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Research Article

# Impacts of Climate Change on Communal Livestock Production: Experiences in Chiredzi District

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## Abstract

The study sought to find and measure climate change impacts on livestock production in Chiredzi district. Purposive sampling was done on 6 selected wards. Primary data on perceived climate change impacts was collected using a pretested questionnaire and 150 households were sampled. Secondary data on climatic records were collected from meteorological department. Climate data was used to establish climatic patterns. Empirical Ricardian regression model and descriptive statistics were used to measure climate change impacts on livestock. Increase in temperatures and decrease in rainfall events were highlighted by 98% and 84% of the farmers, respectively. In relation to forage and water availability 92% and 93% perceived a decrease respectively. Respondents perceived an increase in incidence of climate influenced diseases to include Heart water in goats, Foot and Mouth disease in cattle and Newcastle disease in poultry. Ricardian model concluded that climate change has an economic impact on livestock production at $P < 0.05$. In conclusion, climate change had an impact on livestock production in Chiredzi district as perceived by farmers. Proper livestock adaptation and mitigation strategies to reduce climate change vulnerability are required.

**Keywords:** Climate Change; Communal Livestock Production; Ricardian Regression Model

## Introduction

In Southern Africa agriculture remain the main source of livelihoods for most communal areas [1]. About 65% of the total population is within communal areas and survive solely on agriculture [2]. In addition, it employs 66% of the national labour force [3] contributing about 15% to GDP in Sub Southern Africa [4]. Livestock provides both direct and indirect range of products and services such as food, income, fertilizers, draught power and investment, which help to sustain rural livelihood [5,6]. In sub Saharan Africa 70% of the population is dependent on livestock production [7].

Livestock production covers about 45% of the earth's land area [8]. However, majority of livestock species are being threatened by climate change [9] projected that climate change will have an effect on Southern Africa; affecting agricultural production to include livestock production. It has been projected that from 1970-2004 there has been an increase in temperature by 0.1 - 1°C in parts of South Eastern Zimbabwe. Water availability and runoff in rivers is to decrease by 10 - 30% hence increasing water scarcity [9]. Shift in climatic patterns are likely to cause transition in fodder and forage availability, pests, diseases and physiological functioning of livestock due to altered humidity and ambient temperature [10]. Climate change impacts differ from area to area; hence, need to assess impacts and sensitivity on a finer scale [11]. Moreover, livestock contribute 60% to rural well-being and findings from recent studies focus more on crop farming [12].

## Objective of the Study

The objective of this study was to determine perceived and economic impacts of climate change on communal livestock production. Assessing climate change impacts will assists policy makers to come up with adaptation and mitigation strategies that better complement, reducing climate change vulnerability.

## Materials and Methods

### Study site

The study was conducted in Chiredzi district, located southeast of Zimbabwe occupying a total area of 14 340 km$^2$. The district lies in agro ecological region 5 with an arid index of between 0.2 - 0.5. Mean temperature ranging from 21 - 37ºC and average rainfall of 620 mm or less [13]. Agricultural practice includes a combination of subsistence, cash crop farming and livestock production. Livestock species kept include cattle, sheep, goats and poultry for either commercial animal production or for subsistence farming [14]. Natural veld is mainly identified by savannas dominated by *Colophospermum mopane* woodlands [15].

### Sampling procedure

Purposive sampling was used to select six wards from the sub catchment areas of Save, Runde, Mtirikwi and Mwenezi; one ward was used for pretesting survey questionnaire. This helped to estimate response rate, length of time to complete survey and improving on subject lines. Within wards five villages were sampled. Purposive sampling and snowball sampling were used in selecting farmers who at least owned both goats and cattle. A sample size of 150 famers was used.

### Data collection

Key informant interviews and focus group discussion were done with strategic farmers, local authorities and government institutions. This was to insight on livestock production systems, current climate change impacts and in identifying primary animals. Pretested structured questionnaires were administered to capture information on perceived climate change impacts and effects on livestock production. Summary of climatic patterns for Chiredzi District from 1982 to 2014 was collected from the Metrological Department. District livestock census was obtained from FAOSTAT and ZIMSTAT. Climatic data on rainfall, temperature, sunshine hours and evaporation was used in estimating economic impact of climate change on communal livestock production.

### Data analysis and presentation

Data entry and analysis was done using Microsoft Excel 2010 and IBM SPSS version 20. Qualitative data was categorised, ranked and assigned to quantitative variables. Quantitative data was analysed using non parametric test. An economic impact of climate change on livestock production was measured using the Ricardian model. Ricardian Model was used to establish climate change sensitivity of primary animals which contributed the highest net revenue to farmers within the district (cattle and goats) [5,17]. Livestock data from 1982 to 2014 was converted to cattle and goat net revenue. However, in comparison from [5] evaporation and sunshine hours were included in the model as they have an effect on livestock production.

In the present study the model was expressed as:

$$Y = \beta_0 + \sum[\beta_1 x_1 + \beta_2 x_1^2] + \sum[\beta_3 x_2 + \beta_4 x_2^2] + \sum[\beta_4 x_3 + \beta_5 x_3^2] + \sum[\beta_6 x_4 + \beta_7 x_4^2] + \mu$$

Where:

Y- Livestock net revenue for cattle or goats

$X_1$- Humidity variables

$X_2$- Rainfall variables

$X_3$- Evaporation variables

$X_4$- Sunshine hour's variables

$_o$- Intercept

$_j$- Value of the j$^{th}$ coefficient

- Error term.

## Results and Discussion

### Climatic trends for Chiredzi district from 1982 to 2014

Climatic records for the district showed changes in weather patterns over the 33 year period. Amount of rainfall received from 1982 to 2014 showed fluctuations as shown in figure 1, however, massive decrease in precipitation were experienced after every 2 to 4 years which according to farmers; they referred to as drought years. These results agreed with [18] who reported that in Zimbabwean semi-arid regions droughts are experienced after every 2 to 4 years. Highest annual rainfall (1000 mm) for the district and was since recorded in year 2000. In addition, a positive rainfall trend was experienced for the district from 1982 to 2014. Temperature had a fairly constant trend however; annual fluctuations were experienced (Figure 2). Maximum (24.8°C) and minimum (22°C) temperature was recorded in year 1992 and 1994 respectively.

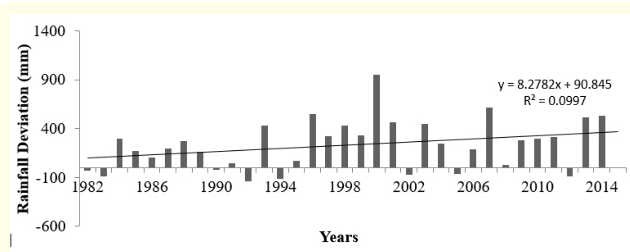


**Figure 1:** Rainfall deviations from mean for Chiredzi district from 1982 to 2014(mm).

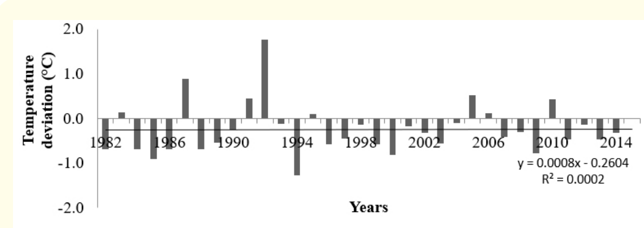


**Figure 2:** Temperature deviations (°C) from mean for Chiredzi district from 1982 to 2014.

### Perceived climate change impacts

Farmers highlighted various effects attributed to climate change. About 84% perceived decrease in occurrences of rainfall events from time of settlement up to present. However, temperature and drought occurrence were perceived to have increased over the past years by 98% and 94% of the respondents respectively. In addition, 66%, 23.3% and 10.7% of the farmers perceived an increase in temperature, erratic rainfall and frequency of droughts, respectively. IPCC predicted temperature increase in South East Zimbabwe of 0.1°C to 1°C. Most Southern African countries have experienced 1°C to 2°C increase in temperature during period of 1970 to 2004 [3]. In Southern Africa precipitation models project that rainfall will decrease leading to drying of water sources. Droughts are expected to increase due to an overall increase in temperature and reduced precipitation [19].

### Farmers perceived climate change impacts on livestock production

Farmers highlighted perceived climate change impacts to directly affect livestock production. Increase in ambient temperatures and concurrent changes in heat exchange cause heat stress which influence growth, reproduction, milk production and animal health and welfare [21].

Perceived climate change impacts on livestock production by farmers are summarised in table 1. Majority of farmers highlighted that climate change has resulted in decrease in grass species and an increase in new shrub species. Less grass species in pastures affect negatively forage availability hence death of livestock due to feed shortages [21]. Forage scarcity results in poor immune response by animals, increasing disease outbreaks and mortalities. Climate change induces changes in niches for grassland species [22], as temperature and carbon dioxide levels change the optimal growth for plant species change altering competition dynamics and composition [23,24] states that increase in carbon dioxide result in increased browse species and will have impact on grazers. Farmers highlighted an increase in drying of water sources; resulting in animals at certain periods of the year travel long distances in search of water. This agrees with and [5] findings on farmer perceived climate change impacts. Death of animals due to heat is due to high temperatures which at some points exceeds upper critical temperature [25] states that body temperature above upper critical zone interferes with homeostasis.

Farmers perceived that during periods of extreme temperatures livestock disease incidence was high (76%) and low (18%) at during heavy rainfall. Increase in temperature has a significant effect on disease causing pathogens and parasites. High temperatures increase development of pathogens in their life cycle reducing generation time [24] and increase in pathogens and parasites forecasts more infections [26].

| Impact | Percentage respondents (%) |
|---|---|
| Less grass in pastures | 92.7 |
| Less shrubs in pastures | 15.4 |
| New grass species | 1.3 |
| New shrub species | 22 |
| Drying of water sources | 93.3 |
| Outbreaks of diseases | 54 |
| Increase in parasite population | 32.7 |
| Death of livestock due to diseases | 34.7 |
| Death of livestock due to heat | 25.3 |
| Death of livestock due to shortage of feed | 84.7 |
| Death of livestock due to lack of drinking water | 44.0 |

**Table 1:** Farmers perceived climate change impacts on livestock production.

In cattle Foot and Mouth disease (FMD) was perceived to have highest incidence rates (40%), followed by Anthrax with lowest incidence rates (5%). Reported, high FMD prevalence rate was due to mixing of livestock and wildlife in veld which are potential carriers [24] states that shifts in ecosystems will results in pasture and water scarcity resulting in mass movement of animals both domestic and wild increasing rate of spreading close contact diseases like FMD. Reported low Anthrax incidence in this present study can be due to quick eradication and effective prevention measures against the highly contagious and zoonotic disease. Incidence can be due to overgrazing, drought and environmental stress that results in exposure of bacterial spores from soil [27].

According to farmers (66%), small ruminants especially goats were mostly affected by Heart water disease. This accedes with [24,28] who reported that high temperatures promote vector distribution due to increased metabolic rate, egg production and reduced mortality resulting in increased feeding frequency. [29] concluded that increase in temperature will increase tick borne disease incidence.

According to farmers' (67%) droughts and feed shortages were the major causes of livestock mortality especially in large stock. Diseases contributed about 20% of mortalities in livestock. High preventive measures taken by farmers including dipping, dosing and vaccinations reduced disease related livestock mortality.

### Economic impacts of climate change on communal livestock production

Ricardian regression was done to measure economic impacts of climate change on livestock production in Chiredzi communal areas. Results show that linear effect of spring sunshine hours and quadratic effect of spring and winter sunshine hours, summer humidity and spring rainfall had significant effect on net revenue ($P \leq 0.05$). Long day length and forage shortages also significantly affect animals as they will spend more time in search of forage compromising energy balance. Increase in day length results in increased exposure of animals to heat stress. In contrast to [5] findings, cattle net revenue was not significantly affected by climate change ($P \geq 0.05$). Goat net revenue was sensitive to linear effect of winter rainfall and quadratic effect of winter rainfall and summer evaporation ($P \leq 0.05$). This was in agreement with [5]. In winter availability of browse and forage is limited due to varied plant physiology. In summer evaporation rates are low due to humid atmosphere these compromise body homeostasis resulting in altered feed intake and feed conversion ratios. In general both goats and cattle were sensitive to climate change. Variables with negative coefficients reflected inverse relationship between climatic variables and net revenue. Increase in temperature and evaporation rates has effects on animal physiological processes to include homeostasis and has direct impacts on animal's production performance [25]. Changes in periods of day light also affect photoperiods; resulting in negative effects on reproductive performance of both cattle and goats [30].

| | Cattle | | Goats | |
|---|---|---|---|---|
| **Variable** | **Coefficient** | **Significance** | **Coefficient** | **Significance** |
| Summer rainfall | -1294.36 | NS | 234121.7 | NS |
| Winter rainfall | -19726.8 | NS | -928990 | * |
| Spring rainfall | -44048.9 | NS | -228622 | NS |
| Summer humidity | -2.78957 | NS | -6.37294 | NS |
| Winter humidity | 204711.4 | NS | 7631601 | NS |
| Spring humidity | -7.85697 | NS | -15.5555 | NS |
| Summer evaporation | -8152.75 | NS | -2462724 | * |
| Winter evaporation | 1573.209 | NS | 2234673 | NS |
| Spring evaporation | -4529.12 | NS | -1550004 | NS |
| Summer sunshine hours | 75029.77 | NS | 1411327 | NS |
| Winter sunshine hours | 4.876217 | NS | 7.712739 | NS |
| Spring sunshine hours | 555983.3 | ** | 3152064 | NS |
| Summer rainfall$^2$ | 47.20178 | NS | -283.761 | NS |
| Winter rainfall$^2$ | 661.1297 | NS | 26545.44 | * |
| Spring rainfall$^2$ | 1581.14 | * | 12241.15 | NS |
| Summer humidity$^2$ | -1343.19 | ** | -15769.6 | NS |
| Winter humidity$^2$ | -1845.76 | NS | -58835.8 | NS |
| Spring humidity$^2$ | -363.754 | NS | -10832.1 | NS |
| Summer evaporation$^2$ | 11.7922 | NS | 5567.825 | NS |
| Winter evaporation$^2$ | -38.5742 | NS | -9994.71 | NS |
| Spring evaporation$^2$ | -63.7818 | NS | 3217.913 | NS |
| Summer Sunshine hours$^2$ | -159.918 | NS | -1970.29 | NS |
| Winter Sunshine hours$^2$ | -31.9013 | * | -464.334 | NS |
| Spring Sunshine hours$^2$ | -1058.89 | ** | -5515.39 | NS |

**Table 2:** Ricardian regression parameter estimates.

*P < 0.05, **P < 0.01, ***P < 0.001.

## Conclusion

The study showed that climate change has posed threats to livestock production in Chiredzi communal areas. Climate change has resulted in decreased forage availability and natural water sources, an increase in ambient temperatures and outbreak of climate influenced diseases as perceived by farmers. Climate change has shown to have an economic impact on livestock production in Chiredzi district. Cattle and goat production are sensitive to climatic variability in the district. In conclusion, livestock production in Chiredzi district is sensitive to climate and they are predicted impacts by farmers; hence, an impact of climate changes on livestock production. Further changes in climatic patterns will result in the reduction of livestock productivity. Farmers need to come up with adaptation options to reduce their vulnerability to the perceived and economic impacts of climate change.

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