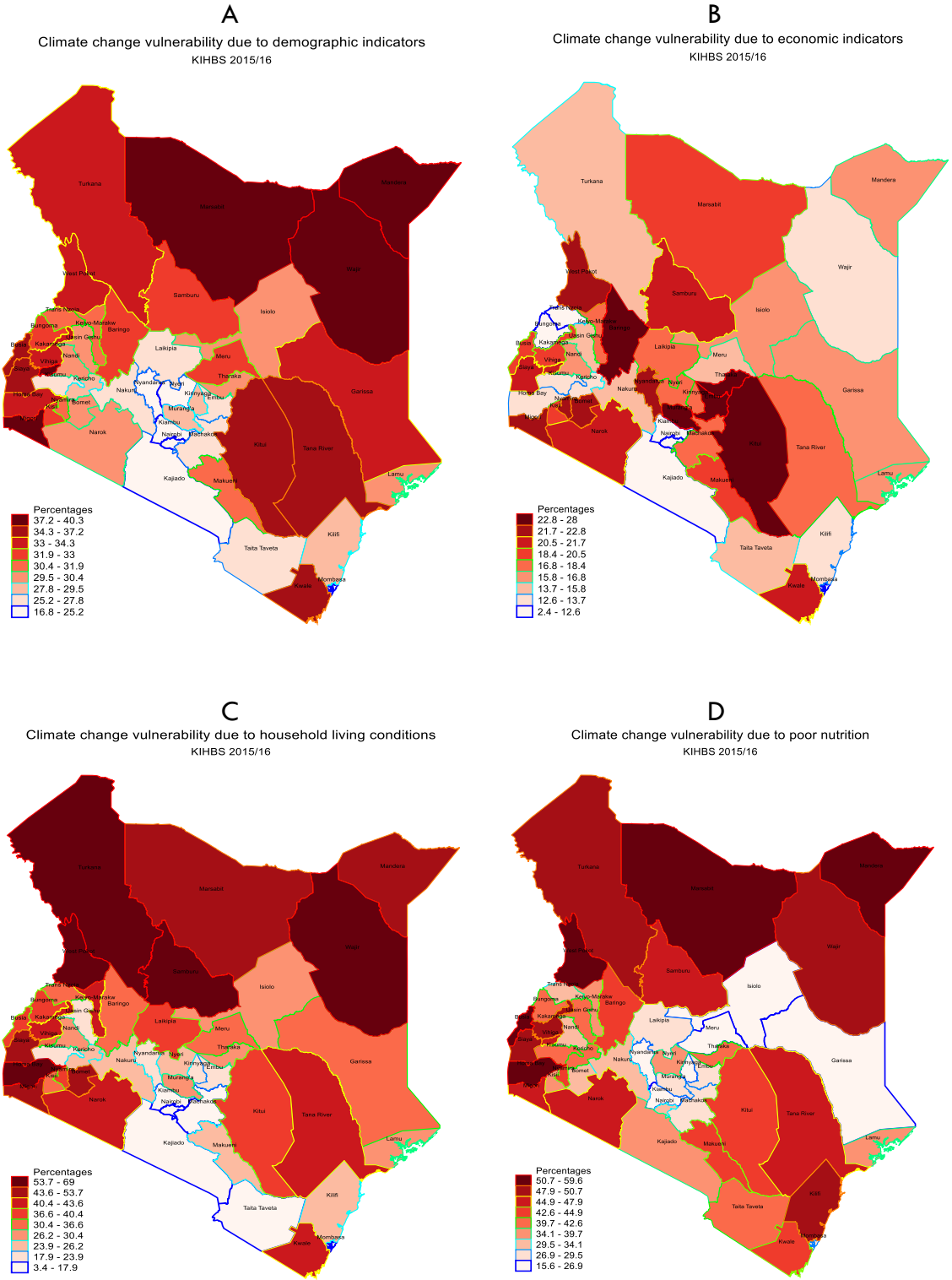


Figure 5: Maps for Household climate change vulnerability indices by county

Source: own calculation based on KIHBS 2015/16

Figure 5 shows maps representing climate change vulnerability indices based on demographic, economic, household living conditions and poor nutrition. Panel A shows that for demographic index, except for counties in central, southern and several counties in rift valley regions of Kenya, demographic sources contribute more to climate change vulnerability to households in the remaining counties, that is, western, northern and eastern and parts of coastal areas. On the other hand, economic sources of sensitivity contribute more to household sensitivity in counties in central and rift valley region and in a few counties in western and coastal regions. As shown in panel C, household living conditions contribute more to households in northern, western, eastern and coastal parts of Kenya compared to those in central and southern parts of Kenya. Finally, panel D shows that vulnerability due to poor nutrition contribute more to households in northern, western, eastern, southern and coastal parts of the country but less for those households in counties in central and rift valley part of Kenya.

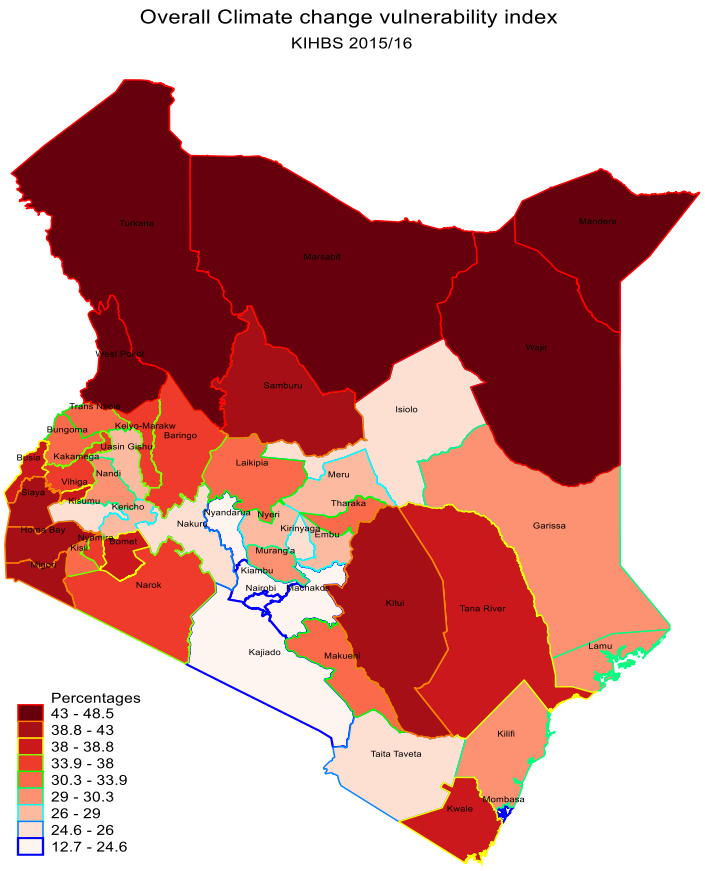


Figure 6: Map for overall climate change vulnerability index by county

Source: own calculation based on KIHBS 2015/16

Figure 6 shows a map representing the overall climate change vulnerability index. As shown on the map a higher proportion of households in counties in western, northern, eastern and coastal parts of Kenya compared to those in parts of the rift valley, central, Nairobi and southern parts of Kenya are vulnerable to climate change shocks.

Climate Change Vulnerability by Gender of the Household Head

Figure 7 show climate change vulnerability indicators and indices by gender of the household head. Most (16.4%) of the female-headed households appear to be vulnerable in four indicators while most (18.2% of the male headed households are vulnerable in two indicators. The proportion of male headed households vulnerable in three or less indicators is higher than that for female headed households while the proportion of female headed households vulnerable in four or more indicators is higher than that for male headed households. A higher proportion of male-headed households (8.5%) are not vulnerable to any of the indicators compared to female headed households (7.6%). Except for economic sensitivity index, on average climate change vulnerabilities, across all sub-categories and the overall index are higher for female headed households than for male headed households. For both male and female headed households, Poor nutrition and Household living conditions contribute more to overall climate change vulnerability than demography and economic indicators.

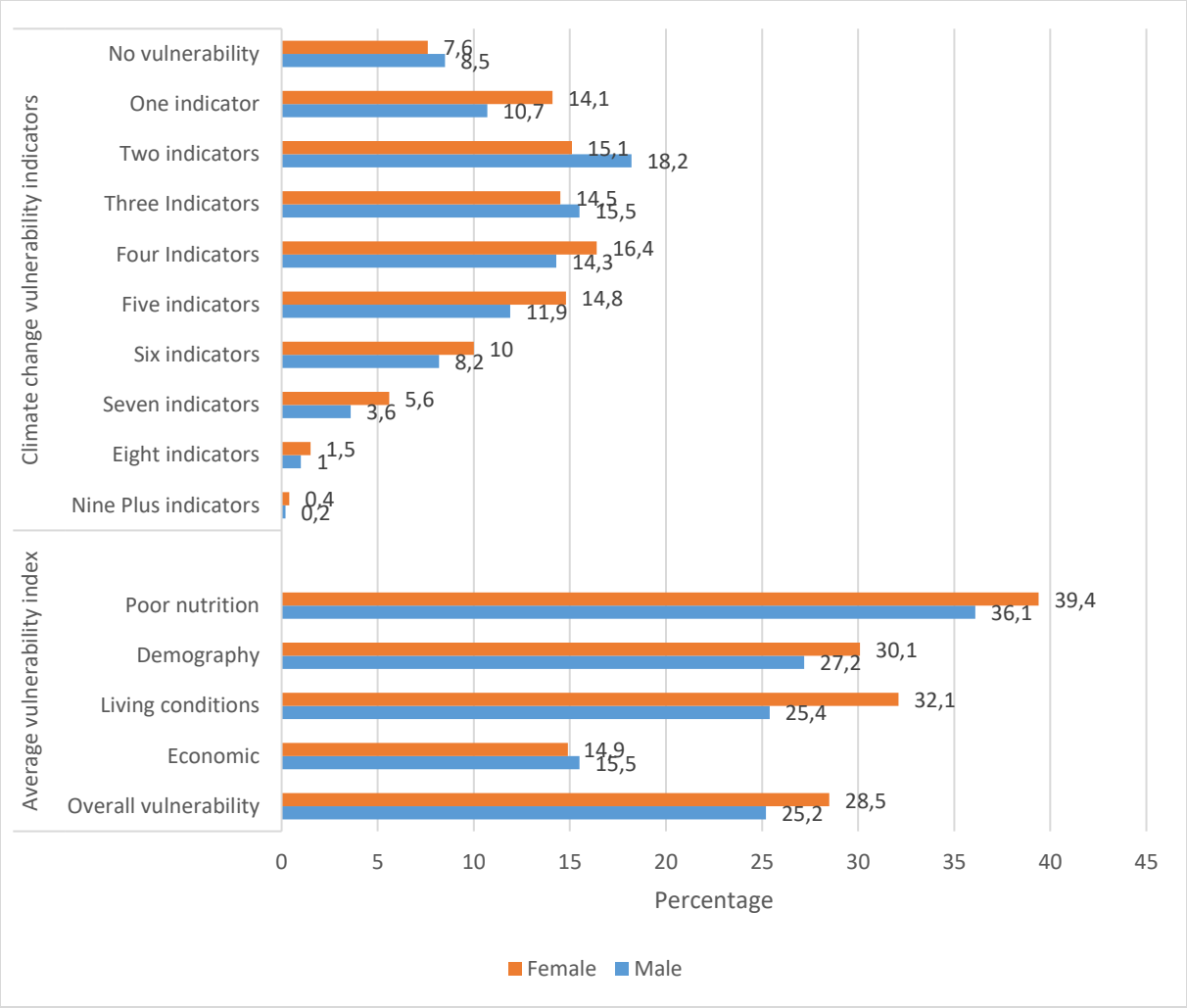


Figure 7: Climate Change Vulnerability by gender of household head, 2015/16

Source: own calculation based on KIHBS 2015/16

Climate Change Vulnerability by Poverty Status

Analysis by poverty status (see Figure 8) shows that most (21.6%) of the non-poor households are vulnerable in one indicator compared to the poor households who are most (19.6%) vulnerable in five indicators. About 10.8% of the non-poor households are not vulnerable in any of the indicators compared to 1.2% for the poor households. Most of the non-poor households appear to be more vulnerable in two or less indicators compared to the non-poor households while poor households appear to be vulnerable in three or higher indicators compared to non-poor households. On average climate change vulnerabilities across all sub-categories are higher for poor households than non-poor household. Poor nutrition and housing living conditions contributed relatively more to the overall climate

change sensitivity index for the poor households while poor nutrition and demographic structure contributed relatively more to climate change sensitivity for the non-poor households.

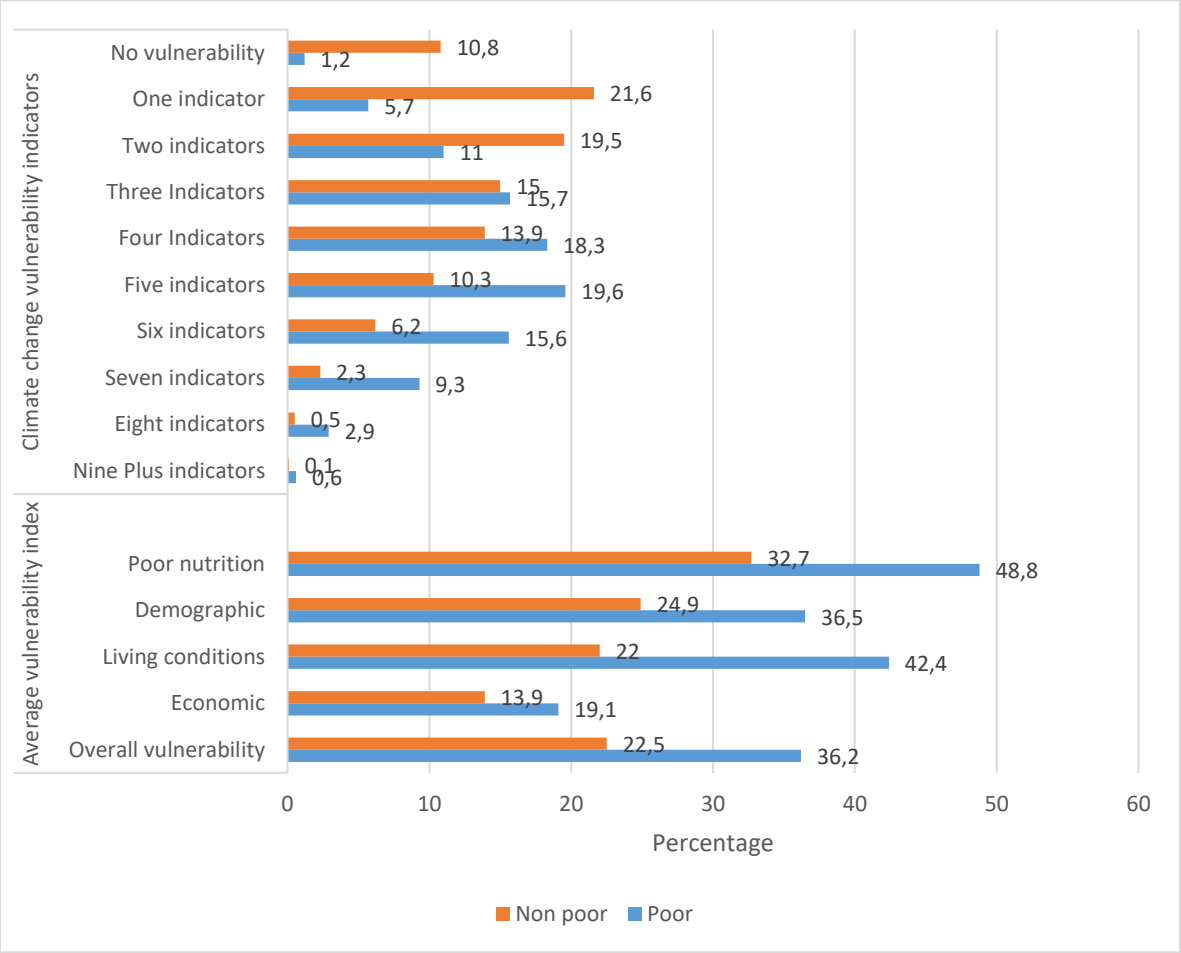


Figure 8: *Climate Change Sensitivity by poverty status, 2015/16*

Source: own calculation based on KIHBS 2015/16

Climate Change Vulnerability by Wealth Quintiles

Figure 9 shows both measures of climate change vulnerabilities by wealth quintiles. As shown in the figure, households that are not vulnerable to any of the climate change vulnerability indicators and those that are affected by one and two vulnerability indicators appear to be more concentrated in the fifth wealth quintile with most of the households in the fifth quintile being affected by one vulnerability indicator. Households in the fourth quintile are most vulnerable in two indicators while those in the third quintile are most vulnerable in four indicators. Finally, households in the first and second quintiles are most

vulnerable in five indicators and dominate those in the fourth and fifth quintiles in sensitivity of more than four indicators.

Further, as shown in the in Figure 9, the overall climate change index shows that those in the poorest quintiles are more vulnerable than those in the richest quintiles and that sensitivity declines as one moves from the poorest quintile to the to the richest quintile. Household living conditions and poor nutrition contributes more to climate change sensitivity for households in the poorest quintile to the fourth quintile while poor nutrition and demographic structure contributes more to household sensitivity in the richest quintile.

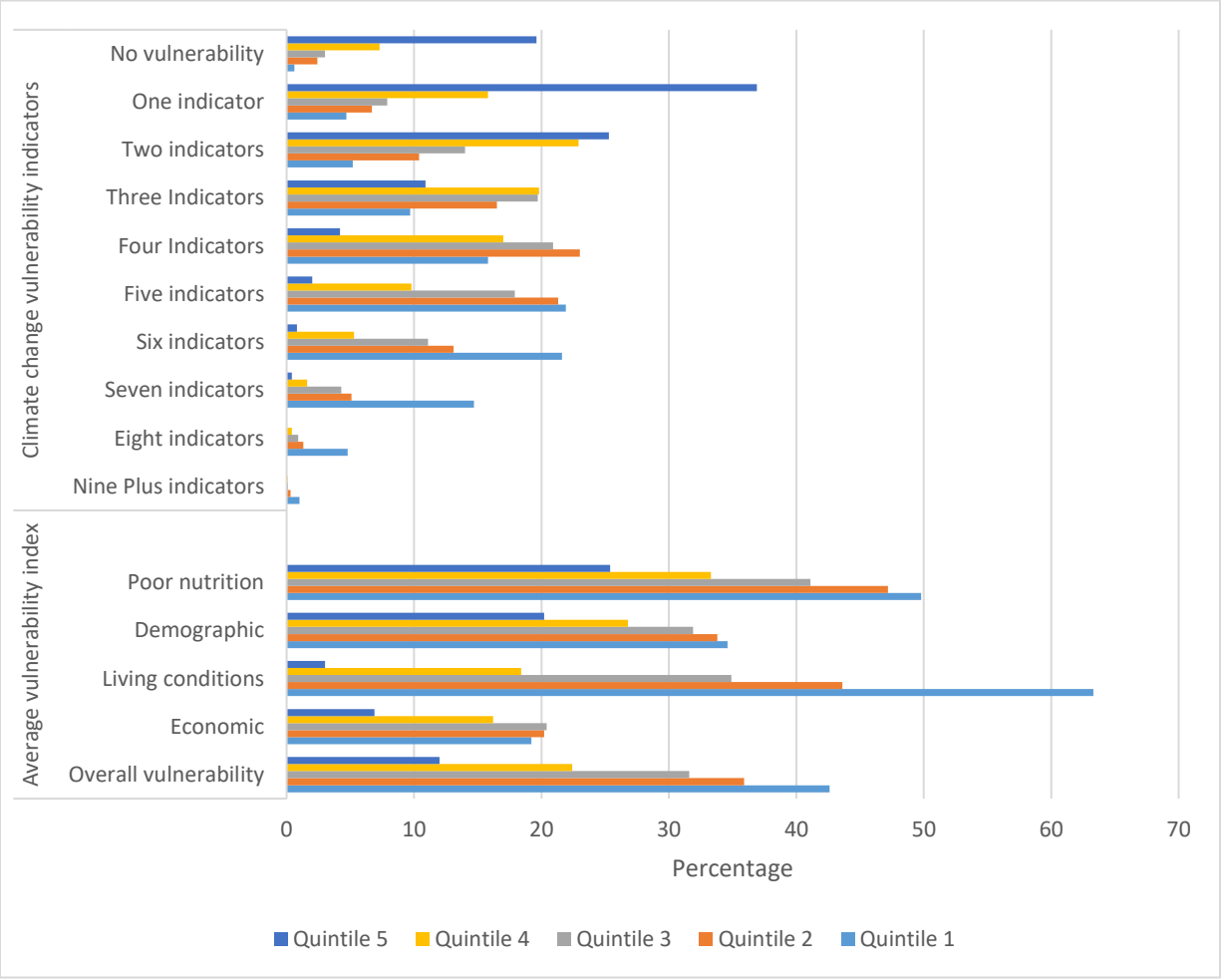


***Figure 9**: Climate Change Vulnerability by wealth quintiles 2015/16*

Source: own calculation based on KIHBS 2015/16

Climate Change Vulnerability by Education Level of Household Head

Figure 10 shows measures of climate change vulnerabilities by education level of head of household. As shown in the figure, households that are not vulnerable to any of the climate change vulnerability indicators and those that are affected by one and two vulnerability indicators seem to be more concentrated in among households whose heads possess secondary and higher education with most of the households being affected by one vulnerability indicator. Households whose head of household has primary education are most vulnerable in four climate change vulnerability indicators while households whose heads have no education are most vulnerable in five and six vulnerability indicators.

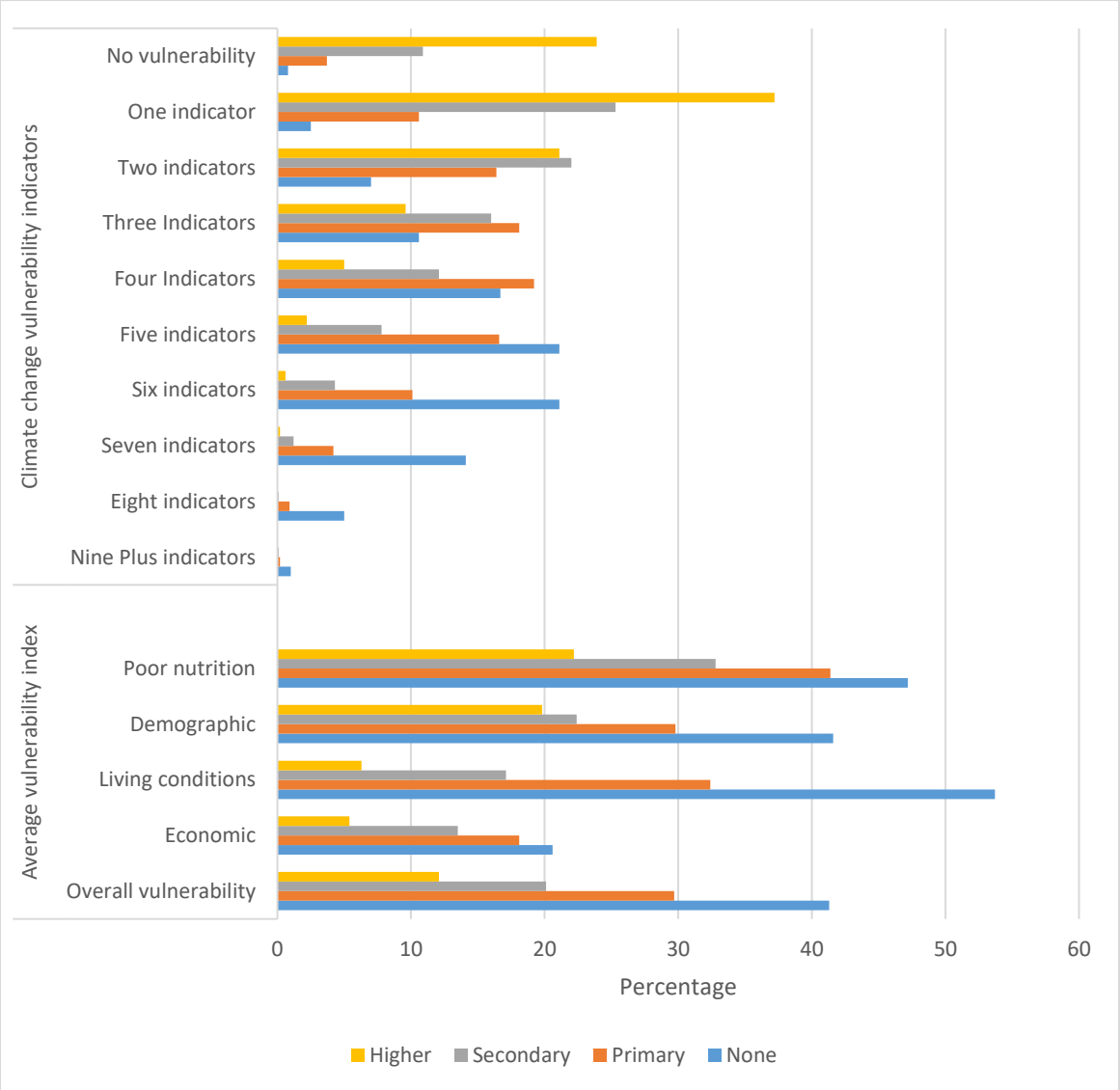


Figure 10: *Climate Change Vulnerability by Education Levels, 2015/16*

Source: own calculation based on KIHBS 2015/16

Figure 10 also shows that the overall climate change index shows that climate change sensitivity declines with level of education. Households whose heads have no education are most vulnerable to climate change shocks and households whose heads have higher education are least vulnerable. Household living conditions and poor nutrition contributes more to climate change sensitivity for households whose head have no formal education and those with primary education while poor nutrition and demographic structure contributes more to household sensitivity in households whose head has secondary education and those with higher education.

Bivariate Relationship Between Climate Change Shocks and Household Climate Change Vulnerability

In this sub-section, we analyse the spatial bivariate correlation between climate shocks and vulnerabilities at the county level for five years preceding and including the survey years 2015/16. 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, non-governmental 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. For Kenya, there has been a total of about 412 events that meet the above criteria between 1997 and 2018. The climate shocks variable used in this paper is constructed as the number of events that occurred in various counties in Kenya

in the five years preceding, and including, the years of data collection.

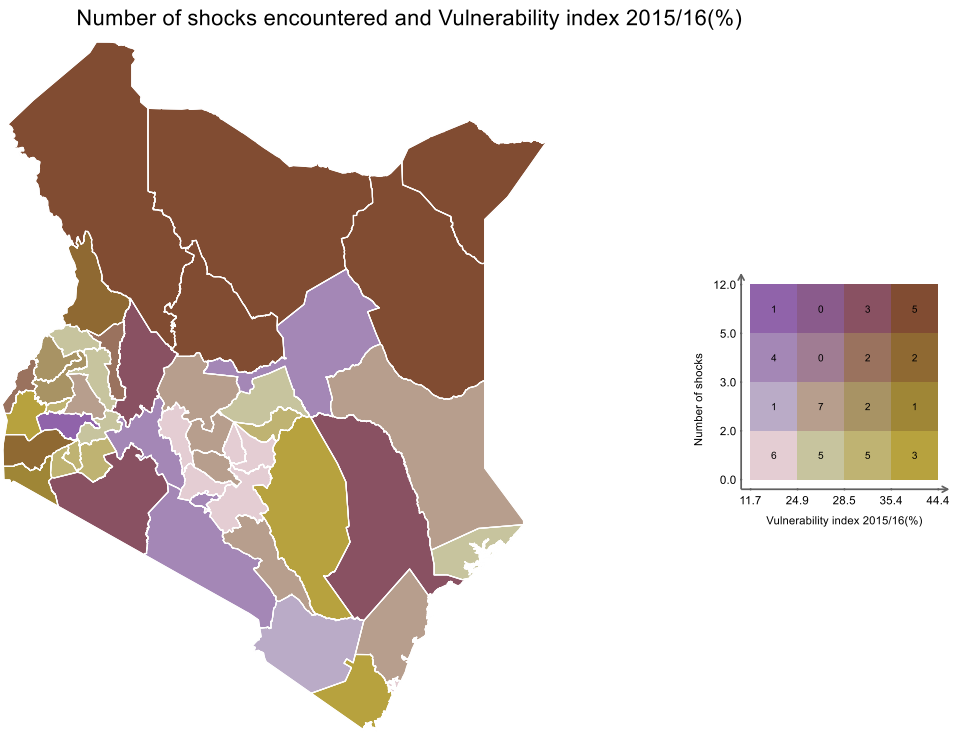


Figure 11: Bimap on number of climate change shocks encountered and sensitivity in each county

As shown in Figure 11, there are strong overlaps in shocks and vulnerabilities in counties in the northern, western, parts of the rift valley and coastal regions of Kenya. There is weak correlation in shocks and vulnerabilities in counties in the central, Nairobi and southern part of Kenya. Generally, the correlation seems to be high in many of the counties identified to have high climate change vulnerabilities.

Summary and Conclusions

There is no doubt that Kenya's climate is changing with the country experiencing rising trend in temperatures which is expected to continue. Kenyans are feeling the impacts of climate change through higher temperatures, unpredictable rainfall patterns, increased incidence of droughts and floods, and rising sea levels. Extreme weather events have led to loss of lives, diminished livelihoods, reduced crop and livestock production, and damaged infrastructure, among other adverse impacts. Given these occurrences, there is no doubt that the Kenyan population is vulnerable to climate Change shocks since the key drivers of the economy are climate sensitive.

This paper uses household level climate change vulnerability indicators to construct climate change vulnerability indices that are used to carry out a spatial and socioeconomic analysis of climate change sensitivity in Kenya. Three datasets, that is, KIHBS 2005/06, 2015/16 and KPHC 2019 are used in the analysis of climate change vulnerability indicators while the KIHBS 2015/16 is used to analyse climate change vulnerability indices through descriptive statistics, spatial and socioeconomic analysis of climate change sensitivity. This is because KIHBS 2015/16 is the only dataset that has data on all the household level climate change indicators required for the construction of the climate change sensitivity indices. Whereas a large and growing literature on climate change sensitivity indices is done at national or sometimes regional level, this study uses household level climate change vulnerability indicators to carry out analysis at national level and by regions and household socioeconomic characteristics. The aim is to identify and map areas and groups that are most vulnerable to climate change shocks in Kenya.

The analysis shows a declining trend in proportion of some of the climate change vulnerability indicators such households with children below 10 years, household experiencing poor housing living conditions, poor sanitation, households receiving inadequate information and households with at least one of its members working in informal ('Jua Kali') sector. The proportion of household practising pastoralism and those with at least an elderly person seem to have remained fairly the same while households practising subsistence farming and household with at least a disabled person increased over time. Finally, the proportion of household using unsafe water declined between 2005/06 and 2015/16 and then increased. Nearly all climate change vulnerability indicators are higher in rural than urban areas, for female headed households than for male headed households, for poor than non-poor household and for lower/no formal education compared to higher education levels. Generally, the indicators decline with household wealth and the level of education of the household head.

The overall climate change vulnerability index is higher for rural households than for urban households with most urban households affected by one vulnerability indicator while most rural households affected by four vulnerability indicators. Poor nutrition contributes more to the overall sensitivity among urban households while, poor nutrition and household living conditions contributes more to overall sensitivity for households in the rural areas. Many of the households in counties in the western, northern, eastern and coastal areas of the country are more vulnerable to climate change shocks than those in Central and parts of the rift valley of Kenya. Also, climate change sensitivity is higher for households headed by women, households whose head has no formal education/lower education and for poor households. Most male headed households are vulnerable to one indicator compared to four indicators for female headed households while most non-poor households are vulnerable to one indicator compared to five indicators for the poor households. Similarly, households headed

by individuals with secondary education or higher are most vulnerable to one indicator compared to those with less than secondary education most of whom are vulnerable to four, five and six indicators. Poor nutrition and poor household living conditions and, in some cases, demographic structure seem to contribute more to the overall climate change sensitivity. Further, climate change seems to decline with household wealth and education level of the head of household. Finally, we observe strong spatial bivariate correlations between climate change shocks and sensitivities at the county level in Kenya.

In terms of policy, our study shows that households that are most vulnerable to climate change shocks are in rural areas and are more concentrated in certain counties than others. Also, most poor households and those that are headed by females and individuals with no education or lower levels of education are more vulnerable to climate change. Clearly there are regions and counties with greater experiences of climate change shocks, plus higher sensitivities. The government can, therefore, target rural areas, the poor and areas that experience climate change shocks and high vulnerabilities in an effort to reduce household sensitivity to climate shocks. Even as the government continues to put in place mitigation measures to reduce and curb greenhouse gas emissions more adaptation measures should be undertaken to help reduce sensitivity to climate change hazards. In particular, action should be taken to ensure long term food and nutrition security and improvements in household housing living conditions by ensuring decent housing and access to safe water and sanitation.

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Appendices

Table1: Difference in climate change estimates when using individual and household level data (%).

Indicators	2005/06 KIHBS		2015/16 KIHBS		2019 KPHC	
	Household	Individual	Household	Individual	Household	Individual
Young children (under 10yrs)	68.9	29.1	56.5	27.8	53.1	25.8
Older people (60 Plus years)	19.1	5.4	18.5	5.7	18.4	5.8
Disabled People	5.3	1.1	9.2	2.8	10.2	7.8
Stunted children under 5 years	-	-	9.6		-	-

Source: Own estimates using data from KIHBS 2016

Table 2: List of assets used in the estimation of wealth index

No	Asset	weight
1	Piped Water	0.0922
2	Flush Toilet	0.0894
3	Refuse removal	0.1165
4	Access to Electricity	0.0116
5	Gas Cooker	0.1520
6	Electric Cooker	79.709
7	Improved Jiko	0.0035
8	Kerosene Stove	0.0026
9	Internet Connection	0.0267
10	Coffee Table	0.0036
11	Dining Table	0.0258
12	Sofa sets	0.0052
13	Chairs	0.0032
14	Beds	0.0018
15	Refrigerator/Freezers	0.6157
16	Washing Machine	240.53
17	Micro-Wave Oven	4.0416
18	Vacuum Cleaner	835.75
19	Sewing Machine	0.2363
20	Water Dispenser	2.8118
21	Rice cooker	35.760
22	Air Conditioner/Fans	1.3499
23	Wheel barrow	0.0197
24	Mobile Handset-basic/smartphone	0.0022
25	Home theatre	2.4542
26	Television/radio	0.0022
27	Antennae (aerial)/Satellite/Decoder	0.0377
29	Computer (Desktop/ Laptop/ Tablet)	0.0533
30	Car for personal use	2.6562
31	Pick-Up for personal use	1.4722
32	Motorcycle for personal use	0.0500
33	Bicycle/Tricycles for personal use	0.0316
34	Animal-drawn vehicles	0.0119

Source: Own estimates using data from KIHBS 2016

Table 3: Household's intensity to Climate change vulnerability 2015/16

County	Not Vulnerable	Vulnerable to 1-3 Indicators	Vulnerable to 4-6 Indicators	Vulnerable to 7 or more Indicators
Mombasa	20.8	73.7	5.5	0
Kwale	3.6	32.6	46.3	17.5
Kilifi	3.9	51.8	40.5	3.9
Tana River	1.1	35.0	50	14.0
Lamu	3.2	54.8	37.3	4.6
Taita Taveta	6.2	57.8	35.2	1.0
Garissa	4.4	49.0	44.2	2.4
Wajir	0.3	10.3	69.6	19.7
Mandera	0	24.7	50	25.3
Marsabit	0.4	22.8	52.8	24.0
Isiolo	10.6	41.6	34	2.4
Meru	7.4	47.7	41.7	3.2
Tharaka Nithi	3.3	41.6	51.3	3.9
Embu	6.0	56.9	35.9	1.2
Kitui	1.6	30.0	54.5	13.9
Machakos	15.4	54.0	27.8	2.7
Makueni	4.2	45.6	48	2.2
Nyandarua	6.7	62.3	30.4	0.6
Nyeri	5.9	55.4	37.6	1.2
Kirinyaga	6.4	57.4	35.1	1.1
Muranga	5.0	47.6	43.7	3.7
Kiambu	23.1	66.6	10.3	0
Turkana	2.4	22.8	46.7	28.5
West Pokot	1.5	18.8	50.5	29.2
Samburu	4.7	25.7	44.8	24.8
Trans Nzoia	6.6	42.1	46.9	4.4
Uasin Gishu	5.4	55.8	34.9	3.8
Elgeyo Marakwet	1.7	37.1	56.9	4.4
Nandi	4.9	49.5	43.9	1.8
Baringo	5.8	36.6	40.1	17.5
Laikipia	12.9	38.6	40.1	8.4
Nakuru	8.7	54.7	34.5	2.0
Narok	6.5	33.2	43.4	16.9
Kajiado	11.8	70.0	15.5	2.8
Kericho	4.9	52.9	39.9	2.4
Bomet	6.5	24.6	59.7	9.3

Kakamega	1.8	29.7	64.2	4.3
Vihiga	2.1	28.2	63.4	6.2
Bungoma	4.3	38.2	52.6	5.0
Busia	2.0	29.1	60.7	8.2
Siaya	1.4	23.9	61.1	13.6
Kisumu	5.2	59.8	33.2	1.8
Homa Bay	2.1	18.4	69	10.5
Migori	3.8	20.4	56	19.8
Kisii	4.5	36.6	56	2.9
Nyamira	7.1	31	54.7	7.3
Nairobi	15.9	81.1	3	0

Source: Own estimates using data from KIHBS 2016

Table 4: Climate change vulnerability indices

County	Demographic Index	Economic Index	Household living conditions index	Nutrition Index	Overall Index
Mombasa	16.8	2.4	6.6	27.9	11.7
Kwale	35.2	21.7	41.9	43.8	35.6
Kilifi	28.8	13.3	24.3	48.8	26.8
Tana River	37.1	18.4	41.0	46.0	35.2
Lamu	30.2	16.0	29.1	36.4	27.3
Taita Taveta	26.4	15.8	17.9	42.6	23.6
Garissa	34.2	16.8	31.9	20.8	26.8
Wajir	40.3	13.0	69.0	48.7	44.4
Mandera	39.1	16.8	53.7	59.6	41.7
Marsabit	37.7	19.4	52.0	59.6	41.6
Isiolo	30.3	16.1	27.7	15.6	23.4
Meru	32.8	13.8	31.4	26.9	26.6
Tharaka Nithi	30.1	26.2	29.3	40.1	30.5
Embu	27.8	24.2	21.2	29.3	24.9
Kitui	37.2	25.7	39.6	44.9	36.4
Machakos	27.3	18.2	16.2	29.5	21.7
Makueni	31.1	20.5	24.7	44.3	28.5
Nyandarua	25.2	22.0	23.9	16.6	22.6
Nyeri	22.7	17.2	26.2	37.9	25
Kirinyaga	28.8	18.3	23.5	23.5	23.5
Muranga	29.5	25.9	27.7	28.1	27.7
Kiambu	19.8	12.6	8.2	16.6	13.6
Turkana	34.2	15.7	63.8	48.2	41.8
West Pokot	34.3	22.4	62.7	51.3	43.6

Samburu	33.0	20.6	54.1	46.3	39.2
Trans Nzoia	31.9	11.9	35.2	34.1	28.4
Uasin Gishu	30.4	13.8	21.7	41.9	25.3
Elgeyo Marakwet	31.1	17.7	42.0	35.6	32.1
Nandi	30.4	16.0	30.4	33.6	27.3
Baringo	32.0	28.0	35.3	43.1	34.0
Laikipia	25.8	17.1	37.8	27.5	27.9
Nakuru	25.4	13.9	24.3	32.2	23.3
Narok	29.7	21.0	43.6	45.2	34.7
Kajiado	21.4	10.2	11.7	39.7	18.4
Kericho	29.4	13.6	24.3	41.3	25.7
Bomet	30.4	22.8	51.0	30.3	35.3
Kakamega	33.4	18.7	40.9	48.8	34.8
Vihiga	39.6	21.6	36.6	47.2	35.3
Bungoma	32.8	10.0	40.4	41.6	31.1
Busia	36.7	19.9	37.5	52.5	35.4
Siaya	35.0	21.7	46.1	50.7	38.0
Kisumu	27.8	13.4	20.6	40.0	23.8
Homa Bay	34.0	13.7	54.4	54.8	39.2
Migori	37.8	22.6	49.1	47.9	39.4
Kisii	32.6	20.4	34.7	35.2	30.7
Nyamira	30.9	21.8	36.9	44.5	32.9
Nairobi	18.0	4.8	3.4	34.1	12.5

Source: Own estimates using data from KIHBS 2016