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VULNERABILITY TO CLIMATE CHANGE HOTSPOTS MAPPING IN TOGO

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ABSTRACT

A recent African map of vulnerability to climate change established by the Intergovernmental Panel on Climate Change places Togo country among the most vulnerable. In light of this and in order to know where the most vulnerable people are located within the country, this paper aims to establish the country's map of vulnerability. The study followed a methodology developed by Heltberg and Bonch-Osmolovskiy 2011, a method that uses indices approach. The results reveal that vulnerability varies across the six retained regions of the country with the most vulnerable being the Savanes region and the least vulnerable being Lomé. The policy message drawn from this study recognizes adaptation capacity building as the urgency of any strategy aiming at reducing vulnerability to climate change. One possible way to face this urgency is to direct future research on how to inform more adaptation initiatives by focusing on the area of farmer innovation at regional level for instance.

Keywords: Climate change, Vulnerability, Togo.

1. INTRODUCTION

The Intergovernmental Panel on Climate Change in its latest report (IPCC, 2014) well established that poor people in the poorest economies are the most vulnerable to the impacts of anthropogenic climate change. This is particularly true because the poor live in heavily impacted areas within those countries and have the lowest adaptive capacities. Although there is an overwhelming studies that dealt with the understanding of vulnerability from conceptual point of view, quantitative estimates of how vulnerability differ across villages, regions, sectors and countries are only starting to emergeHeltberg and Bonch-Osmolovskiy 2011.

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A recent IPCC's map of vulnerability to climate change of Africa places Togo country among the most vulnerable. Thus, adaptation matters for the country as it has the capability to reduce loss due to climate change if appropriately implemented. The National Adaptation Plan of Action of the country established a panel of strategies that can be used to adapt to climate change and hazards in the country framework. To inform these efforts, this papers seeks to assess how vulnerability to climate change and climate hazards vary across regions of the country. Indeed, adaptation program needs to determine where to invest in order to be optimal. Such a program face undoubtedly in many countries a dilemma between protecting the core agricultural economy by investing in the most productive areas and investing in high disaster risk zones. Better understanding of which people and systems are vulnerable to what kind of risks is crucial for such a program. Clearly, vulnerability to climate hazards is important for adaptation plan like poverty is for poverty reduction programs. This study should be seen as an attempt to establish places where the most vulnerable people are located and what make them more vulnerable than others.

Climate extreme events (namely floods and droughts) are established to be the main vulnerability to poverty drivers in Togo. To break that relationships, one needs to know the factors that render households particularly vulnerable to that shocks.

Vulnerability to climate change has been the focus of many studies in recent past years (Lokonon, 2015;Heltberg and Bonch-Osmolovskiy, 2011; Deressa et al, 2008). However, it is not well understood how it varies across countries, regions of countries and sectors and how best it can be reduced. Consequently, the objective of this paper is to establish the country's map of vulnerability, that is, where the most vulnerable people are located. The term vulnerability emerge from the research communities as a recognition that a focus on environmental, socioeconomic and technological perturbation alone is insufficient to understand responses of, and impacts on, systems exposed to such perturbations (De Sherbinin et al, 2007).Because vulnerability is a concept used by various field specialists it has different definitions (Fussel and Klein, 2006). These definitions revolve around three elements: lack of adaptive capacity in social and natural systems, system exposure to crises, stresses and shocks and consequences and attendant risks of slow or poor system recovery. In this study we define vulnerability as the risk of experiencing poverty or some other deprivation during some time interval, consistent with the social constructivist framework for understanding vulnerability following Fussel and Klein 2006. Vulnerability to poverty often focus on the risk of the household falling below the poverty line as a result of changes in income resulting from the occurrence of a risky event. A household is therefore said to be vulnerable to climate change associated risks if the occurrence of these risks result in a loss of well-being which pushes the household below a threshold level of welfare. Thus, vulnerability is seen as a function of exposure, sensitivity and adaptive capacity. Risk

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exposure is defined as the probability that the household livelihood will be impacted by climate change risk and sensitivity as the susceptibility of assets and livelihoods exposed to (Heltberg and Bonch-Osmolovskiy 2011). By adaptation, we mean any adjustment to reduce potential net damage due to climate change (IPCC, 2014). Adaptation include private, club and public goods.

Many studies have attempted to assess vulnerability to climate hazards and change at both global and regional level. These studies have employed four main approaches in their analysis: indicator method, integrated assessment approach, socio-economic approach and biophysical approach.

The socio-economic approach focuses on the political and socio-economic status of individuals or social groups. The variation in vulnerability in this approach is explained by differences in education, wealth status, access to credit and many other characteristics. The focus on variations within society constitutes the main limitation of this method. Among studies that used the socio-economic approach to assess vulnerability one can cite Adger, 2003; Adger and Kelly, 1999; Allen, 2003.

Biophysical assessment of vulnerability approach deals with the level of damage that a specific environmental stress causes on social and biophysical systems. This approach is the pioneer among the vulnerability assessment approaches. It is also used to assess climate change impacts. Studies based on this approach include Mendelsohn et al, 1994; Adams, 1989; Kaiser et al, 1993.

Quantifying vulnerability based on indicator approach use some indices from a set of potential indices and then systematically combine them to assess the level of vulnerability. Two options are available for indicator approach: The first consist of assuming that all indices retained have identical importance and thus assigning them an equal weight. The second option assigns different weights to avoid the uncertainty occurring from equal weighting. Studies that used indicator method to assess vulnerability include Brrooks et al, 1999; Heltberg and Bonch-Osmolovskiy, 2011.The absence of standard weighting approach is the main drawback of indicator approach.

The integrated assessment approach determines vulnerability based on socio-economic and biophysical approaches. It is usually argue that this approach corrects the weaknesses of the other approaches. However, it has its limitations among which the main is the fact that there is no standard method for combining socio-economic and biophysical indices. Integrated assessment approach studies include De Sherbinin et al, 2007;Deressa, 2010; Lokonon, 2015.

The remaining of the paper is organized as follow: The next section presents the theoretical framework of vulnerability to climate change. The section 3 deals with the data and the methodology. The results are discussed in the section 4. The paper ends with a conclusion

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2. THEORETICAL FRAMEWORK OF VULNERABILITY TO CLIMATE CHANGE ANALYSIS

In this study we fallow vulnerability indicator approach to assess the country regional vulnerabilities. The vulnerability indicator consist of the different socio-economic and biophysical attributes of Togo's six considered regions. The different socio-economic and biophysical indicators of each region retained are grouped into three classes as exposure indicators, sensitivity indicators and adaptive capacity indicators based on IPCC 2001 definition of vulnerability. Indeed, according to IPCC, 2001; vulnerability to climate change is the degree to which a system is susceptible, or unable to cope with adverse effect of climate change including climate variability and extremes, and vulnerability is a function of character, magnitude and rate of climate variation to which a system is exposed, its sensitivity and its adaptive capacity.

We based our analysis on the bellow conceptual framework adapted from the one developed by Deressa based on the above IPCC's definition of vulnerability (Deressa, 2010) (figure 1).It indicates that each of the six retained regions of Togo are exposed both to gradual end extreme climate change. Exposure affects sensitivity. This suggests that exposure to higher frequencies and intensities of climate risk, highly affects the outcome. Exposure is also linked to adaptive capacity. For instance, a higher adaptive capacity reduces the potential damage from higher exposure. Sensitivity and adaptive capacities are also linked. Given a fixed level of exposure, the adaptive capacity influences the level of sensitivity. In other words, higher adaptive capacity results in lower sensitivity and vice versa. Thus, a sensitivity and adaptive capacity adds up to total vulnerability. The adaptive capacity affects sensitivity. For instance farmers who use irrigation farming to adapt to climate change reduce significantly their sensitivity to climate exposure.

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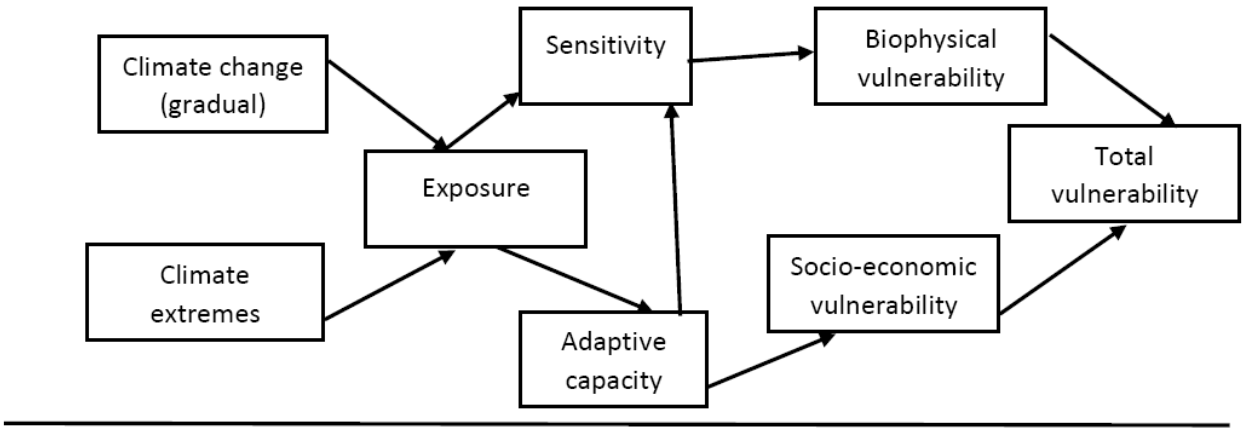
Figure 1: Conceptual framework of vulnerability analysis



Source: Adapted from Deressa 2010.

2. DATA AND METHODOLOGY

2.1 Socio-economic and climatic conditions of the study regions

The Togolese Republic (Togo) is located in West Africa on the Atlantic coast of the Gulf of Guinea. The country spans an area of 54,400 km2 encompassing rolling hills (the Chaîne du Togo) in the north, a southern plateau, and a low coastal plain with extensive lagoons and marshes. Considered to be one of the poorest countries in Sub-Saharan Africa, Togo's average per capita GNP is estimated at US $440.34. This is particularly low compared to the Sub-Saharan Africa average (US $842) and to the Low-Income Countries average (US $650).Togo has 5 administrative regions. But because of the particularities of Lomé zone compare to Maritime region where it is located we considered it like an additional region and finally we end up with six region that are Lomé, Maritime, Plateaux, Centrale, Kara and Savanes. These regions vary in their socio-economic and environmental characteristics.

Togo's climate varies from tropical to savanna. The southern part of the country is humid, with temperatures ranging from 23° C to 32°C. In the north, temperature fluctuations are greater going from 18° C to more than 38°C. Rainfall in the south of the country comes in the form of two seasons (the first between April and July and the second between September and November).

The country is experiencing climatic changes. According to the National Adaptation Programme of Action, a shift in the rainy season has been observed, which can begin up to 30 days later than usual. When there is a delay, the rainy season is punctuated by waves of drought, which interrupt

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crop growth. Likewise, heat waves are now common in all regions of the country with significant consequences on livelihoods and natural resources. Other climatic extreme events like flood and drought are also said to happen more frequently.

2.2 Data source

The data used in this study come mainly from the Unified Questionnaire of Basic Welfare Indicator database (QUIBB, 2011).These data are the result of a survey conducted by the General Direction of Statistics and National Accounting (DGSCN) from 30 July to 30 August 2011 in the five economic regions of Togo. The survey covered 29,676 households. The other needed data come from reports and review on the topic. For more information on sampling technic, please see QUIBB, 2011 report.

2.3 Methodology

This section describes in details the method used. We based our methodology on the one developed by Heltberg and Bonch-Osmolovskiy 2011. The technique takes the IPCC working definition of vulnerability as a function of exposure, sensitivity and adaptive capacity as it starting point and incorporate social, economic and environmental indicators. The index of vulnerability is then constructed as the simple average of three sub-indices: exposure, sensitivity and adaptive capacity. Following the existing literature on vulnerability (Lokonon 2015; IPCC, 2014; Fussel and Klein, 2006) we include a panel of climatic, economic, natural and institutional variables as factors that could explain vulnerability with a special target of climatic variables. Hahn et al, 2009 argue that the main advantage of the approach is the reduction in dependence on climate models and projections which despite recent advances are still presented at too coarse a scale with too high degrees of uncertainty to be useful for regional analysis (Hahn et al, 2009).

2.4 Vulnerability index and sub-indices

Consequently to the above discussion, three sub-indices where developed. The exposure sub-index is comprised of the following variables: Standard deviation of the average monthly temperature between 1971-2011 (sdT_i); the range between minimum and maximum average temperature (rT_i); the range between minimum and maximum average precipitation (rP_i); the frequency of climatic extreme events (flood and drought) between 1971-2011. The equation used to compute the exposure sub-index is the following:

$$E = \left((sdT_1 + \cdots + sdT_{12})/12 + (sdP_1 + \cdots sdP_{12})/12 + (rT_1 + \cdots + rT_{12})/12 + (N_{flood} + N_{drought}\right) / 40$$

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The sensitivity sub-index is comprised of demographic, agriculture and food security. Demographic sensitivity is measured by the share of the population below 5 (S_1) and above 65 (S_2) years of age. Concerning agricultural sensitivity, it is measured through two variables. Share of rainfed agricultural land per capita (S_3) and the share of the population depending on agriculture(S_4). Food security sensitivity is measured by the share of food insecure population. The following equation is used in this study to compute the sensitivity sub-index:

$$S = \left((S_1 + S_2)/2 + (S_3 + S_4)/2 + S_5\right.$$

The last sub-index is the adaptive capacity index. It is comprised of variables measuring consumption, education, income diversification and institutional development. The first variable is captured through household average consumption per capita, the second variable through the share of population with education above secondary, the third one is measured through the Ginevičius index of income diversification[1] (high value indicates more income diversification) (see Ginevičius, R. 2009 for more details on income diversification indices). Regarding institutional development, it is measured through the political involvement (share of individuals that participated in the last presidential election in the country). We therefore compute the adaptive capacity index as follow:

$$A = a_1 + a_2 + a_3 + a_4$$

a_1-Household consumption per capita

a_2-Share of population with higher education

a_3-Ginevičius index of income diversification

a_4- Measure of political involvement

It is worth noting that all $a_i$and S_i variables are normalized by linear transformation.

Finally, we computed the vulnerability index as: $V = (E + S + (1 - A))$

[1] The formulae used to compute Ginevičius index of income is the following: $D_i = 1 - [1/(\sum_j^n \frac{1-s_{mx}}{1-s_j})]$, i stands for regions, smax represents the largest share of income and sj the income share of the source j. Since this study is done at regional level we considered average values per region to compute D.

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3. RESULTS AND DISCUSSION

3.1 Descriptive statistics

3.1.1 Exposure to Climate extreme events per region

Climate or weather extreme event refers to weather phenomena that are at the extremes of the historical distribution and are rare for a particular place and/or time, especially severe or unseasonal weather. Such extremes include severe thunderstorms; severe snowstorms, ice storms, blizzards, flooding, hurricanes, and high winds, and heat waves. However, we considered in this study as extreme event only droughts and floods.

Table 1 below reveals that the study regions' exposure to extreme events varies from one to another. The most exposed region appears to be the Savanes region with 15 percent frequency of extreme events recorded for the period of study, it is followed by Lomé region (13 percent). Kara with extreme events frequency of 9 percent is the less exposed region to climate extreme events.

Table 1: Frequency of drought and flood over 1971-2011

Region	Frequency of droughts and floods (%)
Savanes	15
Kara	9
Centrale	10
Plateaux	12
Maritime	12
Lomé	13

Source: National meteorological service centre

3.1.2 Income diversification

The Ginevičius index of income diversification computed indicates that households living in Lomé region diversify more their livelihood activities on average compare to their counterparts living in other regions. They are followed by households residing in Maritime region. By contrast, the households in the Savanes region diversify less their living activities. These statistics are quite comprehensive since the working opportunities are far inferior in Savanes region compare to Lomé and Maritime regions.

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Table 2: Ginevičius index of income diversification

Region	**Ginevičius index**
Savanes	0.215
Kara	0.383
Centrale	0.316
Plateaux	0.336
Maritime	0.402
Lomé	0.443

Source: Author' computation from QUIBB 2011

3.1.3 Food insecurity sensitivity

The households of the Maritime regionare those with more difficulties of providing the food needs for their members. Come then the households from the Savanes region (58.5%), Lomé (47.9%), Kara (43.9%), Plateaux (37.0%) and the central region (33.8%) (Figure2).

Table 2: Food security sensitivity

Region	Share of food insecure households (%)
Savanes	58.5
Kara	23.9
Centrale	33.8
Plateaux	37.0
Maritime	63.4
Lomé	47.9

Source: QUIBB 2011 report.

3.1.4 Political involvement

We consider participation in the last presidential election (the one of 2015) as the indicator of political involvement. The following table (table 3) show how the degree of involvement varies per region. One can note that Kara region seems to be the most concern with political events followed by Centrale and Savanes regions with a participation rate of 69.91 and 69.07 respectively.

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Table 3: Per region participation rate in 2015 presidential election

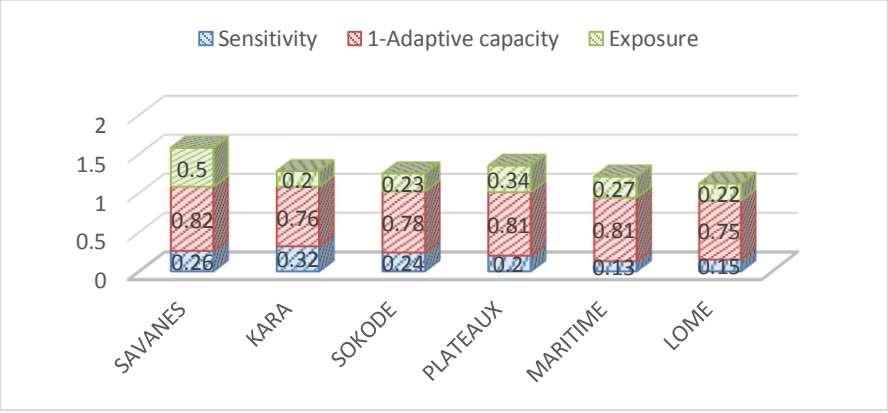
Region	Participation rate (%)
Savanes	69.07
Kara	75.72
Centrale	69.91
Plateaux	58.60
Maritime	50.09
Lomé	55.54

Source: Independent National Electoral Commission (INEC, 2015)

4.1 Vulnerability Across regions

The findings reveal that degree of vulnerability varies across regions with Savanes region being the most vulnerable (figure 2). Lomé region is far the least vulnerable. The vulnerability seems to be higher in regions where economic activities are dominated by agricultural activities. This is because regions more urbanized have the lowest sensitivity and quite highest adaptive capacity (figure 2). This is to say that urban zones have comparatively better socio-economic and institutional development that render them less vulnerable. Compare to more urbanized region, less urbanized regions appear to be vulnerable. The figure 2 in addition reveals that the low adaptive capacity is responsible of the high level of vulnerability of the regions. Thus, the policy message drawn from these results posit adaptation capacity building as the urgency of any policy aiming at reducing regions' vulnerability to climate hazards. These results highlight the fact that the priority should be given to Savanes region.

Figure 2: Vulnerability indices across Togo's regions



Source: Author' computation

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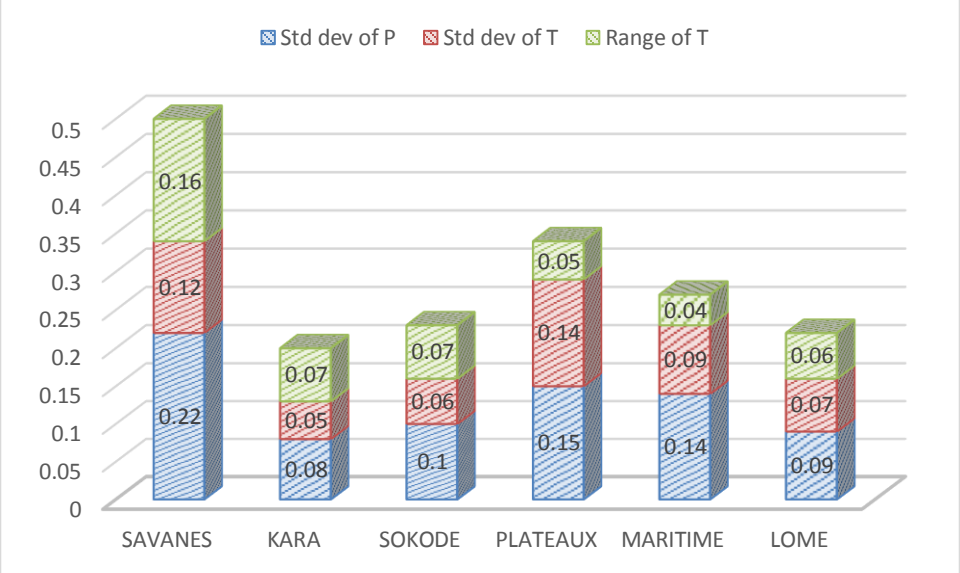
3.2 Exposure components across regions

Exposure to climate change and variability is higher in Plateaux region as well as in Maritime and Savanes regions (figure 3). This is mainly because of their high standard deviation of precipitation and their high standard deviation of temperature. This highlights the higher variability of climate variables (precipitation and temperature) in these regions. Exposure is quite similar between Lomé and Sokode while Kara region is the least exposed to climate variability and change.

Figure 3: Exposure components across regions



Source: Author' computation

3.3 Sensitivity components across region

Kara region surprisingly appear to be the most sensitive region to climate variability and shocks. The major factor driving sensitivity to climatic events is the dependence on agricultural activities for four (Savanes, Kara, Sokode and Plateaux) out of the five regions. For Maritime and Lomé, it is driven by demographic factors and food insecurity respectively. This calls for region's specific sensitivity reduction policies. Indeed, while irrigated agriculture promotion can be seen as a sound policy to reduce considerably sensitivity to climate variability and shocks in the Savanes, Kara, Centrale and Plateaux regions, only policies aiming to reduce food insecurity and the rate of dependency can significantly reduce sensitivity in Lomé and Maritime regions respectively.

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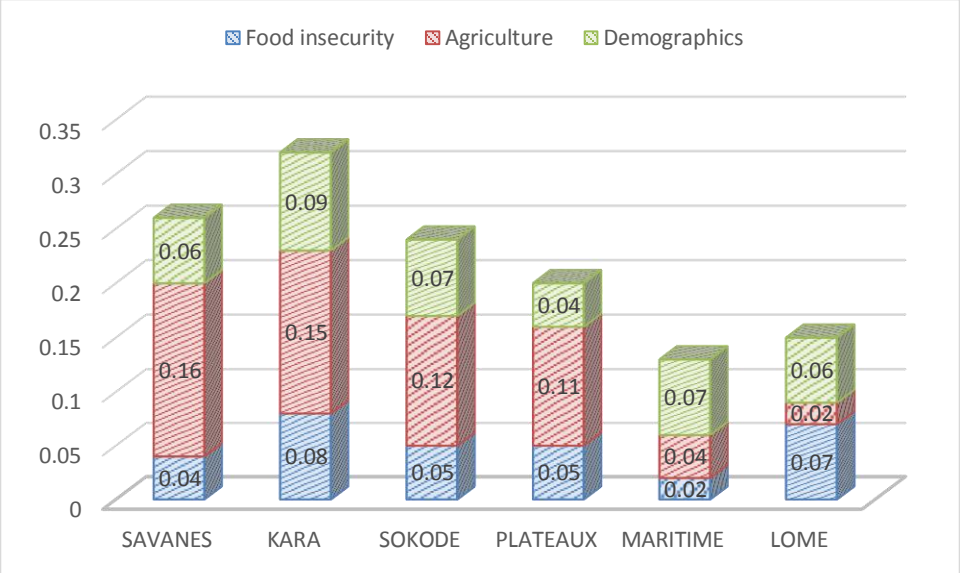
Figure 4: Sensitivity components across regions



Source: Author computation

CONCLUSION

We constructed and presented regional indices of vulnerability to climate change and hazards in Togo based on an existing methodology. The results indicate that vulnerability varies across the six retained regions of Togo. Vulnerability in this study is seen as a result of the interaction between three types of variables: exposure variables, adaptive capacity variables and sensitivity variables.

Looking at the results, one notes that Savanes is far the most vulnerable region followed by Plateau and Kara. Lomé is far the least vulnerable region. These findings reveal that to the extent that policy makers wish to direct funding towards areas with highest vulnerability to climate change, they should concentrate on Savanes region. The results also postulate that the very low adaptive capacity is the main driver of vulnerability of the regions. Thus, the policy message drawn from this study also recognizes the adaptation capacity building as the urgency of any strategy aiming at reducing vulnerability to climate change in Togo.

However, the results tell policy makers little about how to design adaptation. Given that a recent study by Pilo and Adeve 2015 finds that farmers in the Savanes region of Togo who did not adapt would have been worst off if they were to adapt because they would be doing well in terms

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of farmer innovation, to inform more adaptation initiatives future research could focus on the area of farmer innovation in the regions.

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