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# Impacts of Climate Change on Livestock Husbandry and Adaptation Options in the Arid Sahel Belt of West Africa: Evidence from a Baseline Survey

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## ABSTRACT

Drought is a recurrent climatic risk in the Sahel belt of West Africa. This study analyzed its impact on livestock husbandry and determined the factors influencing adaptation choices. The data used were climate change baseline survey data collected from 421 households in Burkina Faso, Mali and Niger. The Probit regression method was used for data analysis. Results show that drought mostly affected sheep with 17.86 and 8.5% in Burkina Faso (BF) and Mali, respectively. New pests and diseases were reported for goats by 19.86 and 11.43% of the farmers from Mali and Burkina Faso, respectively while sheep had 17.73 and 9.29%. Also, 12.86% of the farmers from Burkina Faso introduced new oxen on their farms as a way of coping, while 18.57 and 17.86% of the farmers from Niger stopped keeping dairy cow and goats, respectively. Herd sizes were reduced in Niger, Mali and Burkina Faso by 22.14, 10.64 and 10.00% of the farmers respectively. The Probit regression results show that access to media information, getting assistance during flooding, access to non-farm credit, aged dependency and access to credit were found to influence adaptive capacities of livestock farmers. It was concluded that drought is pressing economic challenge to livestock farmers and efforts to reduce its impact should focus on more provision of assistance and media information.

**Key words:** Drought, climate change, Sahel belt, arid, livestock

## INTRODUCTION

Countries in the Sahel belt of West Africa are among the least developed in the world. Their economic development hurdles are particularly pronounced in terms of low human development indicators, high poverty incidences and low per capita incomes (African Economic Outlook, 2013). Sahel belt countries also exhibit high vulnerability to global economic shocks, with relatively higher impacts always felt by rural households. Low economic development in the Sahel belt is obviously associated with natural resource scarcity and ignominious retrogressive experiences from past droughts. Precisely, there were odious records of rain failure in the early 1970s and 1980s, which all resulted in crop failure, death of livestock, economic hardships and development retrogression. Brooks (2006) also submitted that the Sahel belt of Africa experienced dramatic changes in climate between early 1970s and mid 1990s (Glantz, 1976, 1996). Some studies have noted that future climate change will have serious impacts on the livelihood of the African Sahel region (Zeng, 2003; IPCC, 2007). International Union for Conservation of Nature and Natural Resources (IUCN, 2010). Although, dealings with immediate crisis would not prevent future occurrences, by 1974, international organizations had channeled about US $360 million as relief assistances to countries with adverse climatic exposure (De Lattre and Fell, 1984). More recently, Sahel region was affected

by food and nutrition crises in 2005, 2010 and 2012 (European Commission, 2013). Persistent civil conflicts in some of the countries have aggravated food insecurity with utmost urgent necessity of humanitarian assistances.

IUCN (2010) submitted that there are a number of reasons for analyzing the interrelations of climate change and the livestock sector. Specifically, although animal husbandry had been noted as key contributors to climate change, rural poor households often depend on proceeds from livestock enterprises for meeting critical domestic needs and they serve as sources of credit and savings. Similarly, some residents in semi-arid Sahel belt practice transhumant livestock herding as the main source of income. Seasonal scarcity of forage and pasture due to inadequate rainfall is a critical limitation to animal husbandry in Sahel. Historical and anthropogenic climate change pressure and rising intensive economic exploitation of fragile natural resources often pose serious threats to sustainable development in the Sahel belt. In many instances, changes in agricultural production systems have been propelled by climate change and persistent socio-economic dynamics, which often represent voluntary or involuntary reactions to extreme climatic situations (Raynaut, 1998; Mortimore, 1998).

However, comparative advantages in agricultural production position the Sahel belt for animal husbandry, which is one of the dominant means of livelihoods among the largely rural population. There is the hypothesis that for some farm households, livestock are buffer stock to smoothen consumption expenditure fluctuations which may result from income shocks. Traditional livestock husbandry practices also distinguished Sahelian livestock farmers by their pastoralist production system with essentially transhumance or nomadic features. The livestock composition often portrays significant diversification with *inter alia* a mix of cattle, sheep, goat and donkey. Therefore, livestock is no doubt one of the major means of livelihoods among poor inhabitants of Sahel, although this sector is presently threatened by scarcity of pasture land due to inadequate rainfalls. Changes in climate often result in livestock death due to inability to secure adequate water and pasture. These changes have necessitated significant adaptation with direct focus on sustaining farmers' productivity through livelihoods' diversification and adjustments in production systems (O'Farrell *et al*., 2009).

Therefore, attempts to analyze the impacts of climate change in the Sahel belt will obviously require adequate consideration of changes in rainfall patterns and adaptation options of pastoralists. This is critical for survival of several millions of vulnerable poor households in the drought prone arid region. Analysis of the impact of climate change on livestock is also imperative given the dearth of studies on this vital aspect of research. Precisely, IPCC (2007) submitted that "very little research has been conducted on the impact of climate change on livestock (in Africa)". Similarly, understanding the factors promoting farmers' adaptive capacity against drought and other climate-related problems is imperative for policy design, given that rural residents in Sahel often lack the needed skill for making drastic changes in the event of consumption and income shocks (Downing, 1997; Magistro and Roncoli, 2001).

Exposure to flood can act for or against livestock husbandry. The expectation is that exposure to flooding may imply that the household lived close to flood plains and this can facilitate agricultural activities. However, in some uncommon instances, households may not have experienced flooding before but due to excessive rainfall have to face one. In this situation, production cost may increase due to drowning of livestock. FAO (2011) noted that in 2010, excessive rainfall in Sahel belt resulted in serious flood that affected animal breeding and led to death of

many cattle, whether by drowning or by water-related diseases. It was noted that based on available statistics, in Niger, more than 70,000 heads of cattle died while Malians lost about 3,000.

In the Sahel belt, there have been attempts to enhance adaptation to climate change by promoting tree planting. Reij (2012) submitted that trees have positive impact on agricultural production because they help to maintain or increase soil organic matter content, which increases the water-holding capacity of the soil. It was further noted that some trees can enhance soil nitrogen fixation capacity, while other produce fodder that may make farmers to increase their livestock herds. Also, trees can decrease the speed of wind speed, reduce temperatures and enhance farmers' ability for climate change adaptation. With availability of more trees, there is the likelihood of higher crop yields and ability to keep more livestock enhances the ability of farmers to cope with droughts.

Access to media programmes can influence adaptation behaviour of livestock farmers. This is critical because decision on how to adapt can be based on information received through radio, television, or hand set. Archer (2003) found that women were more inclined towards getting weather-related information from extension workers, while men could listen to radio programmes on a routine basis. Boko *et al.* (2007) submitted that access to credit is critical in explaining adaptation to climate change based on the use to which climate forecast is put. Vogel (2000) also argued that ability to obtain credit may play a decisive role in explaining farmer's climate change adaptation practices.

Also educational attainment of the household can influence adaptation. This is essential for devising an adequate survival strategy in the face of economic adversities. Wamsler *et al.* (2012) found that there are two ways that educational status can influence adaptation to climate change. First, the fact that education increases awareness about impending risky situation predisposes quicker responses from those with formal education. However, secondly, the fact that education can shield people from unwholesome climate-related consequences predisposes the educated to take less decisive investment in adapting. This paper seeks to analyze the impact of climate change on livestock husbandry and the adaptation options in the Sahel belt of West Africa.

## MATERIALS AND METHODS

**Data and sampling procedures:** The data were collected as baseline survey which was conducted by the Climate Change, Agriculture and Food Security (CCAFS) arm of the Consultative Group of International Agricultural Research (CGIAR) (http://www.ccafs.cgiar.org/). Full descriptions of the data had been presented by several authors. The livestock components of the whole data were analyzed in this study along with some socio-economic variables. The countries in Sahel bet which were covered in the survey include Burkina Faso, Mali and Niger. The data collection followed multi-stage sampling procedure with 7 villages randomly selected from selected locations in chosen regions in the Sahelian belt. In each of the countries, 140 farming households were targeted, although 141 were sampled in Mali. In Burkina Faso, the survey was conducted in Yatenga-Tougou region. The selected villages were Tibtenga, Lemnogo and Peulh from Koumbi location, Bagayalogo and Lilligomde from Ouahigouya location, Faogodo and Kononga from Namissiguima location and Salla Foulbe from Titao location. Data collection in Niger took place in Fakara region where Touliel, Baboussay, Kampa and Zarma villages were selected from Koure location and Dey tegui, Tigo zeno, Kouuara zeno and Tafa kouara villages were selected from Fakara location. In Mali, data were collected from Segou region where Folanassibougo and Tongo villages were selected from Cinzana location, N'Tlomabougou, Seiekourani and Kamanago villages

were selected from Diouna location and Bougakoungo and Kallan villages were selected from Katiena location. In all, this study used data collected from 421 households that covered 21 villages in the three countries.

**Specification of the probit model:** The Probit regression is an econometric approach which is applied when the dependent variable is dichotomous (yes/no). Conventionally, dealing with such model requires the use of Maximum Likelihood Estimates (MLE) in the estimation of the parameters because Ordinary Least Square (OLS) would produce biased and inefficient parameters. The model used in this study can be specified by defining a latent variable as:

$$Y^* = X\beta + e \tag{1}$$

$$yi = \begin{matrix} 0 \text{ if } y^*_i \le 0 \\ 1 \text{ if } y^*_i \le 0 \end{matrix} \tag{2}$$

$$y^*_i > \frac{0}{X_i} = y_i > \frac{0}{X_i} = \Pr\ (\varepsilon_i i > -\beta' X_i i) \tag{3}$$

$$\Pr\ (\epsilon_i i/\sigma > -\beta'' X_i i/\sigma) = (\beta'' X_i i/\sigma) \tag{4}$$

$$y_i > \frac{0}{X_i} = 1 - (\beta^{\uparrow} 'X_{\downarrow} i / \sigma) \tag{5}$$

Different models were estimated for Eq. 5 with dependent variable ($y_i$) being the adaptation methods coded as introduced new livestock (yes = 1, 0 otherwise), stopped keeping some livestock (yes = 1, 0 otherwise), raised new breed of livestock (yes = 1, 0 otherwise), reduced herd size (yes = 1, 0 otherwise), increased herd size (yes = 1, 0 otherwise) and changed herd composition (yes = 1, 0 otherwise). The included explanatory variables were based on some findings in literature and they are: households' exposure to flood in the past five years (yes = 1, 0 otherwise), got help during flooding (yes = 1, 0 otherwise), planting tree ((yes = 1, 0 otherwise), number of tree protected, has radio (yes = 1, 0 otherwise), has television (yes = 1 0 otherwise), has cell phone (yes = 1, 0 otherwise), has bike (yes = 1, 0 otherwise), has motorcycle (yes = 1, 0 otherwise), number of household members less 5 years, number of household members greater 60 years, has formal education (yes = 1, 0 otherwise), obtained cash from employment on someone's farm (yes = 1, 0 otherwise), obtained cash from other paid employment (yes = 1, 0 otherwise), cash from business (yes = 1, 0 otherwise), cash as gift (yes = 1, 0 otherwise), other payment from government project (yes = 1, 0 otherwise), loan from bank (yes = 1, 0 otherwise), informal loan (yes = 1, 0 otherwise), cash from rental of machinery (yes = 1, 0 otherwise), Burkina Faso (yes = 1, 0 otherwise) and Mali (yes = 1, 0 otherwise).

## RESULTS AND DISCUSSION

**Livestock affected by drought and associated climate change problems:** Table 1 show the frequency distribution of the different types of livestock that were affected by drought. It reveals that drought mostly affected sheep and goats in Burkina Faso with 17.86 and 15.00%, respectively.

Table 1: Drought and livestock disease impacts across livestock types in sahel belt

| | Frequent drought (%) | | | Resistance to diseases (%) | | | New pests and diseases (%) | | |
|---|---|---|---|---|---|---|---|---|---|
| Livestock | Burkina faso | Mali | Niger | Burkina faso | Mali | Niger | Burkina faso | Mali | Niger |
| Camels | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 6.43 | 3.55 | 2.86 |
| Chicken/hens | 1.43 | 0.00 | 0.00 | 0.71 | 0.00 | 0.00 | 6.43 | 3.55 | 0.00 |
| Dairy cows | 2.14 | 1.42 | 5.00 | 0.00 | 0.00 | 0.00 | 1.43 | 0.00 | 0.71 |
| Donkeys/mules | 0.00 | 2.13 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.71 | 0.00 |
| Doves | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| Ducks | 0.00 | 0.71 | 0.00 | 0.00 | 0.71 | 0.00 | 0.00 | 0.00 | 0.00 |
| Fish-other | 0.00 | 0.71 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| Goats | 15.00 | 4.96 | 0.00 | 5.71 | 0.00 | 0.00 | 11.43 | 19.86 | 1.43 |
| Guinea fowl | 0.00 | 0.00 | 0.00 | 0.71 | 0.00 | 0.00 | 0.00 | 0.71 | 1.43 |
| Horses | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| Other | 0.00 | 7.09 | 0.00 | 0.71 | 0.00 | 0.00 | 0.00 | 4.26 | 0.00 |
| Oxen | 8.57 | 1.42 | 4.29 | 4.29 | 0.71 | 0.00 | 6.43 | 1.42 | 0.00 |
| Sheep | 17.86 | 8.51 | 2.86 | 0.00 | 0.00 | 0.00 | 9.29 | 17.73 | 0.00 |
| Buffalo | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |

In Mali, 8.51 and 4.96% of the farmers indicated that drought affected sheep and goats, respectively. Sheep and goats are among the major livestock in Sahel with very high likelihood of being kept as means for storing wealth. The fact that they are not used for farm activities makes them the first set of animals to be sold in the event of drought in order to safeguard households' consumption expenditures (Toulmin, 1986; Lindborg, 2012). Similarly, oxen were indicated as livestock affected by drought by 8.57% of the households in Burkina Faso. However, in Niger, the farmers indicated that dairy cow and oxen were mostly affected by drought with 5.00 and 4.29%, respectively. Oxen are transport animals that are useful for several production and domestic activities. These are the last set of animals that would be sold in the event of drought in order to meet pressing consumption needs of the households. Nicou and Charreau (1985) also noted that oxen and donkey are used for soil cultivation in the form of animal traction by soil farmers in Sahel. The table also shows that 4.29 and 5.71% of the farmers indicated that oxen and goats were becoming more resistant to pests and diseases in Burkina Faso. None of the farmers from Niger reported resistance to disease by any type of livestock. Thornton *et al.* (2007) noted that resistance to disease by livestock is an outcome of development of adaptive traits. This sometimes takes a lot of years to develop. Examples of such adaptation are African ruminants' trypantolerance and helminth resistance by some breeds of sheep.

Also, new pests and diseases were reported for goats by 19.86 and 11.43% of the farmers from Mali and Burkina Faso, respectively while sheep had 17.73 and 9.29%. In Burkina Faso, 6.43% of the farmers reported new pests and diseases each for chicken, camels and oxen. Discovery of new pests and diseases was not reported as such by farmers from Niger where camels, goats and guinea fowls have 2.86, 1.43 and 1.43%, respectively. Climate change can stimulate incidences of livestock pests and diseases. However, vector-borne diseases are potentially more likely to be induced by climate change. For instance, temperature increases can stimulate development of some vector populations, thereby introducing new diseases into some areas (McDermott *et al.*, 2001).

**Livestock farmers' adaptation options:** Table 2a shows the different adaptation options that were used to cope against drought and other climate-related problems. It reveals that 12.86% of the

Table 2a: Percentage distribution of adaptation options across some livestock types

| | Introduced new farm animals | | | Stopped keeping some animals | | | New breed introduced | | | Reduction in herd size | | | Increase in herd size | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Livestock | B. faso | Mali | Niger | B. faso | Mali | Niger | B. faso | Mali | Niger | B. faso | Mali | Niger | B. faso | Mali | Niger |
| Camels | 0.00 | 0.00 | 1.43 | 0.00 | 0.00 | 8.57 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.71 | 0.71 | 0.00 | 0.00 |
| Chicken/hens | 2.14 | 0.00 | 0.00 | 1.43 | 0.71 | 8.57 | 0.00 | 4.26 | 0.71 | 7.14 | 6.38 | 12.14 | 17.14 | 9.93 | 0.00 |
| Dairy cows | 0.00 | 0.00 | 3.57 | 0.71 | 0.00 | 18.57 | 3.57 | 0.00 | 0.71 | 2.86 | 0.00 | 15.00 | 5.00 | 0.00 | 2.86 |
| Donkeys/mules | 0.00 | 0.00 | 0.71 | 0.00 | 0.00 | 3.57 | 0.00 | 1.42 | 0.00 | 0.00 | 4.96 | 0.71 | 0.00 | 4.26 | 0.00 |
| Doves | 0.00 | 1.42 | 0.00 | 0.00 | 0.71 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| Ducks | 0.00 | 0.71 | 0.00 | 0.00 | 0.71 | 0.00 | 0.00 | 1.42 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| Fish-other | 0.00 | 0.71 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| Goats | 2.14 | 1.42 | 0.00 | 4.29 | 3.55 | 17.86 | 7.86 | 4.96 | 0.00 | 14.29 | 17.73 | 8.57 | 34.29 | 7.80 | 0.00 |
| Guinea fowl | 4.29 | 2.13 | 0.00 | 0.00 | 2.84 | 2.86 | 0.00 | 0.71 | 0.71 | 0.00 | 0.71 | 1.43 | 3.57 | 0.71 | 0.00 |
| Horses | 0.00 | 0.00 | 0.71 | 1.43 | 0.71 | 5.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.71 | 0.00 | 0.00 | 0.00 |
| Other | 0.00 | 1.42 | 0.71 | 0.00 | 1.42 | 4.29 | 8.57 | 31.91 | 0.71 | 0.00 | 8.51 | 0.71 | 0.71 | 10.64 | 0.00 |
| Oxen | 12.86 | 0.71 | 2.14 | 5.00 | 0.71 | 5.71 | 1.43 | 3.55 | 0.00 | 17.14 | 2.13 | 5.71 | 18.57 | 0.71 | 0.71 |
| Sheep | 5.71 | 1.42 | 0.71 | 6.43 | 1.42 | 16.43 | 12.14 | 4.96 | 1.43 | 10.00 | 10.64 | 22.14 | 35.00 | 15.60 | 3.57 |
| Buffalo | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.71 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |

farmers from Burkina Faso introduced new oxen on their farms. Also, new guinea fowls were introduced by 4.29% of the farmers from Burkina Faso, while 2.14% introduced some new goats. In Niger, new dairy cow was introduced on farms by 3.57% of the farmers, while 2.13% introduced guinea fowls in Mali. Introducing some livestock may connote making room for replacement of those sold or died. It may also imply building the stock of available stock of animals. Some Burkina Faso farmers introduced oxen which are critical in land preparation, while new dairy cow that were introduced by Niger farmers are meant for meeting households' needs of milk.

Keeping of some livestock was discontinued by the farmers. This may be as a result of scarcity of pasture, water and other production resources due to drought. In the results, 18.57 and 17.86% of the farmers from Niger stopped keeping dairy cow and goats, respectively. Milk production from dairy cow is a way of boosting households' income and consumption of protein. Bruschweiler and Gabathuler (2006) submitted that milk production can be adversely affected by drought due to non-availability of fresh grasses and concurrent loss of nutritional values. This scenario makes it difficult for cow to produce enough milk, even as their survival is greatly threatened.

Also, while 16.43% discontinued keeping of sheep in Niger, 6.43% did same in Burkina Faso. Farmers from Niger had stopped raising other livestock including chicken (8.57%), camel (8.57%), horses (5.00%) and oxen (5.71%). Also, new breed of animals were introduced by some farmers. Precisely, in Burkina Faso, new breed of sheep was introduced by 12.14% of the farmers as against 4.96% in Mali. Similarly, 7.86 and 4.96% of the farmers from Burkina Faso and Mali introduced new breeds of goat respectively. Very few farmers from Niger introduced new breed of livestock with 1.43% for sheep. Definitely, introduction of new breed.

Some farmers were reducing their herd size in order to cope with scarcity of feed and water during drought. The results show that sheep herd sizes were reduced in Niger, Mali and Burkina Faso by 22.14, 10.64 and 10.00% of the farmers, respectively. However, 17.73, 14.29 and 8.57% of the farmers from Mali, Burkina Faso and Niger reduced the herd size of goats. Some 7.14, 6.38 and 12.14% of the farmers from Burkina Faso, Mali and Niger indicated to have reduced the number of chicken they were raising.

Table 2b: Percentage distribution of adaptation options across some livestock types

| | Change in herd composition | | | Fencing introduced | | | Growing fodder crops | | | Fodder storage | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Livestock | B. faso | Mali | Niger | B. faso | Mali | Niger | B. faso | Mali | Niger | B. faso | Mali | Niger |
| Camels | 0.00 | 0.00 | 7.14 | 0.00 | 0.00 | 0.00 | 0.71 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| Chicken/hens | 2.86 | 0.71 | 8.57 | 12.86 | 0.00 | 0.00 | 0.71 | 0.00 | 0.00 | 7.86 | 0.00 | 0.00 |
| Dairy cows | 0.00 | 0.00 | 20.71 | 0.00 | 0.00 | 0.00 | 0.71 | 0.00 | 2.86 | 9.29 | 0.00 | 15.71 |
| Donkeys/mules | 0.00 | 0.00 | 2.86 | 3.57 | 0.00 | 0.00 | 2.86 | 0.00 | 0.00 | 12.14 | 8.51 | 0.71 |
| Doves | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| Ducks | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| Fish-other | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| Goats | 6.43 | 1.42 | 15.71 | 31.43 | 4.26 | 0.00 | 6.43 | 0.71 | 0.00 | 64.29 | 5.67 | 9.29 |
| Guinea fowl | 0.00 | 0.00 | 5.00 | 0.71 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.71 | 0.00 | 0.00 |
| Horses | 0.00 | 0.00 | 5.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| Other | 0.00 | 2.13 | 5.71 | 11.43 | 1.42 | 0.00 | 0.71 | 2.84 | 0.00 | 0.00 | 17.73 | 0.00 |
| Oxen | 7.86 | 0.00 | 3.57 | 18.57 | 0.71 | 0.00 | 5.71 | 0.00 | 2.14 | 36.43 | 1.42 | 7.14 |
| Sheep | 7.86 | 2.84 | 10.71 | 34.29 | 7.80 | 0.71 | 7.14 | 2.84 | 4.29 | 60.00 | 19.86 | 20.71 |
| Buffalo | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |

Morton and de Haan (2006) submitted that pastoralists are affected by drought from reduction in the quantity of forage and water that is available for livestock consumption. Due to environmental stress which livestock are exposed to, drought undoubtedly increases livestock's vulnerability to many diseases. Myburgh (1994) and Hall (2007) submitted during drought, possession of large herd size creates a condition where available pasture is rapidly overgrazed because pastoralists lack incentives for pasture conservation since they do not have ownership rights. Therefore, starvation of livestock cannot be avoided and the need for having smaller increases. Scoones (1992) noted that livestock farmers can get involved in animal loaning arrangements whereby the stocking rate of livestock is reduced by sending some to relatives in areas that are less affected by drought.

It was also reported that some farmers increased the size of herd of some animals. In Burkina Faso, 35, 34.29 and 17.14% of the framers increased herd sizes of sheep, goats and chicken, respectively. In Mali, 15.60, 9.93 and 7.80% of the farmers indicated that they had increased sheep, chicken and goat herd sizes. Also, 3.57 and 2.86% of the farmers had increased the sheep and dairy cow herd sizes in Niger.Decision to increase their herd size may be directly related to possession of personal grazing land and ability to raise enough money to buy animal feeds during drought.

Table 2b shows that some farmers changed the composition of their livestock herd in order to cope with drought. Specifically, in Burkina Faso, 7.86, 7.86 and 6.43% changed the composition of sheep, oxen and goat herds. Also, in Niger, 20.71, 15.71 and 10.71% of the farmers indicated that they changed composition of their dairy cow, goat and sheep herd sizes. Changes in herd composition were not so much reported in Mali with 2.84 and 1.42% of the farmers effecting changes in sheep and goats, respectively. The table also shows that in Burkina Faso, 34.29, 31.43 and 18.57 and 12.86% introduced fence in sheep, goats, oxen and chicken/hen respectively. Farmers from Mali and Niger did not introduce fencing as such. Specifically, in Mali, 7.80% introduced fencing for sheep while only 0.71% did so in Niger.

Table 2b also shows that some farmers were growing fodder crops in order to cope with scarcity of animal feeds during drought. The results show that 7.14, 2.84 and 4.29% were growing fodder crops for sheep in Burkina Faso, Mali and Niger, respectively. Also, in Burkina Faso, 6.43% of the

farmers grew fodder crops for goats, while 2.86% did for dairy cow in Niger. Storage of fodder was also used by the farmers to cope with drought. The results show that more farmers in Burkina Faso stored fodder crops than in Mali and Niger. In Burkina Faso, Mali and Niger, forage crop storage for sheep to consume was done by 60.00, 19.86 and 20.71% of the farmers, respectively. Storage of forage for goats to consume was carried out by 64.29, 5.67 and 9.29% of the farmers from Burkina Faso, Mali and Niger, respectively.

The strategies for coping with drought may vary from place to place, depending on other economic and policy environment. Jodha (1978) and Rosenzweig and Wolpin (1993) provided some evidences that in India, sale of livestock and purchases served as a strategies for enhancing consumption smoothing. Fafchamps (1996) submitted that where farmer use common pasture, sales and losses of livestock in the event of during droughts will increase the expected returns from surviving animals. It was concluded that this may affect the responsiveness of livestock transactions to climatic shocks. Also, Hudson (2002) found that in Southern Africa, livestock farmers were coping with drought by selling animals, buying fodder, or taking no action.

**Factors explaining decisions to introduce/stop livestock husbandry:** Table 3 shows the Probit regression results of factors explaining livestock farmers' adaptation to drought. It reveals

Table 3: Probit regression results of factor explaining drought adaptation by introducing new livestock, stopping keeping livestock and raising new breed of livestock

| | Introduced new livestock | | Stopped keeping livestock | | Raised new breed of livestock | |
|---|---|---|---|---|---|---|
| Variable | Coef | t-value | Coef | t-value | Coef | t-value |
| Flood in five years ago | 0.6840 | 2.53 | 0.1804 | 0.92 | 0.2460 | 1.26 |
| Got help during flood | 0.1434 | 0.49 | -0.6097 | -2.29 | -0.1507 | -0.53 |
| Tree planting | -0.0191 | -0.14 | 0.1232 | 0.96 | -0.1300 | -1.14 |
| No. of trees protected | -0.0314 | -0.28 | 0.0355 | 0.37 | 0.0992 | 1.08 |
| Has radio | -0.4905 | -1.96 | 0.1422 | 0.72 | 0.2691 | 1.07 |
| Has television | 0.4567 | 1.34 | -0.2637 | -0.62 | 0.2987 | 1.07 |
| Has cell phone | 0.1050 | 0.44 | -0.2349 | -1.29 | 0.4753 | 2.33 |
| Has bike | 0.2458 | 0.67 | -0.1067 | -0.42 | 0.2067 | 0.62 |
| Has motorcycle | 0.2840 | 1.08 | -0.0937 | -0.38 | -0.0222 | -0.11 |
| Household members less 5 years | -0.0447 | -0.86 | 0.0198 | 0.56 | 0.0134 | 0.40 |
| Household members greater 60 yrs | -0.3301 | -2.75 | -0.0216 | -0.26 | 0.0724 | 0.89 |
| Formal education | -0.3531 | -1.55 | 0.2631 | 1.34 | -0.5773 | -2.91 |
| Farm employment income received | 0.2511 | 1.20 | -0.0766 | -0.44 | 0.1268 | 0.67 |
| Cash from other paid employment | 0.0220 | 0.08 | -0.0042 | -0.02 | 0.1259 | 0.58 |
| Cash from business | -0.0521 | -0.24 | -0.4254 | -2.19 | 0.0097 | 0.05 |
| Cash as gift | -0.2553 | -0.93 | -0.2151 | -0.83 | 0.3012 | 1.48 |
| Payment from government project | 0.3899 | 1.37 | 0.0685 | 0.26 | 0.3747 | 1.48 |
| Loan from bank | 0.2963 | 1.15 | 0.2222 | 0.91 | 0.0984 | 0.48 |
| Informal loan | 0.0716 | 0.35 | 0.5467 | 3.26 | 0.1010 | 0.60 |
| Cash from rental of machinery | 0.0218 | 0.07 | -0.0548 | -0.16 | -0.1065 | -0.40 |
| Burkina Faso | -0.3196 | -0.74 | -0.7608 | -2.45 | 0.3015 | 0.75 |
| Mali | -0.3476 | -0.80 | -1.1376 | -3.57 | 0.9266 | 2.35 |
| Constant | -1.2001 | -3.21 | -0.4450 | -1.54 | -2.2985 | -6.29 |
| LR Chi square (24) | 43.62*** | | 97.31*** | | 102.44*** | |
| Log likelihood | -117.0157 | | -179.7873 | | -168.5416 | |

that the estimated model for introduction of new breed is statistically significant ($p<0.01$). This implies that the model produced a good fit for the data. The parameters of experience of flood in the past five years (0.6840), ownership of radio (-0.4567) and number of household members 60 years and above (-0.3301) were statistically significant ($p<0.05$). Experience of flood in the past five years had positive impacts on the probability of introducing new livestock. This is expected because flood often results in death of livestock, which may warrant replacement through introduction of new livestock (FAO, 2011). Ownership of radio reduces the probability of introducing new livestock. Radio is a source of information which may serve to educate farmers on pending climatic problems and market opportunities. Expected impact of radio on climate change risk adaptation can be understood from its function as the primary source of information in rural areas. Therefore, the finding may have been inspired from access to adequate information, which can mitigate against livestock losses during drought. Specifically, Morton and de Haan (2006) advocated for improved education for pastoralist in order to facilitate their coping ability against drought. The major issue is that given the transhumance nature of pastoralism in Sahel, it may be difficult for passing across definite educational programmes through agricultural extension officers. However, use of radio can achieve some successes although its effectiveness will depend on many other issues.

Also, as the number of household members that were 60 years and above increased, the probability of introducing new livestock decreases. This can be explained from the fact that aged people cannot be of any significant assistance when it comes to livestock husbandry. This is particularly valid for drought period when pasture becomes scarce and grazing of livestock may involve long distance trekking (O'Farrell *et al.,* 2009).

Table 3 also presents the results of factors influencing livestock farmers' decision to cope with drought by stopping to keep one or other livestock. The results show that the model was properly fitted by the data because the Likelihood Ratio Chi Square statistics is statistically significant ($p<0.001$). The parameters of got help during flood (-0.6097), cash from business (-0.4254), informal loan (0.5467), Burkina Faso (-0.7608) and Mali (-1.1376) are statistically significant ($p<0.05$). Getting help during flooding reduced the probability of stopping to keep one or other livestock. This is expected because since flooding can be another serious environmental hazard in the Sahel belt, offering of assistance can serve as critical cushioning effect. In addition, getting cash from business reduced the probability of stopping to keep one or other livestock. This is expected because access of income from business may signify diversification of income sources, thereby reducing dependence on proceeds from livestock. Ability to obtain income from other sources may connote signify access to funds to mitigate welfare losses from adverse climatic conditions. Similarly, however, obtainment of informal loan increased probability stopping to keep one or other livestock. This is expected because those that borrowed from relatives and friends may be those that had been badly affected by drought. Therefore, the intention for informal borrowing may be to secure food for the households, rather than expanding the livestock husbandry. Residence in Burkina Faso and Mali also reduced the probability of stopping to keep one or other livestock. These results are showing that livestock husbandry in Niger is more affected in terms of farmers deciding to stop raising one type of livestock or the other.

Table 3 also shows the Probit regression results for the factors influencing raising new breed of livestock. The model produced a good fit for the data because the Likelihood Ratio Chi Square statistics is statistically significant ($p<0.001$).The parameters of ownership of cell phone (0.4753), formal education (-0.5773) and residence in Mali (0.9266) are statistically significant ($p<0.05$). The results indicated that ownership of cell phone increased the probability of introducing new breed

of livestock. This is expected because cell phone may enhance communication, thereby affording the farmers the opportunity of possessing full knowledge of the type of livestock's breeds that area available. However, possession of formal education reduced the probability of introducing new breed of livestock. Education is widely reported to influence technology adoption. However, in Sahel belt and most importantly among rural households, the impact of formal education on livestock husbandry may not be that much because the farmers may have been in the business since childhood. Also, farmers with formal education may possess other businesses or income sources thereby reducing their dependence of livestock. Also, compared with Niger, residence in Mali increased the probability of introducing new breed of livestock.

**Factors explaining decisions to change herd size or its composition:** Other forms adaptation that were reported by the farmers deal with bringing about some changes in the size of livestock herd or its composition. Specifically, Probit regression analyses were carried out for reduced livestock herd size, increased livestock herd size and changed herd composition. The results are presented in Table 4. The model for reduced herd size produced a good fit for the data as indicated by the statistical significance of the Likelihood Ratio Chi Square ($p<0.001$). The variables with parameters that showed statistical significance ($p<0.05$) are number of household members greater than 60 years of age (0.1662), formal education (-0.4201), received other payments from government (0.4603), received informal loan (0.3687), residence in Burkina Faso (-0.6635) and residence in Mali (-0.7955). If the number of household members that are 60 years and above increases, the probability of reducing herd size also increases. This is expected because drought brings about a situation where pasture for livestock becomes scarce. The assistance of young herd boy or man would therefore be sought for leading the livestock into places where pastures might be available. This cannot be effectively done by old men. Also, attainment of formal education reduces the probability of reducing herd size. Educational attainments can increase the income sources of farmers, thereby subjecting them to financial stability. Education may also enhance farmers' coping options against drought without necessarily disposing his livestock assets. Access to other payments from government also increased the probability of reducing herd size. This may be a reflection of high drought vulnerability of the beneficiaries of those projects. Obtainment of informal loan also increases the probability of reducing herd size. This may reflect high drought vulnerability of households that would seek for informal borrowing. It may also suggest that borrowed money are rarely used for livestock expansion because they may be utilized for home consumption.

Table 4 also shows the results of the estimated model for increase in livestock herd. The model produced a good fit for the data as reflected by the statistical significance of the computed Likelihood Ratio Chi Square ($p<0.001$). The results show that the parameters of tree planting (-0.3299), ownership of radio (0.8592), loan from bank (0.4855) and Burkina Faso (1.8205) are statistically significant ($p<0.05$). Specifically, involvement in tree planting reduced the probability of increasing livestock herd size. Tree planting activities in the Sahel belt is an environmental conservation activity for general ecosystem restoration. The finding implies that involvement in tree planting may encroach on livestock farmers' opportunities for herd size expansion. Access to radio increased the probability of increasing herd size. This is expected because radio is a source of information that can enhance livestock farm expansion if well utilized. The results also indicate that access to bank loan increased the probability of increasing herd size. This is also expected if

Table 4: Factors explaining drought adaptation by reducing livestockherd size, increasing herd size and changing livestock composition

| | Reduced livestock herd size | | Increased livestock herd size | | Changed herd composition | |
|---|---|---|---|---|---|---|
| Variable | Coef | t-value | Coef | t-value | Coef | t-value |
| Flood in five years ago | -0.2625 | -1.56 | -0.1152 | -0.58 | -0.4295 | -2.15 |
| Got help during flood | -0.3736 | -1.53 | 0.0684 | 0.24 | -0.2717 | -0.99 |
| Has radio | 0.1854 | 0.95 | 0.8592 | 2.96 | 0.2246 | 1.01 |
| Has television | 0.0446 | 0.15 | 0.0044 | 0.02 | 0.0708 | 0.19 |
| Has cell phone | 0.1393 | 0.82 | 0.1943 | 0.97 | 0.0839 | 0.43 |
| Has bike | -0.2018 | -0.75 | -0.1552 | -0.48 | -0.2256 | -0.75 |
| Has motorcycle | 0.1584 | 0.77 | 0.2392 | 1.17 | 0.0156 | 0.06 |
| Produced tree seedling | 0.3991 | 1.56 | 0.2865 | 1.12 | -0.1455 | -0.44 |
| Purchased tree seedlings | 0.5461 | 2.19 | 0.5561 | 2.25 | 0.2057 | 0.71 |
| Household members less 5 years | 0.0073 | 0.24 | -0.0077 | -0.22 | 0.0056 | 0.15 |
| Household members greater 60 years | 0.1662 | 2.31 | 0.0122 | 0.15 | 0.0690 | 0.8 |
| Formal education | -0.4201 | -2.35 | 0.1489 | 0.73 | -0.0178 | -0.08 |
| Farm employment income received | -0.1285 | -0.78 | 0.1723 | 0.9 | -0.1508 | -0.8 |
| Cash from other paid employment | 0.0674 | 0.33 | 0.1292 | 0.57 | -0.0894 | -0.36 |
| Cash from business | 0.2354 | 1.37 | 0.2213 | 1.2 | -0.2197 | 1.07 |
| Cash as gift | 0.2742 | 1.32 | 0.1534 | 0.76 | -0.1481 | -0.54 |
| Payment from government project | 0.4603 | 1.97 | -0.3387 | -1.25 | 0.4188 | 1.59 |
| Loan from bank | -0.0666 | -0.32 | 0.4855 | 2.25 | 0.4651 | 1.81 |
| Informal loan | 0.3687 | 2.46 | -0.0657 | -0.39 | 0.4943 | 2.81 |
| Cash from rental of machinery | -0.1062 | -0.37 | -0.2762 | -0.99 | 0.3023 | 0.93 |
| Burkina Faso | -0.6635 | -2.09 | 1.8205 | 4.62 | -0.8631 | -2.44 |
| Mali | -0.7955 | -2.52 | 0.7269 | 1.78 | -1.4155 | 3.72 |
| Constant | -0.2633 | -1.01 | -2.8439 | -6.81 | -0.1644 | -0.55 |
| LR Chi square (24) | 62.34*** | | 130.03*** | | 104.73*** | |
| Log likelihood | -212.7056 | | -170.3447 | | -156.6283 | |

the loans that were obtained are utilized for expansion of livestock farm. Residence in Burkina Faso also increased the probability of increasing herd size. This implies that the farmers in Burkina Faso were exploring different opportunities for increasing the sizes of their livestock herds.

The results of the estimated model change in livestock composition are presented in Table 4. These results show that the model produced a good fit for the data with statistical significance of the Likelihood Ratio Chi Square ($p<0.001$). The parameters of the variable with statistical significance ($p<0.05$) are flood in the past five years (-0.4295), informal loan (0.4943), Burkina Faso (-0.8631) and Mali (-1.4155). Experience of flood in the past five years reduced the probability of changing herd composition. Flooding may create disincentives for investment in livestock expansion or changes in herd composition. Also, access to informal loan increased the probability of changing herd composition. This implies that farmers that were borrowing from informal sources had higher probability of changing the composition of their herd. The reasoning could be that farmers borrowing from informal sources may as well be more vulnerable to climate change. Also, compared to Niger, residence in Burkina Faso and Mali decreased the probability of changing herd size.

## CONCLUSION

Recurrent drought in rural Sahel belt of West Africa is a development problem that often degenerates into other socio-economic challenges. Because the livelihood of the farmers in Sahel

belt depend so much on livestock, whatever affects ability to keep them would often have some catastrophic tendencies. This study presents an evaluation of the impact of drought and other climate change related problems on livestock production in Sahel and suitably concludes that rural livelihood in the form of livestock husbandry is seriously threatened by drought and other associated climate change problems. The results showed that sheep, goat and oxen were disproportionately affected by drought. Because of the essential role they play as family savings and source of animal traction, the extent of family resource depletion during drought can be well understood. Although some farmer reported that their animal were becoming more resistant to pests and disease, some new pests and diseases were also reported. This calls for adequate effort to monitor the trend of incidences of animal diseases among farmers in the Sahel. This can form part of the relief programmes for execution during period of emergencies like drought. Access to media information, getting assistance during flooding, access to non-farm credit, higher aged dependency and access to credit were found to influence adaptive capacity of livestock farmers. It is therefore recommended that efforts at promoting climate-related information through radio programmes, building a solid network for quick assistance in the event of climate risk exposure, reinforcement of rural financial institutions for improved access to credit and development of people's requisite skills for income diversification would go a long way is cushioning the welfare impact of income shocks like drought in rural Sahel.

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