Available online at https://asric.africa/agricultural-sciences
ASRIC Journal on Agricultural Sciences Vol.5(2)(2024) 117-126

Climate Change Risk Factors and Adaptation toward Increasing Resilience for Sheep and Goats Value Chain Activities in Borno and Yobe States, Nigeria

Gwary[1]*, D. M., Mohammed, D[1]. and Gwary[2], M. M.

[1]*Centre for Arid Zone Studies, University of Maiduguri, Borno State, Nigeria,
dangwary@unimaid.edu.ng dmsong1980@gmail.com
[2]Department of Agricultural Extension Services, University of Maiduguri, Borno State, Nigeria.
mwadagwary@yahoo.ca

Corresponding Author dangwary@unimaid.edu.ng

Received 11 September 2024; revised 25 October 2024; accepted 10 November 2024

Abstract

Climate change has adversely affected the livestock industry generally as a result of rising temperature, variability in rainfall and pasture with great consequences on the value chain of the industry leading to serious impact on the livelihood of the different participants along the chain. A study was carried out to assess climate change risk factors and adaptation options among sheep and goat value chain activities in Borno and Yobe States, Nigeria with the view to introducing climate smart technologies and practices that improve and sustain the system. Primary data were collected from four value chain actors: input suppliers; producers; processors and marketers. Relevant data were collected using Key Informants Interview (KII) and Focus Group Discussions (FGDs) as well as field observations. Sixteen FGD sessions were held: four from each value chain actor group; and twelve KIIs: three from a given value chain actor group. Data obtained were statistically analyzed. Results revealed that change in rainfall pattern and high temperature were the climate risk factors affecting sheep and goat value chain activities in Borno and Yobe States. The consequences of these risk factors depend on the climate risk factor and the value chain activity under consideration. Adaptation strategies practiced by value chain actors under reduced rainfall include: pasture under irrigation during dry season; use of browsing plants; reduced quantity of processed products; and diversification of markets in sourcing the small ruminants among others. The proposed climate smart agriculture (CSA) options include: water harvesting; cross breeding of local sheep and goats with exotic ones; afforestation/reforestation, particularly, use of browsing plants (eg acacia and wild legumes) and use of modern ranches with all production facilities. The study concludes that climate change affect sheep and goat production in all its chain activities. The study recommends that the proposed CSA to be implemented by government and non-governmental organizations (NGOs).

Keywords: Climate Change, Risk Factors, Adaptation Strategies, Value Chain Actors, Borno and Yobe States, Nigeria

Introduction

Climate change has adversely affected the livestock industry generally as a result of rising temperature, variability in rainfall and pasture with great consequences on the value chain of the industry leading to serious impact on the livelihood of the different participants. Sheep and goats (small ruminants) form an important economic and ecological niche in the Nigeria livestock systems. They are an integral and vital component of the pattern of animal production in most rural communities. There are three prominent breeds of sheep namely; *Balami; Uda; Yankasa* and West African Dwarf (WAD) breeds of goats. Out of these

breeds of small ruminants in the country, the WAD breed is common to southern region against the widespread presence of *Balami, Uda* and *Yakansa* breeds in the northern region of the country. The breeds of goats in Nigeria are largely indigenous; and the common ones include the West African Dwarf (WAD) goat, Sahel/desert goat- known as West African Long-Legged goat; and Sokoto Red/Maradi. The Kalahari goat breed, which is of South Africa origin is gradually being adapted to the Nigeria's ecological zones on experimental efforts. Distribution of the goat breeds in the country showed that the WAD goat is common to southern Nigeria while the Sahel or desert goat and Sokoto Red are common to the northern region of the country. Sheep and goats are reared for immediate cash source, meat, manure, and risk mitigation. They significantly contribute to the socio-economic life of many rural, peri-urban and urban low households through provision of income, and intangible benefits (i.e., savings, insurance against emergencies, cultural and ceremonial purposes).

Sheep and Goats enjoy wider distribution and greater flock dynamism than other livestock species. They are widespread in regions with extensive grazing systems, such as Central Asia, the Middle East, and parts of Africa. Their population in Nigeria was estimated to be 43.4 million and 76 million respectively (FAO, 2022). The more significant proportion of these animals is, however, concentrated mainly in the northern region of the country than the southern part. They are ranked as the second most important suppliers of meat protein to the population after cattle, and they contribute about 35% of the total animal meat production in Nigeria.

Climate change has adversely affected the livestock industry generally in Nigeria and in particular Borno and Yobe State as a result of rising temperature, variability in rainfall and pasture with great consequences on the value chain of the industry leading to serious impact on the livelihood of the different participants along the chain. Specifically, livestock production is affected by climate change through drought, rising heat waves, floods, disease outbreaks, and loss of soil biodiversity, while on the other hand it has been reported to contribute significantly to climate change principally through greenhouse gas emissions. An assessment of climate risks to the various aspects of the value chain and of local adaptation practices to climate change in the livestock value chain in Nigeria will provide the necessary points of intervention through identifying, developing, testing and deploying of climate smart practices.

The aim of this paper is to assess climate risk and propose solutions for climate adaptation for livestock by small holder famers in Borno and Yobe, with a focus on the role of digital solutions in accelerating adaptation. The specific objectives of the study are:

i. assess livestock kept y households:
ii. identify key activities along the small ruminant's value chain:
iii. examine climate risks of small ruminant value chain; and,
iv. identify adaptation strategies and propose CSAs.

Methodology

Location Description

The study was conducted in Borno and Yobe States, Nigeria. The states lie between latitudes 12 - 00N and 14, 00N and Longitude 10 - 00E and 14-00E of north eastern Nigeria. There are 27 Local Government Areas (LGAs) in Borno State spread over three agro ecological zones viz, the Sahel (S), Northern Guinea Savanna (NGS) and the Sudan Savanna (SS) (Mohammed and Shettima, 2021). The State has a land area of 69, 435 square km^2 (Amaza *et al*., 2007). It has a population of 4,151,193 (NPC, 2006) with a projected 2023 estimates of 7,250,480 based on 3.2 population growth rate. The climatic peculiarities are characterized by erratic and unreliable rainfall patterns. Stable rains fall between June and September, followed by a long dry spell. Temperatures are high all year round, with hot season mean temperatures ranging between 39^{o}C and 42^{o}C in the northern part of the State. The annual precipitation ranges from less

than 600mm in the north to 1500mm in the south. Rainfall, however, varies from year to year but has tended to decrease over the last two decades (Amaza *et al*., 2007).

Yobe State is located in the northeastern geopolitical zone of Nigeria bordering with Borno State to the east and Jigawa State to the west. The State has 17 LGA spread across the two agro-ecological zones: Sahel in the north and Sudan savannah in the south. It lies on an area of 54,428sq Km and has borders with Niger republic to the north (Opara and Eze, 2011). The State has population of 2,321,339 in 2006 with a projected 2023 estimate of 4,106,758 based on 3.2 population growth rate. The temperature range is 39ºC– 42º C, with an annual rainfall of 500 mm–1000 mm. The rainy season lasts from June to September in the northern part of the state and May to October in the south. The vegetation comprises of Sahel in the north and Sudan savannah in the south.

Analysis of temperature and rainfall data over 32 years period (1985-2017) in Borno State, indicates that temperature is increasing and rainfall variability is decreasing, thus, climate change exist in the study area (Mohammed, 2021). Droughts are endemic in both Borno and Yobe States. The states are among the eleven desert front line States of Nigeria (WEP, 2011). The main livelihood activity of the people is agriculture producing variety of crops, livestock and fish. Livestock are reared both on small scale and large-scale. Sheep and goats are mostly produced by Fulani and Shuwa herders and small holder farmer groups in both rural and semi-urban areas. However, other practitioners are engaged in production through fattening programmes.

Data Collection

Primary data (qualitative information) were mainly used for the study and collected through Focus Group Discussions (FGDs) and Key Informants Interviews (KIIs). Purposively, a sample of respondents was selected from the actors' associations. These associations include Livestock Feeds' Sellers Association, *Miyetti Allah* Cattle Breeders Association, National Butchers' Association and Cattle Traders Association, representing input supply, production, processing and marketing value chain activities, respectively. From each category, four FGDs were held, making a total of sixteen FGD sessions. In addition, three leaders of these associations were interviewed (KII), making a total of twelve KIIs. Table 1 shows the markets visited for data collection within the two States where livestock business is an important means of livelihood. These six markets, three selected from each State, are the main livestock Centers where all the value chain activities could be studied to represent the States (Gwary *et al.*, 2023).

Table 1: Key Livestock Markets Visited during the study in Borno and Yobe States

State	Market	Ecology
Borno	Maiduguri Livestock Market	Sudan Savannah
	Monguno Livestock Market	Sahel Savannah
	Biu Livestock Market	Northern Guinea Savanna
Yobe	Damaturu Livestock Market	Northern Guinea Savanna
	Potiskum Livestock Market	Northern Guinea Savanna
	Geidam Livestock Market	Sahel Savannah

Data Analysis

Data obtained were transcribed and analysed.

Results and Discussion

Livestock kept by Households

Figure 1 reveals that majority of the breeders are involved in cattle rearing (66.7%). This is closely followed by sheep (16.7%), goats (8.3%).and poultry (8.3%).

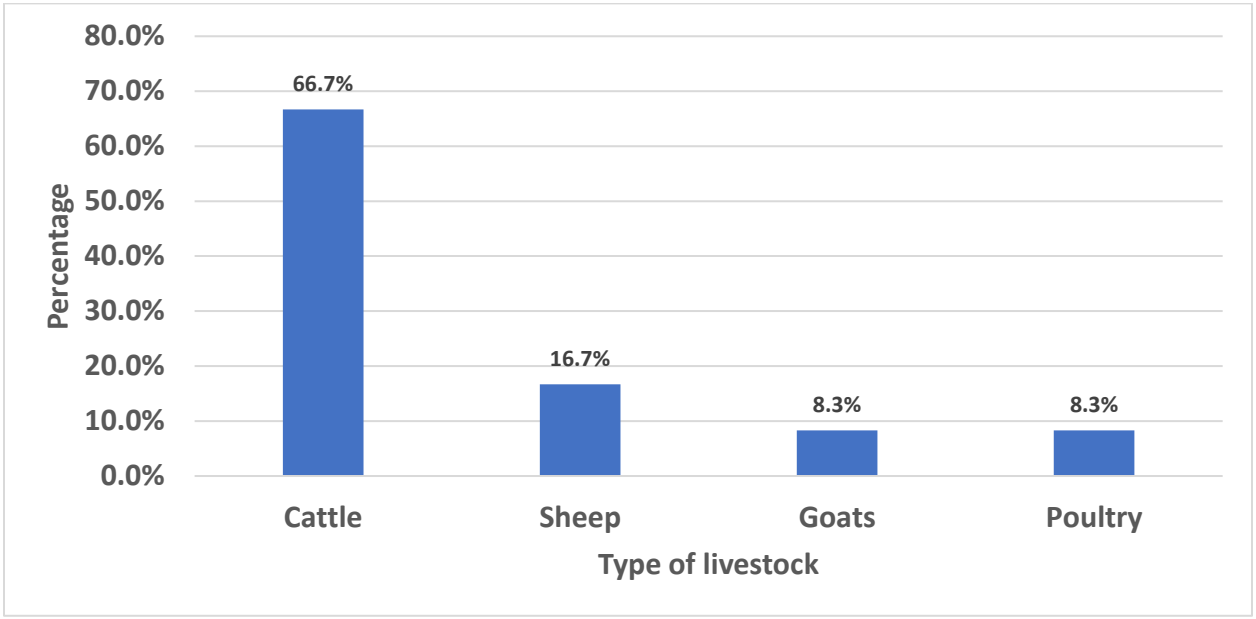

Figure 1: Types of livestock kept by Breeders

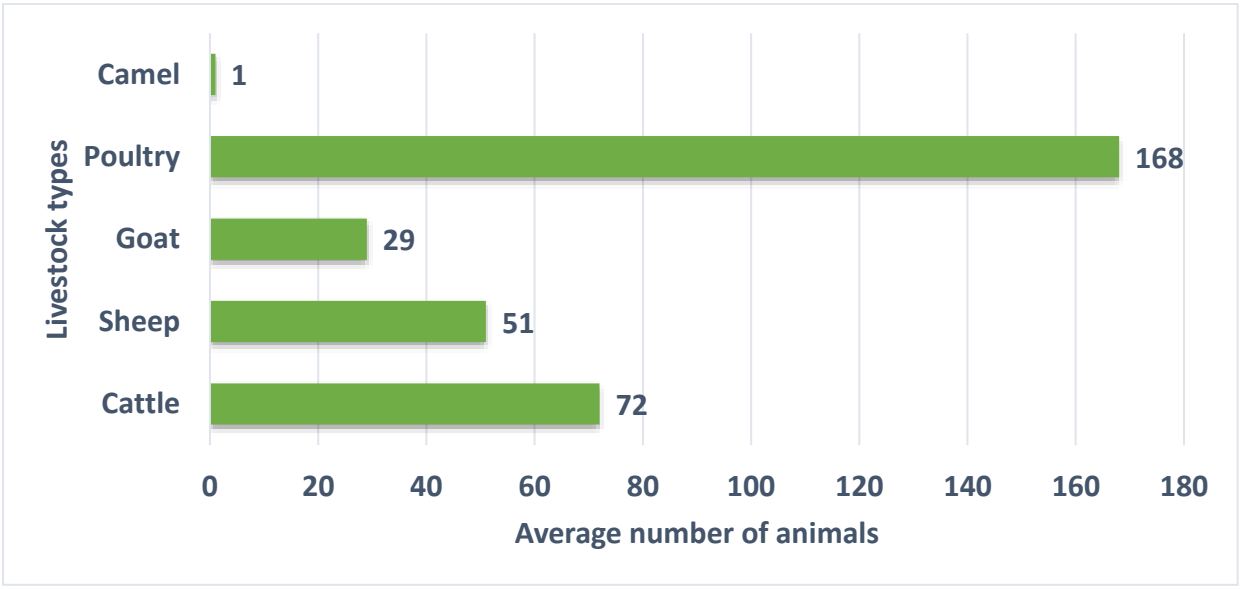

Figure 2: Average Number of Livestock kept by Households

From the results it is clear that small ruminants are very important for food security because by their sizes sheep and goats are smaller animals than cattle and are relatively affordable to keep by most families. Even poor families in rural areas can share a goat between families on normal occasions and more so families use them a lot during festive periods by both Christians and Muslims.

Sheep and goats are also known to have high levels of productivity because they have rapid growth rate due to high weight gain, highly prolific, and good market value. In addition, Sheep and Goats can easily be fed on a wide range of feeds including browse plants. Economically, Sheep and Goats can easily be sold to provide the farmers ready cash at times of need. They are often locally considered the poor man's bank account while large scale farmers make a high turnover from such livestock. The small ruminant value chain creates jobs and significantly contribute to the national economy.

Key Activities along the Small Ruminants Value Chain

A profile of the most important activities along the small ruminants' value chain and their significance in the study area are presented in Table 2 under input supply, on-farm production, post-harvest and output market.

Table 2: Most Important Activities Identified along the Small Ruminants Value Chain

Activities under Small Ruminants Value Chain			
Input supply	**On-farm production**	**Post-harvest**	**Output market**
Feeds and feeding	Feeds and feeding	Slaughtering	Marketing
Housing	Housing	Transportation	Linking farmers and buyers
Breeding	Deworming	Processing	Livestock Sale

Under the input supply of the value chain the most important activities are feeds and feeding, housing and breeding. The ultimate aim of input provision is feed conversion to weight gain achieved under a good animal housing. Small ruminants breeding usually takes place in the animal house and assisted by the herdsmen and livestock owners. The herders ensure that their livestock are grazed on natural pastures and returned to their pens every day. The graze lands are usually at the outskirts of the towns and villages. The urban and semi-urban producers of sheep and goats would supplement the natural animal feeds with hay and other purchased feeds especially during the dry seasons when the pastures have been exhausted.

Three key activities under on-farm production of the small ruminants' value chain are feeding, housing and deworming. This activity which is mostly carried out by the herders is important because it ensures good health and promotes high productivity. The post-harvest activities under the sheep and goats value chain in Borno and Yobe are slaughtering, transportation and processing. Processing is adding value to the animal product for market value and consumer use. Value addition can be by ways of direct consumption of the meat product, refrigeration of the meat for use over a long time by the consumers, frying and storage for a few days or local smoking and temporary storage.

The key activities of output market under the value chain characterization are marketing, linking farmers to buyers and then the sale of the animals. Marketing in particular is an important activity in the small ruminant value chain because it provides benefits to the farmers and herders who are involved along with middle men and the buyers. The majorities of the owners or producers of sheep and goats are the rural poor, and a significant proportion of the urban poor, who keep these livestock and use them in a variety of ways that extend far beyond income generation and in many cases, livestock are a central component of smallholder risk management strategies (Ari *et al*., 2016).

Climate Risks in Small Ruminants Value Chain

To gauge the influence of climate change on livestock production in the state in terms of a) changes in temperature b) rainfall intensity (flooding or drought occurrence) c) diseases or pests, risks the FGD participants agreed on the following: a) Changes in temperature encourages diseases infestation among livestock, also result in heat stress for the animal and reduces production. b) Rainfall intensity-decreased in rainfall intensity affects crop cycle leading to decrease in crop water for animal feeds. Flooding has negative

effect on livestock. c) Drought occurrence-leads to drying up of water bodies thereby making water unavailable for livestock use.

In view of climate risks in the area affecting livestock the FGD participants pondered on the question of how the operations of those involved in livestock value chain would be affected. Specifically, how productivity would be affected and how supply and demand will be affected. Productivity would be affected through increased disease infestation, decrease in water available for livestock and decrease in feeds as a result of climate risks factors affecting crop cycle thereby reducing livestock feeds.

Table 3: Consequences of Various Climate Risks on the Sheep and Goat Value Chain

Climate Risk	Value Chain Actor	Consequences of Climate Risk
Lack of Adequate Water	Input suppliers	Lack of pasture, moderate low supply of feed generally and major high cost of animal feed.
	On-farm producers	Lack of fodder, dehydration and high rate of animal death.
	Processors	Loss of weight, reduced feeding and death. The respondents consider these as serious consequences because they will affect both income and food security.
	Output activities	Loss of quality, low price and failure to sell. Loss of quality and low price are major consequences while failure to sell was considered moderate consequences. Lack of storage facility accompanied by electricity is a serious challenge to the business.
Drought	Input supply	Low supply of production inputs particularly pasture, high demand of inputs and high cost of inputs. These effects are considered as major consequences by the respondents in the small ruminant value chain. Underlying Factors are Economic factor, Cultural factors that tend to exclude girls and women in the sale and distribution of feeds and other supplies, Infrastructure in particular, storage facilities
	On-farm production	Droughts cause livestock population fluctuations through increased mortality and reduced birth rates.
	Post-harvest activity	Loss of quantity and quality of meat and milk, Scarcity of animal products (Meat, Milk, skin, manure etc) and Low livestock productivity.
	Output activities	High prices of products and loss of jobs all of which are classified as major consequences to the LVC.

Lack of Adequate Water as the first Climate Risk

One of the key climate risks in small ruminant value chain is **inadequate water** due to changing climate in the region. The northern Nigeria where most of the national livestock are concentrated, the ecologies are mainly the Sudan Savanna and Sahel where the annual rainfall are 300-500mm and 100-300mm irregularly spread during the season. Three consequences of lack of adequate rainfall which is the main source of water **on input supply** are: major lack of pasture, moderate low supply of feed generally and major high cost of animal feed. Climate change has been projected to change water availability (IPCC, 2015). In addition, Climate change may alter the seasonal pattern and variability of resource availability and crop yield (Greg

et al 2011; Gwary, 2018]), imposing further impacts on livestock production. As the frequency and duration of heat waves increase, animals will suffer from additional heat stress

Similarly, three consequences of the climate risk which is lack of adequate rainfall on **on-farm production are:** lack of fodder, dehydration and high rate of animal death. All of these can be major consequences as water is an important necessity for life more especially in a hot region of the Sudan Savanna and the Sahel.

The consequences of the first climate risk on **post-harvest activity** are loss of weight, reduced feeding and death. The respondents consider these as serious consequences because they will affect both income and food security. The people who will be impacted most according to gender are the male youth who are the largest group of stakeholders in this activity.

With regards to **output activities**, the three consequences of the climate risk 1 are loss of quality, low price and failure to sell. Loss of quality and low price are major consequences while failure to sell were considered moderate consequences.

Drought as a Second Climate Risk

Drought is characterized by a lack of precipitation—such as rain, snow, or sleet—for a protracted period of time, resulting in a water shortage. While droughts occur naturally, human activity, such as water use and management, can exacerbate dry conditions. There is also a relationship between drought and climate change. Changing climate, which influences rainfall and drought, affects livestock production in Nigeria. Drought induces environmental changes in temperature which results in heat stress especially in northern Nigeria has a negative effect on the reproductive capacity of livestock. This is consistent with Ayinde *et al*. (2011) who reported that high temperature depletes soil nutrient making it hard on livestock and agricultural production.

Drought has a monumental effect on input supply in the small ruminant value chain. As a result of drought in Nigeria, three major consequences to input supply include low supply of production inputs particularly pasture, high demand of inputs and high cost of inputs. This is what is obtainable in Borno State of Nigeria and it is similar everywhere else in northern Nigeria.

Besides being susceptible to a general temperature increase from climate change, livestock are also exposed to an increased risk of extreme events like drought. In regions where livestock are expensively reared on rangelands, the effect of drought on rangeland productivity has important bearing on the dynamics of livestock population (Begzsuren *et al*., 2004; Desta and Coppock, 2004). As dry periods progress, livestock are obliged to mobilize body fat reserves to balance for the nutrient deficiency in the diet. Eventually, droughts cause livestock population fluctuations through increased mortality and reduced birth rates (Ellis and Swift, 1988; Oba, 2013).

The implications for drought to post-harvest activities in the small ruminant value chain are loss of quantity and quality of meat and milk, Scarcity of animal products (Meat, Milk, skin, manure etc) and Low livestock productivity. These are all major consequences that threaten the livestock business and means of livelihood (Gwary et al., 2023).

Consequences of drought to output market include low Supply of animals and products to the market, high prices of products and loss of jobs all of which are classified as major consequences to the LVC

Adaptation Strategies

Proposed Climate Smart Agriculture (CSA) Practices

The result of the proposed CSA practices among actors is presented in Table 4. CSA is aimed at reducing emission of greenhouse gasses (GHGs), enhance adaptation and improve productivity and incomes of operators.

Table 4: Adaptation Measures to Various Climate Risks on the Sheep and Goat Value Chain

Climate Risk Factor 1: High Temperature		
Input Supply	**Ongoing Adaptation option**	**Proposed CSA Options**
	1 Seasonal migration in search of pasture and water.	1. Provision of supplemental feeds
	2 Conservation of feed (crop residues and grasses) for off-season	2. Growing of pasture during the rainy season
	3 Water harvesting	3. Efficient water utilization
On-farm production		
	1 Use of drought resistant animals	1. Use of drought resistant animals
	2 Use of Browsing Plants	2. Afforestation/Reforestation (use of browsing plants e.g. acacia and wild legumes)
Postharvest		
	1 Selling off animals as soon as possible	1. Follow recommended stocking density for your region
	2 Process animal into animal products immediately	2. Use modern meat processing and storage
	3 Use of supplementary feeding before sale of livestock	3. Use of supplementary feeding before sale of livestock
Output Market		
	1 Sale of animals	1. Sale of animals
	2 Survey for the best market for a better price	2. Survey for the best market for a better price
	3 Diversification of livelihoods	3. Provision of incentives towards the diversification of livelihood
Climate Risk Factor 2: Reduced Rainfall		
Input Supply	**Ongoing Adaptation option**	**Proposed CSA Options**
	1 Grazing management to avoid the hot part of the day	1. Breeding of heat resistant breeds
	2 Use of supplementary feeds	2. Use of supplementary feeds
	3 Maintenance of good feed hygiene to prevent incubation of disease agents in feeds as a result of high temperature	3. Awareness creation and support in maintaining good hygiene in all chain activities
On-farm production		
	1 Grazing management to avoid the hot period of the day	1. Breeding for heat resistant breeds
	2 Provision of sufficient water regularly	2. Provision of clean cool water all the time
	3 Use of shades for resting during	3. Provision of cool and safe resting sites
Postharvest		
	1 Provision of water to cool the animals and for drinking	1. Provision of clean drinking water
	2 Provision of shade	2. Provision of clean and safe shade
	3 Processing immediately after slaughter to avoid contamination	3. Provision of modern preservation facilities
Output Market		

1	Selling of animals immediately	1. Scout for a good market for good price offers
2	Provide vaccines to keep animals for the market	2. Provide vaccines to keep animals for the market
3	Provide vaccines to keep animals for the market	3. Provision of support for diversification of livestock marketed

Over the last three decades, both local and international development organizations have implemented livestock development projects across Nigeria to strengthen the food system and empower smallholder livestock farmers through specific approaches. These approaches include farmers' capacity for development on good animal husbandry practices, access to veterinary and breeding services, provision of infrastructure, financial literacy, and gender inclusion.

All these CSA strategies identified are intended to reduce carbon sequestration among others. Carbon sequestration can be achieved through decreasing deforestation rates, reversing of deforestation by replanting, targeting for higher-yielding livestock with better climate change adapted varieties, and improvement of land and water management (Melissa Rojas-Downing *et al*., 2017). Improving pasture management can also lead to carbon sequestration by incorporating trees, improving plant species, legume inter-seeding, introducing earthworms, and fertilization.

Conclusion and Recommendation

Two important climate risks of lack of adequate water and associated drought affect the value chain of sheep and goat production in Borno and Yobe States of Nigeria. The value chain consists of input supply, on-farm producers, livestock product processors and marketing. Lack of adequate water has serious consequences of lack of crop- based feeds, pasture and fodder as well as drinking water affecting input suppliers and livestock producers leading to malnourished animals with loss of weight. The final impact of these climate risks is loss of livestock quality and market value putting livestock marketers out of business. Drought accompanied by high temperatures on the other hand causes low supply of production livestock inputs such as pasture and crop-based feeds leading to high demands and high prices. High input prices due to drought causes livestock population fluctuation and quality of the products from the small ruminants decline with implication for prices. The study recommends that the proposed CSA to be implemented by government and non-governmental organizations (NGOs).

References

Amaza, P. S, Olayemi, J. K., Adejobi, A. O, Bila, Y, Iheanacho, I. (2007). Baseline Socio-economic Survey Report: Agriculture in Borno State, Nigeria. International Institute for Tropical Agriculture (IITA) Ibadan, Nigeria 84 p

ARI, M. M., Ogah, D. M., Luka, E.G. (2016). Livestock Value Chain Development in Nigeria: Institutional Framework and Opportunities for Chain Actors. *Journal of Biology, Agriculture and Healthcare*, 6(9):43-52

Ayinde, O. E., Muchie, M. and Olatunji, G. B. (2011). Effect of Climate Change on Agricultural Productivity in Nigeria: A Co-integration Model Approach. *Journal of Human Ecology*, 35(3)

Begzsuren, S., Ellis, J. E., Ojima, D. S., Coughenour, M.B., Chuluun T., (2004). Livestock Responses to Droughts and Severe Winter Weather in the Gobi Three Beauty National Park, Mongolia. *Journal of Arid Environments*, 59(4):785-796

Desta, S., Coppock, D. L. (2004). Pastoralism Under Pressure: Tracking System Change in Southern Ethiopia. Human Ecology 32, 465–486 (2004). https://doi.org/10.1023/B:HUEC.0000043516.56037.6b

Ellis, J. E., & Swift, D. M. (1988). Stability of African pastoral ecosystems: Alternate Paradigms and Implications for Development. Journal of Range Management, 41(6), 450

FAO (2022) Nigeria Agriculture at a Glance. https://www.fao.org/nigeria/fao-in-nigeria/nigeria- at-a-glance/en/

Graeme, M., Nasr-Alla, A. M., Al-Kenawy, D., Fathi, M., Hebicha, H., Diab, A. M., Hussein, S. M., Abou-Zeid, R. M., El-Naggar, G. (2012). Value-chain Analysis: An Assessment Methodology to Estimate Egyptian Aquaculture Sector Performance, Aquaculture, 362–363 18–27

Greg E. Edame, Anam, Bassey Ekpenyong, William M. Fonta, Duru EJC. (2011) Climate Change, Food Security and Agricultural Productivity in Africa: Issues and policy directions. *International Journal of Humanities and Social Science*,1(21).

Gwary, D. M., Mohammed, D. and Gwary, M. M. (2023). Climate Change Risk Factors and Adaptation towards Increasing Resilience for Cattle Value Chain Activities in Borno and Yobe States, Nigeria. *ASRIC Journal of Agricultural Science*, 4(2): 219-227

Gwary, D. M. (2018). Impact of Climate Change on Nigerian Agricultural Sector and Adaptation Strategies. Paper Presented at the Inception Workshop on the development of a Technology Needs Assessment document for Climate Change in Nigeria held on 11th September, 2018 at The Raw Materials Research and Development Centre Abuja.

Intergovernmental Panel on Climate Change (IPCC) (2015). Climate Change: Synthesis report. Contribution of Working Groups I, II and III to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change [Core Writing Team R, Pachauri K, Meyer LA (Eds.)]. IPCC, Geneva, Switzerland. 2015;151

Melissa Rojas-Downing, M., Pouyan Nejadhashemi, A., Timothy Harrigan, S. and Woznicki, A. (2017). Climate Change and Livestock: Impacts, Adaptation and Mitigation. *Climate Risk Management*, 16(145-163).

Mohammed, D. (2021). Assessment of Adaptation Strategies and Vulnerability of Smallholder Farmers to Climate Change in Borno State, Nigeria. Unpublished Report leading to the award of Doctor of Philosophy (Ph. D), Modibbo Adama University (MAU) Yola, Adamawa State, Nigeria Pp. 251

Mohammed, D. and Shetima, B. G. (2021). Analysis of Cost and Returns and Cost- Effectiveness of Climate Change Adaptation Strategies among Crop Farmers in Borno State, Nigeria. *Abuja Journal of Agriculture and Environment (AJAE ISSN (2736-1160*), 1(2):134-142

National Population Commission (NPC). (2006). Nigerian Population Commission, Abuja. Population of Nigeria by State and Sex, 1991 and 2006

Oba, G. (1013). The Sustainability of Pastoral Production in Africa. In book: Pastoralism and Development in Africa (pp.29-36)

Opara, M. N. and Ezeh, N. O. (2011). Ixodid Ticks of Cattle in Borno and Yobe States of Northeastern Nigeria: Breed and Coat Colour Preference. *Animal Research International*, 8(1): 1359 – 1365

Women Environmental Programme (WEP) (2011). Assessment of Gender Knowledge and Awareness, Vulnerability and Adaptation Strategies to the Impacts of Climate Change in Northern Nigeria. A Research conducted by Women Environmental Programme (WEP) with the support from CIDA and BNRCC