



Research Paper

The Effect of Land Degradation and Environmental Changes on Agricultural Production in Somalia.

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ABSTRACT

Somalia is currently grappling with the huge challenge of considerable climate change, which has an extreme impact across various sides of its communities. Land degradation has significantly affected agriculture and livelihood, influencing the well-being and development track of the Somali population. Agricultural production declined, attributed to factors such as land degradation, security restrictions to farming activities in the southwest region, poor infrastructure, recurrent droughts, floods, and conflicts, which have subsequently reduced productivity and impacted the economy of pastoral communities.

This study employs a mixed-methods approach, utilizing remote sensing and GIS tools to assess land degradation caused by droughts, floods, and temperature fluctuations. Field observations and household surveys evaluate real-time agricultural conditions, grazing areas, socio-economic data, and adaptation strategies. The data was analyzed using the R statistical programming language.

The study found that security issues have the most significant negative impact on agricultural production in Somalia. The study showed a clear upward trend, indicating a considerable temperature increase over the decades. Findings also highlight human activities as major contributors to land degradation. Floods and droughts exacerbate environmental changes in Somalia. Floods are the most frequent, comprising the largest segment of other hazards. Additionally, the study identifies social conflict and security issues as significant contributors to land degradation and decreased farming activities.

This research provides valuable insights into the interplay of environmental factors affecting the country's agricultural landscape and pastoral livelihoods.

Keywords: Climate change, Land degradation, Drought, Pastoral communities

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I. INTRODUCTION

1.1 Background

Somalia has been facing significant issues associated with climatic extremes, including droughts, floods, and severe coastal marine systems, which are invariably linked to the loss of life, property destruction, migration, and resource-based conflicts, among other miseries (Ogallo, Omondi, et al., 2018). Land degradation and environmental changes have significantly impacted agricultural production in Somalia (Omuto et al., 2014). Research has indicated that factors such as land degradation, climate change, and ecological degradation play crucial roles in influencing agrarian productivity in the region (Mohamed & Nageye, 2021).

The impact of climate change, particularly variables like rainfall and temperature, has been studied in maize production in Somalia, highlighting these factors' importance for agricultural planning and management (A. A. Warsame et al., 2021). In Somalia, the agricultural sector, which employs most of the working population, is highly vulnerable to climate change impacts due to its reliance on rain-fed agriculture (King & Washington, 2021). Extreme events like droughts have severely affected agriculture, leading to food insecurity and water scarcity (D. A. Ali et al., 2023). Unsustainable land management practices exacerbated by poverty and population growth have further contributed to the challenges faced by the agricultural sector in Somalia (Thalheimer et al., 2023). The implications of land degradation on agricultural productivity have been well-documented, with studies indicating that land degradation reduces the productivity of agricultural land, damages essential resources, and causes biodiversity losses (A. A. Warsame & Turyasingura, 2022).

The production of charcoal involves the burning of biomass, leading to the release of carbon dioxide (Woolf et al., 2010). This process contributes to deforestation and land degradation, as large numbers of trees are felled to produce charcoal (Yusuf et al., 2021). The environmental changes resulting from charcoal production can have adverse effects on agricultural productivity in Somalia (Abdi, 2022). Studies have shown that climate-sensitive agricultural production in Somalia has been significantly affected by extreme climate events (Jama et al., 2023).

1.2 Research Gaps or Problem Statement

This study examines the impact of land degradation and environmental changes on agricultural production in Somalia. It aims to analyze the significant factors contributing to the agricultural decline, including temperature increases, precipitation variability, and the frequency of natural hazards. The research focuses on understanding how these environmental changes affect farm productivity and sustainability in Somalia, providing insights into the challenges faced by the agricultural sector in the region.

Since there was no experience and proper extension services offered to the farmers in Somalia after the collapse of the central government of Somalia, agricultural farmers in Somalia have a lot of problems, including droughts, Floods, lack of governance, diseases, environmental impact, and lack of agricultural equipment. Also, consider the seasonality of water availability and lack of knowledge of water conservation.

1.3 State Research Questions

How to understand the effect of land degradation and environmental changes on agricultural production in Somalia?

What are the major causes of land degradation and environmental changes in agricultural production in Somalia?

1.4 The Significance of the Study

The findings of this study will serve as guidelines for local authorities, civil society, NGOs, and the international community operating in Somalia. The findings of the study will provide research-based and up-to-date information to future researchers and academicians about factors causes of land degradation and environmental changes on agricultural production in Somalia; thus contributing to the body of knowledge about the subject under investigation.

II. LITERATURE REVIEW

Somalia's climate is expected to continue to change and Projections anticipate an increase in mean annual temperature of between 3.2°C to 4.3°C by the end of the century (Meeking, 2013). The annual number of very hot days (daily maximum temperature above 35°C) is projected to rise with high certainty all over Somalia (Ahmad et al., 2022).

Studies by Osima et al., (2018), and (Haile et al., 2020) emphasize the projected climate changes in the Greater Horn of Africa, including Somalia, which are anticipated to have adverse effects on livelihoods due to reductions in rainfall and alterations in wet and dry spells.

These disasters have destroyed ecosystems and posed threats to food security, leading to increased conflicts over scarce resources (Weimer et al., 1993). The research highlights how climate variability, including droughts and floods, has contributed to food insecurity in the country, particularly affecting vulnerable populations (Costantini et al., 2021).

Land degradation in Somalia is a critical issue exacerbated by various factors such as deforestation, overgrazing, and poor cultivation practices (Liao et al., 2020). The impact of land degradation on agricultural productivity in Somalia has been studied, highlighting the need to measure the effects of environmental changes on crop production (Mohamed & Nageye, 2021). Additionally, a debt-based approach has been proposed to assess land degradation globally, emphasizing the importance of understanding and addressing this environmental issue (Wuepper et al., 2021). Efforts to achieve land degradation neutrality require interactive systems to map and inform decision-making, as demonstrated in case studies such as in Ecuador (Teich et al., 2023). Land degradation is a gradual, negative environmental process accelerated by human activity, which lowers land's productive capacity (Collins, 2016). Due to its gradual and subtle nature, in the initial stages, it can go unnoticed for long periods. When it reaches its final stages, observable features are manifested, such as gully erosion, widespread vegetation colonization by alien species, and agriculturally 'exhausted' soil (Africa, 2010).

The charcoal trade, a traditional economic activity in Somalia, has been identified as a contributor to land degradation, further exacerbating the challenges faced by the agricultural sector (Omuto et al., 2014). Deforestation, driven by factors such as the charcoal trade and environmental changes, is a major concern in Somalia and has been linked to frequent droughts over the years (Musei et al., 2021). The loss of forest cover not only contributes to land degradation but also impacts the overall environmental stability of the region. Reports of pastoralists turning to charcoal trade due to bans on livestock exports highlight the complex

relationship between environmental policies, economic activities, and land use practices in Somalia (Ogallo, Mwangi, et al., 2018). The consequences of deforestation and forest degradation extend beyond environmental concerns, affecting biodiversity, water cycling, and contributing to global warming (Ogallo, 2018). The impact of charcoal production on forest degradation underscores the need for sustainable land management practices to mitigate the adverse effects on forest cover and ecosystem health (Sedano et al., 2016). Addressing the drivers of deforestation and land degradation, such as agricultural expansion and timber harvesting, is essential to preserve the ecological balance in Somalia (Jagger & Shively, 2014). Efforts to combat deforestation and promote sustainable land use practices are crucial for mitigating the impact of land degradation on charcoal production and forest cover in Somalia. Strengthening land tenure, implementing forest protection measures, and promoting alternative livelihoods can help reduce the drivers of deforestation and foster environmental conservation in the region (Chan & Sasaki, 2014).

In the context of African dryland ecosystems, changes controlled by soil water play a significant role in land degradation processes (Musei et al., 2021). National assessments of land degradation, like the framework developed for Somalia, are essential for understanding the gradual negative environmental processes accelerated by human activities (Omuto et al., 2014). These assessments are crucial for identifying areas at risk and implementing strategies to combat land degradation and promote sustainable land use policies (Diriye et al., 2022).

Studies have shown that climate change affects water resources and increases the vulnerability of agricultural systems due to land degradation in the region (A. I. Ali et al., 2023). Projections suggest that Somalia is at risk of facing more climate extremes, which could threaten future development and livelihoods without effective adaptation strategies (Ogallo, Omondi, et al., 2018). Smallholder farmers in Somalia are particularly vulnerable to climate change variability, underscoring the importance of evaluating adaptation strategies to minimize the impact on livelihoods (Tahiru & Legon, 2019). Climate risks in Somalia are a significant concern as the country grapples with challenges such as rising temperatures, droughts, and flash floods (A. A. Warsame & Sarkodie, 2022). Projections indicate that Somalia faces future threats from climate extremes, highlighting the urgent need for effective adaptation strategies (Ogallo, Omondi, et al., 2018). The Intergovernmental Panel on Climate Change classifies Somalia as a high-risk country for climate change (Farbotko et al., 2022). The country's vulnerability is exacerbated by sustained conflict cycles, geopolitical shocks, and extreme weather events, with populations in conflict-affected areas being particularly vulnerable to climate change impacts (Thalheimer et al., 2021). Additionally, the impact of climate change on water resources is increasing the risk of flooding in Somalia (A. I. Ali et al., 2023).

Understanding the perception of climate variability and its impact on pastoral systems in Somalia is crucial for addressing climate risks (Abdullah & Mohamed, 2022). Young people's views on forestation as a climate change mitigation strategy in post-conflict Somalia are influenced by various factors, emphasizing the need for tailored approaches to climate adaptation (Jama et al., 2023). The agricultural sector in Somalia, which is essential for the country, is at risk from climate change impacts, affecting food security and livelihoods (King & Washington, 2021). Efforts to mitigate climate change impacts on food security in Somalia are vital, focusing on maintaining a stable environment and implementing actionable recommendations (Said & Bashir, 2023). The susceptibility to malaria risk in Somalia highlights the importance of mapping and understanding health risks associated with climate change (Noor et al., 2012). Undernutrition among children in Somalia is influenced by geographical regions and livelihood systems, underscoring the need for region-specific interventions and climate-smart food production (Donkor et al., 2022).

III. METHODS AND MATERIAL

3.1 Research Design

This study employs a mixed-methods approach, integrating qualitative and quantitative techniques to assess the impacts of land degradation and its causes on agricultural production in central and southwest Somalia.

3.2 Materials

Remote sensing and Geographic Information System (GIS) tools were utilized to evaluate and monitor land degradation. These tools provided spatial and temporal data critical for assessing the extent and patterns of land degradation over time. The analysis involved processing satellite imagery and other geospatial data to detect changes in land cover and land use, identify areas of severe degradation, and correlate these changes with climatic factors such as droughts, floods, and temperature fluctuations.

3.3 Data Collection and Sample Size

Secondary Data: Secondary data were collected from Somalia Water and Land Information Management (SWALIM) and the Food and Agriculture Organization of the United Nations (FAO). This data was used for time series analysis to identify trends and evaluate different years.

Primary Data: Extensive field observations were conducted to gather first-hand data on the current agricultural conditions, the status of production, and visible signs of land degradation. The 120 samples included farmers, pastoralists, and academic respondents. These surveys and questionnaires captured information on household demographics, income sources, land use practices, and adaptation strategies employed by communities to cope with environmental stressors.

3.4 Statistical Methods

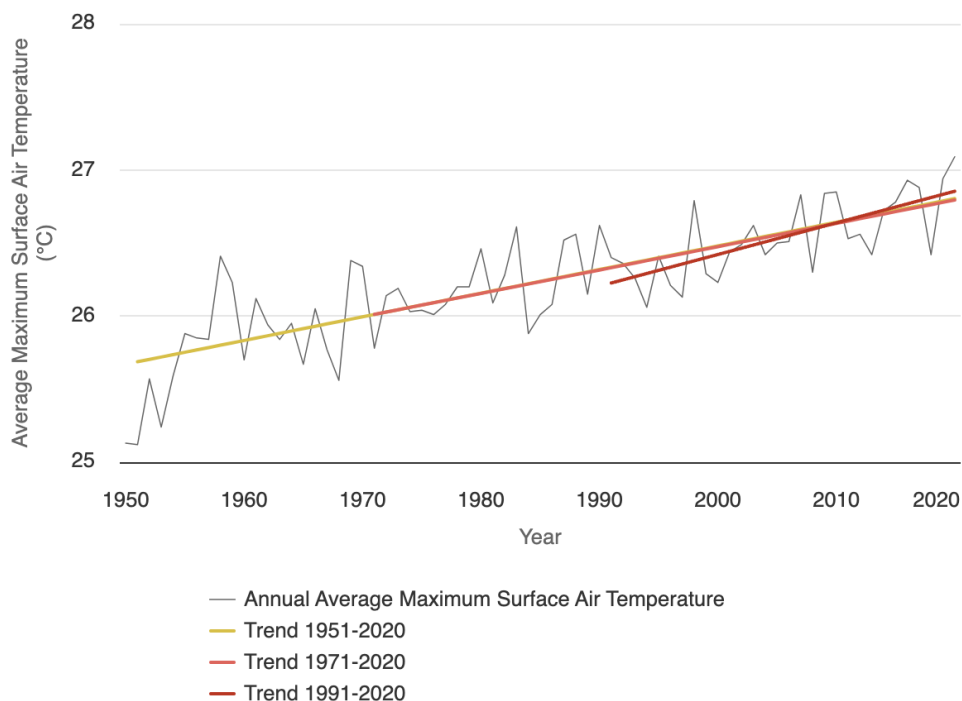
The collected data were analyzed using the R statistical programming language. R was chosen for its robust statistical capabilities and flexibility in handling complex data sets. Multivariate analysis techniques were employed to identify the major causes of land degradation indicators and agricultural production declines.

IV. RESULTS AND ANALYSIS

4.1 Average Maximum Surface Air Temperature in Somalia

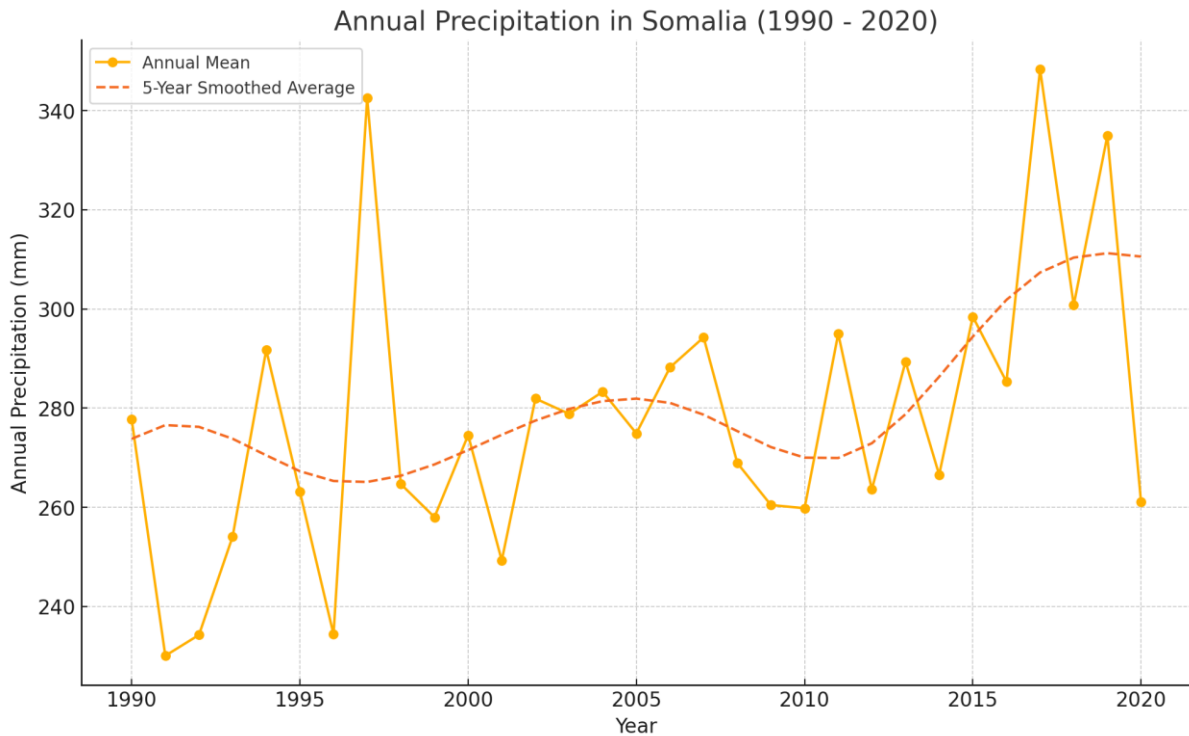
The graph below illustrates the trend in average maximum surface air temperatures in Somalia from 1951 to 2020. It showed a clear upward trend, indicating a significant temperature increase over the decades. The trend lines for different periods (1951-2020, 1971-2020, and 1991-2020) highlight that the warming rate has accelerated in recent years. Specifically, the yellow line (1951-2020) shows a moderate increase, while the red (1971-2020) and orange (1991-2020) lines show progressively steeper slopes, reflecting more rapid temperature rises in the last few decades. This acceleration in temperature increase suggests heightened impacts of climate change in the region.

Average Maximum Surface Air Temperature Annual Trends with Significance of Trend per Decade; 1951-2020; Somalia



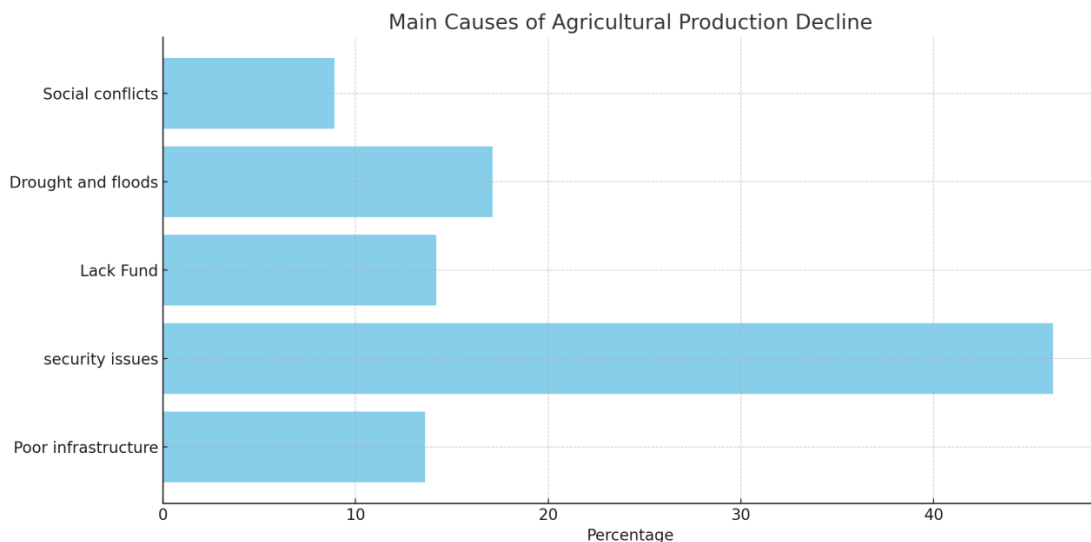
4.2 Annual Precipitation in Somalia

The graph shows the annual precipitation trends in Somalia from 1990 to 2020. The orange line represents the annual mean precipitation, while the red dashed line indicates the 5-year smoothed average, which helps to identify longer-term trends by smoothing out short-term fluctuations. The data showed significant year-to-year variability in annual precipitation, with notable peaks around 1995, 2010, and 2020, and troughs in the late 1990s and early 2000s. Despite this variability, the 5-year smoothed average suggests a general increase in precipitation over the 30 years, particularly from the mid-2010s onwards, indicating a potential shift towards wetter conditions in recent years.



4.3 Main causes of agricultural production decline

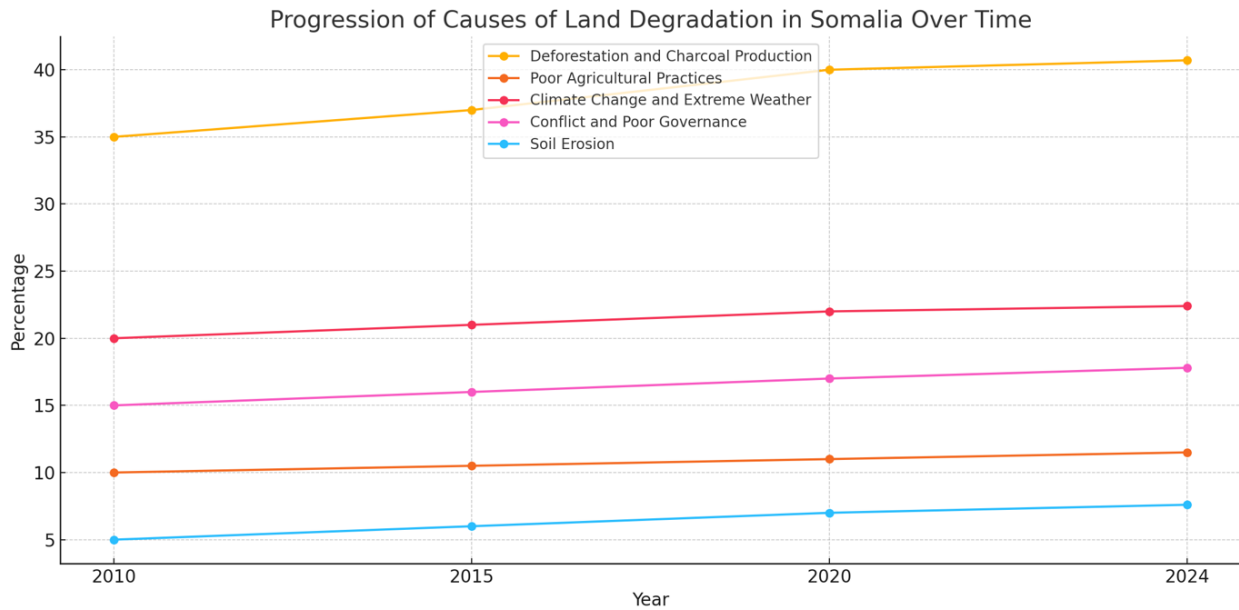
The below bar chart illustrates the primary causes of agricultural production decline, measured in percentages. The leading cause is "security issues," affecting nearly 45% of agricultural output, indicating it is a significant hindrance to production. "Drought and floods" follow, impacting slightly over 25% of agricultural activities, reflecting the vulnerability of agriculture to adverse weather conditions. "Lack of funds" and "poor infrastructure" are also notable factors, each affecting around 20% and 15% respectively, highlighting the importance of financial resources and adequate infrastructure in sustaining agricultural productivity. Lastly, "social conflicts" contribute to about 15% of the decline, suggesting that societal stability plays a crucial role in maintaining agricultural operations. Overall, the chart underscores that a combination of security, environmental, financial, and infrastructural issues critically undermine agricultural production.



4.4 The causes of Land degradation in Somalia

The line chart displayed the hypothetical progression of various causes of land degradation in Somalia from 2010 to 2024. Deforestation and Charcoal Production consistently increased from 35% in 2010 to 40.7% in 2024, highlighting the growing impact of tree cutting for fuel and charcoal on land degradation. Poor

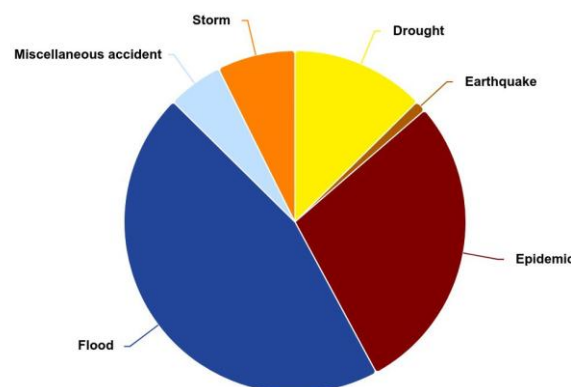
Agricultural Practices showed a gradual rise from 10% in 2010 to 11.5% in 2024. This indicated a slight but persistent increase in the negative effects of unsustainable farming methods. Climate Change and Extreme Weather exhibited an upward trend from 20% in 2010 to 22.4% in 2024, reflecting the increasing frequency and severity of adverse weather events. Conflict and Poor Governance increased from 15% in 2010 to 17.8% in 2024. Persistent conflict and ineffective governance continued to exacerbate land degradation. Soil Erosion started at 5% in 2010 and increased to 7.6% in 2024, indicating that soil erosion due to wind and water became slightly more significant over time.



4.5 Average Annual Natural Hazards in Somalia

The pie chart depicts the average annual occurrences of various natural hazards from 1980 to 2020. Floods are the most frequent, comprising the largest segment of the chart. Epidemics also represent a significant portion, indicating a notable regularity of disease outbreaks over the period. Earthquakes, while less frequent than floods and epidemics, still constitute a considerable part of the natural hazard occurrences. Droughts, storms, and miscellaneous accidents are less prevalent, each occupying smaller sections of the chart, with miscellaneous accidents being the least common. The chart highlights that floods and epidemics are the dominant natural hazards faced annually, underscoring their significant impact compared to other types of natural disasters over the 40 years.

Average Annual Natural Hazard Occurrence for 1980-2020



V. DISCUSSION

The study reported that the annual precipitation trends in Somalia from 1990 to 2020, as depicted in the graph, exhibit significant year-to-year variability with notable peaks around 1995, 2010, and 2020, and troughs in the late 1990s and early 2000s. (Bahaga et al., 2024) discusses the substantial rainfall in Somalia that resulted in flooding, causing significant loss of life and displacement.

Despite this variability, the 5-year smoothed average suggests a general increase in precipitation over the 30 years, particularly from the mid-2010s onwards, indicating a potential shift towards wetter conditions in recent years. This observed increase in precipitation aligns with findings from (Haile et al., 2020), those who noted a significant tendency of increased streamflows in certain rivers, indicating a rise in water availability. Furthermore, (Abdullah & Mohamed, 2022) highlighted that while negative trends in annual precipitation were prevalent in the Mediterranean region, exceptions existed in certain areas showing slight positive trends, which resonates with the overall increase observed in Somalia. Moreover, the study (Haile et al., 2020) emphasized the impact of climate change on Somalia, leading to severe droughts due to its water-scarce nature.

The leading cause is "security issues," affecting nearly 45% of agricultural output, indicating it is a significant hindrance to production. This finding is supported by (Yang et al., 2021), those who emphasized the crucial role of control system security in agricultural production. "Drought and floods" follow, impacting slightly over 25% of agricultural activities, reflecting the vulnerability of agriculture to adverse weather conditions. "Lack of funds" and "poor infrastructure" are also notable factors, each affecting around 20% and 15% respectively, highlighting the importance of financial resources and adequate infrastructure in sustaining agricultural productivity. This is consistent with the discussion by (Adelaja & George, 2021), recognizing the essential link between agricultural security and food security, emphasizing the significance of financial resources in ensuring food security.

The study found that deforestation and charcoal Production consistently increased from 35% in 2010 to 40.7% in 2024, highlighting the growing impact of tree cutting for fuel and charcoal on land degradation. This trend aligns with findings from (Sedano et al., 2016), who highlighted that forest degradation associated with charcoal production is largely independent of deforestation driven by agricultural expansion, emphasizing the significant impact of charcoal production on forest cover change (Kullane et al., n.d.). The study finds Floods are the most frequent in Somalia. Floods are a significant issue in Somalia, as highlighted by (A. M. S. Ali & Mohamed, 2023), (A. A. Warsame & Sarkodie, 2022), and (Bahaga et al., 2024). (A. M. S. Ali & Mohamed, 2023) emphasizes the impact of changing rainfall patterns in Somalia, which has led to a wide range of extreme weather occurrences, with frequent and destructive floods being chief among them. Warsame and Sarkodie (2021) mention increasing temperatures, droughts, and flash floods as major climatic risks in Somalia.

VI. CONCLUSION

This study analyzes the effect of land degradation and environmental changes on agricultural production in Somalia, emphasizing significant findings related to temperature increases, precipitation variability, agricultural production decline, land degradation, and the frequency of natural hazards.

The findings highlight the trend lines for different periods (1951-2020, 1971-2020, and 1991-2020), demonstrating an accelerated warming rate in recent years. The annual precipitation trends in Somalia from 1990 to 2020 exhibit significant year-to-year variability, with peaks around 1995, 2010, and 2020, and troughs in the late 1990s and early 2000s. Drought and floods impact slightly over 25% of agricultural activities, reflecting the vulnerability of agriculture to adverse weather conditions. This highlights the growing impact of tree cutting for fuel and charcoal on land degradation. Poor agricultural practices and climate change exhibit gradual rises, reflecting ongoing challenges in sustainable farming and increasing adverse weather events. The Various natural hazards from 1980 to 2020 show that floods are the most frequent, comprising the largest segment of the natural hazards.

The research provides a comprehensive analysis of environmental and climatic trends in Somalia, offering valuable insights into the region's vulnerabilities and challenges. By highlighting the accelerated warming trends, increasing precipitation variability, and the multifaceted causes of agricultural decline and land degradation, the paper underscores the critical impact of climate change and socio-economic factors on Somalia's environment and agriculture. The findings emphasize the need for targeted interventions to address these challenges, improve resilience, and sustain agricultural productivity. This research contributes to the broader understanding of climate change impacts in arid and semi-arid regions, offering a basis for future studies and policymaking aimed at mitigating these effects.

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