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Effects of Environmental Malpractices in Intensifying Climate Change Impacts in Puntland, Somalia (Garowe, Qardho, and Galkacyo)

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Abstract

The communities of Puntland, Somalia, have long engaged in environmentally harmful practices, including overgrazing, deforestation, urbanization, and illegal wildlife hunting. These anthropogenic activities have exacerbated the region's vulnerability to the impacts of climate change, such as droughts, floods, and biodiversity loss. Despite the arid climatic conditions, the local populace was largely unaware of the negative environmental consequences of their actions. The protracted conflict in Somalia has also facilitated illegal trade, further endangering wildlife species. While previous studies have examined the relationship between human activities and climate change, there is a paucity of research exploring how specific practices like overgrazing, charcoal production, illegal hunting, and deforestation can intensify climate change impacts in Puntland's dry regions. The mechanisms by which these localized human practices interact with and amplify broader climate change processes remain poorly understood. This study aimed to assess the effects of environmental malpractices in intensifying climate change impacts in Puntland. The research employed a qualitative approach using purposive sampling, incorporating in-depth stakeholder interviews and key informant interviews. 95% of key informant interviews mentioned environmental malpractices, including charcoal production, overgrazing, wood collection, drought, floods, desertification, illegal wildlife hunting, and weak law enforcement, as contributors to the region's environmental challenges. The findings highlight the critical need for environmental education, community-level structural reforms, and sustainable rangeland management practices to address the pressing environmental challenges and mitigate the impacts of climate change in Puntland.

Keywords

Environmental Malpractices, Climate Change Impacts, Puntland

1. Introduction

Puntland communities have grappled with a range of environmentally unfriendly practices that have had far-reaching consequences. These malpractices, including overgrazing, the use of trees for energy and shelter, urbanization, new road development, and the unjust hunting of wildlife, have been common across all regions in Puntland. Despite the dry conditions of the region, the communities were largely unaware of the potential backfire and negative environmental impact of their actions. The large livestock population in Puntland has overgrazed the natural pastures, while the demand for cooking energy and shelter has led to the cutting of trees. Urbanization and the development of new roads have also increased in number and size, representing some of the biggest land use practices in the region.

The impact of climate shocks, such as floods, droughts, and heat waves, has further exacerbated the situation, eroding the assets of the poor and undermining their livelihoods in terms of labor productivity, housing, infrastructure, and social networks (IPCC, 2022). The prolonged conflict and instability in Somalia have also facilitated illegal trade, exerting pressure on several endangered species (Calvin et al., 2023). These environmental malpractices have had far-reaching effects on climate change, deteriorating the general outlook of the environment, disrupting ecosystem balance, decreasing natural pastures, and increasing the percentage of barren land. Consequently, this has led to animal feed stress, livestock deaths, and ultimately, human famine.

Despite the challenges, Somalia's large livestock population, which depends on natural grazing, has been particularly vulnerable to these environmental issues. Continued practices of overgrazing and deforestation have resulted in the total failure of rangelands and the loss of livestock, underscoring the pressing need for sustainable rangeland management practices. Furthermore, wildlife protection schemes were largely inactive prior to the collapse of the government, and the few policies developed were never fully implemented. This has led to an open rivalry between Somali livestock herders and native predators, with the nomads often shooting at any predator species they perceive as a threat to their livestock. As a result, many native predator species have migrated to neighboring countries, seeking a more peaceful environment, and the extinction of these species has had a negative impact on the Puntland ecosystem.

Efforts to address invasive species, such as the introduction of Prosopis Juliflora to tackle sand domes, have also had unintended consequences, as the tree has spread across Puntland regions, replacing native acacia trees and displacing entire

rangelands. The historical lack of environmental care and the prevalence of environmentally harmful practices in Puntland have been compounded by the changing climate. While earlier articles highlighted water development and grazing systems as the main problems, the current challenges encompass both cultural malpractices, such as charcoal business, traditional animal fencing making, overgrazing, and urbanization, as well as natural factors, such as the limited annual rainfall in the Puntland regions.

1.1. Problem Statement

The dearth of context-specific research on the correlation between environmental malpractices and their contribution to the impact of climate change in Puntland poses a significant obstacle to addressing the adverse consequences on natural environments, carrying capacities, and ecosystem equilibrium in both rural and urban communities (Abdi, 2022). The prevailing practices, including overgrazing, charcoal business, urbanization, and the construction of new roads, amplify the severity and frequency of climate shocks, thereby escalating the extent of destruction and harm. Consequently, there exists a critical need to undertake an in-depth investigation and comprehension of the precise mechanisms by which these environmental malpractices intensify the impact of climate change. Such research endeavors are essential for the development of efficacious strategies in terms of mitigation and adaptation.

Current research has focused on charcoal production and its effects on pastoral land degradation and livelihoods, but gaps exist in the understanding of other environmental malpractices, such as the use of trees for livestock fencing, crop fencing, and shelter construction. These activities also contribute to the current environmental problems, yet current research speaks less about these issues. This proposed research will focus on all current environmental malpractices and fill the gap, especially in understanding how these malpractices escalate the impact of climate change and climate shocks.

1.1.1. General Research Objectives

The general objective of this study was to assess the effects of environmental malpractices in intensifying climate change impacts in Puntland.

1.1.2. Specific Research Objectives

1. To identify environmental malpractices in Puntland.
2. To investigate the effects of environmental malpractices in Puntland, which intensify climate change and climate shocks.
3. To identify practical solutions and strategies to replace environmental malpractices.

1.1.3. General Research Questions

The primary research question for this study is: What are the common environmental malpractices in Puntland that intensify the impacts of climate shocks?

1.1.4. Specific Research Questions

The research aimed to explore the following questions:

1. What are the common environmental malpractices in Puntland?
2. How can environmental malpractices intensify climate change in Puntland?
3. What is the solution that local communities can implement to reduce environmental malpractices?

1.1.5. Scope of the Study

The scope of this research was limited to the Puntland region, more specifically, the Nugal-Garowe district and the Mudug region's Galkacyo district. Therefore, the findings from this research were limited to these two districts. Moreover, the research did not emphasize other cross-cutting issues, particularly clan conflicts, that may have influenced environmental issues. The research focused solely on the effects of environmental malpractices on climate change in Puntland and the implications that intensified the impact of climate change.

1.2. Significance of the Study

The research study will contribute to the environmental knowledge field in the academia sector by surfacing key common malpractices. Furthermore, the research will inform decision makers to have a better understanding of environmental and climate change-related projects and programs. While prior studies have examined the relationship between anthropogenic activities and climate change impacts, there is a lack of research exploring how specific activities, such as overgrazing, charcoal production, illegal wildlife hunting, and deforestation activities, can intensify the climate change impact in the dry regions of Puntland. Additionally, there is a limited understanding of how common malpractices can intensify climate change impacts, and how existing efforts, such as environmental restoration programs and climate adaptation actions, may require context-specific adaptation strategies to accurately address these issues.

Particularly, there is a lack of empirical investigation into how activities such as overgrazing, charcoal production, illegal wildlife hunting, and deforestation may be exacerbating climate change impacts like drought, desertification, and biodiversity loss in Puntland. The mechanisms by which these localized human practices interact with and amplify broader climate change processes are not well understood. Filling these critical research gaps would provide valuable, actionable knowledge to guide policy, programming, and community-based initiatives aimed at building climate resilience in Puntland's dry, resource-constrained landscapes.

1.2.1. Limitations of the Study

The research encountered several limitations. Firstly, the self-financing nature of the project resulted in transportation and other related costs being borne by the research personnel. This led to the data collection process taking longer than initially anticipated. Secondly, the research was limited by a lack of available resources, particularly in terms of access to relevant academic articles and publica-

tions on the subject area. The scarcity of existing literature on the topic necessitated dedicating a significant amount of time to thoroughly collecting and reviewing the relevant literature, reports, and publications. These limitations posed challenges during the execution of the research project. However, the researcher employed strategies to mitigate the impact of these limitations to the extent possible, in order to ensure the integrity and quality of the overall study.

1.2.2. Conceptual Framework

This conceptual framework diagram 100% belongs to this study and the right should remain on this study

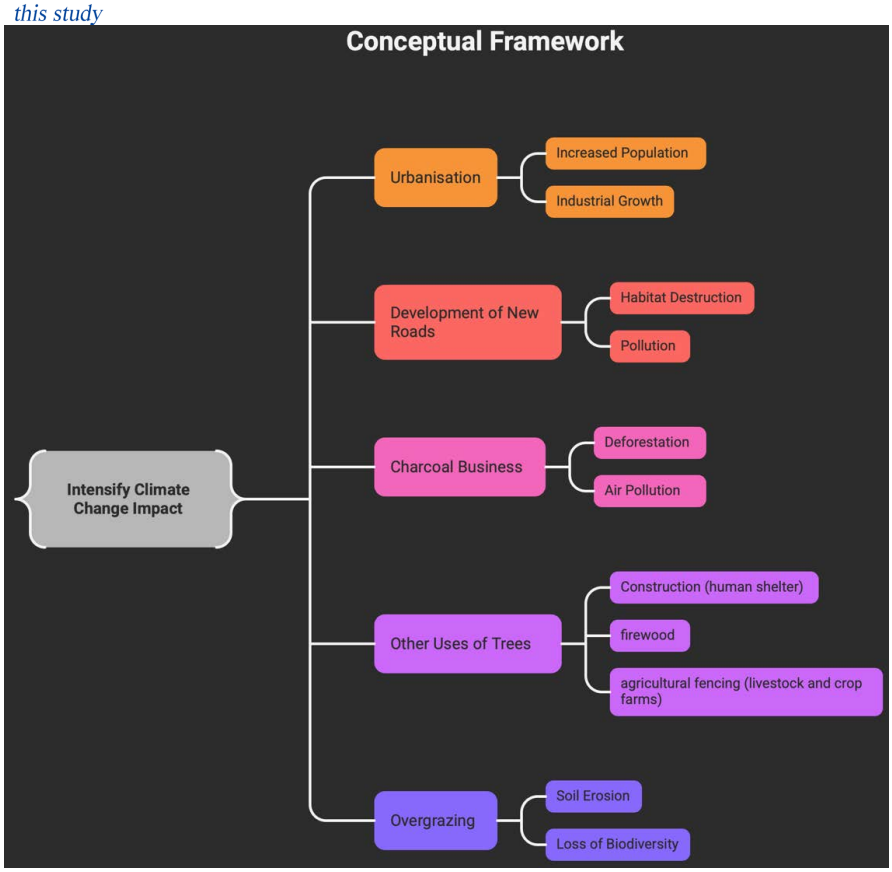

Figure 1. Conceptual framework.

The researchers investigated the relationship between environmental malpractices and climate in the Puntland regions, specifically Mudug, Nugal, and Karkaar. This study aimed to examine the interlink between the independent variable (IV) and the dependent variable (DV). The conceptual framework of the research was outlined in the charts provided. The charts illustrated the hypothesized connections between the environmental malpractices (IV) and the observed climate patterns (DV) in the Puntland region (Mudug, Nugal, and Karkaar). The study employed a rigorous scientific methodology to collect and analyze data pertaining to the environmental conditions and climate trends in the target area. The researchers gathered information from various credible sources, including government re-

ports, academic publications, and field observations, to construct a comprehensive understanding of the phenomena under investigation. Through statistical analysis and modeling, the researchers sought to elucidate the nature and extent of the relationship between the identified variables. The findings of this research contribute to the broader scientific discourse on the impacts of human activities on regional and global climate dynamics.

The conclusions drawn from this study hold significant implications for policymakers, environmental managers, and community stakeholders in the Puntland region. The results can inform evidence-based decision-making and the development of targeted interventions to mitigate the adverse effects of environmental malpractices on the local climate.

Figure 1 is a conceptual diagram that presents the key anthropogenic factors contributing to local climate change intensification in the study area. Major drivers include: 1) urbanization and associated land-cover change, 2) infrastructure development (road networks), 3) charcoal production and biomass extraction, 4) land-use modifications including fencing and fragmentation, and 5) livestock overgrazing leading to land degradation. The framework illustrates the interconnected nature of these drivers and their collective influence on local climate systems. This schematic serves as a conceptual roadmap rather than a mechanistic model, facilitating reader comprehension of the multifaceted human-environment interactions examined in this study.

1.2.3. Assumptions of the Study

The assumption of the present study was that there was a strong relationship between environmental malpractices in Puntland and the impact of climate change. However, there were missing pieces of evidence to prove this relationship. To find out the missing pieces and to prevent any biases, the researchers carried out three steps:

1. The researchers selected relevant respondents from the communities and expected that they knew how environmental malpractices affected climate change based on their local experience.
2. The researchers used an elicitation instrument to capture the respondents' responses.
3. The researchers believed that the respondents would provide honest answers to the questions.
4. The research facilitated intervention activities in a constant manner.

2. Literature Reviews

The review of available resources at the global level will examine the wide-ranging consequences of environmental malpractices and their role in exacerbating climate change. This section will delve into scholarly articles, international reports, and publications that provide a comprehensive understanding of the issue from a worldwide standpoint.

Regional Analysis: The research will then shift its focus to the regional level, addressing the specific challenges and nuances encountered in various geographic contexts. This segment of the literature review will explore how environmental malpractices manifest and impact climate change dynamics at the regional scale, with a particular emphasis on the unique characteristics and vulnerabilities of different regions.

Puntland, Somalia: A local Analysis: The literature review will culminate with a deep dive into the Puntland region of Somalia, exploring the localized issues and their interconnectedness with global and regional trends. This section will synthesize the available data, reports, and scholarly publications pertaining to the environmental malpractices and their climate change implications within the Puntland context.

2.1. Environmental Malpractices

1) Charcoal Business

Traditional biomass, especially charcoal, has been associated with deforestation in some drylands (Mirzabaev et al., 2019). In the context of Somalia, particularly Puntland, where the ecology is dry, firewood is the most commonly used source of cooking energy. The use of charcoal in the East African region remains increasing as urbanization and population growth continue. The majority of households in this region use charcoal as their primary cooking energy source. For instance, 80% of urban households in Kenya and 34% of rural households use charcoal, while Tanzania has a similar situation (Mugo & Ong, 2006). In Ethiopia, a 1996/97 wood energy use assessment indicated that 230,000 tons of charcoal are used annually, with 70% of the total production consumed in towns (Mugo & Ong, 2006). Similarly, in Uganda, biomass use accounts for 90% of the total energy need (Mugo & Ong, 2006).

The market demand shows a great preference for charcoal produced from Acacia trees due to its superior quality. Specifically, 49% of respondents prefer charcoal from *Acacia bussei*, 24% from *Acacia nilotica*, 14% from *Acacia tortiles*, and 13% from *Acacia reficients* (Abdi, 2022). These Acacia trees are also used to feed livestock and provide shelter from the hot climate. The traditional earth-mound kiln method used to produce charcoal results in environmental hazards, such as the clearance of other trees, smoke production, and depletion of surface soil quality (Abdi, 2022).

According to the Puntland Statistics Department in Somalia (2023), charcoal is the second most common source of cooking energy, with the highest percentage in Bari (54.7%) and the lowest in Nugal (44.1%). The highest percentage of charcoal use as a cooking energy source is in Mudug (42.6%), and the lowest is in Nugal (32.6%).

The use of trees as a source of energy is one of the commonly observed environmental malpractices in Puntland. Almost every household uses charcoal, firewood, or both to some extent, with some urban households also using cooking gas. Restaurants predominantly use charcoal and firewood as their main cooking

energy sources. Locals cut trees as a means of income generation, selling charcoal or firewood to households and restaurants. Livestock herders also cut trees to make fences and housing for their animals in small villages and new settlements, further increasing rangeland degradation and deforestation. Prolonged droughts often disturb the livelihoods of nomads, leading them to rely more on the available natural resources, including both living and dead trees, to produce charcoal as a source of income. Despite charcoal production being a source of income for many households, its production has long exceeded environmentally acceptable limits in the Puntland region.

According to a report from the Puntland Information Management Center (IMC), notable land problems in the Qardho area include deforestation, loss of grasses, unpaved roads, water shortages, and overgrazing (Qardho_PNRMP Report.docx). This has led to the overall degradation of the rangeland in the region. The Ministry of Environment and Climate Change has the primary responsibility for controlling the environment, including protecting plant species, and has environmental protection policies that prohibit the cutting of trees, especially live trees (Qardho_PNRMP Report.docx).

However, these policies are difficult to implement for several reasons. Firstly, the deprived individuals in the area may need to cut trees to feed their children, and they may not be able to find dead trees or branches, forcing them to burn live trees and sell the charcoal (Qardho_PNRMP Report.docx). Secondly, there are no active schemes or safety nets in place to support the local population after environmental shocks (Qardho_PNRMP Report.docx). Thirdly, law enforcement is weak, and some individuals continue to use trees for commercial purposes, such as the charcoal business (Qardho_PNRMP Report.docx). Fourthly, the use of alternative energy sources, such as gas, is not progressing quickly enough to replace the overuse of trees (Qardho_PNRMP Report.docx).

The Puntland Ministry of Environment and Climate Change is working to address environmental issues in the region with the support of the World Bank, the African Development Bank, and other environmental projects (Qardho_PNRMP Report.docx). One notable effort is the land rehabilitation and restoration work carried out under the Water for Agropastoral and Resilience Project (The Biyoole project).

The Biyoole project has rehabilitated 35 gully-affected sites selected from Puntland's degraded hotspots, using rock dams as a local technology to reduce the amount and velocity of surface runoff and to isolate active gully heads (Qardho_PNRMP Report.docx). According to the Ministry of Environment and Climate Change reports, this project has successfully rehabilitated a total area of 883 hectares of eroded rangelands (Qardho_PNRMP Report.docx).

Additionally, the Drought Resilience and Sustainable Livelihoods Program (DRSLP-II) has implemented similar interventions to restore gully controls. This project has constructed rock dams and spread animal manure grasses in the Kurtumo, Legdeero 1, Legdeero 2, Legdeero 3, Qeydaruus 1, and Qeydaruus 2 gullies,

rehabilitating a total area of 10 km^2 of gullies that were devastating vast areas of rangelands and grazing valleys for the pastoral communities in the Nugaal region.

In summary, the Puntland Ministry of Environment and Climate Change is proactively addressing environmental degradation in the region through collaborative efforts with the World Bank, African Development Bank, and other environmental projects. The Biyoole project and the DRSLP-II have successfully rehabilitated thousands of hectares of eroded rangelands using innovative, locally-appropriate techniques such as rock dams and the application of animal manure grasses.

Figure 2. Gully rehabilitations 01 (source: Puntland Ministry of Environment and Climate Change—Biyoole project).

Figure 2 illustrates a gully restoration intervention utilizing two parallel check dams. This project was implemented by the Puntland Ministry of Environment, Range, and Climate Change in collaboration with the World Bank Rural Resilience Project. The restoration activities aim to rehabilitate degraded rangelands impacted by gully erosion, which resulted from increased surface water runoff and vegetation loss in the area.

Figure 3. Rangeland rehabilitation (source: SCI report).

Figure 3 is a photo showing gully erosion control measures implemented in the study area. The photograph reveals the formation of distinct erosion channels (gullies), where a series of parallel check dams have been constructed perpendicular to the flow direction. These engineering structures function to: 1) reduce runoff velocity, 2) promote sediment deposition, 3) create temporary water storage zones, and 4) facilitate natural revegetation processes that contribute to long-term soil conservation. This intervention was implemented by the Puntland Ministry of Environment, Range, and Climate Change (MoERCC), with the support of the World Bank.

2) Wildlife Protection in Puntland

Wildlife refers to undomesticated animal species, or in other words, all organisms that grow or live wild in an area without being introduced by humans (Wikipedia, 2024). Wildlife can be found in all ecosystems, including deserts, plains, grasslands, woodlands, forests, and even the most developed urban areas. According to Merriam-Webster, wildlife is "living things and especially mammals, birds, and fishes that are neither human nor domesticated" (Merriam-Webster, n.d.).

Wildlife is part of the ecosystem and plays an important role in balancing the ecosphere. This balance is vital for the sustenance of the ecosystem. However, people usually experience unknown diseases and the emergence of new types of viruses, and the overexploitation of wild animals will diminish the diversity, beauty, and sustainability of the ecosystems (Reid et al., 2005).

Livestock policies need to be reoriented in view of the problems concerning overgrazing, dryland degradation, rangeland fragmentation, and loss of wildlife habitat (Reid et al., 2005). The Somali Democratic Republic established the National Range Agency (NRA) in 1976 under a presidential decree. Initially, the agency's main responsibilities were focused on rangelands, but later, the agency's responsibilities were modified to include the protection of wildlife. However, there is limited research available on the wildlife protection schemes established under the NRA. One of the challenges faced by wildlife was the use of firearms, especially by agropastoral communities, when the central government collapsed, and the firearms fell into the hands of irresponsible people.

Locals, especially the elderly, used to see various types of wildlife, including lions, giraffes, elephants, and rhinos, which are no longer available in Puntland today. These species migrated during the period from 1980 to 1989, with the most notable species including elephants, lions, rhinos, and giraffes. The reasons for their migration may differ on a case-by-case basis. Elephants migrated in search of water and enough pasture due to the increased frequency of droughts, while the case of lions was different, as they were hunted down by livestock owners, and the government failed to manage their emigration even before the collapse of the central government. The government was supposed to dedicate game reserve areas where domestic animals and pastoral communities could interact, but it ignored the open front between wildlife.

Table 1 shows existing laws, policies, regulations, and strategies within the Puntland State of Somalia, specifically in the sectors of agriculture, environment, and

climate change. All 13 documents are available at the Ministry of Environment and Climate and the Ministry of Agriculture. Despite the existence of such laws, policies, regulations, and strategies, there is still a gap in enforcing laws and implementing them as per policies and strategies.

Table 1. Existing laws, polices, and regulations.

#	Document Name	Year
1	PL Environment Management Act	2017
2	PL Waste Management Policy	2016
3	PL Climate Change Strategy	2017
4	PL NRM Decentralization Strategy	2017
5	PL Climate Change Strategy	
6	PL Waste Management Policy	2016
7	PL Rural Land Policy	2017
8	PL Environmental Law	2017
9	PL Environmental Policy	2015
10	PL Environmental Impact Assessment	2016
11	PL Rangeland Management Policy	2016
12	PL Agriculture Policy	2022
13	PL Sustainable Rangeland Management	2022

Sources: MoECC Database.

3) Wildlife Habitat Loss in Puntland Due to Environmental Malpractices

During the civil war in Somalia, less mobile wildlife species migrated within the country, seeking peaceful and quiet environments. Puntland, particularly the Nugal and Barri regions, sustained relative peace compared to the broader anarchy and unrest in Somalia during this period. It was common to observe various species of antelope, ostrich, and other wild animals in these regions. The local population generally refrained from hunting these animals, except in rare circumstances. However, the environment is continuously evolving, becoming more urban, semi-urban, or populated with people and their livestock. This development has disrupted the original peaceful and quiet habitats that were once home to these wild animals. The attached image demonstrates this, depicting a wild warthog grazing amidst residential households. The changing landscape and human encroachment have consequently impacted the natural shelters and distribution of wildlife within Somalia during and after the civil war period. This shift highlights the ongoing challenges faced by these species in adapting to the transforming environmental conditions.

Figure 4. The wild warthog shown on the right side of the photo is grazing; this research is still ongoing.

Figure 4 shows wild warthog grazing in the center of Galkacyo district, near a busy road. This image illustrates how wildlife adapts to living alongside humans and changes happen in their natural habitats, or due to habitat loss. The warthog (Phacochoerus africanus) is a wild member of the pig family that historically inhabited remote or peripheral areas outside of urban centers in Somalia. However, as human settlements and cities have expanded, encroaching upon the warthog's natural habitat, these animals have adapted to exhibit behaviors more akin to domesticated species.

It is evident that environmental malpractices resulted in ecosystem disorder and habitat loss for such wildlife; no protected areas existed, and, as a result, people are moving everywhere, forcing wildlife species to either migrate or cope with such changes. Worthtog is one of the good examples that adopted such a situation; however, during dry seasons, especially water shortage periods, conflicts between Worthtog and people over water access occur. Worthtog normally feeds on bush vegetables, especially roots. However, due to climate changes and frequent drought, bush feeds also declined, and wartogs enter into cities in search of food and water. These changes give more stress to households and people accessing water points, especially public kiosks.

There are a few key factors that have contributed to this behavioral shift. Firstly, the predominant Muslim faith practiced by the Somali people prohibits the hunting of warthogs. As a result, these animals may not face the same degree of perceived threat from local human populations as other wildlife, such as antelope, which are more actively hunted. This religious protection has allowed warthogs to become more comfortable in close proximity to human settlements.

Secondly, the warthog's natural habitat has been subjected to cycles of drought, leading to shortages of water and vegetation. In response, warthogs have been observed venturing closer to human population centers and water sources during the dry season in search of these critical resources. This behavioral adaptation has further contributed to their integration into semi-urban environments. To support the long-term coexistence of warthogs and human settlements, the Somali

government should consider implementing wildlife conservation schemes. This could include the establishment of dedicated areas or corridors where warthogs and other species can access reliable water sources and grazing lands, while also facilitating their natural social and reproductive behaviors. Such proactive measures would help to ensure the continued presence of this unique wild species within the evolving Somali landscape.

The primary threats to wildlife populations in the region appear to be unsustainable hunting practices and habitat loss due to urbanization and overgrazing. Regarding hunting, certain animal species that are permitted to be hunted for subsistence by local religious or cultural traditions are at risk of over-exploitation. Despite the religious allowance, a lack of robust law enforcement has enabled the commercialization of hunting these protected species. Reports indicate that large numbers of antelopes and other wildlife are being poached, often in concentrated events during drought periods when resources are scarce. These unregulated hunting practices threaten to deplete vulnerable wildlife populations.

Additionally, rapid urbanization and the expansive grazing activities of pastoralist communities are rapidly encroaching on natural habitats. As cities grow and pastoral movements increase in search of dwindling grazing lands, wildlife is being squeezed out of its traditional ranges. Without sufficient protected areas and habitat corridors, many species face the risk of local extirpation as their environments are degraded and fragmented. To address these interrelated threats, the government will need to take swift action on multiple fronts. Strengthening wildlife protection laws and their enforcement, designating and managing protected areas, and working with local communities to promote sustainable use of natural resources will be critical to conserving the country's biodiversity. Coordinated, evidence-based policymaking and resource management will be essential to reversing the decline of wildlife populations in the face of growing anthropogenic pressures.

4) Possible Vector and Infectious Diseases that Wild Warthogs Can Transmit to Humans

Wild warthogs (Phacochoerus africanus) have the potential to transmit several zoonotic infections to humans. These include:

1. Brucellosis: A bacterial infection caused by Brucella species, which can be transmitted to humans through direct contact with infected animals or consumption of contaminated meat or dairy products (Service, 1986).
2. Swine Influenza: Wild warthogs can harbor various strains of influenza viruses, some of which are capable of infecting humans and causing respiratory illness (Service, 1986).
3. Hepatitis E: This viral infection can be transmitted to humans through the consumption of contaminated food or water, including meat from infected animals (Service, 1986).
4. Rabies: Wild warthogs can carry the rabies virus, which can be transmitted to humans through bites or scratches from infected animals (Service, 1986).

5. Leptospirosis: This bacterial infection can be transmitted to humans through contact with the urine of infected animals, including wild warthogs (Service, 1986).

These zoonotic risks can arise when wild animals are not properly handled or when they come into close proximity with human populations. For example, if wild warthogs enter cities in the Puntland region and interact with the environment where children play, there is a possibility of disease transmission (Service, 1986). Additionally, wild warthogs may potentially be infected with the African Swine Fever (ASF) virus, which can have significant implications for domestic pig populations and the pork industry (Service, 1986). It is crucial to maintain appropriate biosecurity measures, avoid direct contact with wild warthogs, and ensure proper food safety practices to mitigate the risks of zoonotic disease transmission from these animals.

5) Over-Grazing Malpractices

The Somalia National Range Agency (NRA) was mandated to protect and better manage rangelands, according to a case study report published in 1987 (National Range Agency in Somalia, n.d.). One of the main rangeland challenges identified was overgrazing. During the dry season, a large number of livestock would congregate near water sources, consuming all available grasses and small shrubs that normally cover the soil surface (National Range Agency in Somalia, n.d.). The removal of this vegetative cover left the fertile soil vulnerable to erosion by intensive rains and winds (National Range Agency in Somalia, n.d.).

To address this issue, the NRA introduced a strategic action plan that included the implementation of Seasonal Range Reserves (SRR) (National Range Agency in Somalia, n.d.). During the two wet seasons and early weeks of the dry season, areas spanning 400 square kilometers across different districts were protected from livestock grazing (National Range Agency in Somalia, n.d.).

The NRA also implemented Famine Reserves (FR), a mitigation strategy for drought and food stress periods (National Range Agency in Somalia, n.d.). A total of 64 reserve sites, covering an area of 600 square kilometers, were established, with open procedures implemented once every four or five years to reduce bush encroachment (National Range Agency in Somalia, n.d.).

Additionally, the NRA addressed the threat of sand dune movement, which was constantly disrupting agricultural and crop lands (National Range Agency in Somalia, n.d.). They established several dune projects, including windbreaks and shelter belts, to control dune movements (National Range Agency in Somalia, n.d.).

However, these strategies faced challenges in achieving sustainability within the Somali livestock herding communities before the collapse of the Somali Republic government (National Range Agency in Somalia, n.d.; UNEP & MoECC, 2022). The nomadic nature of the herders, who made their own decisions about where and when to settle and move, regardless of government plans, was a significant obstacle (National Range Agency in Somalia, n.d.). The government also failed to

properly engage the communities during the project design phase, leading to a lack of ownership and acceptance of the strategies (National Range Agency in Somalia, n.d.). Livestock is the most important economic activity in Somalia, accounting for more than 40% of the country's GDP and being the largest foreign exchange earner, including inputs such as cattle, milk, hides, and skins for several manufacturing establishments (UNEP & MoECC, 2022).

The green pasture is minimal due to dry conditions and low rainfall; however, a considerable number of desert trees, locally known as Caday, Qalaanqal, Maygag, Qurac, Higlo, Hareeri, Barde, and Daran, among others, are available for dry period grazing, particularly for camels and goats (UNEP & MoECC, 2022). Other predominant vegetation types include *Themeda triandra*, *Chrysopogon aucheri*, *Bothriochloa insculpta*, *Cenchrus ciliaris*, *Sporobolus*, and various Acacia species (UNEP & MoECC, 2022). These Acacia trees are valuable for grazing, but people routinely cut them down for different reasons. According to UNEP/MoECC, other rangeland management malpractices, such as poor waste management, contribute significantly to rangeland degradation. The lack of effective measures to reduce, reuse, and recycle waste has resulted in the accumulation of large amounts of waste, a majority of which ends up in rangelands. Moreover, *Prosopis juliflora* is actively threatening Puntland rangelands and displacing more indigenous trees, while Beeryaro, a newly discovered alien invasive weed, is also threatening the rangelands. Additionally, sand dunes are reported to have destroyed approximately 6 km (4 × 1.5) of rangelands in Godob Jiiraan, according to a joint assessment conducted by Save the Children and the Puntland Ministry of Environment and Climate Change under the DRSLP project (Joint Technical Assessment on Sand Dunes Fixation in Godob Jiiraan.pdf).

2.2. Cutting Trees for the Purpose of a Fence

Puntland pastoralists commonly utilize the practice of cutting living tree branches to construct fences around their livestock herds. This is done to protect the animals from nocturnal predators such as hyenas and foxes. As Puntland pastoralists migrate to new grazing areas, they are required to establish new fencing, necessitating the repeated cutting of live tree branches. Furthermore, local communities in Puntland may also cut living tree branches for the purpose of constructing housing, particularly in smaller villages. These cultural practices, which result in the damaging of living trees, can be considered environmentally unsustainable or environmental malpractices (EMP). To address this issue, it is recommended that alternative fencing methods and materials be identified and adopted by the Puntland pastoralist communities. This would help to reduce the reliance on the cutting of live tree branches, thereby mitigating the environmental impact of these traditional practices. The introduction of more sustainable fencing solutions could contribute to the preservation of the local tree populations and the overall ecological balance of the Puntland region.

1) Housing and Development of New Unpaved Roads

Pastoralist communities in the region rely on the natural growth of grasses to

feed their livestock herds. However, technological advancements have had a detrimental impact on the local environment. Nowadays, livestock herders increasingly utilize vehicles to rapidly access distant grazing areas. During the process of livestock relocation and movement, the development of new unpaved roads connecting nearby villages has increased.

This mode of transportation using vehicles negatively affects the natural land cover. Herders may create new roads or expand existing ones as they shift from one site to another. The proliferation of these new road networks leads to two primary discernible problems:

Increased bare land area: As new roads are continuously developed, sometimes running parallel to each other, the width of these road networks can reach up to half a kilometer as drivers attempt to avoid the dusty conditions. This removal of land cover results in a rapid flow of water after rainfall events.

Increased dust and topsoil erosion: The clearing of land cover leads to the mobilization and dispersal of the vital topsoil. This dust renders large areas of land uninhabitable. Furthermore, the exposed, cleared land becomes susceptible to gully erosion and land degradation during heavy rainfall. These two issues stemming from the expansion of road networks ultimately result in the total degradation and destruction of the local rangelands, which are essential to the pastoralist way of life. Addressing these environmental concerns through the adoption of more sustainable transportation and land-use practices is crucial for the protection of ecosystem services.

Unsustainable grazing practices in Puntland:

1. Establish an animal feed/fodder industry to meet the current livestock needs in the face of dwindling natural pastures due to dryness and reduced rainfall.

2. Revive cooperative grazing communities to limit the unnecessary movement of livestock and the development of new unpaved roads. These communities can devise drought contingency plans to determine appropriate grazing areas.

3. Upscale the current environmental restoration projects, particularly in rehabilitating large gully sites and increasing reforestation efforts.

Reliance on trees as an energy source: The use of trees as a primary cooking fuel needs to be replaced or minimized to sustainable levels. Encouraging the use of alternative energy sources, such as gas, in urban areas can help mitigate this issue.

Wildlife protection and coexistence: 1) Implement awareness-raising programs to foster an eco-centric environment and promote peaceful coexistence between wildlife and livestock owners, preventing the forced migration of wildlife, 2) Control urbanization and the creation of new villages, which can fragment wildlife habitats. Allocate dedicated game reserve areas for wildlife conservation. 3) Establish strong law enforcement and environmental control measures, such as effective waste management and invasive alien species control. The research findings emphasize the urgency of addressing environmental malpractices to safeguard human well-being, the survival of livestock, and the preservation of natural ecosystems. Implementing the recommended strategies can contribute to a more sus-

tainable future for the Puntland region and its inhabitants.

2) Theoretical Framework

The framework aims to explore the interactions between environmental malpractices and their impact on climate change in Puntland, Somalia. It establishes relationships among the identified variables and provides a roadmap for understanding their consequences on local communities.

3) Conceptual Model

1. Environmental Malpractices
   - Deforestation
   - Overgrazing
   - Charcoal Production
2. Drivers of Environmental Degradation
   - Unsustainable land use practices
   - Lack of environmental governance
   - Socio-economic factors (poverty, population pressure)
3. Impacts of Climate Change
   - Desertification
   - Increased Vulnerability to Droughts
   - Increased Vulnerability to Floods
4. Adaptive Strategies
   - Environmental Education
   - Strengthened Governance
   - Sustainable Rangeland Management
   - Relationships Between Variables
   - Impact Pathway

Environmental malpractices directly contribute to environmental degradation. This degradation exacerbates the effects of climate change, leading to extreme weather conditions (droughts and floods). Communities become more vulnerable, resulting in socio-economic instability.

4) Mitigation and Resilience

- Implementing environmental education can raise awareness and promote sustainable practices. Improved governance can enforce regulations that mitigate malpractices.
- Sustainable rangeland management can restore degraded areas and enhance resilience to climate impacts.

5) Theoretical Underpinnings

- Sustainability Theory: Focuses on the balance between environmental health, economic viability, and social equity.

2.3. Resilience Theory

Emphasizes the capacity of communities to absorb and adapt to changes while maintaining Functional.

Figure 5 illustrates the theoretical framework guiding this investigation. The

framework integrates three key elements: 1) a conceptual model identifying environmental malpractices and drivers of land degradation alongside adaptive strategies; 2) a theoretical model depicting variable relationships, impact pathways, mitigation approaches, and resilience mechanisms; and 3) the theoretical foundation based on sustainability and resilience theories.

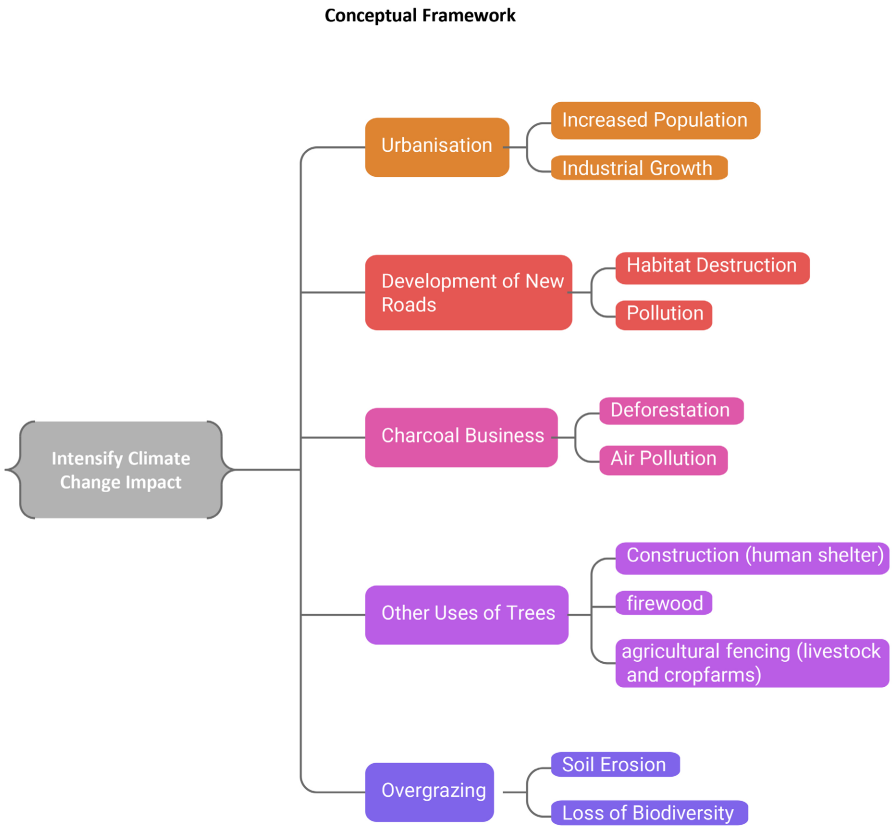

Figure 5. Theoretical framework.

3. Research Methodology

Puntland is a federal member state located in the northeastern region of Somalia, with its capital city being Garoowe in the Nugal region. The territory was declared an autonomous state in 1998 (Wikipedia, 2024). Puntland is bordered by the Khatumo state to the west, the Gulf of Aden to the north, the Guardafui Channel to the northeast, the Indian Ocean to the southeast, the Galmudug state to the south, and Ethiopia to the southwest (Wikipedia, 2024). According to the latest population census, the estimated population of Puntland is 4,334,633 as of January 12, 2024 (Wikipedia, 2024). However, there are significant gaps in the accessibility of essential services, such as water, energy, and sanitation, within the region. The Nugaal region has 69.2% of its population with access to electricity, while the Sool region has only around 38.9% access. Overall, access to electricity is higher in urban areas (82.5%) compared to rural (52.5%) and nomadic (11.9%) areas. The primary sources of lighting are torches (48.0%) and electricity (43.2%), while the

main sources of energy for cooking are firewood (51.4%) and charcoal (34.5%).

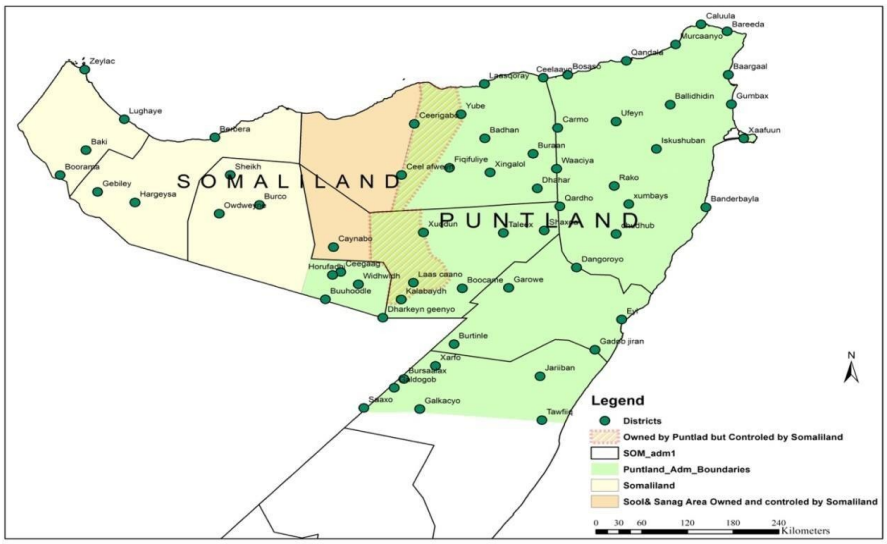

Figure 6. Study area map.

The region's water security also varies seasonally, with 75.5% of the population having access to an improved water source during the rainy season, which decreases by 5.4% during the dry season. In terms of food security, the region faces significant challenges, with 60.4% of Puntland households unable to access nutritious food, 56.0% eating only a few kinds of food, 53.1% skipping at least one meal, 52.4% eating less than they thought they should, 51.6% worrying about not having enough food, 48.6% running out of food, 46.0% experiencing hunger, and 42.9% going to bed without a meal for an entire day in the month preceding the survey. The climate in Puntland is semi-arid, with average daily temperatures ranging from 27˚C (80.6˚F) to 37˚C (98.6˚F). This climate supports a pastoral economy, with the livestock sector dominating the region's economy. Livestock products contribute approximately 80% of the foreign exchange earnings, 40% of the GDP, and 60% of the employment rate in Puntland.

Figure 6 shows the study area, featuring a comprehensive state map of Puntland. Although the map encompasses the entire region, the research specifically focuses on Garowe, Qardho, and Galkacyo, which serve as the sample areas within the study.

3.1. Research Design

This paper adopted a qualitative case study research design using in-depth interviews to explore participants' views, experiences, and beliefs about the effects of environmental malpractices and how those effects intensified climate change impacts. The case study research approach was utilized. This typically involved interviewing thematic experts such as environmentalists, policy experts, climate change advisors, and traditional environmental experts, as well as reviewing environmental and climate change policies and regulations. The qualitative case study meth-

odology provided an in-depth exploration of the complex relationships between environmental malpractices and climate change. The use of semi-structured interviews allowed the researchers to deeply investigate the perspectives and lived experiences of the key stakeholders involved. By incorporating the insights of a diverse range of experts, the study captured a multifaceted understanding of this critical issue.

The review of relevant policies and regulations further contextualized the findings, enabling an assessment of the current frameworks in place to address environmental degradation and climate change. This multilayered approach facilitated a comprehensive analysis of the research problem from multiple angles. Overall, the qualitative case study research design proved effective in uncovering the nuanced connections between environmental malpractices and climate change impacts, offering valuable insights to inform future policymaking and environmental stewardship initiatives.

1) Study Population

The research data were collected from key informant interviews. The research adopted an inductive data analysis approach and used an inductive thematic analysis research strategy to analyze the data collected from the key interviews. The data was gathered based on the experience and knowledge of the interviewees related to the subject of "the effect of environmental malpractices intensifying climate change impact". The research paper also used a longitudinal time horizon due to the nature of the subject under investigation. The main reason this research utilized a longitudinal time horizon was that the key informants needed to be interviewed were located at different institutions, and it was difficult to find them all within a specific timeframe. Therefore, the research selected to use a longitudinal time horizon.

The research interviewed key subject experts selected from relevant institutions such as the Ministry of Environment and Climate Change, as well as other subject practitioners working at NGOs and traditional environmental experts like livestock owners who had a better traditional understanding of environmental outlooks and problems. The key informants and research population were those living in or working within the study area.

2) Target Population

The target population was people working in different climate change-related sectors and individuals with extensive traditional environmental experiences. The specific target population included those working in water resources, environmental and rangeland specialists, livestock experts employed by government institutions, UN agencies, and non-state actors, as well as business people, particularly those working in the energy sector, including charcoal production. Additionally, the farming community's livestock owners who used trees for various purposes, such as fencing and shelter, as well as crop farmers who utilized trees to protect their crops, were part of the target population.

3) Accessible Population

The accessible target population will be individuals working in this sector, es-

pecially those based in the study area. The accessible target population will be those working in the Nugal region, Galkalcyo, and Qardo. Livestock owners and traditional people living within these cities or nearby villages or sub-villages will be targeted.

4) Purposive Sampling

Due to the limited number of the target population, this research adopted a purposive sampling approach and selected 20 individuals with substantial experience on environmental issues, either in scientific knowledge or traditional expertise. The sample was drawn from relevant government institutions, UN agencies, NGOs, environmental field practitioners, and traditional land experts. The quality of the data and the number of interviews per participant determined the amount of usable data obtained. There was an inverse relationship between the amount of usable data obtained from each participant and the number of participants—the greater the amount of usable data obtained from each person, the fewer the number of participants. To maintain the research aims and objectives, as well as to control the quality of the data, the sample size was strictly limited to subject-related individuals.

5) Sampling Techniques

Due to the nature of the research aims and objectives, which necessitated the involvement of subject matter experts in the field, a non-probability sampling technique was selected for the key interviews conducted as part of this study. Specifically, a purposive sampling approach was adopted, as interviewing individuals with limited or no experience in both scientific and traditional knowledge related to the research subject was deemed inappropriate. The selection of the key informants was driven by the need to gather insights from individuals possessing substantial expertise and familiarity with the phenomena under investigation. This non-propagability sampling method enabled the researchers to intentionally identify and engage with participants who could provide the most relevant and informed perspectives, aligning with the fundamental objectives of the research.

By employing this purposive sampling strategy, the study was able to capture the depth and breadth of knowledge required to address the research questions effectively, drawing upon the experiences and understandings of the selected subject experts. This methodological approach ensured that the data collected during the key interviews were of high quality and relevance, facilitating a comprehensive analysis and understanding of the research topic.

3.2. Data Collection Methods

The research data collection methods utilized both secondary data and primary data. The secondary data was gathered and reviewed, which included existing literature reviews, policies, environmental data, and change policies within the study area, as well as in the surrounding region. Secondly, the research also collected primary data using surveys, key information interviews, and observations through transect walks. The respondents were asked direct questions, and their responses were recorded using audio recordings and detailed note-taking as they spoke. This

mixed-methods approach allowed for a comprehensive examination of the environmental factors and changes within the study area. The secondary data provided essential background information and context, while the primary data collection enabled the researchers to gather firsthand insights and observations from local stakeholders and community members.

1) Data Collection Instruments

The research utilized a variety of data collection instruments to gather both secondary and primary data for the study. For the secondary data collection, the researchers conducted a thorough review of existing literature, including academic journal articles, government reports, and organizational policies related to the environmental conditions and change dynamics within the study area and broader region. This secondary data provided essential background information and context to inform the primary data collection. The primary data was collected through several instruments. First, the researchers administered KII questionnaires to purposefully selected individuals based on their relevant academic and experiential backgrounds.

In addition, the research team conducted in-depth interviews with key informants, such as local government officials, environmental experts, and community leaders. These semi-structured interviews allowed the researchers to delve deeper into specific issues and gather more nuanced perspectives from knowledgeable sources. Finally, the researchers employed observational techniques, including transect walks through the study area, to directly observe and document the environmental conditions and changes occurring on the ground. Detailed field notes, photographs, and video recordings were used to capture these firsthand observations.

2) Research Procedures

The researchers adopted an interpretivist qualitative research philosophy to subjectively explore the effects of environmental malpractices on climate change impacts. The second research procedure utilized a deductive approach, tending towards a confirmatory approach. The research procedures followed a systematic series of steps and processes. First, the researchers conducted a thorough literature review on the research topic, examining the current state of knowledge in this area. Additionally, the review explored the present situation relevant to the research. The next step in the research procedures involved data collection. This was achieved through research questions as well as key interview questions posed to subject matter experts and selected samples.

The goal of this research is to identify the key environmental issues and practices in the Puntland region of Somalia that may be exacerbating the effects of climate-related shocks and disasters. By understanding the local environmental malpractices, the findings can inform policy and interventions to mitigate the intensifying impacts of climate change in this vulnerable region. The survey instrument will be designed to elicit information from research participants about the specific environmental challenges, unsustainable practices, and resource management is-

sues they have observed or experienced in Puntland. This data will provide insights into the links between local environmental conditions and the severity of climate change impacts.

3) Quality Control

The research adopted step-by-step procedures to ensure the accuracy of the data collection process. This process began by carefully selecting key interviews to ensure a thorough understanding of the subject matter, allowing the researchers to substantiate their arguments. The second step involved a rigorous quality control process for the data editing. The purpose was to check for completeness of the data, identify any errors, and ensure the readability of the information collected. Interviewers were required to review their completed questionnaires immediately after each interview to verify they were free of errors and omissions. For the coding of data, computers and Excel tools were utilized to avoid unnecessary errors. The data entry was then conducted, followed by a thorough data cleaning process before the final data analysis.

4) Piloting

Prior to carrying out the study, the researchers had implemented pilot exercises at Garowe city and institutions operating in the Nugal region to determine the availability of the research population and information flow. Moreover, the researchers had tested whether the proposed research methodology could be implemented on the ground prior to the main study. The pilot exercises served to assess the feasibility of the research approach and gather preliminary data to inform the design of the main study. By conducting these preparatory activities in the target research sites, the investigators were able to better understand the local context, identify any logistical challenges, and refine the data collection procedures before launching the full-scale investigation.

The findings from the pilot phase helped the research team to validate the suitability of the proposed methodology and make any necessary adjustments prior to commencing the primary data collection effort. This iterative process ensured that the main study could be executed efficiently and effectively, with a high likelihood of generating reliable and meaningful results.

5) Validity of Instruments

The research utilized standard methods throughout the investigation, including literature reviews, the adoption of qualitative approaches and sub-guidelines, population selection, and the application of detailed research methodologies and procedures. The literature review component involved a comprehensive examination of relevant academic and grey literature to establish the current state of knowledge on the topic and identify any gaps or areas requiring further exploration. The qualitative methods and sub-guidelines were carefully selected to align with the research objectives and the characteristics of the target population. The population selection process followed established protocols to ensure the sample was representative and appropriate for the study's aims. Detailed research methodologies and procedures were developed and implemented to guide the data collection,

analysis, and interpretation stages of the project.

This rigorous, systematic approach was designed to produce consistent results over time, unless there were significant changes in the key variables that the research sought to investigate and understand. The consistent application of well-validated methods helped to enhance the reliability and validity of the study's findings, contributing to the overall quality and credibility of the research.

3.3. Data Analysis

The research adopted qualitative data analysis methods. Two types of data were collected. Secondary data was collected from previous articles, publications, and field reports. This secondary data was analyzed through a close study and review of the materials, with conclusions drawn from the content of the articles. Primary data was collected through key informant interviews with a sample population. This primary data underwent a four-step process prior to reporting: editing, coding, entry, and cleaning. The research also utilized the NVivo qualitative analysis software tool to analyze the primary data after successfully completing these four preparatory steps.

Ethical Consideration:

The research considered several ethical issues and paid close attention to these issues during the research process. This included the voluntary participation of the research participants. During the data collection phase, the key informant interviews ensured that participants were briefed on the issue of voluntary participation. Participants were informed that they were free to opt out of the study at any point in time. The research also informed participants about the purpose of the study, as well as the potential benefits and risks. Participants were explicitly made aware that they were free to agree or decline to join the study.

Moreover, the research also considered issues of anonymity and confidentiality. Measures were taken to ensure the protection of participant information and to minimize the potential for harm. Finally, the research process was carefully monitored to ensure it was free of plagiarism or any other misconduct. Overall, the ethical considerations were a central focus throughout the research in order to protect the rights and well-being of the study participants.

4. Results

In response to the first research question, this study identified key factors that intensify climate change impacts in Puntland, categorized into two main groups:

A) Human-Induced Malpractices

1. Unsustainable tree harvesting
2. Livestock overgrazing
3. Charcoal production
4. Uncontrolled urbanization and road development
5. Illegal wildlife hunting
6. Improper waste management

B) Natural Extreme Events

1. Increased drought frequency
2. Intensive flooding episodes

4.1. Livestock Overgrazing

Livestock overgrazing significantly exacerbates climate change impacts in arid ecosystems, particularly in Qardho and Galkacyo districts. Excessive livestock presence disrupts natural vegetation, including grasses and shrubs that play critical roles in water retention and soil stabilization. These plants serve as natural barriers that regulate water flow and mitigate soil erosion.

Vegetation removal increases water velocity and accelerates soil erosion, resulting in gully formation and land degradation. Consequently, large areas become uninhabitable and unproductive for both crop farming and livestock grazing. Gully formation further restricts livestock movement and access to essential resources, creating a cascading effect where pressure shifts to neighboring areas, perpetuating the cycle of overgrazing and degradation.

During dry periods, livestock typically graze on dry pastures, including grass and tree leaves. When overgrazing occurs, these resources disappear entirely, creating conditions locally known as "xaaluf"—a term describing the complete absence of grass, shrubs, and tree foliage. This situation intensifies climate change impacts, creating extreme agricultural drought conditions where livestock survival becomes critically challenging. The degradation cycle not only reduces agricultural productivity but also heightens ecosystem vulnerability to climate variability.

4.2. Charcoal Production

Charcoal production emerged as a major environmental malpractice that depletes natural resources and contributes to climate change through greenhouse gas emissions. This practice destroys rangeland ecosystems through extensive tree cutting and burning processes. Charcoal producers harvest both living and dead trees, including branches, for fuel and charcoal preparation. The removal of dead trees has particularly severe environmental consequences, as these structures provide critical ecosystem services:

- Natural barriers: Dead trees prevent wind and water erosion of tree leaves and topsoil.
- Nutrient retention: They serve as natural repositories for dry pasture and fertile soil.
- Biodiversity support: Dead trees provide shelter for numerous species, including bees that use them for honey production.

The combined effects of charcoal production and extensive firewood collection create ecological drought conditions, intensifying climate change impacts by rendering environments more vulnerable to floods, prolonged dry periods, and wind erosion.

4.3. Increased Drought Frequency

The region has experienced increased drought frequency and intensity, resulting from the aforementioned environmental malpractices that have disrupted natural water cycles and reduced ecosystem resilience. Frequent droughts inhibit natural vegetation regeneration, directly impacting livestock production through reduced pasture availability.

When these conditions occur, agricultural drought intensity increases regardless of water availability. In some cases, water may be accessible through boreholes, yet livestock cannot access sufficient natural pasture upon which the majority depend. Agricultural drought thus serves as a trigger for economic drought in rural areas where communities heavily depend on livestock and livestock products, as observed in Qardho and Galkacyo districts.

4.4. Intensive Flooding

Intensive flooding events were identified as climate change impacts intensified by environmental degradation in Puntland. Vegetation removal has severely diminished the region's capacity to withstand and recover from extreme weather events. Areas lacking natural barriers experience flooding from even modest rainfall, as the landscape has lost its natural water retention capacity.

When land loses its ability to retain water, rainfall cannot benefit the ecosystem as intended. Raindrops fail to penetrate deeply into the soil; instead, surface runoff occurs rapidly, leading to flash floods. This phenomenon results from the removal of natural barriers, particularly dead trees and topsoil, which fundamentally alter the landscape's hydrological properties and compromise its natural water management capacity.

4.5. Urbanization and Road Development

Uncontrolled urbanization and road development were recognized as significant contributing factors to intensified climate change impacts in the region. The transition from traditional transportation methods (donkeys and camels) to motorized vehicles has increased environmental pressures. While camels and donkeys had minimal environmental impact, vehicle use has necessitated extensive unpaved road networks that penetrate previously inaccessible rangelands.

These roads destroy substantial forest areas, transforming natural ecosystems into transportation corridors. Furthermore, improved access facilitates increased and often unsustainable exploitation of forest resources, including:

- Firewood collection
- Tree pole harvesting
- Illegal wildlife hunting
- Extraction of other forest products

The expansion of road networks thus creates multiple pathways for environmental degradation, compounding climate change impacts across the region.

5. Discussions

The findings from key informant interviews (KIIs) and focus group discussions (FGDs) revealed a complex web of environmental malpractices prevalent in the Puntland region that significantly exacerbate climate change impacts. These practices, deeply embedded in local livelihood strategies, have created a self-reinforcing cycle of environmental degradation that threatens the sustainability of pastoral communities and the ecological integrity of the region.

5.1. Unsustainable Tree Resource Exploitation

The overexploitation of tree resources emerged as one of the most critical environmental challenges facing the Puntland region. Trees are harvested extensively for multiple purposes, including charcoal production, housing construction, fencing materials, and firewood collection. This multifaceted pressure on forest resources has led to widespread deforestation and the progressive depletion of natural tree cover across the study area.

A key informant from the scientific community observed:

"*Recurrent droughts, floods, and desertification, combined with environmental malpractices at the community level, intensify climate change impacts in terms of water shortages and grazing land availability. Common malpractices such as charcoal production, overgrazing, and wood collection contribute significantly to these issues.*"

The consequences of unsustainable tree use extend beyond simple forest loss. Deforestation has triggered a cascade of secondary environmental impacts, including accelerated soil erosion, increased desertification rates, and alterations to local climate patterns. These changes create a positive feedback loop wherein environmental degradation intensifies climate vulnerability, which in turn increases pressure on remaining natural resources.

An environmental specialist highlighted the broader ramifications:

"*Desertification and barren land formation create multiple problems, particularly dust storms during the wind season in summer, increased water runoff, and rangeland deterioration. These processes intensify climate change impacts, causing health problems and general discomfort for communities.*"

1) The Overgrazing Crisis

Overgrazing represents another fundamental environmental malpractice that significantly amplifies climate change effects in Puntland. The region supports high densities of livestock, including goats, sheep, camels, and donkeys, which graze rangelands freely without any systematic rotational grazing management at the community level. This uncontrolled grazing pattern has resulted in severe degradation of fragile pastoral ecosystems and substantial reduction of vegetation cover.

The impacts of overgrazing are multidimensional. First, excessive grazing pressure has led to the depletion of palatable plant species and the proliferation of invasive plant species that livestock avoid. Second, the removal of vegetation cover

has exposed soils to erosion, reducing the land's water retention capacity and increasing surface water runoff. Third, overgrazing has contributed to the formation of barren lands and gully erosion features that render previously productive rangelands unusable for pastoral activities.

A pastoralist community member explained the practical consequences:

"*Overgrazing results in the extinction of many grass species and creates shortages of grazing land and available shrubs and pastures. This can lead to conflicts between pastoralists competing for the remaining small areas of pasture. It also facilitates degradation and the spread of invasive plant species, which further degrade the fragile ecosystem.*"

The vulnerability of pastoral communities reaches its peak during drought periods when pasture and water availability are at their minimum. During these critical times, both livestock feed and human food become scarce, livestock market prices collapse, and pastoralists are forced to sell animals at significant losses to survive. This economic stress, combined with increased livestock mortality, undermines the resilience of pastoral livelihoods and perpetuates cycles of poverty and environmental degradation.

2) Charcoal Production and Its Cascading Impacts

Charcoal production has emerged as one of the three most significant contributors to environmental degradation and climate change intensification in Puntland, alongside overgrazing and general tree cutting. The charcoal industry, particularly prevalent in the Mudug, Nugal, and Karkaar subregions, places enormous pressure on tree resources and has transformed vast areas of once-productive rangeland into barren landscapes.

The environmental consequences of charcoal production extend far beyond the immediate loss of trees. The removal of vegetation eliminates the natural barriers that slow water movement across the landscape, leading to increased water runoff during rainfall events. This accelerated runoff creates gully erosion features that fragment rangelands and reduce their carrying capacity for livestock. Additionally, the loss of tree cover diminishes rainfall through reduced evapotranspiration, creates a hotter microclimate, and reduces water availability in the landscape.

A pastoralist informant articulated the community-level impacts:

"*Charcoal business reduces grazing areas for animals, decreases rainfall, and diminishes water availability. These changes lead to conflicts over grazing land, and sometimes conflicts occur between those cutting trees for charcoal production and pastoralist communities who want their livestock to graze these trees.*"

The ecological importance of trees in the pastoral system is often underestimated. Dead plant materials and fallen leaves from trees serve as critical livestock feed resources, particularly during dry seasons or in the first weeks following rainfall when fresh vegetation has not yet established. One pastoralist explained this intricate relationship:

"*The dead plants are the hosts for tree leaves, and these leaves are then used by*

livestock during the dry season. When rainfall comes, the leaves become soft and wet, and livestock feed on them for the first two weeks of rain or until the trees turn green. However, when dead trees are removed as firewood and shrubs are cleared as a result of overgrazing, both plant leaves and topsoil are lost."

The charcoal industry has also contributed to the local extinction of certain tree species. The Dheen tree, for example, has disappeared from Nugal rangelands, particularly near seasonal rivers where it once thrived. This loss of biodiversity reduces ecosystem resilience and eliminates important resources that communities have traditionally relied upon for food, medicine, and livestock fodder.

3) Urbanization and Habitat Fragmentation

Urbanization, though less emphasized than other malpractices, has contributed significantly to environmental degradation in Puntland. The development of both paved and unpaved roads has led to the destruction of rare tree species and the fragmentation of natural habitats, including critical rangelands. This habitat fragmentation disrupts wildlife movement patterns and migration routes, ultimately resulting in biodiversity loss as animals are displaced from their native habitats. The construction of unpaved roads has been a particularly important driver of deforestation and habitat loss. These roads facilitate access to previously remote areas, enabling further resource extraction and settlement expansion that compounds environmental pressures on the landscape.

4) Illegal Wildlife Hunting and Biodiversity Loss

Illegal wildlife hunting emerged as a serious threat to biodiversity and ecosystem integrity in the Puntland region. Uncontrolled poaching has led to the migration or local extinction of numerous wildlife species. Large predators such as lions, tigers, and cheetahs have either migrated to neighboring countries in search of peaceful environments or have been eliminated from the region entirely. Similarly, large herbivores, including elephants and giraffes, have migrated in search of pasture and water resources.

The ecological consequences of predator loss have been profound. With apex predators removed from the ecosystem, populations of some species, such as monkeys and warthogs, have increased substantially. Meanwhile, remaining predators such as foxes and hyenas face daily conflicts with human communities as they turn to hunting domestic animals—goats, sheep, cattle, and camels-creating friction between wildlife conservation and pastoral livelihoods.

This pattern of wildlife displacement and extinction represents not only an ecological crisis but also a form of "wildlife desertification" that parallels the agricultural and environmental desertification occurring across the landscape.

5) Improper Waste Disposal

Improper disposal of both household and industrial waste was identified as a common practice in the Puntland region. This malpractice leads to contamination of soil and water resources, posing health risks to local populations and degrading the surrounding environment. While perhaps less immediately visible than deforestation or overgrazing, waste contamination contributes to the cumulative environmental burden facing communities and ecosystems in the region.

5.2. The Interconnected Nature of Environmental Malpractices

The key informant interviews and focus group discussions revealed that environmental malpractices in Puntland do not operate in isolation but rather form an interconnected system of degradation. According to respondents, the three most significant contributors—overgrazing, tree cutting, and charcoal production-create a cascade of environmental consequences that amplify each other's impacts.

This cascade begins with the removal of vegetation through tree cutting, charcoal production, and overgrazing, which leads to limited pasture availability and livestock feed scarcity. The loss of vegetation cover then facilitates barren land formation and accelerates soil erosion, creating gully features that further reduce productive rangeland. These degraded landscapes have diminished capacity to support vegetation recovery, perpetuating the cycle of degradation.

The impacts of this degradation cascade are most severe during drought and dry periods when resource availability is already minimal. During these critical times, the reduced resilience of degraded ecosystems translates directly into livestock mortality, food insecurity, economic losses, and increased migration pressure as communities seek viable grazing and water resources elsewhere.

1) The Multifaceted Role of Trees in Pastoral Systems

The research findings illuminated the multifaceted importance of trees in local communities, extending across economic, subsistence, and ecological domains. Economically, trees provide income through charcoal production, firewood sales, provision of construction poles for shelter, and materials for fencing to protect livestock and crop farms. For subsistence, trees supply traditional medicines, direct food resources, and critical fodder for livestock, particularly during dry seasons.

Ecologically, trees provide natural shelter for livestock, offering shade from the sun and protection from cold weather at night. They also protect against dust storms, prevent topsoil movement, and maintain soil fertility through leaf litter and organic matter inputs. The loss of trees, therefore, represents not merely the loss of individual organisms but the unraveling of complex ecological and social systems that have sustained pastoral communities for generations.

A pastoralist key informant emphasized this fundamental dependence:

"*Our lives depend critically on trees because all livestock products-milk, meat, butter, and ghee—are directly derived from the natural environments that include trees and other vegetation.*"

2) Climate Change Intensification through Environmental Malpractices

The second research objective examined how environmental malpractices intensify climate change impacts in Puntland. The findings revealed several critical pathways through which local environmental degradation amplifies broader climate change effects.

Deforestation and Carbon Sequestration Loss: Extensive charcoal production and unsustainable tree harvesting reduce the landscape's capacity to sequester carbon, contributing to atmospheric greenhouse gas accumulation while simultane-

ously increasing local temperatures through loss of shade and evapotranspiration cooling. Reduced Rainfall and Hydrological Disruption: The loss of tree cover diminishes local rainfall through reduced evapotranspiration and altered atmospheric moisture dynamics. Simultaneously, the removal of vegetation increases water runoff and reduces groundwater recharge, intensifying water scarcity during dry periods. Desertification and Soil Degradation: Overgrazing, wood collection, and charcoal production accelerate desertification processes, including soil erosion, loss of arable land, and the spread of invasive species. These changes create harsher living environments with increased temperatures and reduced access to natural environmental amenities such as shade and forest resources.

Amplified Drought Vulnerability: Environmental degradation reduces ecosystem resilience to climate variability. Communities reported that the combination of environmental malpractices with recurrent droughts creates compound stress that results in crop failures, livestock losses, infrastructure damage, and forced migration. The degraded landscapes have diminished capacity to buffer communities against climate extremes.

Extreme Weather Event Intensification: Respondents described experiencing various manifestations of climate change, including increased temperatures, variable rainfall patterns (both excessive and deficient), increased flooding frequency, and more frequent droughts. Environmental malpractices intensify the impacts of these climate changes, making communities and ecosystems more vulnerable to climatic extremes.

One key informant synthesized these interconnections:

"*Limited and unreliable rainfall affects the regeneration of trees, shrubs, and forests in general. Reduced rainfall—either missing two consecutive rainy seasons or receiving less than the expected amount—intensifies the impact of climate change. While climate change is happening regardless, locals experience different types of changes such as increased temperature, increased or reduced rains, and increased floods. These changing patterns can be extreme, moderate, or normal based on the ground context and environment type. Increased frequency of droughts, however, intensifies such changes and makes locals, including their environments, more vulnerable.*"

3) Resource Conflicts and Social Dimensions

Environmental degradation has created new sources of social conflict within and between communities. Competition for diminishing resources, particularly grazing land, water, and tree resources, has led to disputes between different user groups. Conflicts arise between charcoal producers and pastoralists over access to tree resources, between different pastoral groups over grazing territories, and between communities and remaining wildlife over livestock predation.

These resource conflicts sometimes result in the migration of rural families and their livestock populations, creating additional pressure on host environments as newcomers compete for access to pasture and water. This situation further exacerbates environmental degradation in receiving areas, spreading the cycle of resource depletion across broader landscapes.

4) Implications for Sustainability and Resilience

The findings demonstrate that environmental malpractice in Puntland have created a critical sustainability crisis that threatens both human communities and natural ecosystems. The interconnected nature of these malpractices means that addressing any single issue in isolation is unlikely to achieve lasting improvements. Instead, comprehensive and coordinated interventions are required that address the full system of environmental degradation while supporting alternative livelihoods and strengthening community resilience.

5) Codes of the Emerged Themes

During the data analysis, different key themes emerged from the research question as research findings. Below are the codes' themes that emerged from key interview respondents.

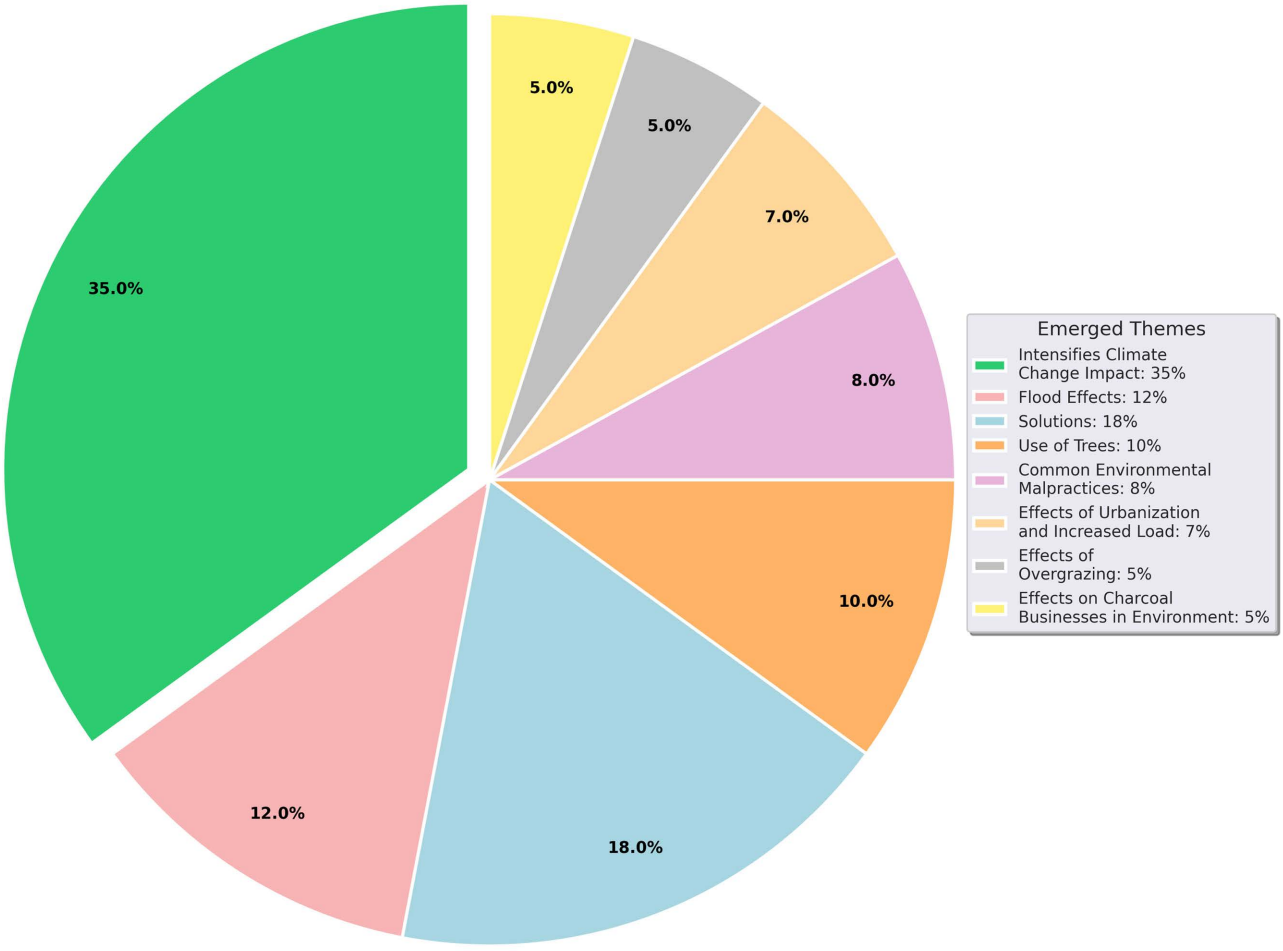

Figure 7. Codes for the emerged themes.

Qualitative data were analyzed using thematic analysis following Braun and Clarke's framework. The distribution of emerged themes is presented in Figure 7, where segment size corresponds to the proportion of coded references to each

theme.

Figure 7 shows the themes emerged from qualitative analysis. Relative frequency of eight themes identified through thematic coding (n = 8 themes). Segment size is proportional to coding frequency. Pie chart showing the distribution of eight themes emerged from qualitative analysis. Climate Change Impact is the largest segment at 35%, followed by Solutions at 18%, Flood Effects at 12%, Use of Trees at 10%, Environmental Malpractices at 8%, Urbanization Effects at 7%, and both Overgrazing and Charcoal Business Effects at 5% each.

Unsustainable uses of trees: The overexploitation and unsustainable use of trees, particularly for charcoal production, housing construction, and fencing, were identified as a significant environmental malpractice in the region. This has led to deforestation and the depletion of the natural landscape.

"*Unsustainable land use practices exacerbate desertification and soil erosion, further deforestation and impacting the region's climate.*"

5.3. Emerged Common Environmental Malpractices

The findings from the key informative interviews and FGDs revealed several common environmental malpractices prevalent in the Puntland region, particularly within the research area. These are shown in Figure 8:

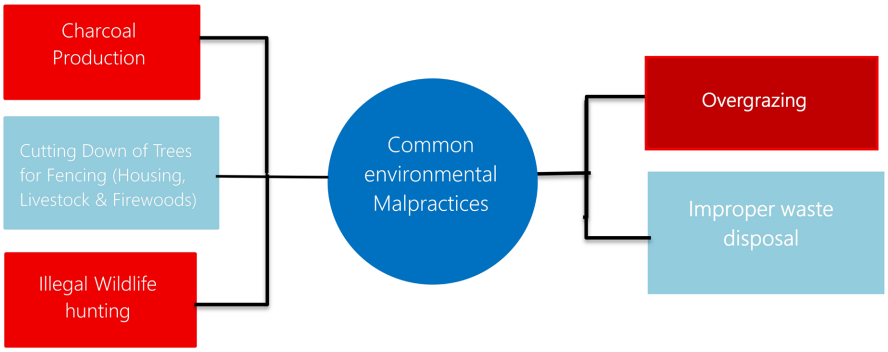

Figure 8. Emerged common environmental malpractices.

Figure 8 depicts the primary anthropogenic activities driving environmental degradation in the study area. Overgrazing, deforestation, and charcoal production were identified as the most significant contributors to land deterioration. These practices result in reduced pasture availability, livestock feed scarcity, accelerated soil erosion, gully formation, and progressive rangeland degradation, ultimately compromising environmental sustainability and ecosystem resilience.

"*One of the key informants from the pastoralist community mentioned that the maximum impact is observed during droughts and dry periods, when pasture and water availability are at a minimum. During these times, both livestock feed and food for people become scarce. Livestock market prices also drop, forcing pastoralists* (*livestock owners*) *to take loss prices in order to survive, leading to increased livestock mortality.*"

1) Charcoal Production

The findings indicate that the production of charcoal is a common practice in the Puntland region. Charcoal production often involves unsustainable harvesting and cutting down of trees, which can lead to deforestation and degradation of the local ecosystem. Charcoal producers used both dry trees and live trees duringproductionn 1.

Figure 8 also illustrates the emergence of tree clearing for fencing as a common environmental malpractice. The data reveal that trees are frequently cleared to provide materials for fencing used in housing construction, livestock enclosures, and as firewood. This tree clearing contributes significantly to the loss of forest cover and disrupts the natural habitats of local wildlife.

According to respondents, particularly livestock owners with direct experience in fencing practices, each household cuts an average of 300 trees per annum for livestock shelter construction. The most commonly preferred species for livestock fencing include Acacia and thick-stemmed trees locally named *Jeerin*, *Qurac*, *Cadaad*, and *Bilcil*, among others.

Trees provide a variety of environmental benefits, including livestock feed in the form of green or dried leaves, shelter, shade, and protection of stored materials from wind and floods. Thus, trees serve as natural storage silos for natural pasture, especially dried pasture such as leaves and grasses. This organic matter enriches soil fertility and protects topsoil from erosion. However, when deforestation intensifies, the entire forest ecosystem is destroyed, losing its resilience to withstand wind and floods.

Illegal Wildlife Hunting and Its Ecological Consequences: Interview data revealed that illegal wildlife hunting represents a significant conservation challenge in the Puntland region. This unregulated exploitation threatens vulnerable species populations and disrupts the ecological balance of local wildlife communities. Illegal poaching has precipitated the migration and local extinction of several native species that were once abundant in these areas. Species documented as locally extinct due to combined pressures of human conflict and overhunting include the *biciid* (Somali wild ass), *goodir* (greater kudu), and gari (giraffe). Additional species have undergone range contraction and migration from the region, driven by habitat degradation, water scarcity, declining pasture availability, and anthropogenic disturbance as wildlife seek undisturbed refugia.

These selective pressures have created pronounced imbalances in wildlife community structure. Some species, particularly primates such as *Papio* spp. (baboons), have exhibited population increases, likely due to reduced predation pressure and ecological release. Conversely, apex predators, including lions (*Panthera leo*), have been completely extirpated from the region. Despite the local extinction of several large carnivores, remnant populations of hyenas (*Crocuta crocuta* and *Hyaena hyaena*) and cheetahs (*Acinonyx jubatus*) persist in low densities. These remaining predators experience persistent human-wildlife conflict, primarily stemming from livestock depredation—a behavior intensified by the depletion of natural prey

populations. Retaliatory killing by pastoralists protecting their livestock further compounds predator population declines.

The persistence of these conservation threats is exacerbated by inadequate protection mechanisms, characterized by limited law enforcement capacity and insufficient community awareness regarding the ecological value of predators and broader wildlife conservation. Strengthening institutional frameworks for wildlife protection and implementing community-based conservation education programs are critical interventions needed to mitigate ongoing biodiversity loss in the region. Locals only see that the viable solution currently available is to eliminate the threat, where government capacity to regulate illegal hunting is minimal.

Overgrazing: The findings suggest that overgrazing by livestock is a significant problem in Puntland. Excessive grazing can lead to soil degradation, loss of vegetation, and the disruption of the natural ecosystem.

Improper Waste Disposal: The data indicates that the improper disposal of waste, including both household and industrial waste, is a common practice in the Puntland region. This can lead to the contamination of soil and water resources, posing health risks to the local population and the surrounding environment.

These environmental malpractices, if left unaddressed, can have serious negative impacts on the fragile ecosystems of the Puntland region, threatening the long-term sustainability and well-being of the local communities. Comprehensive and coordinated efforts to address these issues, such as sustainable resource management, environmental education, and enforcement of environmental regulations, are crucial to mitigate these challenges and protect the natural resources of the Puntland region.

2) Results and Findings on Objective 2

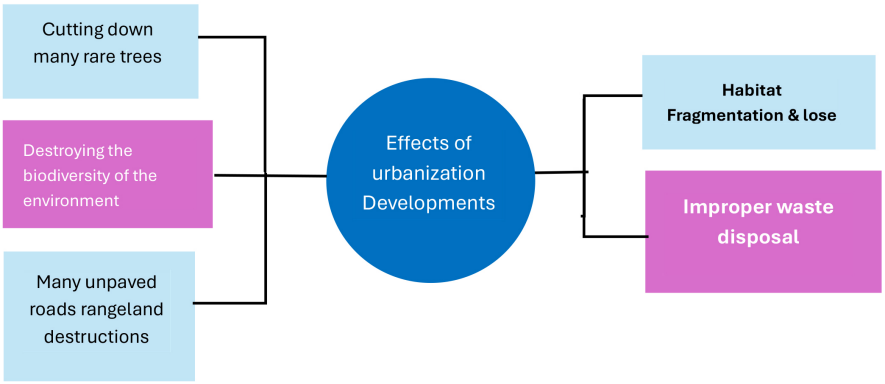

Figure 9. Key issues affecting environments as a result of urbanization developments.

The research also seeks to answer how environmental malpractices can intensify climate change in Puntland, in order to understand the interplay between environmental malpractices and the impacts of Climate Change. Based on the Key Informant Interviews (KIIs) and the Focus Group Discussions (FGDs), the figure below illustrates how common environmental malpractices can exacerbate the im-

pacts of Climate Change.

Figure 9 shows common anthropogenic practices within species range areas, including selective logging of rare tree species and unpaved road construction, demonstrating direct contributions to habitat fragmentation, habitat loss, and disruptions to wildlife migration patterns.

3) Deforestation and Biodiversity Depletion

Urban infrastructure development, encompassing both paved and unpaved road networks, has precipitated extensive deforestation characterized by the removal of endemic and rare tree species. This anthropogenic disturbance has resulted in substantial degradation of local biodiversity, with notable reductions in canopy cover and the extirpation of species with limited geographic distribution. The loss of these keystone and rare species represents a critical threat to ecosystem integrity and functional diversity within the region.

4) Habitat Fragmentation and Faunal Displacement

Urbanization has induced significant habitat fragmentation, particularly affecting contiguous rangeland ecosystems. This spatial discontinuity disrupts essential ecological processes, including wildlife dispersal, seasonal migration corridors, and gene flow between populations. The resultant landscape mosaic creates barriers to animal movement, leading to population isolation, reduced habitat connectivity, and cascading biodiversity losses as native fauna are displaced from their historical ranges. These disruptions compromise both species' persistence and ecosystem resilience.

5) Infrastructure-Driven Land-Use Change

The proliferation of unpaved road networks has emerged as a primary vector of environmental degradation in the study area. These transportation corridors facilitate land clearance and serve as conduits for further anthropogenic encroachment into previously undisturbed habitats. The clearance and expansion of unpaved roads act synergistically with other urbanization pressures, amplifying deforestation rates and accelerating habitat conversion processes.

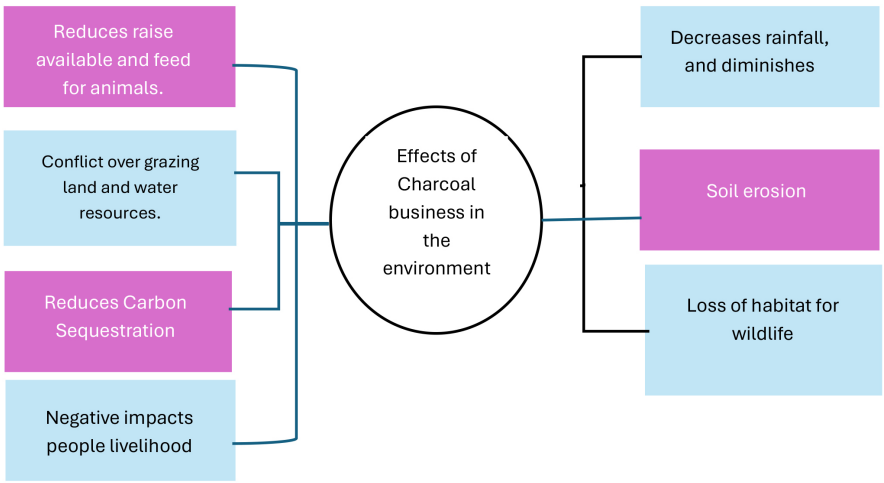

Figure 10. The key impacts of charcoal production.

Figure 10 shows the primary environmental impacts of charcoal production in the Puntland region, specifically within the Mudug, Nugal, and Karkaar subregions. The charcoal industry demonstrates a substantial dependence on natural forest resources, resulting in widespread deforestation and land degradation. Barren land formation represents a critical consequence of charcoal production, exacerbated by synergistic anthropogenic pressures, including overgrazing. The removal of vegetation cover has significantly reduced the natural barriers provided by shrubs and groundcover, consequently increasing surface water runoff. This hydrological alteration has accelerated soil erosion processes, leading to gully formation that has rendered previously productive rangeland areas unsuitable for grazing activities.

"*One of the key informants from the pastoralist community: Charcoal business reduces grazing areas for animals, decreases rainfall, and diminishes water availability. These changes can lead to conflicts over grazing land and, sometimes, conflicts happen between those cutting the trees to make charcoal production and pastoralist communities want their livestock to graze these trees.*"

One of the key informants from the pastoralist community said: Charcoal production and firewood collection cleared the forests, turning them into non-grazable areas, the dead plants are the host for the tress leaves, these leaves are than used by the livestock during the dry season or when the rainfalls the leaves become soft wet and livestock feeds for the first two weeks of rain or until the tress turns into green. However, when dead trees were removed as firewood and shrubs were cleared as result of overgrazing the both plant leaves and top soil moved.

Overall, charcoal production has many negative impacts on people, livelihoods, and the environment. Similarly, rare species of biodiversity can also lead to extinction as a result of deforestation and barrel and creation. This leads to loss of habitat for wildlife, soil erosion, and contributes to climate change by reducing carbon sequestration. It also has social and economic impacts, as the depletion of forests can lead to conflict over resources and loss of livelihoods for communities that depend on the forest.

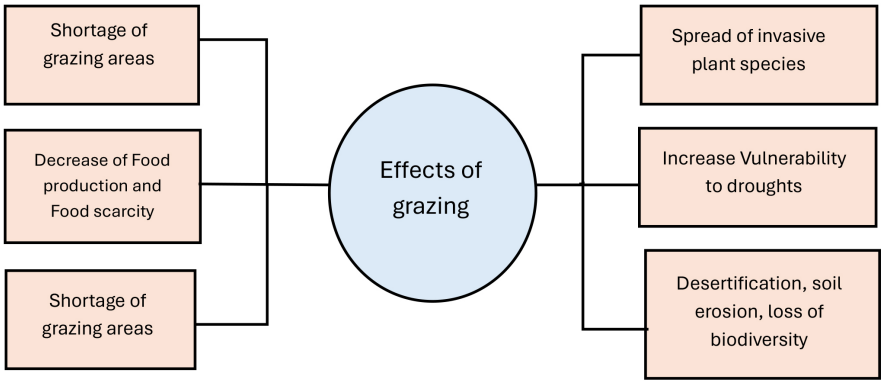

Figure 11. The key impacts of overgrazing.

Figure 11 illustrates the principal impacts of overgrazing documented in the

study area. Focus group discussions revealed that the region supports high livestock densities, predominantly comprising goats, sheep, camels, and donkeys. These animals engage in continuous free-range grazing without community-level rotational grazing management systems. This absence of structured rangeland management has precipitated multiple adverse ecological and socioeconomic consequences. Respondents identified critical forage shortages, particularly during seasonal dry periods, which cascade into food insecurity for both livestock and human populations. The unregulated grazing regime has facilitated the establishment and expansion of invasive plant species, as livestock exhibit selective avoidance of these unpalatable taxes. Additionally, the synergistic effects of overgrazing and diminished pasture availability have amplified the region's susceptibility to drought-induced perturbations.

The reduced vegetative cover and water scarcity have diminished the land's water retention capacity, leading to increased water runoff and the formation of gully erosion features. Below are some key words from their key interviews:

"*One of the key informants from the pastoralist community said*: *Overgrazing can result in the extinction of many species of grasses and a shortage of grazing land and availability of shrubs and pastures*, *which can also lead to conflicts later between the pastoralists*, *conflicting small remaining areas for pasture*. *Degradation and the spread of invasive plant species can further degrade the fragile ecosystem*."

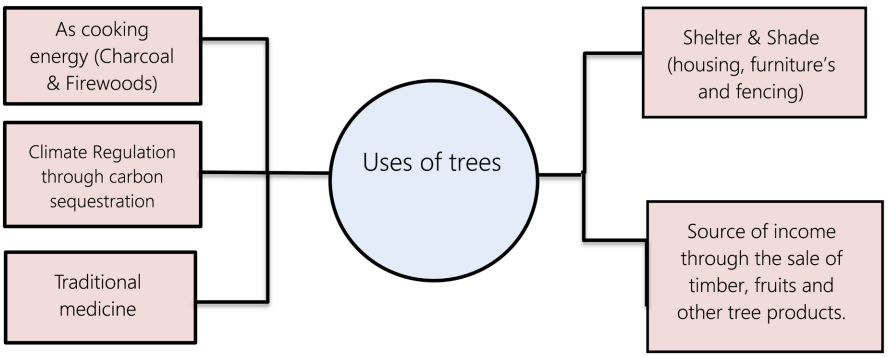

Figure 12. The main uses of trees which can contribute to the intensification of climate change.

Figure 12 shows the diverse ecosystem services and socioeconomic functions that trees provide to local communities in the study area. Based on the data collected, trees demonstrate three primary categories of importance.

1. Economic Significance

Trees constitute a critical source of livelihood for local communities through multiple revenue-generating pathways:

- Energy production: Charcoal production and firewood harvesting represent primary income sources.
- Construction materials: Provision of timber poles for shelter construction and infrastructure development.

- Agricultural support: Supply of materials for fencing to protect livestock and crop farms from external threats.
- Non-timber forest products (NTFPs): Frankincense (*Boswellia* spp.) resin extraction constitutes a significant economic activity, with production concentrated in the mountainous areas of Bari, Gardafuu, Karkar, and Sanaag regions, contributing to both local and export markets.

2. Subsistence Value

Trees provide essential non-market goods that directly support household welfare and food security:

- Ethnobotanical resources: Trees serve as sources of traditional medicine and direct food products for local populations. (Miro)—naturally grown fruits, roots, and leaves.
- Pastoral livelihoods: The pastoralist community exhibits high dependency on tree resources, as livestock derive nutrition directly from the natural environment, including browse from trees and associated shrub vegetation. As a result, livestock production increases in terms of milk and meat. The livestock quality depends on the type of grazing.

3. Ecological Functions

Trees perform vital environmental services that sustain both human and animal populations:

- Microclimate regulation: Trees provide natural shelter and shade for livestock, offering protection from solar radiation during the daytime and thermal insulation during nocturnal periods. In the study area, with a hot climate, shady trees are essential for both humans and their livestock to hide from the long sunny days.
- Soil conservation: Tree cover mitigates wind erosion, reduces dust dispersion, and prevents topsoil displacement through root stabilization.
- Biodiversity maintenance: Trees contribute to ecosystem integrity, though evidence indicates localized species loss, particularly the Dheen tree, which has experienced extirpation from Nugal rangelands, especially in riparian zones adjacent to seasonal watercourses.

5.4. Causal Loop Diagram Environment (Negative Impact on Activities and Positive Effect on Activities)

Figure 13 illustrates the causal loop diagram (CLD) depicting both negative and positive feedback loops between human activities and climate change impacts. Human activities can negatively affect the environment and ecosystem services through several pathways: overgrazing, unsustainable tree use (for energy and shelter), illegal hunting and overexploitation, poor environmental practices and waste management, and limited environmental protection awareness all contribute to and intensify climate change impacts. Conversely, positive human interventions can enhance resilience to climate change. For instance, based on key informant interview (KII) responses, restoring degraded land provides regrazing opportunities and improves pasture availability. The prohibition and regulation of charcoal

production safeguard forest sustainability and maintain forest pasture productivity, thereby reducing grazing pressure on livestock. Additionally, trees provide shade, shelter, and carbon sequestration benefits. Limiting and regulating illegal hunting and poaching fosters coexistence between wildlife and human communities. For example, in some areas of the Nugaal region, local communities prohibited illegal ostrich hunting, which subsequently led to a notable increase in ostrich populations. These community-led conservation efforts demonstrate the potential for positive feedback mechanisms in climate adaptation strategies.

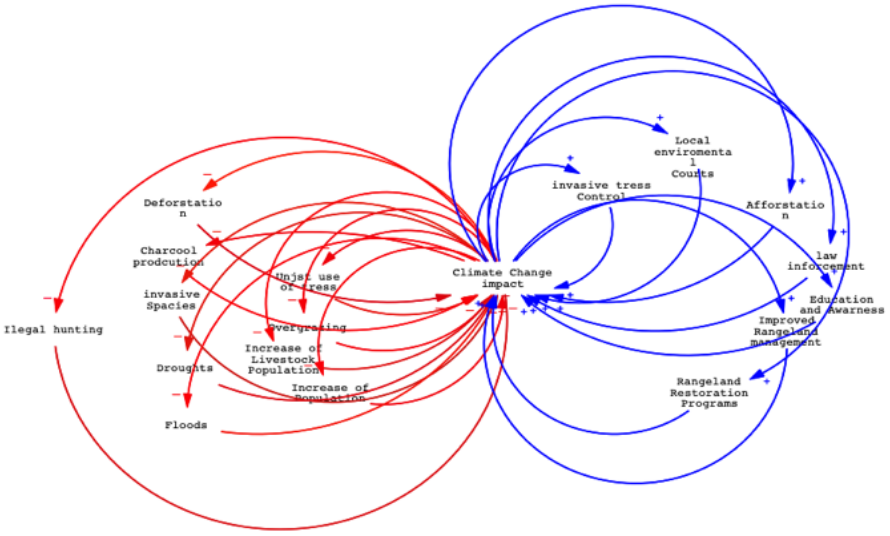

Figure 13. CLD shows both negative-impact activities and positive-impact activities.

6. Conclusion

Charcoal remains the second most common cooking energy source in Puntland (44.1% - 54.7% usage across regions), driving severe deforestation. The preference for the Acacia species (49% favor *Acacia bussei*) is particularly problematic as these trees provide critical ecosystem services, including livestock fodder and climate adaptation. Traditional earth-mound kiln methods compound environmental damage through inefficient conversion, smoke pollution, and soil degradation. While charcoal production provides essential income for impoverished households, especially during droughts, production has far exceeded environmentally sustainable limits.

Puntland has experienced dramatic wildlife losses, with elephants, lions, rhinos, and giraffes migrating or becoming locally extinct between 1980 and 1989. Contributing factors include habitat degradation, drought-induced resource scarcity, human-wildlife conflict, and firearm proliferation following state collapse. The current encroachment of wildlife (e.g., warthogs) into urban areas creates zoonotic disease risks, including brucellosis, swine influenza, hepatitis E, rabies, and leptospirosis.

Multiple factors drive rangeland degradation: overgrazing near water sources during dry seasons, proliferation of unpaved roads (up to 0.5 km wide) created by

vehicle-based livestock movement, poor waste management, invasion of alien species (*Prosopis juliflora* and *Beeryaro weedii*), and sand dune movement destroying approximately 6 km of rangeland. Historical rangeland management initiatives (Seasonal Range Reserves covering 400 km^2 and Famine Reserves spanning 600 km^2) failed due to insufficient community engagement and conflicts with nomadic mobility patterns.

Despite existing environmental protection policies under the Puntland Ministry of Environment and Climate Change, implementation faces critical barriers: 1) immediate survival needs of impoverished populations lacking alternatives to tree cutting, 2) absence of social safety nets following environmental shocks, 3) weak law enforcement allowing continued commercial exploitation, and 4) slow adoption of alternative energy sources.

The Biyoole project has rehabilitated 883 hectares across 35 gully-affected sites using rock dams to control runoff. The DRSLP-II project restored 10 km^2 of gullies in the Nugaal region through rock dams and animal manure grass spreading. These initiatives, supported by the World Bank and African Development Bank, demonstrate that locally appropriate technologies can achieve meaningful landscape restoration in degraded dryland environments.

The environmental malpractices documented in this review create a dangerous trajectory threatening human well-being, livestock production systems, and biodiversity. The charcoal economy exemplifies a fundamental tension between economic survival and environmental sustainability. A challenge that cannot be resolved through conservation policy alone but requires integrated development approaches addressing poverty, energy access, and livelihood diversification. The failure to establish effective wildlife reserves and the subsequent biodiversity collapse represent irreversible losses that diminish ecosystem resilience. Rangeland degradation, accelerated by modern infrastructure development, threatens the pastoral production system upon which the majority of Puntland's population depends.

7. Recommendations

The recommendation is merely based on the emerging themes from the KII responses; therefore, each emerging theme addresses the pressing environmental challenges and mitigates the impacts of climate change. Key informative interviews (KII) were conducted to gather insights into potential solutions. The research extracted relevant information from both traditional knowledge and scientific sources to tackle the current environmental malpractices.

1. **Need for environmental education and awareness:** Enhancing knowledge related to environmental protection is crucial, and this can be achieved through both formal and informal educational avenues. For instance, introducing university degrees in environmental studies and incorporating environmental courses into school curricula can significantly contribute to building a more environmentally conscious population.

2. **Community structural reforms:** Community-based structures should be able to implement and create a safer and more sustainable environment, working on environmental sustainability through establishing environmental protection committees and environmental courts to oversee and enforce environmental regulations. Encouraging initiatives such as waste disposal management programs and leveraging technology for environmental monitoring can also be effective measures.
3. **Sustainable rangeland practices:** Proper management of rangelands, a critical natural resource for livestock grazing, is vital to ensure food security for both animals and humans. Implementing community-based conservation efforts, such as reforestation and responsible grazing practices, such as rotational grazing, can help maintain the ecological balance and prevent resource depletion.
4. **Robust enforcement mechanisms:** Introducing and enforcing strict laws and regulations against illegal activities, such as unauthorized cutting, overgrazing, and improper waste disposal, can serve as a deterrent and promote responsible environmental stewardship. Creating a training environment for police to deal with such environmental crime and enforcing existing policies, regulations, or frameworks is essential.
5. **Ownership:** Community involvement and cross-sectoral collaboration. Engaging local communities in environmental conservation efforts, such as tree planting initiatives and clean-up drives, can foster a sense of ownership and responsibility towards the environment. Collaborating with environmental organizations, government agencies, and businesses can also enable the development of comprehensive and coordinated strategies to combat these environmental challenges.
6. **Increasing restoration and rehabilitation efforts:** Already degraded rangelands need sustainable restoration and rehabilitation, such as gully erosion control measures, the fixation of sundumes, and the control of invasive species. Suchefforts were rrecommended

In summary, the KII responses propose a multifaceted approach to create a sustainable environment and address environmental malpractices. This includes enhancing environmental education and awareness, reforming community structures, enforcing environmental regulations, promoting community involvement, and fostering cross-sectoral collaboration. By implementing these strategies, the local communities can work towards mitigating the impacts of climate change and restoring the delicate balance of their natural ecosystems.

Conflicts of Interest

The author declares no conflicts of interest regarding the publication of this paper.

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Appendix

Table A1. Common environmental malpractices.

Name	Description	Sources	References
Effect of urbanization and unpaved roads	Unsustainable developments of cities, roads, and unpaved roads	1	4
Effects of overgrazing	Unsustainable uses of rangeland grazing	1	4
Effects on the charcoal business in the environment	Environmental problems related to Charcoal Production.	1	6
Flood effects	Effects of intensive floods on the environment ecosystems	1	4
Drought	Effect of droughts on the environment		
Uses of trees	Unsustainable uses of trees	1	4

Table A2. Environmental malpractices and climate change.

Name	Description	Sources	References
Common environmental malpractices	Unjust environmental malpractices	1	4
Effect of urbanization and unpaved roads	Unsustainable developments of cities, roads, and unpaved roads	1	4
Effects of overgrazing	Unsustainable uses of rangeland grazing	1	4
Effects on the charcoal business in the environment	Environmental problems related to charcoal production	1	6
Environmental malpractices intensify climate change impact	Human activities that exacerbate or worsen the impact of climate change	1	14
Flood effects	Effects of intensive floods on the environmental ecosystems	1	4
Uses of trees	Unsustainable uses of trees	1	4