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Spatio-temporal analyses of impacts of multiple climatic hazards in a savannah ecosystem of Ghana

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ABSTRACT

Ghana's savannah ecosystem has been subjected to a number of climatic hazards of varying severity. This paper presents a spatial, time-series analysis of the impacts of multiple hazards on the ecosystem and human livelihoods over the period 1983–2012, using the Upper East Region of Ghana as a case study. Our aim is to understand the nature of hazards (their frequency, magnitude and duration) and how they cumulatively affect humans. Primary data were collected using questionnaires, focus group discussions, in-depth interviews and personal observations. Secondary data were collected from documents and reports. Calculations of the standard precipitation index (SPI) and crop failure index used rainfall data from 4 weather stations (Manga, Binduri, Vea and Navrongo) and crop yield data of 5 major crops (maize, sorghum, millet, rice and groundnuts) respectively. Temperature and windstorms were analysed from the observed weather data. We found that temperatures were consistently high and increasing. From the SPI, drought frequency varied spatially from 9 at Binduri to 13 occurrences at Vea; dry spells occurred at least twice every year and floods occurred about 6 times on average, with slight spatial variations, during 1988–2012, a period with consistent data from all stations. Impacts from each hazard varied spatio-temporally. Within the study period, more 70% of years recorded severe crop losses with greater impacts when droughts and floods occur in the same year, especially in low lying areas. The effects of crop losses were higher in districts with no/little irrigation (Talensi, Nabdam, Garu-Tempane, Kassena-Nankana East). Frequency and severity of diseases and sicknesses such as cerebrospinal meningitis, heat rashes, headaches and malaria related to both dry and wet conditions have increased steadily over time. Other impacts recorded with spatio-temporal variations included destruction to housing, displacement, injury and death of people. These impacts also interacted. For example, sicknesses affected labour output; crop losses were blamed for high malnutrition; and reconstruction of properties demanded financial resources largely from sale of agricultural produce. These frequent impacts and their interactions greatly explain the persistent poverty in the area.

1. Introduction

Since 1900, global mean temperatures have risen and there is evidence that the warming rate is accelerating (IPCC, 2012). As indicated by the IPCC (2012), increases in average global temperature are very likely to alter precipitation and atmospheric moisture due to changes in atmospheric circulation and increases in evaporation and water vapour. Variability

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and/or changes in climate are most likely to bring about hazards such as high temperatures, heavy rainfall/floods, dry spells/droughts and windstorms, which will have deleterious impacts on both humans and ecosystems (Yiran, 2014). In spite of uncertainties in predicting the precise degree, nature and magnitude of changes in temperature and rainfall, and consequently, the final outcome of climate change and its impact, there is high consensus among climate scientists and global leaders on the reality of climate change (IPCC, 2014). This consensus is built upon intense research on climate variability and change (CVC) (see IPCC, 2007, 2014).

Many studies have examined the impacts of CVC and its related hazards, mostly focusing on agriculture in Africa (Challinor et al., 2007). Most of these studies have predicted the impacts of climate change on food production based on climate scenarios from global climate or general circulation models (GCMs) (Connolly-Boutin and Smit, 2015). Impacts noted in these studies vary widely but generally show negative outcomes for food crops (Challinor et al., 2007). Studies show that rainfall is expected to be more variable and less predictable with a reduced length of the growing season in West Africa (Connolly-Boutin and Smit, 2015), which could lead to a drop in crop yields by 20–50% by 2050 (Sarr, 2012). In the Upper East Region (UER) of Ghana, studies have shown severe impacts CVC on agriculture, leading to losses in crop and livestock production (e.g. Antwi-Agyei et al., 2012; Aniah et al., 2013), affecting food security (WFP, 2012; Yaro, 2013). It has also been established that climate related diseases, particularly cerebrospinal meningitis (CSM), malaria and malnutrition, are on the rise in UER (Ghana Health Service, 2012). Both ground and surface water have suffered negative consequences from CVC (UNEP-GEF, 2013), while properties and lives have been lost due to climate related events (NADMO, 2011). The impacts on these vital sectors that underpin livelihood activities (agriculture, health, water and infrastructure) combine to perpetuate poverty in UER. The impacts can be classified into direct impacts (crop and livestock losses, diseases/sicknesses, destruction of houses, displacement and injuries of people) and indirect impacts (loss of labour and incomes, cost of healthcare, and malnutrition, etc.) (IPCC, 2014).

Many existing impact studies are top-down and model-based, predicting the impacts of climatic events on yield (see Connolly-Boutin and Smit, 2015). They are also conducted at macro scales (e.g. Sarr, 2012). Other types of research examine how people have adapted to past changes and how they may adapt to future changes (e.g. Cooper et al., 2008; Jankowska et al., 2012; Sarr, 2012; Simelton et al., 2012). Yiran and Stringer (2015), for example, showed that farmers in the savannah ecosystem of Ghana are using several strategies including dry season gardening, irrigation, planting early-maturing and/or drought resistant crop varieties to adapt to poor rainfall distribution and frequent droughts. Nevertheless, most research has focused largely on impacts of single hazards on single sectors (e.g. Jones and Thornton, 2009; Antwi-Agyei et al., 2012; Grace et al., 2012). While these studies have indicated that climatic hazards affect aspects of livelihoods, what remains unclear is how the frequent and alternate occurrences of different types of hazards have cumulatively affected human livelihoods and socio-economic conditions. This is particularly important as the climate related events occur year in, year out in UER (Yiran, 2014). This study fills this knowledge gap by investigating the cumulative impacts of these hazards on different aspects of people's livelihoods over space and time, informing efforts to help the region to better bounce back from the multitude of hazards it faces.

2. Methodology

Mixed methods were used to collect data and analyse the impacts of multi-hazards over a 30-year period (1983–2012), spatially and temporally, using the UER as a case study for the savannah ecosystem. The period 1983–2012 was chosen because it is the warmest in the last 1400 years (IPCC, 2014) and data for this period are largely accessible. The UER is in north-east Ghana (Fig. 1). UER is dominated by Guinea and Sudan savannahs. It experiences all hazards that occur across the savannah systems and can act as a window to better understand the hazards across the savannah (Yiran, 2014). UER receives the lowest rainfall in the savannah zone, 1000 mm per annum on average (Logah et al., 2013) and yet, rainfed agriculture is the major economic activity. When dams in nearby Burkina Faso are spilled, water from the dams enters the UER before any other area, causing flooding. UER is also the poorest region in Ghana, with more than 89% of its inhabitants classed as poor and dependent upon their own farm produce for household food supplies (Ghana Statistical Service et al., 2009). The combination of these factors makes it a very useful area to study as it can provide wider lessons.

Primary data were collected between June and September 2013 using questionnaires, focus group discussions (FGD) and in-depth interviews (IDIs) with institutional heads or representatives as well as local people. One community was selected from each of the 13 districts in the region. The names of communities in each district were written on pieces of paper, thoroughly mixed and one community randomly selected.

In order to ensure that characteristics of urban areas were captured, the 3 largest towns were purposively selected and sampled for their respective districts. In selecting the other communities, a condition that no selected community should be within 10 km from another community was applied. This ensured good spatial distribution. This approach is similar to restricted random selection (see Stevens and Olsen, 2004). The stratification of districts into urban and rural is based on Ghana Statistical Service's (2012) classifications where districts in which rural populations are greater than urban populations are classified as rural. Urban areas were sampled in higher numbers based on the function (regional, municipal and district capital) of the town. A major reason for entering each district was because they are divided along the major ethnic groups in UER, thus stratifying the sample ethnically. A total of 210 households were then randomly sampled from the 13 selected communities in order to administer a questionnaire survey (Table 1).

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