Climate Variability and Food Security: The Vulnerability of Rain-Fed Maize Farmers in Central Malawi

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Abstract—This study presents the current scenario of the understudied spatial variation of climate impact and how it determines the vulnerability of rain-fed maize farmers in mid-upland and lakeshore areas of central Malawi. The study, conducted in December 2015, interviewed 110 rain-fed maize farmers in a household survey on the types of climate impact they had observed and experienced in the past 10 years (2005 – 2015). Climate data of the same period was also considered. High, moderate and low vulnerability classes of rain-fed farmers were determined. The results showed stark differences in climate impact according to geographical locations. The mid-upland plains of Lilongwe district experienced severe drought and prolonged dry spells in 6 of the 10 years under study. In the lakeshore area of Salima district, farmers experienced alternating floods and dry spells, often both within the same growing season. On average the area got flooded in 3 years while all farmers observed dry spells in 6 of the 10 years, the worst being the 2014/15 growing season. These climate impacts differed in length, intensity and characteristics. 62% of total households faced critical maize yield losses higher than 50%, 22% experienced moderate maize yield losses between 50% and 30% and the rest encountered minimal losses of less than or equal to 30%. Self-adaptation was adopted by every household mainly by modifying farming practices and engaging in innovative farming systems. Collective adaptation was deemed costly. This analysis would be essential for informed policy decisions and guidance in programing weather-dependent food security initiatives and climate variability investment decision making.

Keywords— Climate Variability/ Vulnerability Assessment/ Rain-Fed Farmers/ Adaptation/Weather-dependent food security initiatives.

I. Introduction

The agricultural sector is among the most susceptible spheres to climate variability due to its high dependability on climate seasonality, especially quantity and distribution patterns of rainfall and temperature fluctuations. Malawi, just as most of the countries in the Sub Saharan Africa, relies heavily on rain-fed agriculture. During the last several decades, Malawi had, almost annually, faced a number of adverse climatic risks and threats.

Malawi Environmental Affairs Department (2002) [1] had evidently stated that the country is facing a range of climatic stresses, which included extreme rainfall, floods, seasonal droughts, multi-year droughts, dry spells, cold spells, hailstorms, thunderstorms, landslides, winds, heat waves and mudslides, among many others. Floods and droughts have surged in occurrence, intensity and degree since the 1980s' and had negatively affected food production, water availability, water quality, hydro power generation. Along with other factors such as population growth, the rural communities had limited capability to sustain their household livelihoods [2].

Malawi has 99 per cent of its 3 million hectares of agricultural cultivatable land under rain-fed cultivation, mainly for staple maize. The rain-fed nature of smallholder farming makes agricultural production susceptible to unfavourable weather conditions [3]. Farmers' household livelihoods as well as the national economy as a whole are very vulnerable to climate impact due to over-reliance on rain-fed agriculture; hence the majority of farmers' households experience persistent nutritional deficiencies in almost the whole country from year to year. Most recently in January 2015, Malawi recorded its worst floods which largely reduced staple maize crop yield by 40% [4], rendering almost 30% of the national population food insecure in 2015/16 consumption period alone [5].

Malawi's development and economic growth are highly jeopardised by climatic hazards, brought about by climate variability and extreme weather events. With about 65% of the population living below the poverty line [6], the adverse impacts of extreme weather events had, to a greater magnitude, lowered the capacity of the vulnerable communities to cope with, or adapt to climate variability [7][8].

In Malawi, food security is extensively associated to sufficient maize production which is estimated to account for more than 60% of the country's total food production. Therefore, due to climate impact, Malawi continued to grapple with the twin problems of pervasive food insecurity and chronic food shortages. In the advent of climate variability, for instance, identifying vulnerable populations and determining causal factors and degree of this vulnerability including foreknowledge of seasonal weather can afford the government the opportunity to make decisions that could enhance agricultural productivity and maximise returns on inputs of land, labour and capital.

Rain-fed farmers across the country have become more vulnerable to climate variability, facing its negative impacts on

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their farms. Farmers' vulnerability in terms of degree and characteristic may vary between agro-ecological zones due to different climate hazards experienced. Different household living conditions also determine the extent to which individual households are impacted. However, it seems a significant knowledge gap exists in terms of these perceived differences in vulnerability.

Nevertheless, with continued climate variability, climate stress would continue to occur and cause indelible damage to maize productivity. Vogel and O'brien (2004) [9] stated that understanding the varied roots and aspects of vulnerability is a precondition for the modelling and actualisation of adaptation policies and strategies that would sustainably advance equitable development.

The study investigated the understudied spatial variations of climate impact and how it determines the vulnerability of rain-fed maize farmers in mid-upland and lakeshore areas of central Malawi. The study would further explored adaptation options to climate variability as a steady preparation to cope with continued climate scenarios. Such assessment would be essential for informed policy decisions and guidance in programing weather-dependent food security initiatives and climate change investment decision making.

II. Methodology

A. Study Area

This survey focused on vulnerable communities of Maluwa and Chikumba villages in Lilongwe district and Ngolowindo and Lifuwu villages in Salima district in the central region of Malawi. Administratively, Lilongwe district belongs to Lilongwe Agricultural Development Division (LADD) whereas Salima district is in Salima Agricultural Development Division (SADD).

The two districts were selected for several reasons: firstly, because of their difference in altitude. Lilongwe is a mid-upland plain lying at 1050m AMSL and Salima is a lakeshore district at 513m AMSL. Salima lies 103 km east of Lilongwe. Its entire eastern boundary is almost 100 kilometres of purely beautiful Lake Malawi. Secondly, 47 % of the national land dedicated to food crops production (such as maize, groundnuts, rice and pulses) was located in the central region of Malawi [10]. These areas were some of the most vulnerable and affected agricultural divisions which faced an integration of delayed onset of rains and early cessation of rains, floods, and prolonged dry spells of 2014/15 growing season which affected the whole country [11]. Also, due to the limited time for data collection, this region was chosen for logistical purposes. In addition, accessibility to the site by the research team was considered important, for the purposes of building trusting relationships with the targeted population and that data quality and credibility of the study were reasonably assured [12].

Over 50% and 90% of the population in Lilongwe and Salima, respectively, were dependent on rain-fed agriculture. Main agricultural activities include crop production, livestock production and marketing of agricultural produce. Agricultural production is majorly for livelihood sustenance, with farmers cultivating for household consumption while the surplus is sold in local markets.

Lilongwe district (LADD) lies in the mid-upland agro-ecological zone whereas Salima (SADD) is a lakeshore district. According to Malcomb et al. (2014) [13] (Figure 1), both districts lie in the higher vulnerability areas to floods and droughts. They also have considerable numbers of smallholder rain-fed maize farmers hence they also produce higher maize yield per unit area. Homogenously, the two villages each in the two districts were randomly sampled as there were no noticeable differences in the people's livelihoods.

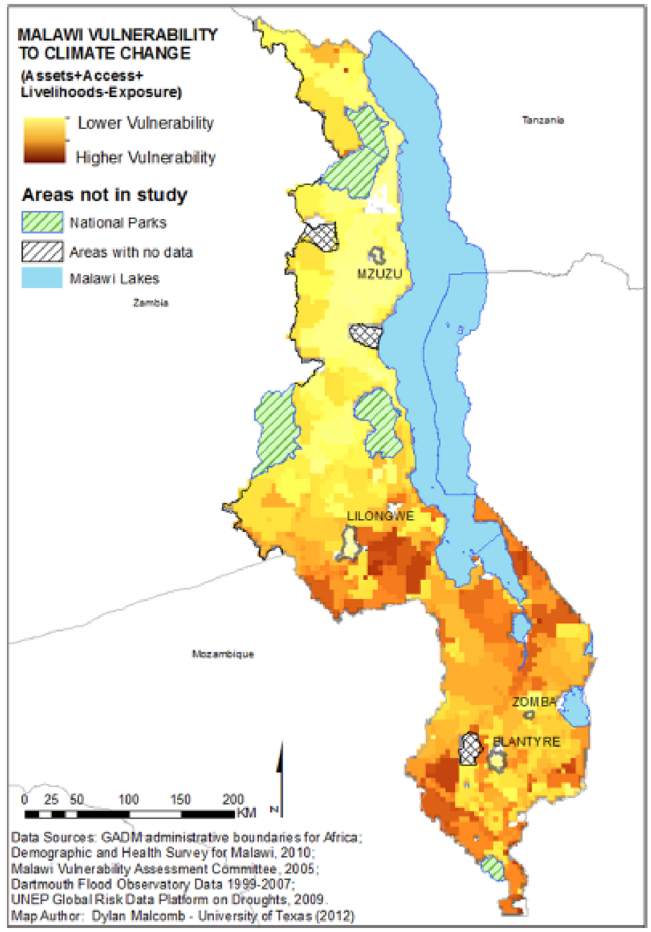

Fig. 1: Malawi Composite Vulnerability Index map (Malcomb et al., 2014).

B. Data Source

Primary data was collected from a household survey by randomly administering a structured questionnaire to smallholder rain-fed maize farmers in the selected areas. The farmers were interviewed on their observations and experiences on rainfall and temperature fluctuations over a period of 10 years (2005-2015) so as to present various climate and environmental issues in the two districts. The collected socio-economic data included demographics of household, total land under cultivation, total land under maize production, land under other field crops, annual total maize yield, estimated annual income; access to agricultural inputs (improved seed and chemical fertilizers), farming practices, labour and land availability, weather patterns and variability, climate change issues, soil condition and other incomegenerating activities. Historical data on precipitation and temperature from the period 1970-2015 were obtained from the Department of Climate Change and Meteorological Services (DCCMS).

C. Conceptual Framework of this Vulnerability Assessment

The survey based its understanding of climate variability, impact and vulnerability on the IPCC (2014) [14] definition of vulnerability as 'the extent to which a system is prone to, or incapable to cope with adverse effects of climate change, including climate variability and extremes. Vulnerability is a function of the character, magnitude and the rate of climate change and variation to which a system is exposed, its sensitivity and its adaptive capacity.'

The study focused on climate impact variations in the two targeted areas and the degree at which these were exposed to climate hazard. The study also hypothesized that environmental and social interaction would be specific of a place. The variables chosen in this study indicated climate stress extent incurred per household hence the study was able to determine the areas and households more exposed to particular climate impacts including degree of risk. Soil fertility and farmer experience with crop failure in the 10 years understudy were also assessed to find out the extent of climate hazard. Socio-economic characteristics which influenced vulnerability were also discussed with the farmers so as to find out their efforts in adapting to climate variability.

III. Results and Discussion

A. Serious Issues on farm

The geographical locations of mid-upland and lakeshore showed significant differences in the serious issues they faced in rain-fed maize farming. The major problem that 95% of the interviewed rain- fed farmers faced was drought or dry spells, this included all the 62 sampled households of the mid-upland (Lilongwe) which had a normal temperature range between 18-24°C and mean annual rainfall of 900mm. With normal mean annual temperature of 22°C and mean annual rainfall of about 1200mm [15], farmers in the lakeshore area faced both dry spells and floods during the same growing season. Drought was observed to be getting harder, longer and more frequent in both areas.

While 48% of the total sample reported soil fertility as another problem affecting their maize production, almost 60% of the total attributed some of the decrease in productivity to lack of fertilizer due to poverty. Labour, limited investment and lack of irrigation systems were other problems facing the farmers (20%, 20% and 18% of the total, respectively).

The study looked into the characteristics of climate impact in the past ten years (2005/06 – 2014/15). There was stark difference in the climate impact according to geographical locations. The two villages in the mid-upland plains of Lilongwe experienced severe drought and prolonged dry spells in 6 of the 10 years under study. The dry spells were crucially severe immediately after planting and tasseling of maize and were characterized by high temperatures, dry conditions and heavy winds. The length of dry spells increased and averaged 32 days in one growing season.

The two villages in the lakeshore area of Salima experienced alternating floods and dry spells, sometimes both within the same growing season or from one season to another. In the past 10 years under study, on average the area got flooded in 3 years while all farmers observed dry spells in 6 of those 10 years, the worst being the 2014/15 growing season. The delay in the onset of the rainy season had brought strong incessant rains within a short period of time causing flooding in the area washing away crop fields and property.

The changing rainfall patterns and amounts plus higher temperatures had forced farmers to shorten growing seasons. First planting rains had shifted from mid-November to late December while it was also stopping earlier forcing farmers to change to early maturing hybrid maize varieties.

B. Past climate variability impact and adaptation options

All the interviewed 110 households reported to have experienced climate variability and the increasing frequency and intensity of its impact of either drought/dry spells or floods or both in the 10 years under study. All the 62 households (56% of total households interviewed) of Maluwa and Chikumba villages of Lilongwe were severely affected by dry spell and all the 48 households (44% of total households interviewed) of Ngolowindo and Lifuwu villages of Salima district were worst hit by alternating or combining floods and dry spells.

Due to differences in other factors such as climate impact severity, soil fertility levels and amount of fertilizers applied, each household experienced climate impact differently in terms of maize yield losses. The study classified the severity of the climate phenomena into critical, moderate and minimal maize yield losses. 68 households (62% of total households) faced critical maize yield losses higher than 50%, 24 households (22% of total households) experienced moderate maize yield losses between 50% and 30% and rest of the 18 households encountered minimal losses of less than or equal to 30%. Table 3.1 gives a summary of the climate variability impact and maize yield losses.

TABLE I: LEVELS OF MAIZE YIELD LOSSES AGAINST MEAN CLIMATE VARIABILITY IMPACT PHENOMENA

Classes of maize yield loss	Number of Households affected	Climate impact phenomena mean frequencies
>50%	68	Once in every 2 years
30-50%	24	Once in 4 years
≤ 30%	12	Once in 4 years

To adapt to the climate variability, farmers changed farm operations during climate stresses aimed at minimizing the climate impact such as engaging in integrated agriculture by crop diversification and livestock farming; alternating arable crops with legumes to help improve soil fertility. 53% engaged in water management practices by irrigating their fields with water cans. To conserve soil and water, 83% of the interviewed farmers engaged in agroforestry and water harvesting technology. Considering the persisting severity of climate change impact on maize production, half of the interviewed households agreed to continue growing maize citing no alternatives to the staple crop, while the other half argued that they would grow commercial field crops, using the income realized from the sales of the field crops to purchase maize.

IV. Conclusion and Recommendations

The increasing frequency and intensity of climate impacts, such as floods and dry spells, are exacerbating poor crop production in central Malawi, mostly staple maize thus aggravating food and economic insecurities of rain-fed maize farmers and the nation as a whole. The household survey was significant in understanding spatial variations and farmer perceptions of climate variability, vulnerability and adaptation.

The results showed that mid-upland area of Lilongwe and lakeshore area of Salima faced different climate impact and risks leading to different vulnerabilities. The methodology used in this study provided insight in assessing vulnerability by focusing on the spatial variations in climate variability. It accords an opportunity to policy-makers and mitigation experts to categorise households based on their degree of vulnerability hence formulation of separate policy strategies to tackle particular households' needs. Government must make sure that local adaptation strategies are accessible, inclusive and adopted by the local communities. Environmental issues should be mainstreamed in all sectoral development strategies to widen the platform for discussion.

In adaptation, priority should be given to interventions that build people's resilience by enhancing the viability of their socio-economic set-up and minimising the intensity of climate impact. Taking advantage of Lake Malawi in the lakeshore district of Salima, and other areas that have residual moisture, government in partnership with the private sector would opt for the initiation of affordable and sustainable smallholder irrigation facilities for food production with low maintenance costs.

Appendix

Appendixes, if needed, appear before the acknowledgment.

Acknowledgment

The preferred spelling of the word "acknowledgment" in American English is without an "e" after the "g." Use the singular heading even if you have many acknowledgments. Avoid expressions such as "One of us (S.B.A.) would like to thank ... ." Instead, write "F. A. Author thanks ... ." Sponsor and financial support acknowledgments are placed in the unnumbered footnote on the first page.

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