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Climate Change-Related Hazards and Livestock Industry Performance in (Peri-)Urban Areas: A Case of the City of Masvingo, Zimbabwe

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Abstract: In an effort to improve their quality of life and battle poverty, many urban residents are turning to agriculture as an alternative source of income, employment, and food security. However, climate-related hazards such as heatwaves, floods, and droughts have had an effect on urban agriculture. The purpose of this study was to determine how climate change-related hazards affected the urban livestock industry in Masvingo City. These researchers administered a structured questionnaire on urban livestock farmers, the results of which were triangulated with in-depth interviews with livestock stakeholders. The results show that the urban livestock industry is significantly impacted by climate-related hazards. Farmers lose livestock to diseases, poor pastures, and extreme weather conditions. Furthermore, the hazards badly affect the storage and distribution of livestock products, the labour supply and productivity, and the profitability of livestock enterprises. This study contributes to the body of knowledge on the urban livestock industry and climate change-related hazards. The results are significant to policy makers and livestock stakeholders to understand climate change effects on the urban livestock sector so as to formulate mitigation, adaptation, and coping strategies against any adverse effects. This paper is a foundation for future studies and these researchers suggest that future studies be on location-specific adaptation strategies.

Keywords: climate change; hazards; urban farming; peri-urban farming; livestock

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1. Introduction

As urban populations have grown, peri-urban and urban agriculture has drawn more attention globally as a potential area for developmental interventions. Many urban dwellers are turning to agriculture as a source of alternative income, employment, and increased food security as they strive to improve their quality of life and fight poverty, which affects the majority of urban people in sub-Saharan Africa [1]. Scientific data predict that by 2050, 68 percent of the world's population, up from the present 55 percent, will live in urban areas [2,3]. The urban population in sub-Saharan Africa was 41.25 percent in 2020, with anticipated percentage increases of 3.9 and 4.2 in 2023 and 2024, respectively. Similarly, Zimbabwe's urban population increased by 0.19% in 2020 and was expected to reach 32.3% by 2021 [4]. The United Nations Sustainable Development Goal (SDG) 2, which aims to eradicate hunger, achieve food security, and improve nutrition, is likely going to be affected by this rapid population expansion [5]. To meet the need for a high standard of living and food security in the future, an increase in agricultural productivity is a requirement.

Urban and peri-urban agriculture plays an important role in supplying food to city residents. Climate change, however, may destabilize agricultural productivity and increase risks for investment in urban agriculture. The recent droughts, floods, and infrastructural damage have brought the phenomenon of climate change to wider public awareness. Global population expansion, migration, fast urbanization, and increased inequality have

all exacerbated the risks caused by climate change-related hazards [6]. The impact of climate change also depends on whether these storms, floods, or droughts overlap with other hazards such as COVID-19, in addition to the social, political, and economic conditions of the country [7]. Climate change-related hazards also affect livestock production.

Many of the world's poorest people largely depend on livestock for their livelihoods. Livestock provides urban households access to food and acts as a source of alternative income. The economy of Zimbabwe is highly dependent on livestock and livestock products. Demand for animal-sourced protein has significantly increased worldwide [8]. Consequently, in an effort to match this rising demand for animal-sourced proteins, animal production must increase in the coming years.

The majority of studies on the effects of climate change on urban agriculture have concentrated only on primary crop production [9], ignoring livestock production and the entire subsequent stages in the whole supply chain [10]. Furthermore, there has not been direct research on how these climate change-related hazards affect Zimbabwe's urban livestock business. This study's objective was to fill this knowledge gap by examining the impact of hazards brought by climate change on livestock production in the Zimbabwean city of Masvingo.

The rest of this paper is organised as follows: Section 2 presents a review pertaining to the influence of climate change-induced hazards on livestock farming operations. Section 3 is the methodology section, and Section 4 presents the results and discussions of the results. The last section concludes and summarises the findings of this study and gives recommendations for future studies.

2. Literature Review

2.1. Urban Livestock Production

Urban agriculture (UA) is the practice of agriculture in peri-urban and urban areas and can take the form of the cultivation of crops, livestock rearing, and other practices to produce agricultural products [11]. Some scholars have also defined UA as the process of producing, processing, and distributing agricultural products in urban or peri-urban areas [11,12].

Based on its location, urban agriculture (UA) can be categorized into three types: farming performed on plots around houses, farming performed in public open spaces, utility-service areas, and agricultural allotments, and the raising of crops and livestock outside the city boundaries [13]. However, it must be noted that most farmers practice mixed farming systems in which farmers produce both livestock and crops. For example, some livestock farmers produce fodder crops as well as other crops whose residues act as feed for the livestock. For the purpose of this study, livestock includes beef and dairy cattle, pigs, sheep, goats, poultry, mules, asses, and beekeeping.

2.2. Climate Change-Related Hazards

Climate change encompasses a variety of complex effects on the climate, including physical traits, underlying causes, and outcomes [11]. Some scholars equate climate change to global warming. Therefore, climate change is defined as the global phenomenon of a climate transformation/shift characterized by lengthy variations in the usual and normal climate of the planet with regard to temperature, precipitation, and wind, among others, especially those caused by human activities. The shift in the weather pattern of the earth puts the natural ecosystem under threat [12]. Climate change is characterized by extreme hazardous phenomena such as droughts, storms, floods, heat waves, and wildfires. Drought is a prolonged period of environmental stress, characterized by periods of low rainfall during the agricultural season. The number of people exposed to droughts across the world is predicted to double in less than 80 years [11]. Heatwaves are prolonged extreme temperatures across a wide geographical area. Climate change causes heat stress and extreme weather events to occur more frequently. One of the deadliest and most often occurring climatic extremes with overlapping hazards is heatwaves. During the COVID-19

pandemic, about 431.7 million people around the world were exposed to high heat [7]. The livestock industry will be particularly impacted by these climate change-related hazards.

2.3. Climate Change-Induced Hazards and Livestock Production

Climate change-induced hazards affect livestock production throughout the whole industry, from primary production to processing, storage, distribution, marketing, and finally, consumption in a number of ways.

2.3.1. Quantity and Quality of Livestock Output

Climate change affects livestock farmer output through several pathways. There have been studies that have focused on the effects of climate change-related hazards on livestock health, production, and reproduction. Climate change has increased animal mortality rates during extreme weather situations. Reference [14] describes how climate change-related hazards directly or indirectly affect animal health and welfare. At extremely high temperatures, livestock liveweight gain, milk yield, and fertility are negatively affected. The healthy status of livestock is affected directly through increased temperatures and heat waves and subsequently by reducing the supply and quality of feeds and water, as well as through disease outbreaks. There is also increasing evidence that hot weather conditions disrupt several reproductive processes [15]. Heat stress has reduced growth, decreased meat quality, and increased mortality in the pork industry [16,17].

In warmer regions, poor forage quality due to drought-affected grass growth reduces animal growth, fertility rates, and feed conversion rates. The amount of milk produced significantly declines as temperature and humidity rise [18]. Increases in temperatures in Nepal have reduced the number of Cattle, whilst, for the same reason, milk production in West Africa and China has declined [19]. The extent to which climate change has affected livestock output in Zimbabwe is scantly documented.

2.3.2. Profitability of Livestock Production

Climate change impacts production costs. Decreases in fodder production and grain from dry land and irrigated pastures result in higher feed costs. Illustratively, the costs of the inputs used by dairy farms, such as feed, fuel, and energy, will change due to climatic change events such as rising temperatures, droughts, and cyclones [20]. This was supported by [19] who found that extreme temperatures had economic costs and predicted that livestock farmers will face financial losses that range between USD 15 and 40 billion annually. Both studies showed that the dairy business will incur higher costs as a result of climate change-related hazards, thereby reducing farmers' profits. The degree to which agricultural output and energy prices respond to climate change will determine how much livestock farmers are impacted.

2.3.3. Storage of Livestock Produce

Heat stress is likely to have an impact on perishable products for urban farmers who sell fresh produce. Storage conditions get worsened as the temperature increases, which impacts products' storage life. Temperature management (air conditioning and refrigeration) can help to lessen some of the negative effects of climate change on agricultural delivery and production, to sustain the required shelf lives. However, this leads to higher energy bills and decreased usage of fresh produce. As a result, rising temperatures can lead to contamination and spoilage. Ref. [21] also discussed climate change as a contributor to increased biological and insect pest damage to agricultural produce during storage.

2.3.4. Distribution of Livestock Produce

The livestock industry can be affected by climate change anywhere along the supply chain, from farm production to human consumption. Extreme weather events can also damage major transportation infrastructure (road, rail, and ports), thereby restricting the distribution of products and increasing the costs of moving people and goods. For example,

in the United States, Ref. [22] observed that the Mississippi River basin, a significant route for global agricultural exports, was severely impacted by the extreme summer drought of 2012, resulting in substantial food shortages and other economic losses due to a decrease in ship traffic and the number of products carried. In the spring of 2013, there was flooding throughout the Mississippi river, which affected ship movements, thereby affecting food transportation.

2.3.5. Human Labour Productivity

Reduced economic production, especially for informal workers, is a result of climate change's effects on both labour supply and productivity [23], because those who are under a lot of heat stress take longer breaks and need more water to cool off. This is done to prevent death or long-term health problems from heat stress [24]. When workers face extreme heat stress, performance during working hours is lower because they take relatively more breaks than when working under expected good temperatures. Dehydration and high body temperature can also lead to more errors being made, which can lead to more accidents [25]. Due to increased urbanization and population density, there are now hotspots inside cities, increasing the risks that workers must cope with. The effects of heat stress are geographically and industrially unequally spread, with Southern Asia and Western Africa predicted to be the worst-affected regions in their agricultural sectors [26].

3. Materials and Methods

These researchers used a descriptive research approach because it aids in identifying the most important components of the issue being investigated [27]. The study relied on questionnaires (see Appendix A) with 159 livestock farmers randomly sampled from an estimated population of 270 regular farmers in the City of Masvingo. Masvingo city was preferred as it is one of the cities in Zimbabwe where livestock production is the most predominant activity among farmers. The questionnaires were triangulated with semi-structured interviews (see Appendix B) with 16 urban livestock stakeholders (supermarket managers, butcheries, livestock and veterinary officers, dairy officers, and consumers) to ensure the reliability of the research instruments. Interview participants were purposively sampled by intentionally selecting specific stakeholders whom the researchers knew to have experience in the livestock business, a characteristic that was needed to answer the research question. The researchers had a detailed discussion with livestock experts about their perceptions of and experiences with climate change. Interviews enable clarity on hidden views that cannot be solicited on questionnaires and provide richer data that are used to generate themes [28]. The researchers used the participants' validation to ensure the validity of the in-depth interviews and, hence, the credibility of the results [29]. Consent for voluntary participation was obtained through a signed letter of consent by the respondents, as the findings of the research will be publicized for academic purposes [28]. The study respondents and participants were informed of their right to pull out of the study without giving reasons if they no longer felt comfortable with the proceedings of the study. To ensure the validity of the questionnaire, the researchers used the Cronbach alpha test, obtaining a coefficient of 0.84—a value greater than 0.70, which is considered satisfactory for a reliable research instrument [30]. Descriptive and inferential statistics were used to analyse the quantitative data, and the results were reported in tables. The study used a regression analysis model to predict the impact of climate change-related hazards on livestock production performance, so as to make judgments on future urban livestock production activities and influence policy. The climate change-related hazard index variable used was the average of the different variables that measure climate change-induced hazards. Livestock production performance is a variable constructed by averaging Likert-scale responses on the decline in the number of livestock raised; poor health and welfare of livestock; reduced pasture productivity; reduced quality of livestock products; increase in incidents of livestock deaths; difficulty in transport and distribution of livestock products. Since discrete data with many categories were used, a robustness check was

conducted using OLOGIT and OPROBIT regression analyses, where particular fundamental regression coefficient estimates were evaluated to see how they changed when the regression specification was altered by adding or removing regressors. The qualitative data were thematically analysed in NVivo software and presented in vignettes.

Study Area

The study was delimited to the Masvingo urban area located in Masvingo province. Masvingo province is located in agro-ecological regions 3, 4, and 5. Masvingo city is classified as being in agro-ecological regions 4 and 5, which are drought-prone areas, and was therefore dedicated to livestock production [31]. As temperature patterns point to an uptick and warmer winters, rainfall trends in Masvingo province show a decline over time [32]. A map of Zimbabwe showing the position of Masvingo province and the City of Masvingo is shown in Figure 1 (yellow colour).

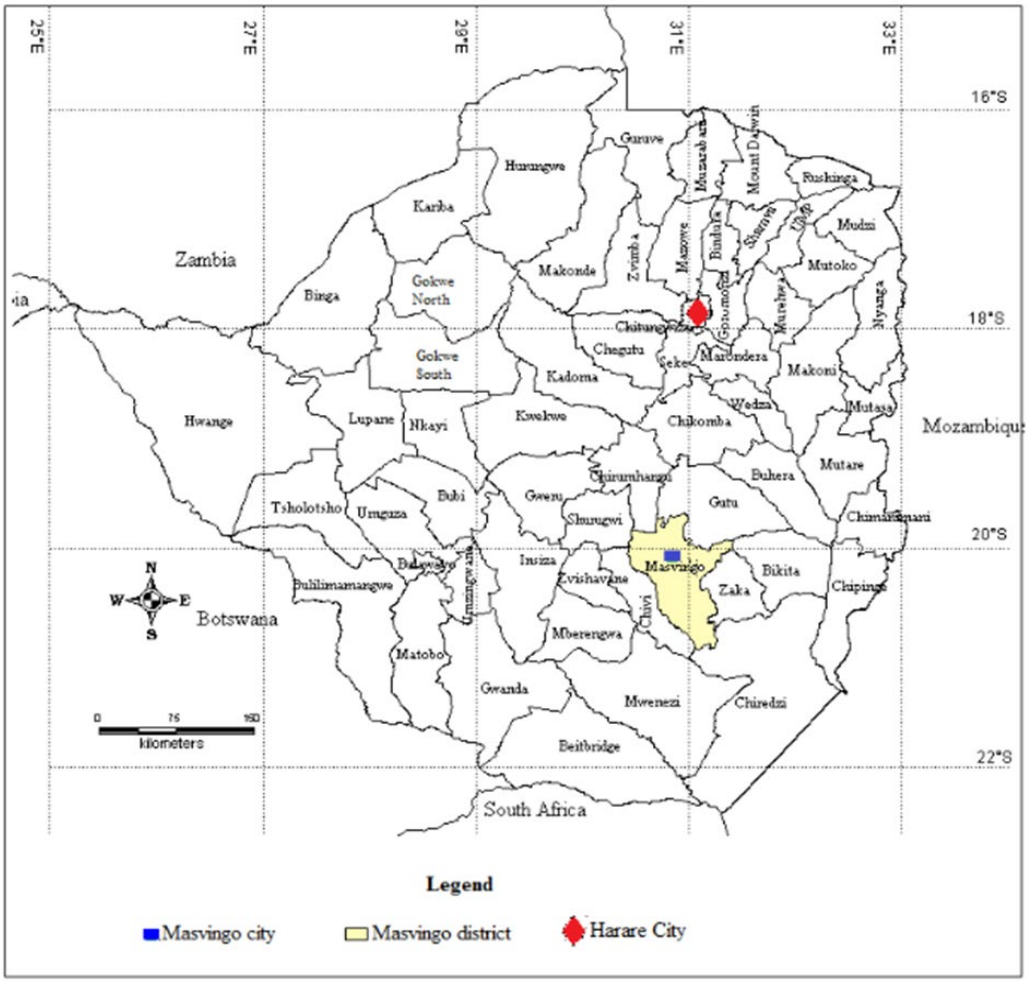

Figure 1. Map of Zimbabwe showing the City of Masvingo [31].

4. Results and Discussion

This section presents the results and discussions on the impact of climate change-induced hazards on peri-urban livestock farming operations in the City of Masvingo.

4.1. Demographic Characteristics

The study discusses demographic data in terms of gender, age, level of education, experience in livestock production, and income of farmers. The results are presented in Table 1.

Table 1. Demographic characteristics of urban livestock farmers.

Demographic Variable	Variable	Frequency	Percentage
Gender:	Male	104	67.10
	Female	51	32.90
Age:	18 ≤ age ≤ 30	06	03.87
	31 ≤ age ≤ 45	37	23.87
	46 ≤ age ≤ 59	72	46.45
	Age ≥ 60	40	25.81
Level of education:	Primary/secondary education	33	21.29
	Diploma	64	41.29
	Degree	58	37.42
Experience in livestock farming:	0 ≤ years ≤ 5	21	13.55
	6 ≤ years ≤ 15	56	36.13
	Years ≥ 16	78	50.32
Income (USD)	0.00 ≤ Income ≤ 200	94	60.65
	201 ≤ Income ≤ 500	32	20.65
	Income ≥ 501	29	18.70

Table 1 reveals that there are more male-headed households that participate in urban livestock production than those headed by women. Specifically, 67.1% of the households are male-headed versus 32.9% of the households that are headed by women. Furthermore, the table shows that the respondents who are engaged in livestock production are relatively senior people in the age ranges of 46 ≤ age ≤ 59 (46.45%) and age ≥ 60 (25.82%). The findings illustrate that most of the livestock farmers are highly educated, with those holding diplomas (41.29%), and 37.42% have at least a first degree. This agrees with the high literacy level in Zimbabwe. The results from the table also indicate that a majority of the farmers (50.32%) have reared livestock for at least 16 years and are therefore considered to be experienced. On the other hand, 13.55% of farmers had no more than 5 years of experience, while 36.13% had 6 to 15 years of experience. Taking the above results, it is evident that the sample included respondents with many years of experience in livestock rearing. Considering the alternative incomes of the respondents, the results in the table show that a larger proportion of respondents (60.65%) in the sample are in the lower-income bracket (0.00 ≤ income (USD) ≤ 200), while 18.7% earn more than USD 500.

4.2. The Impact of Climate Change-Induced Hazards on Livestock Production in the City of Masvingo

A climate change index variable was used as the main independent variable. It is the average of the different variables that measure climate change-induced hazards. Since measurement error in the constituent variables is cancelled out when using index variables, the impact of climate change-induced hazards is better measured. Likewise, livestock production performance is a variable constructed by averaging Likert-scale responses on the decline in the number of livestock raised; poor health and welfare of livestock; reduced pasture productivity; reduced quality of livestock products; increase in incidents of livestock deaths; difficulty in transport and distribution of livestock products. In computing inferential statistics on the impact of climate change-induced hazards, the researchers considered the demographic variables of the respondent characteristics of livestock farmers as the control variables. It can be noted that the respondent characteristics and demographic data may affect the performance of (peri-)urban livestock farming, hence the need to isolate their effects [29]. The researchers had to control for the influence of gender, age, experience, level of education, or income of farmers. Therefore, the results for these variables are presented in Table 2 but are not analysed or discussed [29].

Table 2. OLS, OLOGIT, and OPROBIT estimates: The impact of climate change on the performance of (peri-)urban livestock business in the City of Masvingo, Zimbabwe.

	OLS	**OLOGIT**	**OPROBIT**
Variables	(I)	(II)	(III)
Climate change index	0.364 *** (0.325)	2.765 *** (0.420)	3.856 *** (0.287)
Male	0.365 *** (0.207)	1.258 *** (0.438)	0.862 *** (0.248)
18 ≤ age ≤ 30	−0.1431 (0.439)	0.0732 (0.912)	−0.0316 (0.362)
31≤ age ≤45	−0.191 (0.782)	−0.305 (0.645)	−0.217 (0.702)
46 ≤ age ≤ 59	0.765 (0.308)	0.822 (0.723)	0.461 (0.846)
Age ≥ 60	0.455 ** (0.375)	1.224 *** (0.768)	1.029 *** (0.219)
O Level	0.0425 (0.314)	0.832 (1.447)	0.245 (0.659)
Diploma	0.168 (0.601)	0.713 (1.291)	0.615 (0.285)
Degree	0.129 (0.624)	0.553 (1.838)	0.891 (0.479)
0 ≤ years ≤ 5	0.351 (0.136)	0.518 (1.227)	0.644 (0.664)
6 ≤ years ≤ 15	−0.226 * (0.272)	−1.279 * (1.083)	−1.042 * (0.691)
Years ≥ 16	−0.562 *	−1.029 *	−1.032 *
	(0.519)	(1.026)	(0.258)
USD 0.00 ≤ Income ≤ 200	−0.167	−0.621	−0.518
	(0.476)	(1.014)	(0.857)
USD 2.01 ≤ Income ≤ 500	−0.274	−1.046	−1.028
	(0.382)	(1.013)	(0.431)
Income ≥ USD 501	0.359	1.371	1.057
	(0.417)	(1.836)	(0.581)
Constant Cut1		12.53 *** (2.191)	11.34 *** (2.527)
Constant Cut2		17.64 *** (4.682)	18.05 *** (2.448)
Constant	0.395 (0.428)		
Observations R-squared	155 0.426	155 0.2825	155 0.2926

Robust standard errors in parentheses. *** $p < 0.01$ (significant at 1%), ** $p < 0.05$ (significant at 5%), * $p < 0.1$ (significant at 10%). Cut1 and Cut2 are the estimates of the cut-points of Mean 1 and Mean 2. The "cut-point" coefficients reflect the expected ratios of cases across the "cut-points" in the distribution of the dependent variable when all the independent variables are zero.

The results presented in Table 2, columns (I), (II), and (III), indicate that climate change-induced hazards have significantly influenced urban livestock production activities in the city of Masvingo. When the climate change-induced disaster index increased by one unit, the livestock production decreased by 0.364 units, holding all other factors constant. The *p*-values for the climate change-induced hazard index in the OLS, OLOGIT and OPROBIT models are smaller than 0.01, implying a statistically significant impact at a 1% level of significance. This implies that if climate change-induced hazards continue to increase without specific adaptation strategies, many urban household livelihoods will be affected

negatively. These results are consistent with previous studies. For example, increases in temperatures in Nepal reduced the number of cattle, whilst, for the same reason, milk production in West Africa and China has also declined [33]. This result further concurs with a previous study by [22], which revealed climate change-induced hazards disrupted the shipping of agricultural products.

The study triangulated the questionnaire instrument results with the interview results of the livestock stakeholders. The triangulation process proved that there was a significant corroboration of the results. The interviews with key informants revealed that livestock production has suffered major drawbacks due to droughts, heat stress, animal diseases, and pests. The interview results confirm the themes from the literature review, which showed that livestock production has suffered from climate change-induced hazards. These themes are primary production, storage, transport and distribution, and profitability.

The interviews with key informants revealed that climate change affects livestock farmer output through several pathways. Due to the impact of climate change, water levels in dams, rivers, and boreholes have been very low. More so, the study confirms that Masvingo urban farmers who rely on artificial water bodies have suffered competition for water supply with industrial and domestic use. This was illustrated by one veterinary doctor who said:

> "There have been negative effects of climate change on livestock production, especially beef and dairy cattle farming. Due to recurrent droughts, there has been poor quality or shortage of feed and water supply, resulting in starvation and malnutrition. Urban farmers have also reported massive deaths of cattle due to animal disease and pest outbreak as climate change sometimes brings more extreme wet and warmer conducive environments for disease and pest outbreaks. This and last year we lost many of our cattle to January disease (Theileriosis), a tick-bone common warm rainy weather." (Veterinary Doctor, 15 June 2022)

This was further confirmed by a veterinary officer who lamented huge losses in broiler chickens by farmers.

> "When we experience very high temperature, which has now become common with climate change, it affects the size and weight of broiler chickens and sometimes many of them die hence reducing the profit attainable." (Veterinary Officer, 17 June 2022)

In other instances, livestock experts reported a massive decline in milk productivity. One informant said:

> "We used to have enough rainfall in the past. However, our milk production has been reduced since we started experiencing these heat waves, droughts and erratic weather patterns. Climate change has affected the quality of grass for our dairy cows to graze. Climate change has made Masvingo city extremely hot or cold depending on the time of year, and these conditions are not conducive for pasture growth. Sometimes we get intense rain over a few days rather than steady rain events across a season making the rain not sufficient for pasture growth." (Dairy Officer, 01 July 2022)

These results support the results in the literature showing that hot weather conditions have disrupted several reproductive processes [17]. Heat stress has also reduced growth, decreased meat quality, and increased mortality in the pork industry [16]. This was further corroborated by [15], who established that hot environments strongly and negatively affect the quantity and quality of animal milk and meat production.

The results from the interviews also show that the livestock industry can be affected by climate change through interference with distribution from farm production for human consumption. Climate change has increased the frequency and intensity of floods, storms, and cyclones, which the participants confirmed as threats to road transport infrastructure.

Damaged and flooded roads restrict the distribution of products and increase the costs of repairing vehicles.

> "The recent cyclone Idai have left us with no roads. They were washed away by the heavy rains, making them impassable. This situation is further exacerbated by our already weak transportation infrastructure. It was difficult for farmers to transport their livestock and livestock products." (Local Supermarket Manager, 17 June 2022)

Key informants also revealed that the storage conditions for milk, beef, and other meat products have worsened as temperatures increase, reducing the product storage life. Some have tried to mitigate these adverse effects by refrigeration to sustain the required shelf lives. However, this has resulted in increased energy costs and utilization. The incessant rains that also come with climate change have been confirmed as a threat to the storage and preservation of livestock products.

> "Increasing temperatures have contributed to spoilage and contamination of milk and meat. Sometimes the extended humid weather can have equally bad effects. There are some people who rely on drying meat for preservation. The meat will be difficult to dry in incessant rains that accompany the now common cyclones"

This result supports the findings of [21], who also discussed climate change as a contributor to increased biological and insect pest damage to agriculture produce during storage.

Further, the results from interviews suggest that climate change-induced hazards, such as excessive heat, effects both labour supply and productivity.

> "Temperatures have generally been increasing. It is not good for farmers to stand in the heat for too long. Due to heat exhaustion farmers often experience headache, nausea, dizziness, weakness, irritability, confusion, thirst, and heavy sweating, our local knowledge has confirmed. Herd boys sometimes fall asleep leaving cattle and goats to go astray. There have been reports of farmers who lose livestock this way." (Farmer, 13 June 2022)

Ref. [23] also found that climate change-related hazards have had an effect on the labour supply by changing the time allotted to labour beyond a given point, especially in environments where workers are highly exposed to climatic elements, such as in the agriculture sector. Climate change affects labour productivity because workers who are under acute heat stress have reduced work rates and require longer breaks to refresh and cool off.

The results from the agricultural experts reveal that, due to climate change, farmers have experienced changes in costs and revenue from raising livestock and processing livestock products. Livestock stakeholders have incurred more costs as they try to mitigate the effects of climate change-related hazards. These changes in farm income and expenditures have had a significant impact on their enterprises' profitability.

> "Natural hazards increase financial losses and costs due to higher fodder expenses, while at the same time reduce farm revenue leaving farmers with reduced profits. Farmers have also sold their livestock for a 'song' as their herds succumb to drought." (Butchery Owner, 12 June 2022)

This was also reiterated by an Agriculture Extension Officer with the excerpt below:

> "We have short-term drought effects including increases in crop and forage prices that results in decreased live cattle prices as farmers are induced by droughts to liquidate their beef cattle herd. Crop and forage price increases will in the long-run indirectly force farmers to reduce livestock inventory, leading to fewer animals moving through the meat supply chain and increased livestock prices". (Agriculture Extension Officer, 28 June 2022)

The results confirm the quantitative results in Table 2, showing that urban livestock production in Masvingo city has been significantly and negatively influenced by climate

change-induced hazards. These results are in line with findings from earlier research that indicated increases in the costs of inputs due to climate hazards [19,20].

5. Conclusions and Recommendations

This study sought to examine the effects of hazards brought on by climate change on the livestock value chain in the Zimbabwean city of Masvingo. Based on the above findings, this study concludes that livestock farmers in the City of Masvingo are vulnerable to climate change-induced hazards. Based on the findings, it is evident that livestock farming in urban and peri-urban areas of Masvingo has been significantly affected by climate change-induced hazards, which include drought, shifts in the rainy season and floods, crop and livestock pests and diseases, and heatwaves. This has resulted in farmers losing their livestock to diseases and poor pastures. Farmers have also destocked because they have been faced with extreme weather conditions. These hazards have also badly affected the storage, transport, and distribution of livestock products. Furthermore, the hazards have reduced labour supply and productivity and the profitability of the whole livestock enterprise.

This research contributes to the body of literature on the impact of climate change on urban livestock business. While climate change effects are highly localised, the findings of this study can still provide additional insights into similar situations across cities in sub-Saharan Africa. The results of this paper are of significance to policy makers and donor communities to understand the climate change effects on urban livestock production so as to formulate mitigation, adaptation, and coping strategies against any adverse effects. This publication establishes a foundation for further research, and these researchers propose additional research on location-specific adaptation strategies. In addition to non-farming activities, stakeholders must take into account strategies that provide green infrastructure, strengthen grey infrastructure's resilience, provide fodder banks, and relocate cattle to better pastures.

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Appendix A

Questionnaire with urban livestock farmers.
Section A: Demographic Data.

1. Gender.

Male	01
Female	02

2. Indicate your age group.

$18 \leq$ age ≤ 30 years	01
$31 \leq$ age ≤ 45 years	02
$46 \leq$ age ≤ 59 years	03
Age ≥ 60 years	04

3. Education Level.

O Level	01
Diploma	02
Degree	03

4. Income per month outside agriculture.

USD 0.00 $\leq$ Income $\leq$ 200	01
USD 201 $\leq$ Income $\leq$ 500	02
Income $\geq$ USD 501	03

5. Experience of farming in urban area.

0 $\leq$ years $\leq$ 5	01
6 $\leq$ years $\leq$ 15	02
Years $\geq$ 16	03

6. Climate change-induced hazards.

Instructions: Please indicate the extent to which you agree or disagree that the following hazards affect urban livestock farming by placing a check mark in the appropriate box. 1—"Strongly disagree" (SD); 2—"Disagree" (D); 3—"Uncertain" (U); 4—"Agree" (A); 5—"Strongly agree" (SA).

Section B: Climate Change-Induced Hazards	**SD**	**D**	**U**	**A**	**SA**
6.1 Droughts	1	2	3	4	5
6.2 Animal Diseases	1	2	3	4	5
6.3 Pest outbreaks	1	2	3	4	5
6.4 Incessant rains	1	2	3	4	5
6.5 Floods	1	2	3	4	5
6.6 Cyclones	1	2	3	4	5
6.7 Heat waves	1	2	3	4	5
6.8 Human diseases	1	2	3	4	5

7. Indicate how the following aspects of (peri-)urban livestock business have been affected by climate change.

Section C: Livestock Business	**SD**	**D**	**U**	**A**	**SA**
7.1 There has been decline in the number of livestock you raised over the years	1	2	3	4	5
7.2 There has been an increase in poor health and welfare of livestock over the past years	1	2	3	4	5
7.3 There has been reduced natural pasture productivity over the past years	1	2	3	4	5
7.4 There has been reduced quality of livestock products in the past years	1	2	3	4	5
7.5 There has been increased of incidents of livestock deaths over the past years	1	2	3	4	5
7.6 There has become difficult and costly distribution of livestock products over the past years	1	2	3	4	5
7.7 Extreme weather conditions have negatively affected livestock products storage	1	2	3	4	5
7.8 Extreme weather conditions have reduced labour productivity	1	2	3	4	5
7.9 Climate Change have negatively affected profitability of livestock production business	1	2	3	4	5

Appendix B

Interview Schedule
Interview with (peri-)urban livestock stakeholders
Questions
Impact of climate change-induced disaster risks on (peri-) urban livestock production activities
1. How have climate change-induced hazards affected feed supply in peri-urban areas?
2. How have climate change-induced hazards affected the quality of livestock produce in peri-urban areas?
3. To what extent have climate change-induced hazards affected the distribution of livestock products in peri-urban areas?
4. To what extent have climate change-induced hazards affected the storage of livestock products in peri-urban areas?
5. To what extent have climate change-induced hazards affected labour performance in livestock production in peri-urban areas?

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