Asian Journal of Agriculture and Rural Development
Volume 10, Issue 2 (2020): 645-658

http://www.aessweb.com/journals/5005

THE EFFECTS OF CLIMATE CHANGE ON RURAL LIVESTOCK FARMING: EVIDENCE FROM LIMPOPO PROVINCE, SOUTH AFRICA

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ARTICLE HISTORY:

Received: 17-Mar-2020
Accepted: 29-Jul-2020
Online Available: 01-Sep-2020

Keywords:

Climate change,
Effects,
Limpopo Province,
Rural livestock farming,
South Africa

ABSTRACT

The objective of this study is to identify the perceptions of the conspicuous rural livestock farmers as well as the officials from the Department of Agriculture, Forestry and Fisheries (DAFF) on the effects of climate change on rural livestock farming practices. From a qualitative standpoint, this study purposively selected participants from Limpopo Province, focusing on Giyani, Lenting, Ga-Mphahlele and Malamulele areas comprising of rural livestock farmers [12:3 = 36] and DAFF officials [6:2]. Overall, 42 participants formed part of this study through Face-to-Face and Focus Group Discussions. It is found that the loss and damage related to the contrary effects of climate change are insufficiently applied in the chosen rural areas of Limpopo Province. The local and regional collaborations by the responsible spheres of government are not strengthened and promoted, leading to inefficient strategies and approaches to addressing related conditions. Therefore, the significance of risk transmission and dissemination via regional cooperation regarding climate change adaptation are pivotal in rural settings.

Contribution/ Originality

A few studies have looked at the effects of climate change on rural livestock farming practices. This study presented variability in weather and climate conditions, which affected agricultural production in selected rural areas of South Africa. It is confirmed that quintessential modern rural livestock farming remains a contradiction; it seemed lucrative, yet fuelled with vast problems and sufferings; it is risky, yet seductive, this requires urgent research interventions.

DOI: 10.18488/journal.ajard.2020.102.645.658
ISSN(P): 2304-1455/ ISSN(E): 2224-4433

How to cite: Witness Maluleke, Ntwanano Patrick Tshabalala and Jaco Barkhuizen (2020). The effects of climate change on rural livestock farming: Evidence from Limpopo Province, South Africa. Asian Journal of Agriculture and Rural Development, 10(2), 645-658.

1. INTRODUCTION

The scientific and anecdotal evidence presented by the effects of climate change on rural livestock farming in the selected areas of Limpopo Province is quite overwhelming, at least a nightmare for many. Alternatively, Zwane and Montmasson-Clair (2016) affirm that the agriculture and mining sectors are two fundamental components of economic development. Sustaining food systems and agricultural activities create an essential pillar of sustainable development. However, climate change is undeniably, progressively altering the ecological, social, and economic conditions, negatively impacting the agricultural sector in large. Consequently, heat waves, wildfires, superstorms are all clear reminders of where we are right now (2020). The natural balance of our planet is changing, and this is just the beginning; we either come together and make climate change an urgent priority or let chaos reign … [*For considerations, we might not be able to stop the clock on the effects of climate change on rural livestock farming practices, however, protecting and preserving livestock can be beneficial* – Researchers' emphasis]. Climate change is often related to the increasing concentration of the Greenhouse Gases (GHGs); this occurs in the atmosphere involving small quantities of water vapor, Carbon Dioxide (CO2), Methane (CH4), Nitrous Oxides (Noxs) and Chlorofluoro Carbons (CFCs) permitting shortwave solar radiations to reach the 'Earth's surface,' to absorb existing long-wave radiations emanating from the-said 'Earth's surface.' Therefore, this absorption results in warming of the lower atmosphere, inducing temperatures experienced. In the absence of this process, the 'Earth' would be much colder than the present state (Kgakatsi *et al.*, 2012).

Subsequently, Kgakatsi *et al.* (2006) share that this condition can be restricted to any alteration of climate on a timely basis; this can be of natural changeability or human activities. It is enormously, difficult and relatively poorly understood by many individuals. In response to this condition, Smallhorne (2018) expresses that regional planning for climate change throughout the country is attaining more attention. Steps to reduce GHG emissions are taken by hundreds of local governments, including the Atlanta region. The benefits of lessening detrimental emissions prolong beyond acclimatising to a climate change and new federal legislation. The Carbon Dioxide equivalent (CO2e) emissions are now 60% higher than the levels in 1990 and growing at about 2.5 percent (%) per annum. CO2e emissions will continue to rise, primarily driven by the increasing population and economic growth, without anticipated mitigations. In essence, when compared to pre-industrial levels, if the world proceeds with this trajectory, the global mean surface temperatures are likely to increase from 3.7 degrees Celsius (°C) to 4.8°C in the projected 2100. Therefore, climate change poses a significant threat to South Africa's food security, water resources and health, biodiversity, infrastructure and ecosystem services.

Available projections suggest that climate change in South Africa will depict a significant warming 5-8°C over the interior by the year 2050. It will pose a drier environmental risk to both the South and West sides of the country, together with turbulent weather risk conditions along the Eastern portion of the country as well. Therefore, this industry will experience distinct risks concomitant with climate change such alterations will present unstable rain patterns intensified higher temperatures, evaporation rates, increased pests and diseases and alteration, reduced production and spatial shift in optimum growing African regions. Consequently, inceptions of the cited risks call for immediate, determined action ensuring the resilience of the agricultural sector by adapting to climate change impacts in South Africa (Zwane and Montmasson-Clair, 2016).

The primary objective of this study was to identify actual perceptions of [both] prominent rural livestock farmers and DAFF officials from the selected rural areas of Limpopo Province. It was done to explore the effects of climate change on rural livestock farming practices, while restricted to the following secondary objectives:

- To assess the effects of climate change on rural livestock farmers in the selected rural areas of Limpopo Province.

- To examine the relationship of relevant stakeholders in responding to the effects of climate change on rural livestock farmers in the selected rural areas of Limpopo Province.
- To evaluate the challenges facing relevant stakeholders in responding to the effects of climate change on rural livestock farmers in the selected rural areas of Limpopo Province.
- To ascertain the effectiveness of current strategies employed by relevant stakeholders in responding to the effects of climate change on rural livestock farmers in the selected rural areas of Limpopo Province.

2. LITERATURE REVIEW

Conventionally, the 'Anthropogenic' view demonstrates that humankind is the most important centre of existence characterised by contrasting sentiments. This allows human beings to exploit precious natural resources beneficial to their livelihood and development; equally important; the 'Anthropocene' epoch left a significant footprint on the planet through altering topography, while affecting ecosystems and causing climate changes, as a result; large planetary-scale changes in biological and ecological processes are witnessed, to this end; since the beginning of the Industrial Revolution in the mid-1700s, human activities added more gases into the atmosphere (Boonzaaier, 2018). Agriculture and food security are regarded as pivotal sectors to respond to climate change. The production of the former is highly vulnerable as 2°C (low-end) for global mean temperatures in 2100 are predicted, this will render major implications for rural and urban poverty and food security (Usman *et al.*, 2011). This essential sector requires a significant increase in productivity to sustain sufficient availability of food and other raw materials for future population expansions, which is estimated to exceed 9 billion by the year 2050 worldwide, despite this; the rapidly changing climate resulting from global warming is making this situation worse, making the rural livestock farmers deviate from this practice owing to increased input costs and low benefits (Sainger *et al.*, 2015). Certainly, the largest known economic effects of climate change on agriculture rests in the agriculture industry due to the size and sensitivity of this sector. Unquestionably, existing evidence presents that GHGs began to warm the planet, with various effects expected from global climate change by causing the greatest harm to this sector in developing countries [South Africa rural areas included], as many farms in the low latitudes endure extremely hot climates (Mendelsohn, 2009).

Practically, South Africa's richest agricultural areas also encompass Limpopo Province, which supplies the market with vegetable products. This province enjoys the sub-tropical climate in this province renders the opportunity to cultivate a range of products such as Coffee, Tea, Mango and distinct Tropical fruits. Conversely, the province, through forestry, renders enormous economic contribution by producing the following products: Tobacco; Sunflower; Wheat; Cotton; Maize; and Groundnuts. In addition, livestock farming for both commercial and subsidence farming is practiced in the Limpopo province (Maponya and Mpandeli, 2012). In the South African context, several studies were conducted on the effects of climate on water resources, largely neglecting the effects of related conditions on rural livestock farmers' practices phenomenon. However, it is predicted that the effects of climate variability and change on water resources nor livestock practices will vary according to regions; hence, the need to identify locally specific effects. Given the variations on the existing effects of climate change on rural livestock farming practices, it is expected that each region develops unique ways to deal with their specific challenges and consequences of climate effects. It is hoped that the future effects of climate variability can be mitigated if necessary adaptation is made and coping strategies are put in place (Mmbadi, 2019). This is collaborated by findings regarding performance progress of the Department of Water and Sanitation (DWS) to achieve key challenges set by the Africa Water Vision 2025 objective [Of ensuring water security for food production, delivery of services, climate change and reverse of water resource degradation]; however, very little happened in terms of strategies and preparation for climate change (Boonzaaier, 2018).

Another key point is that the documentation of the GHGs emissions as one of the major reasons for climate change at the global level can ease this process in recognizing that agriculture sectors are directly affected by changes in temperature, precipitation and CO2 concentrations in the atmosphere (Yadav *et al.*, 2019). As largely deduced from modeling studies based on predictions of rising temperatures and changing rainfall patterns, the present and ongoing climate changes, including drought, heat, and light stresses, and interactions between these factors are often witnessed globally (DaMatta *et al.*, 2018). Correspondingly, heavy rainfalls and floods, forest fires and the spread of new diseases are widely documented worldwide as climate change effects. The socio-economic and environmental effects of veld fires form part of the various discourse, with missing solutions offered mostly to rural areas. The veld fires are reported to increase due to unfavourable conditions, involving intense and long-burning with warm, hot and dry conditions, further attributing to climate change. It is likely to affect poor rural households who largely depend on land-based natural resources, for example, field crops, forests harvest, grazing land for livestock. With warm, drier and hotter conditions, it is emphasised that rural areas who share boundaries with mountains, rangelands, forests and wetlands are predicted to face greater threats from veld fires because of the dry flammable biomass (Taruvinga *et al.*, 2020). The effects of climate change on the global hydrological cycle are expected to vary the patterns of demand and supply of water for agriculture, regarded as the dominant user of freshwater. The livelihoods of rural communities and food security of the urban population will be at risk from water-related impacts linked primarily to climate variability and the vulnerable rural poor are also likely to be disproportionately affected. Therefore, adaptation measures building upon improved land and water management practices will be fundamental to boosts overall resilience to climate change (Turral *et al.*, 2011).

Unsurprisingly, global climate change made observable effects on the environment. Holistically, the range of published evidence indicates that the net damage costs of climate change are likely to be significant and to increase over time. Thus, scientists bestowed high confidence in predicting that global temperature will continue to rise for decades. Largely due to GHGs produced by human activities, the associated effects of global climate change are now occurring, namely: loss of sea ice, accelerated sea-level rise and longer and more intense heat waves (National Aeronautics and Space Administration [NASA] (2020). Sodangi *et al.* (2011) support this contention by providing that climate is the primary important factor for agricultural production in African countries. It accommodates the notion that science has made sterling efforts in understanding climate change and its related causes to develop a strong understanding of the current and potential postmodern effects and future challenges. It is believed that the earth is currently facing a period of rapid warming brought on by rising levels of GHGs in the atmosphere. The-indicated GHGs retain the radiant energy (Heat) provided to earth by the sun in a process known as the greenhouse effect to allow this process occurring naturally, withstanding that the planet would be too cold for life sustainability.

Notably, one of the most important challenges of the 21st Changes in global supplies and demands is climate change. This latter presents one of the greatest threats to African [Especially the Eastern and Southern African regions]; this is caused by water scarcity, adaptability and associated variability facing agricultural livelihoods (Sibanda and Sibanda, 2019). Reducing the risks of food security from climate change conditions is one of the major challenges in the 21st century (Campbella *et al.*, 2016). The effects of this system will have far-reaching impacts on crop, livestock and fisheries production, further changing the prevalence of crop pests. Many of these impacts nor effects are already measurable nor understandable. Climate change and agriculture are cited as interrelated processes taking place on a global scale. However, the overall effects of climate change on agriculture depends on the balance of the existing effects. Resulting from global warming and human activities, the frequency of droughts in several tropical countries increased, with flooding reported in several countries, further disrupting food production and carrying capacity of the biosphere (Srivastava, 2013). Crop yields dominate the studies on the associated effects resulting from severe conditions despite limitations of climate-crop modelling [and livestock

mortalities in the rural settings], little attention is paid on components of cropping, other dimensions of food security [Rural livestock farming practices are no exception]. This study highlighted that climate change would have far-reaching impacts on food security. The studies must address food security aspects other than the crop yields, given the serious threats; action-oriented research is a priority; the responsible stakeholder-driven portfolios of options should be a focus for research and combining adaptation and mitigation is a key challenge (Campbella *et al.*, 2016).

Subsequently, Killmann (2008) collaborates that the effects of climate consist of four dimensions of food security, namely: Food availability, accessibility, utilisation and systems stability. This negatively contributes to human health, livelihood assets, food production, distribution channels, changing purchasing power and market flows. The projected effects have both *short-term* challenges, resulting from frequent and intense extreme weather events and *long-term* hindrances caused by changing temperatures and precipitation patterns; vulnerable individuals with food insecurity are likely to be first affected, selected South African rural areas included. It is argued that the already vulnerable agriculture-based livelihood systems to food insecurity face immediate risks of increased crop failure, new patterns of pests and diseases, lack of appropriate seeds and planting material. Those who stay on the coasts, floodplains, in the mountains, drylands and the arctic are reported to be at high risk. As an indirect effect, low-income individuals in urban areas will be at risk of food insecurity owing to loss of assets and lack of adequate insurance coverage; this may also lead to shifting vulnerabilities in both developing and developed countries. The food systems will also be largely affected through possible internal and international migrations, resource-based conflicts and civil unrest triggered by climate change and its probable effects. Therefore, agriculture, forestry and fisheries will not only be affected by these conditions, but emitting GHGs will also contribute to this process. It can only be mitigated by reducing GHGs emissions to change existing agricultural practices. The resilience of rural people should be strengthened in helping the affected parties to cope with additional threats to food security. The climate change adaptations are linked with mitigation; the adaptation and mitigation measures need to be integrated into the overall development approaches and available schedule.

Consequently, Rust and Rust (2013) argues that the impacts of climate change on agricultural production and [rural] livestock practices are problematic to create and differentiate from other alterations in the earlier stated natural and human environmental settings. Numerous non-climatic drivers are interconnected with climate change impacts such as 'migration, overgrazing of natural pastures, change in livestock management, and alteration in livestock practices and human population can benefit this sector.' Susceptibility to climate change depends on biological, physical, and socio-economic features and low-income populations depending on subsistence agriculture such as the rural livestock farmers and are painted to be at risk of being affected. The effects on local and regional food production are expected to be more severe in low latitude regions, arid and semi-arid areas, precisely the rain-fed, non-irrigated production systems.

Significantly, Kgakatsi *et al.* (2006) state that South Africa is susceptible to climate changeability and rural livestock farming practices abundantly rely on the quality of the consistent rainy seasons. Changes in arable Crops and annual yield environments are directly related to climate conditions and notably to rainfall and related patterns. Scenarios on climate change envisage that "rainfall over most parts of the country could decrease; temperature could increase; runoff into main river systems could be reduced; veld cover and composition could deteriorate significantly, and the frequency of wildfires could increase." Evidentially, a study in South Africa based on one of the Hadley Centre in the United Kingdom (HADCM2) scenarios further predicts a low rainfall in distinct regions South Africa, the summer rainfall region by 15%, and winter rainfall by 25% by 2050. Therefore, the temperature will rise between and 3°C. Runoff into main rivers is likely to be reduced, for example, an expected decrease in an outflow from the Orange River of 12% to 16%. There will be a rise with 2.5% increase in the frequency of fires, saltation crises will transpire, and there will be a rising demand for irrigation; these forecasts remain a common occurrence to the

rural livestock farmers' practices, impact negatively on economic activities, biodiversity animal and human health and water resources.

The forecasted weather conditions can further result in extreme weather events, which can both affect the first and second economies. It, however, can jeopardize the following: the objectives of the Agricultural Strategy, the Accelerated and Shared Growth Initiative of South Africa (ASGISA), and the New Partnership for Africa's Development (NEPAD). Consequently, the annual crop production will be negatively affected by the consistent dry seasons throughout the country and possibly negatively impact veld cover and structure as well as the influence that this could have on carrying capacity for livestock and game (Kgakatsi *et al.*, 2012). The study of Maponya and Mpandeli (2012) show that drought in Limpopo province has serious ecological and economic consequences and will proceed to pose increasing challenges to communities [Rural areas included] owing to global climate changes. Also, the results of this study indicated that severe weather condition in the Limpopo Province was a contributory factor to the severe drought, contributing to the experienced reduced grazing and water for livestock and irrigation that negatively impacted this sector and eventually resulted to the scarcity of food. In some parts of this province, livestock farmers are instinctively bound to sell their livestock because of these conditions, such as severe temperature changes on rainfall patterns and accelerate the frequency of droughts, further posing a serious challenge, Maponya and Mpandeli (2012).

Similarly, an increase for three days or more of over 35°C heatwave can directly damage crops or reduce production. Killer heat that people endure by sitting in front of a fan or an air-conditioned environment can also negatively affect livestock such as Poultry and Cattle. If the heat from the sun compels animals into the shade for the relief, animals' time to graze automatically becomes less and this disrupts the animals' amount of feed needed for their nutrition. As a result, this can hinder production. Heat can cause stress in cows, for instance, decrease milk production and this can negatively affect the milk market. High temperatures for prolong duration, particularly without ample water, may result in the death of livestock. Persistent high temperatures above the expected average, such as sun heat that can last for days without cool down significantly at night, are especially hard on humans and animals. Therefore, livestock farmers need to consider simple measures to protect *animals* from the impacts of high temperatures during the day, Smallhorne (2018). Van den Berg (2017) also reveals that increased high temperatures are transpiring in South Africa. It is a fact that global temperatures have increased by about 1°C on average over the past century twenty century.

Most importantly, people residing in the rural areas of developing countries such as South Africa significantly rely on livestock farming practices for sustainability. It also incorporates the selected rural areas of Giyani, Lebowakgomo, and Malamulele as this study presents. It remains a common knowledge that livestock is often affected by the surrounding immediate environment. Equally, excessive temperatures, heavy rainfall, and drought can be detrimental to this sector. Drought related problems are cited to be massive in South Africa in general as it is becoming the unofficial capital of the country, while believed to be one of the recurring problems in the Limpopo Province relating to climate change. However, there are numerous resources to reveal the implications of climate change; some present information focuses on historically observed changes (Temperature and precipitation, among others) while others project changes into the future-based alternative scenarios (Involving frequency of intense storms in the future), United States Environmental Protection Agency (2019).

In collaboration, DAFF (2018) highlights that the overall climate change susceptibility in the South African agricultural sector should be perceived as representing both the risk and the opportunity. Risks regarding the potential alteration in food security and the contrary impacts of climate change, socio-political conditions, and population growth and opportunities encompass factors associated with the regional trade in sub-Saharan Africa and technological sharing. South Africa's livestock

sector in South Africa is essential to the agricultural economy and normally receives minimal attention than crops in bearing in mind the impacts of climate change. Approximation of the effects of climate change on the livestock sector, simulations and different measures have been exerted in South Africa, such as the development of heat stress (i.e., maximum ITH) and humidity (Temperature-Humanity Indices - THI) indices for livestock. Minimal and maxim critical temperatures control the thermally comfortable zone per livestock type to ensure optimum productivity and development. In the future, heat stress possibilities are expected to rise.

Furthermore, Erasmus (2018) indicates that [livestock] farming sector is one of the sectors greatly affected by climate change, having a critical impact on food production. A 6°C increase in temperatures in Southern Africa would mostly make varieties of farming impossible. During the twenty century, a rise in temperatures had been perceived nearly everywhere in the world. Temperatures had generally risen at a rate of nearly twice the global average, or about 1.5% in South Africa, compared with the worldwide average of 0.8°C. Further concern was the greater maximum rate of rising in the long-term average minimum temperatures of about 2.2°C. Since minimal areas on earth have rainfall data that goes back 100 years or more, it was more challenging for scientists to determine whether the alteration in rainfall patterns resulted in more than cyclical patterns.

Van den Berg (2017) shares that climate change is an everlasting departure from the average or mean, whether it is warmer, cooler, wetter, or drier. The resulted alterations transpire because of human actions, such as rising levels of GHGs released into the atmosphere. Whereas climate changeability refers to distinction around the mean. It can happen in normal cycles over the years, or it can transpire greatly randomly in the absence of precise patterns. It is also possible that climate change can affect climate changeability by raising the frequency of extreme climatic events. Climate variability is accountable for most of the variation seen in the climate. Up until presently, climate change has had a considerably minimal impact. As a result, cities and the consequences of climate change are noticeable Den Hartigh (2016) divulges that the future of family farms, [rural] poor communion the agricultural sector. Maintainable agricultural production, poverty and climate variation in the context of a reducing economy are the main problem facing the agriculture sector; the government should play an active role in understanding and developing solutions.

Consequently, this has led the Food and Agriculture Organisation (FAO) to commence negotiations on how to deal with the impact of climate change. Increasingly, the world has placed its focus on climate change. The FAO has its attention to the impact of climate change precisely on how agriculture and food security is being affected. Animal and Crop disease medications can positively aid this cause, as households can adapt to the changing circumstances by bringing new technologies, embracing sustainable natural resource management practices. It is changing patterns of making a living and can render an estimate of the number of people living in the different livestock production systems (Van de Steeg and Tibbo, 2012).

It is envisaged additional stresses from climate change can intensify, emanating from the already evident vulnerability of climatic alteration in various sections of African regions. In the Central, West Asia and North Africa (CWANA), the analysis of the coefficient of variation of the maximum Normalised Difference Vegetation Index (NDVI) for the period of 1982-2000 depicts that there is already enough confirmation of hotspots of reply and susceptibility to climatic change in this region. Therefore, this is likely to affect the quantity and quality of the present 'Feeds, Heat stress, available Water, Livestock diseases and Disease vectors and Genetic diversity,' with forecasted a loss of 25% in an animal in livestock production depending on diversified crop-livestock systems in developing countries as a result. This loss will mainly emanate from heat stress and the reduction in feed resources (Van de Steeg and Tibbo, 2012).

The inference made by Marigi (2017) highlights that the development plan for Kenya is widely affected by climate change and its resultant effects, costing the economy a significant percentage of the country's GDP. Certainly, the cumulative effects of climate change have the potential to reverse much of the progress made towards the attainment of the Sustainable Development Goals (SDGs) and Kenya's development 'Blueprint-Vision 2030.' Most residents of Kenya are said to be vulnerable to this effect owing to poverty, with approximately 46% classified as poor. The over-reliance of many individuals to rain-fed agriculture and livestock production puts them in vulnerable positions based on adverse weather conditions on their production systems and also due to fluctuating market prices for their produce, both locally and internationally. Climate change of Kenya is restricted to long term variations in the statistical circulation of weather patterns, for example; rainfall and temperatures over decades to million years; it has negative effects on agricultural activities, with pastoralism mostly cited in terms of access to forage and water, forcing most of them to reconsider its viability. This sector still faces a myriad of unaddressed challenges relating to the variability in climate, making it extremely difficult for pastoralists to access key resources such as water and forage that are vital for the survival of their *livestock* (Waithira and Kathula, 2020).

Ogallo *et al.* (2018) concluded that Sub-Saharan Africa is vulnerable to climate change due to its dependence on rain-fed agriculture in general. Specifically, Somalia has faced severe challenges linked to climate variability, exacerbated by conflict and limited governance persisted for decades. In 2018, climate extremes such as floods, drought, and coastal marine severe systems were associated with the destruction of property and livelihoods, losses of lives, livestock, migrations and resource-based conflicts. Equally, increasing evidence can link climate change of this country to the major and minor threats to natural systems, threatening environmental, social and economic developments. Comparatively, it is projected that the Asian and global agriculture will be under significant pressure to meet the demands of rising populations resulting from the use of finite, degraded soil and inadequate water resources predicted to be stressed by the effects of climate change. Considerably, agriculture and land-use change are also cited as essential sources of GHGs emissions. Thus, fertilizer applications, *livestock* rearing and land management affect levels of GHG in the atmosphere, amount of carbon storage and sequestration potentials (Rosegrant *et al.*, 2008).

Complementary to this, the Intergovernmental Panel on Climate Change (IPCC), including [more than] 1,300 scientists from the United States and other countries, forecasted a temperature rise of 2.5 to 10 degrees Fahrenheit over the next century. According to the IPCC, the extent of climate change effects on individual regions will vary over time and with the ability of different societal and environmental systems to mitigate nor adapt to the envisaged change (NASA, 2020). Yuan and Mitchell (2014) collected temperature data from 1920-2010 of four (4) rural Minnesota stations [Minnesota of US], classified into three 30-year timeframes and examined for differences and trends in temperature (Maximum recorded Temperature - Tmax and Minimum recorded Temperature - Tmin), precipitation, and growing season variables. This study found a warmer 1980-2010 based on a significant increase in Tmin at all four stations in the study locations. This period was touted as the most significantly wet of 91 years. The Change Point analyses result further support these findings by highlighting that enhanced CO2 at the planetary scale and a regional increase of water vapor comprised part of the explanation increasing Tmin from 1980-2010 at all four rural *Minnesota* stations. The combined temperature results from the four stations (Tmin and Tmax) and precipitation trends especially reflected more water in the Earth/Atmosphere system over *Minnesota*. Other anthropogenic land covers nor use practices supplement the study findings. However, assigning an accurate weight to each factor remains an unsolved problem.

While this is this discussion, various stress factors imposed by climate change significantly reduce the yield per unit area in *Pakistan*. It is shared that 'Ozone' and climate change are directly linked with each other; an increase of Ozone on earth's surface results in more retention of heat, leading to

high temperatures and disturbance of other components of the atmosphere, resulting in severe climate change which affects agriculture negatively. Expressively, inadequacy irrigation of water supply remains a potential threat to the economy of *Pakistan*. It maximizes the probability of extreme weather events occurrences, such as drought and floods. The government of *Pakistan* is financing almost all hi-technology research institutions to carry out research projects focusing on the discovery of appropriate ways of tackling disastrous effects and major challenges of climate change (Usman *et al*., 2011).

In *Romania*, climate change is expressed through droughts, floods, less rainy days during the year, extreme heatwaves, generating serious effects on agricultural and forestry activities of rural areas households. In developing countries, rural areas are altered by climate change, especially in regions depending on subsistence agriculture, where the population is not properly equipped to adapt to unforeseen climatic conditions may express vast effects in the economic sectors, such as *agriculture*, food industry, energy sector, and tourism, among others. Moreover, the effects felt by vulnerable poor rural households are associated with various risks, namely: Lack of income, aging population, low income and lack of access to essential services needed in the protection against climatic threats (Surugiu *et al*., 2018).

3. PROBLEM EXPOSITION

It is envisaged that African will enormously be affected by climate change, as massive regions could be stricken by the downfall of production with 50% by the year 2020, because of an increasingly hotter and drier climate. It will, therefore, threaten food security and livelihood of people in different areas of Africa after food scarcity. In connection with this statement, Limpopo Province has already experienced some of these weather events, encompassing floods and droughts. For example, in 2000 and 2012, crops and infrastructure were shattered by floods, which consequentially affected the harvesting period. Altering rainfall distribution and extreme temperature changes are probable to increase the frequency and magnitude of extreme weather events like drought.

By the year 2020, the livestock farmers in the selected rural areas of Limpopo Province are experiencing a severe decline because the area has been hard hit by drought and water deficiency in the post years. The importance of this study, however, is to introduce a baseline in understanding the implications of climate change in this sector to bring about both reactive and proactive measures by the affected farmers. There is evidence that subsistence livestock farmers are greatly susceptible to climate change than commercial livestock farmers. At the same time, large-scale irrigated production is probably the least vulnerable to climate change, conditional upon enough water supply for irrigation is available (DAFF, 2018).

The main findings of the study conducted by Maluleke and Mokwena (2017) indicate that the rural livestock farmers in the Greater Giyani Municipality of Limpopo Province are extremely susceptible to the results of climate change. Deterioration in livestock farming practices in the regions caused by related health and sustenance difficulties carried forward by excessive temperatures, droughts, and heavy rainfall indicated to have harmful effects on rural livestock farmers in the designated regions. Kriel (2017) mentions that livestock farmers South Africa must acclimatize to limit the effects of climate change on livestock production and animal health, resulting in 1-2% incline in the average temperature along with coastal areas of South Africa, and 2-3% incline the in inner regions by 2050. Livestock farmers will have to contend with drier climatic conditions, faster evaporation and more frequent incidences of extreme weather such as floods and droughts to carry on producing food. For the *'animal nutrition'* - Forecasters have foreseen that climate change will have an enormous impact on the quality and quantity of forage crops. Warmer temperatures could result in the deterioration of pasture quality and quantity, making it extra challenging for farmers to align production with their animals' nutritional

requirements. Producers will have to synchronize breeding seasons with nature better. This synchronisation has transpired naturally to counterpart the accessibility of natural veld with their feeding requirements." For *'Immunity'* - Climate change will also affect animals' immunity; unfavourable climatic conditions and food scarcity cause stress, which negatively affects the immunity.

4. METHODS AND MATERIALS

This study adopted the phenomenology paradigm as a philosophical worldview, aligned with a qualitative research approach to transforming scientific knowledge into meaningful facts about the effects of climate change on rural livestock farming practices. For this study, this research approach was applied to study the selected participants' perceptions, interpretations and beliefs regarding this subject (Creswell, 2007). This approach was used to gain in-depth information further, personal ideas and experiences, viewpoints on the primary and secondary objectives of this study, Brynard and Hanekom (2006), Welman *et al.* (2005). The exploratory research objective was also applied to enable researchers to compile a profile picture by listening to the participants; this was used in conjunction with their personal experiences using empirical research, involving going to the field to conduct face-to-face interviews and Focus Group Discussions (FGDs) to ascertain their respective on this subject (Maxfield and Babbie, 1995; and Mouton, 2009). For study locations, the following rural areas were selected from Limpopo Province: Mavambe Village under Collins Chabane Municipality, Xikukwani Village under Greater Giyani Municipality and Lenting, Ga-Mphahlele under Lepelle Nkupi Municipality.

Furthermore, the sample size and procedures enabled allowed for the purposeful selection of participants with a broader understanding of this subject. The selected participants comprised of rural livestock farmers [12:3 = 36] and DAFF officials [6:2] (e.g., Veterinary Services; Land and Infrastructure and Natural Resource Management Managers). Overall, 42 participants were selected for this study. The selection of the participants was based on their experience and knowledge on the subject matter; this included the local livestock farmers as victims of this plague. Leedy and Ormrod (2013), Leedy and Ormrod (2013) and Welman *et al.* (2005).

Moreover, as initially stated, face-to-face interviews with Six DAFF officials and the FGDs with 36 rural livestock farmers were used to solicit data from these selected participants. The literature review was adopted to enhance the credibility of the participants' responses, De Vos *et al.* (2011), Flick (2009), and Leedy and Ormrod (2010). For data analysis methods, the researchers read all transcriptions and write down notes while listening to the voice recorder of the conducted interviews with the selected participants, and identify common features to respond to the objectives of this study. After going through transcripts, the filtering process was done to implement critical data, Mouton (2009).

5. STUDY FINDINGS AND DISCUSSIONS

In this section, the focus will be on findings from data collected via interviews [Face-to-face interviews and FGDs conducted with the selected participants from Limpopo Province were explored]. These findings are arranged in terms of the Interview Schedule Guide used during this process; what the participants shared with the researchers was triangulated with the previously presented literature studies on this subject. The purpose of the data gathered was to answer the objectives of this study, as indicated in the introduction section.

5.1. What are the effects of climate change on rural livestock farming practices in your area?

As discussed by DAFF (2018) and Maluleke and Mokwena (2017) that the estimation of effects relating to climate change on rural livestock practices was shared by revealing that several approaches are used in South Africa to develop heat stress (maximum ITH) and humidity (THI)

indices for livestock, droughts, excessive temperatures and heavy rainfall has a detrimental effect on rural livestock farmers. This supports the findings of this study, whereby the selected participants stated that they had not experienced heavy rain in Seven (07) years period; it should be stated that rain is important; without it, we suffer, we are taking risks by practicing livestock farming; as anything can happen without notice, we urge the local DAFF to teach us how to feed them despite unpredictable climate change, this will allow us to avoid unforeseen livestock casualties and mortalities.

5.2. Can climate change be effectively addressed by DAFF and other relevant stakeholders [rural livestock farmers included] relationship in your area? (Please elaborate on your answer)

Out of Ten livestock, the escaping Lions and Hyenas from Kruger National Park can kill and eat Three; if a wound is created, the livestock can live for Four months, to be exact and eventually dies. These animals break the spinal cord of livestock and fest on the carcass stomachs and intestines only. Positively; when livestock is killed and eaten by a Lion or Hyena, the livestock owner can take a picture of the scene to the local DAFF for R5 000.00 compensation, only if the livestock in question corresponds with the Stock card after validations; however, we still see this as little money as our livestock remains dead, we take this money as there is nothing we can do, it is better than nothing, to be honest. Another problem relating to this remedy by [local DAFF] rests on corruption involving the residents who take pictures to submit to the local DAFF, acting as if the livestock belongs to them, causing misinterpretations and ownership disputes. Thus, the 'Livestock Committees' in the rural areas should prevent this corruption by working closely with the Veterinary Services official who tends to know all the livestock in the rural village. It collates with the envisaged contribution of this study of providing a broader understanding of actual perceptions, to be solicited from the prominent livestock farmers and DAFF officials [from the selected areas of Limpopo Province] on this subject. It will create awareness to these rural areas by suggesting possible strategies to address the associated effects.

5.3. Are the current strategies effective enough, as employed by the local Department of Agriculture, Forestry and Fisheries (DAFF) in responding to climate change in your area? (Please elaborate on your answer)

The findings of this study stated that the local DAFF brings fodder to us; this depends on the number of livestock we keep, for example; Five Cattle, Goats and Sheep equals to Two fodder each [Five stock] if your livestock is many; more fodder and Maize Malt are delivered for free; however, we are way too many for us to be all satisfied or catered for. All livestock farmers should be registered members of the village (permanent native residents). The DAFF also visits our rural areas for different vaccinations injections throughout the year; they commence in February to continues with seasonal inspections. Equally, from July 2019; our livestock use to drink Stream water, it is dried up now, we have to buy water for this livestock from those who have Boreholes, this cost R25.00 per 20 litres to cater for One (01) Cattle in two days, further causing financial strain to us, it will take time to ease this process since the Streams collect soil instead of water owing to the unattended arable land in our rural communities. This was confirmed by Camelia *et al.* (2018) in the introductory section of this study, who contended that climate change has an adverse impact on the livelihoods of rural communities and the responsible State departments should launch awareness campaigns regarding the adoption of different adaptation strategies.

5.4. What are the existing challenges faced by DAFF in addressing climate change in your area?

The selected participants outlined that Foot and Mouth diseases as transmitted to our livestock by the local Buffalo escaping from Kruger National Park; they often infect the leaves they eat, their Drool is very dangerous; it can make our livestock to be swollen and eventually dies in the process. In response, the local DAFF works adequately to respond to this challenge by immediately injecting the whole livestock in the rural village if cases of this nature occur or are reported. It

supports what DAFF (2018) stipulated in the introduction section of this study by stating the associated risks and opportunities in the agricultural sector should be looked at holistically to understand the effects and impacts of climate change.

6. CONCLUSION AND RECOMMENDATIONS

It is *concluded* that the effects of climate change drastically work against effective practices by livestock farming with limited resources to overcome the various existing challenges, for example; in cases where there is an outbreak of diseases, such as; Brucellosis, Foot-and-Mouth Diseases, Redwater and Tick-borne, among others resulting from extreme weather conditions, poorly disadvantaged rural livestock farmers often fail to purchase recommended stock remedies to treat their livestock, this result in having a negative impact on human health through contaminations nor consumptions of the infected livestock products.

It is *recommended* that the rural livestock farming activities of today require modern and rural wisdom; the effects of climate change in our rural communities differ drastically with the urban findings. Due to the existing many different effects of climate change, this practice recently become win or lose business; it is no longer lucrative. During the 1960s-1980, it was great. The rural livestock farmers shouldn't have much livestock, for example, 60-100 Cattle, as taking care of them can be problematic and taxing, as it requires buying of food owing to the turbulent climate change and the local DAFF incapacity to render effective services to all of us. This lead to [many] rural livestock farmers to sell their livestock to buy adequate food and vaccinations. This practice does help them despite the expensive nature of this practice; proper planning is highly sought in this regard.

Funding: The University of Limpopo financially supported the research through a grant award of R50 000.
Competing Interests: The authors declared that they have no competing interests.
Contributors/Acknowledgement: Authors' would like to express their appreciation to the 42 selected participants who formed part of this study, from the rural areas of Limpopo Province

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