Effects of Climate Change on livestock production and available alternatives in Rwanda. A review

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Abstract: Globally, little research has been done on the effects of climate change on livestock production. Climate change and its negative impacts are the most important threats to the global functions of life. Climate change threatens biodiversity and ecosystem functions in both natural and agroecological zones as more living organisms (plants, fungi, microorganisms, and animals) are not able to cope with the gradual, rapid changes in temperatures and moisture gradients caused by global warming or cooling depending on the given geographical zone of the globe. The current review aims to summarize the effects of climate change on Rwandan livestock production. This information is critical for identifying climate change threats and the factors that accelerate hazards and increase risks, alerting all stakeholders and actors to the need for long-term climate change adaptation, mitigation, and investment in convectional livestock alternatives for current and future generations.

Keywords: Rwanda, Climate change, Livestock, Biodiversity loss

1. Introduction

Globally, the livestock sector is a pillar of the global food system, which has basic importance in poverty reduction, food security, and agricultural development (FAO, 2022). According to Steinfeld et al. 2006), livestock systems represent 30% of the terrestrial surface area on the planet, with a significant income of about $1.4 trillion. The livestock sector is increasingly organized in long market chains that employ at least 1.3 billion people globally and directly support the livelihoods of 600 million poor smallholder farmers in the developing world (Steinfeld et al., 2006; WB, 2022). The milk, meat, eggs, oil, and related animal derivatives like manures, medicinal products, cloths, and other items produced by farm animals provide much of what humans need with regular cash incomes.

With the current population's exponential growth, the farming land decreases and the livestock rearing becomes more difficult; this results in an extreme price increase for meat, milk, eggs, and all other farm animal-related products that are not affordable to lower-level communities (Turyasingura & Chavula, 2022b), which has led to food deficiency and malnutrition in different parts of the world.

In 2018, an estimated 69 billion chickens; 1.5 billion pigs; 656 million turkeys; 574 million sheep; 479 million goats; and 302 million cattle were killed for meat production (Hannah & Max, 2019). Global meat production was 340 million tons in 2018, with global consumption of 43 kg per person per year in 2014 (Hannah & Max, 2019). Due to these factors, the growth in global meat consumption is projected to increase by 14% by 2030 compared to 2018-2020 (FAO, 2018–2022). At the same time, it is projected that as the world warms, climate and weather variability will increase, which will have a significant consequence for humans and all living organisms by increasing the frequencies of heat stress, drought, and flooding events (IPCC, 2012).

This could also be the main challenge in the production of stable meat. According to Turyasingura et al. (2022), climate change has many elements, affecting biological ecosystems in different ways. Although the considerable climate change impacts on human and plant health have been widely studied, very limited studies have been conducted locally or internationally to understand the impact of climate change on livestock and livestock products. So, this review aims to summarize the impacts of climate change on livestock production in Rwanda.

2. Background of agriculture and livestock production in Rwanda

Located in East Africa, Rwanda is a small country with a current population of 13,626,507 living on a 26,338 km2 area, which is represented by a population density of more than 525 per km2 (Worldometer, 2022). The country's landscape is mostly grassy uplands and hills; relief is mountainous, and the climate has two rainy seasons (February to April and November to January), which is remarkable for the ecosystem's flora and fauna species diversity and composition. Agriculture is a major economic sector in the

Rwandan community; more than 90% of the population is dependent on agriculture, and about 70% of the total population is employed by this sector (RDB, 2022). Livestock plays a big role in Rwanda's agricultural inputs and is a crucial factor in the country's economy and food system. As at the global level, Rwandan livestock is dominated by diverse livestock types, where poultry, cattle (beef), pigs, sheep, and goats, to a lesser extent, are more raised (Figures 1 and 2) and consumed (Hannah & Max, 2019).
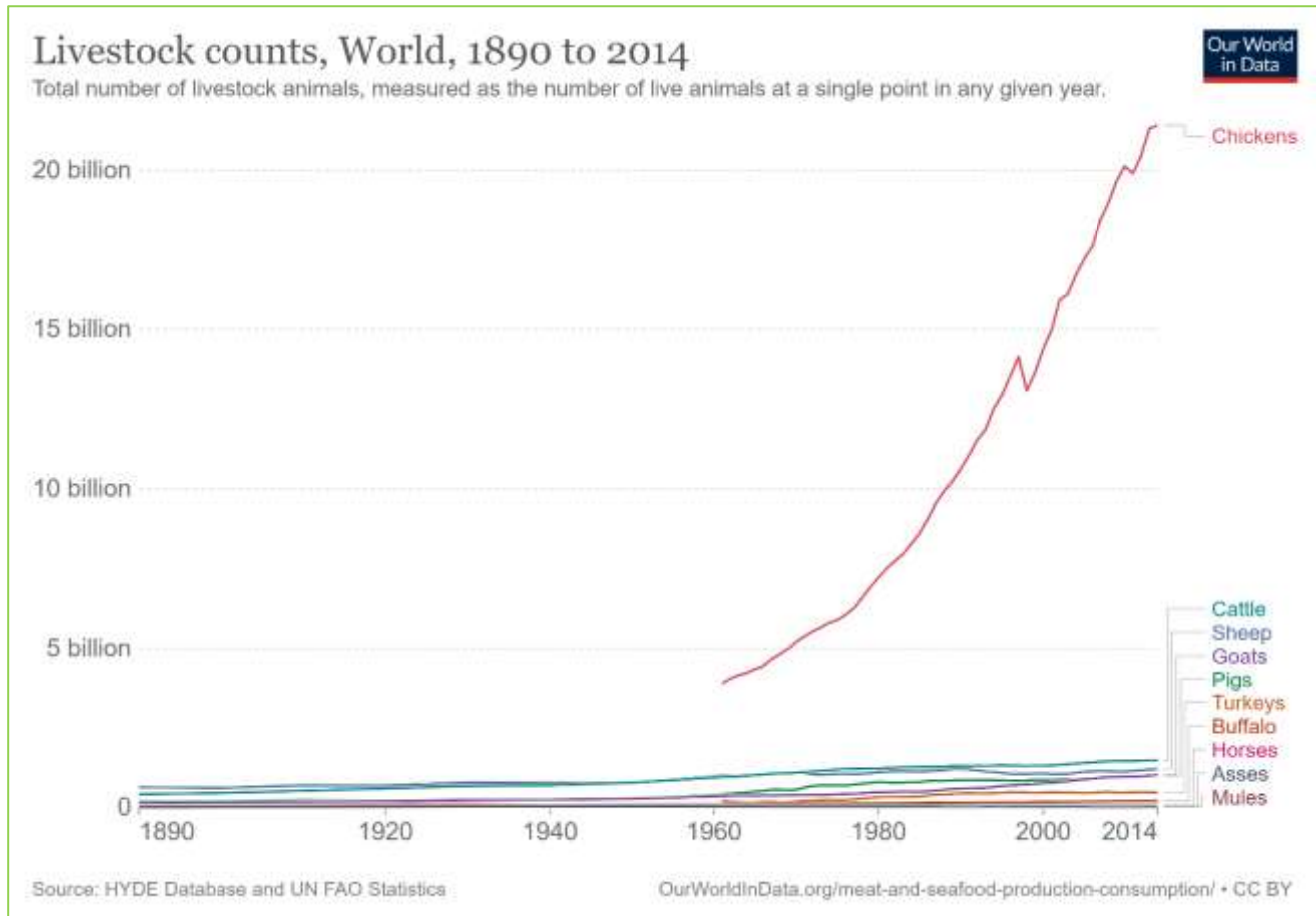

Figure 1 Global status of livestock variation chart from 1890 to 2014

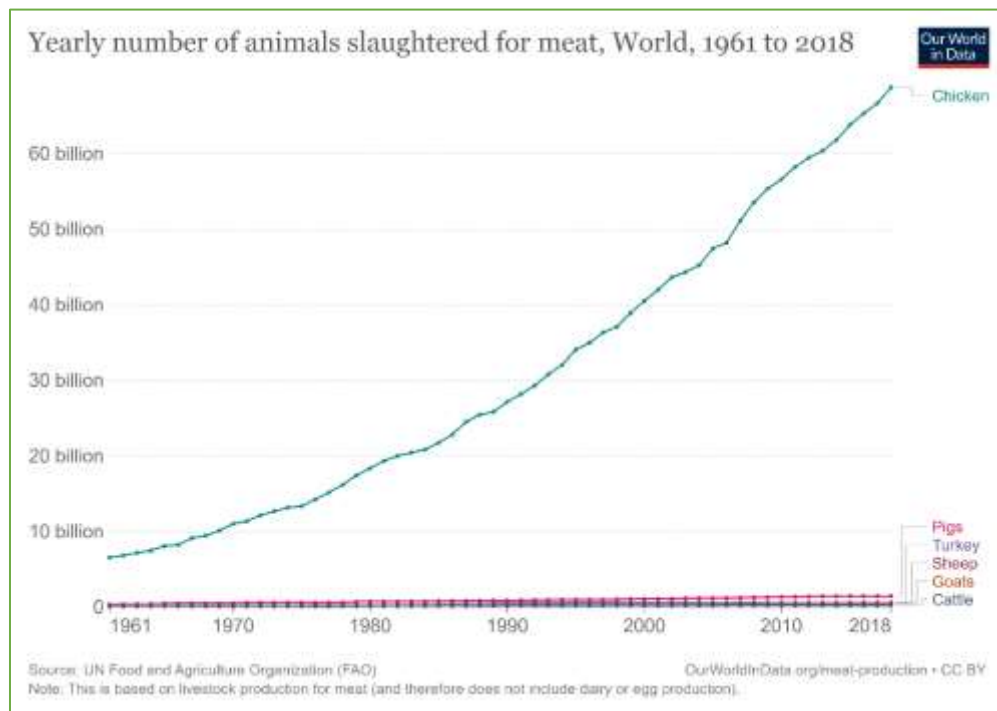*Figure 2. Livestock production index from 1965 to 2015, Rwanda*

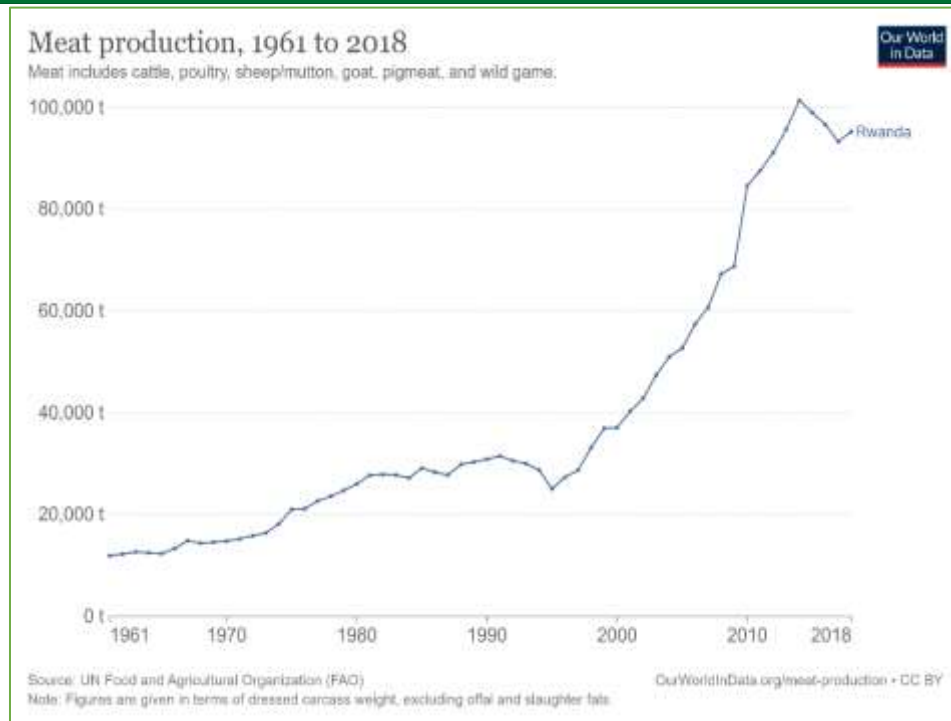*Figure 3. Global meat production status from 1961 to 2018.*

Figure 4. Meat production variation in % from 2061 to 2018, Rwanda

According to the meat production chart, livestock type has changed since 1961 (Figures 3 and 4), which is a similar situation in Rwanda, where the distribution of meat types varies significantly across the country. Although production of all major meat types has increased in absolute terms, in relative terms, the share of global meat types has changed significantly over the last 50 years. Similarly, in Rwanda, in 1961 and around, every family had a couple or a farm of cows. At period, it was a culture that "Taboo to sell, buy or exchange with milk". Milk was a free service to travelers and neighbors.

3. Why and what drivers to the dramatic change from culture to cash?

Within few decades, Rwanda's livestock industry has experienced a vast transition and shifting from type to type, with profound effects on domestic (family) social and global food provision changes in resources share and use as in line with (Turyasingura & Chavula, 2022). Factors which have triggered the changes are:

a) **Population growth:** While the land or country area is stable, Rwanda has shown an exponential growth of population from 2.998 million (1961) to more than 13 million (2022) to be the most populated country in Africa. This has reduced the land for animal grazing and feeds. This has created pressure to farmers to raise the high consuming like cows and shift to low consuming livestock such chicken (FAO, 2022; Steinfeld et al., 2006).

b) **Climate change:** Climate change is one of the top main causes of biodiversity loss, ecosystems degradation is human-made and natural phenomena which have associated to reduce the nature's potential to regulate greenhouse gas (GHGs) effects (Turyasingura, Ayiga, et al., 2022). As result, the global increase in temperature is alarming to pass the action line (Hirwa et al., 2022; Turyasingura, Alex, et al., 2022). More researches and projections have been made to actions calling. It is said that if the world temperature rises by 2°C, glacial mountains and rivers will start to disappear and more floods and landslides due melts will occur in coastal (EU Research & Innovation Magazine, 2022). Also, the findings predict that at 2 to 4°C, the ecosystem will collapse with 1/3 of life on earth will extinct at the rate of 1 in 10 species extinct (IPCC, 2022).

According to the updated Rwanda climate forecast and projection (Figure 5) temperature will increase at about 2.5°C which surpass the global temperature increase average at 2100 (Climate Expert, 2022; REMA, 2022; WB, 2021; WB/CCKP, 2019). This explains the multitude loss of biodiversity and ecosystem degradation due to the potential natural hazards like erratic rain, flooding, extended drought and species extinction due to death of survival failure or migration, which explain the livestock loss of habitats and feeds as well as human overconsumption of meats as alternative foods.
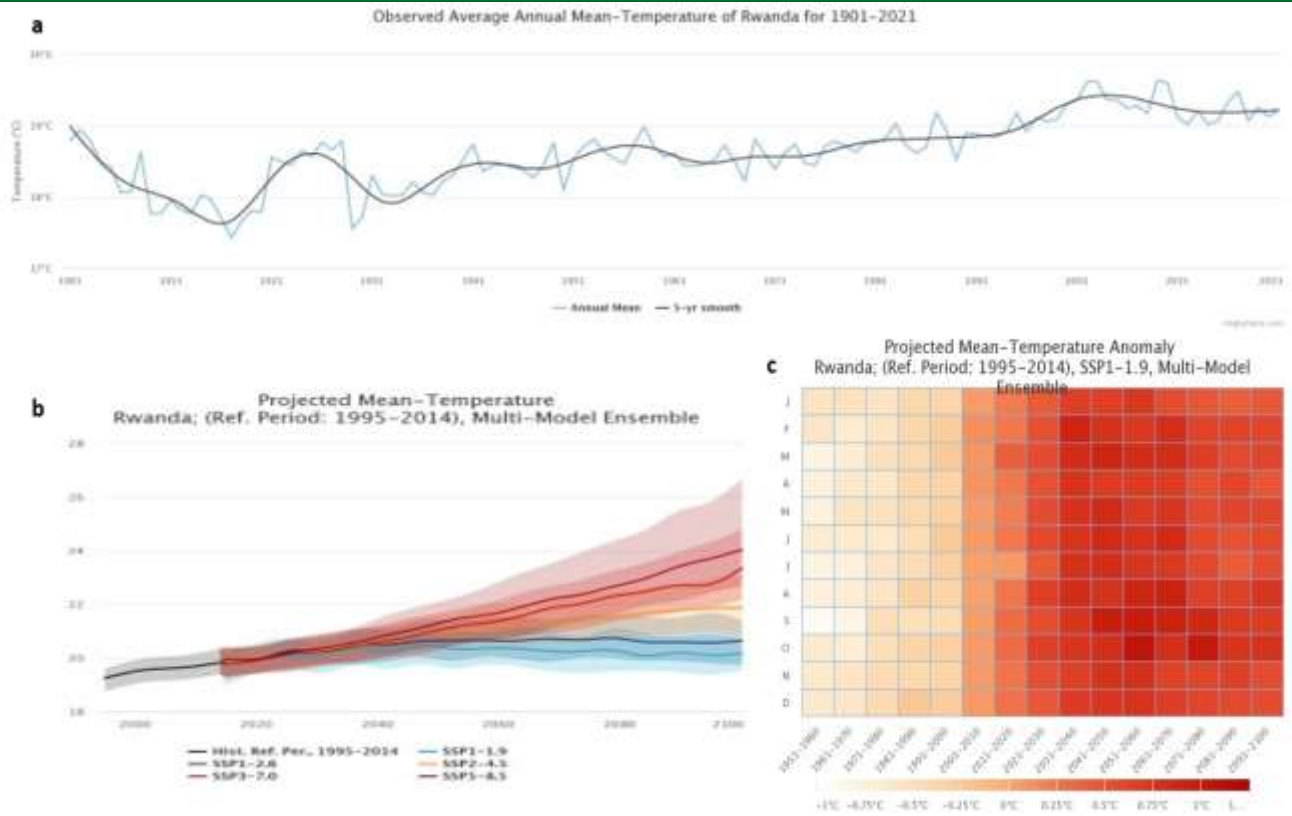
*Figure 5. Climatological event forecast in Rwanda using 1995-2014 scenario. (**a**) Temperature variation in 10 years interval of time from 1991-2021; (**b**) 2020-2100 temperature projection in 20 years interval of time; (**c**) 1951-2100 temperature indices variation in 9 years interval of time.*
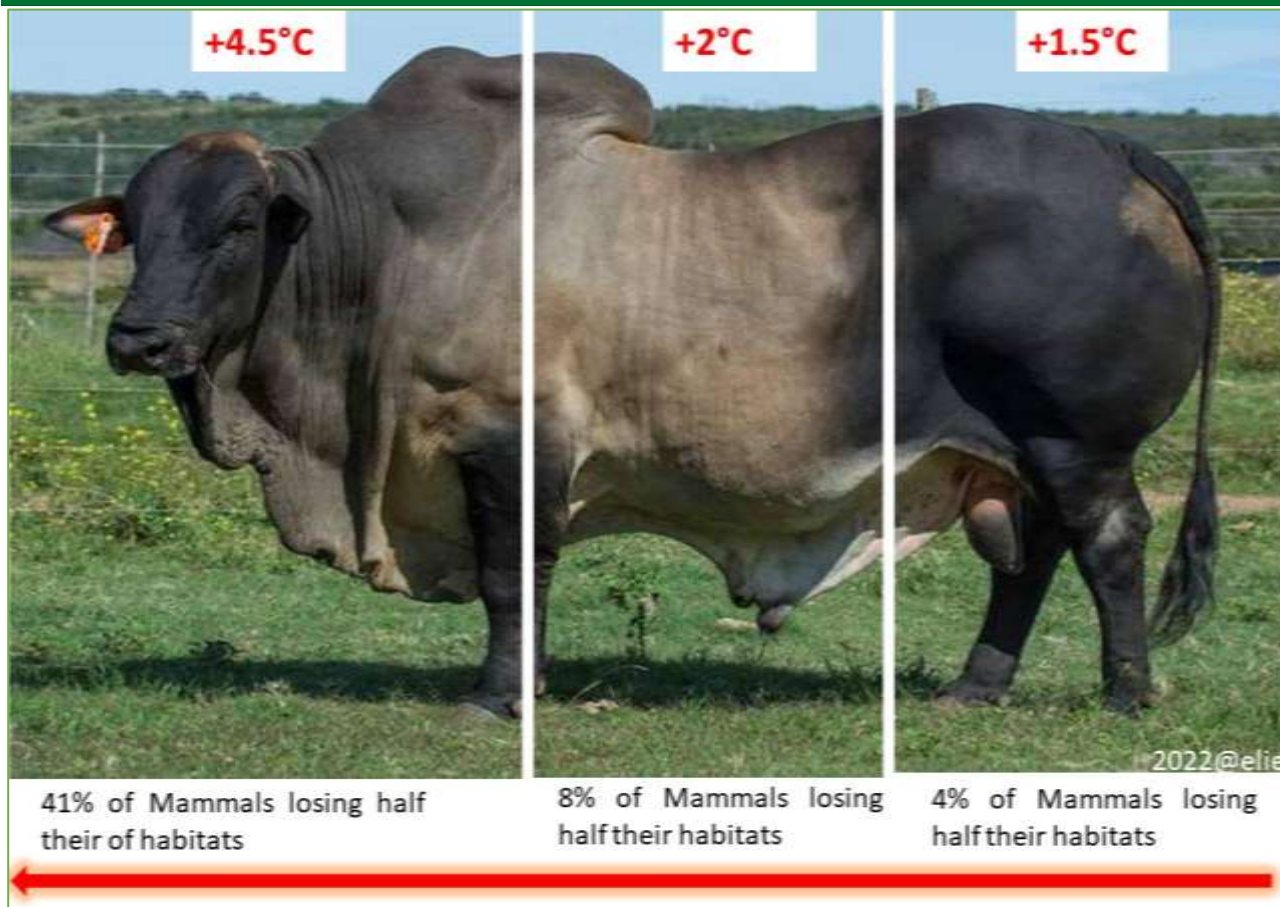
Figure 6. Climate change and increase in temperature effects projection to mammals (including livestock) habitats loss

The meaning of habitats loss has multiple meanings, added to the existing of a given organism's ecological niche loss, the author adds that for herbivores, their ecological niche plays a double role of hosting and food sources to the organisms. According to (UNFCCC, 2006) report, increase in temperature at +1.5, +2, 4.5 the 4%, 8%, 41% of mammals will lose the half of their habitats which is at the sometimes feeds to livestock, respectively (Figure 6).

c) **Reproduction performance:** Also, weather conditions variability has been found to have a strong correlation with animal reproduction shifting or delaying. This has affected much the higher wild animals like elephants, lions, Rhinos etc (Dejene et al., 2021; Moore et al., 2018; NASA, 2020). This has showed non-yet scientifically proved or reported strong effects on highly sensitive domestic animals like cows, rabbits, and sheep with extreme reduction in only 3 decades of Rwandan history.

d) **Milk and Meat production:** like in Human, lactation and growth performance both are controlled by physiological mechanisms of neurons and hormones. Irregular and extended heat stress could lead to low milk and meats productivity in farm animals as well as product quality. During the long dry period, heat stress reduces increase the heat stress hormones such as *thyroxine, cortisol, growth hormone and catecholamines* (Aggarwal & Upadhyay, 2013; Wang et al., 2015) of which their action opposes or inhibit s*omatotropin* (Growth hormone) and Prolactin (milk hormone)**.** This resulting in growth retardation and lower milk production (Bianca, 1962; David et al., 2021; Marai & Haeeb, 2010; West et al., 2003).

Conclusion

Global food and feed demand are increasing due to the exponential growth of the global population on stable land. This is associated with global climate change and leads to biodiversity loss and ecosystem degradation due to natural hazards and human overexploitation activities. This has a potential impact on habitats and resources. As a result, climate smart agriculture could be one of the tools for biodiversity conservation and ecosystem restoration, thereby promoting naturally sustainable livestock production systems. This could be achieved through multi-partnerships with all actors, from local authorities to national, regional, and international collaborations, which could be built at the grassroots level. Also, it is suggested to invest in education and scientific research that focus on conventional livestock alternatives for present and future foods and feeds.

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