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Application of livelihood vulnerability index in assessing smallholder maize farming households' vulnerability to climate change in Brong-Ahafo region of Ghana

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ABSTRACT

Climate change is adversely affecting smallholder farming households in Africa and in particular in Ghana because their activity depends on climate-regulated water resources. This study examined the vulnerability of smallholder maize farming households to climate change in the Brong-Ahafo region of Ghana by employing the Livelihood Vulnerability Index with particular emphasis on access to and utilization of water resources. The primary data were based on 150 maize farming households, complemented by secondary data on rainfall and temperature over the period 1983–2013. To assess the climate change effects and related vulnerability, a comparative analysis was performed for the Wenchi and Techiman municipalities in the Brong-Ahafo region. The empirical results revealed that farming households in Wenchi municipality were more vulnerable to climate change and weather variability in terms of food, water, and health than those in Techiman municipality. Furthermore, farming households in Wenchi municipality were more vulnerable in terms of adaptive capacity, taking into account the socio-demographic aspects, social networks, and livelihoods of households in the municipality than those in Techiman municipality. These results have implications for the initiation and implementation of climate change adaptation and household resilience projects by the government, donor agencies, and other related organizations in the two municipalities in the region.

Introduction

The adverse effect of climate change and variability has become an environmental and socio-economic problem which is increasingly causing climate-driven hazards to people around the world (Scholze, Knorr, Arnell, & Prentice, 2006). They argued that climate change serves as a serious inhibitor to the attainment of food security and also to the fulfillment of major developmental agenda in the majority of global economies from which Ghana cannot be exempted. Climate change has attracted the attention of the academic community, governmental, and non-governmental organizations. Intergovernmental Panel on Climate Change (IPCC) (2014) mentioned that climate change is any change in climate over a period of time which comes about as a result of both human activity and natural variability. Montle and Teweldemedhin (2014) noted that adverse effects of climate change are likely to affect poor people

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whose daily existence depends on semi-subsistence agriculture. The reason for the adverse effect of climate change on the poor can be found in Food Agriculture and Natural Resources Policy Analysis Network (FANRPAN) (2011), which reported that a higher proportion of rural households are limited by the essential ability to adapt to the adverse effects of climate change. This is due to the fact that policy response is inadequate, institutional arrangements are very feeble, and interventions are introduced without consultation with local households. Minia (2004) predicted that globally, the total annual rainfall will decline by 9–27 percent while the mean daily temperatures will rise by 2.5–3.2 °C by 2100. Boko et al. (2007) revealed that agricultural production as well as food security in many African regions and countries has the highest probability to be severely compromised by climate change and variability.

Agriculture contributes significantly to the Ghanaian economy. For instance, in 2013 according to the Institute of Statistical, Social and Economic Research (2014), agriculture contributed 22 percent to the nation's Gross Domestic Product (GDP). In addition, approximately two-thirds of the manufacturing value-addition is based on agricultural raw materials and provides employment to about 56 percent of the work force (FAO, 2010). To reduce food insecurity, maize (*Zea mays* L.) is Ghana's number one staple food crop followed by rice (*Oryza sativa* L.) and domestic demand for these staples is increasing. The domestic demand for maize is projected to grow at 2.6 percent annually between 2010 and 2015 (Millennium Development Authority, 2009). However, the 21st century has seen a shortage in the per capita global food production by 7 percent; the shortage is believed to be caused by climate change and variability and low soil productivity (Rosenzweig & Parry, 1994). Smallholder farming households dominate the agricultural sector in the Ghanaian economy with about 90 percent being resource poor (Ghana Statistical Service [GSS], 2008). Smallholder farmers primarily depend on family labor and also operate under rain-fed conditions (Chamberlin, 2008). This has contributed to the inability of Ghana to produce more maize to feed its people leading to average shortfalls of 12 percent in domestic supply (Millennium Development Authority, 2009). In the Brong-Ahafo region, farmers are predominantly smallholders and are usually involved in the cultivation of staple crops including yam (*Dioscorea* spp), maize (*Z. mays* L.), cassava (*Manihot esculenta)*, cowpea (*Vigna unguiculata)*, and groundnut (*Arachis villosulicarpa)*. Farmers also engage in the rearing of small ruminants such as sheep and goats (Ministry of Food and Agriculture, 2011). The adverse effects of climate change and variability on crop growing and animal rearing cannot therefore be overstated. Models and information about climate variability and change are only available at global, national, and continental levels. Models are not yet able to forecast the impacts at very small scales; hence extension officers face challenges in providing farmers with knowledge that is location specific and ecologically specific. Without suitable policies or adaptive measures in place, the smallholder farming households will find it difficult to undertake sustainable crop production and rearing of animals in an environment with erratic climatic conditions (Al-Hassan, Kuwornu, Etwire, & Osei-Owusu, 2013; Kuwornu, Al-Hassan, Etwire, & Osei-Owusu, 2013; Nakuja, Sarpong, Kuwornu, & Asante, 2012). Past studies on vulnerability in Ghana have mostly been based on poverty (Novignon, Mussa, & Chiwaula, 2012). These studies measured vulnerability to extreme climatic events in Ghana using national aggregates without household level data. Only a few studies have focused on the household level (for example, Etwire, Al-Hassan, Kuwornu, & Osei-Owusu, 2013). The current study fills the gap in the literature by employing household data to analyze farmers' vulnerability to climate change and variability using the lens of the livelihood vulnerability frameworks.

Literature Review

The Livelihood Vulnerability Index (LVI) was used to assess the vulnerability of farming households to climate change and variability. This index was developed by Hahn, Riederer, and Foster (2009) and is based on the IPCC's definition of vulnerability. The LVI approach involves several variables which capture the level of smallholder maize farming households' exposure to natural hazard and climate change, their adaptation capacities and their sensitivity to climate change impacts (Hahn et al., 2009). The computation of the index is simpler once rainfall and temperature data are available, as it uses primary data from households. Numerous studies have measured vulnerability in the context of natural hazards (for example, Parmesan & Yohe, 2003). The term vulnerability is used in many diverse ways by various intellectual communities such as poverty and food security analysts as well as in natural hazards research and each area conceptualizes it differently (Bryan, Deressa, Gbetibouo, & Ringler, 2009). Several strands of literature have provided similar definitions of vulnerability to climate change and variability (FAO, 2006, 2009; IPCC, 2007). These studies define vulnerability as the extent to which geophysical, biological, and societal systems are prone to, or at risk of, and are unable to deal with the negative effect of climate change and variability. IPCC (2001) defines vulnerability to climate change as the degree to which a system is liable, or incapable of surviving under negative effects of climate change and variability. FAO (2006) has suggested that vulnerability to climate change differs across space and time due to the numerous contributing factors. The vulnerability level of a system to climate change and variability is dependent on the character, degree, and the rate of climate change and variation to which the system is exposed, its sensitivity, and its adaptive capacity (FAO, 2009; IPCC, 2007). Climate change exposure is believed to be location specific. For example, communities in semi-arid areas may be most exposed to drought whereas coastal communities will have a higher exposure to sea level rise and cyclones. Sensitivity is the extent to which a body is either adversely or beneficially, directly or indirectly affected by climate change and variability (IPCC, 2007). For example, a tropical ecosystem will be less sensitive to a decrease in rainfall than a fragile, arid or semi-arid one, due to the successive influence on water flows. Also, a mining community is less sensitive to changing rainfall patterns than one dependent on rain-fed agriculture for its livelihood (IPCC, 2007).

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