Extreme Weather Events and Conflict impacts on Health Facilities: Case Study Somalia

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1. INTRODUCTION

The intersection of armed conflict and climate variability presents a complex challenge to healthcare systems in vulnerable regions, particularly in conflict-affected countries where adaptive capacity is severely limited (Sitati et al., 2021). These nations face disproportionate vulnerability to environmental stressors, as their institutional infrastructure and social systems are already strained by ongoing conflicts, creating a compound effect that amplifies both challenges. Armed conflicts, especially prevalent in Sub-Saharan Africa (SSA), have long been recognized for their devastating impact on vulnerable communities. However, their specific effects on health outcomes and healthcare systems have only recently become a focus of systematic academic investigation (Wagner et al., 2018).

The relationship between conflict, climate events, and healthcare system functionality represents a critical yet understudied area of research. While existing literature has documented the direct impacts of armed conflicts on mortality rates, there remains a significant knowledge gap in understanding the broader implications for healthcare coverage and service delivery. This gap is particularly pronounced in regions experiencing both conflict and climate-related stresses, where the compounding effects of these challenges may create unique barriers to healthcare access and delivery (Wagner et al., 2018). Recent studies have begun to explore these intersections, suggesting that the combined impact of conflict and climate events may be greater than the sum of their individual effects on healthcare systems.

In the Horn of Africa, particularly Somalia, health facilities face unprecedented challenges from the dual threats of persistent armed conflict and increasingly severe climate-related disasters, including both droughts and floods (Akresh et al., 2012). These conditions create a complex emergency scenario where healthcare infrastructure must contend with multiple, simultaneous threats to its operational capacity. The structural integrity of health facilities is directly compromised by conflict-related damage, while climate events can render facilities inaccessible or inoperable, creating significant barriers to healthcare delivery. This situation is further complicated by the chronic nature of these challenges, as both conflict and climate-related events tend to occur in cycles that can prevent effective recovery and reconstruction efforts.

The impact of these combined stressors extends beyond the physical infrastructure to affect the entire healthcare delivery system. Healthcare workers may be displaced or unable to reach facilities, supply chains can be disrupted, and patients may face increased barriers to accessing care. Understanding these dynamics is crucial for developing effective interventions and building more resilient healthcare systems in conflict-affected regions. This research gap becomes particularly significant as climate change continues to exacerbate environmental stressors in regions already destabilized by conflict.

This study aims to contribute to this critical area of research by conducting a comprehensive investigation into the combined impacts of armed conflicts and climate events on health facilities across Somalia. By examining the geographical distribution of healthcare facilities in relation to both conflict zones and areas affected by extreme weather events, this research seeks to identify patterns of vulnerability and resilience in healthcare infrastructure. The analysis will focus on understanding how these dual threats affect the coverage and accessibility of health services, with particular attention to areas where conflict and climate stresses overlap.

The significance of this research extends beyond academic understanding to practical applications in humanitarian response and healthcare system strengthening. By identifying areas where healthcare facilities are most vulnerable to the combined effects of conflict and climate events, this study aims to provide valuable insights for policymakers, humanitarian organizations, and healthcare providers working in complex emergency settings. These findings can inform more effective strategies for protecting and strengthening healthcare infrastructure in regions facing similar challenges, ultimately contributing to improved healthcare delivery and population health outcomes in conflict-affected areas experiencing climate stress.

Given the increasing global prevalence of both armed conflicts and climate-related disasters, understanding their combined impact on healthcare systems becomes increasingly crucial for developing effective mitigation strategies and building more resilient healthcare infrastructure. This research seeks to address this critical knowledge gap and provide actionable insights for improving healthcare delivery in some of the world's most challenging contexts

2. OBJECTIVES

Main Objective

The primary objective of this project is to examine the combined impacts of armed conflicts and climate variability on the coverage and extent of health facilities in Somalia.

Research Specific Objectives

RO1. To analyze the impact of armed conflicts on the health facility coverage in Somalia.

- *How do armed conflicts affect the geographical distribution of health facilities in Somalia?*

RO2. To assess the effects of extreme weather events (droughts and floods) on health facilities in Somalia.

- *What is the impact of both drought and floods on health coverage?*

RO3. To identify the combined effects of conflict and extreme weather events on health service coverage in Somalia.

- *How do the overlapping impacts of conflict and climate events exacerbate damage to health service in Somalia?*

3. LITERATURE REVIEW

The complex interplay between armed conflict, climate vulnerability, and healthcare systems presents a critical challenge in conflict-affected regions, particularly in Sub-Saharan Africa. Recent studies have demonstrated the profound and far-reaching impacts of these combined stressors on healthcare delivery and infrastructure. Wagner et al. (2018) conducted an extensive geospatial analysis that revealed how armed conflicts significantly increase child mortality rates, with effects extending up to 100 kilometers from conflict zones. Their research established a clear spatial relationship between conflict intensity and degradation of healthcare services, highlighting how violence creates ripple effects throughout regional health systems. These findings are particularly significant as they demonstrate that the impact of conflict on healthcare extends far beyond immediate battle zones, creating systemic challenges for healthcare delivery across entire regions.

The vulnerability of healthcare systems in conflict zones is further complicated by the increasing prevalence of climate-related stressors. Sitati et al. (2021) established a crucial framework for understanding how conflict-affected countries face heightened vulnerability to climate variability, demonstrating that regions already struggling with conflict have significantly reduced adaptive capacity. Their research revealed that healthcare infrastructure in these areas faces a double burden: not only must facilities contend with direct conflict-related damages, but they must also navigate the challenges posed by increasing climate variability. This combination of stressors creates a complex emergency scenario where traditional healthcare delivery models may prove inadequate or unsustainable.

The concept of complex emergencies becomes particularly relevant when examining healthcare systems in regions like Somalia, where multiple forms of stress interact and compound each other. Akresh et al. (2012) provided foundational research examining how conflict impacts health outcomes and infrastructure, particularly in regions experiencing environmental stresses. Their work demonstrated that healthcare facilities in conflict zones face multiple, overlapping challenges that compromise both their structural integrity and operational capabilities. These findings suggest that the relationship between conflict and climate stress is not merely additive but potentially multiplicative, with each factor amplifying the impact of the other on healthcare systems.

The temporal dynamics of these combined stressors present additional challenges for healthcare systems in conflict zones. Research has shown that while acute events such as battles or floods may cause immediate disruption to healthcare services, the long-term effects of chronic stress from both conflict and climate change can gradually erode healthcare capacity over time. This erosion manifests in multiple ways, from the physical degradation of infrastructure to the loss of trained healthcare workers and the disruption of essential supply chains. Understanding these temporal dynamics is crucial for developing effective interventions and building more resilient healthcare systems.

The spatial distribution of healthcare facilities in relation to both conflict zones and areas affected by climate events represents another critical area of investigation. Studies have demonstrated that healthcare coverage often becomes increasingly fragmented in conflict-affected regions, with some areas experiencing severe shortages while others maintain relatively stable service delivery. This spatial variability is further complicated by climate-related events, which can affect large geographic areas and create additional barriers to healthcare access. The intersection of these spatial patterns – where conflict zones overlap with areas prone to climate-related disasters – may represent particularly vulnerable points in healthcare systems.

Research has also begun to examine the specific pathways through which conflict and climate events affect healthcare delivery. These impacts occur through multiple mechanisms, including direct damage to infrastructure, disruption of supply chains, displacement of healthcare workers, and changes in population health needs. In conflict zones, healthcare facilities must often operate with reduced staff, limited resources, and compromised security conditions. When climate-related stresses are added to this equation, the challenges become even more complex. For example, drought conditions may increase population mobility and disease burden while simultaneously reducing the resources available for healthcare delivery.

The role of institutional capacity and governance systems in mediating the impacts of conflict and climate stress on healthcare systems represents another important area of investigation. Studies have shown that regions with stronger institutional frameworks and more robust healthcare systems may be better equipped to maintain service delivery even in the face of significant stresses. However, in many conflict-affected regions, these institutional capacities are themselves compromised by ongoing violence and instability, creating a cycle where reduced capacity leads to increased vulnerability to both conflict and climate-related stresses.

Understanding the interaction between conflict, climate events, and healthcare systems is particularly crucial in the context of global climate change. As climate-related events become more frequent and severe, healthcare systems in conflict-affected regions may face increasing challenges in maintaining service delivery and responding to population health needs. This situation underscores the importance of developing more resilient healthcare systems capable of functioning effectively even under conditions of compound stress.

4. STUDY AREA

Somalia is situated in the Horn of Africa and bordering several key regions. It borders Ethiopia in the west, Kenya in the southwest, and Djibouti to the northwest. The country has the longest coastline in Africa, 32 500 km^2, which reaches the Gulf of Aden on the northern coastline, plus the Indian Ocean on the eastern coastline, and Somalia extends over 637 600 km^2 . The country contains 18 regions, with the capital being Mogadishu. Besides that, Somalia has faced periodical conflict since the fall of its central government in 1991, a factor that has contributed to a high level of displacement and weakened institutional structures at large in the country (Khayre, 2016).

Moreover, Somalia has four different seasons with two of them are rainfall seasons, each shaping its climate. The Jilaal season, from December to March, is hot and dry. It's followed by Gu, the main rainy season from April to June, bringing essential rainfall. The Xagaa season, from July to September, is a drier period with moderate temperatures. Lastly, Deyr, the secondary rainy season from October to November.

Additionally, as shown in Figure 3 below, the average annual rainfall for Somalia is about 250 mm. While the northern regions of the country are hot and arid with less than 250 mm average annual rainfall, the parts lying in the south and southwest receive rainfall amounts as high as 400 and 700 mm, respectively. In the central semi-arid areas of the country, annual rainfall as low as 50–100 mm/year is obtained. Annual mean temperatures are near 30 °C. Maximum temperatures of average monthly temperatures occur in the country during the months of April through June as indicated in Figure 2 below. The hottest months for the northern regions are from June to September. In contrast, for the south, the hottest weather is from December to March.

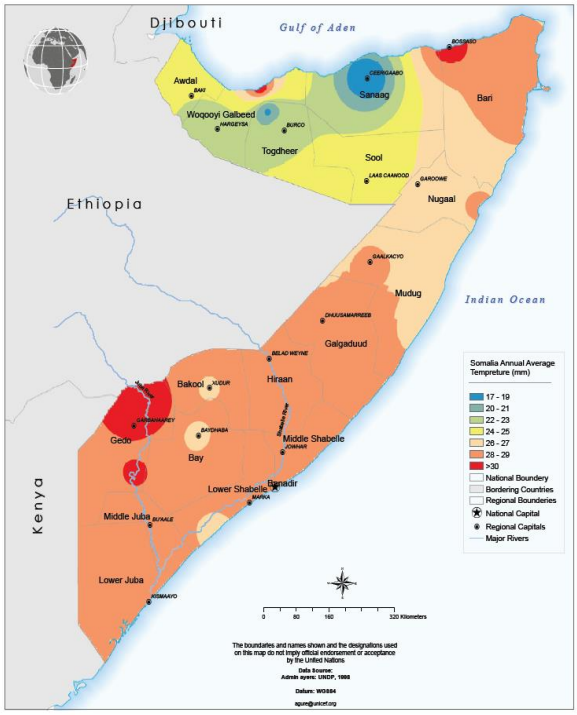


Figure 1: Average Annual Temperature Map of Somalia (1981-2018)

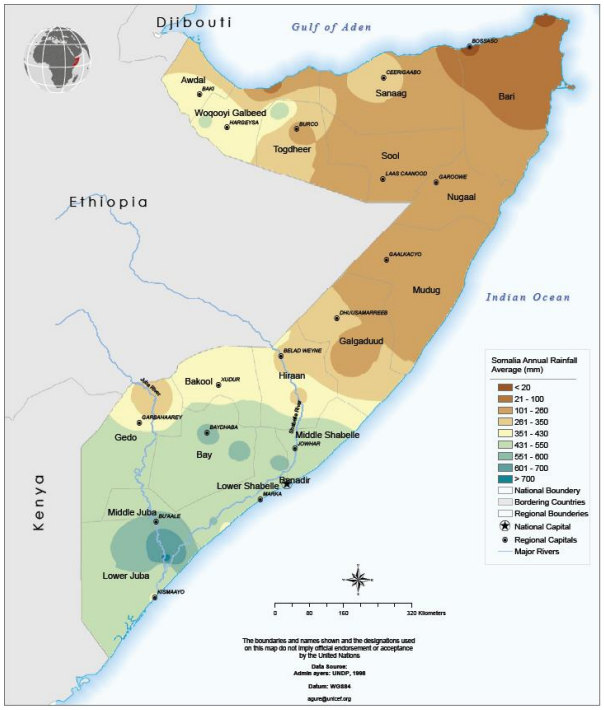


Figure 2: Average Annual Rainfall Map of Somalia (1981-2018).

(Gure, 2021)

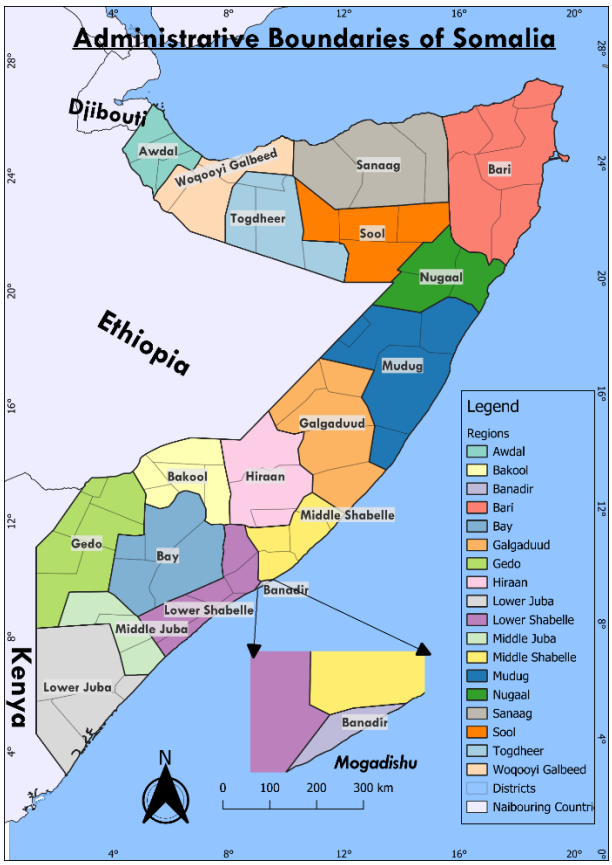


Figure 3: Administrative Boundaries of Somalia

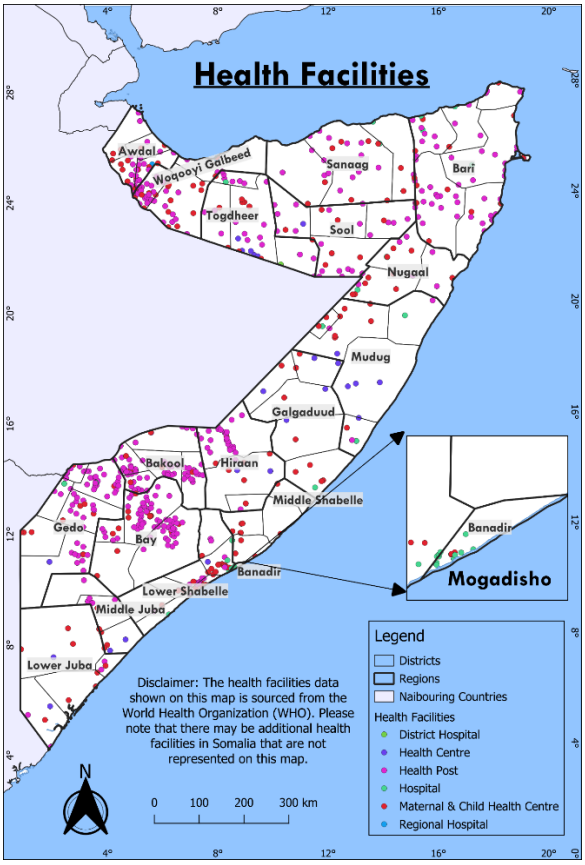


Figure 4: Health facilities map of Somalia

Figure 3 illustrates the administrative boundaries of Somalia, showing its 18 regions and their geographical distribution, along with neighboring countries Ethiopia, Kenya, and Djibouti. The map provides a structural overview of Somalia's governance and regional divisions. Figure 4 presents the distribution of health facilities across Somalia, including district hospitals, health centers, health posts, maternal & child health centers, and regional hospitals, based on data sourced from the World Health Organization (WHO). While comprehensive, the dataset may not include all existing health facilities. Together, these maps offer valuable insights into regional administration and healthcare accessibility, aiding in spatial analysis of healthcare service distribution in Somalia.

5. METHODOLOGY

This study employs a quantitative geospatial analysis approach to examine the combined impacts of armed conflicts and climate variability on health facilities in Somalia. The methodology builds upon the spatial analysis framework established by Wagner et al. (2018) in their study of armed conflict's impact on child mortality in Africa, adapting it to specifically examine healthcare infrastructure resilience.

5.1 DATASET DESCRIPTION

The research utilizes three primary data sources: conflict event data from the Armed Conflict Location & Event Data Project (ACLED), climate data from multiple sources, and health facility location data. The ACLED dataset provides detailed information on various types of conflict events, including violence against civilians, remote violence/explosions, protests, riots, battles, and strategic developments involving disrupted weapons use. This comprehensive conflict dataset allows for a nuanced understanding of different types of security threats facing healthcare facilities, following the analytical approach demonstrated by Sitati et al. (2021) in their systematic assessment of climate change adaptation in conflict-affected countries.

For climate data analysis, the study incorporates multiple datasets to ensure robust coverage of both drought and flood events. Drought analysis utilizes CHIRPS Daily/Pentad precipitation data, IGAD ICPAC data, and MOD13Q1.061 Terra Vegetation Indices (16-Day Global 250m). These datasets are processed to generate the Vegetation Condition Index (VCI) using Google Earth Engine, providing a comprehensive assessment of drought conditions. Flood risk analysis incorporates Somalia Flood Prone Areas data covering 2013-2023, enabling the identification of healthcare facilities at risk from flooding events. This multi-source approach to climate data follows the methodology established by Akresh et al. (2012) in their analysis of environmental stressors on health systems.

The health facility dataset, sourced from the World Health Organization (WHO), provides comprehensive spatial and attribute data on healthcare facilities across Somalia. This dataset includes information on the distribution of different types of healthcare facilities, such as district hospitals, health centers, health posts, hospitals, maternal & child health centers, and regional hospitals. The data is structured in Excel/CSV format and is integrated into the spatial analysis using georeferenced health facility locations. This enables an assessment of health service accessibility in relation to conflict zones and climate hazard exposure. The dataset follows global health mapping standards, ensuring consistency with previous research on healthcare vulnerability assessments in crisis-prone regions.

Table 1: Datasets intended for use in the research

Dimension	Factor	Indicator	Data source	DATA TYPE
Conflict	Civilians	ACLED data classified as "Violence against civilians"	ACLED	Point Shapefile Data
Conflict	Remote violence/explosions	ACLED data classified as "Remote violence/explosions"	ACLED	Point Shapefile Data
Conflict	Protests	ACLED data classified as "Protests"	ACLED	Point Shapefile Data
Conflict	Riots	ACLED data classified as "Riots"	ACLED	Point Shapefile Data
Conflict	Battles	ACLED data classified as "Battles"	ACLED	Point Shapefile Data
Conflict	Strategic Development (Disrupted weapons use)	ACLED data classified as "Strategic Development (Disrupted weapons use)"	ACLED	Point Shapefile Data
Climate	Drought(meteorology)	CHIRPS Daily/Pentad precipitation	CHIRPS Daily	Raster
Climate	Drought(meteorology)	IGAD ICPAC	ICPAC	Raster
Climate	Drought(agriculture)	MOD13Q1.061 Terra Vegetation Indices 16-Day Global 250m	MODIS	Raster
Climate	Vegetation Condition Index	VCI Index	GEE Code	Raster
Climate	Flood Extent	Somalia Flood Prone Areas	Flood Extent 2013-2023	Polygon Shapefile Data
Health	Health facility	Health facility per region	WHO	Excel/CSV

The spatial analysis proceeds in three distinct phases aligned with the research objectives. The first phase examines the relationship between conflict events and health facility coverage through spatial overlay analysis, creating buffer zones around conflict events and calculating distance relationships between health facilities and conflict zones. This approach enables the identification of gaps in healthcare coverage resulting from conflict, building on the methodological framework established by Wagner et al. (2018).

The second phase focuses on climate impacts, analyzing both drought and flood effects on health facilities. Drought analysis involves processing CHIRPS and MODIS data to create drought severity indices, while flood impact analysis maps health facilities against flood-prone areas to calculate exposure risks. This dual approach to climate risk assessment follows the methodology outlined in recent studies examining climate vulnerability in conflict settings (Sitati et al., 2021).

The final phase implements a multi-hazard overlay analysis to examine the combined effects of conflict and climate events on health facilities. This analysis creates composite risk maps that identify areas where conflict and climate stressors overlap, allowing for the calculation of cumulative impact scores for affected facilities. The approach builds on existing frameworks for analyzing compound risks in complex emergency settings, as demonstrated in recent literature on climate adaptation in conflict-affected regions.

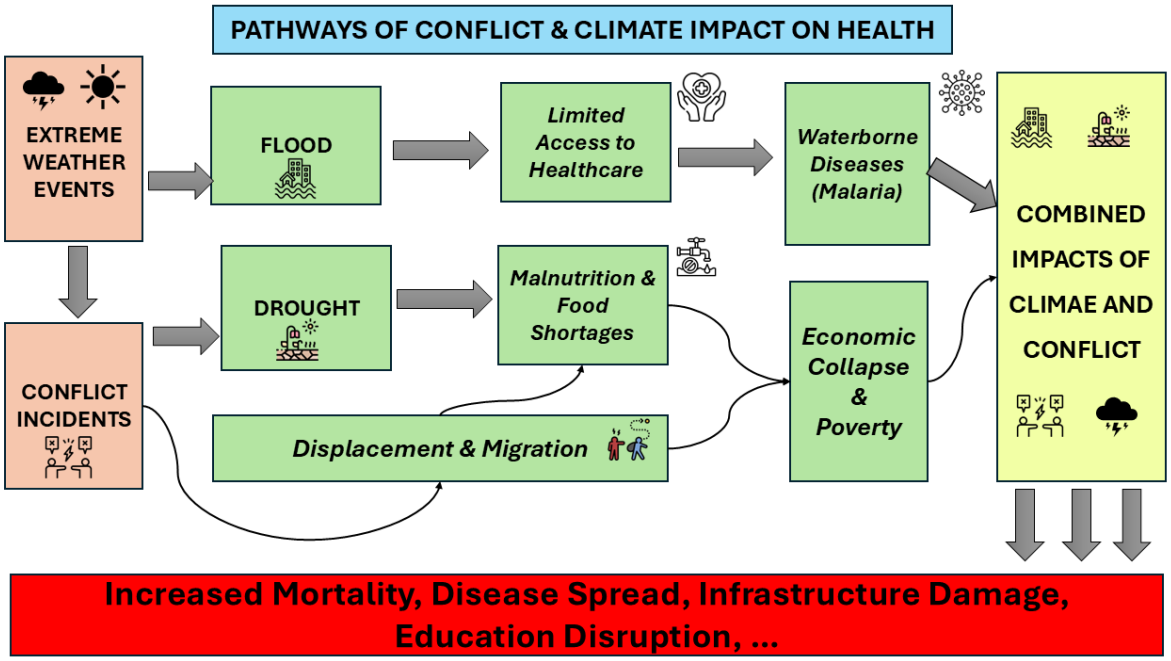


Figure 5: Pathways of conflict and climate impact on health.
Source: Author

Data processing utilizes a combination of Geographic Information System (GIS) software for spatial analysis, Google Earth Engine for remote sensing data processing, and statistical software for data analysis. The processing workflow includes data cleaning and standardization, coordinating system harmonization, temporal alignment of datasets, resolution matching for raster datasets, and rigorous quality control procedures. This comprehensive approach to data processing ensures compatibility across different data sources while maintaining analytical rigor.

Statistical analysis includes spatial correlation analysis, temporal trend analysis, hotspot identification, and risk factor analysis, with significance testing for identified patterns. The methodology incorporates validation procedures including cross-validation of spatial relationships, uncertainty assessment, and sensitivity analysis for key parameters. These analytical procedures are designed to provide robust results while acknowledging the limitations inherent in working with complex spatial data in conflict settings.

The study acknowledges several important limitations, including temporal gaps in data coverage, spatial resolution limitations, potential reporting biases in conflict data, access constraints in conflict zones, and health station coverage limitations. These limitations are carefully considered in the analysis and interpretation of results, following the approach recommended by recent studies in similar contexts (Wagner et al., 2018).

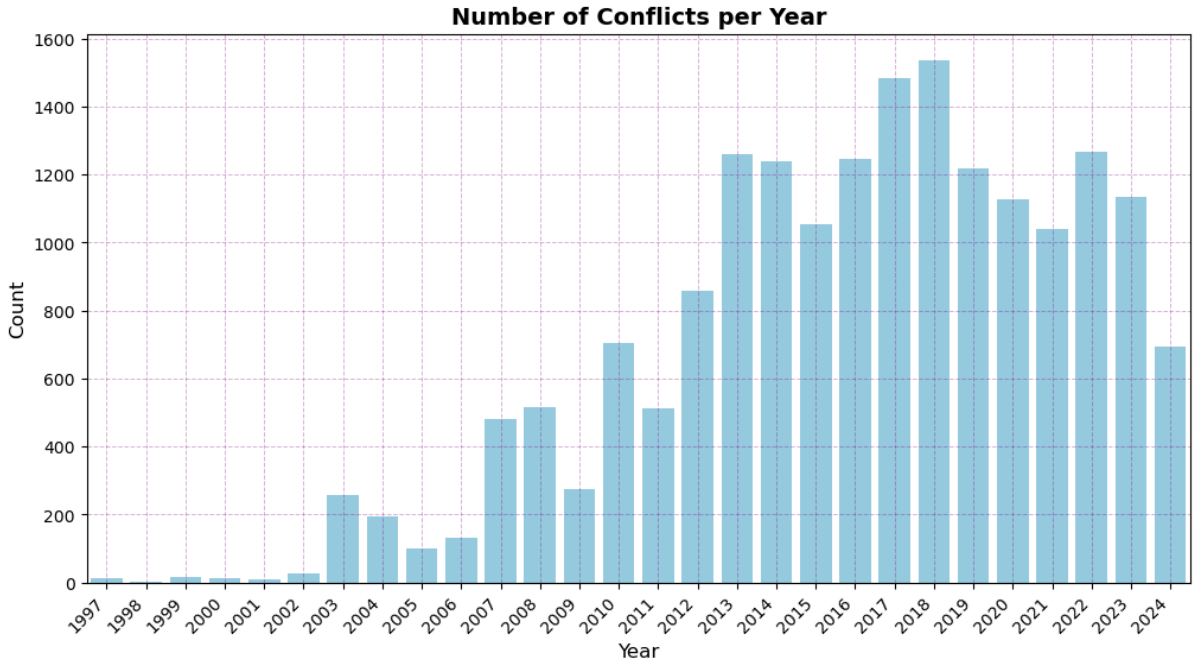


Figure 6: Number of conflicts per year in Somalia (1997-2024).
Source: ACLED

The analysis of conflict events in Somalia from 1997 to 2024 reveals significant temporal variations and a notable escalation in conflict frequency over the study period. The data demonstrates three distinct phases of conflict intensity, characterized by different patterns of violence and instability. During the initial phase (1997-2006), Somalia experienced relatively low levels of recorded conflict events, with annual incidents rarely exceeding 200 events per year. This period showed minimal fluctuation, with the lowest recorded incidents occurring

between 1997 and 2002, where annual conflict events remained below 50 per year. However, a slight increase began to emerge around 2003, marking the beginning of a transition to higher conflict intensity.

The second phase (2007-2013) marked a significant escalation in conflict events, with a sharp increase from approximately 200 events in 2006 to over 400 events in 2007. This period showed considerable volatility, with notable peaks in 2010 (approximately 700 events) and 2013 (over 800 events). This escalation coincides with significant political and security developments in the region, suggesting a transformation in the nature and intensity of conflict dynamics. The most recent phase (2014-2024) represents the period of highest conflict intensity, characterized by sustained high levels of conflict events exceeding 1,000 incidents annually. The data shows a dramatic peak during 2017-2018, where annual conflict events reached approximately 1,500 incidents. This period represents the highest recorded conflict intensity in the dataset, marking a more than sevenfold increase from the earliest recorded levels. Following this peak, there was a slight decline in conflict events from 2019 onwards, though numbers remained significantly higher than pre-2014 levels, consistently exceeding 1,000 events per year.

The latest data point in 2024 shows approximately 700 conflict events, suggesting a potential downward trend, though this figure may be incomplete due to the ongoing nature of the year's data collection. Despite this recent decrease, the overall temporal pattern indicates a substantial and sustained increase in conflict activity over the 27-year period, with particularly intense conflict activity in the latter decade of the study period. This temporal analysis provides crucial context for understanding the evolving security challenges facing healthcare facilities in Somalia, suggesting that health infrastructure has had to operate under increasingly challenging security conditions, particularly since 2014. The sustained high levels of conflict in recent years indicate a persistent threat to healthcare delivery systems, necessitating robust adaptation strategies for maintaining healthcare access in this volatile environment.

5.2 Disaster Types and Frequency in Somalia

Analysis of the EMDAT Database reveals a diverse range of disasters affecting Somalia, with hydrometeorological events dominating the disaster profile. The data demonstrates distinct patterns in disaster occurrence, with floods emerging as the most frequent disaster type, accounting for 50 recorded incidents. This represents approximately 40% of all disaster events in the dataset, highlighting the significant vulnerability of Somalia to flooding events.

Epidemics represent the second most frequent disaster type with 31 recorded incidents, comprising approximately 25% of all disasters. This high frequency of epidemics suggests a significant public health challenge that directly impacts healthcare facilities and service delivery. The co-occurrence of epidemics with other disaster types, particularly floods, indicates potential compound disasters that may overwhelm healthcare systems.

Drought events, while fewer in number (17 incidents), represent a significant chronic stressor on the healthcare system. These events, combined with the 12 water-related disasters, indicate persistent challenges in water security that affect both healthcare facility operations and public health outcomes. The temporal distribution of these drought events suggests recurring cycles of water stress that require long-term adaptation strategies.

Weather-related disasters, including storms (7 incidents) and floods, collectively account for the majority of recorded disasters, emphasizing the vulnerability of Somalia's infrastructure, including healthcare facilities, to climatic events. Infrastructure-related disasters, including road incidents (4) and explosions (3), while less frequent, represent additional challenges to healthcare accessibility and service delivery.

The presence of multiple low-frequency disasters, including air-related incidents (1), earthquakes (1), and infestations (1), indicates the need for comprehensive disaster preparedness in healthcare facilities. This diverse disaster profile suggests that health facilities must maintain preparedness for a wide range of potential disruptions while focusing particular attention on flood resilience and epidemic response capabilities.

The distribution of disaster types demonstrates the complex risk landscape within which Somalia's healthcare system must operate, with facilities needing to address both acute disaster responses and chronic stressors. This analysis provides crucial context for understanding the environmental and public health challenges facing healthcare facilities in Somalia, informing both immediate response strategies and long-term resilience planning.

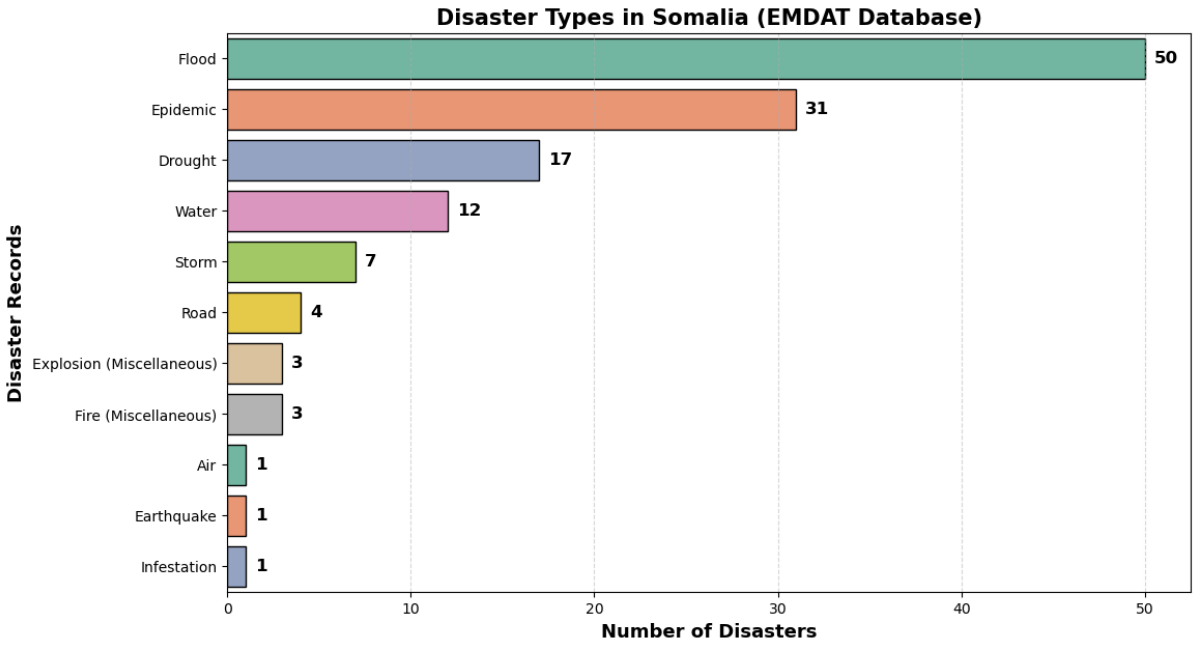


Figure 7: Disaster Events, Source: EM-DAT Database

6 ANALYSIS AND RESULT

6.1 OBJECTIVE 1

To analyze the impact of armed conflicts on the health facility coverage in Somalia.

The spatial analysis of conflict events in Somalia reveals pronounced regional variations in conflict intensity, with clear patterns of concentration in specific areas. The data from the Armed Conflict Location & Event Data Project (ACLED) demonstrates significant spatial heterogeneity in conflict distribution across the country's regions.

Mogadishu, the capital city, emerges as the epicenter of conflict with 4,655 recorded events, representing the highest concentration of conflict in any single administrative area. The capital region alone accounts for a substantial proportion of total conflict events, highlighting the intense urban nature of many conflicts. This is further emphasized by the surrounding regions, which show a pattern of gradually decreasing conflict intensity with distance from the capital.

Southern Somalia exhibits the highest overall conflict density as shown in figure 8, with several regions recording over 1,000 conflict events. Notable hotspots include regions adjacent to Mogadishu, with one region recording 4,020 events and another 1,002 events. This southern concentration of conflict creates a significant challenge for healthcare delivery in what is historically one of the country's most populous areas. The region containing Kismayo, another major urban center, recorded 1,425 conflict events, establishing it as another significant conflict hotspot.

Central Somalia shows moderate to high levels of conflict activity, with regions recording between 544 and 1,230 events. This creates a belt of persistent conflict that effectively divides the country's northern and southern regions, potentially impacting cross-regional healthcare access and supply routes.

The northeastern region of Puntland shows varying conflict intensity, with the highest concentration (602 events) in its easternmost region, while adjacent regions report lower numbers ranging from 150 to 256 events. This spatial pattern suggests more localized conflict dynamics in the northeast, possibly related to coastal and maritime security issues.

Northwestern regions, including Somaliland, demonstrate the lowest conflict intensity, with some regions recording as few as 23 events. This north-south gradient in conflict intensity indicates significantly different security environments for healthcare operations across the country, with potentially better conditions for healthcare delivery in the northwest.

The spatial distribution of conflict events has important implications for healthcare facility operations and accessibility as shown in figure 8. Regions with high conflict density (>1,000 events) likely face severe challenges in maintaining consistent healthcare services, while areas with lower conflict intensity (<200 events) may offer more stable conditions for healthcare delivery. This spatial heterogeneity suggests the need for regionally tailored approaches to healthcare system resilience and security measures.

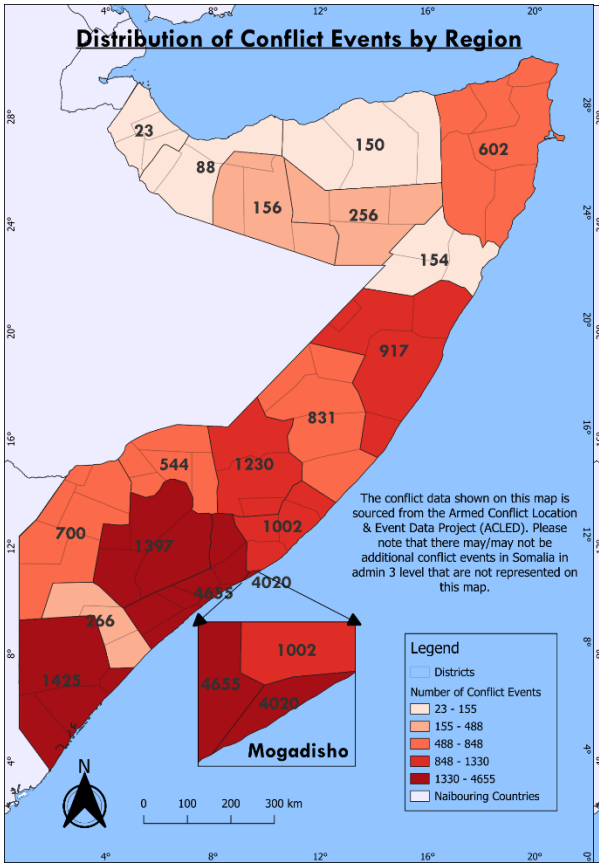


Figure 8: Distribution of Conflict Events

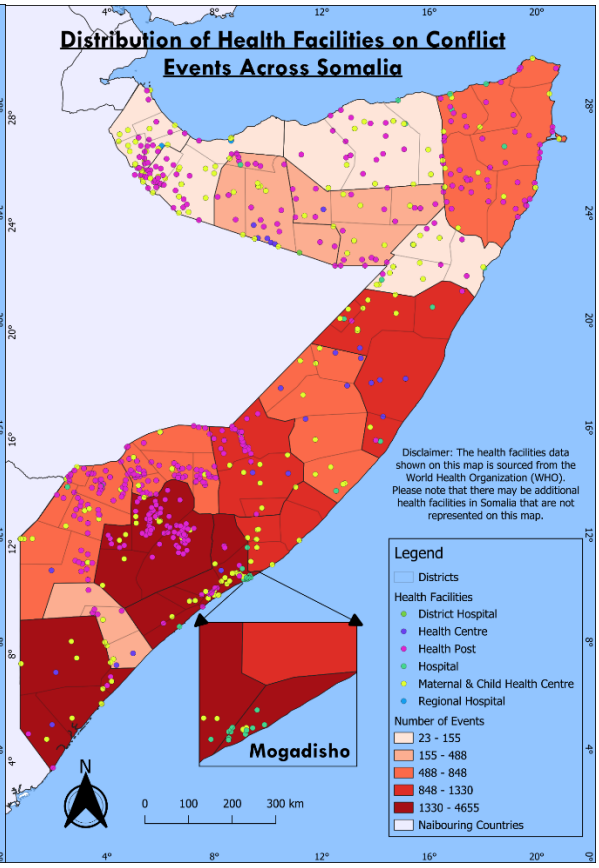


Figure 9: Distribution of Health Facilities Relation to Conflict Events

Source: Author

The spatial analysis of health facilities distribution in relation to conflict events reveals complex patterns of healthcare accessibility across Somalia's conflict-affected regions. The World Health Organization (WHO) data demonstrates significant variations in both the density and type of health facilities across regions with different conflict intensities as shown in figure 9.

In Mogadishu, despite having the highest concentration of conflict events (4,655), the capital region maintains a relatively dense network of health facilities, particularly district hospitals and health centers. This suggests an attempt to maintain healthcare infrastructure despite intense conflict, though the high conflict density likely impacts facility functionality and accessibility. The inset map of Mogadishu in figure 9 shows a cluster of health facilities, indicating the urban concentration of healthcare services in an area of extreme conflict intensity.

The northwestern regions, particularly Somaliland, demonstrate the highest density of health posts (indicated by pink dots) despite experiencing lower conflict intensity (23-155 events). The area shows a more evenly distributed healthcare network, with a mix of facility types including district hospitals, health centers, and maternal and child health centers. The

relatively stable security situation in these regions appears to support a more systematic distribution of healthcare facilities.

Central Somalia shows a sparse distribution of health facilities despite moderate to high conflict levels (488-848 events). The facilities in this region are predominantly health posts and health centers, with fewer district and regional hospitals. This pattern suggests that conflict may have influenced the type and distribution of health facilities, favoring smaller, more dispersed units over larger healthcare institutions.

The northeastern region (Puntland) exhibits a moderate density of health facilities, with a notable presence of maternal and child health centers (yellow dots). The distribution pattern appears to follow population centers and major routes, though the facilities must operate in areas with varying conflict intensity (150-602 events).

Southern Somalia, excluding Mogadishu, shows significant variation in health facility distribution. Areas with high conflict intensity (848-1,330 events) generally show fewer facilities, particularly in the types of higher-level care facilities such as regional hospitals (blue dots). However, there are notable clusters of health posts and health centers, suggesting attempts to maintain basic healthcare access despite security challenges as highlighted in figure 10.

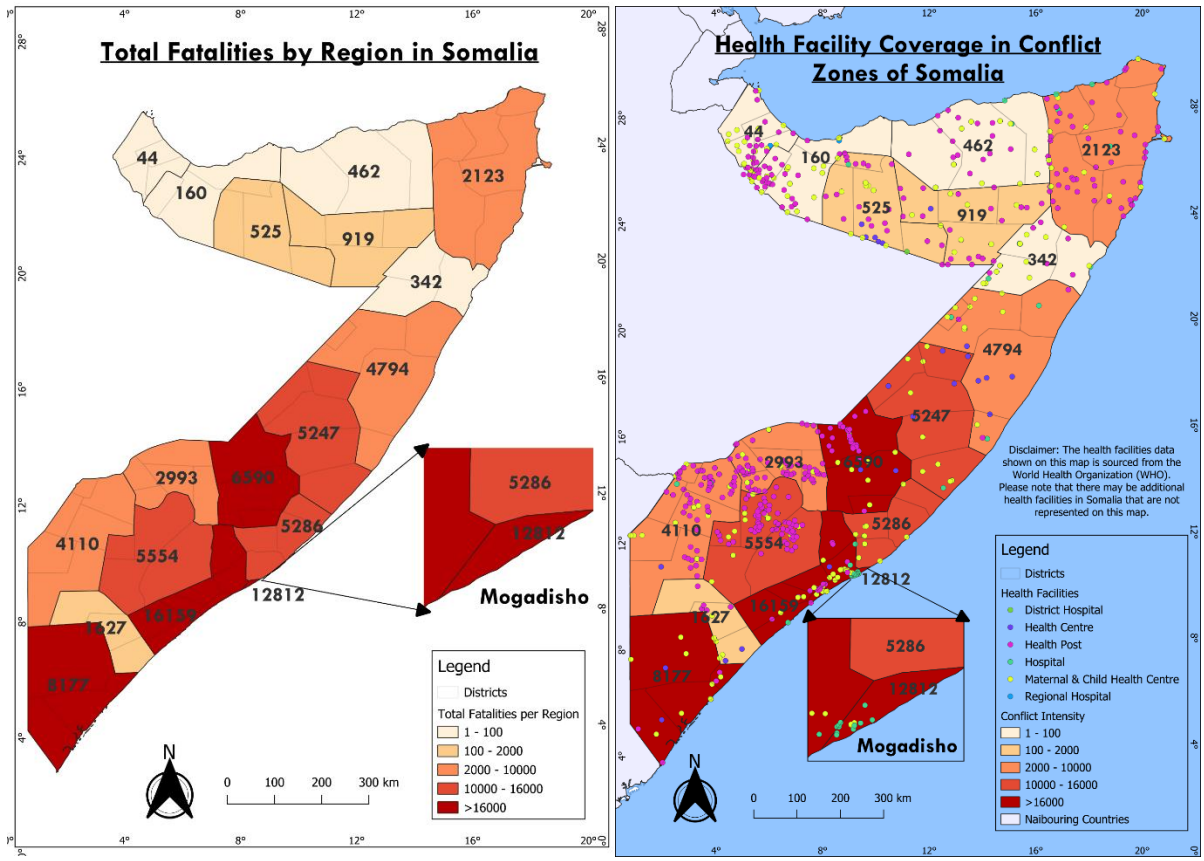
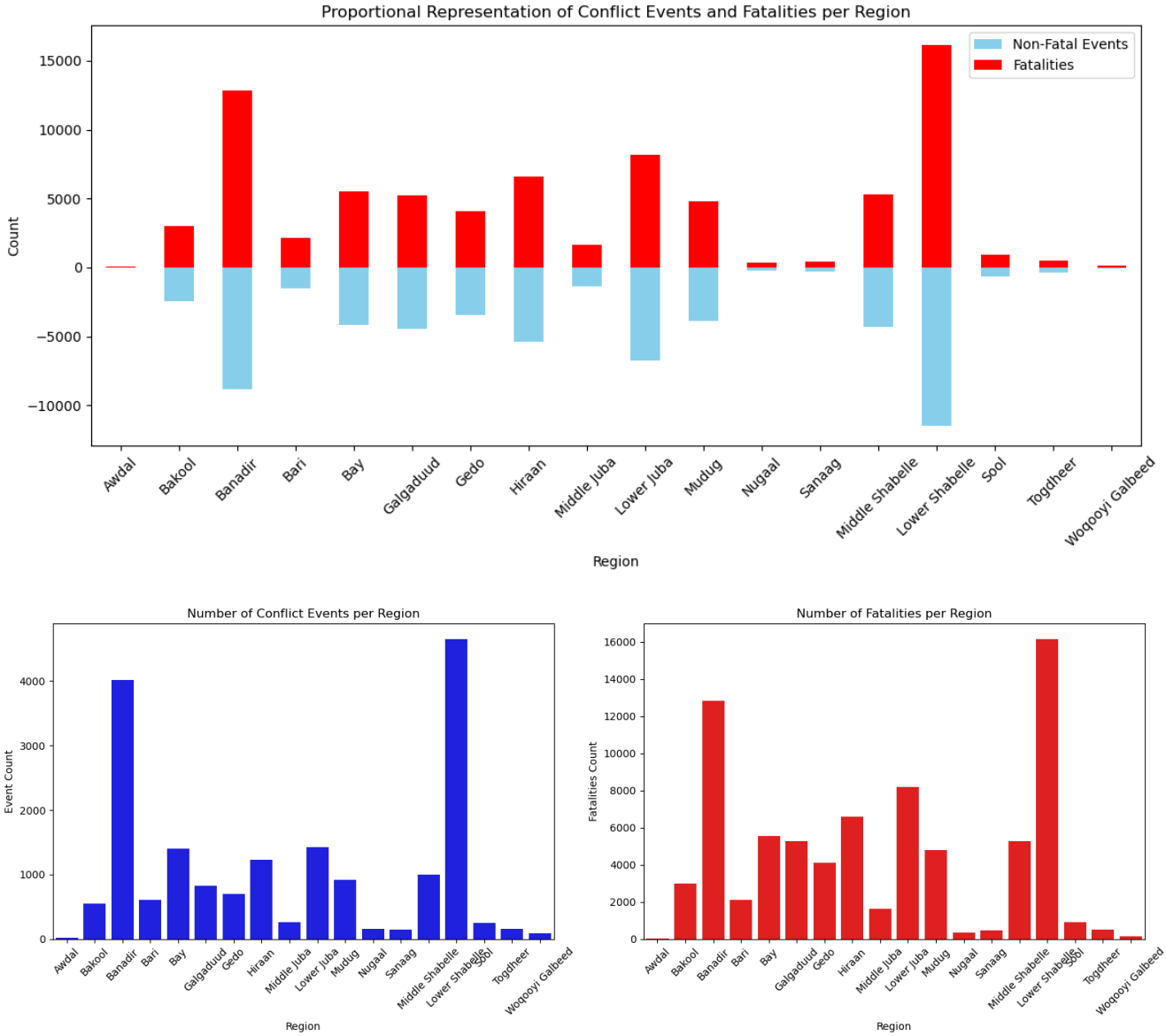


Figure 10: Conflict Events and Fatalities
Source: Author



The graphs illustrate the distribution of conflict events and associated fatalities across various regions in Somalia, highlighting significant regional disparities. The first graph presents a proportional comparison of non-fatal conflict events (blue) and fatalities (red), showing that regions like Banaadir, Lower Shabelle, and Middle Juba experience both high conflict events and elevated fatalities, indicating intense and deadly conflict dynamics. The second set of graphs further breaks down these trends, with the left graph depicting the total number of conflict events per region, where Lower Shabelle and Banaadir emerge as the most affected areas. Meanwhile, the right graph highlights fatalities per region, reinforcing that Lower Shabelle records the highest number of conflict-related deaths, followed closely by Banaadir and Middle Juba. These findings suggest that certain regions not only experience frequent conflict but also suffer from disproportionately high fatality rates, which has significant implications for security, humanitarian response, and healthcare accessibility in Somalia.

6.2 OBJECTIVE 2

To assess the effects of extreme weather events (droughts and floods) on health facilities in Somalia.

The spatial analysis of extreme weather events in Somalia shows the significant impact of droughts and floods on healthcare infrastructure, with notable variations across different regions. Using flood extent return period data and drought severity indicators, this study reveals key geographic areas where health facilities are at heightened risk due to extreme climatic conditions.

As shown in figure 11 below, regions along southern and central river basins, particularly those near the Juba and Shabelle rivers, experience the most severe flood exposure, as shown by 100-year flood extent zones. These areas, which include Lower Shabelle, Middle Juba, and Gedo, host a high concentration of health facilities that are vulnerable to seasonal flooding. The presence of district hospitals, health centers, and maternal & child health facilities in flood-prone areas underscores the critical need for flood-resistant infrastructure and contingency planning.

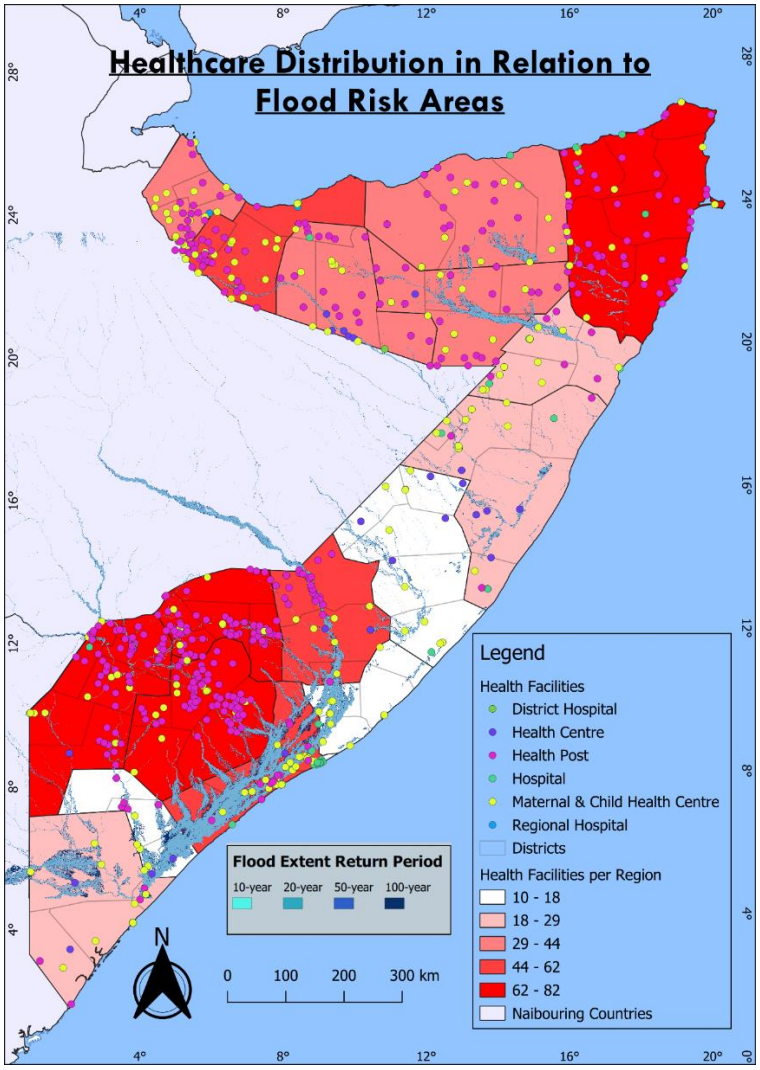


Figure 11: Health distribution in flood risk areas
Source: Author

Conversely as mapped in figure 12, drought exposure is more widespread, affecting almost the entire country, with the most severe conditions observed in northern and central Somalia, particularly in Sool, Sanaag, and Galgaduud. These regions show extreme and severe drought classifications, indicating prolonged vegetation loss and water shortages that can significantly disrupt healthcare services. Given the high density of health facilities in these drought-affected zones, disruptions in water access, medical supply chains, and patient influx are major challenges.

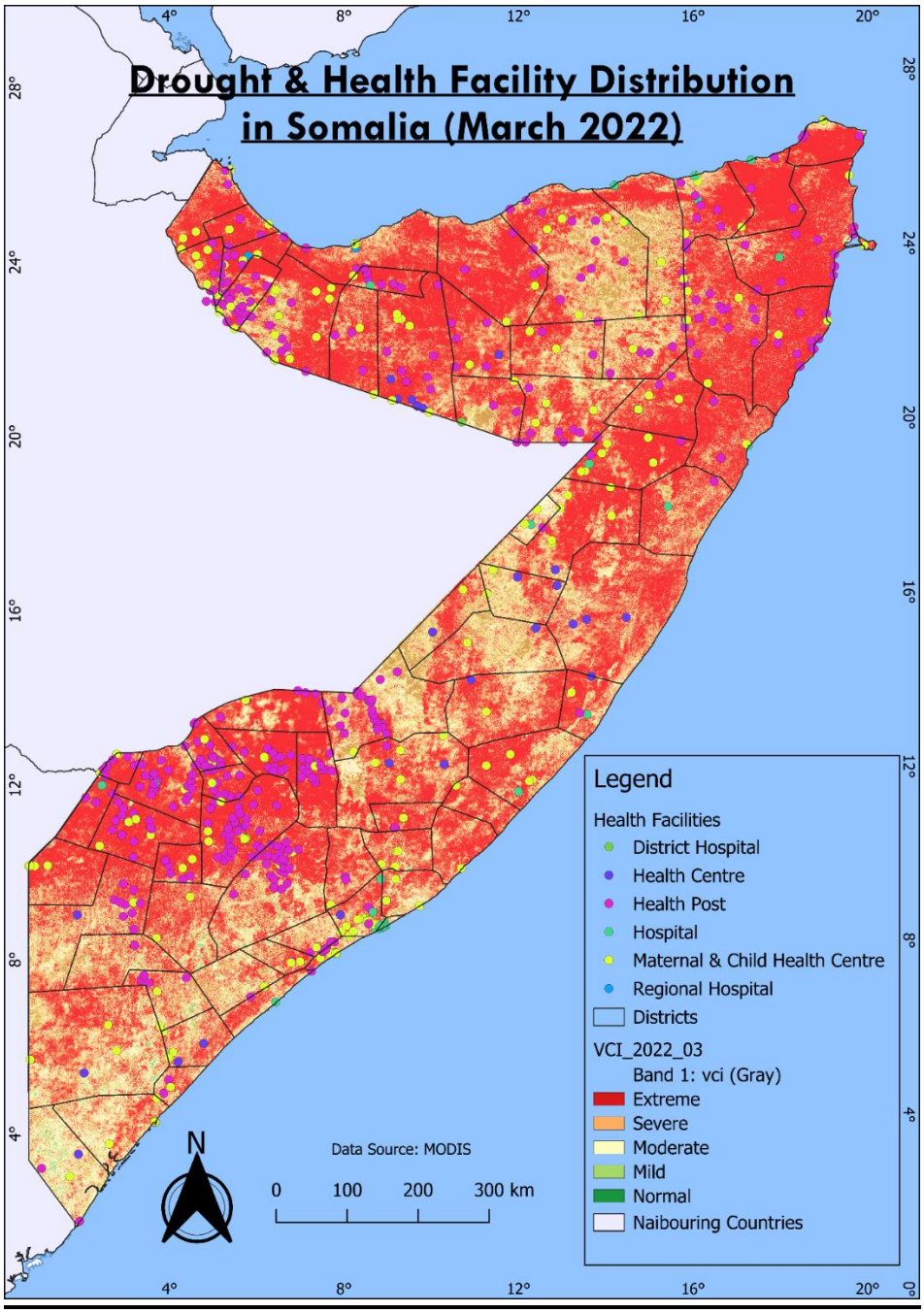


Figure 12: Health distribution in drought risk areas
Source: Author

The spatial correlation between drought and flood-prone areas and health facility locations shows the dual burden of extreme weather on Somalia's healthcare system. Facilities in southern Somalia face recurrent flood damage, while those in northern and central Somalia struggle with drought-induced resource shortages as supported by figures 13 and 14. The compounding effects of climate hazards necessitate adaptive healthcare strategies, including early warning systems, climate-resilient infrastructure, and enhanced emergency preparedness to safeguard essential health services in Somalia's most vulnerable regions.

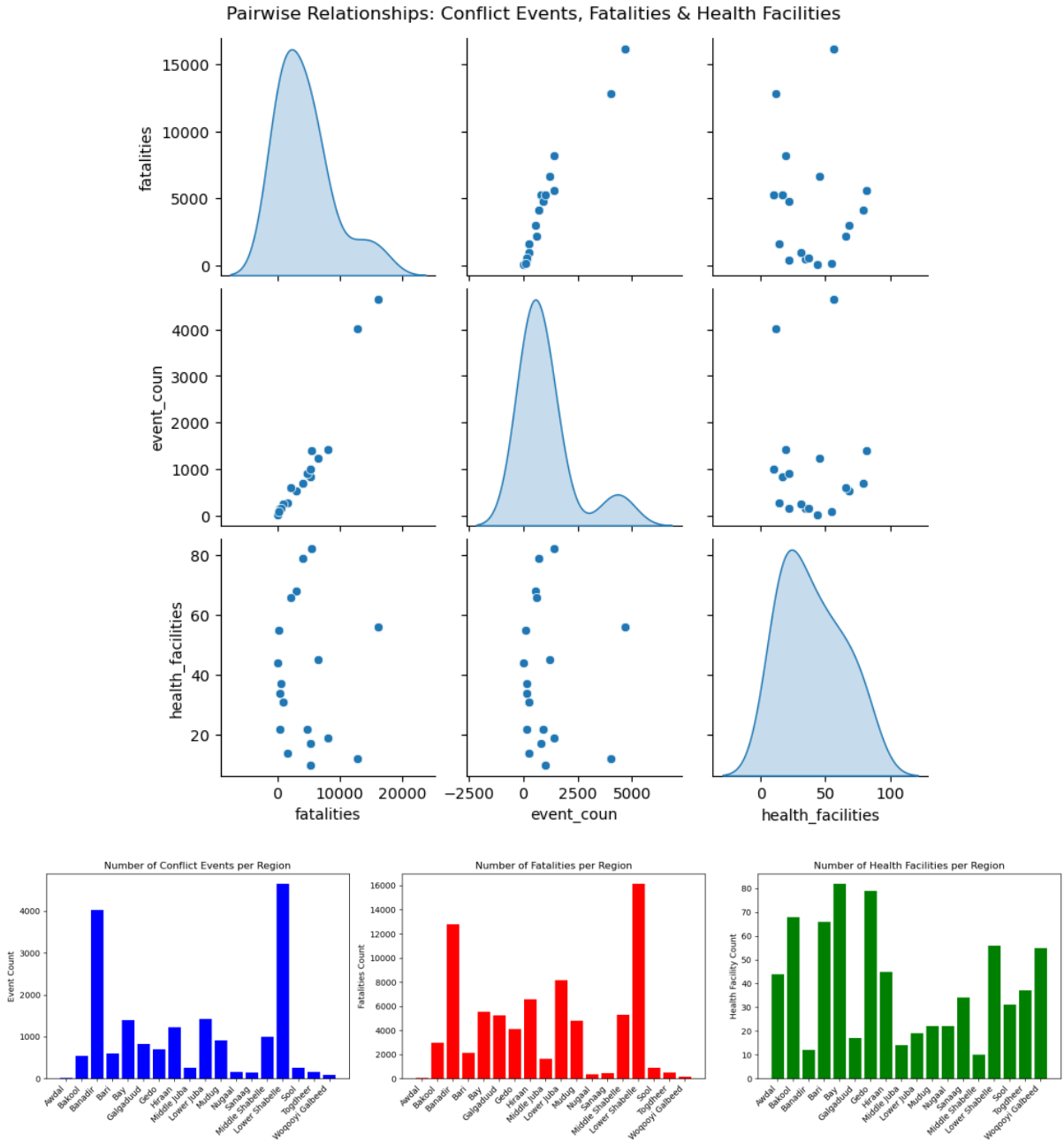


Figure 13 and Figure 14: Proportional of conflict, number of fatalities and health facilities
Source: Author

6.3 OBJECTIVE 3

To identify the combined effects of conflict and extreme weather events on health service coverage in Somalia.

The integrated risk mapping of conflict, floods, and droughts in Somalia shows the compounding effects of these hazards on health service coverage, with significant regional disparities. The spatial overlay of conflict intensity, flood-prone areas, and drought severity reveals that many health facilities are located in regions facing multiple, overlapping risks, increasing the vulnerability of healthcare infrastructure and access.

Regions in southern and central Somalia emerge as the most highly exposed areas, where severe conflict coincides with extreme weather events. For example, areas along the Juba and Shabelle river basins, including Lower Shabelle, Middle Juba, and Gedo, experience both high conflict intensity and frequent flooding, putting health facilities at risk of damage and disruption. The 100-year flood return zones indicate that several hospitals, health centers, and maternal & child health facilities are within flood-prone regions, increasing the likelihood of service interruptions during extreme weather events as shown in figure 15.

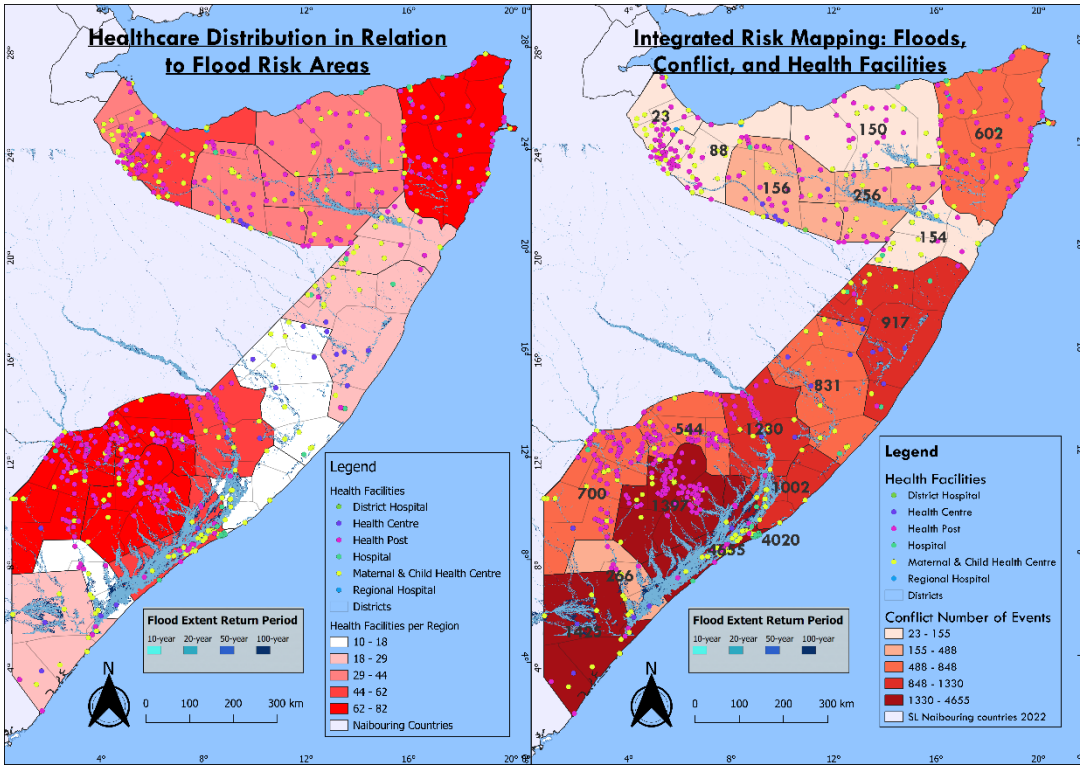


Figure 15: Integrated Risk Mapping of floods, conflicts and health facilities
Source: Author

Additionally, northern and central Somalia, particularly in Sool, Sanaag, and Galgaduud, face a different but equally critical challenge—widespread extreme drought combined with ongoing conflict (see figure 16). These regions exhibit severe vegetation loss and prolonged water scarcity, affecting health facility operations due to limited access to clean water, disrupted medical supply chains, and increased patient demand from climate-induced health crises. The high concentration of health facilities in drought-affected regions suggests that prolonged climate stress can lead to long-term declines in healthcare service delivery, particularly in rural and semi-urban areas as shown in figure 16 below.

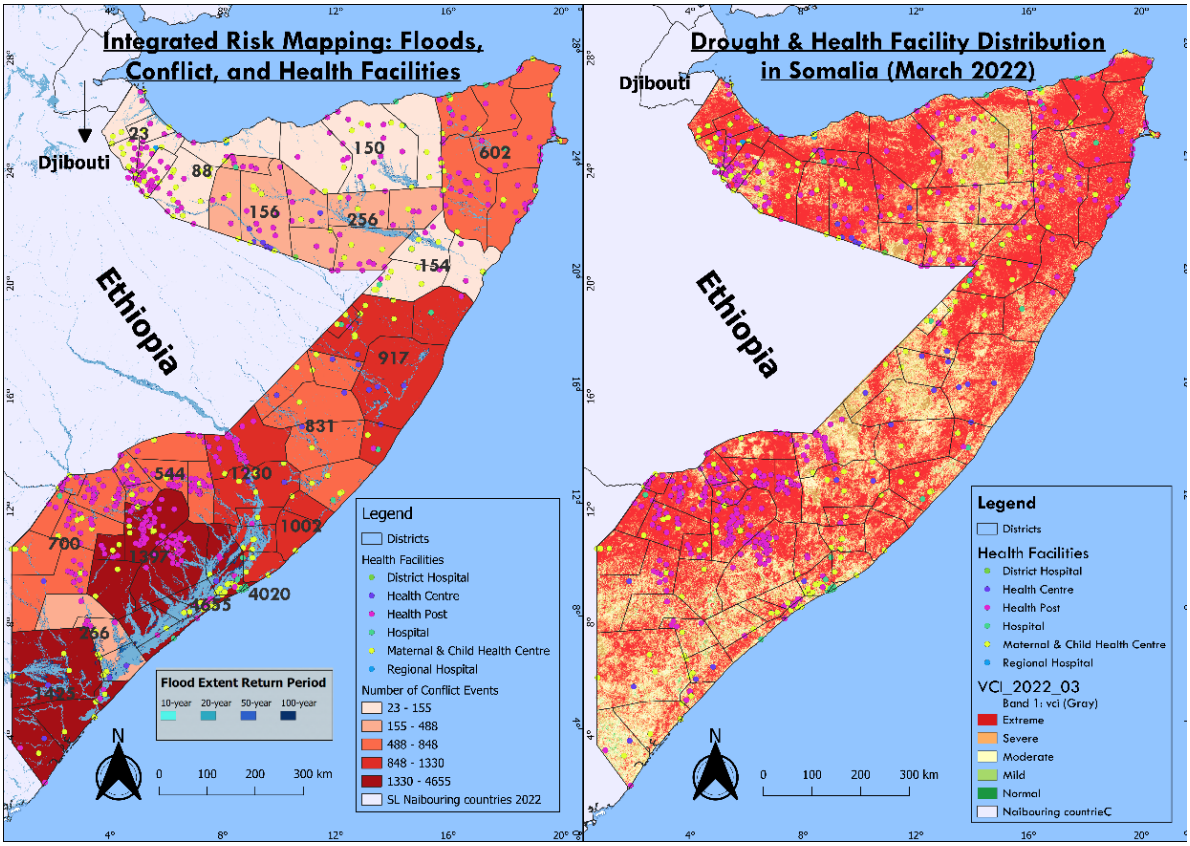


Figure 16: Integrated Risk Mapping of drought, floods, conflicts and health facilities
Source: Author

The combination of conflict and climate hazards has a detrimental impact on healthcare access, as facilities in conflict zones often face security challenges, staff shortages, and restricted movement, while extreme weather events further strain resources. This intersection of risks calls for integrated disaster risk management strategies, including conflict-sensitive health service planning, climate-resilient infrastructure investments, and enhanced emergency preparedness. Addressing these overlapping vulnerabilities is crucial to ensuring sustainable healthcare access for Somalia's most at-risk populations.

CONCLUSION AND RECOMMENDATIONS

This study highlights the complex and interconnected challenges that conflict and extreme weather events pose to healthcare systems in Somalia. The findings reveal that armed conflict significantly disrupts healthcare access, with high-intensity conflict zones experiencing reduced health facility coverage and increased operational challenges. Additionally, floods and droughts further strain healthcare services, leading to infrastructure damage, supply chain disruptions, and increased patient vulnerability.

The compounding effects of conflict and climate hazards emphasize the need for integrated risk management approaches that incorporate climate resilience, conflict-sensitive planning, and emergency preparedness. While identifying high-risk regions and assessing healthcare accessibility in crisis-prone areas, this research provides valuable insights for policymakers, humanitarian organizations, and healthcare planners. Strengthening health infrastructure, improving early warning systems, and fostering multi-sector collaboration will be essential in ensuring sustainable healthcare delivery in Somalia's most vulnerable regions.

LIMITATIONS

One of the key limitations of this study is the incompleteness and inconsistency of healthcare facility data, which affects the accuracy of vulnerability assessments and risk mapping. Many regions lack comprehensive, up-to-date records on healthcare facility capacity, service availability, and operational status, making it difficult to fully assess the impact of climate hazards and conflict. To improve future assessments, enhanced data collection efforts—including real-time health service mapping, better facility reporting, and integration of remote sensing with field data—are recommended.

Additionally, collaborating with local health agencies, international organizations, and community networks can help fill data gaps and provide a more detailed understanding of healthcare vulnerabilities. Addressing these limitations will enable more precise risk assessments and better-targeted interventions to support healthcare resilience in Somalia.

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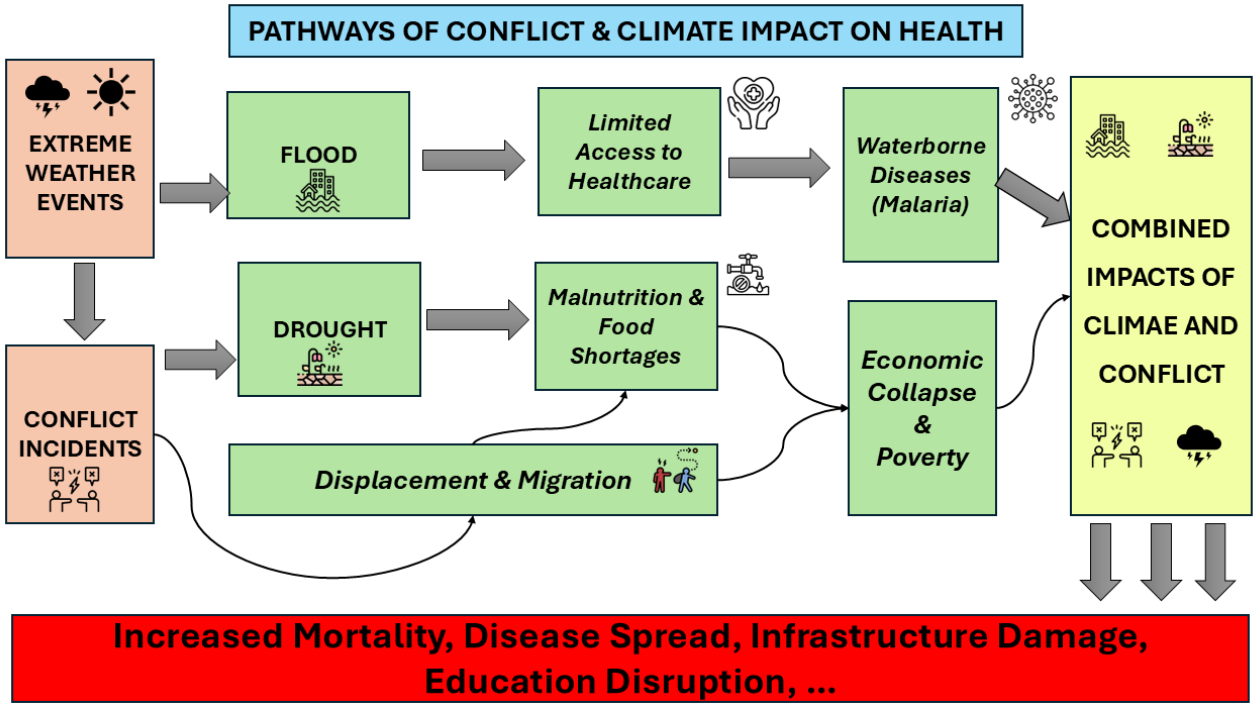
APPENDIX A: SOMALIA MAP

APPENDIX B: PATHWAYS OF CONFLICT & CLIMATE IMAPCTS ON HEALTH



APPENDIX C: TOOLS UTILIZED IN ASSIGNMENT PREPARATION

"During the preparation of this work, the author used ChatGPT to assist in improving the writing and clarity of the report. The tool was utilized for refining sentence structure, enhancing readability, and ensuring coherence in academic writing. After using this tool, the author carefully reviewed, revised, and validated the content to ensure accuracy, originality, and alignment with the research objectives. The author takes full responsibility for the final content of the work.

Use of AI in Education at the University of Twente

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January 2025

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