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Climate change effect on Somalia's pastoralists: Systematic review

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Abstract: This paper offers the findings of a comprehensive review of the research literature on how pastoralists are being affected by climate change, what are the observed impacts of climate over the past few decades, how resilient are the pastoralists against climate change, and what are the predicted climate impacts in the coming decades. A total of 357 papers were properly screened based on research title and abstract. 156 papers were excluded as a result of the exclusion criteria (duplicates, studies not focused on climate, etc.), while 149 publications were before 2013. Finally, 52 papers qualified to be considered for review. Somalia has experienced above 30 climate-related shocks since the 1990s, including 19 floods and 12 severe droughts. Since 1991, Somalia has experienced a continuous increase of 10C to 1.50C in median annual temperatures. The average daily maximum temperature ranges from 300C to 400C and according to long-term predictions, temperatures will continue to rise by 3.20C to 4.30C by 2100. As per the findings, there are five basic adaptation techniques used by herders: transferring livestock to better grazing regions, adopting drought-resistant crops and livestock, planting early, and relocating to other settlements. Climate change has had substantial direct and indirect effects on Somalia's pastoralists; water resources and pasture due to recurrent droughts and floods, which has increased the vulnerability of the pastoral communities. To address the above-highlighted impacts, purpose-driven policies and climate programs are needed to promote water management, a sustainable environment, early warning systems, and social safety net programs for pastoralists.

Keywords: *Agriculture, Climate change, Droughts, Floods, Migration, Pastoralists, Somalia.*

1. Introduction

1.1. Background

The impact of climate change has become a daily reality for more than three billion people in developing countries (Chatham House, 2021). It leads to food insecurity, water scarcity, increased mortality and morbidity rates, and forced displacements. The repercussions of climate change have gained significant attention in public debates, as it is recognized as one of the major global challenges today (Godson-Ibeji, Ibe, Chikaire, & Aminu, 2022). It is unequivocal that in at least the last 2000 years, human influence warmed the climate (the atmosphere, ocean, and land) at a rate that is unprecedented, making each of the last four decades successively warmer than any decade that preceded it since 1850 (IPCC, 2022). Moreover, global surface temperature has been increasing since the 1970s compared to any other 50 years period over the last 2000 years. Similarly, the level of seas has risen globally faster since 1900 than over any preceding century over at least in the last 3000 years (IPCC, 2022). The human-induced climate change is causing detrimental effects across all regions, manifesting as extreme heatwaves, droughts, floods, heavy precipitation, and tropical cyclones. Against this backdrop, climate change is exacerbating agricultural and ecological droughts, significantly impacting the livelihoods of pastoralists. Rapid climate change forecasts indicate a projected increase in surface temperatures ranging from 1.4 to 5.8 degrees Celsius by 2100 (Godson-Ibeji, Ibe, Chikaire, & Aminu, 2022).

1.2. Overview of Climate Change Impacts on Africa

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Africa has been identified as one of the most vulnerable regions to the impacts of climate change (Coumou, et al., 2016). Sub-Saharan Africa, in particular, is experiencing significant damage due to climate change, with regions in East Africa, the Sahel, and Southern Africa being the most affected (Soest, 2020). The negative consequences of climate change on Africa are expected to be substantial, considering that the continent is home to 1.3 billion people living in poverty, with nearly 60 percent of them relying on livestock as their primary source of livelihood (Godson-Ibeji, Ibe, Chikaire, & Aminu, 2022). Pastoralism is prevalent in Africa and Asia, with over 100 countries practicing this livelihood system (Uddin & Kebreab, 2020). Pastoralism plays a significant role in the economies of several Central Asian and African countries, contributing 10-44 percent to Africa's GDP (Nyariki & Amwata, 2019). For instance, in Ethiopia, pastoralism employs approximately 27 percent of the workforce, contributes 30 percent to the country's GDP, and generates over 90 percent of the nation's hard currency earnings through livestock exports (Erena & Bogale, 2022). Similarly, in Somalia, livestock production constitutes more than 50 percent of the country's GDP and over 80 percent of its export earnings (IGAD, 2018).

The Somali region of Ethiopia has experienced five moderate and one severe drought between 1983 and 2017, leading to rangeland degradation, increased aridity, and worsened drought conditions. Mismanagement of rangeland areas and environmental degradation over the past 40 years have contributed to these challenges (Abrham & Mekuyie, 2022). Climate change has also resulted in resource scarcity, population displacement, and conflicts in the Horn of Africa, as predicted (Musau, 2021). The continent of Africa already faces food insecurity and malnutrition, and climate change exacerbates these issues (Welsh, 2021). Despite the economic development role of pastoralism at the national, regional, and global levels, the sector faces formidable challenges that impede the realization of its full potential. These difficulties include climate change, urbanization, worsening security, expansion of cultivated areas, and pastoral economies that are not valued enough (Nyariki & Amwata, 2019). By 2050, the gross domestic product (GDP) of Sub-Saharan Africa could be decreased by up to three percent. Subsequently, agriculture is critical to the economic growth of Africa, while the sector is vulnerable to climate shocks since it is heavily dependent on rainfall. Climate change could undermine local markets, exacerbate food insecurity, negatively influence economic growth, and increase the risk to sector investors (Ray, 2021). Climate change has already caused economic losses in agriculture, infrastructure, tourism, and manufacturing, contributing to income inequalities among African nations. It is estimated that Africa's GDP per capita for the period from 1991 to 2010 was 13.6 percent lower than it would have been without the impacts of climate change (IPCC, 2022).

1.3. Overview of Climate Change Impacts on Somalia

1.3.1. Pastoral Communities in Somalia

UNICEF (2013) defined pastoralist as a way of life for a large number of Somalis in which people make a living by livestock production (camels, cattle, goats, and sheep) moving across borders into Ethiopia and Kenya in search of water and forage. Livestock constitutes approximately 40 percent of Somalia's GDP (UNDP, 2015) and serves as the country's primary export, accounting for 80 percent of total exports (The Federal Government of Somalia, 2022). Many nomadic and semi-nomadic communities in Somalia depend on livestock as their main source of livelihood. A severe drought that occurred in early 2022 resulted in the death of around 70,000 camels, sheep, cattle, and goats in various parts of Somalia (SCI, 2022). Climate change projections indicate that the situation is expected to worsen, with significant repercussions on various aspects of life in the country.

Sub-Sahara African countries are susceptible to the warming trend as the region is experiencing frequent occurrence of extreme heat waves, erratic rainfall, increasing aridity, harsh weather, and periodic droughts and floods that inundate the economic infrastructure and displace millions of vulnerable communities every year (Serdeczny, et al., 2016). Somalia, with a population of over 15.8 million people (2020), has around 60 percent of its population categorized as nomadic or semi-nomadic pastoralists. The country's economy heavily relies on agricultural production, which accounts for approximately 65 percent of its GDP, making the performance of Somalia's economic sector highly

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dependent on climate conditions (WB, 2020). Climate change and its consequences have been one of the key focus areas of the Horn of Africa nations, and that is the reason why the Intergovernmental Authority on Drought and Devevelopment (IGADD), now the Intergovernmental Authority on Development (IGAD) came into existence in 1986 to prevent drought, desertification, and famine that perennially affected the Horn of Africa (Musau, 2021).

1.3.2. Recent Climate Shocks and Somalia

Somalia has experienced above 30 climate-related shocks since the 1990s, including 19 floods and 12 severe droughts. Somalia is highly vulnerable to the impact of climate change as one of the indicators is the loss of trees; from 2001 to 2021, there was a 4.9 percent decrease in tree cover, 429,000 hectares loss of trees which has created 840,000 tons of equivalent carbon dioxide (Dubow, 2022). The production of charcoal has contributed to this loss, with approximately 8 million trees being cut down for charcoal purposes every 30 seconds between 2011 and 2017, mainly exported to Gulf States and neighboring countries (UNDP, 2015).

In Somalia, climate change has swept across its regions, undermining basic livelihoods, ruining infrastructure, stressing state budgets by shaking national economics, and, most importantly, taking both human and animal life. The country heavily relies on agriculture, with 46 percent of the employed population working in the agricultural sector, including crop cultivation, herding, and fishing-related activities. Climate change, particularly severe droughts, has had a negative impact on agricultural production, especially for pastoralists (WB & FAO, 2018). The climate contributes to the insecurity as the pastoralists compete over the meager available resources, especially in the water sector, as due to the declining groundwater levels rise-up, the water prices get higher and increase the likelihood of pastoralists conflict over the water.

Due to its proximity to the equator, Somalia does not experience significant seasonal variations in its climate. However, Irregular rainfall, period monsoon winds, floods during the rainy season, and dust storms exacerbate the hot conditions degrading the environment and making the situation of people's lives in the country even worse (Andrew, 2021). The devastating impact of droughts on the population was evident between October 2010 and April 2012 when more than a quarter of a million (260,000) people perished in the famine and about half of them were children; an estimated 10 percent of children under 5 and 4.6 percent of the total population perished only in Southern and Central regions of Somalia (Giovetti & McConville, 2020). In Somalia, drought-impacted over 1.6 million people classified as in 'crises' and emergency levels of food insecurity due to the consequence of high livestock mortality and agricultural output losses of pastoralists and agro-pastoralists during the failed Deyr season followed by a poor Gu' 2016 harvest (FSNAU & FEWS NET, 2016) as the water shortages, crop and livestock losses affected over 5 million people in different ways. The drought forced over 926,000 rural people to leave their homes in search of alternative sources of water and food between November 2016 and September 2017. Mogadishu, Kismayo, and Baidoa hosted about 40 percent of all drought-related displaced people, while 60 percent is accommodated by other secondary cities in Somalia (Government of Somalia, 2018). The drought severely impacted the agricultural sector, which is the second most important source of economic activity, employment, and export with total aggregate production losses estimated at USD 63.8 million, almost representing 4 percent of Somalia's 2016 nominal GDP estimated at USD 6.2 billion (World Bank, 2016). More recently, according to NRC (2022), 745,000 people have been displaced by droughts in Somalia since last year including, 500,000 people displaced in the first quarter of 2022 due to three consecutive failed rainy seasons.

Comparing the recent three worst droughts in Somalia, as each drought is unique, the 2011/12 drought, which led to both human and animal loss, was shorter and more severe than the 2016/2017 and 2021/2022 droughts. In 2011/12, drought conditions were evident from October 2010 and lasted for ten months in 2011, peaking in March 2011. The drought in 2016/17 lasted for 23 months from May 2016 to March 2018. The current drought (2021/22) has been ongoing for the last 17 months and will continue as anticipated rainfall forecast for the coming Deyr rainy season in 2022 would likely be below the average (SWALIM & FAO, 2022). Due to the weak animal condition and the worsening

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drought severity in most regions of Somalia, livestock sales have decreased with low purchasing power putting immense pressure on pastoralists and leaving 90 percent of Somalia under extreme drought conditions (SWALIM & FAO, 2022). Futhermore, Somalia has seen extreme weather events over the past 25 years and is very vulnerable to the effects of climate change and unusual weather, such as long periods of drought, flash floods, irregular rainfall, dust storms, cyclones, powerful winds, sandstorms, and monsoon seasons disruption (Eklow & Krampe, 2019).

There is evidence of a causal relationship between extreme weather events and civil conflicts, particularly in Somalia. Studies have shown that deviations from rainfall patterns and temperature changes can substantially affect human conflicts (Maystadt & Ecker, 2014). Burke, et al., (2015) found strong evidence that human conflict can substantially be affected by deviations from rain precipitations, temperature patterns, and climatic changes. From a global perspective, interpersonal violence and intergroup conflicts rose by 4 percent and 14 percent respectively with each one standard deviation change in climate toward hotter temperatures or more extreme rainfall; projected temperatures are expected to warm 2 to 4 standard deviation by 2050 and for Somalia's most parts are expected to subject an increase of 3 standard deviations (Burke, Hsiang, & Miguel, 2015). Previous studies have indicated that extreme weather conditions and erratic rainfall may have contributed to civil war in Somalia and in generally in Africa. Roy (2022) found that El Nino/Southern Oscillation may have had a contributory role in 21 percent of all civil conflicts since 1950.

1.3.3. Future Climate Change Predictions on Somalia

Since 1991, Somalia has experienced a continuous and gradual increase of 1^{o}C to 1.5^{o}C in median annual temperatures. The average daily maximum temperature ranges from 30^{o}C to 40^{o}C and according to long-term predictions, temperatures will continue to rise by 3.2^{o}C to 4.3^{o}C by 2100 (NUPI, 2021). On the other hand, Somalia's precipitation patterns are erratic, with interannual and intraseasonal variations. The north is scorching and arid (250 mm rainfall) while the south and south-west are wetter (approximately 400 mm and 700 mm, respectively). It is anticipated that by 2050, precipitation will increase by approximately 3 percent, particularly during the rainy season, while seasonal variability will also increase. While this may benefit agriculture in some regions, it could lead to flooding and soil erosion in areas with limited or degraded forests. The Intergovernmental Panel on Climate Change (IPCC) has indicated that climate change is real and sound knowledge is inevitable to monitor local future climate change scenarios. The Horn of Africa has historically suffered adverse climatic conditions and periodic droughts that occur almost in every decade that worsen the economic conditions of pastoralists particularly and exacerbate the already existing social and political conflicts. The IPCC predicted that by 2050, rainfall would decline in the Horn of Africa by 10 percent (Musau, 2021).

Ogallo, et al., (2018) conducted a study using downscaled Coordinated Regional Downscaling Experiment (CORDEX) RCMs data to investigate climate change projections and their potential impacts on Somalia. The study focused on projected changes in rainfall and temperature for the periods of 2030, 2050, and 2070. Their findings indicate that Somalia's future livelihoods and development will face increased threats from climate extremes unless effective climate-smart adaptation strategies are developed and integrated into national development plans.

Several studies in the region have highlighted the impacts of climate change on pastoralists, including animal and human disease epidemics, loss of livestock and human life, reduced pasture availability, water contamination and depletion, and disruptions to production systems (Ayele, Dedecha, & Duba, 2020; Tamene, et al., 2023). However, there is a lack of comprehensive information and limited prior studies that have closely assessed the scale of climate change and its effects on Somalia's pastoralists. This knowledge gap hampers policymakers in making informed decisions regarding environmental conservation and pastoralist development projects. This paper aims to fill that gap by examining the climate change effects on Somalia's pastoralists. The specific objectives of this review are to **(1)** examine climate change effect on Somalia's pastoralists, and **(2)** provide policy recommendations to decision-making authorities and interest groups. The paper seeks to address the following questions: **(1)** what are the observed impacts of climate change on the pastoralists of Somalia over the recent-past

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decades?, **(2)** How resilient are the pastoralists against climate change?, **(3)** How effective have been the recent policy responses by Somalia to improve the resilience of its pastoralists?, and **(4)** What are the possible policy solutions to repsond to predicted climate change impacts in the coming decades?

2. Methodology

The researcher conducted a comprehensive literature search concentrating on the main research databases. Scopus, JSTOR, Science Direct, Google Scholar and other journals were included in the databases. In addition, published materials and documents from the databases of key organiatons, such as the Intergovernmental panel on Climate Change (IPCC), The World Bank (WB), Somalia Water and Land Information Management (SWALIM), Food and Agricultural Organization (FAO), and among other internation non-governmental organizations were examined. A qualitative method has been used for this study to analyze the climate change effects on Somalia's pastoralists. A preliminary desk review based on the analysis of secondary sources and documents consultations in both English and Somali languages were conducted to identify the climate change and its effects on pastoralists. Literature on climate change and environmental policies, and the role of the political actors were evaluated and analyzed to develop an analytical and emprical data interpretation framework. To gather the relevant literature for analysis, the study used secondary literature published between 2013 to 2023 for reviewing and analyzing the recent trends. Google and google scholar were used as a search engine. The study employed an approach to the systematic review and synthesis of findings from several research known as a "narrative synthesis" that predominantly uses words and text to summarize and explain the synthesis's conclusions (Popay, et al., 2006).

To explore climate change effects on Somalia's pastoralists, a keywords, namely; recurrent droughts, flash floods, climate adaptive solutions (adaptive and transformative solutions), displacement, climate induced migration, livestock, building resilience, short-term mitigation, long-term adaptive strategy, projected climate variability (rainfall), deforestation, and increasing aridity overgazing were usued. Finally, due to the unavailability of pastoralists data in Somalia, the studys adapts the systematic review and synthesis approach consulting diverse published and unpublished documents including reports, policies, and news written in both English and Somali languages. The specific keywords used in this study were manually selected from published articles, journals, news papers, and policies related to climate change and pastoralist. The study was conducted between June 2023 to December 2023.

3. Results

3.1. Retrieved Papers

The search lasted from June 2023 all the way through to December 2023, and it produced a total of 357 papers. The papers considered for this systematic review were published between 2013 to 2023 as indicated in Figure 1.

3.2. Screening Process and Results of Retrieved Papers

After removing duplicates and selecting the relevant papers, 357 papers were properly screened based on their research title and abstract. Considering the inclusion and exclusion criteria, a 156 papers were excluded as a result of the exclusion criteria (duplicate, studies not focused on climate change and its repurcussion on pastoralist/agro-pastoralist communities, and studies that were not related to the context of East Africa). The remaining 201 papers were reviewed closely and 149 of the papers were excluded for different reasons as indicated in Figure 3.2 below. Finally 52 papers qualified to be considered for review since these papers were concentrating the impact of climate change on pastoralists and their livelihoods. The 52 identified publication are provided in Table 1. At the conclusion of the process, the 52 qualified papers for review, where 18 papers that concentrated the impact of climate change on pastoral and livestock, 12 were studies on pastoral adaptation and resilience, 11 studied the impact of climate change on agro-pastoralists, while 9 and 2 were conflict/security and livestock, and environemntal change respectively.

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Therefore, after conducting a comprehensive literature search concerntrating on the climate change effects on Somalia's pastoralist, the researcher considered 52 articles published between 2013 to 2023 as indicated in Figure 1 below. These papers were selected due to their geographical location and other similar circumstances including vulnerability to climate change, pastoral/agro-pastoralists, economic condition, conflict/insecurity, and environmental change.

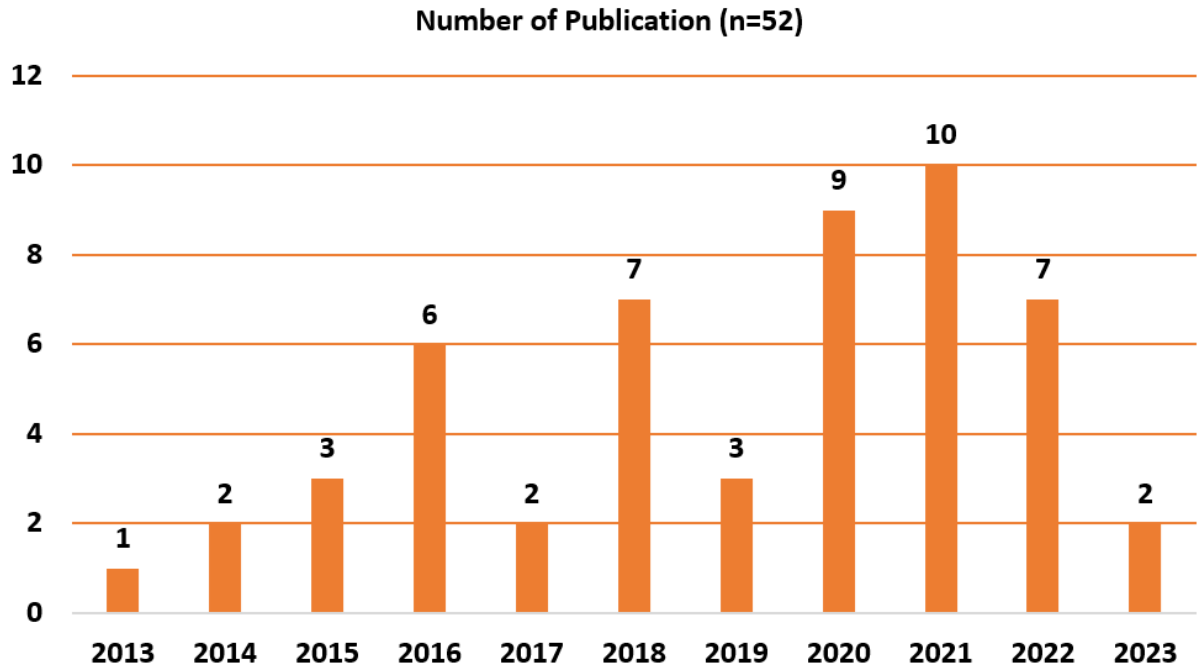

Figure 1.
Number of publications in each year.

As indicated in figure 2 below, using keywords, research databases were searched on Google Scholar Scopus, JSTOR, Science Direct, IJCCSM, AJCC, CMSD, Climate Analytics, J. Arid Environ., ILRI, J. Environ. Manage, JAPR, and among other publications by the World Bank (WB), Intergovernmental panel on Climate Change (IPCC), Food and Agriculultural Orgnization (FAO), and Food Security and Nutrition Analysis Unit, Somalia (FSNAU).

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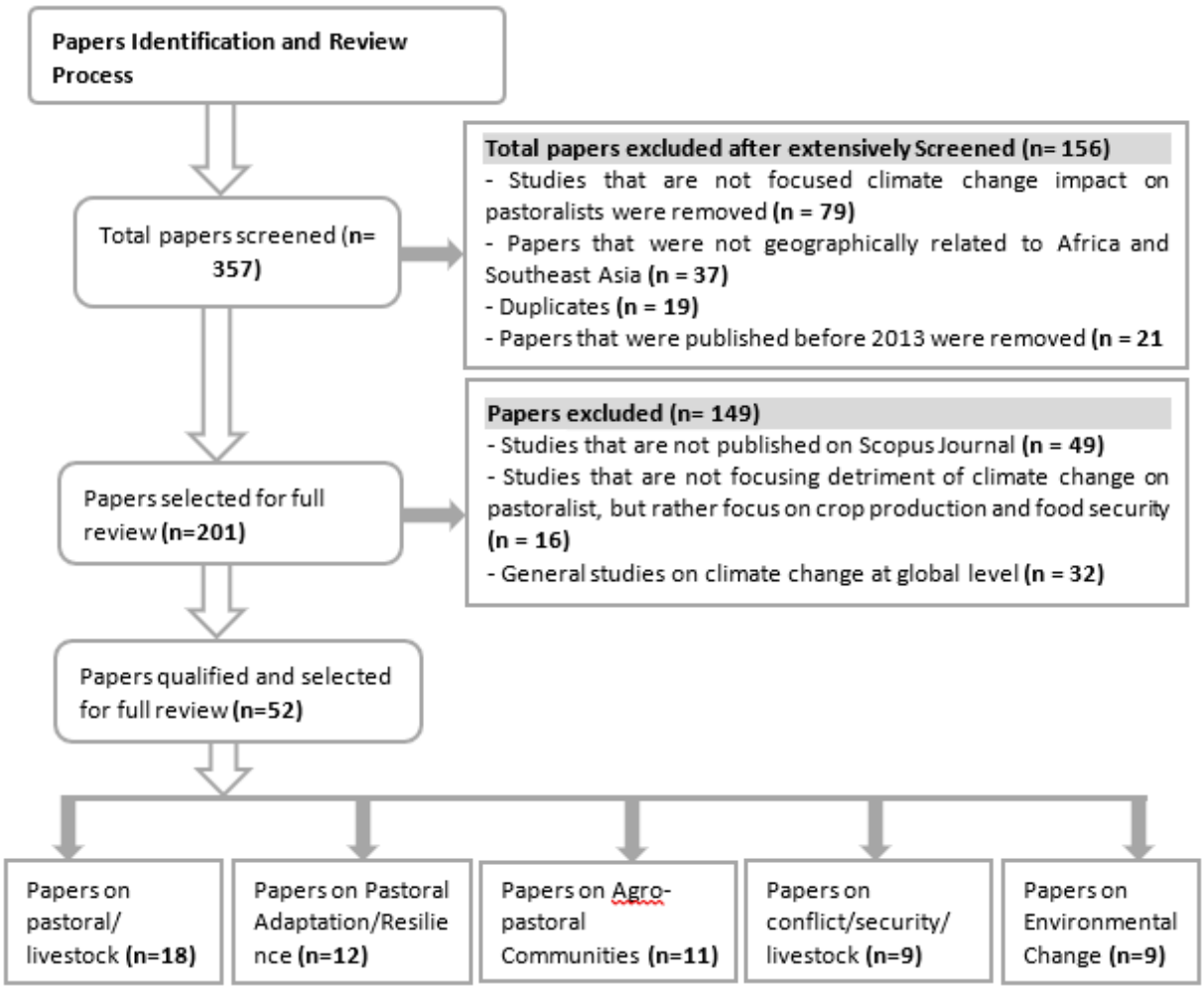

Figure 2.
Paper identification and review process.

4. Discussion

Droughts have severe consequences for livestock, including dehydration, malnourishment, reduced fertility, and even death. Livestock is a vital asset and source of income for pastoralists, and the severity of droughts, floods, and diseases leads to significant losses in livestock herds, thereby affecting the livelihoods of pastoralists (Ahmad & Afzal, 2021; Twumasi & Jiang, 2020). Droughts, in particular, are one of the most devastating meteorological events, gradually impacting community livelihoods over time, but they are not fully understood Lelamo, et al., (2022. Pastoralists have employed various adaptation and coping mechanisms, but conflicts and insecurities, such as livestock raids, pose significant barriers to effective adaptation (Opiyo,et al., 2015). Pastoralism plays a crucial role in the economies of many East African countries, contributing significantly to their GDP. For instance, in Somalia, it accounts for approximately 40 percent of the GDP and over 80 percent of the country's total exports (UNDP, 2015; WB, 2018), while in Ethiopia, the livestock sub-sector contributes 45 percent to the agricultural GDP (FAO, 2017).

Sub-Saharan Africa has been affected by harsh weather due to climate change, with drought being a prominent extreme weather event. This poses a threat to livestock production in the region, which is a vital source of food and income (Serdeczny, et al., 2016). Pastoralists, who concentrate their livestock

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grazing on limited areas, are particularly vulnerable to climate change, leading to increased vulnerability and livestock mortality (Descheemaeker, et al., 2016; Ndiritu, 2021). Studies have highlighted the negative impacts of climate change on cattle production in Tanzania, such as reduced rainfall, rising temperatures, prolonged droughts, water and forage shortages, and increased cattle deaths and diseases (Kimaro, et al., 2018). Limited access to modern disaster risk reduction strategies and early warning systems further exacerbates the risks faced by pastoralists (Nkuba, et al., 2019).

Different agricultural and livestock adaptation techniques have been observed among pastoral and agro-pastoral communities, including supplemental feeding, herd destocking, livestock species diversification, and herd movement (Menghistu, et al., 2020; Inman, et al., 2020). Climate change not only affects crop yields but also impacts the productivity, quality, and reproduction of livestock species, posing economic and socio-cultural threats to the pastoral industry (Uddin & Kebreab, 2020). Despite the daunting challenges that pastoralists face, Nyariki & Amwata (2019) affirmed that through both traditional and non-traditional pastoral principles, pastoralism is a significant contributor to Kenya's economy. Honey, gum-resins, firewood, fishing, and tourism are some of the non-traditional enterprises that are increasingly contributing to the lives of pastoralists. Adaptation to climate change among agro-pastoralists is influenced by factors such as knowledge of climate change, access to credit, and agricultural practices, while limitations such as age, gender, poverty, household size, and lack of credit hinder effective adaptation (Kgosikom, et al., 2018).

The Somali region of Ethiopia has experienced severe droughts, leading to livestock losses and reduced rainfall over the years (Lelamo, Shenkut, & Abdilah, 2022). Precipitation decreased significantly, resulting in higher average temperatures. The Korahe zone in the Somali region was particularly affected by severe droughts between 2015 and 2017 (FAO, 2017). In response to the prevailing drought, cattle keepers in the Southeastern region of Ethiopia have been transitioning to drought-resistant livestock species such as camels and goats (Habte, et al., 2022). Climate change has been perceived by pastoral and agro-pastoral communities in the region through decreasing rainfall patterns, delayed monsoon seasons, rising temperatures, and heat stress trends (Habte, et al., 2022; Uddin & Kebreab, 2020; Abrham & Mekuyie, 2022; Lelamo, et., 2022; Kimaro, et al., 2018).

Decreased rainfall, water scarcity, increased temperature, drought intensities, declining forage quality and availability, reduced livestock performance, heat stress, and the risk of animal diseases have been reported by pastoral and agro-pastoral communities in the Southeastern region of Ethiopia between 1986 and 2017 (Habte, et al., 2022). Droughts in the Somali region of Ethiopia have caused significant cattle mortality, with a substantial increase in deaths between 1990 and 2003 (Erena & Bogale, 2022). Similarly, Somalia has been severely affected by droughts, resulting in pasture and water shortages and the deaths of millions of livestock (Farmers Review Africa, 2022; Save the Children, 2022). The drought has had a devastating impact on the population, with millions of people experiencing food insecurity, displacement, and lack of access to safe water (OCHA, 2022). Climate-related crises are expected to persist in Somalia, affecting millions of people due to ongoing drought conditions, conflicts, and high food prices (FSNAU, 2022). The drought has also had a significant toll on human lives, with an estimated 43,000 deaths, primarily among children under five years old (UNICEF, 2023).

4.1. Causes of Climate Change

Nomadic pastoralists frequently express their concerns about the increasing frequency and severity of severe events, with drought being a major threat to their way of life. According to FGS & UNCCD (2020), the lack of rainfall is the primary factor contributing to drought. Extreme weather and climate change have made Somalia particularly vulnerable to phenomena including prolonged drought, flash floods, irregular rainfall, disruption of the monsoon seasons, high winds, cyclones, sandstorms, and dust storms. Over the past 25 years, Somalia has experienced a rise in the frequency of extreme weather events and rapid-onset disasters (NUPI, 2021). Droughts are becoming increasingly frequent in all dryland pastures. In Somalia, droughts have become more often and severe due to human-caused climate change, and decades of fighting have severely weakened the country's ability to respond to disasters

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(IRC, 2022). The severity and frequency of droughts have made it increasingly challenging for pastoralists to sustain their livestock (Welsh, 2021). However, Nkuba, et al., (2021) suggest that pastoralists with large livestock are more likely to rely on scientific forecasts to guide their migration to distant regions in response to the effects of drought and flooding. For agro-pastoral communities in Somalia, agriculture and livestock rearing are the primary sources of livelihood, with over 70% of Somalis relying on climate-sensitive practices (FGS, 2020).

Livestock productivity in the Somali regions is negatively affected by the degradation of rangelands, vegetation loss, and other forms of land degradation, exacerbated by frequent and ongoing droughts (FGS, 2020). The Somali government's National Adaptation Programme of Action (NAPA, 2013) identifies meteorological events such as droughts, strong winds, significant flooding, and high temperatures as contributing factors to the loss of livelihoods, livestock, and increasing poverty. In Kenya's drylands, more frequent, longer, and severe droughts are impacting water resources, leading to drying of dams and wells, animal mortality, reduced earnings, increased poverty, and fatalities (Tugjamba, Walkerden, & Miller, 2023). Climate change in South Sudan, as evidenced by meteorological data, is associated with conflicts, droughts, and floods, with increasing temperatures and decreasing rainfall since the 1970s, and an increase in droughts and floods since 1900 (Tiitmamer, Mayai, & Mai, 2018).

Somalia's vulnerability to climate change is exacerbated by its geography, socio-economic challenges, and inadequate infrastructure. The lack of mobility leads to overgrazing of accessible rangelands, negatively impacting pastoral productivity and their assets (GIZ, 2022). Activities such as fossil fuel consumption, deforestation, and unsustainable agriculture in Somalia contribute to greenhouse gas emissions and exacerbate climate change. Drought, in particular, has significant environmental and livelihood consequences in Somalia, making it a major driver of climate change. Addressing these concerns requires a collaborative effort among the Somali government, international community, civil society organizations (CSOs), and the private sector to mitigate the impact of climate change, promote sustainable land use practices, and adapt to its effects.

4.2. How Do Climate Change Impact Pastoralists

The detrimental impacts of climate change encompass prolonged droughts, delayed rainy seasons, and severe floods, leading to economic losses, food insecurity, and resource scarcity. These consequences can further escalate social tensions and trigger conflicts (Ng'ang'a, et al., 2020; Kabubo-Mariara & Kabara, 2015). According to a recent study by Welsh (2021), agricultural yields have decreased by 21% globally over the past 60 years due to climate change. In this time, relatively warm regions like Africa have seen the greatest overall effects of climate change, which have contributed to a 33 percent decline in yield. Based on the report presented by FAO (2021), infestations, diseases, and pests in crops and livestock are a significant stressor for these agricultural subsector. Losses in livestock and crop production due to biological catastrophes accounted for **9 percent** for the period between 2008 to 2018 in Africa (FAO, 2021). The livestock production in Africa is also threatened by climate change. Increased temperatures, shifting patterns of precipitation, an increase in the frequency of extreme weather events, an increase in heat stress, and decreased water availability are anticipated to have a negative impact on livestock production and productivity worldwide (Welsh, 2021). Moreover, recurrent droughts, which have a negative impact on pastoral livestock productivity, are one of the factors that amplify the negative effects of climate change as it has the greatest impact on livestock production (Megersa, et al., 2014). Similary, according to Soest (2020), the impact of climate change might lead to an increase of conflict, threaten food security and the livelihoods of vulnerable communities.

Moreover, Tarif's study (2022) in West Africa shows that there is a mounting evidence that violent conflict is more likely and more intense as a result of climate change's negative impact; deteriorating livelihood conditions, growing migration and shifting pastoral movement patterns, armed group tactical concerns, and elite exploitation of community grievances. Similarly, climate change can also cause problems between states (intrastate conflit) and there is more chance of violence and danger amplified

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by climate change, especially if there is no effective governance across borders (Serdeczny, et al., 2016; Tarif, 2022; Soest, 2020).

Pastoralists bear the brunt of drought's direct consequences, including livestock losses, decreased livestock prices, health issues, increased food costs, and water resource depletion. Changes in water availability, rising temperatures, and rainfall variability all endanger the livelihoods of pastoralists. The increasing frequency and severity of droughts, combined with other climate shifts, pose a significant threat. Climate change affects various aspects of agriculture, such as yields, animal production, land quality, on-farm storage, water supply, labor movement, population dynamics, farm income, and farmer skills (Erena & Bogale, 2022). Variability and changes in climate have negative impacts on rural populations and their livelihood strategies (Kolawole, et al., 2016). These climate change consequences intersect with socioeconomic changes that marginalize nomadic lifestyles. Climate change also exacerbates existing tensions and resource conflicts, leading to more social tensions and conflicts (Schmidt & Pearson, 2016).

Households equipped to deal with climate-related hazards can significantly reduce their vulnerability to negative consequences. Diversified livestock can ensure food security, protect biodiversity, improve diets, increase family income, and enhance the resilience of pastoralists to climate change (Mekuria & Mekonnen, 2018). Aditionally, understanding long-term patterns, such as climate change, can also help pastoralist manage their resources to adapt over time (Lwanga-Ntale & Owino, 2020). Semi-arid regions are particularly vulnerable to the effects of climate change processes including rising maximum temperatures and increasingly erratic rainfall exacerbated by population growth and environmental degradation have reduced natural resources needed for rural livelihoods, worsening living conditions and perhaps increasing conflict (Schmidt & Pearson, 2016). Therefore, climate change has a considerable effect on Somalia's pastoralists, affecting their livelihoods and threatening the natural resources and livestock that pastoralists heavily depend on. Water scarcity and recurrent droughts, conflict and migration, food insecurity, and livestock diseases are the major impact of climate change. A multi-faced climate change approach including mitigation measures, adaptation strategies, effective practices of sustainable land use, and water harvesting such as building dams and water reservoir is inevitable to address effectively the impacts of climate change on Somalia's pastoralists. The figure 3 below presents some of the climate change impacts on pastoralists. Its purpose is not to provide an entire list, but rather to illustrate the myriad of potential climatic impacts that might be felt by pastoralists as well as the complexities of climate change.

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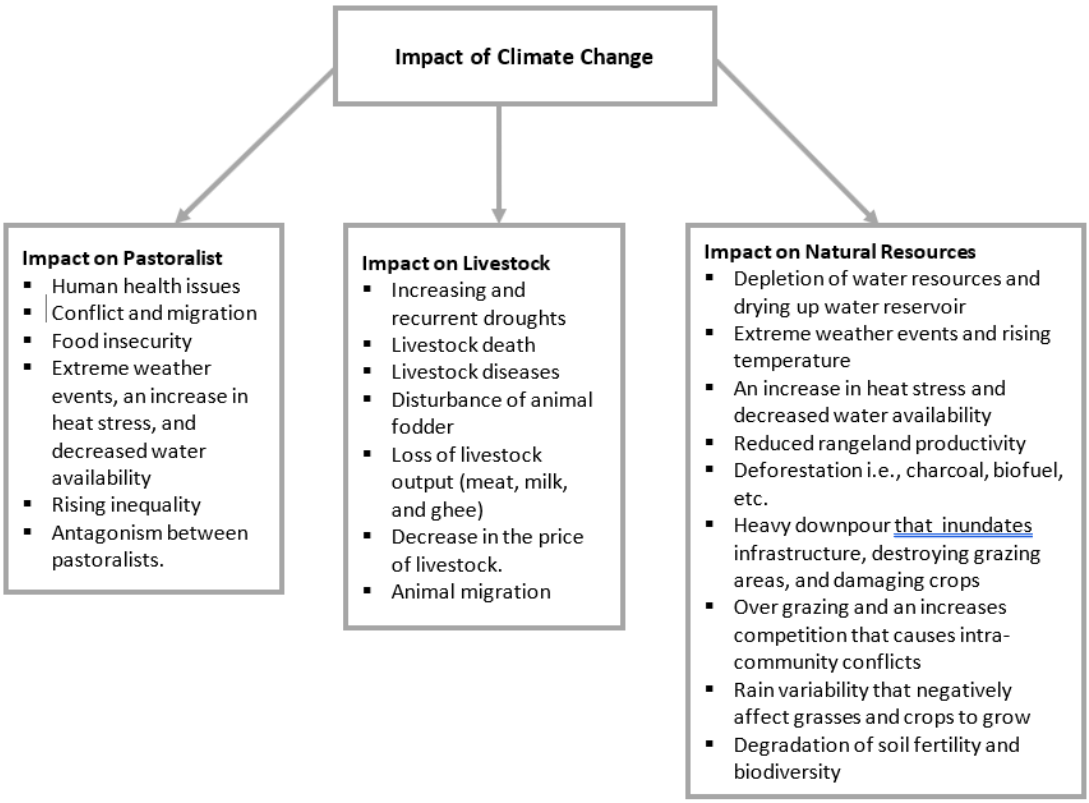

Figure 3.
Impact of climate change on Somalia's pastoralist.

4.3. Pastoralists' Adaptation Approaches

Nomadic pastoralists have evolved their adaptation strategies through extensive observations of the landscape while herding their livestock, and these approaches are changing in response to climate and socio-ecological changes. Educational status can positively influence adaptation approaches among agro-pastoralists, but limited options and increased climate variability intensify their vulnerability (Tamene, et al., 2023). Different livestock species exhibit varying levels of adaptability, with camels showing the highest capability, followed by goats and sheep, while cattle are more vulnerable to climate change impacts (Megersa, et al., 2014). According to (Tugjamba, Walkerden, & Miller, 2023), the pastoralists adaptation tactics are divided into four categories: adjusting movement patterns to better match the availability of water and feed; modifying herd composition; using planting, feed storage, and water storage to decrease risk; and diversifying their livelihood. Migration is one approach for adapting to climate change that can lead to improved outcomes (Welsh, 2021). Adaptation is shown when households use multiple climate strategies, such as livestock migration, rearing of mixed herds (i.e., goat, sheep, camel), livestock commercialization, irrigation, better livestock breeds, destocking, fodder production and selling livestock to buy animal feed, diversification of livelihoods or income, and climate insurance to lessen the impact of climatic and non-climatic shocks that threaten their way of life (Snaibi, Mezrhab, Sy, & Morton, 2021). This shows that households can change and respond to the effects of climate change (Ng'ang'a, et al., 2020; Bryan, et al., 2013; Mekuyie & Mulu, 2021).

The pastoral households are diversifying their livelihoods by adopting numerous tactics, such as the migration of livestock and irrigation, in addition to livelihoods that are not reliant on the climate (non-climate dependent livelihoods), such as small trading, exploring alternative livelihood strategies, and ideas for income generation (Bryan, et al., 2013; Lind, et al., 2020). Unfortunately, the dryland of Eastern Africa (EA) are expereincing actual climate change, making them the worst-affected region in

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the world due to their sensitivity, high levels of vulnerability, and limited capacity for adaptation (Ng'ang'a, et al., 2020).

Increased migration among pastoralists as an adaptation measure has led to resource competition in less severely impacted regions Tarif (2022; Welsh (2021). The effectiveness of climate adaptation strategies is limited by insufficient livestock husbandry knowledge and inadequate financial resources (Megersa, et al., 2014). Borana pastoralists in Ethiopia also face constraints in coping and adapting to climate extremes (Ayal, Radeny, Desta, & Gebru, 2018). However, the extent to which pastoralists are able to adapt to climate change is influenced by a variety of factors such as socioeconomic status, climate perceptions, geographical location as well as a pastoralist's herd size that could increases the frequency and variety of adaptive practices (Snaibi, Mezrhab, Sy, & Morton, 2021). Additionally, Tesfaye & Seifu (2016) suggest that government support is necessary for the development of more effective climate change adaptation strategies.

Somali pastoralists have a long history of livestock mobility and migration, and they have developed different copying approaches to limit the effects posed by climate change, including moving their livestock to regions with better water resources and pasture, diversifying their animals, small-scale businesses (farming, trading, etc.), and livestock breeding. Unfortunately, due to the magnitude of climate change over the past 40 years, it is difficult for pastoralists in Somalia to adapt to climate change because the country lacks the administrative capacity to plan and fund adaptation efforts (GCF, 2015).

4.4. Pastoralists' Resilience Approaches

In Somalia, vulnerability, conflict, and natural disasters are deeply intertwined, and the uncertain sustainability of households and communities poses the greatest challenge for the most vulnerable populations (SCI, 2016). Environmental degradation and rapid population growth undermine household resilience and raise concerns about the future viability of livelihoods, particularly pastoralism (Lwanga-Ntale & Owino, 2020). The increasing vulnerability and declining resilience to climate change place pastoralism at significant risk, although mobile pastoralism demonstrates more resilience compared to agro-pastoralism due to access to larger rangelands and a diverse range of livestock (Michael, 2017). On the other hand, enhancing market access, social safety nets, local infrastructure improvements, livestock extension services, asset-based support rather than food aid, and fundamental services like education would all help pastoralist/agro-pastoralists become more resilient to climate change ((Gebeyehu, Snelder, Sonneveldd, & Abbinka, 2021); Melka, Jordaana, & Mekuyie, 2018).

Traditional weather forecasting has helped pastoralists avoid losing animals, their major source of income (Joseph & Kaswamila, 2017). However, incorporating climate risk information into national and local planning and budgeting remains lacking in Somalia, highlighting the need for support and investment in climate resilience (GCF, 2015). The problem originates from the unstable political history of Somalia. Additinally, Communities often lack the financial, technological, and informational resources, as well as the expertise, to build resilience to climate change and prepare for extreme weather impacts at the local level (UN, 2017). Rising temperatures and considerable interannual and seasonal variability in rainfall have been having a negative effect on livestock and crop production (Abrham & Mekuyie, 2022). Pastoral and agropastoral families have adapted to climate change for generations. However, with the rise of recurrent droughts, increased geographical and temporal rainfall variability, and preexisting socioeconomic disadvantages, pastoralists have grown less resilient to climate change and unpredictability in recent years (Abrham & Mekuyie, 2022). Simalarly, according to Concern Worldwide (2022) due the failed seasons over the past consecutive five years, Somalia is hit by the worst drought in 60 years and this has led to an official declaration of famine in the country. The recurrent droughts in Somalia has had devastating effects on the livelihoods of pastoralists, forcing many to evacuate drought-stricken areas and rely on humanitarian assistance.

The capacity of pastoralists in Somalia to continue sustainable livelihoods has been hampered by years of political and economic marginilisation, development of ineffective policies, rising resource competition, and an increase in extreme weather conditions. Somalia's partoralists require access to financial resources for quality basic services such as education, health services, flood-proof infrastructure

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and community facilities, technical assistance and financial support, opportunities for livestock market promotion, early warning systems for drought and flood to mitigate their effects, climate information accessibility, and efficient conflict-resolution techniques. These approaches will increase the resilience of pastoralists against climate change.

5. Conclusion and Recommendations

To enhance adaptation among pastoralists in Somalia, it is crucial for the government to implement programs that increase access to climate change information and effective adaptive strategies. Policy options that facilitate credit access, investment in livestock production and technologies, and the introduction of livestock breeds suitable for drier conditions should be made available to reduce pastoralists' vulnerability to climate change. Livestock production is a key economic sector in Somalia, accounting for a significant portion of GDP and export earnings, so pastoral communities require access to drought-resistant crops, early-maturing varieties, and improved livestock breeds. Implementing interventions related to water, such as small-scale irrigation and water harvesting during favorable rainy seasons, is essential to enhance local resilience to climate change.

Over the past 40 years, Somali pastoralists have observed a decrease in rainfall and experienced various climate-induced challenges. Recurrent droughts, livestock mortality, rainfall variability, depletion of traditional water sources, pasture degradation, climate-induced migration, conflicts arising from droughts and floods, and declining livestock prices are among the problems they face. In response, pastoralists have adopted adaptation strategies such as transferring livestock to better grazing areas, temporary migration, adopting drought-resistant crops and livestock, early planting, and relocating to other settlements. However, conflicts over livestock raids and a sense of insecurity pose significant barriers to desirable adaptation and coping mechanisms. Climate change contributes to insecurity and resource competition among pastoralists, particularly in the water sector, as declining groundwater levels increase water prices and the likelihood of conflicts.

The pastoral sector, which holds great economic and socio-cultural significance, faces substantial challenges posed by climate change. Understanding the causes and mechanisms is crucial for developing successful policies to mitigate the negative consequences for Somalia's vulnerable pastoralists. Supporting pastoralists in establishing appropriate traditional coping mechanisms and promoting livelihood diversification through entrepreneurial training, climate education (including Community-based Early Warning Systems and Disaster Risk Reduction), and access to financial markets are essential. Research is needed to identify livestock species, particularly camel and goat strains, that can withstand drought-prone regions in Somalia. Further research is necessary to gain a deeper understanding of how climate change impacts the pastoralism industry, which plays a vital role in the Somali economy.

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