Importance of Geographical and Sociological Factors in Household Livelihood Vulnerability to Climate-related Crisis in Rural Burundi

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Abstract

This paper analyses the vulnerability of 2 communes in the provinces of Kirundo and Bubanza in Burundi to climate change using social and geographic variables. Primary socio-economic data was collected through surveys where 450 households were involved in responding to a questionnaire. Data collected included demography, livelihood sources, asset ownership, land management practices, social organization and information sources. Initial data consisted of more than 1000 quantitative and categorical variables but these were reduced to the most representative 14. Selected variables were then used in Multiple Factor Analysis (MFA). Results showed that the first 6 dimensions of MFA contributed most variability to the data and represented financial and human capitals. Variables strongly correlated with dimensions were: education; rainwater harvesting; use of inputs; land access and food access. Clustering was then done based on the 6 dimensions and yielded 3 clusters with a mix of households from the two provinces. Elevation and land cover were analyzed to explain the clusters' geographic features. Cluster 2 had more households at higher elevation and more shrub and grasslands and consequently more cattle and sheep. Cluster 3 had the highest proportion of animals, wheat, use of inputs and highest education levels. The study concludes that cluster 3 is least vulnerable presently. Cluster 2 is vulnerable to shrinking grasslands, loss of livestock, poor wheat yields and inadequate access to food in the dry periods. Cluster 2 and 3 households will have to make changes to reduce vulnerability to future climate-related hazards.

Keywords: Vulnerability, Clustering, Burundi, Climate change, Household livelihoods

Introduction

Burundi is a country exposed to multiple stresses including impacts of natural hazards. Multi-year droughts have been registered in the periods of 1999-2005, 2007-08, 2010-11 and 2016-17 ((Vinck, Bizuneh, Rubavu, & Tahirou, 2008) with dire consequences. With almost 90% of its labour force engaged in agriculture, and the agricultural sector making up to 30% of the country's GDP, dependence on rain fed crop production significantly increases the vulnerability of Burundian communities to the negative impacts caused by vagaries of variable weather and climate.

Vulnerability is a combination of the risks people are exposed to and their social, economic and cultural abilities to cope with the damages incurred (Coulibaly et al., 2015; Yusuf & Francisco, 2009). Yet studies have been narrow, mainly analyzing the biophysical factors that contribute to vulnerability, without accounting for the role played by socio-economic dynamics. Socio-economic conditions have been found to profoundly affect food system and in turn vulnerability, through drivers such as soil fertility, irrigation, fertilizer use, demography and socio-politics. On matters scale, while there may be cross-scale interactions due to interconnectedness of economic and climate systems, local social, cultural and geographic features may differ and significantly affect vulnerability levels (Malone, 2009). In fact social vulnerability has been shown to be a partial product of social inequalities and place inequalities (Boko et al., 2007). Ludeña & Yoon (2015) noted that attempts to adapt to climate change impacts differed among communities based on geographical location, community attributes and industrial sectors. Local level assessment of vulnerability also provides a better understanding of where and when to invest and who should make the investment (Malone, 2009; Downing et al., 2005).

Bubanza and Bugabira are two rural communes in the provinces of Bubanza and Kirundo in Burundi, located approximately 97 km apart. Nyairo et al. (2014) in their paper described these two locations as being climate analogues, meaning they currently have different climates, with Bubanza being the hotter region. Using mean annual precipitation, minimum and maximum daily temperatures, Global Climate Models (GCMs) have predicted that due to climate change, the climate of Kirundo Province in the 2050s will be almost similar to the current climate of Bubanza. IPCC 2014 predicts that semi-arid regions will experience more frequent and intense droughts due to climate change. This means that negative effects of extreme events that are now being experienced in these locations may worsen and render the communities more vulnerable. While their research helped to shed some light on the expected future of these communes, Nyairo et al. (2014) failed to account for socio-economic variability as well as geographic differences between the two locations which may serve to exacerbate or ameliorate the predicted negative impacts.

The aim of this study was to assess levels of vulnerability generated by social-economic processes interacting across geographic scales in the two communes. The objectives were to identify the drivers of vulnerability and determine the vulnerability levels in the communes. Through use of surveys, this research adopted a participatory approach to evaluate the vulnerability of households in Bugabira the target location and Bubanza the analogue location. Households were clustered into 3 categories of vulnerability.

Data collection and analysis

This study utilized both quantitative and qualitative primary data that had been collected using a semi-structured questionnaire as described by (Nyairo et al., 2014). The questionnaire contained questions on household size, age, education levels, asset ownership, use of farm inputs, sources of food, land size, whether households identified with community groups and water access and any other changes in resource management and livelihood strategies. More than 1000 variables were obtained. Digital Elevation (DEM) and Land Cover maps were downloaded from open access sites on United States Geological Survey (USGS, 2014) and European Space Agency (ESA, 2017) portals.

For analysis, Multiple Factorial Analysis (MFA), Hierarchical Clustering on Principal Components (HCPC) and geographical analysis were combined so as to assess household vulnerability. 38 adaptation-specific variables were selected by expert judgement based on the aspects of demography, infrastructure, household assets, production inputs, food security and social groups. These variables were then reduced further to 14 based on the ability of policy changes to effect changes on the variables. To conduct MFA, variables were broadly grouped into the following 6 categories: education, rainwater harvesting, land access, usage of farm inputs, food access in the first dry season and food access in the second dry season. The advantage of MFA is its ability to handle both qualitative and quantitative analysis, by applying Principal Component Analysis to the quantitative data and Multiple Correspondence Analysis to the qualitative data (Fekete, 2009). The first 6 dimensions of the MFA result were retained and used for clustering household samples. All statistical analysis was done in R Statistics software version 3.4.1. The R packages FactoMineR and Factoextra were used for conducting MFA while the ggplot2 package was used for visualizing cluster results. For geographical analysis, elevation and land cover types were the main variables and analysis was conducted in ArcMap 10.4.1.

Household clusters

MFA of surveyed variables found that the cumulative contribution of top 6 dimensions explained more than 50% of total variation. Summary of variable groups as represented by dimensions is shown in table 1.

Clustering analysis yielded 3 clusters each having households from both locations with Cluster 1 dominated by households from Bubanza and cluster 2 and 3 dominated by households from Bugabira (Table 2). The total number of households in cluster 1 was 67 and that in cluster 2 was 377 while cluster 3 had 6. Cluster 3 had the highest levels of education with all household heads having attained tertiary education. The cluster also had the highest number of animals and cropland area, growing mainly wheat. Cluster 3 households are better placed education-wise to learn new technologies and adapt to their predicted future climate. Moreover, educated populations have the capacity to take advantage of various employment opportunities outside of agriculture thus reducing their vulnerability (Mertz et al., 2011).

More households in cluster 3 utilized inputs than those in the other 2 clusters. Generally, farmers whose access is enhanced either by government subsidies or better road network experience higher crop yields. In a study by Fraser et al. (2013), it was found that fertilizer use in wheat production was positively associated with adaptive capacity in tropical and arid countries.

There was a proportionate number of livestock in all clusters. In a majority of African rural households, livestock is an important capital serving as both a source of food and income (Dougill et al., 2010). Livestock is an especially important source of food during dry seasons because rain-fed crop cultivation is more sensitive to climatic shocks than livestock production (Mertz et al., 2011).

Table 1: Significant variable groups per dimension

Dimension	Group represented
1	Inputs, rainwater
2	Education, season B*
3	Education, Land, Rainwater
4	Education
5	Education
6	Education, season A*

*Seasons A and B denote the different periods suffering by food shortage.

Table 2: Households by clusters in locations

Cluster	Bugabira	Bubanza	Total
1	17	50	67
2	225	152	377
3	5	1	6
Total	247	203	450

Geographic features

Two-thirds of households in cluster 1 were below the overall average mean elevation while more than two-thirds of the households in clusters 2 and 3 were above the average. Elevation affects climatic condition and crop yields and types, with lowlands generally experiencing low, erratic rainfall. Wheat generally does very well at 1200m above sea level and results showed that across clusters households generally grew wheat. Temperature is an important limiting factor for livestock, given that heat stress is known to cause high mortality rates in dairy cows, affects broilers and reduces reproductive efficiency in pigs. Higher, cooler areas are therefore suitable for dairy and sheep as evidenced by the percentage of households keeping cattle in cluster 2 which was almost twice that in cluster 1. More households in cluster 1 than cluster 2 reported hens as being important. This was linked to the adaptation strategy of shifting from large to small animals that do not require extensive grazing areas as was proposed by the government of Burundi in its second national communication.

Croplands were dominant across all the clusters with cluster 3 having the highest proportion followed by cluster 1. Cluster 2 had a significantly higher number of households occupying shrub and grassland areas thus promoting grazing which could explain the higher number of cattle in that cluster. However, cluster 3 had the highest proportion of shrublands. The proportion of tree cover was proportionate in both clusters 1 and 2.

Conclusion

The evaluation of household livelihood vulnerability based on socio-geographic condition was achieved using factorial and cluster analysis. This paper has demonstrated that the options for improving crop production systems are virtually inexistent in the study areas. Cluster 2 will suffer diminished grasslands, a shift from large to small animals, probable poor harvest of wheat and food shortage in the dry seasons in the future climate. Cluster 2 households are thus more vulnerable to increased temperatures and reduced water quantities than cluster 1 households. Cluster 3 is the least vulnerable in the current climate but will need to change in order to remain so in future climates. In this study a direct link between education and household food security could not be established as there was no correlation between education and the other variables. However, capacity building through technical and vocational training can raise the skills of stakeholders and help to increase farm production for example through value addition.

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