

Research Article

Assessment of Determinants of Climate Change Resilience Among Agro-pastoral Communities in Kongwa District, Dodoma-Tanzania

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Abstract

Climate change is affecting climate-sensitive sectors including agriculture in developing countries. Tanzania as one of the developing countries is hit by the climate change impacts, especially in semi-arid areas. This study aimed to analyze the agro-pastoralists' perceptions on climate change, adaptation strategies and determinants of adaptation to climate change of agro-pastoralists. The study was conducted in Kongwa district, Dodoma region in central zone Tanzania. A cross-sectional design was used to collect quantitative data by using structured questionnaires. Two wards, Ugogoni and Mtanana were used in this study where 240 respondents were interviewed under consent using the structured questionnaire. Focused group discussion (FGD) and key informant interviews (KII) were also used. The results showed that most of the agro-pastoralists perceive decrease in rainfalls' distribution (95.4%), decline in rainfalls' intensity (88.8%), delay of rainfall (88.8%), early cessation of rains (97.9%), increase in temperatures (91.3%), re-occurrence of floods (74.9%), and droughts (91.3%) over the past 20 years. The mostly used climate change adaptation strategies in crop production were changes of planting dates (98.8%), planting density (96.3%), crop diversification (92.1%), use of improved crop varieties (34.2%), crop rotation (16.3%), and tree planting (10.0%), whereas in livestock production, were livestock diversification (30.8%), storage of feed and crop residues (21.3%), and feeding strategies (10.0%). The binary logistic regression model results showed that the determinants of climate change that significantly influence resilience in Kongwa district were geo-location, with 4.288 odds; age (0.953 odds/ 95.3%), number of livestock owned (1.056 odds), and land size (6.097 odds). The study revealed that livestock sector's adaptive capacity is lower as compared to crop production sector. The study suggested that government should improve the accessibility to inputs and subsidies, such as improved crop, pasture and animal seeds to foster resilience of agro-pastoralists.

Keywords

Climate Change, Adaptation, Agro-pastoralists, Determinants, Kongwa District

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Received: 29 September 2025; **Accepted:** 10 October 2025; **Published:** 29 December 2025



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1. Introduction

Climate change (CC) has emerged as one of the most pressing and complex global challenges, particularly for agriculture-dependent communities. Its impacts; ranging from altered precipitation patterns, rising temperatures, to increased frequency and intensity of extreme weather events, are disrupting food systems and threatening rural livelihoods, especially in developing regions. Recent studies highlight that climate change is altering rainfall distribution, intensifying droughts and floods, and contributing to heat stress in many parts of Sub-Saharan Africa (SSA) [1-5]. For instance, projections show that average temperatures in the region may rise by 1.3 °C to 2.9 °C by the 2050s, with significant implications for agro-ecological systems [6-8]. These climatic changes are especially pronounced in arid and semi-arid zones, where communities already face fragile ecological conditions and limited adaptive capacity [9-12].

Agro-pastoral communities in these areas are particularly vulnerable due to their dependence on climate-sensitive sectors such as crop and livestock production. In SSA, agriculture supports nearly 80% of the population, making it a cornerstone of food security, employment, and income generation [13, 14]. However, the increasing variability in weather patterns; such as erratic rainfall, extended dry spells, and more frequent droughts is undermining these livelihoods. The consequences are far-reaching, affecting not only household food security but also broader efforts toward sustainable development [15].

Resilience, defined as the ability of communities to anticipate, cope with, and recover from climatic shocks while maintaining or improving their well-being, has thus become central to climate adaptation discourse [17]. Building resilience among agro-pastoralists involves both structural and behavioural responses, including adaptation strategies in livestock and crop production. These strategies range from livestock mobility, diversification, and use of indigenous knowledge, to crop rotation, irrigation, soil conservation, and the adoption of drought-resistant crop varieties [7, 9, 18-25].

Yet, the effectiveness of these strategies is highly influenced by a combination of socio-economic, institutional, and environmental factors. Factors such as access to extension services, credit facilities, land ownership, education level, gender, household income, and local climate information play a crucial role in shaping adaptive capacity [26-28]. While these factors are increasingly recognized across SSA, their specific dynamics and interactions remain context-dependent.

In the case of Tanzania; particularly in semi-arid districts such as Kongwa, there is limited empirical evidence on the key determinants that enable or hinder climate change resilience among agro-pastoral communities. Despite being among the regions most affected by climate change, Kongwa remains

understudied in this regard, creating a significant knowledge gap that limits the development of locally appropriate adaptation strategies.

This study addresses that gap by assessing the determinants of climate change resilience among agro-pastoral communities in Kongwa District, Dodoma Region. Specifically, it (i) examines local perceptions of climate change, (ii) identifies the adaptation strategies employed, and (iii) analyzes the key socio-economic and institutional factors that influence resilience. The findings provide essential insights for policymakers, researchers, and development practitioners seeking to support climate-resilient livelihoods in similar semi-arid settings.

2. Materials and Methods

2.1. Study Area

The study was conducted in Kongwa district, located in the central part of Tanzania. The study will be conducted in two wards of Ugogoni and Mtanana. Kongwa district was selected for the study due to the following reasons: firstly; it is one of the areas found in semi-arid zone of Tanzania in which there are repeated crop failures due to erratic rainfall patterns [29]. Secondly, the area gives a chance to study the determinants of climate change resilience on crop and livestock production. Moreover; it is within the project area on “Enhancing Climate Change Adaptation for Agro-Pastoral Communities in Kongwa District” funded by the Foundation for Energy, Climate and Environment (FECE).

Kongwa district council is a semi-arid climatically and one of the districts forming Dodoma region with 22 wards, 87 villages, 383 suburbs and 2 township authorities. Its longitude and latitude is 6.0593 °S, 36.5230 °E, respectively. Its micro-climate is greatly influenced by its altitude. The mean temperature is about 26.5 °C, but sometimes temperature can go down to as much as 11 °C. The coolest weather occurs in January to June when temperatures fall between 20 °C - 33 °C. The temperatures get slightly lower in the months of May to July. The highest temperature recorded is 31°C while the lowest temperature is 18 °C. The rainfall pattern of the district is a uni-modal which normally rains between December and April whose range is 400- 650 mm/annum. The district lies on leeward side (rain shadow/ downwind) of Ukaguru Mountains. Most of the time, winds from the ocean are dry and run parallel to the land making moisture uncertain to precipitate hence leading to low rainfalls in Kongwa district.

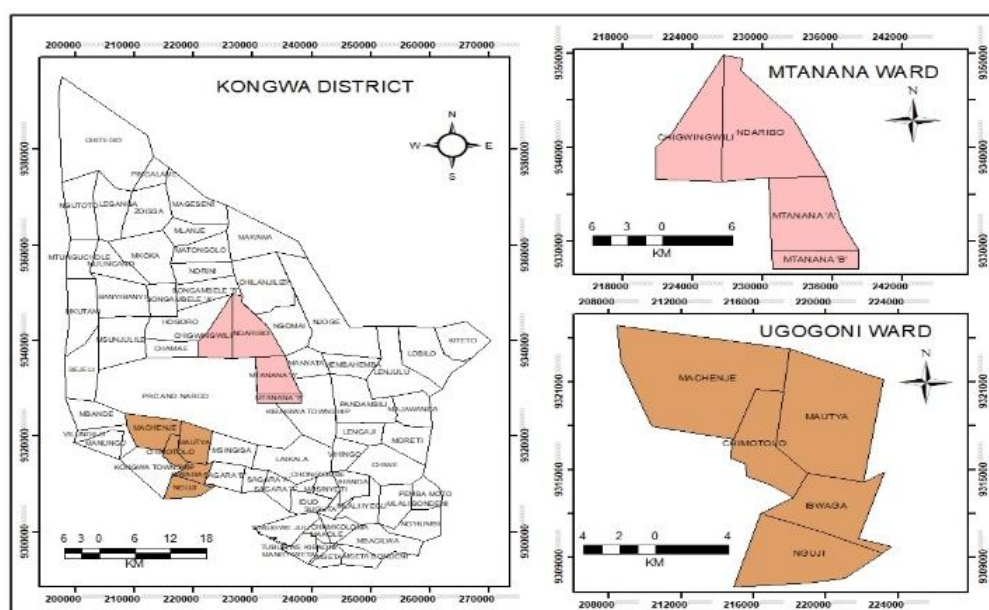


Figure 1. Map of Kongwa district showing the study wards of Ugogoni and Mtanana.

2.2. Data Collection

Data collection was conducted between November and December 2024, in Kongwa district, central zone, Dodoma Tanzania.

2.2.1. Research Design

A cross-sectional design was used to collect quantitative data by using structured questionnaires. The study employed a structured questionnaire to obtain primary data from agro-pastoralists by making face-to-face interviews after agro-pastoralist's consent to make sure agro-pastoralists understand and can respond accurately to the questionnaire, hence increasing the rate of response. The face-to-face interview-approach is commonly employed when gathering primary data from agro-pastoralists as it leads to a high rate of response compared to other data collection approaches [30]. Moreover, the qualitative data were collected from a purposively selected focused-group discussion (FDG) and Key Informant Interview (KII) participants using open-ended questions so that to triangulate the information obtained from household survey interviews' results.

The structured questionnaire captured agro-pastoralists' perceptions on climate change, such as changes in temperature, rainfall, flood occurrence, and drought events in the past 5 to 10 years. Different studies stress that indigenous knowledge owned by local people coupled with long history of interaction between nature of these people; equip them with high ability to understand climate change and variability as well as weather forecasting [31]. To combat the impacts of climate change more efficiently, local knowledge and scientific information should be blend together as they are highly

connected [32]. It also encompassed the adaptation strategies employed by agro-pastoralists to combat the effects of climate change. Furthermore, the questionnaire captured factors influencing agro-pastoralists' adaptation to climate change.

2.2.2. Sample Size and Sampling Techniques

The study was carried out in two wards of Kongwa District, Mtanana, whereas three villages from each ward were sampled for this study. Three villages from Mtanana were Mtanana A, Mtanana B and Ndalibo whereas in Ugogoni ward, were Machenje, Ibwaga and Chimotolo. These wards were purposively selected for this study based on the following reasons; first, because of their severity to climate change resilience among their dwellers, accessibility, high population size hence good representation of the research area and they were beneficiaries of the project, "Enhancing climate change adaptation for agro-pastoral communities in Kongwa district" funded by the Foundation for energy, climate and environment (FECE). The selected wards were inhabited by agro-pastoralists. Whereby, 120 agro-pastoralists from each ward (making 240 households) were randomly sampled for household interviews by the using village registers in consultation with village executive officers. Sample size of the household was computed by using the model of [33] that assumes 95% confidence level with $\pm 5\%$ precision error and 50% ($p = 0.5$) variability.

$$n = \frac{N}{1 + N(e)^2} \quad (1)$$

Where, n = the sample size, N = the population size, and e = the desired level of precision. Eight key informants were purposively selected from district agriculture, livestock and fisheries office, district environmental and forestry depart-

ment office, and district executive of Kongwa. A total of two FGD sessions with a total of 20 participants (10 participants per session) were organized in each ward. In order to obtain the views of different social groups of the agro-pastoral community; the FGD members were heterogeneous with different sex, age and economic status.

2.3. Data Analysis

The household data collected by the structured questionnaire survey were analyzed using descriptive and inferential statistics such as binary logistic regression model whereas data obtained from FGD, observation and key informant interviews, were analyzed by using thematic content analysis. To analyze the qualitative data, audio recordings were first transcribed into written text. The transcribed content was then organized into categories. This was followed by a thorough review of the text; reading and re-reading; to identify recurring themes, ideas, behaviors, and interactions. These themes were grouped into meaningful categories to effectively summarize the entire dataset [34]. Finally, content analysis was applied to present the qualitative findings in alignment with the quantitative results. Descriptive statistics, like standard deviation, mean, coefficient of variation, percentage and plots (such as bars, histograms, and pie chart) were employed to analyze agro-pastoralists' perceptions on climate change indicators, and adaptation strategies to climate change impacts employed by agro-pastoralists.

The binary logistic regression model was used to identify the key determinants which influence the choice of adaptation strategies to combat climate change impacts by the sampled households in Kongwa district. The statistical package for social sciences (SPSS), version 25 and Microsoft excel; version 10 were used to do these analyses. Then the results obtained were discussed.

2.4. Theoretical Framework

Binary logistic regression is a type of regression analysis employed to estimate the relationship (probability) between a dichotomous dependent variable and a set of both dichotomous and a set of both continuous and categorical variables (independent/predictor) variables in applied social sciences. The binary logistic regression model was chosen due to the following reasons; firstly, the model may be applied to analyze the relationship between a categorical dependent variable (response) and a set of both categorical and continuous variables and secondly, the model best suits for modeling non-linear distribution data, which is not suitable for ordinary least squares [35]. Many different variables of interest are dichotomous e.g., for this study we can say whether or not someone is resilient to climate change. These kinds of variables are known as discrete or qualitative and they can be termed as events. Dichotomous (dummy) variables are usually coded 1, indicating "success" or "yes" (or resilient, for

this study) and 0, meaning "not resilient" [36]. The mean of a dichotomous variable coded 1 (resilient) and 0 (not resilient) is equal to the proportion of cases coded as p and $1-p$ respectively.

Discrete regression models include both logit and probit models [37]. The logit model, also called logistic regression, is categorized as binary logistic regression when the dependent variable (in this case, resilience) has two possible outcomes—resilient or not resilient. When the dependent variable has more than two outcomes, it is referred to as multinomial logistic regression. The probit model is similar to the logit model, and both typically give comparable results. The key distinction lies in their underlying assumptions: the logit model assumes the dependent variable follows a logistic distribution, whereas the probit model assumes a cumulative normal distribution. Additionally, the logit model assumes a homogeneous population where all individuals have an equal likelihood of interacting with one another.

The maximum likelihood method is employed to estimate the parameters of each independent variable (in this case, the determinants of CC resilience) in the binary logistic regression model at a specified level of statistical significance [37]. This process involves analyzing the probability density function (PDF) of each independent variable. To represent a discrete regression model that incorporates all variables, a joint PDF is utilized. Generally; a logistic model is expressed as:

$$\frac{dnt}{dt} = \beta \frac{nt}{N} (N - nt) \quad (2)$$

Whereby n , is the number of individuals who are CC resilient at time t in the study area, N is the total population of potential resilient agro-pastoralists, and β is a parameter reflecting the rate of CC resilience (equation adopted from [38].

2.5. Empirical Framework

In binary logistic regression, the outcome variable takes values between 1 and 0. In this case, 1 represents "being resilient (p)" and 0 stands for "not being resilient ($1-p$)". The expected value is the probability, p that the response variable takes the value of 1. This implies that the probability of not being resilient is $1-p$. Because of non-linearity of the logistic distribution (log transformation), thus the term "logit" is employed. Therefore, the logistic model may be re-expressed as presented in equation (3) as the *log-odds* of resilience being expressed as a linear function of the independent variables [39].

$$\text{Log} \frac{p}{1-p} = \beta_0 + \beta_1 X_1 + \beta_2 X_2 \dots \beta_q X_q \quad (3)$$

Where, β represents the estimated coefficient, while X denotes the independent variable, predictor, or explanatory variable (in this case, the determinant of CC resilience). The logistic coefficient indicates the log-odds of the explanatory variable in relation to others concerning the modeled outcome

(dependent variable). Typically, β coefficients are exponentiated to express the results in terms of odds. Thus, the equation can be rewritten as:

$$\frac{\text{Prob}(\text{resilient})}{\text{Prob}(\text{none resilient})} = e^{\beta_0 + \beta_1 X_1 + \beta_2 X_2 + \dots + \beta_i X_i} \quad (4)$$

Where, e raised to the power of the coefficient represents the factor by which the odds change when the i^{th} independent variable increases by one unit. If the coefficient is positive, $E(\beta_i) > 1$, indicates an increase in odds. Conversely, if the coefficient is negative, $E(\beta_i) < 1$, it means the odds decrease. When the coefficient is zero, $\beta_i = 0$, $E(\beta_i) = 1$, it signifies that there is no change in odds. The logistic model follows a symmetric S-shaped diffusion pattern, reaching its highest diffusion rate when 50% of potential agro-pastoralists have achieved resilience to CC. In this study, the logistic regression model can be expressed as:

$$\ln \frac{P}{1-P} = \beta_0 + \beta_1 X_1 + \beta_2 X_2 + \dots + \beta_n X_n + e \quad (5)$$

Whereby; X_1 = Gender of the household head, X_2 = Gender of the household head, X_3 = Age of the household head, X_4 = Marital status of the household head, X_5 = Education level of the household head, X_6 = Social status of household head, X_7

= Number of household members, X_8 = Number of adults in the household, X_9 = Land size owned Proximity to the farm, X_{10} = Total number of livestock owned by the household, X_{11} = Household's source of income, X_{12} = Accessibility to the climate information, X_{13} = Distance to the market, X_{14} = Accessibility to institutional supports, β_0 = Constant (regression coefficient), and ϵ = Error term.

The binary logistic regression model was used to determine the determinants which influence agro-pastoralists to combat climate change impacts. The common regression challenges of the model were tested, such as, mode of fit, model specification, and multicollinearity, whereby factors found to have problems were dropped from the first model. The variance inflation factor (VIF) was used to determine multicollinearity, which showed that the largest VIF was only 1.640 in the second model. A VIF > 5 signifies the presence of multicollinearity, that needs attention. The Hosmer and Lemeshow's goodness-of-fit indicated that the probability model fitted the data well and was correctly specified, with statistically insignificant results, which indicates that the model fits well the data and has no specification error. Also, the Omnibus tests of Model Coefficients produced statistically significant results indicating that the model fits the data well. The determinants of climate change resilience are described in Table 1 below:

Table 1. Description of independent variables hypothesized to influence resilience to climate change in Kongwa district.

Variable	Variable name in full	Description	Hypothesized sign
GENDER	Gender	Binary, 1=men, 0=Female	+/-
WARD	Ward	Binary, 1=Ugogoni, 2=Mtanana	+
AGE	Age	Continuous	+/-
MARTST	Marital status of house hold head	Binary, 1=Married, 0=Un-married	+
EDLEV	Education level	Categorical	+
SCSTT	What is your social status in this area?	Binary, 1=Leader, 0=Not leader	+
HHMEMB	How many members live in the household?	Continuous	+/-
HHMEMBPT	How many family members do participate in economic activities?	Continuous	+/-
LANDSIZE	Land size owned by the household	Continuous	+
TOTLIVST	Total number of livestock kept	Continuous	+
ENCSOURCE	What is your primary source of income	Categorical	+
DISTMARKT	What is the distance to the markets in hours or, minutes?	Continuous	-
CCINFO	Have you ever heard of Climate change?	Dummy, 1=Yes, 0=No	+
INSTTAVAILAB	Is there any institution that helped you to combat CC impact?	Dummy, 1=Yes, 0= No	+

+ = the factor influences adaptation to climate change positively, - = the factor influences adaptation to climate change negatively. Source: own survey data, 2024

3. Results

3.1. Agro-pastoralists' Perceptions on Climate Change

A plenty of respondents in study perceived, (96.7%) that have realized changes in climatic condition over the past 5-20 years. The results revealed that agro-pastoral community in Kongwa had witnessed various indicators pertaining climate change (Table 1). Most of the agro-pastoralists perceived the decline of rainfall distribution (95.4%) and rainfall intensity (88.8%) in the rainy seasons over the last two decades. The majority of the respondents in a study also observed signifi-

cant delay of onset (92.9%) and early cessation of rains (97.9%) during the rainy seasons over past 20 years. The erratic rainfalls lead to crop failures and poor livestock productivity. This in turn culminates in food insecurity and poor livelihoods among agro-pastoralists. In addition, re-occurrence of floods was reported by a considerable number of respondents (74.9%). The un-predictable high rainfalls lead to flood incidences, which lead to loss of farmers' assets and resources. The majority of the agro-pastoralists in Kongwa reported an increase in temperature and drought occurrences by 91.3% over the past 20 years. The high temperature and droughts were thought to be major causes of crop failures and the decreased livestock productivity.

Table 2. Perceptions of agro-pastoralists on the changes of some climatic parameters in Kongwa over last 20 years.

Parameter	Perception	Occurrence	
		Frequency	Percent (%)
Rainfall distribution in a rainy season	Poor	229	95.4
	no change	10	4.2
	Good	1	0.4
Rainfall intensity	decreased	213	88.8
	no change	25	10.4
	Increased	1	0.4
Onset of rainfall in a rainy season	Early	11	4.6
	no change	6	2.5
	Delayed	223	92.9
End of the rainfall	Early	235	97.9
	no change	4	1.7
	Delayed	1	0.4
Temperature	I can't tell	6	2.5
	decreased	15	6.3
	Increased	219	91.3
Drought re-occurrence	Low	16	6.7
	Moderate	3	1.3
	High	219	91.3
Flood occurrences	Low	34	14.1
	Moderate	26	11
	High	180	74.9

Source: Own survey data, 2024.

3.2. Adaptation Strategies Employed by Agro-pastoralists

The study showed that out of 240 sampled agro-pastoralists, most of them, 98.8% had used adaption strategies as the means to combat climate change impacts. The strategies used were grouped into two groups; first was crop production adaptation strategies, such as changes of planting dates planting density, crop diversification, use of improved crop varieties, crop rotation, tree planting, agroforestry, use of fertilizer, water storage and conservation and irrigation. The second group was the livestock production adaptation strategies, such

as livestock diversification, storage of feed and crop residues, feeding strategies, herd diversification, use of crossbred animal breeds, and establishing pastures. The mostly used adaptation strategies by the most agro-pastoralists in crop production were changes of planting dates planting density, 237 (98.8%), crop diversification, 231 (96.3%), use of improved crop varieties, 221 (92.1%), crop rotation, 82 (34.2%), and tree planting, 39 (16.3%) (Figure 2). To counteract the challenges of reduced rainfall, delay of rainfall, and early cessation of rainfall, change of planting dates was used by the most agro-pastoralists to combat crop failure challenge.

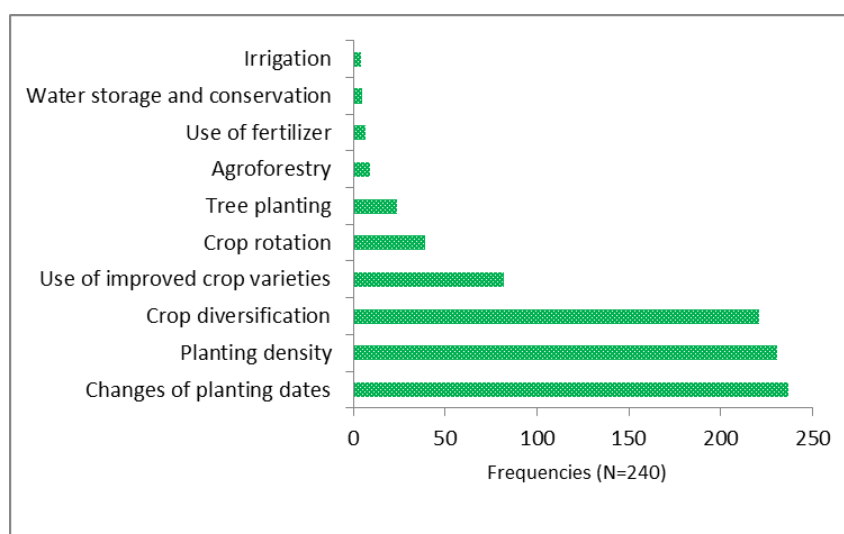


Figure 2. Crop production adaptation strategies in Kongwa district. Source: Own survey data, 2024.

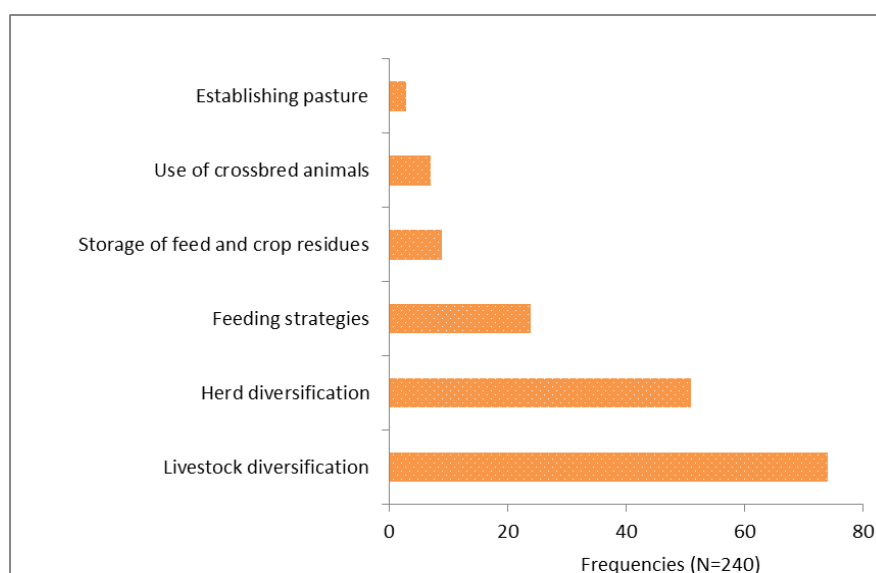


Figure 3. Livestock production adaptation strategies used in Kongwa district. Source: Own survey data, 2024.

The least used adaptation methods in crop production sector were agroforestry 9 (3.8%), use of fertilizer 7 (2.9%),

water storage and conservation 5 (2.1%), and irrigation 4 (1.7%). They were rarely used in the study area due to dif-

ferent reasons, such as limited land resource, lack of credits (lack of funds), high price of improved crop varieties, limited land, and poverty. For example, lack of land, and communal land use for grazing especially during the dry seasons also limited the tree planting and agro-forestry. Thus, in order for agro-pastoralists to be more climate-resilient, irrigation, use of drought-resistant crop varieties, soil conservation, water storage, mixed crop-livestock production, use of fertilizer, economic diversification and improved access to institutional services should be put in place.

In the livestock production, results showed that the most adaptation strategies employed by the agro-pastoralists were livestock diversification, 74 (30.8%), storage of feed and crop residues, 51 (21.3%) and feeding strategies, 24 (10.0%). The least used adaptation strategies in livestock sector were storage of feed and crop residues, 9 (3.8%), use of crossbred animals 7 (2.9%) and establishing pasture, 3 (1.3%) (Figure 3).

3.3. Determinants of Resilience to Climate Change

The ability to withstand the climate change shocks differed between wards (Ugogoni vs Mtanana) in the study area as shown in Figure 4. Ugogoni ward's agro-pastoralists were less adaptable (39 out of 120) to CC shocks compared to their counterparts Mtanana (70 out of 120). The higher adaptability of Mtanana agro-pastoralists might be due to their proximity to Kibaigwa Township and market where they obtain easily the agricultural inputs and sell their agricultural produce as compared to those living in Ugogoni ward. Also, Mtanana ward is favored by being close to Dodoma-Dar-es-salaam main road whereby their residents can transport their produce and inputs to and from these cities, hence increasing the adaptability as compared to their counterparts living in Ugogoni ward.

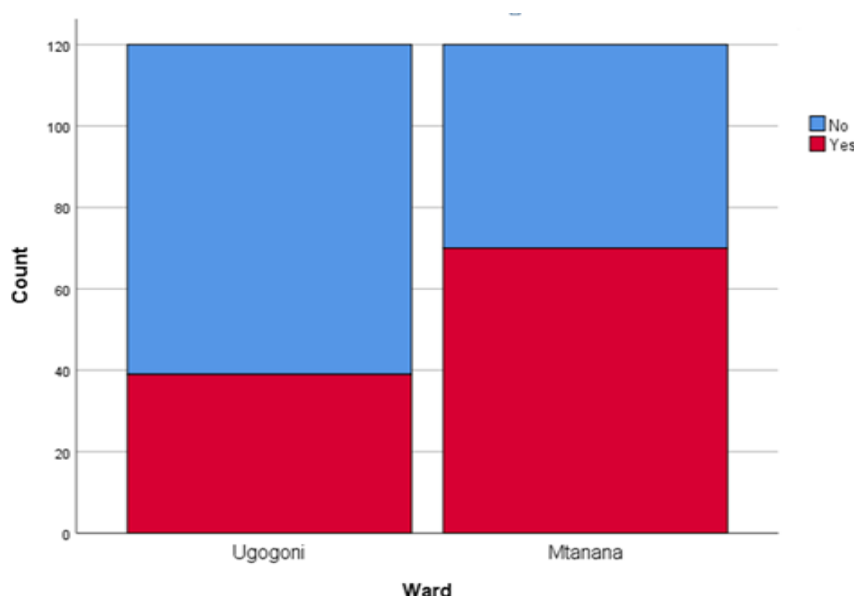


Figure 4. Fraction of ability to withstand the climate change shocks between Ugogoni and Mtanana wards' agro-pastoralists. Source: Own survey data, 2024.

Table 3. Determinants of resilience to climate change in Kongwa district.

Variable	Coefficient	S. E	Wald	Sig.	Odds ratio	VIF
GENDER	-0.319	0.379	0.707	0.400	0.727	1.319
WARD	1.456*	0.414	12.380	0.000*	4.288	1.375
AGE	-0.049*	0.014	12.915	0.000*	0.953	1.106
MARTST	1.249	0.687	3.308	0.069	3.487	1.337
EDLEV	-0.199	0.356	0.314	0.576	0.819	1.253
SCSTT	-1.173	0.654	3.215	0.073	0.309	1.171
HHMEMB	0.100	0.101	0.978	0.323	1.105	1.607

Variable	Coefficient	S. E	Wald	Sig.	Odds ratio	VIF
HHMEMBPT	-0.099	0.171	0.332	0.565	0.906	1.640
LANDSIZE	0.054	0.035	2.484	0.115	1.056	1.502
TOTLIVST	0.055*	0.018	9.569	0.002*	1.057	1.392
ENCSOURCE	0.056	0.064	0.778	0.378	1.058	1.146
DISTMARKT	0.065	0.125	0.272	0.602	1.067	1.257
CCINFO	0.393	0.345	1.302	0.254	1.482	1.160
INSTTAVAILAB	1.808*	0.776	5.427	0.020*	6.097	1.137
N (240)						
Constant	-2.694	1.533	3.087	0.079	0.068	

* = there is statistical significance at $p < 0.05$, S.E = standard error, and VIF = variance inflation factor. Source: Own survey data, 2024.

4. Discussion

4.1. Agro-pastoralists' Perceptions on Climate Change

Majority of the agro-pastoralists in Kongwa reported erratic rainfall incidences in the study area over the past two decades. These incidences included low rainfall, delayed rainfall onset and early cessation of rainfalls during the rainy seasons. The changes in rainfall patterns were connected to the climate change in the study area. Erratic rainfalls lead to poor agricultural productivity (both crop and livestock). The erratic rainfalls were also reported by other studies in different areas in Tanzania [17, 40, 41] and other Sub-Saharan African countries [9, 10]. In addition, re-occurrence of floods reported in the current study might be due to un-predictable high rainfalls in the study area. The un-predictable high rainfalls lead to flood incidences, which lead to loss of farmers' assets and resources. This was supported by the results from the FGD discussion, one respondent in Mtanana B village, said,

"There has been re-occurrence of heavy rains in our area in recent years.

....for instance, last year (2023) it rained heavily and my five acres of farm were flooded, I incurred significant losses in which my maize crops were drawn in flooded water. To avoid other losses in the future, I have decided to improvise by changing that piece of land from maize and sunflower farm into paddy farm".

Flood incidences were also reported by other studies in the Sub-Saharan African countries [9, 42]. For example, [42] stressed that a decreasing trend of rainfall indicates that there is a high chance of drought incidences and the opposite trend (increasing trend) signifies flooding. In addition, the result showed an increase in temperature and drought occurrences in the study area. This might be caused by increased number of

hot days in the area as projected by [43] that temperature will raise by 3.4-4.2 °C by the end of 21st century. Moreover, a study by [6] stressed that temperature is expected to rise to 1.3-2.7 °C in the 2050s. An increase in temperatures leads to heat stress for both livestock and crops production sectors. [21] reported that heat stress is one of the alarming effects of climate change in arid and semiarid lands. The high temperature and droughts were thought to be major causes of crop failures, feed shortages and the decreased livestock productivity. The result of increased temperature has also been reported by other studies in other areas in Tanzania [17] and other places in Sub-Saharan African counties [6, 7, 9, 16].

4.2. Adaptation Strategies Employed by Agro-pastoralists

Climate change hampers well-being and food security of the agro-pastoralists. Therefore; when agriculture is adversely impacted by the climate change; innovative interventions are inevitable to increase adaptive capacity of agro-pastoralists. The results revealed that Kongwa agro-pastoralists employ different adaptation strategies to reduce the climate change shocks in their agricultural production (crop and livestock), just as the case of farmers in other areas in Tanzania [17] and other arid and semiarid areas in other Sub-Saharan African countries [10, 22, 23, 27, 44, 45]. In crop production, agro-pastoralists mostly used adaptation strategies were changes of planting dates, planting density, crop diversification, use of improved crop varieties, crop rotation, and tree planting. For change of planting is used due to the fact that rainfalls have been erratic in the recent years, so forcing farmers to change their time of cultivating and planting their fields. This also was elaborated by one of farmers in FGD in Ibwaga village claimed,

"These days, rains are coming too late while ceasing too early, so we prepare our farms and plant early so that our crops might survive the dry spell even after the rains have

gone...otherwise, the rains may cease too early while leaving our crops at the blooming stage, in which we end up harvesting nothing”.

This current finding has also been the case in other areas in other Sub-Saharan-African countries [7, 22, 25]. The other methods (use of fertilizer, water storage and conservation, and irrigation) were rarely employed in Kongwa due to various constraints, such as lack of funds, limited land and poverty. For example, lack of land, and communal land use for grazing especially during the dry seasons also limited tree planting and agro-forestry practices. This was revealed by agro-pastoralists in FGD in Ndalibo village, where one of the respondents claimed,

“We can’t plant trees in our cultivation fields since we have limited pieces of land for crop production, and others don’t have their own lands...but they lease or borrow others’ lands to cultivate annual crops. Moreover, after harvesting our crops, we graze our animals communally in the harvested fields to feed crop residues, especially in the dry seasons....thus we fear to plant trees in our fields to avoid livestock to trample on them (planted trees)”.

Moreover, on the use of local seeds instead of the improved ones, another FGD respondent in Machenje village said,

“We plant our own local seeds every year; this leads to low crop yields and quality, we wish to use the drought-resistant crops, but they are sold at a very high price that we can’t afford to buy them. However, we were promised by the district authority to be given the subsidized seeds and inputs, but it’s un-fulfilled promise for years now...it is a high time the district authority to fulfill its promises to us so that we can improve our ways of crop production, hence improve our livelihoods”.

Thus, in order for agro-pastoralists to be more climate-resilient, irrigation, use of drought-resistant crop varieties, soil conservation, water storage, mixed crop-livestock production, use of fertilizer, economic diversification, and improved access to institutional services should be put in place. This finding was supported by KII discussion, in which experts highlighted that,

“In order to be climate resilient for Kongwa district’s agro-pastoralists, they should adopt different adaptation strategies, such as climate smart agriculture, (CSA), afforestation, agroforestry, planting trees, soil conservation, use of drought-resistant seeds, changing of planting dates and creating awareness to agro-pastoralists on climate change”.

In addition, livestock officer in KII added that,

“Agriculture and livestock research should embark on pasture establishment, and introducing drought-tolerant animal breeds....on the other hand, more awareness on the CC and mitigation strategies should be emphasized via different platforms, such as schools, religious gatherings. In schools; from primary school to universities curriculums should add the lessons about climate change and mitigation measures”.

These results in this study were also reported by [8, 10, 22, 25] in different countries of Sub-Saharan Africa. The study revealed that livestock production adaptive capacity was generally low as compared to the crop production. The few highly used adaptation methods in livestock sector were livestock diversification, storage of feed and crop residues, and feeding strategies. This result is in line with [10, 16, 18, 46]. For example, [18] highlighted that keeping poultry and browsers act as a hedge against harsh conditions such as prolonged droughts and feeds shortages. In order to foster the adaptive capacity of the livestock sector, methods like, use of crossbred livestock breeds, pasture establishment, the use of supplementary feeds, destocking and improved extension services should be emphasized.

4.3. Determinants of Resilience to Climate Change

The results from binary logistic regression model stressed factors to climate change adaptation are ward (geo-location), age, number of livestock and land size. The results revealed that Mtanana ward agro-pastoralists are more adaptive to CC than their counterparts of Ugogoni ward. This might be due to the fact that Mtanana ward is near to Kibaigwa market and township, which enable Mtanana residents to access agricultural inputs and selling their agricultural produce easily compared to their counterparts Ugogoni dwellers who are far away to the Market requiring more than 3 hours to Kibaigwa market.

Moreover, Mtanana ward is along Dodoma-Dar es salaam main road, thus making agro-pastoralists in this ward accessing social services to Dodoma and Dar es Salaam cities more easily, hence increasing their resilience capacity than those living in Ugogoni. The accessibility to markets plays a pivotal role to the adaptive capacity of agro-pastoralists since they can access easily their basic food to at the markets [47]. This finding is consistent with [26, 48] who reported that the exposure of farmers to a particular area led to more experience on climatic condition and hence more adaptation to climate change.

In addition, household head’s age affected negatively the adaptive capacity to climate change. This result suggests that younger agro-pastoralists are more adaptable to climate change than their counterpart older ones, possibly due to their ability to adopt new technologies, diversify income sources, or engage in more labor-intensive climate adaptation strategies. Older agro-pastoralists might struggle with adaptation due to physical limitations, resistance to change (rigidity), or reliance on traditional practices. This result is in line with that of [27] who stressed that age negatively influences adaptive capacity of farmers due to the fact that older farmers are more rigid to adapt new technologies and they are more risk-averse compared to younger ones.

The results also indicated that the number of livestock owned by the family positively influence the adaptive capac-

ity of agro-pastoralists. This might be due to the fact that, the number of livestock can signify how wealthy a particular agro-pastoralist is, and hence how adaptable to climate change such agro-pastoralist might be. Furthermore, the results showed that institutional services availability; positively influence the adaptive capacity to climate change of the agro-pastoralists.

The results showed that access to institution services increases, the adaptability to CC increases by 6.097 odds than those agro-pastoralists who cannot access the institutional services. This might be due to the fact that the presence of institution to agro-pastoralists indicates that various services are provided to farmers, such as education and training on good agricultural practices, extension services, subsidy, food relief aids and others. This leads to improvement of livelihoods of the agro-pastoralists and hence high resilience to climate change impacts. This finding corroborates with that of [26, 48] who highlighted that accessibility to institutional services such as accessibility to irrigation water, arable land and climate information's accessibility determine farmer's capacity to climate resilience and determine the extent to which agro-pastoralists are resilient to climate change impacts.

5. Conclusion and Recommendations

This study highlights that the majority of agro-pastoralists in Kongwa District are aware of the erratic rainfall patterns and rising temperatures in recent years. In response, they have adopted various adaptation strategies to mitigate the impacts of climate change on their livelihoods. However, the study also revealed that the adaptive capacity of the livestock sector in Kongwa District is generally lower compared to the crop production sector. Common adaptation methods in livestock production include livestock diversification, feed storage, and strategic feeding practices. Key factors influencing climate change adaptation were identified as geo-location, age, livestock numbers, and land size. The limitation of this was generalizability.

The study suggests strengthening climate change adaptation in the livestock sector of Kongwa District, targeted interventions are needed. These include improving access to veterinary and extension services, promoting feed storage and strategic feeding practices, and enhancing the dissemination of climate information. Policymakers should support livestock-focused adaptation programs and consider socio-demographic factors such as age, location, livestock numbers, and access to social services. Finally, further research in other regions is recommended to improve the generalizability of the findings.

Abbreviations

CC Climate Change

SSA	Sub-Saharan Africa
FECE	Foundation for Energy, Climate and Environment
FDG	Focused-group Discussion
KII	Key Informant Interview
SPSS	Statistical Package for Social Sciences
VIF	Variance Inflation Factor

Acknowledgments

The authors acknowledge the Kongwa district local communities for their willing participation in the study.

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Funding

This study was funded by the Foundation for Energy, Climate and Environment (FECE) under Enhancing Climate Change Adaptation for Agro-Pastoral Communities in Kongwa District, implemented between year 2021 to 2025.

Data Availability Statement

The data is available from the corresponding author upon reasonable request.

Conflicts of Interest

The authors declare no conflicts of interest.

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