



Analysis of farmers' adaptation to weather extremes in West African Sudan Savanna



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ABSTRACT

There have been recent incidences of weather extremes in the West African Sudan Savanna and farmers have responded through implementation of relevant adaptation strategies. For a deeper insight into farmers' adaptation to climatic shocks, this study documents farmers' perception of recent changes in the local climate, and identifies factors that influence the number and choice of strategies implemented. Interdependencies among strategies are explored and joint and marginal probabilities of adoption estimated. Upper East Ghana and Southwest Burkina Faso are used as the case study regions. These regions were selected due to extreme reliance of inhabitants on agriculture for sustenance, and their recent exposure to weather extremes. Through estimation of a Poisson regression and multivariate probit model to identify the major factors that influence the number and choice of strategies adopted, we discover that, limited access to credit, markets, and extension services, smaller cropland area, and low level of mechanization could impede effective adaptation to weather extremes. To enhance farmers' adaptive capacity, policy makers and various stakeholders need to contribute towards improving farmers' access to credit, markets, and extension services, and implement measures to promote mechanization.

1. Introduction

Agricultural productivity in the Sudan Savanna zone of West Africa has in recent decades been hindered by diverse technological, institutional, and infrastructural constraints. These constraints have already taking a toll on production outcomes and is reflected by low productivity of farming systems and high yield gaps for the major crop species cultivated in the area (Chauvin et al., 2012; MoFA, 2013). Despite policy and research efforts made to overcome low productivity of crop fields, there is not much evidence of success (Walker et al., 2016). While investors, policy makers and researchers continue to battle with production challenges posed by persisting constraints, increasing frequency, intensity and duration of weather extremes stand further reducing the already low observed yields and meagre farm incomes. This could, in the medium to long-term, lead to a reduction in food availability and access, and increased poverty. Enhancing farmers adaptive capacity, could, to a greater extent help to minimize adverse agricultural impacts of weather extremes. Adaptive capacity enhancement, however, requires appropriate identification of barriers to adaptation and implementation of pro-active measures to overcome such barriers. In this study, we analyze farmers' adaptation to recent

weather extremes in West African Sudan Savanna, and make policy recommendation on measures needed to build resilience in the region and other regions that share similar attributes with the current study area.

Farming in the study area is dominated by the rural poor, small-scale and subsistence farmers (Terrasson and Mojaisky, 2008). These farmers produce mostly on marginal lands with inherent terrain and poor soil fertility constraints (Laube et al., 2012). Majority of these farmers have limited access to input and output markets, limited access to credit (Tambo and Abdoulaye, 2013), limited access to weather-related information and water resources, and do face high cost of production (Ndamani and Watanabe, 2015). Above all these, farmers in the study area rely heavily on rain for appreciable yields (CGIAR, 2013). Given these attributes, increasing incidence of extreme weather events, amidst low adaptive capacity of farmers (Tambo and Abdoulaye, 2013), could at the farm-level, exacerbate production and livelihood challenges by causing further reduction in crop yields and current meagre farm incomes. Besides this, climatic shocks could impact on the limited asset base of farmers and trigger distress sale of productive assets, thereby reducing future investment capacity. Such localized impacts could yield regional and national ramifications.

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Among the likely macro-level effects are reduced regional and national agricultural production, increasing food prices due to reduced supply, increasing land values due to scarcity of fertile lands, general modification of trade and investment patterns, depletion of savings, and increasing hunger (FAO, 2016). A number of studies have been conducted in the study area to assess farmers' adaptation to changing local climatic conditions, and recommendations made towards minimizing potential effects of climate change, variability and extremes at local, regional and national levels (e.g. see Tambo and Abdoulaye, 2013; Antwi-Agyei et al., 2014). Besides being generally qualitative in nature, majority of the studies conducted so far, have either looked at on-farm and off-farm (coping) strategies (e.g. Antwi-Agyei et al., 2014), or jointly documented adaptation strategies and barriers without placing emphasis on dimensions¹ (e.g. Tambo and Abdoulaye, 2013). With the few that placed emphasis on dimensions, hardly were the differences in resource requirements considered in formulating such dimensions. Plausible interdependencies among strategies were as well not explored. With the few that explored interdependencies among adaptation strategies (e.g. Tambo, 2016), emphasis was placed on establishing spatial differences in resilience to climate extremes using climate resilience index, and in generally assessing determinants of number and choice of adaptation strategies. In the global literature, although a lot of research has been done to inform policy decision on measures needed to enhance farmers' adaptive capacity (e.g. see Hassan and Nhemachena, 2008; Deressa et al., 2009; Uddin et al., 2014; Abid et al., 2015), to the best of our knowledge, very little (if any) has been done to identify adaptation strategies, analyze determinants, predict joint and marginal probabilities of adoption of strategies, and explore interdependencies along critical dimensions. Bridging of this research gap could prove very useful for policy and investment decisions in the study area and at the global level.

In this study, and to complement efforts made so far (e.g. Antwi-Agyei et al., 2014; Mulwa et al., 2015; Tambo, 2016), we identify and assess adaptation strategies, their determinants, probabilities and interrelations under two primary headings; direct measures and supportive measures. Conceptually, direct measures refer to varietal and crop-related adjustments made by farmers, which generally demand low cash outlay in the medium to long-term, but with a probable high initial investment in required inputs and with a high potential for preserving majority of such inputs for future use. Supportive measures on the other hand refer to insurance based and/or stress-reducing measures implemented by farmers, which generally demand relatively high cash outlay in the medium to long-term, with both low and high probability of high initial investment, and may require repeated application both within and between seasons for effectiveness. Given however, that adaptation involves a multistage process of signal detection and response (Maddison, 2006), we analyzed farmers' perception on recent changes in climatic conditions (and validated this with climatic data), their adaptation to such changes, determinants of number and choice of adaptation strategies used, joint and marginal probabilities of adoption within and between measures, and explored prevailing within-measure and between-measures complementarities and substitutions. We analyzed the determinants of adaptation strategies, probabilities, and interdependencies using a multivariate probit model, and analyzed determinants of number of strategies implemented using a Poisson regression model. This study uses data obtained from 450 heads of farm households in Upper East Ghana and Southwest Burkina Faso. These two regions were selected due to extreme reliance of inhabitants on agriculture for sustenance, dominance of rural population in the respective regions, their limited use of irrigation facilities, and their recent exposure to

various extreme weather events. By analyzing determinants of, barriers to, and joint and marginal probabilities of farmers' adaptation across two vulnerable regions in two countries, this study makes a vital contribution to literature on adaptation to weather extremes in Africa. In addition, this is the first study conducted in West Africa where adaptation is analyzed along cost-related dimensions, interdependencies among strategies explored, and joint and marginal probabilities of adaptation estimated at the same time. We make use of both primary data (gathered through a household survey between October 2014 and July 2015) and historical daily climate data extracted from NASA's Climatological database. In all, 29 communities were covered across 7 districts in the two regions. To effectively address the goals of this research, we aimed at answering the following research questions:

1. What perceptions of recent changes in climatic conditions are held by farmers in the study area?
2. Which direct and supportive measures of adaptation have farmers implemented following recent exposure to weather extremes?
3. Are there significant within-measure and between-measures interdependencies among the strategies used?
4. What are the relevant determinants of adaptation strategies used and intensity of their use?
5. What are the chances for the average farm household to adopt each of the revealed adaptation strategies, all adaptation strategies, strategies deemed direct measures, and strategies deemed supportive measures?

The remaining sections of this paper are organized as follows. In Section 2, we provide a conceptual framework on which this study is founded. Methods are covered in Section 3. Under methods, we provide an overview of the study area, sampling and data, analytical framework, and descriptive statistics on variables. In Section 4, we present and discuss findings on farmers' perception of recent changes in climatic conditions. Results and discussion of relevant findings on determinants of the number and choice of strategies implemented, interdependency among strategies, and probability of adoption are covered in Section 5. In Section 6, we draw conclusion and make relevant policy and stakeholder recommendations.

2. Conceptual framework

In a given location, farmers usually adjust to gradual changes in climatic conditions with a mindset of either moderating harm from such changes or exploiting beneficial opportunities. When exposed to extreme events, adjustments made are primarily aimed at reducing the actual adverse effects from current exposure or anticipated effects from future exposition (Smith et al., 2000). Given the focus of this study, we define adaptation as the implementation of measures by farmers based on their recent exposure to weather extremes and with a purpose of reducing actual and/or anticipated effects of future weather extremes. Farming systems are generally exposed to two distinct climatic challenges: challenges related to changing dynamics of weather shocks and challenges related to long-term shifts in relevant climatic indicators for a given location (temperature, rainfall patterns, etc.) (Baez et al., 2012). Impacts of climate change, variability and extremes on farming systems are therefore yielded either through shifts in long term means or climatic shocks. We place emphasis however on the latter.

Depending on exposure and sensitivity of farming systems to such shocks, low crop yields and farm incomes are usually observed, farm lands are in some cases destroyed or degraded, access to input and output markets becomes limited, changes in water supply for production and for domestic use are usually observed by virtue of either overflow (in times of intense precipitation and/or flooding) or scarcity (in time of droughts and extreme heat), and prices of inputs and outputs become highly volatile. Effects are usually more pronounced on the poor rural households, who are more vulnerable to climatic shocks

¹ Dimension in this context refers to analysis of adaptation and interpretation of outcomes in a particular direction, placing emphasis either on time, place, input requirements, or costs on a broader perspective.

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