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Perception and Adaptation Adjustments to Climate Variability Within the Santa Agrarian Basin in the Western Highlands of Cameroon

Zephania N. FOGWE[1] and Bonglam Chofor Zoum[2]
Department of Geography and Planning, Faculty of Arts, Box 39 University of Bamenda,
Department of Geography, FLSS, Box 3132, Douala, University of Douala

ABSTRACT:- This study was carried out in Santa Highland in the Western plateau of Cameroon to ascertain how farmers perceived climate variability and determine coping and adaptation strategies within the agricultural sector. Primary and secondary data were used. Primary data were obtained using different Participatory Research Approaches (PRA) including in-depth interview, focus group discussions and household questionnaires. Findings showed that farmers and grazers perceived changes in rainfall and temperature. The changes have affected the livelihood of integrated crop and animal farmers in a number of ways resulting in improved productivity. Communities within the Santa Highland are vulnerable to climate variability and so study posits that, knowledge on coping and adaptation that farmers should constitute a foundation for designing agricultural innovation systems to deal with impacts of climate variability.

KEYWORDS: *Adaptation measures, climate variability, communities, perception, strategies*

I. INTRODUCTION

The actions of man through changes in land use, deforestation and increase in population are responsible for the accumulation of greenhouse gases in the atmosphere that result in global warming. The effects of climate variability on agriculture in the developing countries have been well established through field experiments, statistical analyses recorded in crop yields, and monitoring of agricultural production. Increase intensity and frequency of climate-related hazards such as severe storms, drought and flooding, soil erosion, sea level rise, salinity intrusion and river bank erosion have implications for future food availability in Africa. The impact of climate variability represents a major challenge to sustainable development, food security and high level of poverty in Cameroon in general and the Santa agrarian basin in particular.

The Santa Highland is vulnerable to climate variability because of its dependence on rain fed agriculture, high levels of poverty, low levels of human and physical capital and poor road infrastructure. Mixed crop–livestock systems are the backbone of the Santa Highland agriculture, providing food security and livelihood options for thousands of people. Less is known about the impacts of climate variability on the crop and livestock mixed enterprises in the Santa Highland. This is a serious gap because these interactions may offer some buffering capacity to help smallholders adapt to climate change. The climate is changing and adaptation is therefore critical and of concern in the Santa Highland where vulnerability is high because ability to adapt is low. Climate variability is expected to affect food and water resources that are critical for livelihoods in the Santa Highland where much of the population, especially the poor, rely on local supply systems that are sensitive to climate variation. Farmers can reduce the potential damage by making tactical responses to these changes. Analyzing the perception of farmers of climate variability is therefore important for finding ways to help farmers adapt in the rural economies like the Santa Highland. Our analysis is considering farmers' adaptation measures. This includes farmers' perceptions of climate variability and the adaptations they perceive as appropriate. The rural poor farmers are likely to suffer the more damage from climate variability because they are least endowed with resources to combat the problem, and their economies are based largely on natural resources-dependent sectors that are climate sensitive. In the face of these impact of perceived environmental changes there are two responses to the crises: mitigation (how to stop further releasing greenhouse gases into atmosphere) and adaptation (how people can survive in the presence of these changes). IPCC, (2001) saw adaptation as response to actual or expected climate stimuli or their effects which allow the system to moderate harm or exploit beneficial opportunities. Located to the south of Mezam Division (Figure 1), the study area is about 532.67 square kilometers and lies between latitude $5^{\circ}42'$ and $5^{\circ}56'$ north of the equator and between longitude $10^{\circ}01'$ and $10^{\circ}19'$ East of the Greenwich Meridian.

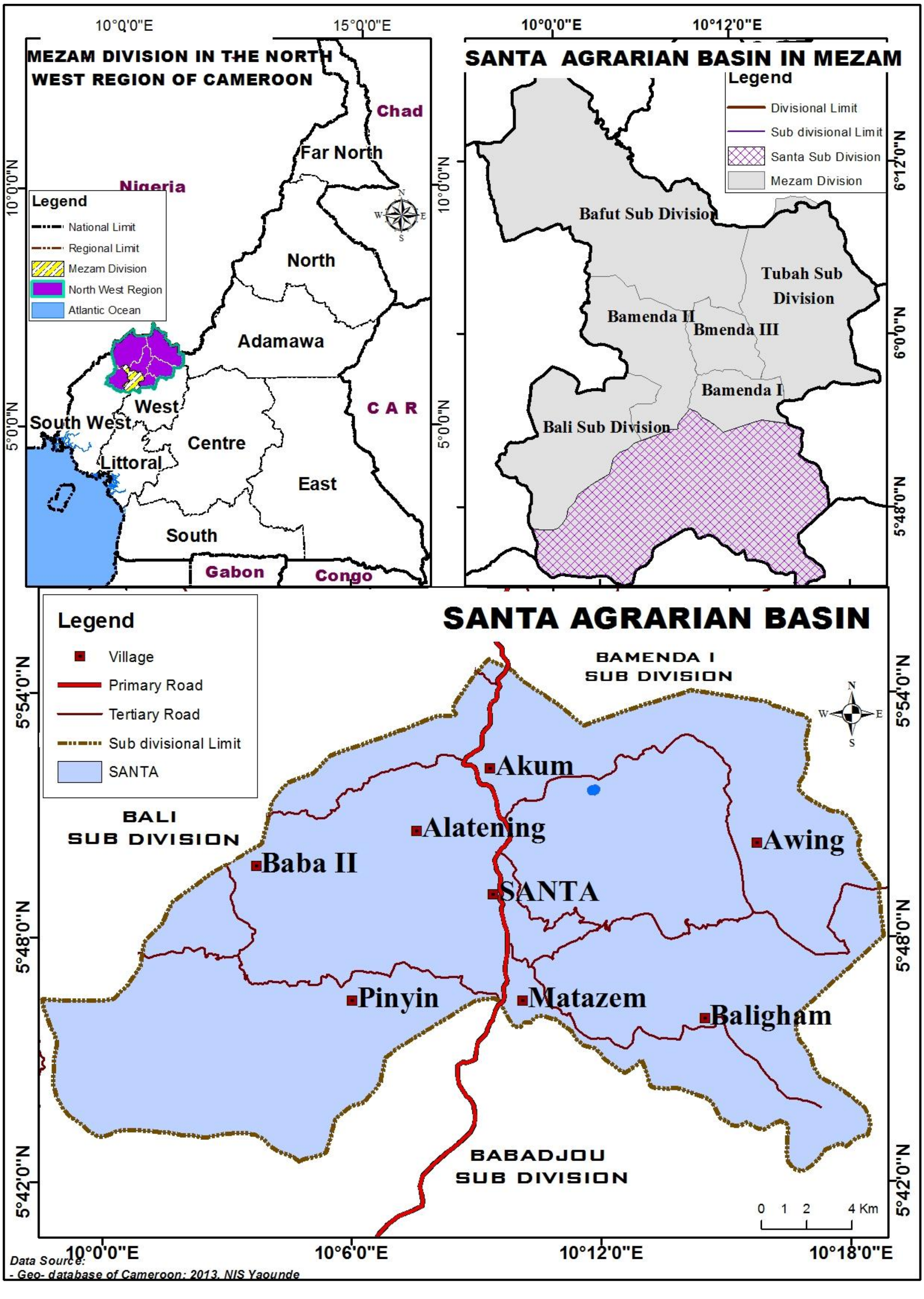
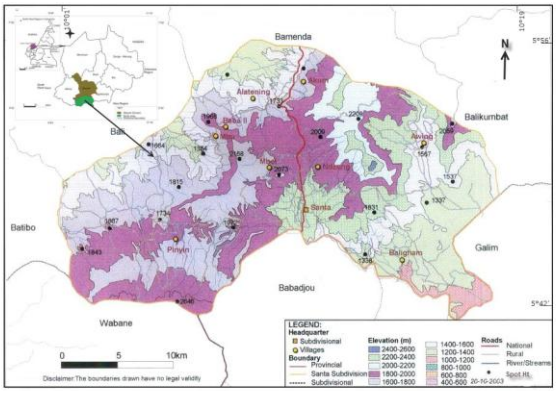


Figure 1: Location of the Santa Agrarian Basin study area

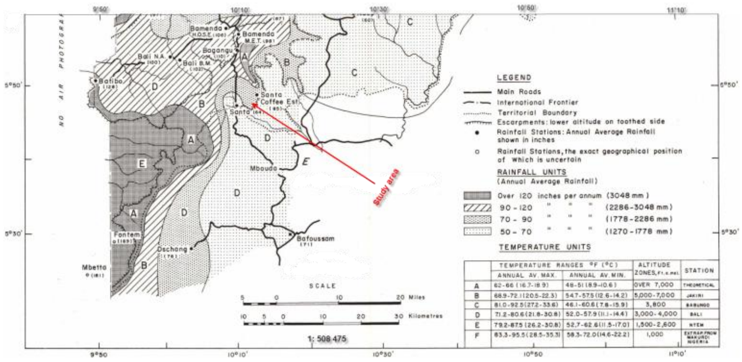
This longitudinal and latitudinal extent of the Santa agrarian basin presents a wide diversity in its physiographic traits in terms of its relief and drainage characteristics (Figure 2). This diversity permits a perfect environment *par excellence* for the cropping of different crops and vegetables on a highland area.



Source: Adapted from the Santa Rural Council and CAMGIS, 2003

Figure 2: The relief and drainage of Santa Highland within the Western Highlands of Cameroon

The mean annual temperature of the area varies from 21.8°C to 30.8°C (Figure 3). The area receives abundant insolation during the day. Rainy season commences around March and extends to September, with July/August as then peak months, while the dry season occurs between October and February, reaching its peak in January when the North East Trade winds wind sweeps across the area. The vegetation is mainly the montane rainforest formation, which has been distorted in the course of the years. Most disturbances are through human influence for which there is ample evidence in the form of farms, human settlement, cutting of fuel wood, logging and continuous soil erosion. The soils in this area are fertile and support a large human population. The population of the area estimated in 2008 was 99 851 (Fogwe, 2014), and 90% of this population are engaged in farming and grazing. Two seasons mark the area, being the rainy and dry season. The annual rainfall is averagely between 2000-3000 mm mostly from March to September and the dry season is from October to February. In August torrential rainfall results from the strong Monsoon winds from Southern Cameroon and conversely strong dry northeasterly winds blow from the North from November to January. Springs dry up as stream discharge drops and the vegetation dries up triggering the start of transhumance. The altitudinal range is from 600 to 2600 m (Figure 2) making this highland favourable for animal rearing, crop and vegetable cultivation aptly qualifying this region as an agricultural production basin in the Western Highlands.



Source : Adapted from Hawkins and Brunt, (1965).

Figure 3: Rainfall and temperature distribution on the Western Highland

The people are made-up of mainly farmers and some Bororo cattle grazers and also there is a formal and informal business and other commercial activities taking place in the area. Farming and grazing activities have been disrupted with few coping and adaptation mechanisms available to the local people. There is a growing range of evidence that individuals and communities across the Santa Highland, including smallholder farmers, have historically responded to a varying number of climatic and non-climatic pressures and opportunities, where local knowledge and experience have played an important role in agricultural decision-making. Climate-related hazards make biogeophysical resources of the area susceptible to climate-related extreme events such as erosion and excessive rise in temperature. Of late, the frequency of these events has become alarming. The livelihoods of the rural resource-poor people who are mainly farmers are at high risk due to the extreme climatic induced events. Numerous studies on climate change and climate variability have been conducted in temperate and highly industrialized countries (Mendelsohn, 2000). Elsewhere little research has focused on developing regions such as those in the tropical rainforest where the poor who may be most vulnerable to climate changes live. There is not much relevant information on the perception of climate variability on the livelihood of communities in the Santa Highland of Cameroon about the perception of farmers on both temperature and precipitation. This study therefore examines the perception of farmers about their changing environment and determine coping and adaptation measures in the Santa Highland.

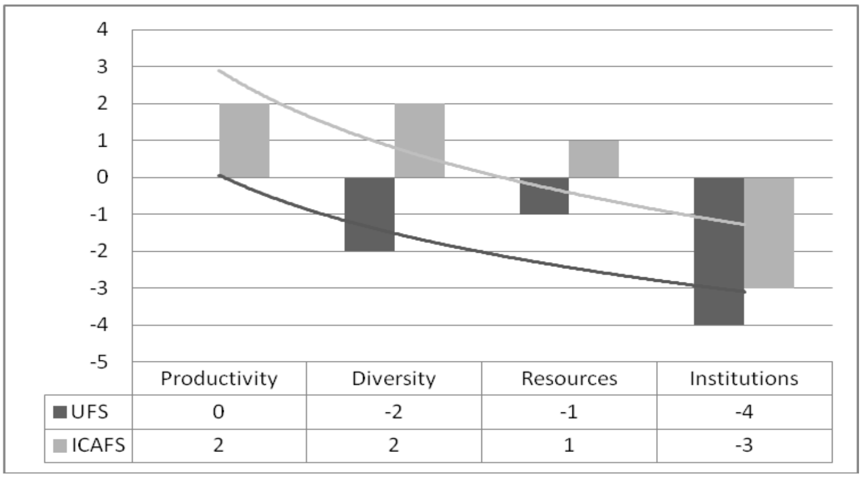
II. METHODOLOGY

This study uses primary and secondary data. The primary data were obtained using field surveys, in-depth interviews, focus group discussion and questionnaire administered to the farmers and grazers in study area. Information on the communities and climatic conditions were obtained from heads of communities, community chiefs, the spokesmen, elders and other opinion leaders that have live in the place for the past 30 years. These people are privileged to know the communities very well. The questionnaires were structured to elicit much information as possible on the climate-related extreme events; these included any previous studies on all possible impacts of climate change, identifying particularly vulnerable area and capacity building which may be taken to prepare for adaptation to climatic hazards in the area. Secondary data were collected from the Santa Rural Council, Agricultural Development Programme, Sub-Divisional Delegation of Agriculture and Rural Development for Santa, Seminars, conferences, workshop proceedings and text books.

III. RESULTS AND DISCUSSION

1. **Trends of integrated agrarian system adaptive options in Santa**

A qualitative assessment of each trend and its impact on of adaptive capacity was carried out using primary data to assess whether it had a positive or negative impact on farming system productivity, diversity, resources and informal/formal institutions. Qualitative analysis focuses on overall trends, i.e., incremental changes, rather than specific shocks or stresses. Each impact that was deemed to have a positive impact was given a score of 1. Those that were deemed to be negative received a score of −1. The number of positive and negative impacts relating to this farming system was summed to provide a basis for a quantitative comparison (Figure 4). A score of zero, for example productivity (Figure 4), highlights that positive and negative impacts act to cancel each other out, rather than meaning that no impacts were recorded.



Source : Fieldwork, 2014

Figure 4: Components of adaptive capacity for the integrated farming System

When impacts of the trends are analysed collectively, there have been overall positive impacts on the ICAFS (Integrated Crop and Animal Farming System), and a range of negative impacts on the adaptive capacity of the UFS (Unintegrated Farming Systems) (Figure 4). Interrogating the data shows the biggest difference between the UFS and ICAFS is in how the shift from traditional to modern farming has impacted upon the adaptive capacity of the farming system, highlighting that the farming systems have had different experiences of shifting towards modern farming methods. In UFS, such methods have largely replaced traditional farming practices, crop varieties and methods, whereas in ICAFS they have been integrated into traditional practices.

Overall, trends, including the shift from traditional to modern farming, have had a positive influence on the productivity and diversity of the ICAFS. In the UFS they have had an overall neutral effect on productivity, but have negatively impacted upon diversity. Furthermore, the same trends have had an overall positive impact on resources in the ICAFS, whilst negatively impacting upon the UFS. The biggest similarity between the trends is the collective impact they have had on informal or formal institutions, where there is a negative effect in both the UFS and ICAFS. Whereas, the biggest difference is how the trends have impacted upon on diversity, where there is currently less diversity in terms of crops, livestock, and income generating activities in the UFS.

2. Adaptive capacity factor analysis in the Santa Highland

Through the data presented in this work, various factors that enable or constrain adaptive capacity can be identified. Reflecting on the similarities and differences between the farming systems provides insight into specific interventions needed to strengthen adaptive capacity both in Santa and in farming systems more broadly. These are:

- *Highland enhancing and adaptive enhancing factors*

Higher levels of diversity have been maintained in the ICAFS compared with the UFS. Integrating modern farming methods rather than replacing traditional methods has contributed to higher levels of diversity. Although it is unclear whether this is an intentional approach adopted by farmers, government research and extensions or NGO programmes, it confirms that as more crops and livestock are introduced, traditional production systems and associated local breeds are marginalised. Subsequently, this leads to a loss of genetic and cultural diversity in both crops and livestock. Maintaining diversity will be important in fostering future farming system adaptive capacity. Formal institutions, for example government policies, extension services and NGO programmes influence farming system adaptive capacity. This demonstrates that policy pathways are contingent on historical pathways and can be difficult to change. Government research and extension services and NGO programmes are thinking about the extent to which their approaches are enhancing or undermining adaptive capacity. Results permit to notice that farmers have changed their agricultural practices and livelihood strategies in response to a range of pressures and opportunities within the Santa Highland. Adaptation to climate variability therefore does not take place in isolation in the Santa Highland. Many management decisions and resource allocations, influenced by multiple factors operating across spatial scales, are made at the household level. This confirms that farmers, who make these management decisions, influence the impacts of future changes. However, farmers do not operate in a vacuum, and the decisions they make are based on outside influences. Such decisions influence farm-scale adaptive capacity, and therefore contribute to the overall resilience or vulnerability at a farming system scale. Future analysis of farming systems should recognise the agency of farmers and context of decision making processes as crucial to determining adaptive capacity. There is a need to understand how farm management and resource allocation decisions are made, how such decisions shape adaptive capacity and ultimately, the vulnerability and resilience of farming system. Trade-offs made at the farm-scale and how they impact on adaptive capacity also need to be explored fully; presenting data collectively at the farming system scale can mask farm-scale variations.

- *Highland constraining factors to agrarian adaptive schemes*

A focus on productivity in the short term discounts the importance of fostering future adaptive capacity. This includes maintaining long term productive capacity. Good agricultural and adaptation policies are built on the farmers' traditional techniques as a means to fostering future adaptive capacity. Moreover, national and international agricultural research need shift focus from the short to longer term. Despite the fact that overall the trends have had a positive impact on the adaptive capacity of the ICAFS, other weaknesses in the farming system still exist. Whilst productivity, diversity and farm-scale resources have been maintained, there is inconclusive evidence about the extent to which the ICAFS has been able to grow and develop, thus raising important questions about resilience, development and poverty reduction and the synergies and trade-offs between them. The evidence on the extent to which crop and animal interplay farming systems with high levels of adaptive capacity are able to maximise productivity and increase incomes is inconclusive, highlighting additional areas for future research. This raises important questions about trade-offs between short term socio-economic development and productivity with enhancing overall adaptive capacity, including productivity, in the long term. Some issues such as the decline of informal institutions need some common actions to enhance this component of crop and animal interplay adaptive capacity. External actors and formal institutions are undermining informal cultural and social institutions. The interplay between formal and informal institutions can shape adaptive capacity.

3. Perceived adaptation strategies of integrated crop and animal farmers

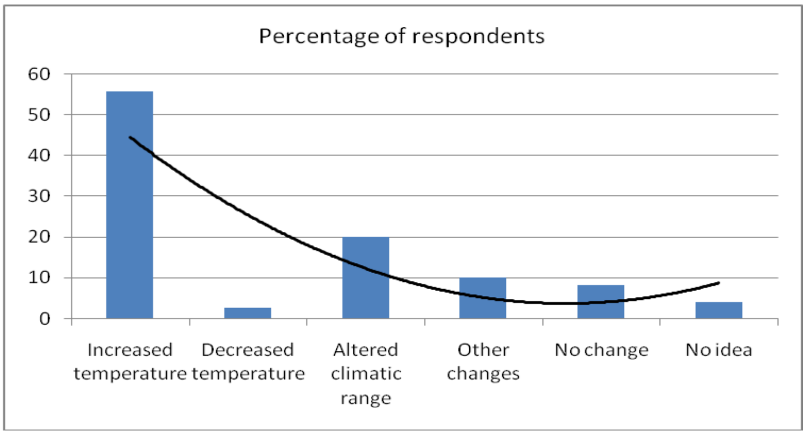
There has been temperature and rainfall variability in the Santa Highland from 2001 to 2014 (Table 1). The climatic variables of rainfall and temperature considered in this paper shows annual rainfall peak in 2005 (2625.5 mm) while temperature peak was attained in 2008 and 2009 (21.3° C).

Table 1: Farmer perceptions of long-term temperature and precipitation changes

Year	Annual rainfall	Annual temperature
2001	2306	19,6
2002	2554,8	19,09
2003	1914,6	19,1
2004	2376,7	19,3
2005	2625,5	20,3
2006	2305,4	19,3
2007	2173,6	21,3
2008	2221,3	21,3
2009	2550,1	19,9
2010	2555,7	20,4
2011	2201,8	19,56
2012	1883,5	19,53
2013	2129,6	19,54
2014	2546,5	19,6

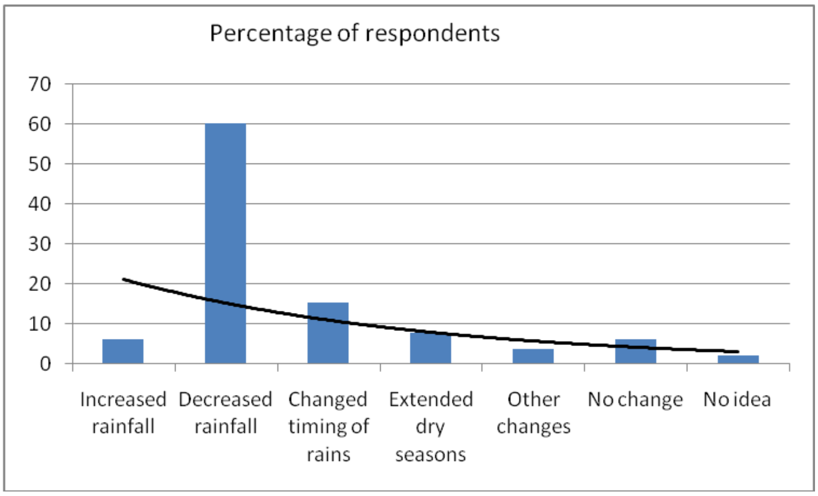
Source: Regional Service of Meteorology for the North West Region (2014) and Regional Delegation of Transport Bamenda (2013)

Integrated crop and animal farmers' perceptions of climate variability and the strategies they consider suitable for adapting to these changes from a sample of 150 surveys are given in figures 5 and 6.



Source : Field work, 2014

Figure 5 : Farmers perception of long- term temperature changes



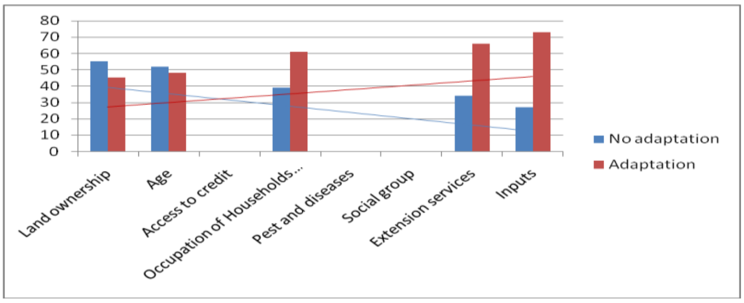
Source : Field work, 2014

Figure 6: Farmers perception of long- term rainfall changes

In this sampling integrated crop and animal farmers were asked questions about their perceptions of long-term temperature and precipitation changes and what measures and practices they have typically opted for in order to cope with such changes over the years. The results (Fig. 5) show that half of the farmers sampled perceive that long-term temperatures are warming, half (Fig. 6) of them believe rainfall is declining, a third believe there have been pronounced changes in the timing of the rains, while one sixth think dry season is more intensive.

3.4. Factors influencing the choice of climate variability adaptation strategies by households in the Santa Highland

The results show that perceptions of households towards climate change, high food prices, access to credit and land category significantly influence the choice of not adapting to climate variability compared to adapting using new varieties and shifting planting time (Figure 7). The results suggest that when households perceive a change in climate, the probability for not adapting becomes reduced compared to that of adapting by using new resistant varieties of plants and animals and shifting planting time. High food prices reduce the probability for not adapting to climate variability compared to adapting by using new varieties and shifting planting time. This is because households will adapt to increase crop production so that they will be able to produce their own food to avoid high food prices in the markets. Owning land increases the probability that the household will not adapt to climate variability by 55% compared to adapting by using new tolerant varieties and shifting planting time. This shows that renting land increases the likelihood of adapting because rural households do not have enough money to buy hybrid seeds, so they would rather not adapt by using new tolerant varieties. Age of household head (age) significantly 52% influence the choice of not adapting to climate variability compared to adapting using new tolerant varieties and shifting planting time. This implies that for every additional year in age of the household head, the probability of not adapting to climate variability increases compared to adapting by using new tolerant varieties and shifting planting time. This implies that as the household head gets older, he or she is reluctant to use new technology, but rather opt for not adapting to climate change.



Source: Fieldwork, 2014

Figure 7: Adaptation strategies acceptability by crop and animal integrated farmers in the Santa highland

Occupation of the household head and perceptions of households towards climate variability significantly 61% influence the choice of adapting to climate change. This implies that when the household head is a farmer the probability of adapting to climate variability is high. This is because when fully engaged in farming, households will have enough time to explore more adaptation options and focus all their resources to farming since it is their livelihood than those with other sources of income. Access to credit and high incidence of crop pests and diseases, significantly influence the choice of adapting to climate variability using conservation agriculture, drought tolerant varieties and shifting planting time as adaptation strategies compared to using drought tolerant varieties and shifting planting time. The results suggest that access to credit increases the probability of farmers adapting to innovations by 76.6%. Households would use credit to purchase hybrid seeds than focussing on conservational agriculture. High incidence of crop and animal pests and diseases reduces the chances of adapting using conservation agriculture, drought tolerant varieties and shifting planting time by 34.3% compared to adapting to new varieties and shifting planting time. However, conservational agricultural methods such as crop rotation reduces crop pests and diseases such that when households have observed increased crop pests and diseases, they are expected to include conservation agriculture as they adapt to climate change. These results are contrary to *a priori* expectations where the variables were expected to increase the probability of adapting using conservation agriculture and shifting planting time.

Being a member of a social group and access to extension services significantly influence the choice of household adapting to climate variability using conservation agriculture and shifting planting time as adaptation strategies compared to using integrated crop and animals and shifting planting time. This implies that being a member of a social group increases the probability of adapting using crops and animals and shifting planting time by 18.5% over and above that of adapting using conservational farming practices and shifting planting time. This is because social groups such as farmers' cooperatives provide farming credits and resources that can be used when adapting to climate change. Access to extension services reduces the probability of using conservation agriculture and shifting planting time by 66%. Access to extension services and perceptions of households towards climate variability significantly influence the choice of adapting to climate variability using conservation agriculture and shifting planting time as adaptation strategies compared to using crop and animal integrated farming system and shifting planting time. High input prices significantly influence the choice of adapting using conservation agriculture and shifting planting time as adaptation strategies compared to using drought tolerant varieties and shifting planting time. High input prices increase the probability of adapting using crop and animal integrated farming and shifting planting time by 46.2%. This implies that households lack resources to buy inputs such as drought tolerant varieties and inorganic fertilizers.

5. Agrarian adaptation signatures indicative of climate variability in Santa

Integrated crop and animal farmers were asked to identify with the adaptation strategies they have engaged to neutralise the adverse effects of climatic change and variability in at least the past ten years. Findings revealed that coping changes were made in crop and animal agronomy, water and soil conservation. Specifically of a sample of 150 farmers there have been structural and agronomic adaptations of different categories (Table 2). The changes made were climate-smart strategies adopted to revert adverse effects of climate variability.

Table 2: Adaptation strategies used by farmers

No	Variable	Frequency	Percentage
1	Change to the use of fertilizers	29	19.33
2	Use of different crop planting dates	25	16.66
3	Diversification of crop and animal varieties	23	15.33
4	Engage alternative soil farm conservation	21	14.00
5	Improving storage and post-harvest storage/security	14	9.33
6	Move/shift to a new farm site/activity	13	8.66
7	Irrigation of the farms	9	6.00
8	Change from crops to livestock farming	7	4.66
9	Involve farm insurance	5	3.33
10	Change from livestock to crop farming	4	2.66

Source: Field work 2014

The adaptation strategies that farmers perceive as appropriate (as opposed to the on farm running strategies) include crop diversification; using different crop varieties; varying the planting and harvesting dates; increasing the use of animals; increasing the use of water and soil conservation techniques (Table 2). The farmers' adaptation options can be classified into two main kinds of modifications in the production systems: a) increased diversification, and b) protecting sensitive growth stages by managing the crops and animals to ensure that these critical stages do not coincide with very harsh climatic conditions such as mid-season dryness.

Farmer adaptation strategies that serve as forms of insurance against rainfall variability include increasing diversification by planting crops and raising animals that are resistant to temperature stresses; taking full advantage of the available water and making efficient use of it; and growing a variety of crops and animals on the same plot or on different plots, thus reducing the risk of complete crop failure since different crops are affected differently by climate events. These strategies can also be used to modify the length of the growing season, for instance by using the additional water from irrigation and water conservation techniques.

IV. CONCLUSION

The study has been able to establish that rainfall has been decreasing while temperature and relative humidity showed increasing trend from 2001-2014. These trends in climatic elements negatively affects farming in the area. 90% Farmers in the Santa Highlands are aware of climate variability but 38.2% of them responded not adapting to the changed climate in order to reduce the negative impact and increases resilience on crop and animal integrated farming systems in the Santa Highland. Those who adapt to climate variability use manure, diversified crop and animal production, changed planting dates, soil conservation and irrigation as adaptation strategies. Explanatory variables that influenced the choice of households when adapting to climate variability are socio-financial. This study recommends that such measures needs to be strengthened. Encouraging the coping strategies of local farmers through appropriate public policy and investment and collective actions can help increase the adoption of adaptation measures that will reduce the negative consequences of predicted changes in future climate, with great benefits to these vulnerable rural communities. The impacts can be significantly reduced through adaptation.

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