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ADOPTION OF CLIMATE SMART LIVESTOCK TECHNOLOGIES IN BORGU LOCAL GOVERNMENT AREA OF NIGER STATE, NIGERIA

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SUMMARY

The adoption of climate smart livestock technologies was assessed among farmers in Borgu Local Government Area of Niger State, Nigeria. Data collected from 120 randomly selected farmers using an interview schedule were analyzed with the aid of descriptive and inferential statistics. The findings showed that majority (72.4%) of the respondents were males with a mean age of 35 years while 54.3% of the respondents were married. Most (73.3%) of the respondents were educated, mean family size was eight persons while mean annual farm income was ₦559,662.45. A large proportion (83.6%) had 1-5 contacts with extension agents while mean years of farming experience was five years. The farmers were aware of Climate Smart Livestock Technologies (CSLTs) with farmers' association and extension agents being the major sources of awareness. The commonly adopted CSLTs were supplementary feeding (94.0%), animal health and disease prevention (88.6%) and improved feeding practice (86.2%) while the least commonly adopted were anaerobic digesters for biogas and fertilizer (21.6%) and the practice of agroforestry (21.6%). Major constraints to the use of CSLTs were high investment cost (mean value= 2.5), lack of access to climate smart technology (mean value = 2.3), high risk of the technology (mean value = 2.2) and inadequate technical know-how (mean value = 2.2). Binomial logistic regression showed that awareness of CSLTs ($p = 0.003$; $p<0.05$) significantly affected adoption. The current study recommends increase in awareness creation among farmers through effective channels of communication.

Keywords: Climate Change, Livestock Faming, Climate Smart Technologies, Borgu

INTRODUCTION

Globally, the livestock sector has demonstrated not only its support for the livelihoods of over one billion poor rural households but also its contribution to 40% of global agricultural gross domestic product. It engages 1.1 billion people in employment and provides approximately 33% of the globe's protein consumption and 7% of world kilocalorie intake (World Bank, 2022; Pampori and Sheikh, 2023). This could be among the major reasons why Park (2022) maintained that the livestock sector is one of the substantial sectors in global food security. Livestock production is so important that it contributes to the livelihoods of millions of Nigerians and plays a prominent role in the food supply of the country.

Meanwhile, climate change poses great challenges to agriculture and food security, particularly in developing regions like Niger State, Nigeria. Traditional livestock farming practices are often inadequate in addressing the challenges posed by climate change. Certainly, climate change is an all-encompassing phenomenon that has transcended various components of human conditions, including socio-economic, ecological, socio-political, and environmental factors (Tesfaye *et al*., 2015; Luu, 2020). The varying degrees of climate change cannot be disregarded as a global phenomenon affecting all countries and regions, though Sub-Saharan African countries are among the worst hit, as confirmed by numerous studies (Hassan and Nhemachena, 2008; Hammed *et al.,* 2019; Ahmed *et al.,* 2020; Fiker *et al.,* 2021; Sisay *et al.,* 2023).

Similarly, the livestock sector, which is crucial for the livelihoods of many farmers in Borgu Local Government Area, is not exempt from the negative effects of climate change, manifesting in various forms such as increased temperatures, altered rainfall patterns, and the prevalence of diseases (Feliciano *et al*., 2022). Corroborating this view, the United Nations noted the impact of climate change in terms of long-term shifts in temperatures and weather patterns (Food and Agriculture Organization FAO, 2022). Thus, climate-smart livestock technologies offer innovative solutions that can enhance productivity, improve animal health, and reduce environmental impacts (Saha *et al*., 2019; Guido *et al*., 2020); These technologies include practices such as supplementary feeding, improved animal health management, and the integration of agroforestry systems, which collectively aim to optimize resource use and increase resilience to climate stressors.

Despite the availability of climate smart livestock technologies designed to mitigate these impacts and enhance productivity, the adoption rates among farmers remain suboptimal. For instance, Feliciano *et al*., (2022) and Ayal and Mamo (2023) found that awareness and access to these technologies are critical factors influencing their adoption. However, many farmers in Borgu Local Government Area (LGA) face significant barriers, including high investment costs, inadequate technical knowledge, and limited access to extension and advisory services, which hinder their ability to implement these practices effectively (Leal *et al.*, 2022). Furthermore, the socio-economic characteristics of farmers, such as education level, income, and family size, may also play a role in their willingness and ability to adopt climate-smart technologies. Hence, this study aims to assess the adoption of climate-smart livestock technologies among farmers in Borgu LGA, Niger State, Nigeria. Achieving this aim will not only provide insights that can inform policy interventions and extension services aimed at promoting sustainable livestock production in the face of climate change, but it will also contribute to a deeper understanding of the dynamics at play in the adoption process and highlight the necessary steps to facilitate the transition towards more sustainable livestock farming practices in Niger State, Nigeria.

MATERIALS AND METHODS

Description of the study area:

The study was conducted in Borgu LGA of Niger State, Nigeria. The area is one of the 25 LGAs in the state, with the headquarters in New Bussa. The area is about 16,200 sqkm with a population of 172,835 based on the 2006 census. It shares boundaries with Benin Republic to the west, Agwara local government to the south. Borgu Local government lies between latitude $9^0$53'N and longitude $4^0$31'E.

Sampling technique:

The study adopted a multi-stage sampling technique in which stage one comprised purposive selection of 40% of the 10 wards in the area to give four wards. There was random selection thirty respondents from the four selected wards to arrive at (120) respondents which became the sample size of the study. A structured interview schedule was used to gather data from the respondents while frequency distribution table, mean scores and percentages were used to summarize, present results and achieve the research objectives.

Statistical analysis:

The Binary Logit regression was used to determine the factors affecting the adoption of climate smart livestock technologies among the farmers. The dependent variable was adoption of climate smart livestock technologies which was operationalized thus: used =1 or not used = 2. The independent variables were farmers' personal characteristics, farm characteristics, awareness of climate smart technologies and constraints to climate smart livestock technologies. In this study, the choices of farmers on adoption of Climate Smart Livestock Technologies (CSLTs) are represented by a dummy variable:

y = {1 if CSLTs farmer; 0 if non-CSLTs farmer}

The logistic regression for the adoption of CSLTs can be expressed by the methods of Ullah et al. (2015) as follows:

$$\text{In } [Pi/(1-Pi)] = \beta_o+\beta_1 X_1+\beta_2X_2 +\beta_3X_3 + \beta_4X_4 + \beta_5X_5 + \beta_6X_6 + \beta_7X_7 + \beta_8X_8 + \beta_9X_9 + \beta_{10}X_{10} + \beta_{11}X_{11}$$

Where, i represents the i^{th} observation in the sample.

P is the probability that a farmer adopts CSLTs and this is denoted as Pi, and the probability that a farmer does not adopt CSLTs (or non-CSLTs farmer) is 1- Pi.

β_o is the intercept term:

$\beta_1, \beta_2, \beta_3, \beta_4, \ldots, \beta_n$ are the coefficients which relate to each independent variable;

X_1 = Age of farmer (years);

X_2 = Educational qualification dummy (1 if farmer is literate, 0 otherwise)

X_3 = Sex of farmers dummy (1 if farmer is male, 0 otherwise)

X_4 = Marital status dummy (1 if farmer is married, 0 otherwise)

X_5 = Household size (number of persons)

X_6 = Annual income (Naira)

X_7 = Farming experience (years)

X_8 = Number of animals

X_9 = Membership of farmers' association dummy (1 if famer is a member 1, 0 otherwise)

X_{10} = Extension contact (number of contacts)

X_{11} = Awareness of CSLTs dummy (1 if farmer is aware of CSLTs, 0 otherwise)

Constraints to climate smart livestock technologies was measured using a three-point Likert rating scale rating such; as Serious Constraint= 3, Mild constraint = 2, and not a constraint = 1**.** The mean value of the scores were obtained and on the basis of the responses, any score below the mean score (2.00) indicated that the item is not a constraint while a score 2.00 and above indicated a constraint. The mean cut of point was obtained as follows: (3+2+1)/3 =2.00.

RESULTS AND DISCUSSION

Personal characteristics of respondents:

As shown in Table 1, majority (72.4%) of the respondents were males while only 27.6% were females, indicating that the men were the majority of the livestock farmers in the study area. This may be due to the labour intensive nature of livestock production which may not afford the women folk the opportunity to do so because of the household chores. Male-headed households have better access to technologies and climate information than female households due to freedom of mobility, participation in different meetings and trainings (Deressa *et al.*, 2008). The current results also revealed that the mean age of the respondents was 35 years indicating that the farmers were relatively young and in their middle age. Farmers in this age have strength for the rigorous task involved in livestock farming. They are also expected to have the strength to practice energy demanding climate smart technologies (Dembele *et* al., 2019). A little above half (54.3%) of the respondents were married indicating that the respondents were married people with some family responsibilities. Their involvement in livestock production serves as a means of meeting their family needs for additional income and livelihoods.

According to results in Table 1, most (73.3%) of the respondents were educated since they had at least primary education. This relative high level of education might aid the use of adaptation strategies which is expected to increase production and ultimately improve standard of living. The mean family size was eight persons implying a medium family size while the mean annual income from the farm was ₦559662.45 indicating a medium annual income. Higher farm income may be related to favourable disposition to technology adoption as opinned by Alabi *et al*., (2014) that a farmer with a profitable supplementary income could become an early adopter of an innovation that may necessitate requesting for credit facilities. A little above average (57.6%) of the respondents did not belong to farmers association while the remaining (42.4%) of the farmers belonged to one farmers association or the other. Farmers association in most cases serves as an effective means of information and technology transfer among farmers. Majority (83.6%) of the farmers had 1-5 contacts with extension agents. This is also related to their acceptance of innovation coming from the extension agents.

Gavin (2018) reported that agricultural information accessed and utilized by smallholder farmers is very relevant in climate change adaptation as it affects farming decisions. The positive role of extension and advisory services on the adoption of technology was documented elsewhere (Berhane *et al*., 2018). Mean years of experience was five years indicating a relatively low experience. The expectation is that as the experience of farmers increases, the probability of adopting innovation would likely increase. According to Nhemachena and Hassan (2007), the longer the farming experience, the higher the probability of a farmer adapting to climate variability.

Table 1. Personal Characteristics of the respondents

Variables	Frequency (n=116)	SD
Mean of Age (years)	35.1	8.8
Sex (male %)	72.4	
Marital Status (married %)	54.3	
Mean Family Size (persons)	5.6	1.9
Educational Level (literate %)	73.3	
Membership of Farmers Association (non-members %)	57.6	
Extension Contact (1-5 contacts %)	83.6	
Mean Annual Income (Naira)	559622.45	503120.00
Mean Farming Experience (years)	6.3	3.8

Source: Field data, 2022. SD = Standard Deviation

Farmers' awareness of climate smart livestock technologies:

Table 2, showed that the farmers were aware of most of the CSLTs with improved feeding practices (95.7%), animal health and disease prevention (94.8%), changing livestock breed (94.8%) and supplementary feeding (94.0%) ranking top of the technologies. The reason for this may be that these technologies had been in existence for a considerable long time before the issues of climate change adaptation and mitigation. The relatively new technologies including anaerobic digesters for biogas and fertilizer (35.3%) and weather-indexed insurance (39.7%) had low awareness among the farmers, this is quite expected. On the sources of awareness of the CSLTs, farmers' association came top for grazing/pasture management (63.4%) and manure management (54.3%) while it was low for other CSLTs. This indicates that farmers' association is not seen as a very effective means of disseminating climate change information. Elia (2017) opined that farmers' associations are active, independent and democratic means of social enterprise and part of their major functions is educating and disseminating agricultural information to member farmers. Extension agents were significant sources of awareness for warning systems (70.7%), weather-indexed insurance (68.1%), agroforestry practices (57.8%), anaerobic digesters for biogas and fertilizer (55.2%) and energy use efficiency (52.6%). These results showed the relevance of extension agentsin disseminating technologies considered to be relatively complex such as the ones disseminated by extension agents in the study. The strength of public extension systems is their wide reach and broad networking potential, which make it a tool for promoting agricultural information dissemination (Mchombu, 2021).

Table 3, also showed that research institutes are responsible for disseminating animal health and disease prevention (49.1%), disease surveillance and monitoring (46.6%) and cross-breeding and selections that are stress-tolerant breed (42.2%). Though saddled with the responsibility of generating innovations, research institutes though their outreach programmes disseminate their research findings to the end users. The mass media recorded low as sources of awareness of CSLTs among the farmers. The implication for this is that farmers should be encouraged to use these as sources of awareness since they has proven to be very effective means of agricultural information (Sawe, 2022).

Table 2. Awareness and Sources of Climate Smart Livestock Technologies

Climate Smart Livestock Technologies	Awareness 116(%)	Sources of awareness Extension Agent	Farmers Ass.	Mass Media	Research Institute	NGO
Supplementary feeding	109(94.0)	37(31.9)	49(42.2)	1(0.9)	28(24.1)	1(0.9)
Grazing/pasture management	107(92.2)	30(25.9)	62(63.4)	1(0.9)	22(19.0)	-
Animal breeding	107(92.2)	36(31.0)	32(27.6)	4(3.4)	44(37.9)	-
Animal and herd management	106(91.4)	41(35.3)	37(31.9)	7(6.0)	28(24.1)	3(2.6)
Animal health and disease prevention	110(94.8)	31(26.7)	25(21.6)	3(2.6)	57(49.1)	-
Agroforestry practices	55(47.4)	67(57.8)	18(15.5)	11(9.5)	19(16.4)	1(0.9)
Anaerobic digesters for biogas and fertilizer	41(35.3)	64(55.2)	24(20.7)	7(6.0)	20(17.2)	1(0.9)
Manure management	103(88.8)	32(27.6)	63(54.3)	4(3.4)	17(14.7)	-
Energy use efficiency	67(57.8)	61(52.6)	28(24.1)	5(4.3)	21(18.1)	1(0.9)
Improved feeding practices (e.g. precision feeding)	111(95.7)	48(41.4)	31(27.7)	5(4.3)	32(27.6)	-
Warning systems	90(77.6)	82(70.7)	13(11.2)	9(7.8)	11(9.5)	1(0.9)
Weather-indexed insurance	46(39.7)	79(68.1)	9(7.8)	7(6.0)	20(17.2)	1(0.9)
Temperature control systems e.g. fans, and air-conditioners	101(87.1)	44(37.9)	25(21.6)	9(7.8)	36(31.0)	2(1.7)
Disease surveillance and monitoring	104(90.4)	43(37.1)	15(12.9)	4(3.4)	54(46.6)	-
Building resilience along supply chains	69(59.5)	56(48.3)	14(12.1)	7(6.0)	36(31.0)	3(2.6)
Reduce livestock numbers (match animal numbers to available resources)	107(92.2)	36(31.0)	29(25.0)	8(6.9)	43(37.1)	-
Cross-breeding and selections that are stress-tolerant breed.	105(90.5)	33(28.4)	26(22.4)	8(6.9)	49(42.2)	-
Use of weather information	95(81.9)	49(42.2)	29(25.0)	7(6.0)	29(25.0)	2(1.7)
Changing livestock breed	110(94.8)	30(25.9)	39(33.6)	3(2.6)	42(36.2)	2(1.7)

Source: Field data, 2022; Frequency (n=116); NGO = Non Governmental Organization

Farmers' adoption of climate smart livestock technologies:

As shown in Table 3, the commonly adopted CSLTs among the farmers were supplementary feeding (94.0%), animal health and disease prevention (88.6%) and improved feeding practice (86.2%). Others include animal breeding (76.7%), grazing/pasture management (73.3%), reducing livestock numbers (match animal numbers to available resources) and animal herd management (72.4%). The least commonly adopted technologies were anaerobic digesters for biogas and fertilizer (21.6%) and agroforestry practices (21.6%). The reason for this variation could be due to the cost and technicality involved in the use of these technologies. The technologies that were commonly adopted by the farmers seemed to be relatively cheaper and easy to handle such as supplementary feeding and animal health and disease prevention. Those considered to be relatively complex and will be requiring technical assistance and high cost especially anaerobic digesters for biogas and fertilizer were adopted by a very few farmers. Tedonkeng *et al*., (2022) found that majority of farmers in Northwest zone of Cameroon did not adopt climate change adaptation practices due to limited finance and insufficient knowledge about different adaptation options.

Table 3. Adoption of Climate Smart Livestock Technologies

Climate Smart Livestock Technologies	Frequency	Percentage	Ranking
Supplementary feeding	110	94.0	1st
Grazing/pasture management	83	73.3	5th
Animal breeding	89	76.7	4th
Animal and herd management	84	72.4	7th
Animal health and disease prevention	103	88.8	2nd
Agroforestry practices	24	20.7	19th
Anaerobic digesters for biogas and fertilizer	25	21.6	18th
Manure management	82	70.7	8th
Energy use efficiency	49	42.2	17th
Improved feeding practices (e.g. precision feeding)	100	86.2	3rd
Warning systems	55	47.4	14th
Weather-indexed insurance	50	43.1	16th
Temperature control systems e.g. fans, and air-conditioners	72	62.1	12th
Disease surveillance and monitoring	82	70.7	8th

Table 3. Cont.

Climate Smart Livestock Technologies	Frequency	Percentage	Ranking
Building resilience along supply chains	55	47.4	14th
Reduce livestock numbers (match animal numbers to available resources)	85	73.3	5th
Cross-breeding and selections that are stress-tolerant breed.	67	58.8	13th
Use of weather information	74	63.8	11th
Changing livestock breed	76	65.5	10th

Source: Field data, 2022; Frequency (n=116)

Constraints to adoption of climate smart livestock technologies:

According to the results in Table 4, almost all the constraints were major constraints to the use of CSLTs among the farmers based on the mean values. The constraints include high investment cost (mean value = 2.5), lack of access to climate smart technology (mean value = 2.3), high risk of the technology (mean value = 2.2), inadequate technical know-how (mean value = 2.2), lack of information on climate smart technology e.g. weather forecast (mean value = 2.2) and insufficient extension and animal health services (mean value = 2.2). High investment cost has been identified as one of the major reasons for inability of farmers to adopt climate smart agriculture (Tedonkeng *et al*.,2022). Thornton *et al*., (2016) observed that farmers may face up-front infrastructural or technological costs before some types of technological interventions can be implemented. This finding showed that these constraints can prevent or reduce the adoption capacity of the farmers hence, efforts should be made by relevant authorities to eliminate these constraints and encourage the adoption of the CSLTs among the livestock farmers.

Table 4. Constraints to adoption of Climate Smart Livestock Technologies

Constraints	Serious	Mild	Not a constraint	Mean value	SD
High investment cost	73(62.9)	33(28.4)	10(8.6)	2.5	6.6
High risk of the technology	46(39.7)	48(41.4)	22(19.0)	2.2	0.7
Lack of access to climate smart technology	63(54.3)	33(28.4)	20(17.2)	2.3	0.7
Inadequate technical know-how	56(48.3)	30(25.9)	30(25.9)	2.2	0.8
Lack of information on climate smart technology e.g. weather forecast	47(40.5)	46(39.7)	23(19.8)	2.2	0.7
Inconsistency with local tradition and culture	36(31.0)	40(34.5)	40(34.5)	1.9	0.8
Insufficient extension and animal health services	50(43.1)	46(39.7)	20(17.2)	2.2	0.7
Inadequate supply and poor-quality control of drugs and veterinary supplies,	46(39.7)	46(39.7)	24(20.7)	2.1	0.7

Source: Field data, 2022; Frequency (n=116), SD = Standard Deviation

Determinants of farmers' adoption of climate smart livestock technologies:

Results in Table 5 revealed that, of all the variables included in the model, awareness of CSLTs ($p = 0.003$) is the only variable that significantly affects adoption of CSLTs among the farmers. Other variables as shown in the table do not have significant effect on the use of CSLTs among the respondents ($p > 0.05$). The result is an indication that increased awareness of CSLTs among the respondents has led to increase in the adoption of CSLTs. Awareness of an innovation is the first stage of adoption process. Increased awareness is crucial for encouraging farmers to adopt CSLTs as they can help increase production while mitigating climate change. Farmers need to be informed about the benefits of CSLTs and how they can be used to improve their production. Nagelkerke Square value of 0.27 shows that the factors were accountable for 27% variation expressed in the dependent variable (adoption).

Table 5. Determinants of farmers' adoption of climate smart livestock practices

Independent Variables	B	SE	Wald	Sig
Age	0.013	0.033	0.157	0.692
Educational level	0.122	0.093	1.728	0.189
Sex	-0.270	0.508	0.282	0.595
Marital status	-0.102	0.588	0.030	0.863
Household size	-0.013	0.113	0.014	0.906
Annual income	0.000	0.000	0.703	0.280
Experience	0.089	0.071	1.583	0.208
Sum of animals	0.000	0.000	0.688	0.407
Membership of farmers association	0.865	0.487	3.157	0.076
Extension contacts	0.078	0.110	0.630	0.427
Awareness of CSLTs	**0.253**	**0.086**	**8.663**	**0.003**
Constant	-13.514	3.745	13.023	0.000

Source: Field data, 2022; Cox & Snell R Square: 0.20 Nagelkerke Square: 0.27β: parameter estimate, Wald: Wald statistic, SE = Standard Error

CONCLUSION AND RECOMMENDATIONS

The current study showed that the livestock farmers were aware and had adopted the CSLTs. Awareness of these technologies was the only factor that affected the adoption of the technologies. The study recommends an increased awareness creation among the farmers through different means as this will increase their adoption of the technologies while also making efforts to reduce the cost of the technologies.

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تبنى تقنيات الثروة الحيوانية الذكية مناخياً فى منطقة بورجو، بولاية النيجر، نيجيريا

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تم تقييم تبنى تقنيات الثروة الحيوانية مناخياً بين المزارعين فى منطقة بورجو بولاية النيجر، نيجريا. تم جمع بيانات من ١٢٠ مزارع تم إختيارهم عشوائياً. وقد أوضحت النتائج أن معظم المستجيبين (٧٢,٤ %) ذكور بمتوسط عمر ٣٥ سنة، وكان (٥٤,٣ %) متزوجون. معظم المستجيبين (٧٣,٣ %) متعلمون، بلغ متوسط حجم الأسرة ٨ أفراد، بينما بلغ متوسط الدخل المزرعى السنوى نحو ٥٥٩,٦٦٢,٤٥ نيرا. نسبة كبيرة نحو (٨٣,٦ %) تواصلت نحو ١ - ٥مرات مع مراكز الإرشاد، بينما بلغ متوسط الخبرة الزراعية نحو ٥ سنوات. كان المزارعون على علم بتقنيات الثروة الحيوانية الذكية مناخياً وكان المصدر الرئيسى لهذه التوعية جمعيات المزارعين ومراكز الإرشاد. ومن تقنيات الثروة الحيوانية الذكية الشائعة التبنى مكملات التغذية (٩٤ %)، صحة الحيوان ومقاومة الأمراض (٨٨,٦ %)، تحسين ممارسات التغذية (٨٦,٢ %). بينما كانت الأقل شيوعاً المهضمات اللاهوائية للغاز الحيوى والسماد. وكذلك زراعة الغابات (٢١,٦ %). كانت التكاليف الإستثمارية من أعظم قيود تبنى تقنيات الثروة الحيوانية الذكية مناخياً (متوسط القيمة = ٢,٥)، ضعف الوصول لتقنيات المناخ الذكية (متوسط القيمة = ٢,٣)، المخاطر العالية للتقنيات (متوسط القيمة = ٢,٢) عدم كفاية المعرفة الفنية (متوسط القيمة = ٢,٢). أظهر الإنحدار الثنائى أن الوعي بتقنيات الثروة الحيوانية الذكية مناخياً كان له تأثيراً معنوياً على التبنى. الدراسة الحالية أوصت بزيادة خلق التوعية بين المزارعين عن طريق قنوات إتصال فاعلة.