# Towards disentangling the interrelationships between hydro-meteorological hazards, conflict and displacement: a case study (for droughts and floods) in Somalia

ABDILLAHI OSMAN OMAR

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SUPERVISORS:

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ABDILLAHI OSMAN OMAR

Enschede, The Netherlands,
JUNE 2025

Thesis submitted to the Faculty of Geo-Information Science and Earth Observation of the University of Twente in partial fulfilment of the requirements for the degree of Master of Science in Geo-information Science and Earth Observation.
Specialization: Geoinformatics

SUPERVISORS:
Dr.ir. Janneke Ettema
Prof. dr. Marc van den Homberg

THESIS ASSESSMENT BOARD:
Prof. dr. Victor Jetten (Chair)
Alessia Matano (External Examiner, Vrije Universiteit Amsterdam)
Bruno Virgilio Portela (Procedural Advisor)

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# ABSTRACT

This thesis investigates how conflict and extreme weather events specifically drought and floods have influenced internal displacement patterns in Somalia during 2022 and 2023. The research is guided by three objectives: (1) assess the relationship between conflict, drought, and displacement in 2022; (2) examine displacement in relation to conflict and floods in 2023; and (3) evaluate how spatial and temporal resolution affect the analysis of cascading hazard impacts.

To achieve this, multiple datasets were analysed at a monthly temporal scale and regional spatial level. Displacement attribution was classified into different categories: conflict-driven, drought-driven, flood-driven and compound (conflict + hazard). Findings show that in 2022, drought was the primary trigger of displacement in central regions such as Bakool and Hiraan, while conflict alone explained large-scale displacement in areas like Bay. Compound displacement which is linked to both conflict and drought was observed in Lower Juba and Lower Shabelle. In 2023, displacement occurred during the flood events in the rainy seasons, especially in flood-affected regions of Hiraan, Gedo, and Lower Juba, interconnecting with conflict events. The study also finds that the monthly regional aggregation gives consistent attribution, but it may obscure short-term or localized impacts. Moreover, the research acknowledges the need for high resolution, harmonized datasets to monitor multihazard internal displacement in fragile contexts to build resilient communities against future climate challenges at the same time looking for stability and peace on the internal displaced persons (IDPs).

In conclusion, the findings in this research contribute to a deeper understanding of displacement patterns in Somalia and offer a valuable starting point for advancing the climate, conflict, migration nexus. They identify the importance of spatial and temporal disaggregation when attributing displacement to multiple, overlapping triggers such as drought, flooding, and conflict. These findings are relevant to both academic researchers and humanitarian actors, policy planners, and organizations engaged in displacement risk forecasting and preparedness. Our findings indicate that conflict and extreme weather events drive displacement. However, future research should also investigate the reciprocal effect of displacement on conflict, as well as explore and quantify immobility patterns in fragile settings. In short, this research concludes that there is a pressing need for faster, smarter, less bureaucratic and more effective work for settlement, shelter and displacement situation to enable tailored approaches appropriate for countries affected by both hydro-meteorological hazards and conflict.

Keywords: Internal displacement, conflict, drought, floods, compound hazards, displacement attribution, Somalia, Africa

# ACKNOWLEDGEMENTS

I begin by expressing my gratitude to God Almighty, for blessing me with health and motivation throughout this journey.

First and foremost, special thanks to my supervisors, Dr. Ir. Janneke Ettema and Prof. Dr. Marc van den Homberg for their support, motivation, mentorship, and advice throughout the research. From day one, working with you has been an enriching experience, and I have learned immensely from your guidance. Thank you for your guidance in helping me become a more thoughtful researcher and a sharper writer, always pushing me to be self-critical and reflective of scientific ideas. I also thank Prof. Dr Victor Jetten who has always chaired the assessment board during this research.

I am deeply grateful to the scholarship providers, the Netherlands University Foundation for International Cooperation (NUFFIC), Orange Knowledge Program (OKP) and ITC, for their invaluable support in making this journey possible. A special mention is reserved for the GFM mentor, Wan Bakx, whose kindness and support have given me a compass to navigate my academic and professional aspirations in this field. Thank you.

I also wish to extend my gratitude to my classmates and to my friends; Otobong Nse, Michael Offei, and many others who have celebrated me, and provided support during challenging times. My journey was easy and fun at ITC because of you all, all the deep meaningful discussions, inspiration, advice, support and fun times will be forever in my memories. To Ahmed Hemoudi and Nazif Umar (ITC Alumni), I'm not quite sure how my experience in ITC would have been without all the wonderful discussions we've had, and your readiness to help with any and all Netherlands-related matters. Thank you also for encouraging me to be a member of the ITC faculty council.

Importantly, I extend my heartfelt thanks to the inspiring team of Humanitarian Engineering research group (University of Twente). Thanks to Isaac, Sahara, Patrick and Garbhit. Your warmth, collaboration, and support made every step worth it.

To my family, your unwavering faith in me and constant encouragement have been the courage of my journey. Your love, countless prayers and support kept me going, and this accomplishment is as much yours as it is mine. Thank you for being so patient with me in these times.

Lastly, I would like to acknowledge everyone who, in one way or another, contributed to the successful completion of this thesis. Your help and support are deeply appreciated.

*Thanks to me! for doing all this hard work, for having no days off and especially for never quitting!*

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| | |
|---|---|
| ACLED | Armed Conflict Location & Event Data |
| CHIRPS | Climate Hazards Group InfraRed Precipitation with Station data |
| EIP | European Institute of Peace |
| FAO | Food and Agriculture Organization of the United Nations |
| ICPC | IGAD Climate Prediction and Applications Centre |
| ICRC | International Committee of the Red Cross |
| IDMC | Internal Displacement Monitoring Centre |
| IDP | Internally Displaced Persons |
| IFRC | International Federation of Red Cross and Red Crescent Societies |
| IOM | International Organization for Migration |
| IPC | Integrated Food Security Phase Classification |
| OCHA | United Nations Office for the Coordination of Humanitarian Affairs |
| PRMN | Protection and Return Monitoring Network |
| SWALIM | Somalia Water and Land Information Management |
| UNDRR | United Nations Office for Disaster Risk Reduction |
| UNHCR | United Nations High Commissioner for Refugees |
| UNOSAT | The United Nations Satellite Centre |

# 1. INTRODUCTION

## 1.1 Background

In recent years, internal displacement has reached record levels worldwide. According to the Internal Displacement Monitoring Centre (IDMC), by the end of 2024, over 83.4 million people were living in internal displacement. This number has doubled since 2018 (40.6 million), spanning 117 countries and territories. Africa alone accounted for 38.8 million displaced persons, representing nearly 47% of the global total. Internal displacement occurs when individuals are forced to flee their homes without crossing international borders. This often disrupts lives and leads to prolonged vulnerabilities, as internally displaced persons (IDPs) might face challenges in accessing basic rights and essential services such as clean water, healthcare, education, and safe shelter (Joshua et al., 2021; Olanrewaju et al., 2022).

In Somalia, displacement has become a growing crisis over the past three decades since the collapse of the central government, which has weakened the state's capacity to manage and respond to the increasing number of displaced persons (Bakonyi et al., 2019). Since the outbreak of civil war in 1991, Somalia has lacked central government control (Maystadt & Ecker, 2014). Following this, the conflicts in Somalia range from battles between state forces and armed groups to inter-clan violence, riots, protests, and acts of remote violence. With the collapse of the government in 1991, it is estimated that over a million Somalis left the nation, with an additional million being internally displaced (Horst & Nur, 2016). (Lindley, 2011) identifies three distinct phases of displacement in Somalia: (1) a major displacement crisis in the early 1990s triggered by the outbreak of civil war; (2) a period of relative stabilization between 1996 and 2006, with lower levels of new movement; and (3) a renewed transformation of the Somali conflict since 2006, leading to persistent internal displacement. Moreover, the absence of effective national governance created a power vacuum, leading to the rise of clan-based militias, armed insurgent groups, and localized conflicts particularly in areas where disputes over land and natural resources remain unresolved (Hoehne, 2014). While progress has been made through local reconciliation efforts, parts of the country especially in the south-central regions continue to experience insecurity. As of early 2025, over 3.8 million people were internally displaced in Somalia (UNHCR, 2023), making it the third highest in Africa after Sudan and the Democratic Republic of Congo.

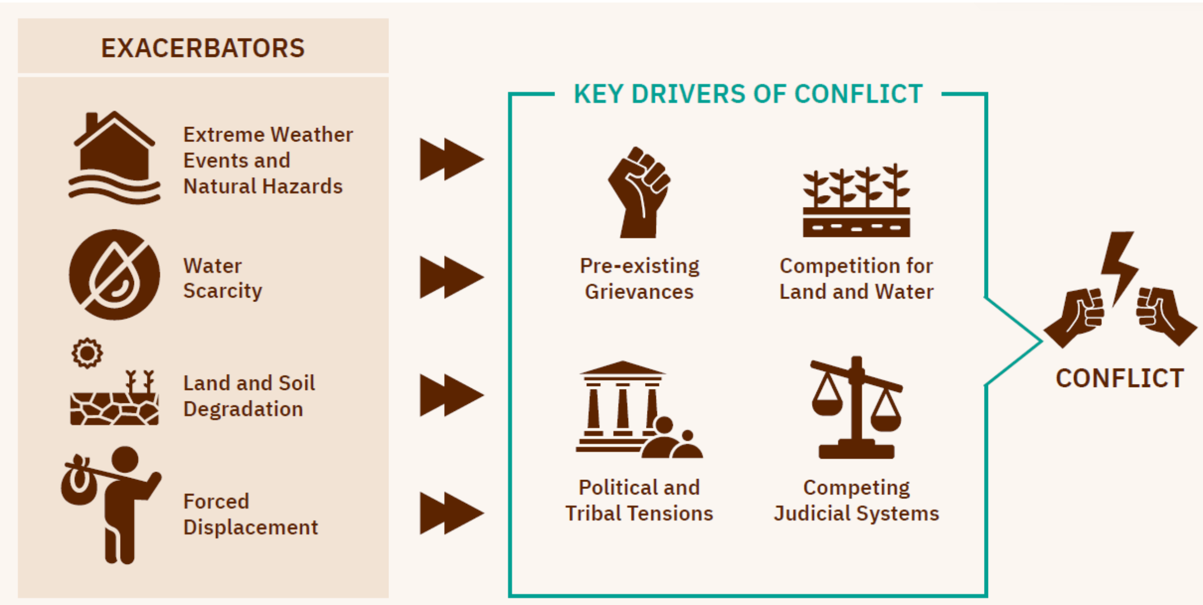


Figure 1: Pathways between exacerbators and key drivers of conflict in Somalia (EIP, 2024)

In Figure 1 above, the European Institute of Peace (EIP, 2024) shows the pathways between exacerbators and key drivers of conflict in the Somali context. In this study, conflict is defined as a state of protracted violent struggle between organized groups such as political factions, armed militias, or clans, which may be exacerbated by environmental stressors like droughts or floods (Maystadt & Ecker, 2014). The EIP framework divides these dynamics into two main components: 1) exacerbators which refer to external stressors that heighten the risk or intensity of conflict, such as extreme weather events, water scarcity, land and soil degradation and forced displacement, 2) core drivers of conflict which are structural or systemic conditions that directly contribute to conflict, including pre-existing grievances, competition over land and water, political and tribal tensions and competing judicial systems. Although the framework in Figure 1 shows a linear pathway, it is important to note that some relationships are bidirectional. For instance, conflict can lead to further displacement, which in turn may act as an exacerbator and fuel more conflict emphasizing the feedback loop between these dynamics (Abel et al., 2019). Moreover, conflict may intensify the effects of other exacerbating factors such as water scarcity, land and soil degradation (Behrend, 2016; Malley et al., 2008). The following sections is structured according to this framework, examining each exacerbator and driver in detail.

## Extreme weather events

Figure 1 lists extreme weather events and natural hazards as one of the exacerbators of conflict drivers. Natural hazard events, such as droughts and floods, are considered to be one of the major exacerbators of displacement in Somalia, and the increasing frequency and intensity of these extreme weather events have worsened the displacement crisis (Thalheimer et al., 2023). Somalia is highly vulnerable to drought due to the failure of the seasonal rains, which leads to catastrophic consequences such as food insecurity and displacement (Gure, 2017). In the past three decades, the country has faced multiple drought events of varying intensities and durations (Sharmake et al., 2022; Gure, 2021). For example, in 2021-2022 alone, drought-impacted over 3.2 million people across the country, forcing more than 169000 individuals to leave their homes (UNOCHA, 2021). Furthermore, floods in Somalia are another frequent exacerbator of displacement, impacting both urban and rural areas, especially along the Juba and Shabelle rivers (Said & Hassan, 2024). In the 2023 El Niño event, about 85% of Beledweyne city in Somalia was submerged, and the city hosted almost 100,000 displaced persons who had migrated earlier from drought but again relocated due to this flooding (UNOCHA, 2023). In this way, extreme weather events significantly exacerbate the conditions that fuel conflict and displacement in Somalia.

## Water scarcity & land soil degradation

Another exacerbator of conflicts in Somalia is the water scarcity, along with land and soil degradation, as illustrated in Figure 1 (EIP, 2024). In conflict-affected regions, the essential water infrastructure is often intentionally targeted during conflicts (Schillinger & Özerol, 2024). As water resources decline and access to clean water becomes more restricted, the resulting reduction in vegetation cover diminishes agricultural productivity and increases the risk of food insecurity, particularly for displaced populations (Baumann & Kuemmerle, 2016; Eklund et al., 2017; Schillinger et al., 2020). In addition to threatening livelihoods, limited access to safe drinking water also elevates the risk of waterborne diseases, such as cholera, especially in overcrowded IDP settlements, where sanitation infrastructure is often inadequate (Gulumbe et al., 2023). On the other hand, land and soil degradation act as exacerbators of conflict by reducing agricultural productivity and intensifying competition over arable land. For example, in rural areas where communities dependent on agriculture, overgrazing and deforastation have led to decline in soil fertility and erosion. As a result, communities are forced to compete for shrinking fertile zones, which frequently fuels disputes between clans and livelihood groups (A. A. Mohamed & Nageye, 2020)

**Forced displacement**

The fourth exacerbator of conflicts is the forced displacement. While displacement is commonly understood as outcome of conflict, it also acts as an exacerbator of conflict dynamics. In rural areas, the arrival of displaced populations in already resource-scarce areas increases pressure on water, land, and services, often triggering tensions with host communities (Anderson et al., 2021). Similarly, in urban areas, the informal settlement by displaced populations often occurs without proper alignment of land registration systems, causing land disputes (George & Adelaja, 2021). In both settings, forced displacement exacerbates conflict dynamics and also local tensions between communities, which may in turn lead to renewed or prolonged displacement. Consequently, the fourth exacerbators outlined in Figure 1 collectively intensify the underlying drivers of conflict and displacement in Somalia.

**Pre-existing grievances & competition for land and water**

Additionally, two key drivers of conflicts in Somalia are the pre-existing grievances and competition over land and water resources. Historical grievances are deeply rooted in clan-based exclusion, marginalisation, and unequal access to political representation. These long-standing tensions which some originated from the centralised and often repressive governance of the pre-1991 era have been compounded by years of civil war and the absence of transitional justice mechanisms (Cassanelli, 2018). In Somalia, many communities continue to feel sidelined from national and local decision-making processes, which has caused widespread distrust toward state institutions and opened space for armed actors to mobilise around narratives of injustice and exclusion (Cassanelli, 2018). Subsequently, these grievances intersect with resource-based tensions, particularly over access to land and water. In agro-pastoral regions, disputes over grazing areas, boreholes, and water points have often led to violent clashes between clans and livelihood groups (A. A. Mohamed & Nageye, 2020). The lack of clearly defined land tenure systems, together with the pressures of population displacement, has further intensified these disputes (Osman & Abebe, 2023). All these drivers show how unresolved historical injustices and competition over important resources continue to escalate violence and undermine peacebuilding efforts in Somalia.

**Political/tribal tensions & competing judicial systems**

Moreover, another key conflict drivers in Somalia are the political and tribal tensions, as well as the existence of competing judicial systems, as shown in Figure 1. Somalia's long-standing struggles with state-building have resulted in fragmented authority, where power is often decentralized and contested among clan leaders, regional administrations, militant groups, and the federal government (EIP, 2024). These divisions have deepened political mistrust and fuelled inter-clan rivalries, especially in regions where access to land, leadership positions, or aid resources is perceived to be distributed unequally (Leonard, 2009). Similarly to these tensions is the presence of multiple and overlapping legal systems, including formal state institutions and Sharia-based courts (Abdulahi, 2023). The lack of harmonisation between these systems creates confusion over legal jurisdiction, particularly in land and property disputes, criminal justice, and local governance, which undermines the legitimacy of judicial decisions

(EIP, 2024). In areas where one group dominates a legal or political structure, other groups may feel excluded or unprotected, further exacerbating inter-communal tensions (Abdulahi, 2023). Therefore, pre-existing and unresolved grievances, competition of land and water, political tensions and competing judicial systems are the key drivers of conflicts in Somalia, while the extreme weather events, water scarcity, land and soil degradation and forced displacement are the exacerbators of these drivers.

However, the overlapping of multi-hazards and conflict events creates additional layer of analytical complexity in understanding displacement patterns (Thalheimer et al., 2023). This complexity arises not from the data itself, but from the fact that displacement is often the result of interacting drivers that co-occur in time and space (See et al., 2024). For instance, when droughts and floods coincide with intercommunal violence, it becomes difficult to pinpoint the exact cause of displacement. In one scenario, communities may initially be displaced by water scarcity, but competition over limited resources may escalate into conflict, forcing more people to migrate to regions with better water access (Headey et al., 2014). Conversely, conflict may push people into flood-prone regions, leading to secondary displacement relocation (Ahmed et al., 2019). Moreover, the decision to displace is shaped by a web of environmental and socio-political stressors which is context specific (See et al., 2024; Siddiqi, 2018). Thus, addressing this complexity requires moving beyond single variable analysis and applying integrated approaches that can capture these dynamic interactions.

In conflict-affected regions, the limited quality of data creates huge challenges for accurate analysis and introduces several uncertainties (Dutta, 2018). The limited data quality refers to fragmented, incomplete and inconsistently reported data and information across different sources. These include outdated data (such as no recent census), no geodata availability in disaster settings, low spatial and temporal granularity and coverage, coverage of only a limited number of risk indicators (such as only data about houses damaged but no data on health impacts), and uneven data representation across communities (van den Homberg et al., 2018). Such imbalance can lead to unequal interventions, as decisions are shaped by what is visible in the data. Initially, gathering reliable, up-to-date data on displacement is important for understanding its causes, patterns, and impacts.

One of the key strategies to address the data quality and accessibility challenges in conflict-affected and disaster-prone areas is the use of remote sensing (RS). RS technologies offer consistent, wide-coverage data that can be collected without physical presence to bridge gaps where ground data collection is limited by insecurity, poor infrastructure, or lack of coordination. Many reviews have used RS applications for displacement monitoring, including mapping human settlements, identifying informal shelters or refugee camps (Nelson et al., 2020; Kaplan et al., 2022; Quinn et al., 2018; Wang et al., 2015). Moreover, it also has been used to assess the damage of buildings and critical infrastructure caused by the conflicts which affected the humanitarian efforts (Witmer, 2015), such as the case of Darfur region in Sudan during the periods of ethnic clashes (Knoth & Pebesma, 2017; Hagenlocher et al., 2012). Others have applied remote sensing data to monitor displacement flows in Afghanistan using nighttime light data (Scuitti et al., 2023). In hard-to-reach regions, where direct data collection is limited due to security or infrastructure, satellite data fills an important information gap. For example, in Somalia, it supports the monitoring of population movements, the assessment of flood and drought impacts and the mapping of IDPs in areas affected by armed conflicts and climate extremes. Consequently, remote sensing has become important in supporting humanitarian operations in hard-to-reach areas (Engstrom et al., 2013).

Up to date, internal displacement in Somalia continues to increase due to a combination of weather-related events, conflict, and other exacerbating and driving factors, as illustrated in Figure 1. Studies on extreme weather events on displacement have highlighted the role of environmental stressors in shaping human mobility. For instance, Black et al. (2013) identified multiple pathways through which environmental change affects migration, while Oliver-Smith (2018) emphasized that displacement rarely occurs in isolation from social and political factors. Brzoska & Fröhlich (2016) further argue that environmental stress contributes to displacement mainly where governance is weak, and Momeni et al. (2024) demonstrate how droughts correlate with rural migration but caution against ignoring co-occurring drivers like conflict. Conversely, conflict-focused studies such as Das et al. (2016) and Mugizi & Matsumoto (2021) argue that violence are the key determinants of displacement, particularly in fragile states. Additionally, George & Adelaja (2022) show how local conflicts such as farmer-harder clashes can lead to large-scale population movements specifically when layered over the other exacerbators such as environmental degradation.

## Research gap

This research aims to analyse how conflict and extreme weather events (drought and floods) influenced the spatial and temporal patterns of internal displacement in Somalia during 2022 and 2023. Despite previous studies who often examines these aspects in isolation, few studies have explicitly explored how conflict and weather-related events interact to produce displacement in Somalia. For example, Thalheimer et al. (2023) found that extreme weather events, particularly higher temperatures and reduced precipitation, are associated with the rising number of displacements in the country. Building on these findings, Oh et al. (2024) explored the network patterns of IDPs driven by natural disasters compared to conflict independently, suggesting future research would explore how these two displacement exacerbators interact. In Somalia, Kyriazi (2018) also used machine learning to examine how conflict-linked drivers shape migration patterns. The study also concluded that additional issues, such as higher water prices, create extra burdens on migrating populations entering conflict-affected regions, which is supported by the EIP framework in Figure 1. While extensive of research explore the impacts of each exacerbators individually, there is a gap to digest how exacerbators interact to create displacement in Somalia.

This research focuses displacement at the centre of analysis because it represents both a measurable outcome of interactions between exacerbators and a practical entry point for humanitarian action. From a scientific perspective, displacement captures the complexity of multi-source data—drawing from conflict events and extreme weather hazards—making it especially suitable for spatial-temporal analysis. From a societal standpoint, displacement reflects the human consequences of intersecting crises and is central to humanitarian response planning in Somalia. One of the characteristics of displacement is the lack of understanding the local situation, what is happening and how to support those people who are displaced for one reason for hydro-meteorological hazards or another in giving them a safer living environment away from conflicts[1]. Focusing on displacement thus offers both analytical value and real-world relevance, making it a current subject for research on Somalia.

[1] An Agenda for Expanding Forecast-Based Action to Situations of Conflict focuses on ways to improve EWS and FbA in conflict areas, with the goal of better safeguarding vulnerable communities, especially displaced people in conflict-affected areas.

https://www.anticipation-hub.org/download/file-77

Between 2022 and 2023, Somalia experienced a severe drought followed by intense flooding, with conflicts were happening at the same time which led to widespread humanitarian impacts such as displacement crisis across the country. Rather than focusing on a single region, this study analysed a national perspective to capture the full extent and variability of flood, drought, conflict and displacement. Because the fact that drought and conflict are not confined to one specific area but have affected multiple regions. However, the analysis of floods is limited to the regions that experienced riverine flooding in Somalia during the study period. Moreover, internal displacement has been recorded across all regions and examining the country as a whole gives the identification of broader displacement patterns in time and space. These years were selected due to the convergence of conflict with both drought and flood events, which significantly influenced internal displacement across the country.

## 1.2 Research objectives

### Main objective

The main objective of this research is to investigate how conflict and extreme weather events (drought and floods) influenced the spatial and temporal dynamics of displacement across Somalia in 2022 and 2023.

### Specific Objectives[2]

**RO1:** To analyze the relationship between internal displacement, conflict, and drought in Somalia during 2022.

**RQ1**: What was the spatiotemporal relationship between internal displacement, conflict, and drought in 2022?

- **RQ1.1:** What were the spatial and temporal patterns of internal displacement?
- **RQ1.2:** What was the distribution of conflict events?
- **RQ1.3:** What was the extent and severity of drought conditions?
- **RQ1.4:** How can displacement patterns be attributed to conflict and drought?

**RO2:** To analyze the relationship between internal displacement, conflict, and flooding during the El Niño-driven events in Somalia in 2023.

**RQ2:** What was the spatiotemporal relationship between internal displacement, conflict, and flooding in 2023?

- **RQ2.1:** What were the spatial and temporal patterns of internal displacement?
- **RQ2.2:** What was the distribution of conflict events?
- **RQ2.3:** How can displacement patterns be attributed to conflict and flood-affected areas?

**RO3:** To evaluate the influence of resolution on the ability to analyze displacement dynamics in relation to conflict and weather events.

- **RQ3** What is the adequate temporal and spatial resolution to assess the displacement dynamics in relation to cascading conflict and weather events?

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[2] Before addressing RO1–RO3, the analysis starts with a qualitative foundation: an event timeline and impact chain that contextualize the displacement dynamics observed in both 2022 and 2023. These elements, referred to as "Objective 0," are not associated with a separate research question but support the interpretation of findings across all three objectives.

## 1.3 Conceptual model of climate, conflict and displacement

Figure 2 shows the conceptual framework of the research. The displacement induced by extreme weather events and conflicts will be assessed in Somalia between 2022 and 2023. It is important to acknowledge that the nature of displacement differs significantly depending on the trigger. For example, individuals displaced by flooding often intend to return once conditions normalize, making this type of displacement temporary. In contrast, displacement caused by tribal violence or political conflict may result in long-term or even permanent relocation**,** due to persistent insecurity (Garip & Reed, 2025). These different motivations and return expectations shape both the temporal dynamics of displacement and the type of humanitarian intervention required. This research focuses only the overlapping and interacting exacerbator of displacement, where climate-related hazards and conflict co-occur and amplify each other's impacts. The study zooms on identifying the spatial and temporal intersections of these exacerbator to better understand compound displacement dynamics in Somalia regions.

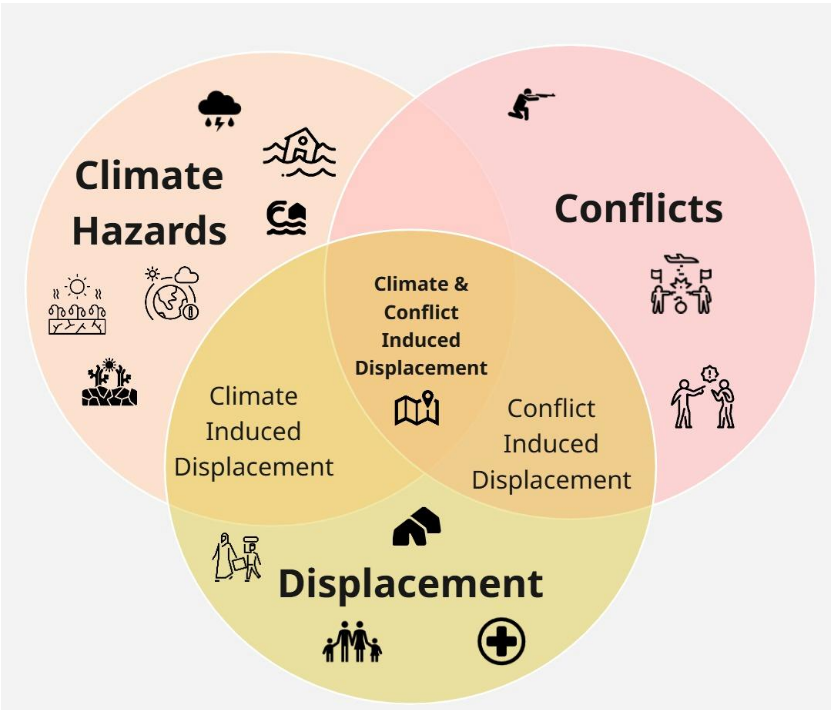



Figure 2: Intersecting challenges of climate hazards, conflict, and internal displacement (Created by author).

In this research, climate-induced displacement refers to population movements that are triggered or exacerbated by extreme weather events, such as droughts and floods, which are also categorized as exacerbators in Figure 1. The "conflict" component in Figure 2 refers to the same forms of conflict depicted in Figure 1 and should be interpreted broadly. While tribal and clan-based tensions are one dimension, the term also includes armed conflict, political violence, and inter-communal disputes that contribute to instability and displacement.

## 1.4 Thesis structure

This thesis is organized into seven chapters. Chapter 1 introduces the research background, objectives, and conceptual framework. Chapter 2 provides the case study context. Chapter 3 outlines the methodology and datasets used. Chapter 4 presents the results of the analysis. Chapter 5 discusses the findings in relation to the research questions together with recommendations and Chapter 6 concludes the study.

# 2. Case-study context: Somalia

This thesis focusses on Somalia, one of the poorest countries in the world. Somalia has a troublesome history (Abdi Ali et al., 2025). Yet, Somalia is a country rich in natural resources and contains a large variety of cultures and economic activities (Nor & Razak, 2024). Important economic activities across the country include its maritime economy, tourism activities, a large agricultural sector, and Somalia's largest coastline put the country as one of the largest hub producers in Horn of Africa (African Development Bank Group, 2023). In recent decade, Somalia has made significant economic and social progress (M. H. Mohamed, 2024). Nevertheless, many challenges remain such as repeated occurrences of climate disasters, high levels of poverty, limited access to healthcare, social inequality, amongst others. Besides that, Somalia has faced periodical conflict since 1991, a factor that has contributed to a high level of displacement and weakened institutional structures at large in the country (Khayre, 2016).

Somalia is 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$^2$ (Carbone & Accordi, 2000). The country contains 18 regions as shown in figure 3 (A), with the capital being Mogadishu. Somalia, historically a rural nation, has experienced rapid urbanization, with urban dwellers rising to 45% (6.83 million) of the population in 2020, projected to grow by 4 million by 2025 (UN-Habitat, 2020). Unregulated urban expansion exacerbates inequalities and increases climate vulnerability, particularly in informal settlements lacking basic infrastructure (UN-Habitat, 2020). Somalia's land cover is highly diverse, ranging from grasslands and shrublands to floodplain woodlands and irrigated croplands concentrated along the Juba and Shabelle Rivers. As shown in figure 3 (B), northern regions are characterized by degraded vegetation and sparse shrub cover, while the south supports more productive agricultural and woodland zones specifically the riverine regions in Jubba and Shabelle (Gure, 2021). (For higher resolution of Figure 3B see in the Appendix F: Somalia landcover classification).

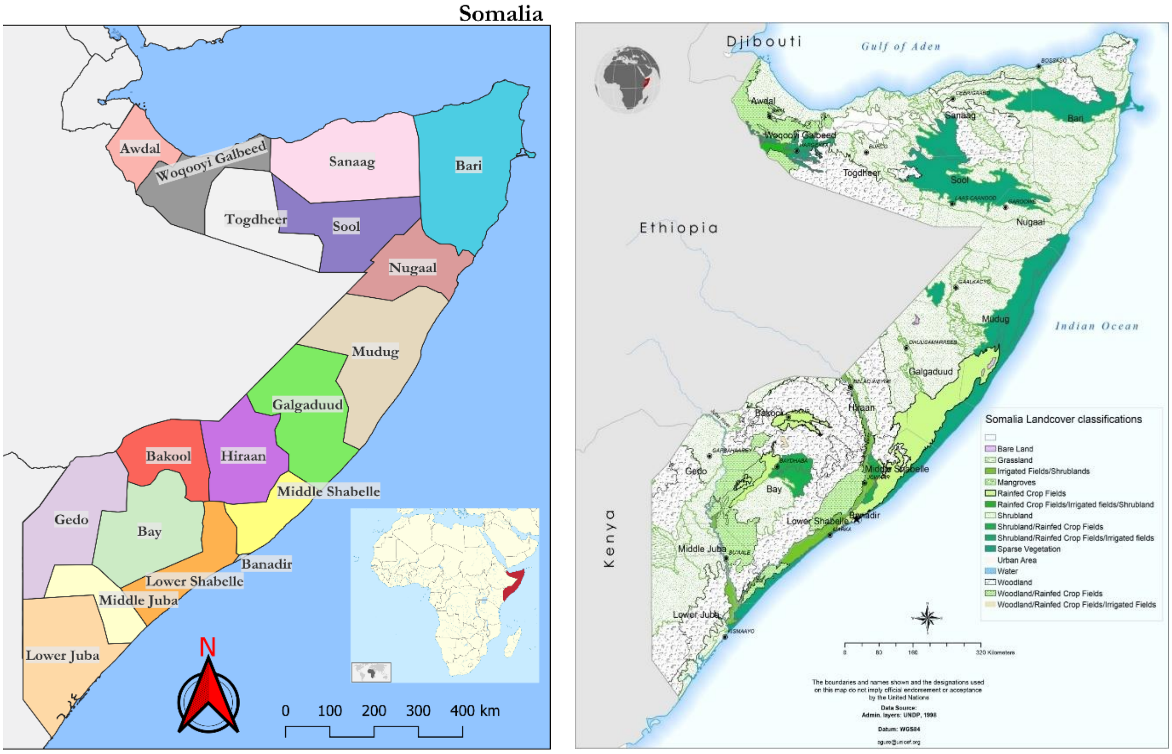



Figure 3: Map of Somalia (A) & 18 regions and land cover types(B)

(Created by author (A) and Gure, 2021 (B)).

## 2.1 Climate

Somalia is located in the inter-tropical zone, and its climate is classified into four general climatic zones: desert, very arid, semi-arid, and humid-semi-arid. The northern and central regions are predominantly desert and very arid, while the southern areas transition into semi-arid and humid-semi-arid zones. The country experiences four distinct seasons, two of which are characterized by rainfall, and each season plays a significant role in shaping the climatic conditions across these zones. The *jilaal* season, from December to March, is hot and dry. It's followed by *gu*, the main rainy season from April to June. The *xagaa* season, from July to September is a drier period with moderate temperatures. Lastly, *deyr* the secondary rainy season is from October to November (Gure, 2021)

As illustrated in Figure 4 and depicted on the accompanying map, Somalia's average annual rainfall is approximately 250 mm. The map shows that the northern regions are predominantly hot and arid, receiving less than 250 mm of rainfall annually. In contrast, the southern and southwestern regions, such as Lower Juba and Bay, experience significantly higher rainfall, with amounts reaching between 400 and 700 mm per year. Central areas, including parts of Galgaduud and Mudug, are classified as semi-arid and receive some of the lowest annual rainfall, typically ranging from 50 to 100 mm (J. Mohamed & Adam, 2022). The map also shows the annual average temperature distribution across the country, with most regions experiencing mean temperatures near 30°C. The hottest period for much of Somalia occurs from April to June, while in the northern regions, peak temperatures are observed from June to September. In the southern regions, the hottest months are generally from December to March (Gure, 2021).

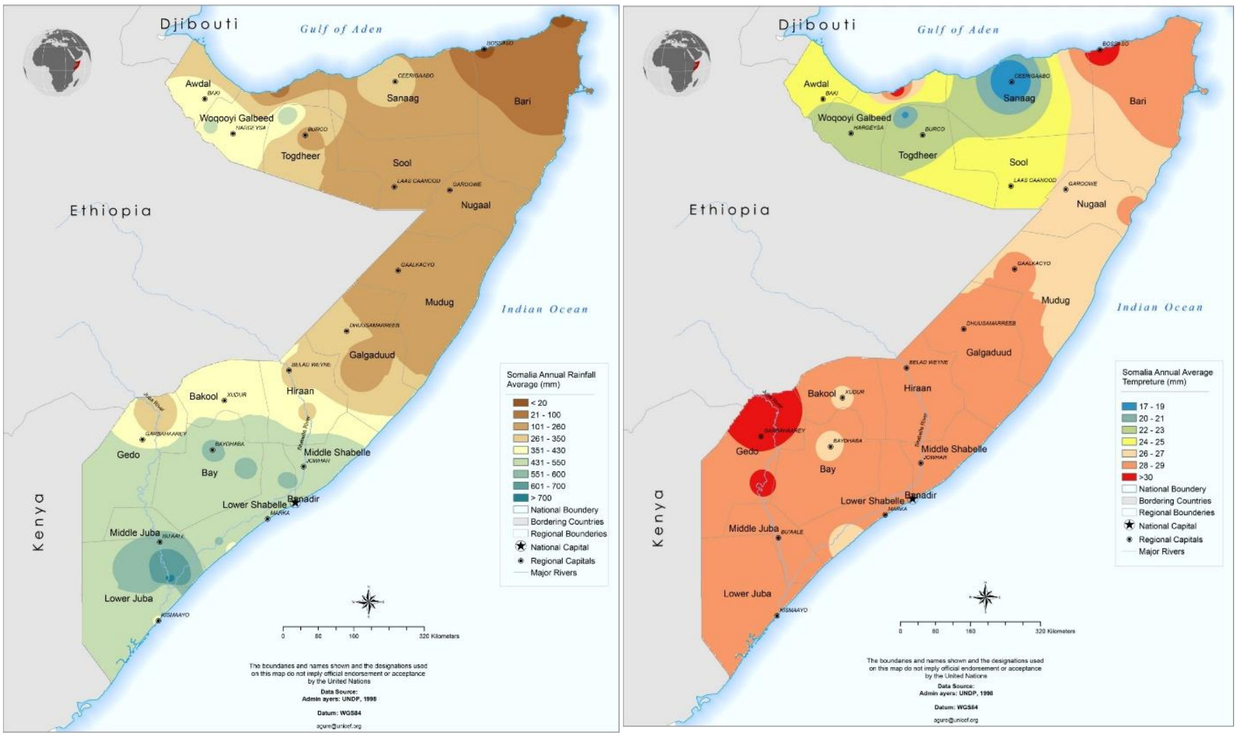



Figure 4: Average Annual Temperature (°C) & Rainfall Map of Somalia (1981-2018) (mm)

(Gure, 2021)

## 2.2 Seasonal Calendar

Somalia's seasonal calendar is shaped by climatic variability, where changing weather patterns influence the timing and reliability of rainfall across the year. As illustrated in figure 5 below, the timing of harvests varies by crop type, but in general, Somalia experiences two main harvest seasons. For the *gu*, farmers plant their crops in April and harvest them around July/August, and for the *deyr*, farmers plant their crops in October and harvest them in January/February. Similarly, the livestock movement follows a seasonal rhythm. From January to March and again from October to December, pastoral communities migrate toward dry season grazing areas in search of water and pasture. As the rains return from April through September, herders shift toward wet season grazing lands where conditions temporarily improve (Samatar, 2024). These movements are essential for survival but can also lead to tensions when access to shared resources becomes contested (FAO, 2023).

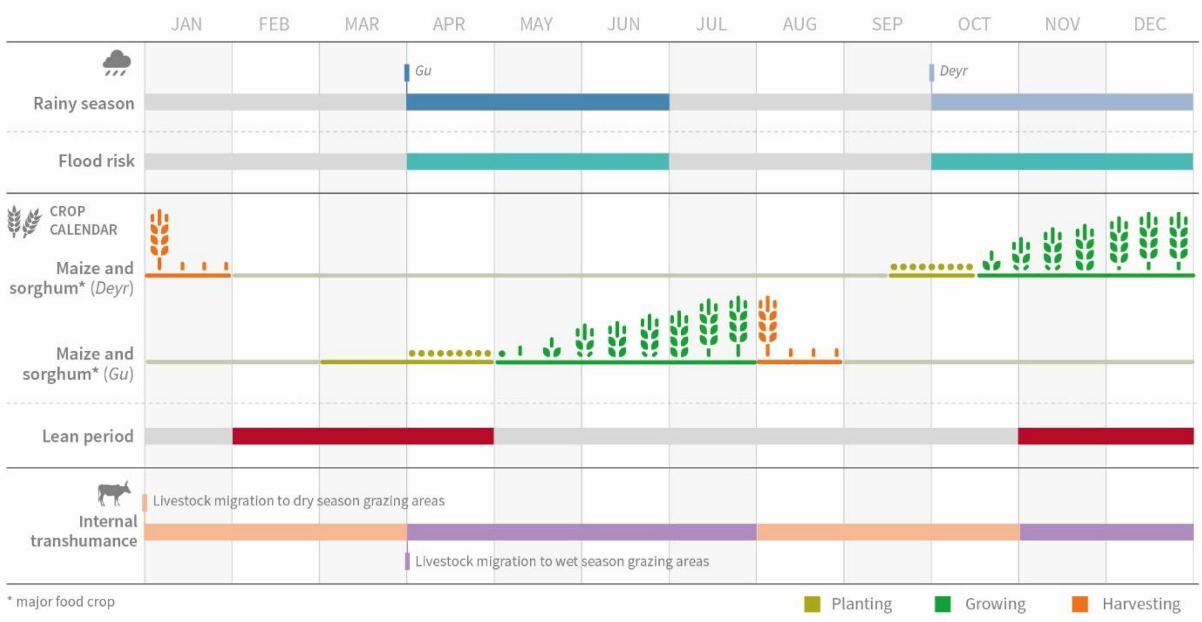



Figure 5: Seasonal calendar for Somalia (FAO, 2023)

This calendar shows key seasonal dynamics in Somalia, including rainfall periods (Gu and Deyr), dry seasons (Xagaa and Jilaal), and associated climatic risks such as flood hazards. It also displays the cropping calendar for maize and sorghum with the planting, growing, and harvesting periods as well as lean periods associated with food insecurity. Additionally, it tracks livestock migration, indicating seasonal transhumance in response to water and pasture availability.

The seasonal calendar in figure 5 is a tool that marks climate and climate-related risks in a year, based on past events and relevant literature. It shows how hazards such as flood risk, disease outbreaks, and food insecurity tend to follow predictable seasonal patterns. A good understanding of these patterns can support better planning and response, particularly in contexts of displacement. While this cropping calendar reflects general patterns, spatial variability does exist between regions depending on local microclimates. For example, northern Somalia experiences slight shifts in planting or harvesting dates compared to southern regions, particularly in areas with different altitudes or proximity to the coast (Sharmake et al., 2022).

# 3. Methods and datasets

This chapter describes the datasets and methods used to examine the spatial and temporal dynamics of internal displacement in Somalia in relation to conflict and extreme weather events (drought and flooding) across 2022 and 2023. The research starts with analyzing 2022 drought and conflict related displacement (RO1), 2023 flood and conflict related displacement (RO2), and RO3 evaluates how data resolution influences attribution outcomes.

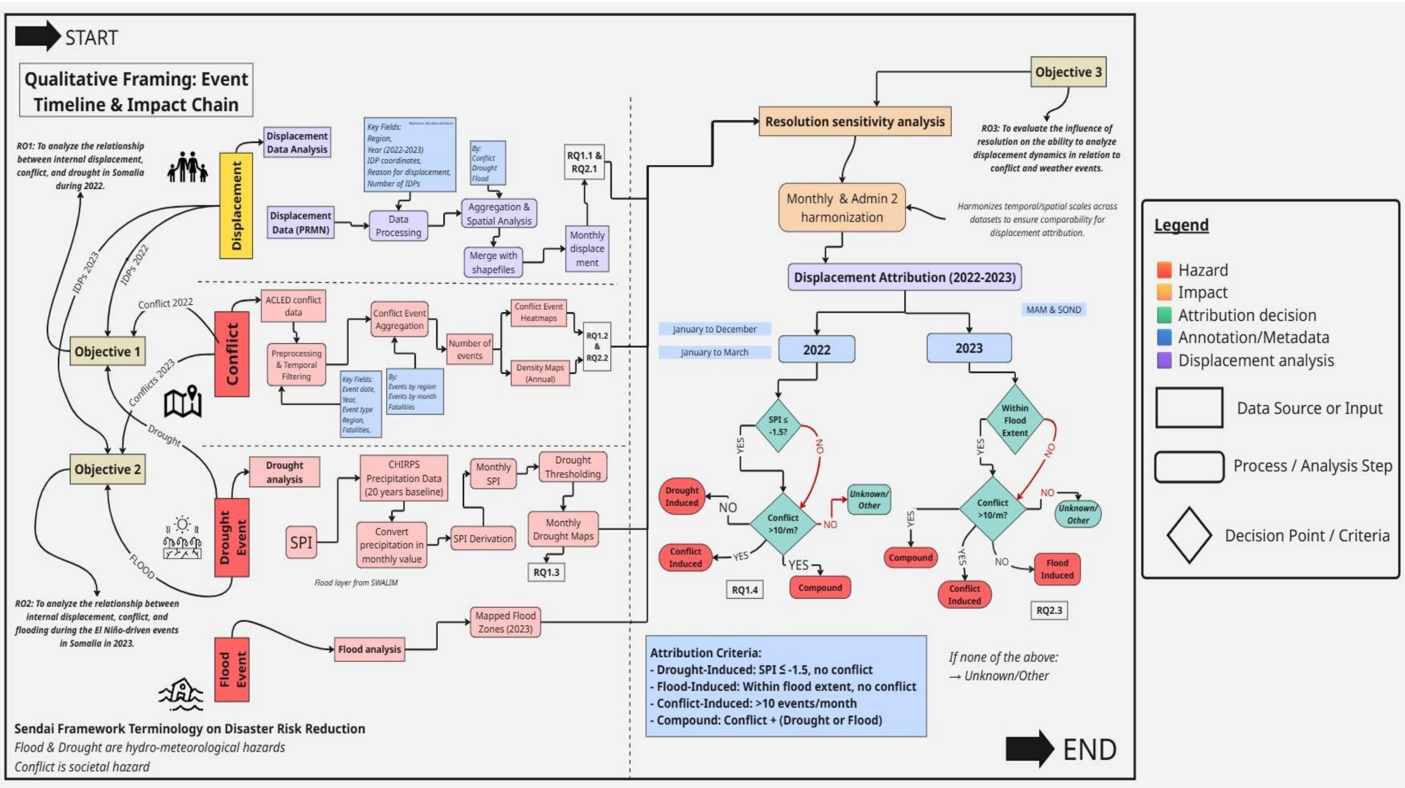
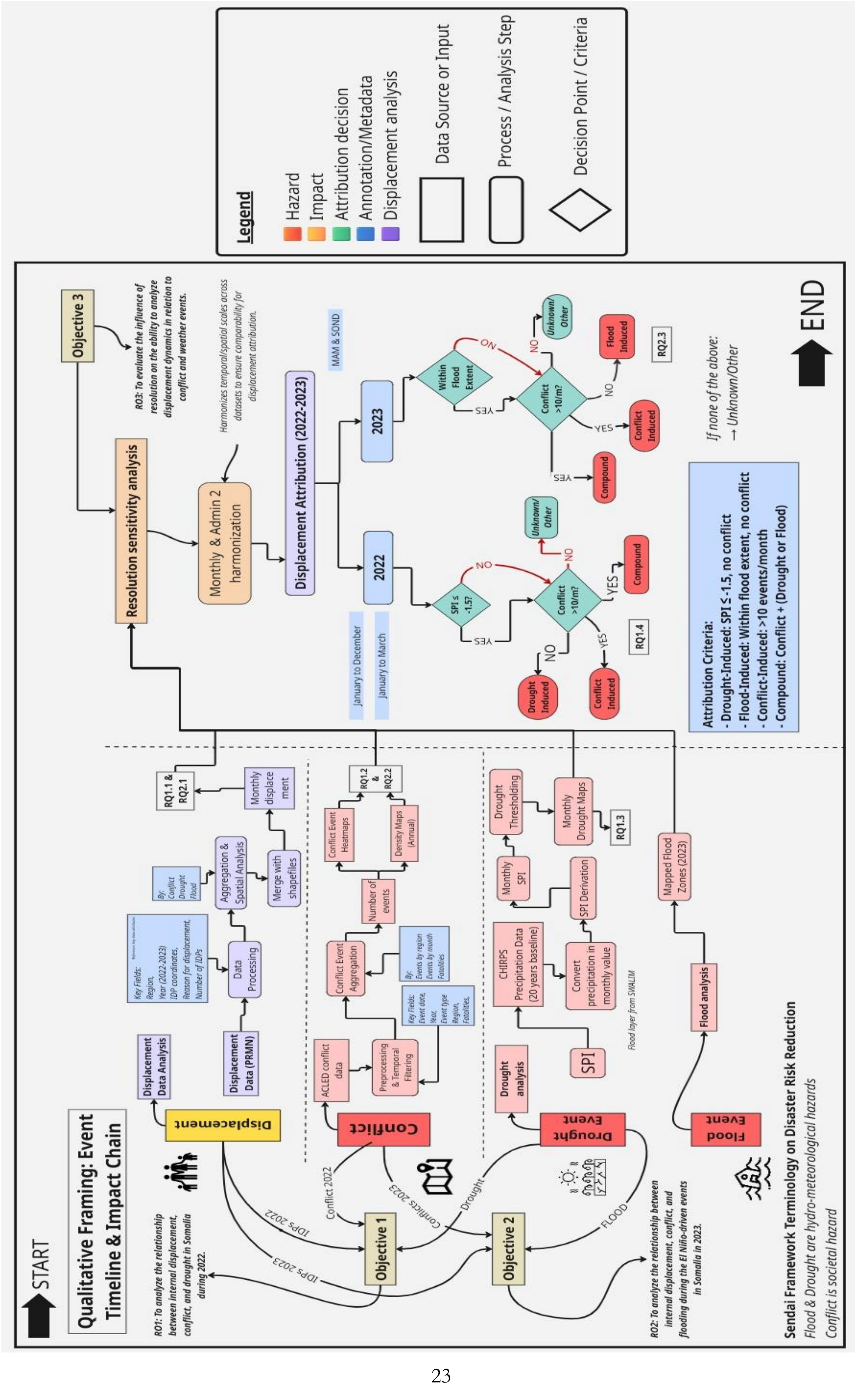



Figure 6: Flowchart of methods used in this study.

Figure 6 provides a visual overview of the methodological workflow. It maps the flow of data inputs into the relevant analysis streams of conflict, drought, and flood. These steps are further elaborated in the sections that follow. Section 3.1 provides an overview of the datasets used in the analysis. Section 3.2 describes the development of the impact chain and timeline that support the interpretive framework. Sections 3.3 to 3.6 detail the specific processing methods used for displacement, conflict, drought and flood mapping. Finally, Sections 3.7 and 3.8 explain how these layers were intersected and how displacement attribution to multiple hazards and conflict drivers was carried out with resolution.

Together, this flowchart illustrates how the qualitative and quantitative components of the study are sequenced to produce understanding of displacement dynamics in Somalia.


START
Qualitative Framing: Event Timeline & Impact Chain
RO1: To analyze the relationship between internal displacement, conflict, and drought in Somalia during 2022.
Displacement
Displacement Data Analysis
Displacement Data (PRMN)
Key Fields: Region, Year (2022-2023) IDP coordinates, Reason for displacement, Number of IDPs
Data Processing
By: Conflict Drought Flood
Aggregation & Spatial Analysis
Merge with shapefiles
Monthly displace ment
RQ1.1 & RQ2.1
IDPs 2023
IDPs 2022
Conflict 2022
Conflicts 2023
Drought
FLOOD
Objective 1
Objective 2
Objective 3
Conflict
ACLED conflict data
Preprocessing & Temporal Filtering
Key Fields: Event date, Year, Event type Region, Fatalities,
Conflict Event Aggregation
By: Events by region Events by month Fatalities
Number of events
Conflict Event Heatmaps
Density Maps (Annual)
RQ1.2 & RQ2.2
Drought Event
Drought analysis
SPI
CHIRPS Precipitation Data (20 years baseline)
Convert precipitation in monthly value
SPI Derivation
Monthly SPI
Drought Thresholding
Monthly Drought Maps
RQ1.3
Flood layer from SWALIM
RO2: To analyze the relationship between internal displacement, conflict, and flooding during the El Niño-driven events in Somalia in 2023.
Flood Event
Flood analysis
Mapped Flood Zones (2023)
Sendai Framework Terminology on Disaster Risk Reduction
Flood & Drought are hydro-meteorological hazards
Conflict is societal hazard
Resolution sensitivity analysis
RO3: To evaluate the influence of resolution on the ability to analyze displacement dynamics in relation to conflict and weather events.
Monthly & Admin 2 harmonization
Harmonizes temporal/spatial scales across datasets to ensure comparability for displacement attribution.
Displacement Attribution (2022-2023)
MAM & SOND
January to December
January to March
2022
2023
SPI ≤ -1.5?
YES
NO
Conflict >10/m?
NO
YES
Drought Induced
Conflict Induced
Compound
Unknown/ Other
RQ1.4
Within Flood Extent
Flood Induced
RQ2.3
Attribution Criteria:
- Drought-Induced: SPI ≤ -1.5, no conflict
- Flood-Induced: Within flood extent, no conflict
- Conflict-Induced: >10 events/month
- Compound: Conflict + (Drought or Flood)
If none of the above: → Unknown/Other
END
Legend
Hazard
Impact
Attribution decision
Annotation/Metadata
Displacement analysis
Data Source or Input
Process / Analysis Step
Decision Point / Criteria

## 3.1 Overview of datasets

The primary objective of this study is to understand the dynamics of internal displacement, particularly at the intersection of conflict and weather-related events in Somalia during 2022 and 2023. To approach this, the research used a diverse range of data sources, including:

### 3.3.1 Administrative boundaries

This dataset contains Somalia administrative level 0 (country), 1 (states), 2 (regions), and 3 (districts) boundary polygons. The dataset was primarily used for spatial aggregation and alignment of conflict events and displacement records data. The resolution corresponds to vector polygon data and there is no temporal variation in administrative boundaries during the study period (2022–2023).

### 3.3.2 Displacement data

In this research, the central theme was displacement dynamics, and the study covers from January 2022 to December 2023. It is used the IDP location dataset from the UNHCR Protection and Return Monitoring Network (PRMN). The PRMN (Protection & Return Monitoring Network) acts as a platform for identifying and reporting on displacements (including returns) of populations in Somalia as well as protection incidents underlying such movements. The PRMN dataset includes key attributes such as the date of displacement, region of departure and arrival, reason for displacement (e.g., conflict, drought, floods) and the estimated number of individuals or households affected. The data is collected by UNHCR staff interviewing displaced persons (from 'household-level' reports) primarily at points of arrival and by interviewing key informants (generating 'group reports') at IDP settlements, transit centres and other strategic locations. During the interview, both the point of departure and reason for departure are recorded; sensitive personal information is not stored (Humanitarian Data Exchange, 2024). More information on UNHCR PRMN Somalia can be found on the UNHCR Somalia Data Portal .

Although the IOM Displacement Tracking Matrix (DTM) was initially considered for the research, it was excluded from the final analysis due to its lower temporal resolution and challenges in aligning it with conflict and hazard data. Therefore, this study relies exclusively on the PRMN dataset, which offered a greater temporal granularity and consistent coverage over the study period.

The UNHCR PRMN dataset has a temporal resolution in weekly and monthly. It collects data only regional level. Despite this spatial constraint, the dataset's consistent reporting across time supported the analysis of displacement temporal trends at a national scale. In this research, it is used to examine when displacement occurs, while recognizing that finer spatial disaggregation remains a limitation of the current data landscape.

### 3.3.3. Conflict data

The Armed Conflict Location & Event Data Project (ACLED) was the primary and secondary source of daily conflict data used in this study. ACLED provides georeferenced data on political violence and protest events, with detailed attributes such as event type, actors involved, dates, and precise locations (Carboni & Raleigh, 2024). The ACLED collects data from various media outlets, NGOs, and local reports to provide a comprehensive temporal overview of conflict events as illustrated in Figure 6. The ACLED data also contains categories of conflict, including violence against civilians, explosions, remote violence, protests, riots, and battles (Eklund et al., 2017). For this research, conflict events in Somalia during 2022 and 2023 were extracted at the second administrative level (Admin 2). More information of ACLED Somalia data can be found https://acleddata.com/africa/horn-of-africa/somalia/

## 3.3.4 Rainfall data

The Climate Hazards Group InfraRed Precipitation with Station data (CHIRPS) was used as the primary rainfall dataset for assessing meteorological drought conditions in Somalia. CHIRPS provides gridded rainfall data at a spatial resolution of 0.05 degrees (~5 km) and a daily temporal resolution, spanning from 1981 to the present. The dataset integrates satellite imagery with in-situ station data to produce consistent and reliable precipitation estimates in long term period, making it particularly suitable for drought monitoring in data-scarce regions like Somalia (Dinku et al., 2018). This dataset was developed by the Climate Hazards Center (CHC) and is available https://www.chc.ucsb.edu/data/chirps in GeoTIFF format for GIS analysis within Google Earth Engine.

As displacement data was reported at both weekly and monthly temporal resolutions. In this study, CHIRPS precipitation data was aggregated to a monthly temporal resolution to align with the temporal scope of the displacement dataset during. CHIRPS was selected because of its long temporal record, higher spatial resolution, and demonstrated performance in arid and semi-arid environments like Somalia (Dinku et al., 2018). Additionally, its long historical record and spatial detail allowed for the identification of regional meteorological drought severity and spatial trends when overlaid with displacement and conflict datasets.

## 3.3.5 Flood data

The flood extent dataset for the Juba and Shabelle rivers during the El Niño-induced 2023 food season was compiled from multiple sources to improve accuracy and coverage. It incorporates data from the Global Flood Monitoring System retrieved on 14 November 2023, a WorldView-3 image from 16 November 2023 analyzed by UNOSAT (spanning 5 November to 3 December 2023), and Sentinel-2 imagery from 15, 20, and 30 November, as well as 5 and 10 December 2023.

The Somalia Water and Land Information Management (SWALIM) flood dataset was selected due to its contextual relevance, local validation, and event-specific detail tailored for Somalia. Despite this multi-source approach, the mapped extent may underestimate the actual flooding due to persistent cloud cover during key observation dates and limitations in radar and optical imagery, particularly in detecting inundation within densely built-up urban areas or under vegetation. For this study, the dataset specifically includes flood extents along both the Juba and Shabelle rivers. The full dataset is titled *"Juba Shabelle River Floods – El Niño – Deyr 2023."*

**Table 1: Datasets used in the research**

| *Data Category* | *Dataset* | *Spatial Resolution* | *Temporal Resolution* | *Data Type & Format* | *Source of Data* | *Role in study* | *URL* |
|---|---|---|---|---|---|---|---|
| ***Administrative boundaries*** | Country, states, regions, disticts | National to sub-national level | Static | Vector, Shapefile | Global Administrative Areas | RO1 & RO2 | Somalia |
| ***Historical Flood Event Data*** | Historical flood | Polygon flood extent | Event based | Raster, GeoTiff | SWALIM | RO2 | Juba Shabelle River Floods |
| ***Meteorological Data*** | Rainfall (20 years) | 5566 meters pixel size | Daily | GeoTiff | CHIRPS | RO1 & RO3 | CHIRPS |
| ***Displacement Data*** | Data on displacement patterns | Aggregated data Admin 2 | Weekly to monthly | Tabular, CSV with coordinates. | UNHCR | RO1, RO2 & RO3 | PRMN |
| ***Conflict*** | Conflict events recorded in the study period | Point data Admin 2 | Daily events 2022 and 2023 | Vector, Shapefile | ACLED | RO1, RO2 & RO3 | ACLED |
| ***Impact*** | Natural hazard events include the date, disaster type, area and number of affected people | Region Admin 2 | Based on event | Excel .xlsx | EM-DAT database | RO1 & RO2 | EM-DAT |

## 3.2 Impact chain and event timeline

This section introduces the impact chain and event timeline developed to provide a qualitative foundation for analyzing displacement patterns in Somalia during 2022 and 2023. These tools offer a contextual overview of the sequence and interplay between climate hazards (droughts and floods) and conflict events across both years.

To construct the multi-hazard event timeline, events were identified through a literature analysis. Conflict events were selected from the ACLED database and filtered based on their study period (2022–2023) in Somalia. Only major escalations or tensions reported in humanitarian briefings were included. Drought and flood events were derived from IPC (Integrated Food Security Phase Classification) bulletins, OCHA situation reports, SWALIM flood monitoring archives, ICRC and ICPAC early warnings, and additional UN updates. Drought entries emphasized seasonal failures (Gu, Deyr, Jilaal), food insecurity, and population exposure, while flood entries were limited to events with documented impacts on households, displacement, or infrastructure. All entries were categorized by the hazard type (conflict, drought, flood), arranged chronologically, and cross-validated to ensure consistency in timing, geographic coverage, and relevance to displacement dynamics. The final timeline visualizes how these events unfolded in sequence, helping to contextualize this research.

Moreover, impact chains are conceptual models used to visualize and document the interconnections between hazards, vulnerability, and exposure that collectively contribute to the emergence of a specific risk. A generic impact chain was developed for the study area of Somalia to represent the interconnected nature of hazard-related and conflict-driven risks of displacement. The impact chain allows for understanding of compound and consecutive hazards affecting entire regions, rather than analyzing each hazard in isolation (Crespi et al., 2023; De Risi et al., 2022; Thaler et al., 2023).

For this research work, the chains were based on literature review of what happened during research time frame and data analysis. The approach from (Sparkes et al., 2024) was used for developing this impact chain: first, it identifies the climatic hazard: drought 2022 and El Nino Flood 2023. Second, identify the climatic triggers which caused impacts or increased risk of displacement. Next, it identified the intermediate impacts and pathways leading to displacement. Finally, the exposed elements to risk within the displacement risk system.

In this study, the impact chain was developed using a top-down approach, which begins with the identified impact internal displacement and systematically maps the contributing factors that lead to it. This includes tracing back from the impact through layers of hazards, exposure, vulnerability, and preconditions. The structure of the impact chain is informed by the established frameworks in climate risk and disaster displacement research (Thalheimer et al., 2023; Zebisch et al., 2022), and was adapted to the Somali context through a combination of literature review of the events happened during the study period. Additionally, the construction of the impact chain was used by a combination of sources. First, a literature review was used to identify common drivers and pathways of displacement in fragile and climate-affected regions. Second, the structure of the chain was shaped by thematic analysis of the datasets used in this study, including displacement data, conflict event data, and climate hazard indicators derived from remote sensing, such as rainfall anomalies and flood extents. The impact chain framework conceptualizes the cascading relationships between conflict, weather extremes, and displacement, directly supporting the analytical logic behind RQ1, RQ2, and RQ3.

## 3.3 Displacement analysis

The analysis of regional displacement patterns in Somalia for the years 2022 and 2023 was conducted using data from the UNHCR Protection and Return Monitoring Network (PRMN). Many researchers have used origin-destination datasets aggregated at monthly intervals to study the spatio-temporal dynamics of displacement. For example, Yuen et al. (2022) analyzed monthly PRMN data to examine crisis-driven displacement trends in Somalia. Following this approach, the current study grouped displacement variations by region of origin and region of arrival, allowing for analysis of both where people left from and where they went. The data is spatially aggregated at the regional (Admin 2) level, as this is the only resolution at which consistent displacement records are available. Temporally, the data is aggregated on a monthly basis to align with the temporal granularity of other key variables of conflict events and drought. Additionally, Obse et al. (2024) applied spatio-temporal techniques to identify displacement trends in Ethiopia, disaggregated by conflict and drought causes. The monthly displacement was merged with the regional shapefiles of the study area to visualize movement patterns across space (region) and time (month) in GIS analysis. These were mapped in QGIS, to show a clear representation of internal displacement dynamics and assess how internal movement patterns evolved over time and space contributing to RQ1.1 and RQ2.1.

## 3.4 Conflict mapping & threshold

To explore the temporal and spatial distribution of conflict events in relation to drought and flood-affected areas and their impact on displacement, the research focused on conflict mapping at regional level during 2022 and 2023 using ACLED data. Next, the filtered dataset was saved as a separate CSV file to streamline subsequent GIS analysis. In order to quantify conflict impact, events were grouped by region (Admin 2 level) and month using the event's geolocation and timestamp fields. It is used temporal and spatial aggregation, calculating both the total number of conflict events and cumulative fatalities per region and month. Therefore, the aggregation allowed the generation of a summary table with two key indicators: (1) conflict frequency and (2) intensity, measured by fatalities. Furthermore, the monthly conflict data were merged by spatial join with a regional shapefile of the study area for GIS analysis. Finally, this merged dataset was exported as a new shapefile using QGIS, which served as the primary input for conflict intensity mapping in the study. These were used as the basis of producing heatmaps and annual density relevant to RQ1.2, RQ2.2

In this research, conflict threshold was applied for conflict severity within the study period to ensure both temporal and cumulative conflict intensities were adequately captured. Specifically, monthly conflict events were assessed in RQ1.2, RQ2.2 and RQ3, then regions recording fewer than 10 conflict events per month were excluded from further analysis, as such frequencies were deemed insufficient to reflect sustained or impactful violence. This approach is consistent with prior research which shows that low-frequency conflict regions often introduce noise or misleading patterns in spatial models (Schutte & Kelling, 2022). Furthermore, the approach to disregard low-frequency conflict regions in the analysis is also applicable in Somalia context because conflict events are rarely random or evenly distributed across space and time. Instead, conflict events often repeat in the same regions over time, with violence clustering in already high-risk areas and continuing across consecutive months (Berman et al., 2017; Walther et al., 2025). Therefore, this thresholding balanced that the research focuses on regions faced both monthly and annual conflict patterns, which are attributed as conflict-induced displacement regions relevant to RQ1.4 and RQ2.3.

This workflow is saved as script in the thesis GitHub repository at https://github.com/3bdillahiomar, under the repository titled "som_climate_conflict_displacement".

## 3.5 Drought measurement SPI

To start with, drought is a phenomenon that is triggered by inadequate availability of freshwater supplies for human and ecosystem's needs over an extended period. It is typically initiated by a persistent deficiency in precipitation. Apart from the reduced rainfall, droughts are further characterized by a decline in soil moisture content, diminished streamflow, and a drop of groundwater levels (Balint et al., 2013). Drought can be broadly categorized into three main types based on its causes and impacts. Meteorological drought occurs when a region gets way less rain than usual over a long stretch of time. It's not just a few dry days either; it's when the pattern shifts so much that it no longer matches the area's typical weather. Secondly, hydrological drought arises when the prolonged precipitation deficits lead to reduced water availability in surface and subsurface systems, including diminished streamflow, lower reservoir, water boreholes, and decreased groundwater recharge. Agricultural drought manifests when both meteorological and hydrological droughts affect soil moisture levels to the extent that crop growth, irrigation, and other agricultural operations are impacted. Therefore, meteorological droughts attempt to determine the primary causes, while the other droughts attempt to explain the secondary impacts of meteorological droughts.

In general, drought is a covariate shock, meaning it affects large areas simultaneously and dryness persistence (Tijdeman et al., 2022). Because of this broad geographic coverage, high spatial resolution becomes less critical, and coarser regional averages (SPI at Admin 2 level) are sufficient to capture meaningful drought trends for this research as well as to align with the displacement data at regional levels. Therefore, this study uses meteorological drought, measured by the Standardized Precipitation Index (SPI), to reflect short-term rainfall deficits. The use of SPI is supported by contextual evidence from Somalia, where a lack of rainfall directly reduces water availability, depletes pasture and crop yields, and also undermines food security which are key drivers of population displacement (Samatar, 2024). Moreover, the SPI-1 was used to monitor monthly variations in drought intensity, aligning with the temporal resolution of displacement and conflict data.

Rainfall is the most important indicator in the determination of meteorological drought globally (Mishra et al., 2022). A deviation from the Long Period Average of 30 years is considered a credible indicator of drought and to assess the meteorological drought in 2022, the Standardized Precipitation Index (SPI) has been used. The SPI is a drought index that relies solely on precipitation as input. It involves fitting precipitation data to a two-parameter gamma distribution to establish the relationship between precipitation amounts and their probability of occurrence. The fitted data is then transformed into a standard normal distribution with a mean of zero and a standard deviation of one (Keyantash, 2021; Tirivarombo et al., 2018). In this study, SPI-1 was selected to evaluate monthly drought conditions during 2022, allowing for a detailed temporal comparison with monthly displacement and conflict data. Numerous studies have applied the SPI for drought analysis (Ángeles Clemente et al., 2024; Liu et al., 2021; Singh et al., 2023). In Somalia, it is also used to measure drought severity and analyse the variability of drought events (Gure, 2017; M. J. Mohamed et al., 2022). This analysis supports RQ1.3 by quantifying drought severity using SPI at monthly intervals.

The selection of SPI was supported by the availability of long-term, CHIRPS high-resolution precipitation datasets and the recognition that precipitation is the primary trigger influencing drought onset and severity (Mayasari et al., 2017). Therefore, a temporal coverage of at least 20 years was used to establish statistically robust long-term monthly averages for each calendar month (January through December). In the first stage, daily precipitation values were aggregated into monthly totals for each year in the dataset. It involved summing daily rainfall observations to compute a single total rainfall value for each month, across all years of observation. Subsequently, the rainfall data for the year of interest (2022) was then aggregated monthly following the same approach. With both the long-term monthly precipitation records and the current year's monthly totals available, the Standardized Precipitation Index (SPI) was computed to quantify rainfall anomalies using the formula:

$$SPI = \frac{P - \bar{P}}{\sigma_P}$$

Where P is the precipitation value, $P^{-}$ is the long-term mean precipitation, and $\sigma_p$ is the standard deviation of precipitation. These parameters were used to standardize rainfall data for SPI calculation.

Regarding the thresholds, the SPI calculation for location is based on the long-term precipitation record for a desired period which means positive SPI values indicate greater than mean precipitation while negative values indicate less than mean precipitation. For any given region, meteorological drought conditions are signaled when SPI values fall below –1.0, with severity increasing as SPI approaches –2.0. Conversely, values above 1.0 indicate unusually wet conditions (Keyantash, 2021). In this study, regions with SPI values between –1.5 and –2.0 were specifically selected for detailed drought impact analysis and understanding as shown in Table 2 below.

All the process has been analyzed using Google Earth Engine and exported to QGIS for map making, the scripts used in the drought analysis can be found in the GitHub repository at https://github.com/3bdillahiomar, under the repository name **"som_climate_conflict_displacement"**.

**Table 2: SPI drought classification**

| *Class* | **SPI Value Range** | **Drought Severity** |
|---|---|---|
| *1* | SPI ≥ 0.00 | No Drought (Normal or Wet) |
| *2* | 0.00 to –0.99 | Mild Drought |
| *3* | –1.00 to –1.49 | Moderate Drought |
| *4* | –1.50 to –1.99 | Severe Drought |
| *5* | ≤ –2.00 | Extreme Drought |

## 3.6 Flood detection and mapping

In this study, the flood extent maps were obtained from the SWALIM geoportal and used to identify flood-affected regions along the Jubba and Shabelle rivers during the floods of 2023. These maps were integrated with the displacement and conflict data by aligning the flood-affected areas to administrative boundaries (Admin 2) relevant to RQ2.3. Where possible, flood timing was verified using the river gauge data from the Somalia National River Flow Archive (SNRFA), to confirm consistency with reported displacement events. The SWALIM flood layers were used for regional-scale analysis which means only regions in the riverine areas has been used for the research scope. In this research, no additional flood mapping was conducted by the author; this study used the already processed flood extent layers with buffers.

Since floods can have effects that extend beyond the precise inundation zones, buffer zones were applied to justify displacement linkages near flood-affected areas. However, displacement occurring at a significant distance from the flood extent was not classified as flood-related or compound.

## 3.7 Disentangling displacement and hazard interaction through data analysis

First, to ensure consistency across datasets and extract meaningful intersection of displacement with climate and conflict hazards, this research standardized both the spatial and temporal resolutions used in the analysis. All datasets were harmonized to a monthly temporal resolution, covering the period January 2022 to December 2023. Monthly resolution was selected to align with the reporting frequency of displacement data from PRMN, and to capture short-term hazard dynamics, such as SPI-based drought fluctuations and monthly conflict trends. Daily CHIRPS rainfall data was aggregated to monthly totals to calculate the SPI at a one-month timescale (SPI-1). Similarly, conflict event data from ACLED was aggregated to monthly counts to keep temporal alignment across the different datasets.

Spatially, all datasets were analyzed at regional level to align with the displacement data, which is reported at regional levels. Conflict data (from ACLED) and hydrometeorological hazard data (SPI and flood) were also aggregated or clipped to this level for comparability. Moreover, event-based flood extent polygons were obtained from SWALIM for 2023. The vector layers were spatially intersected with the study area second administrative boundaries (Admin 2) using QGIS only regions affected by the flood event. A region was considered flood-affected if any part of the flood polygon overlapped with its boundary during the month of the flood event. The flood data is clearly showing regions flooded so this method assumes that if any part of a region is flooded, that region is considered affected. Additionally, the SPI-1 dataset is gridded at approximately 0.05° spatial resolution (~5 km). To align the pixel-level SPI-1 data with the displacement and conflict datasets, regions were classified as experiencing drought if a substantial portion of SPI pixels within the region recorded values of $\leq -1.5$. Specifically, each month's SPI raster was overlaid with the study area region shapefile in QGIS.

To answer the research question RQ1.4 and RQ2.3, all datasets were standardized to a monthly temporal scale and spatially aggregated to regional level. It is important to acknowledge inherent differences in their original resolutions. On the other hand, regional displacement data gives a balance between spatial granularity and reporting reliability, whereas Admin 3 (district-level) often contains missing and inconsistent records for the displacement. Therefore, data harmonization ensured that all hazard indicators (drought, conflict, flood) could be assessed in relation to reported displacement patterns within a common spatial unit and time step, minimizing potential bias due to mismatched data granularity.

Next, after harmonizing both spatial and temporal resolution, to analyze of overlap between internal displacement and its exacerbator, specific criteria were applied to define when a region was considered affected by each hazard to answer RQ1.4. First, a region-month was classified as drought-affected if the SPI-1 value was equal to or below –1.5, indicating moderate to severe meteorological drought. Second, it was marked as conflict-affected if more than 10 conflict events were recorded during that month, based on ACLED data. Next, flood-affected regions were identified through spatial intersection with SWALIM flood extent polygons for the relevant months of 2023 for RQ2.3. The monthly displacement dataset was constructed in table, so regions affected by drought were highlighted in bold text, while those affected by conflict were marked with underlined text. Where both hazards overlapped in a given region and month, it was formatted in bold and underlined, indicating the presence of compound stressors. Finally, these clear definitions are used for the multihazard displacement attribution analysis in the next section.

## 3.8 Attribution of Displacement to Multiple Hazards

An attribution framework was applied to assess which hazard(s) most plausibly triggered or influenced the observed displacement patterns. The objective of this framework was to distinguish between single-hazard and compound-hazard displacement events, for better understanding in 2022-2023. Displacement cases were attributed based on a rule-based logic, where each region-month was evaluated for the presence of drought (SPI-1 ≤ –1.5), conflict (>10 events/month), or flood exposure. The classification assigned displacement events to one or more hazard categories: conflict-induced, drought-induced, flood-induced, or compound (conflict + (drought or flood)). This output was used to quantify the relative contribution of each hazard type and to support further analysis in the results and discussion chapters.

Similarly to this approach, Thalheimer et al. (2024) applied probabilistic event attribution to assess the role of climate change in flood-related displacement in Somalia. In contrast, this study applies a rule-based framework to attribute displacement to conflict, drought, or flood events based on spatio-temporal overlap, without isolating the climate change signal only for 2022-2023.

**Table 3: Research objectives with corresponding methods, outputs, and results sections**

| Research Objective | Methodology | Outputs | Results Section |
|---|---|---|---|
| Objective 0: To establish a contextual timeline and impact chain of conflict and weather-related displacement across 2022–2023. | Literature review, event sequencing from conflict and weather reports (Section 3.2) | Qualitative timeline and impact chain used to frame subsequent results. | 4.1 |
| RO1: To analyze the relationship between displacement, conflict, and drought in 2022. | Spatial analysis of PRMN (3.3), ACLED conflict data (3.4), and drought severity via SPI (3.5); and attribution (3.8) | Maps and charts showing 2022 displacement patterns, drought severity, and conflict clustering. | 4.2–4.5 |
| RO2: To analyze displacement, conflict, and flooding in 2023 (El Niño period). | Spatial analysis and SWALIM flood mapping (3.6), overlay with conflict and displacement data (3.3–3.4), and attribution approach (3.8) | Attribution of 2023 displacements to floods and conflict zones. | 4.6–4.8 |
| RO3: To evaluate the influence of resolution on displacement analysis. | Sensitivity testing by varying spatial/temporal resolution of input data (3.7). | Recommended spatial/temporal resolutions for analysis. | 4.9 |

# 4. RESULTS

This chapter presents the results of this research. Section 4.1 presents the qualitative overview of the crisis context (Section 4.1), which includes impact chain and event timeline. Sections 4.2 to 4.5 present findings related to RO1, with each sub-section addressing a specific sub-research question: RQ1.1 (displacement patterns) in Section 4.2, RQ1.2 (conflict distribution) in 4.3, RQ1.3 (drought severity) in 4.4, and RQ1.4 (displacement attribution) in 4.5. Sections 4.6 to 4.8 address RO2, covering displacement and conflict patterns in 2023 (RQ2.1 and RQ2.2) and their attribution to flood events (RQ2.3). Section 4.9 addresses RO3, evaluating how temporal and spatial resolution affects the ability to analyze displacement dynamics (RQ3). The structure mirrors the sub-research questions and aims to first describe each phenomenon individually before synthesizing their interactions in space and time.

## 4.1 Impact chain and event timeline

First, the two main hazards (drought in 2022 and flooding in 2023) were identified using climate bulletins from the government. These events were linked to La Niña and El Niño conditions respectively, forming the base of the impact chain because of their clear connection with displacement trends in Somalia (J.-F. Maystadt & Ecker, 2014; Warsame et al., 2023). Next, the key climatic signals such as low rainfall and heavy precipitation were confirmed via remote sensing assessment supported by the report from UNOCHA (2023). The interconnectedness between the hazards was guided by frameworks from Raymond et al., (2020), which helped structure how initial climatic triggers evolved into more linear risks like water scarcity and river breakage.

Next, Poor infrastructure intensified the impacts of both drought and flooding, increasing the overall vulnerability of affected regions in Somalia. Pape and Wollburg, (2019) showed that inadequate water systems and fragile flood protection measures severely limit the ability of communities to manage climate shocks. In rural Somalia, households without access to infrastructure suffered the greatest declines in consumption during drought events. Similarly, recurrent floods in riverine areas have caused widespread infrastructure damage and displacement, partly due to weak and insufficient preparedness (Ahmed et al., 2022). As shown in Figure 7 below, conflict emerged as a key intermediate factor, often compounding drought and flood impacts. Displacement data analysis, supported by survey interviews from UNHCR, indicated that conflict was often triggered by competition over water resources and poor coordination, both of which significantly heightened vulnerability. Therefore, the exposed elements were included in natural (e.g., cropland), infrastructure (e.g., river barriers), socio-economic (e.g., poverty, food access), and human systems (e.g., displaced populations, host communities).

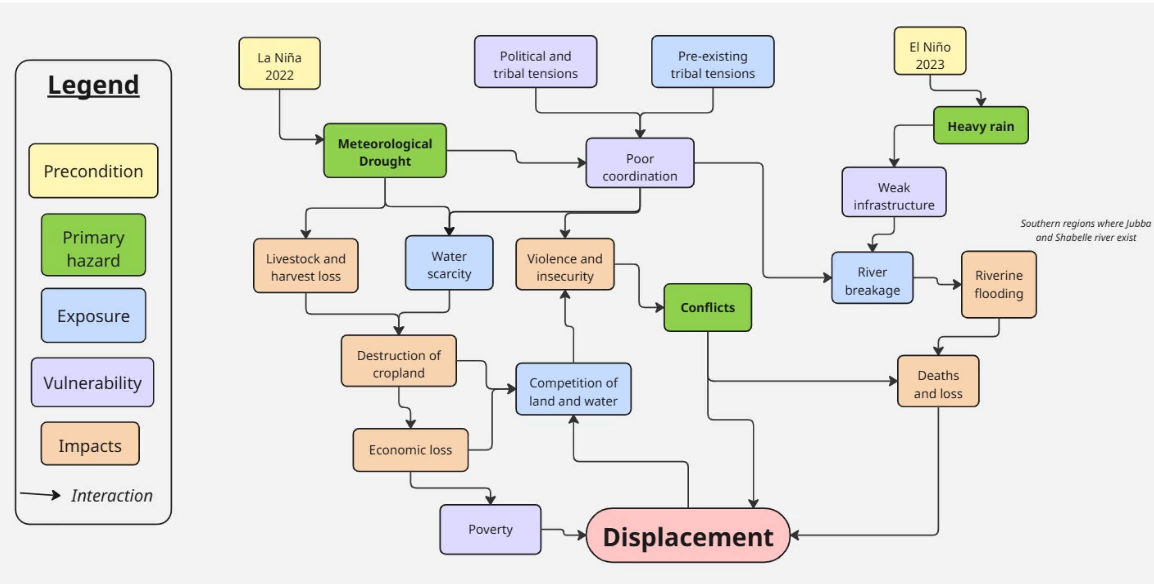


Figure 7: Generic impact chain for Somalia 2022-2023

Between 2022 and 2023, Somalia experienced a combination of climate and socio-political shocks such as continuous drought, widespread riverine and a change in political leadership of the election in May 2022. Building on the preceding discussion of Somalia's exposure to recurrent hazards, Figure 8 presents an event timeline for the research spanning from 2022 to 2023. The visual framework captures the generic interplay between seasonal rainfall patterns, drought persistence, conflict escalations, and major flood occurrences.

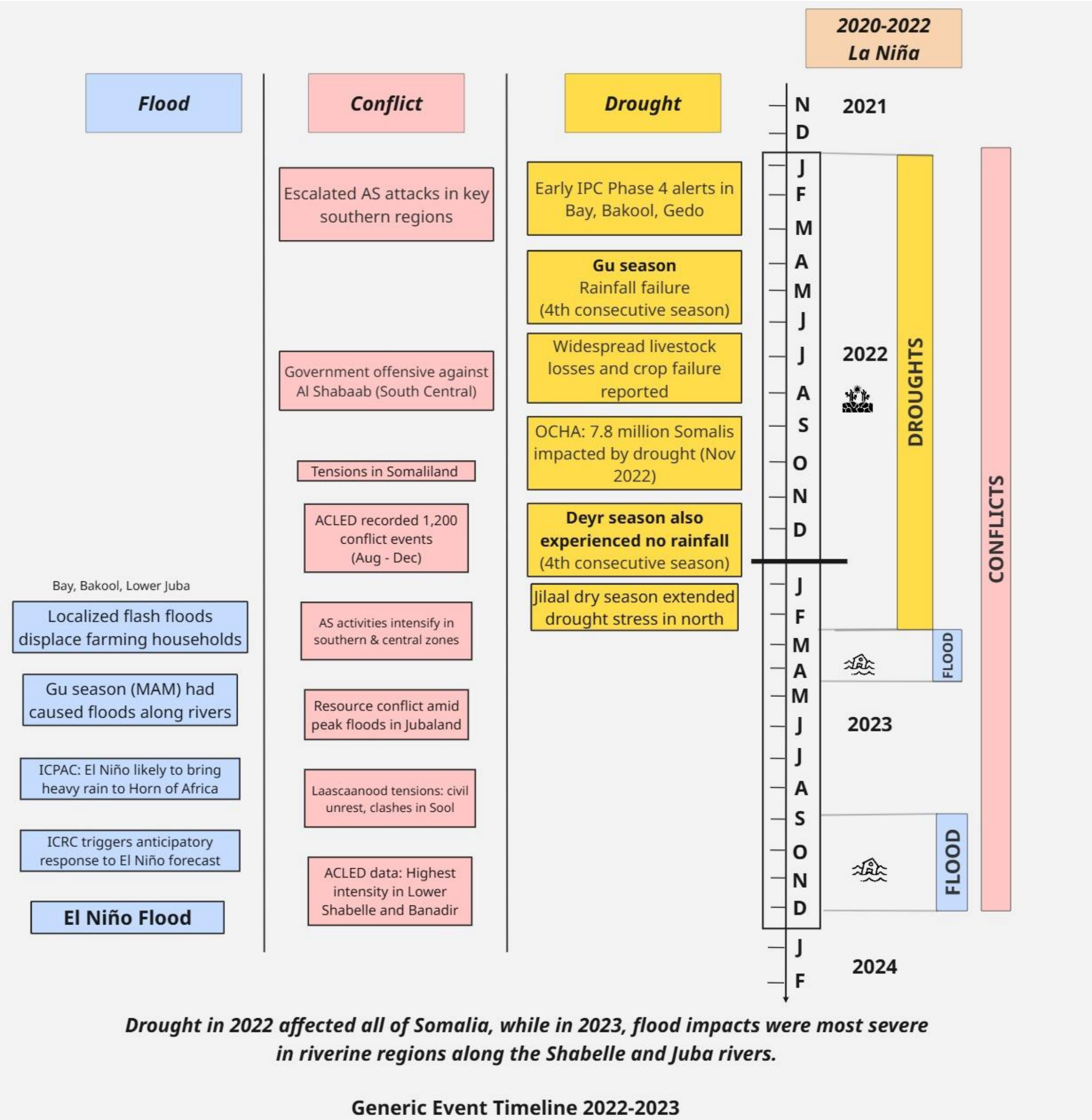



Figure 8: Event Timeline

A representation of major climatic and conflict-related events affecting Somalia between 2022 and 2023, key seasonal patterns, drought conditions, flood, and conflict.

## 4.2 Displacement patterns in 2022

In 2022, internal displacement in Somalia was highly uneven across regions, with variation in both number and distribution. As can be seen in figure 9 left below, the most affected displacement origin regions were concentrated in the southern and central parts of the country, particularly Banadir, Bakool, Hiiraan, and Galgaduud, each with over 200,000 internally displaced individuals. These areas experienced the highest outflows, in contrast, the northern regions such as Awdal, Togdheer, and Sanaag saw relatively low displacement levels, typically below 30,000.

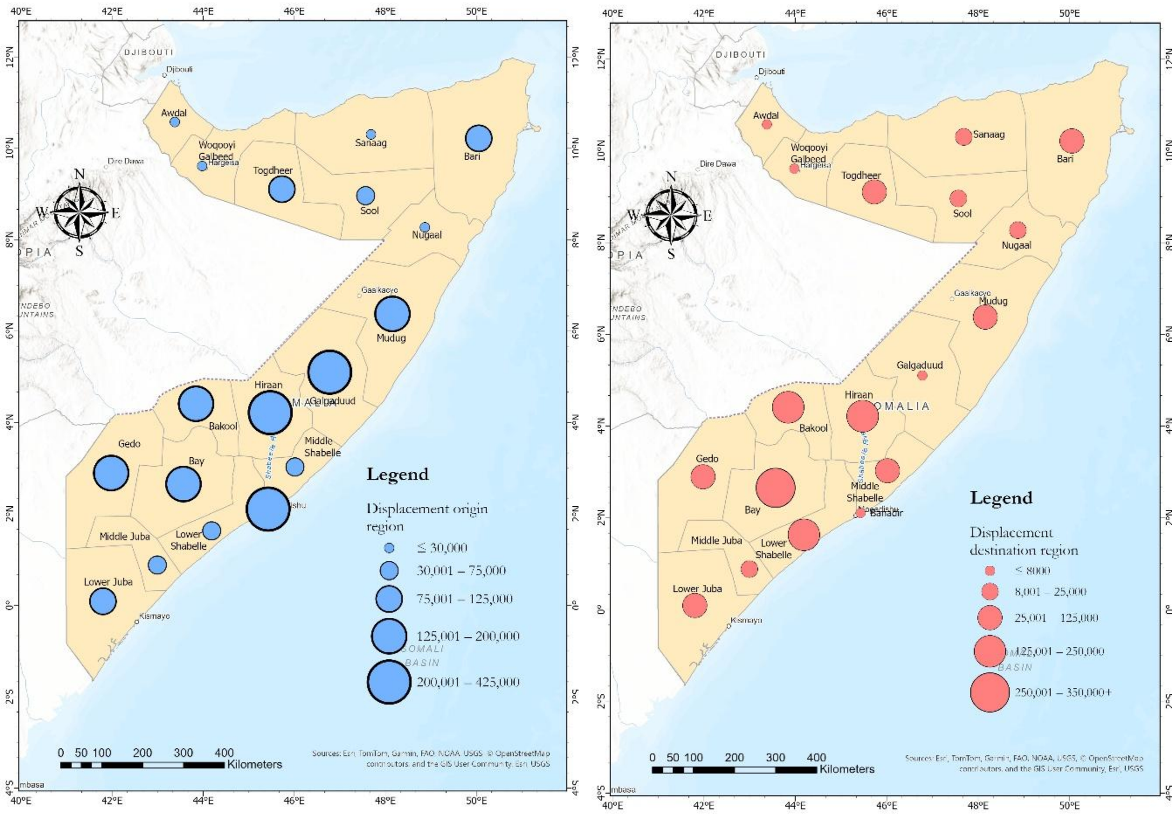



Figure 9: Origin and Destination displacement in 2022

On the other hand, the destination to which IDPs arriving on the right-side map shows that it is concentrated in southern regions, particularly in Bay, Lower Shabelle and Bakool.

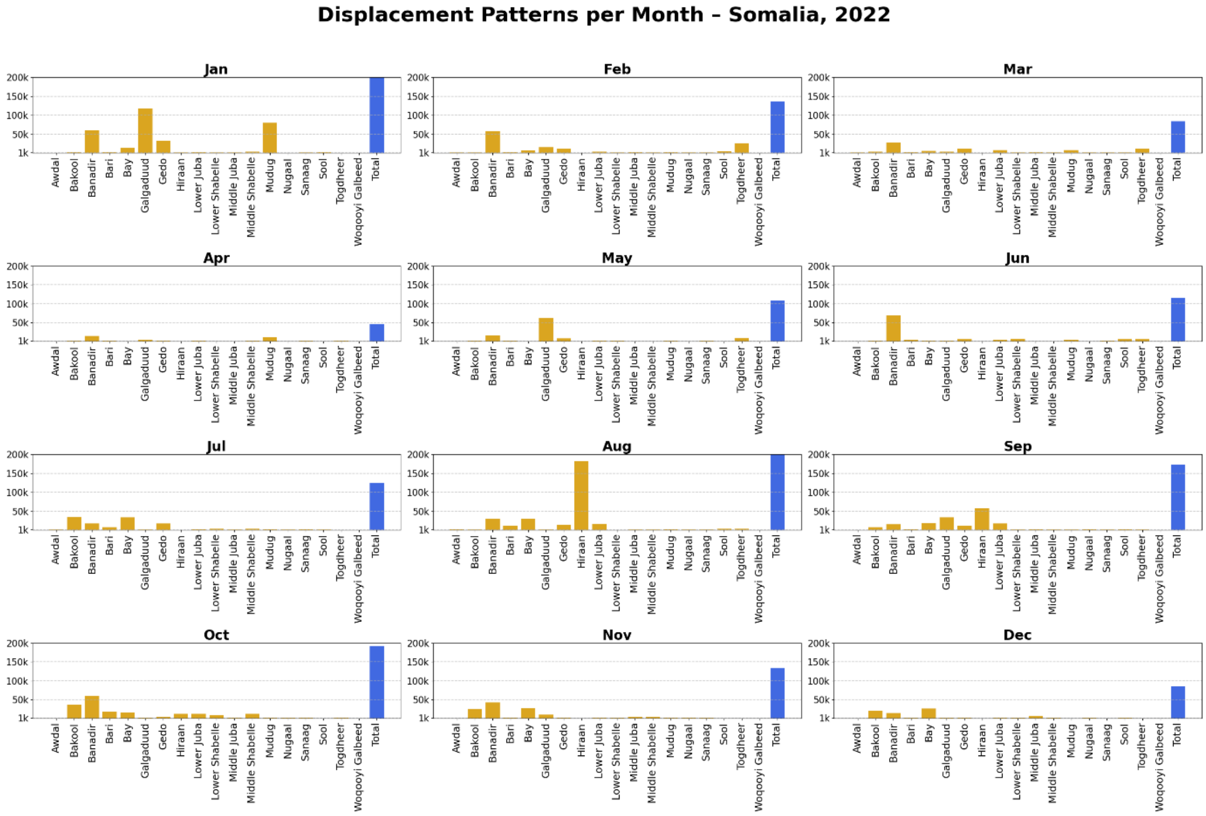



Figure 10: Monthly displacement patterns by region in Somalia, 2022.

Next, the subplot shows the number of displaced persons per region for the given month, illustrating both spatial and temporal variation. The bars represent displacements departing from each region. Total monthly displacement is in orange and blue for the totals. Peaks include August in Bay region and May in Galgaduud.

To address the spatial and temporal patterns of internal displacement in Somalia during 2022, the figure above shows that the highest displacement occurred in January (over 310,000 individuals) and August (approximately 300,000), with additional levels observed during the SON season (September–November). The temporal trends show a strong alignment between displacement surges and seasonal or crisis-specific drivers. Next, the research explores what were the main reasons and attributions behind these fluctuations and movement.

## 4.3 Conflict assessment in 2022

In 2022, the assessment of conflict events and their impact series analysis for individual regions shows various patterns including months with higher events, differences in duration, timing and total amount. Figure 11 shows that Lower Shabelle recorded the highest number of conflict events, with over 1,100 incidents, significantly surpassing other regions for 2022. Additionally, Middle Shabelle, Banadir and Lower Juba also experienced relatively high levels of conflict activity, followed by Hiraan and Galgaduud. In contrast, when examining conflict fatalities, Middle Shabelle stands out as the most lethal region, recording the highest number of deaths, despite ranking slightly lower in event frequency. Other regions with high fatality counts include Galgaduud, Lower Shabelle, and Hiraan, indicating not only a high occurrence of conflict but also a greater intensity or deadliness of those events.

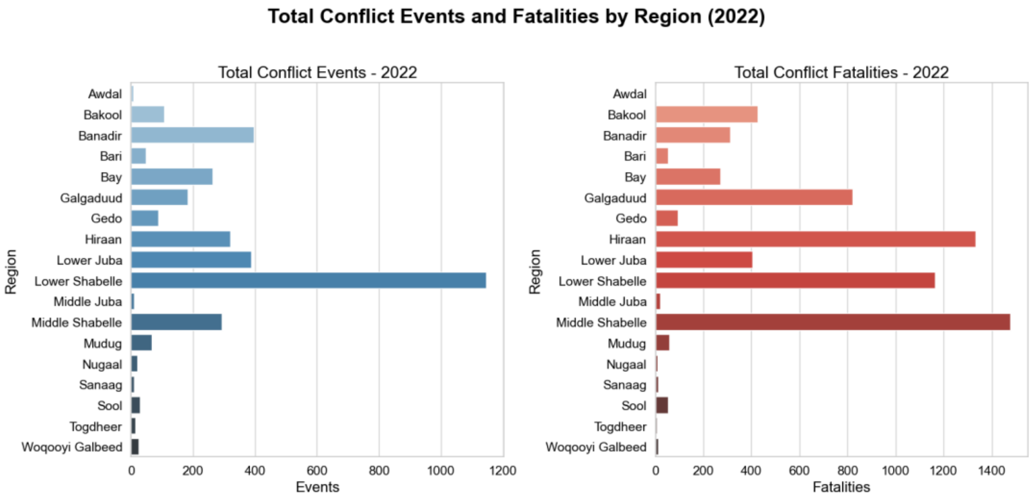



Figure 11: Conflict events and fatalities per region in 2022

Table 4 below summarises the temporal understanding of when the conflict happened, the results show that conflict intensity was consistent throughout the year, specifically in the southern regions. Bolded values indicate the highest monthly count per region. For example, Lower Shabelle, the most conflict-affected region overall, experienced its highest conflict levels in May (127 events), August (104), November (103), and December (113). Similarly, Hiraan also reported elevated conflict activity during September, while Middle Shabelle peaked in October (49 events). These temporal fluctuations are further analyzed in relation to displacement dynamics in the subsequent sections.

**Table 4: Monthly conflict events per region in 2022**

| Region | 01 | 02 | 03 | 04 | 05 | 06 | 07 | 08 | 09 | 10 | 11 | 12 | Total |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| *Awdal* | 2 | 1 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 2 | 1 | 8 |
| *Bakool* | 12 | 6 | 8 | 10 | 4 | 3 | 17 | 11 | 8 | 11 | 10 | 8 | 108 |
| *Banadir* | 32 | 33 | 32 | 36 | 41 | 22 | 25 | 39 | 28 | 46 | 21 | 42 | 397 |
| *Bari* | 4 | 8 | 7 | 1 | 4 | 7 | 4 | 4 | 3 | 2 | 2 | 3 | 49 |
| *Bay* | 17 | 23 | 16 | 23 | 14 | 25 | 13 | 34 | 31 | 18 | 25 | 24 | 263 |
| *Galgaduud* | 23 | 7 | 11 | 9 | 12 | 10 | 12 | 19 | 33 | 12 | 18 | 18 | 184 |
| *Gedo* | 9 | 4 | 6 | 7 | 5 | 15 | 8 | 8 | 9 | 8 | 6 | 4 | 89 |
| *Hiraan* | 21 | 16 | 28 | 18 | 24 | 21 | 18 | 33 | 62 | 26 | 25 | 28 | 320 |
| *Lower Juba* | 26 | 26 | 35 | 37 | 28 | 22 | 26 | 47 | 40 | 35 | 41 | 26 | 389 |
| *Lower Shabelle* | 76 | 82 | 60 | 102 | 127 | 102 | 89 | 104 | 95 | 92 | 103 | 113 | 1145 |
| *Middle Juba* | 1 | 2 | 0 | 1 | 0 | 0 | 1 | 0 | 2 | 1 | 2 | 1 | 11 |
| *Middle Shabelle* | 28 | 16 | 18 | 27 | 20 | 22 | 17 | 14 | 14 | 49 | 36 | 33 | 294 |
| *Mudug* | 5 | 4 | 8 | 7 | 5 | 2 | 6 | 1 | 10 | 8 | 3 | 7 | 66 |
| *Nugaal* | 3 | 1 | 0 | 3 | 0 | 3 | 2 | 1 | 0 | 3 | 2 | 2 | 20 |
| *Sanaag* | 1 | 2 | 1 | 0 | 0 | 1 | 0 | 2 | 0 | 1 | 2 | 0 | 10 |
| *Sool* | 2 | 2 | 1 | 3 | 4 | 2 | 0 | 3 | 0 | 2 | 2 | 9 | 30 |
| *Togdheer* | 2 | 0 | 1 | 1 | 1 | 4 | 1 | 0 | 0 | 2 | 3 | 0 | 15 |
| *Woqooyi Galbeed* | 1 | 3 | 1 | 3 | 4 | 1 | 3 | 0 | 1 | 2 | 4 | 2 | 25 |

For this research, only regions with ≥10 conflict events per month and >100 conflict events annually were included in the analysis to ensure focus on areas experiencing both acute and chronic conflict intensity as shown in the table above. These regions were shown in blue color in the table above and the rest of regions were excluded from the analysis in 2023 to have more clear understanding on the displacement caused by the conflicts and hazards.

## 4.4 Meteorological Drought Assessment (SPI)

In Somalia, the March to May (Gu season) is the main rainy season in Somalia, and secondary rainy season of September to November (Deyr season) (Gure, 2017). Therefore, to understand the spatiotemporal analysis of drought conditions of 2022 using SPI shows that throughout the year, particularly between April and September, extensive regions of south-central Somalia were affected by drought. Regions including Bakool, Hiraan, Bay, Galgaduud, and Mudug consistently recorded extreme to severe drought conditions, as indicated by the persistent red and orange zones in the SPI maps below. For example, in May and June, nearly the entire central belt of the country experienced SPI values below –1.5, indicating acute rainfall deficits during the Gu season, which is normally one of displaced main rainy periods. In contrast to the central and southern regions, the northern regions were relatively less affected during the Gu season as shown in Figure 12 below but showed signs of moderate-to-severe drought again by October and November, coinciding with the Deyr season onset.

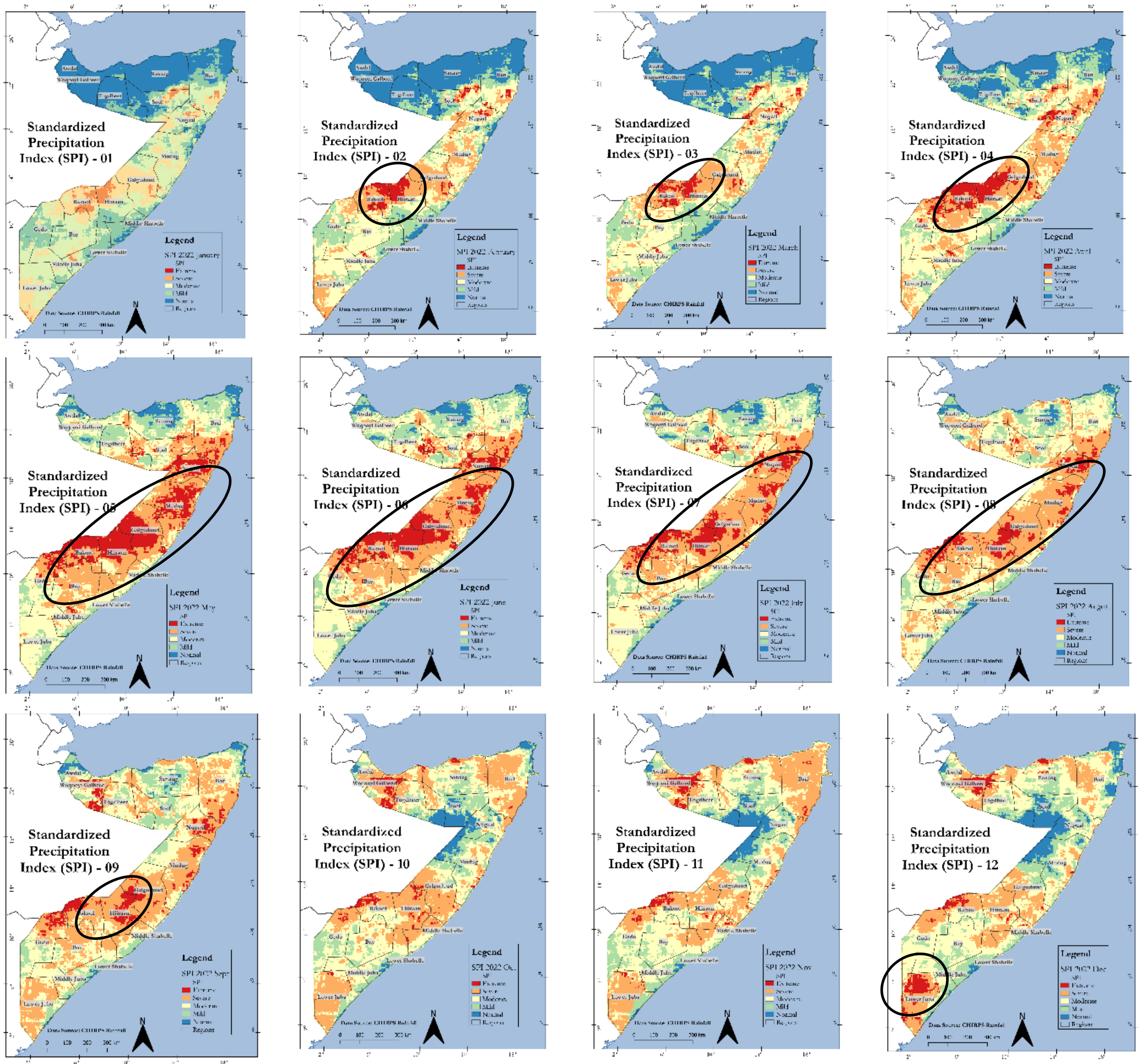



Figure 12: Monthly Standardized Precipitation Index (SPI) Maps.

The series of maps shows the monthly variation in drought severity across Somalia during 2022, based on the SPI. Higher resolution maps have been attached to the appendix E

## 4.5 Displacement Attributed to Conflict and Drought

In this research, the spatial and temporal analysis of monthly internal displacement patterns in Somalia during 2022 shows an overlap with both conflict occurrences and drought-affected regions for RQ1.4. All datasets were harmonized to a monthly temporal and regional spatial resolution (as described in Section 3.7). The analysis was conducted by comparing displacement numbers with regional drought conditions as determined using SPI in section 4.3, and conflict intensity, based on the thresholds in section 4.2.

From the results, three different categories of attributions were observed:

1. Displacement aligned with conflict intensity, where regions surpassed the conflict event thresholds but did not meet drought severity conditions. (Middle Shabelle)
2. Displacement driven by drought conditions, particularly in areas meeting the SPI threshold (SPI ≤ –1.5) without corresponding conflict activity. (Bari faced droughts during this period. Bakool also experienced drought in the rainy seasons months as shown in Figure 12)
3. Compound displacement, where both intersected in the same region and month (Lower Juba and Lower Shabelle)

| Region | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Awdal | 307 | 698 | 477 | 690 | 1128 | 897 | 503 | 2080 | 372 | 660 | 893 | 634 |
| Bakool | **__2077__** | **1191** | **2730** | **__1128__** | **2710** | **1180** | **__34556__** | **__1244__** | **7364** | **__35943__** | **__24718__** | **20432** |
| Banadir | __60141__ | __58016__ | __27993__ | __14744__ | __15387__ | __68300__ | __17033__ | __29148__ | __14928__ | __59277__ | __42763__ | __14730__ |
| Bari | **1522** | **2261** | **2194** | **1898** | **1903** | **3944** | **7804** | **12096** | **2371** | **17275** | **20537** | **20131** |
| Bay | __12989__ | __2890__ | __501__ | __745__ | _6781_ | _2194_ | __33440__ | __20969__ | __2906__ | __12065__ | __27347__ | __26309__ |
| Galgaduud | __117896__ | 15041 | __2682__ | **3078** | **1800** | **__5520__** | **__17200__** | **__13789__** | **__1700__** | **__1728__** | **__9847__** | 1903 |
| Gedo | **32150** | 10976 | 10159 | 5925 | 2989 | 1606 | 18226 | 15794 | 57288 | 11850 | 6000 | 2509 |
| Hiiraan | **_669_** | **_1098_** | **_165_** | **_177_** | **_700_** | **_700_** | **_170_** | **_266_** | **_132_** | **_200_** | **_200_** | **_165_** |
| Lower Juba | **__1965__** | **__3629__** | **__7894__** | **__1799__** | **__2766__** | **__3255__** | **__2324__** | **__15888__** | **__16813__** | **__12199__** | **__2900__** | 2084 |
| Lower Shabelle | **__1303__** | **__1266__** | **__808__** | **__634__** | **__1090__** | **__1194__** | **__800__** | **__1659__** | **__1629__** | **__2388__** | **__1339__** | **__1350__** |
| Middle Juba | 733 | 2200 | 2009 | 1089 | 582 | 1028 | 1072 | 1085 | 2288 | 2285 | 677 | 677 |
| Middle Shabelle | __2853__ | __1394__ | __1414__ | __1161__ | __1104__ | __965__ | __2884__ | __1419__ | __641__ | __1129__ | __3520__ | __1063__ |
| Mudug | 79826 | 2454 | 7400 | **11265** | **10620** | **12250** | **12950** | **15932** | _15290_ | 12059 | 3063 | 673 |
| Nugaal | **1284** | **1222** | **466** | 536 | **446** | 442 | 452 | 452 | 452 | 452 | 452 | 452 |
| Sanaag | 1101 | 902 | 1340 | 1200 | 637 | 1261 | 1644 | 810 | 619 | 1130 | 1139 | 933 |
| Sool | 1919 | 4088 | 5007 | 5124 | 5164 | 3970 | 1991 | 1657 | 1692 | 1629 | 1870 | 1570 |
| Togdheer | 347 | 25515 | 10972 | 2361 | 1983 | 6168 | 198 | 2811 | 1209 | 2382 | 667 | 833 |
| Woqooyi Galbeed | 80 | 111 | 143 | 87 | 77 | 211 | 144 | 178 | 215 | 227 | 233 | 144 |

Figure 13: Displacement patterns attributed hazard type

The figure 12 above shows results these patterns using the abovementioned classification. Regions experiencing severe or extreme drought conditions are highlighted in **bold (orange),** while those surpassing the conflict thresholds are expressed with **underlined text (blue).** Regions and months where both conflict and drought thresholds were met simultaneously are displayed in bold and underlined text **(yellow).**

The key observation from the analysis is that the displacement attributed by the conflict intensity is exemplified by Bay, which recorded 12,989 displaced individuals in January, 20,969 in August, and 27,347 in November, despite not meeting the SPI threshold for severe drought in these months. In contrast, the displacement driven by drought conditions is shown in regions such as Bakool. Bakool recorded 7,364 in September and 24,718 in November as illustrated in figure 12 above. Indeed, the region has most of all months met or exceeded the SPI threshold for severe to extreme drought but did not concurrently surpass the conflict intensity threshold as shown in the conflict analysis.
Additionally, compound displacement, which was influenced by both drought and conflict in 2022, was observed in regions such as Lower Juba and Lower Shabelle. For example, Lower Juba recorded 16,813 displaced persons in September, 15,888 in August, and 12,199 in October, with all three months corresponding to periods of both conflict escalation and extreme drought. Similarly, Lower Shabelle (which was also the highest on conflict event recorded as shown in section 4.2) saw consistent displacement peaks, including 2,388 individuals in October and 1,620 in September, in conjunction with the presence of compound stressors. The key observation from the analysis is that displacement in Somalia during 2022 was not driven only by a single factor, but rather overlapping hazards.

## 4.6 Displacement patterns in 2023

To begin with, in 2023, the spatial distribution of internal displacement in Somalia continued to display regional disparities. As shown in Figure 14 below, the highest levels of displacement were recorded from central and southern regions, with Hiiraan, Bay, Gedo, and Banadir as the most significantly affected areas, each recording totals exceeding 200,000 displaced individuals. In contrast, regions such as Bakool, Middle Shabelle, and Middle Juba showed moderate displacement levels.

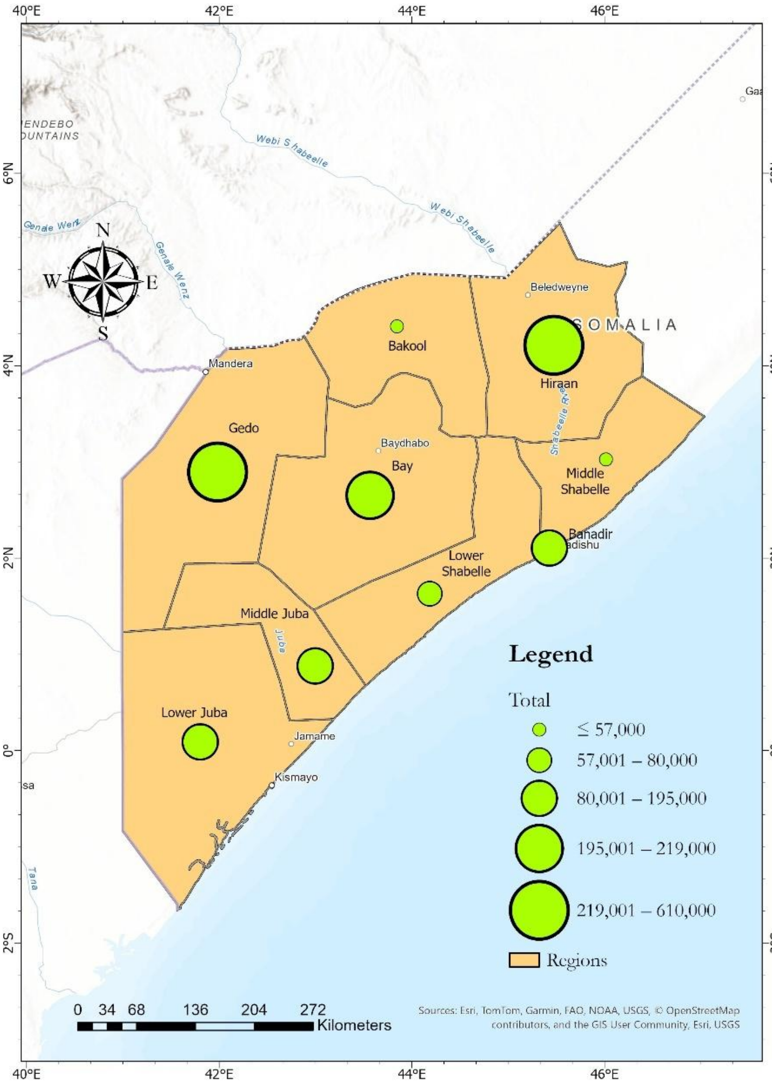



Figure 14: Displacement per Region (2023)

Legend categories use Natural Breaks (Jenks) classification, with manually rounded values for interpretability. The next section will outline these displacement patterns in time and space.

Moreover, the temporal patterns of internal displacement during 2023 showed a monthly variation, the highest observed in November, during which displacement was more than 200,000 individuals as shown figure 15 below. It also represents the highest monthly displacement recorded across the year, corresponding to the El Niño-driven floods that affected much of southern and central Somalia. Moderate displacement levels were recorded in March and May of the year, except in the Hiiraan region, while the remaining months, specifically from June to September, experienced a relatively lower number of displacements.

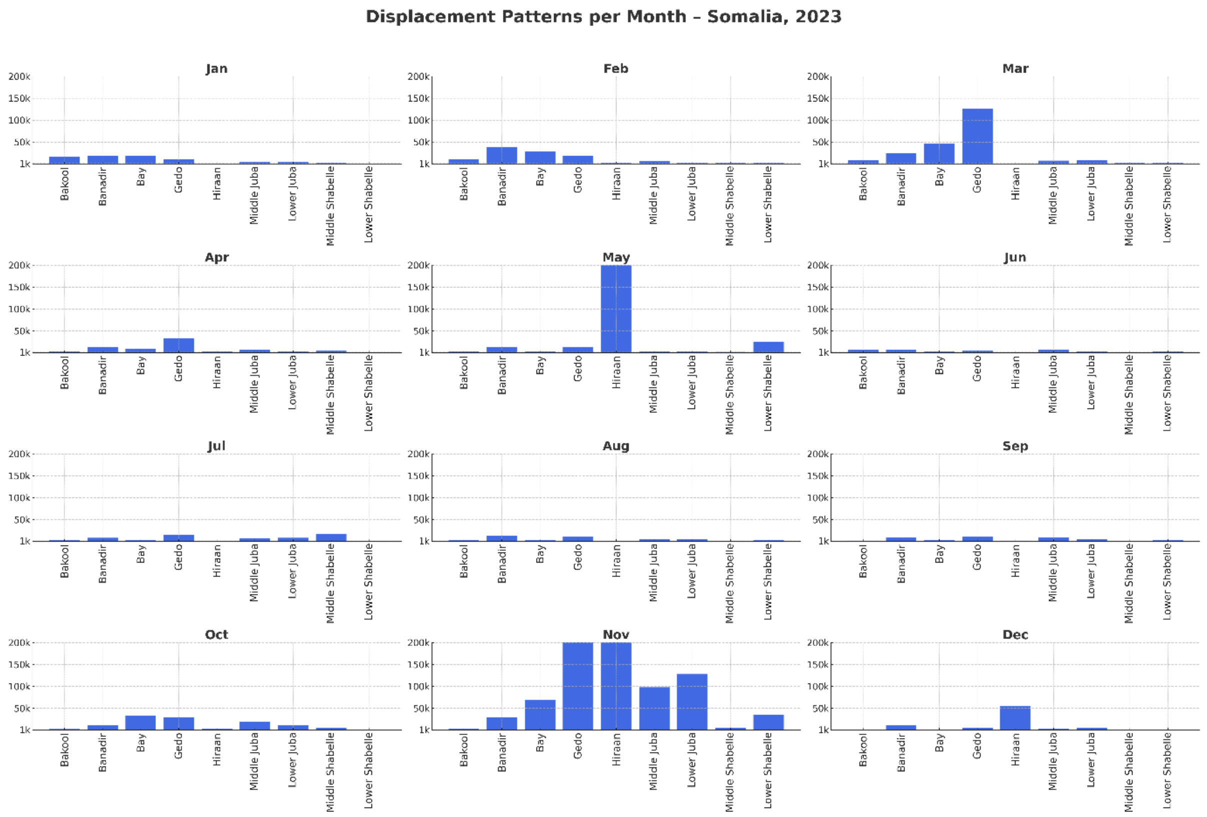



Figure 15: Monthly displacement patterns by region in Somalia, 2023

The subplots for Figure 15 show the number of displaced persons per month, showing spatial and temporal variations.

## 4.7 Conflict assessment in 2023

The analysis of conflict dynamics for the year 2023 shows regional variations in both the number and intensity of violence. As shown in Figure 16 below, Lower Shabelle experienced the highest concentration of conflict events, with over 900 recorded incidents, above the other regions same as the previous year in 2022. Other regions such as the Bay, Hiiraan and Banadir were also observed higher and persistent. On the other hand, Lower Shabelle again recorded the most severe fatalities compared to the rest of regions. Middle Shabelle, Lower Juba and Hiraan were recorded lower conflict fatalities compared to the previous year 2022. Furthermore, the heatmap shows the temporal variation in conflict events, illustrating that not only do regions differ in total conflict levels, but also in the timing of their peak conflict periods between 2022 and 2023.

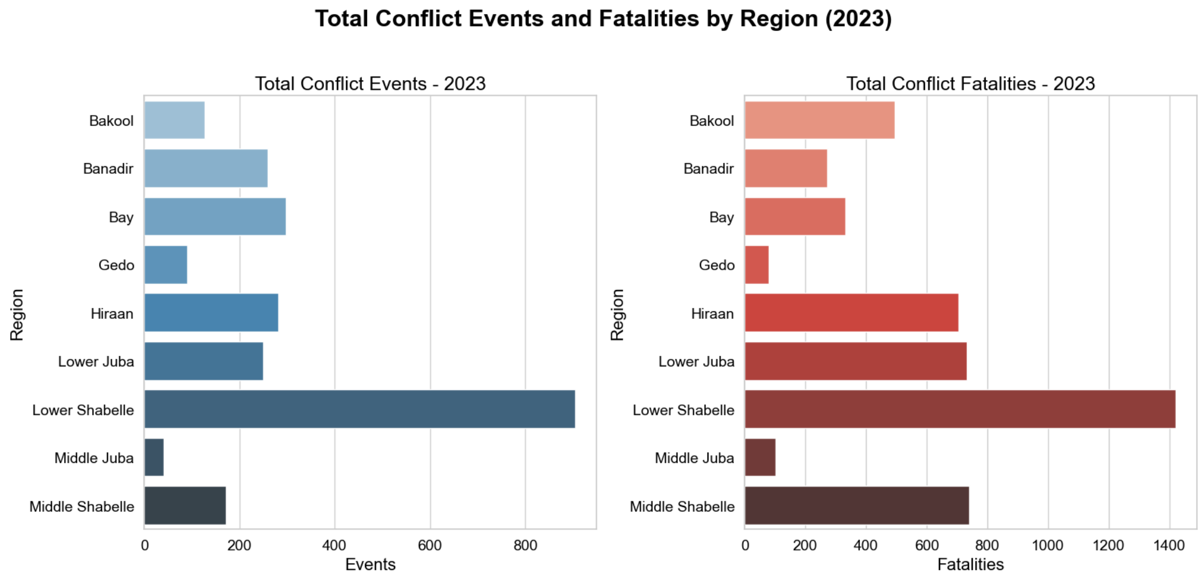



Figure 16: Conflict events and fatalities per region in 2023

The heatmap below in Figure 17 summarises to address the temporal understanding of when the conflict happened. The key observation is that Lower Shabelle records out as the most consistently and severely affected region, registering high conflict intensity throughout the year. For example, conflict incidents were the highest in December (100 events) and remained elevated across multiple months, including June (99 events), October (92), and November (92). Despite this, other regions such as Bay, Banadir, and Hiiraan also show higher levels of conflict but with more moderate fluctuations across this year. For example, Bay recorded sustained incidents between January and August, while Hiiraan experienced a decline in conflict activity from March onward, suggesting potential seasonal or situational influences. In contrast, there are regions like Gedo, Middle Juba, and Bakool witnessed relatively lower levels of conflict, with monthly totals rarely surpassing 15 events. These temporal fluctuations are further analyzed in relation to displacement dynamics of 2023 in the subsequent sections.

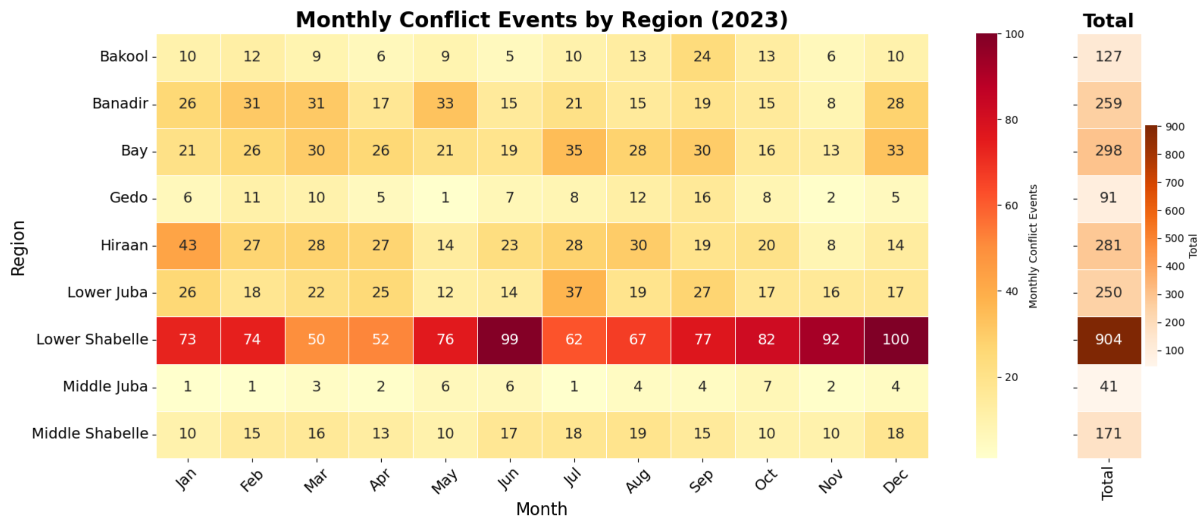



Figure 17: Monthly Distribution of Conflict Events with totals by region (2023)

## 4.8 Displacement Attributed to Conflict and Flooding

The flood exposure during 2023, as shown in Figure 18 (El Niño Flood Extent 2023), shows that the regions most affected by riverine flooding were predominantly those along the Juba and Shabelle River basins. These include Hiraan, Middle Shabelle, Lower Shabelle, Gedo, Middle Juba, and Lower Juba, all of which intersect with major flood-affected zones delineated by satellite-derived flood extents from SWALIM. The inundation observed in these regions corresponds with areas identified as historically flood-prone due to proximity to river catchments and low-lying floodplains (Ibrahim et al., 2024). Notably, the El Niño-induced floods in 2023 were extensive, affecting multiple months and resulting in significant disruption to local livelihoods and internal displacement patterns for example the case in Beledweyne (IDMC, 2021).

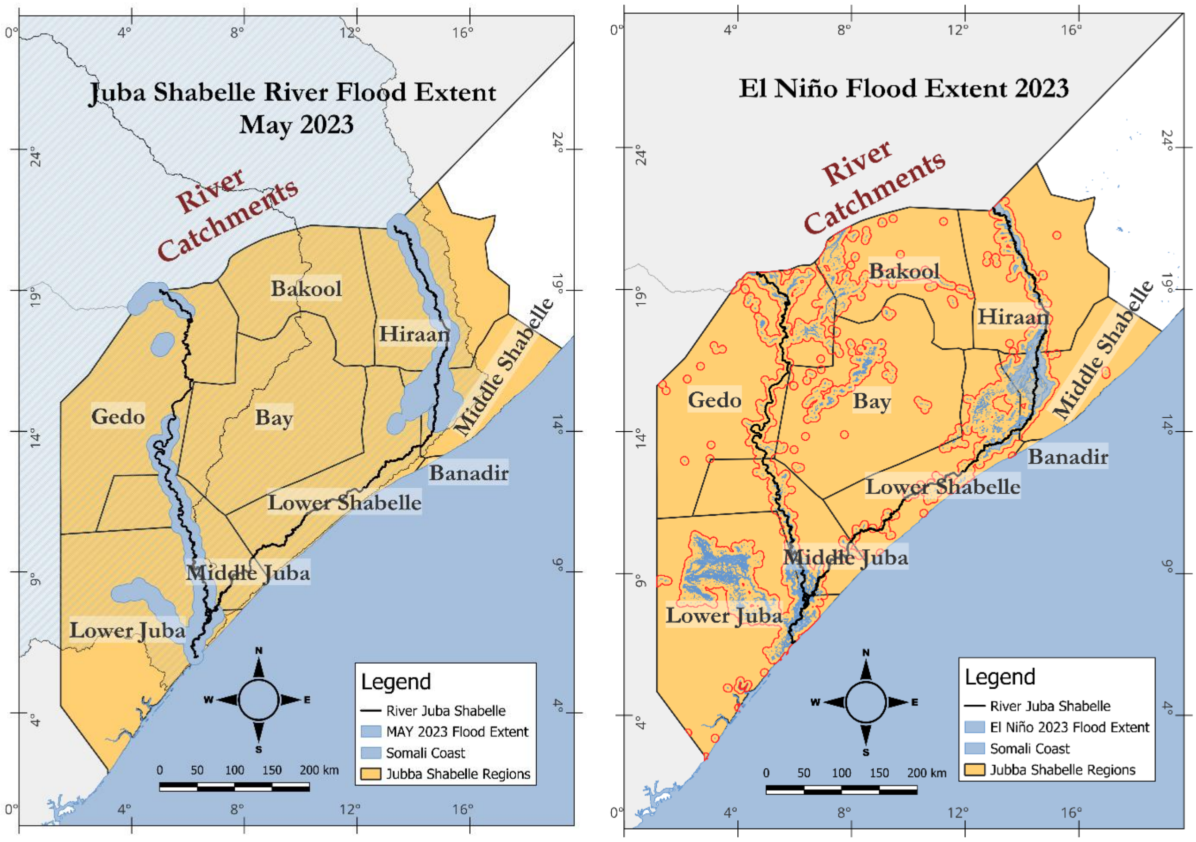



Figure 18: Spatial Extent of Gu season and El Niño Floods in Somalia (2023).

The map shows flood-affected areas in May and November 2023, with a 5 km buffer to capture indirect impacts of the floods (red lines in the 17b are the buffer). These were the two most significant flooding episodes in Somalia during 2023, both concentrated along the Shabelle and Juba river basins. See event timeline in Figure 8 for flood period distribution.

Another important aspect is that the study identifies three categories of displacement attribution in 2023: (i) displacement driven by flooding alone, (ii) displacement triggered only by conflict, and (iii) compound displacement resulting from the overlap of both flood and conflict events.

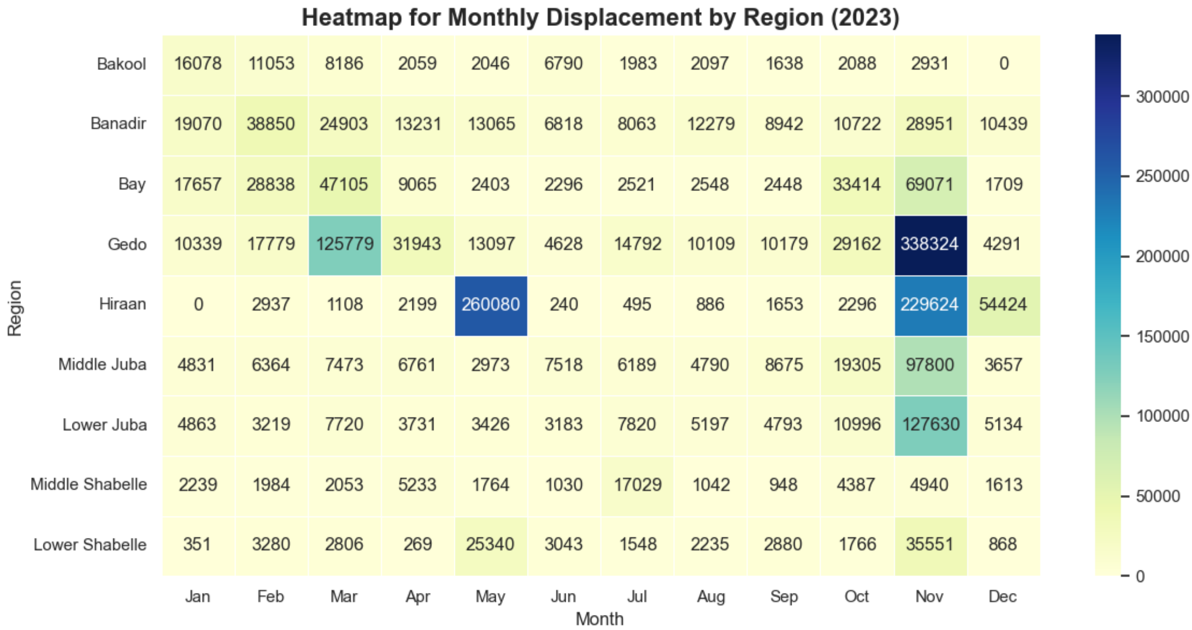



Figure 19: Monthly internal displacement by region in Somalia (2023)

**Displacement with floods**

The El Niño flood event in Somalia spanned from early November to mid-December 2023, led to significant displacement in riverine regions, particularly those along the Juba and Shabelle rivers. During this period, Gedo emerged as the most severely affected region in terms of flood-induced displacement. As shown in Figure 19 above, the regions were recorded with the highest flood extent and higher displacement number. For example, in November alone, Gedo recorded 338,324 displaced individuals, while Lower Juba reported 127,630.

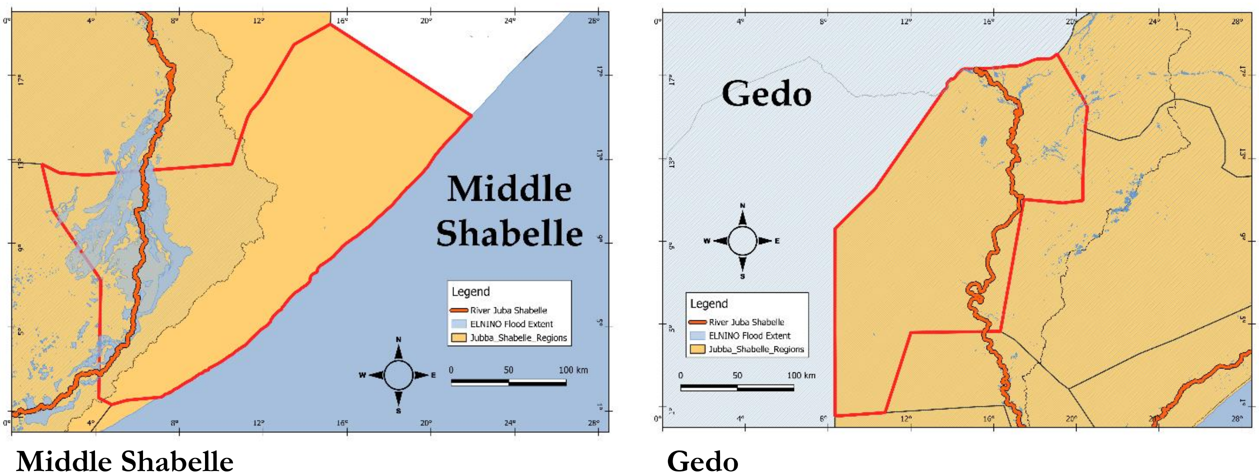



Figure 20: Flooded areas in Middle Shabelle and Gedo regions.

**Displacement with conflicts**

As shown in figure 19 above, in 2023, the Bay region experienced continuous conflict-related displacement, particularly concentrated in the first quarter of the year. Notably, March recorded a peak of 47,105 displaced individuals, coinciding with elevated conflict activity as illustrated in figure 18 above. These numbers show that insecurity was the primary driver of movement in the absence of significant flooding during that period of dry seasons.

**Compound displacement attributed by conflicts and floods**

In 2023, regions such as Lower Shabelle and Hiiraan experienced compound displacement driven by both flooding and conflict. In November, a period marked by widespread riverine flooding, Hiiraan recorded over 229,000 displaced individuals, while Lower Shabelle reported 92,312 as shown in figure 19, with both regions simultaneously experiencing high conflict activity as shown in section 4.6. Hiiraan also experienced flooding during the earlier rainy season in May, which coincided with the highest displacement levels recorded that month, as shown in Figure 18 and 19 above.

**Flood Affected** **Conflict Affected**

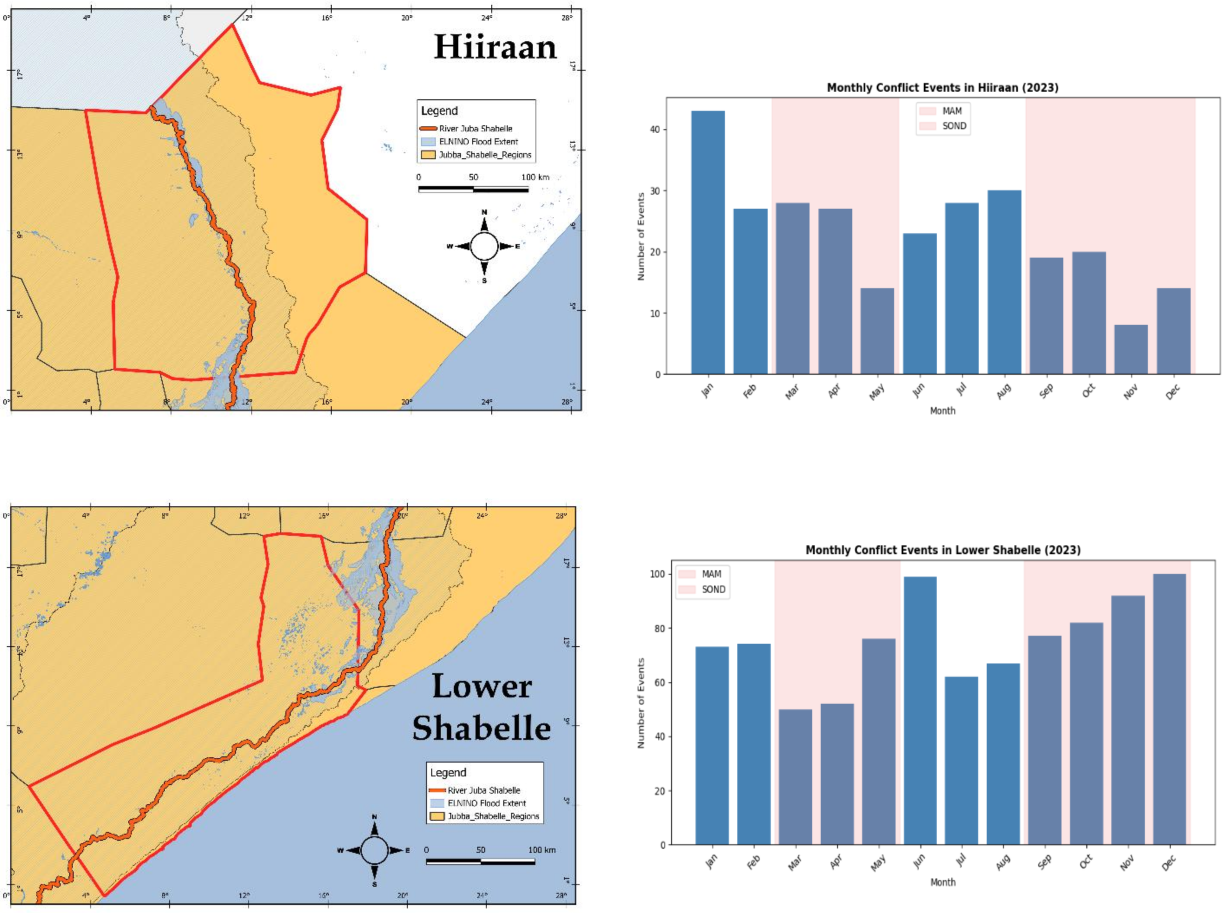



Figure 21: Spatial and temporal patterns of compound displacement in Hiiraan and Lower Shabelle, Somalia, during 2023.

The left maps are the flood extent maps show areas impacted by the El Niño-induced floods in November 2023, along the Jubba and Shabelle rivers. Right panels also show the monthly conflict events in each region, with shaded areas reflect the Gu rainy season (MAM) and the Deyr/El Niño period (SOND). These patterns reflect the compounding effect of floods and conflict events in the same region and temporal overlap of shocks escalates displacement risk.

## 4.9 Resolution and data granularity impacts

Next, this section addresses RQ3, which examines the influence of spatial and temporal resolution on analyzing displacement dynamics in relation to cascading conflict and weather events.

As shown in Table 5 below, the original datasets varied widely in resolution. The conflict and rainfall data were available at high temporal (daily) and fine spatial scales (point-based and ~5 km raster, respectively), displacement data from PRMN was only accessible at the regional (Admin 2) level and on a monthly. Therefore, to ensure comparability, all datasets were harmonized to a monthly temporal resolution and regional spatial scale (Admin 2) as explained in section 3.7. The harmonization supported for consistent cross-dataset analysis of the classification and attribution of displacement events by hazard type. However, it also introduced limitations. For instance, the monthly scale likely smoothed short-term fluctuations, making it difficult to capture rapid-onset events such as sudden flash floods or short-term conflict escalation.

Despite these constraints, the selected resolution was sufficient to identify seasonal trends, compound hazard overlaps, and regional differences in displacement drivers. In the absence of reliable displacement data and higher-frequency reporting, the monthly scale gave enough balance between data completeness and its limitations.

**Table 5: Spatial and temporal harmonization of datasets**

| Dataset | Original Spatial Resolution | Original Temporal Resolution | Processed Spatial Resolution | Processed Temporal Resolution |
|---|---|---|---|---|
| UNHCR PRMN (Displacement) | Region (Admin 2) | Monthly | Admin 2 | Monthly |
| ACLED (Conflict) | Point-based | Daily | Admin 2 | Monthly |
| CHIRPS (Rainfall) | ~5 km raster (pixel level) | Daily | Admin 2-level drought classification | Monthly (SPI-1) |
| Flood Extent | Event-based shapefiles | Event-specific | Admin 2 (via spatial overlap) | Months of the event |

# 5. DISCUSSION AND RECOMMENDATIONS

In this chapter, the results for each identified research objective and question will be critically reflected upon. This study presents one of the first studies on displacement attribution across Somalia. Not only does this study examine this at a country level but also at a more regional level. First, findings for each research question are briefly summarized, followed by a discussion of the results and limitations per research objective. Next, recommendations for future areas of research are presented. In the end, the main limitations of this research are discussed.

## 5.1 Research Objective 1

The analysis of displacement patterns in 2022 suggests that regional disparities in internal displacement across Somalia. The results confirm that displacement was concentrated in the southern and central regions, specifically Bay, Bakool, Lower Shabelle, Hiiraan, and Galgaduud, each of which recorded over 200,000 displaced individuals. These regions emerged as major displacement origins, primarily due to the severity of drought conditions and local vulnerabilities. In contrast, northern regions such as Awdal, Togdheer, and Sanaag exhibited significantly lower displacement figures, often below 30,000, indicating relatively fewer environmental stressors during this period. The analysis identified a concentration of displacement into urban hubs such as Banadir, indicating a growing trend toward crisis-driven urbanization. The shift is exacerbating urban sprawl and placing additional strain on already limited infrastructure and public services (Hassan et al., 2023). The results also identified that temporally, displacement peaked in January and August, with additional surges during the SON (September–November) season which is rainy season in Somalia. These peaks suggest that displacement was closely linked to seasonal stressors and water scarcity at the height of the drought.

After having displacement patterns, the research demonstrated that the conflict events in Somalia during 2022 was shown by both high spatial and temporal variations. The analysis identified that Lower Shabelle recorded the highest number of conflict events, outpacing other regions with over 1,100 incidents. However, conflict intensity was not only determined by frequency; regions such as Middle Shabelle and Galgaduud, though facing fewer events, recorded disproportionately high fatality rates, revealing the severity of violence in those areas. The analysis provided insight into how different regions experience conflict in different ways. In some areas, frequent but less deadly conflicts were common, while in others, fewer incidents led to higher casualties, suggesting that the nature and intensity of violence vary significantly across the country. Additionally, the findings point out that temporally, conflict activity spiked during the months of June, August, October, and December, with key regions like Lower Shabelle, Hiraan, and Lower Juba exhibiting heightened volatility during these periods. Many studies have examined conflict dynamics in Somalia, pointing to its complex and evolving nature (Kinyoki et al., 2017; Linke & Raleigh, 2011). These findings emphasize that both the timing of conflict such as the drought periods and the specific regional context specifically the more volatile southern regions.

Next, the analysis also revealed that drought conditions in Somalia during 2022 were both widespread and persistent, particularly across the south-central regions during the critical *Gu rainy season*. The SPI indicated that regions such as Bakool, Hiraan, Bay, Galgaduud, and Mudug experienced sustained extreme to severe drought from April through September. These prolonged rainfall deficits, especially during the *Gu rainy season* (as shown in Figure 5 seasonal calendar) which is a period typically important for agricultural productivity and water availability had implications for food security and displaced populations (Warsame et al., 2023). In contrast, northern regions were less affected during the *Gu rainy season* but began to exhibit drought stress by October and November, on top with the *Deyr rainy season*. The attribution was applied consistently, but the research reflects that in very dry regions, the SPI may not fully capture ground realities. It is an area for future refinement and validation is recommended.

Although drought is a complex slow onset hazard that can be measured in different ways. Moreover, drought is a multidimensional phenomenon, and no single index fully captures its hydrological, agricultural, and socio-economic aspects. It is also important to critically reflect on the limitations of using SPI, as SPI is normalized index, SPI can underrepresent drought severity in extremely arid areas where low rainfall is already the baseline. There are many indices that have been developed to measure different drought types. Other studies in Somalia, such as (Muse et al., 2023) have explored additional indices including the Percent of Normal Index (PNI), Discrepancy Precipitation Index (DPI), and Deciles Index (DI), which may offer complementary insights. In terms of hydrological drought, the Standardized Precipitation Evapotranspiration Index (SPEI) that considers evaporation temperatures. SPEI has been shown to reflect prolonged drought periods in Somalia by capturing both precipitation deficit and evaporative demand (Alasow et al., 2024; Musei et al., 2021). Recent studies also demonstrated that combining SPEI with vegetation indices like NDVI at district scales can effectively illustrate how both rapid and slow-onset droughts triggered displacement in Somalia between 2016 and 2019 (Momeni et al., 2024). An alternative approach is combination of SPEI and Multi-Source Weighted-Ensemble Precipitation (MSWEP)[3] dataset to capture both precipitation deficits and evaporative demand, offering a more comprehensive view of drought impacts linked to displacement (Odongo et al., 2025)

In addition, the research investigated the intersection of conflict intensity and drought severity into their attribution of internal displacement in 2022. In this study, the analysis identified three distinct attributions: conflict-driven displacement, drought-driven displacement, and compound displacement where both hazards co-occurred and attributed to the displacement. The research findings are consistent with recent research by Thalheimer et al., (2023)*,* who demonstrated that during the 2016–2018 drought period in Somalia, both reduced rainfall and increased conflict significantly contributed to internal displacement. It is further supported by Momeni et al. (2024)*,* who used remote sensing to empirically establish the link between climate variables and displacement patterns in Somalia. Unlike *Oh et al. (2024)* who excluded aggregated "drought-related" and "flood" reasons into a single disaster-induced displacement category, our analysis differentiates and examines each driver distinctly as well as collectively. Specifically, the research disaggregated displacement attributed to drought, conflict, and compound causes, showing a more refined understanding of the heterogeneous impacts and interactions underlying Somalia's displacement dynamics.

[3] Multi-Source Weighted-Ensemble Precipitation https://www.gloh2o.org/mswep/

## 5.2 Research Objective 2

According to the results in section 4.5, the analysis of this study showed that the displacement patterns recorded in 2023 reflect the influence of seasonal flooding, particularly during El Niño-driven events, on internal mobility across Somalia. The analysis identified a highest in displacement in November, when nearly one million individuals were uprooted (the highest monthly figure recorded throughout the year). The dramatic surge is attributable to widespread riverine flooding across the Shabelle and Juba River basins, exacerbating existing vulnerabilities in already fragile areas. Next, the temporal concentration of displacement in a single month contrast with more distributed displacement patterns observed during drought periods in 2022. It means that flood events triggered shorter, more intense displacement shocks, unlike the slower-onset migration driven by drought. Therefore, these findings reflect the importance of anticipatory action frameworks, such as Forecast-Based Financing and IFRC's Early Action Protocols, in enabling time-sensitive and geographically targeted flood responses to anticipate and reduce displacement.

Next, the results in section 4.6 show that the 2023 conflict analysis points out that both continuity and change in regional violence patterns. As in 2022, Lower Shabelle remained the epicenter of conflict, registering the highest number of events (over 900) and the most severe fatality counts, showing a persistently volatile security environment. For this reason, the consistency over two consecutive years reinforces the region's status as a conflict hotspot with the presence of fighting between the government and Al Shabaab (Tar & Mustapha, 2017). Similarly, regions such as Bay, Banadir, and Hiiraan experienced continuous conflict levels, while Hiiraan's activity notably declined after March potentially reflecting shifting political and seasonal dynamics. For example, in the period from 1 January 2023 to 1 April 2023, 98 security incidents were recorded in Hiraan representing an average of 10 security incidents per week. Meanwhile, conflict remained comparatively low in regions such as Gedo, Middle Juba, and Bakool, where monthly totals rarely exceeded 15 events. Therefore, these findings support the need for region-specific conflict analysis, as the timing and impact of violence vary widely, influencing how displacement triggered across the southern regions in the country.

Afterwards, the 2023 analysis showed that displacement in Somalia was not only driven by isolated events of conflict or flooding but also by their convergence in several high-risk regions. The analysis identified three distinct displacement patterns: those attributed only to flooding, those attributed to conflict alone, and compound displacement resulting from the interaction of both. The most striking cases of flood-induced displacement were observed in Gedo and Middle Shabelle during November, where extreme El Niño-driven riverine flooding led to the displacement of over 338,000 and 127,000 individuals respectively. These movements occurred in the absence of significant conflict activity, confirming that climatic shocks alone can serve as dominant triggers of internal migration.

In contrast, the Bay region exhibited a clear example of conflict-induced displacement, particularly in the first quarter of the year. In March, the region recorded over 47,000 displacements despite no flooding, emphasizing the persistent role of insecurity in shaping mobility patterns. Most critically, compound displacement was observed in Hiiraan and Lower Shabelle, where both flooding and heightened conflict activity coincided in November. These regions experienced substantial population movements over 229,000 and 92,000 displaced individuals respectively pointing out how overlapping hazards amplify displacement pressures. It is important to notice that general living conditions influence the individual decision to feel. In Somalia, where living standards are typically low, people may feel less rooted in their communities, making displacement more likely and numbers recorded higher (Osman & Abebe, 2023).

In terms of displacement attribution, it is checked with the displacement reason metadata from the PRMN dataset which includes interview-based reporting on the primary reasons of displacement, such as drought, flood, conflict/insecurity, or other causes as described in the data section in section 3.1. Next, regional monthly proportions of these self-reported reasons were examined alongside the hazard-attribution timeline developed in this study. Moreover, there is strong alignment between the derived attribution and reported reasons. For example, in Gedo, displacement during November 2023 classified as flood-induced was substantiated by a marked increase in flood-related displacement reports. Although the research did not explore full validation of the whole regions and all attribution categories, it is a must to acknowledge the limitations remain (Supporting visualizations are provided in the appendix D). The reasons for displacement are self-reported and may involve multiple overlapping drivers and the data is only available at the region-month scale.

These findings affirm with broader research on drought-to-flood transitions, where socio-hydrological feedbacks and human-water interactions intensify vulnerability, especially in fragile settings (Matanó et al., 2022). It also reinforces the need to move beyond single-hazard analyses in both academic and humanitarian contexts. The simultaneous presence of hydrometeorological and conflict-related stressors creates a compounded crisis environment that challenges both response planning and resource allocation affectively (ICRC, 2024). In Somalia, anticipatory action strategies and early warning systems must be tailored to recognize such multi-hazard scenarios, particularly in flood-prone and conflict-affected regions, where vulnerabilities are deeply intertwined. They found that a violent event in an area prone to recent violence caused more displacement effects than violent events in relatively peaceful areas (Tai et al., 2022).

## 5.3 Research Objective 3

This section reflects on RO 3, which aimed to evaluate how the spatial and temporal resolution of the data influenced the ability to attribute displacement dynamics. According to the results in section 4.8, the monthly temporal resolution was appropriate for capturing the displacement patterns, it likely obscured the timing of short-term or rapidly evolving events. However, displacement events tied to sudden conflict outbreaks may transpire and reverse within a month, making it difficult to pinpoint precise causal timing (Zens & Thalheimer, 2025). For example, displacement linked to sudden conflict may not align precisely within a single reporting month, introducing temporal ambiguity in attributing cause as shown results in figures 19 and 20. Next, spatial aggregation to the regional level ensured data comparability, but at the cost of granularity. In regions such as Bay and Lower Shabelle, which contain multiple high-risk zones, the regional scale may have diluted localized hazard-displacement relationships. Otherwise, the lack of reliable displacement camp data limited the potential for higher spatial attribution. Thus, their interpretation of the conflict events might be blurry and subjective. Nonetheless, the harmonization process supported a coherent analysis of displacement attribution across hazards for both years. The use of thresholds supported systematic classification of compound events, achieving the objectives of the research.

## 5.4 Common discussion points

### 5.4.1 Alignment with existing research

The findings of this research broadly align with and expand upon existing research on the triggers of internal displacement in conflict-affected and climate-vulnerable settings. Prior studies have consistently emphasized the role of natural hazards particularly drought and flooding as key displacement triggers in the Horn of Africa (Ali et al., 2023; Etzold & Müller-Koné, 2023; Wens et al., 2025). The research also affirms those insights through spatial and temporal attribution: in 2022, drought was the primary driver of displacement, particularly during the rainy seasons; in 2023, El Niño-induced floods triggered the most significant displacement spikes, particularly in riverine regions of Somalia.

The results also support earlier observations that conflict acts as both a standalone driver and a compounding factor in displacement (Kinyoki et al., 2017). However, this study contributes a new layer by spatially identifying compound displacement zones areas where conflict and climate hazards intersect such as Hiiraan and Lower Shabelle. While prior literature has discussed the overlap between climate stress and insecurity qualitatively (Buhaug, 2015; Maystadt & Ecker, 2014), few empirical studies in the Somali context have visualized and measured this interaction as directly as the present research (Kelly-Hope et al., 2023; Thalheimer et al., 2023).

Furthermore, the absence of a strong link between the arrival of IDPs and subsequent increases in local conflict contradicts some existing assumptions in displacement literature, particularly those based on the regional conflict spillover theories (Döring & Mustasilta, 2024; George & Adelaja, 2022). Our findings suggest that while displacement may change social and economic dynamics at the destination, it does not necessarily lead to heightened insecurity at least in the short term for Somalia.

### 5.4.2 Novel Contributions

To date, few studies have applied such a comprehensive, empirical approach to internal displacement attribution in Somalia, across both drought and flood seasons together with conflicts (Oh et al., 2024; Thalheimer et al., 2023). The conclusions of these studies align with our findings on the role of weather and conflict as primary triggers of displacement; this research extends the literature in several keyways. First, it incorporated flooding alongside drought, using monthly and regional data, and identifying compound displacement zones, our study provided more granular relevant results. Unlike earlier research that focused on average climate shifts, this study is event-based, mapping actual displacement dynamics tied to specific drought and flood events which is the case for Somalia.

Furthermore, this research fills a gap in the literature on multi-hazard displacement in conflict-affected settings. A key innovation of this research is the disaggregation of displacement triggers into categories: conflict-induced, climate-induced (drought and flood), and compound displacement. Most existing literature addresses displacement in aggregate terms, without distinguishing between these factors. While applying this attribution method, the study shows a clearer understanding of how different hazards trigger displacement at specific times and locations. One of the most novel contributions of the study is to our knowledge, this is the first study to systematically track both the 2022 drought and the 2023 El Niño flood impacts across Somalia, using disaggregated displacement, conflict, and extreme weather data.

## 5.5 Limitations

While this study provided valuable results and discussion into the triggers of internal displacement in Somalia, several limitations must be acknowledged regarding both data and methodology. As already critically reflected in previous chapters, several assumptions were made during this research, all of which were supported by reasonable arguments. The section below lists some key limitations along with recommendations to improve it in the future where and when possible.

a. **Displacement cause attribution**

The UNHCR data is disaggregated by displacement reason, providing different spatial coverage and time scales of internal displacement since 2016. However, displacement data report only a single primary cause, without capturing the complex, multi-causal nature of many displacement decisions. As a result, the data is final product of the displacement drivers, and this classification may miss underlying factors such as climate change as driver, political fragility and previous events of disasters and conflicts especially in regions where all of these interact simultaneously across space and time.

b. **Limited exploration of return and secondary displacement**

The analysis focused exclusively on initial displacement flows and where people ended up, but the data did not capture return movements, prolonged displacement, and repeated displacements. It limits the ability to fully examine the displacement cycle, including the transitions between temporary migration, protracted displacement, and resettlement.

c. **Temporal scope and representativeness**

The study analyzed two consecutive years of displacement data (2022–2023), corresponding to Somalia's drought crisis followed by El Niño-induced flooding. This window captures short term shocks and important analysis, but it does not encompass the full range of long-term displacement patterns in Somalia. People have been displaced for many years and therefore, the findings may not fully represent the cumulative impact of historical droughts or escalating conflict scenarios after 2023.

d. **Conflict threshold sensitivity**

The methodology applied a threshold-based classification of conflict-affected regions. However, determining a suitable threshold for categorising high-conflict periods could be inherently uncertain. Conflict dynamics vary across space and time, and some low-frequency events may still produce disproportionately large displacement effects which needs to explore and verify with local news data. Therefore, the threshold may affect the conflict attribution to be scalable in another region as it fits in Somalia context.

## 5.6 Recommendation

There is still room for the potential development of this work as well as considerable potential to build upon the current findings. Below are some of the recommendations for future researchers:

- This research could be expanded to explore border regions and transboundary dynamics, where displacement and migration occur across national boundaries. It is also the same case because the extreme weather events have no boundaries and conflict situation in the region.

Therefore, exploring cross-border displacement during climate shocks (Kenya or Ethiopia) is innovative research for holistic regional response planning.

- The current research analyzed displacement linked to conflict just by the number of events. However, not all events have same consequences. Moreover, since violence type, involved actors and locations have direct impact on the displacement, it is recommended to explore event severity weighting rather than event counts only.
- Another branch of research could be about the immobility. The study concentrated on populations that were displaced, it did not address the immobility which are those who are unable to displace despite exposure to hazards and conflicts (voluntary vs. involuntary immobility). Many residents may face mobility constraints due to poverty, insecurity, legal status, or physical isolation. These populations remain under-represented in displacement data, yet they experience heightened vulnerability and protection risks. If organisations continue to approach assistance based on simplistic triggers of displacements, there is a risk that communities will miss lifesaving assistance and be left behind.
- A valuable next step would be to validate attribution findings by comparing them with qualitative outputs, such as those obtained through semi-structured stakeholder interviews. This study did not use the displacement reason variable available in the PRMN dataset, integrating this information could offer a useful benchmark to evaluate whether hazard-based attributions align with reported causes at the household level. Such triangulation is important for enhancing both the reliability and contextual depth of displacement analyses.
- Future research could also evolve to better capture the overlapping impacts of climate change and conflict on displacement. It can explore how humanitarian, development, and peacebuilding efforts intersect in climate-affected contexts. This study recommends integrating social science methods with climate science to strengthen interdisciplinary analysis. These include such as the peacebuilding and conflict sensitivity which brings evidence from both science and social approaches to delve deeper the climate security in Somalia. Remote sensing can play huge role on such integration.
- Further research is to develop future projections of mobility in high-risk situations. It can help operationalize such systems for anticipatory humanitarian action for displacement, aligned with Early Action Protocols (EAP). Therefore, further work can incorporate probabilistic attribution or machine learning classifiers trained on the reason-for-departure in the displacement combined with early warning information and forecasts to develop displacement prediction models and movement projection analysis.

# 6. CONCLUSION

This research contributes to the growing body of research at the intersection of extreme weather events, conflict, and displacement by offering one of the first subnational, empirical assessments of both drought and flood induced displacement in Somalia. The disaggregating of the triggers of internal displacement across time and space, and incorporating both meteorological and geospatial conflict data, the analysis provided a detailed understanding of how different hazard types and their interactions shape population movement. The findings confirm that climate shocks specifically simultaneous increase in the risk of droughts and increasing extreme rainfall, alongside persistent conflict, are key triggers of displacement, with certain regions such as Hiiraan and Lower Shabelle experiencing compound pressures. Although this study focuses specifically on Somalia, the research methods offer a scalable framework that can be applied in other climate-conflict-affected regions. The findings are based on two consecutive years (2022 and 2023), broader temporal analysis could further validate displacement trends under compounding risks. With improved access to high-resolution data, the method can be tested and applied in other climate-conflict-affected zones.

The study also offers actionable information by aligning its empirical evidence with anticipatory policy frameworks such as Forecast-Based Financing (FbF) and Early Action Protocols (EAP). These findings demonstrate the need for faster, more flexible, and less bureaucratic approaches to displacement analysis particularly in fragile and conflict-affected contexts. Future research should continue to deepen this work by integrating higher-frequency displacement reporting, conflict severity indicators, and household-level data as well as exploring immobility to better understand vulnerability and resilience at a finer scale.

# ETHICAL CONSIDERATION

All ethical considerations were monitored during the study based on the Research Ethics Policy of the University of Twente. There are no specific ethical concerns that are anticipated during this research period. In order to ensure the research results are robust, all data will undergo rigorous technical review with documentation. The data gathered from the UNHCR was treated as confidential, all research materials, including data, documents, and reports, was securely archived and made accessible at the following link: https://github.com/3bdillahiomar under the repository titled "Somalia-Climate-Conflict-Displacement-Research." Sensitive or personally identifiable information was not uploaded to the public repository.

Privacy concerns are carefully considered during the research process to protect private information. Therefore, no phase of the research process involved the sharing or release of any personal data. Moreover, the occasional use of ChatGPT for grammar check, suggesting some word synonyms, clarity and speeding up some code writing was very helpful. After using these tools, the author reviewed and edited the content as needed and takes full responsibility for the content of the work in line with the guidelines stated in Use of AI in Education at the University of Twente (June 2023).

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# APPENDICES

## Appendix A: Displacement from where to where?

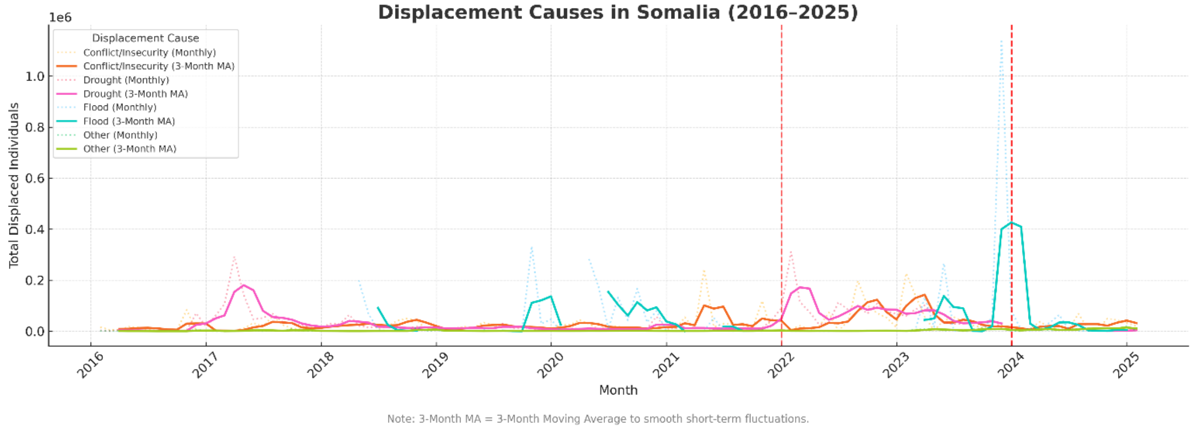



Figure 22: displacement causes (2016-2025)

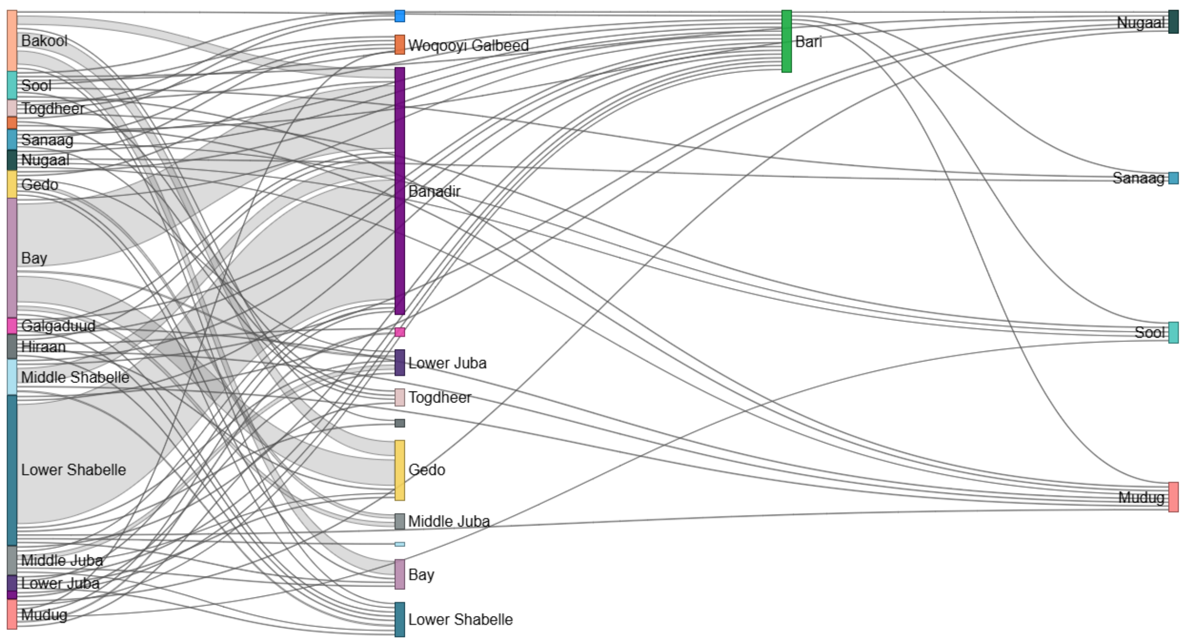



Figure 23: Internal displacement flows between regions

# Appendix B: Conflict event types

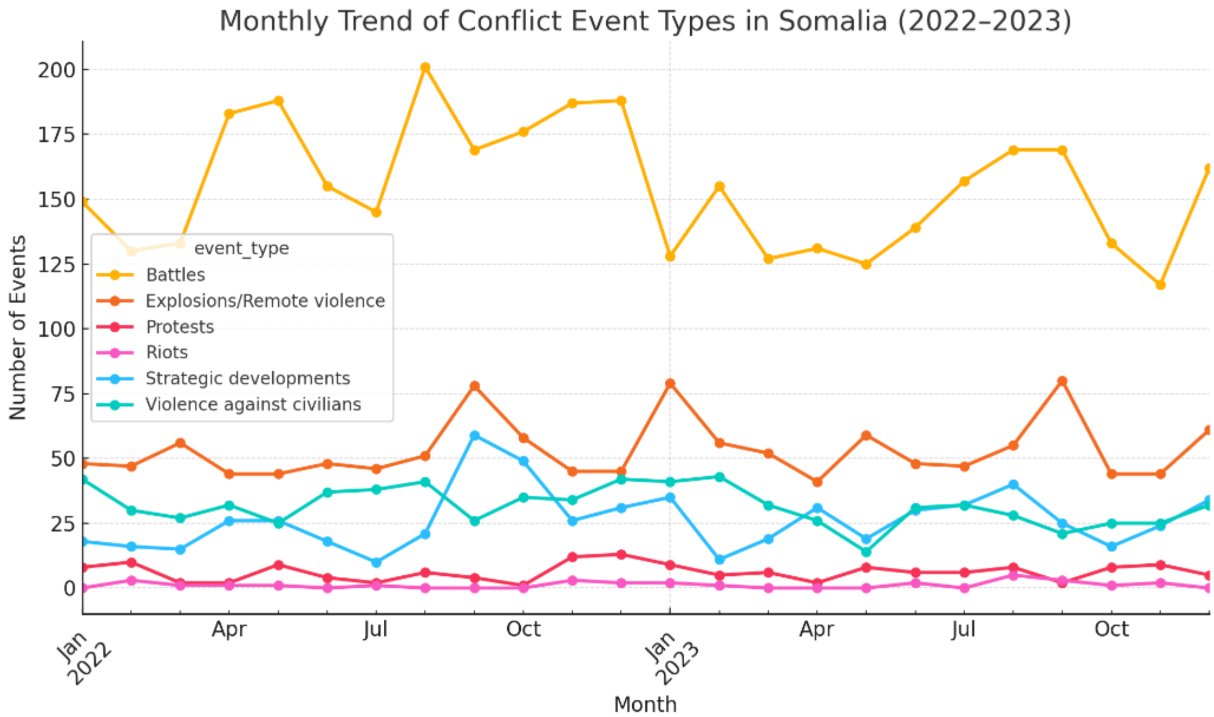
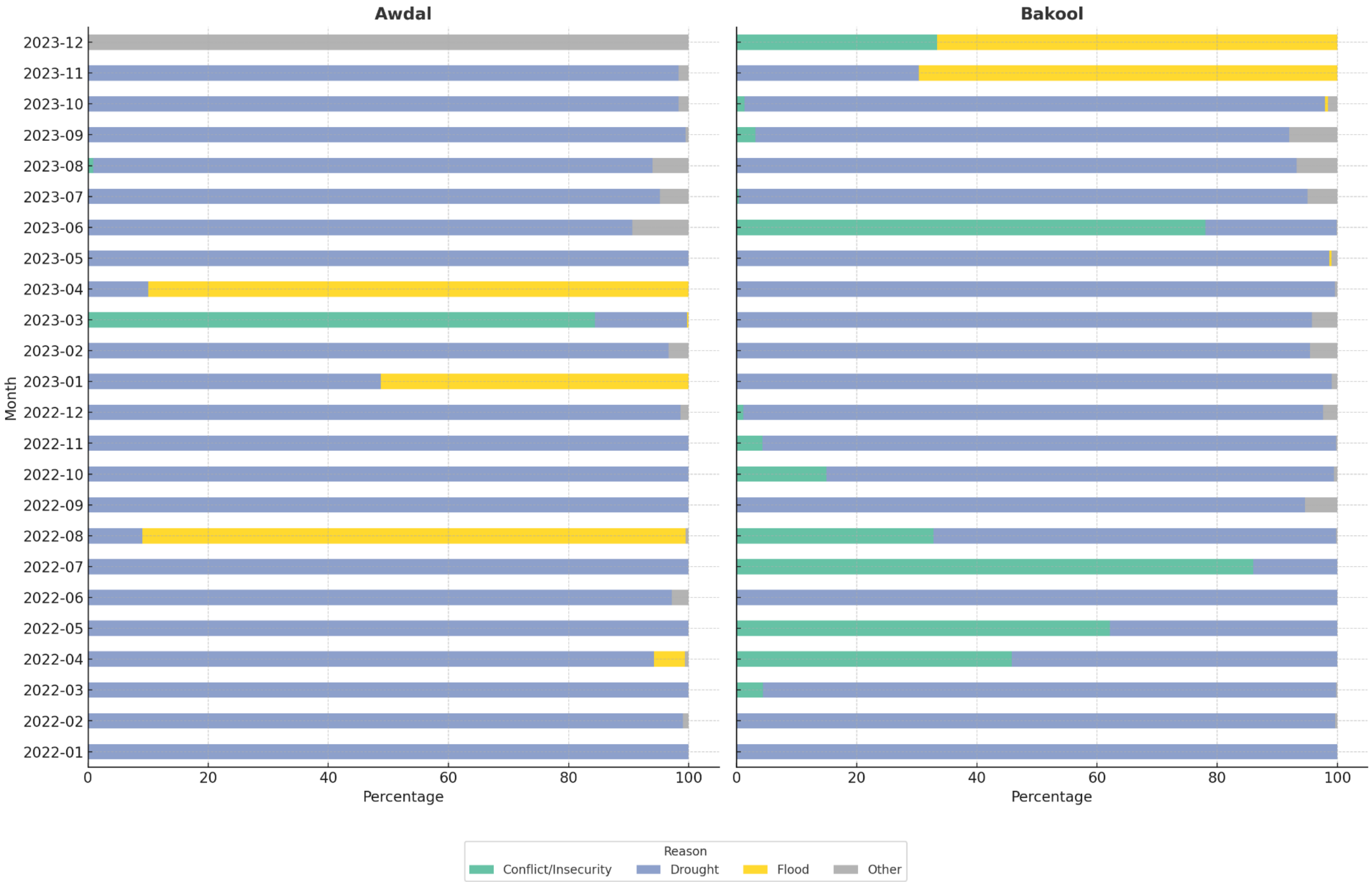


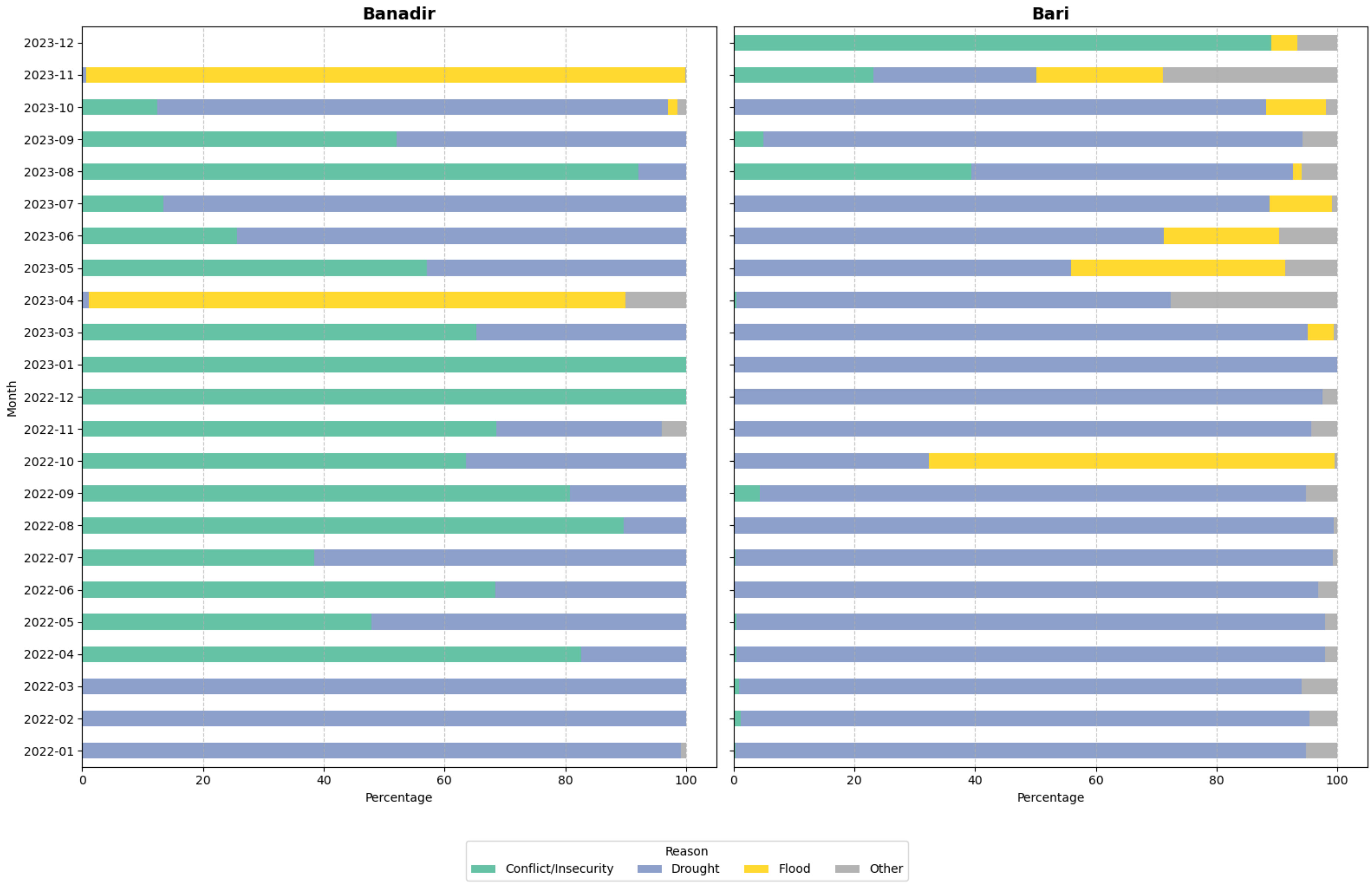

Figure 24: Monthly trends of conflict event types in Somalia (2022–2023)

# Appendix C: Somalia map


Figure 25: Map of Somalia and 18 regions *(UN Geospatial, 2011).*

# Appendix D: Reported displacement reasons from PRMN data

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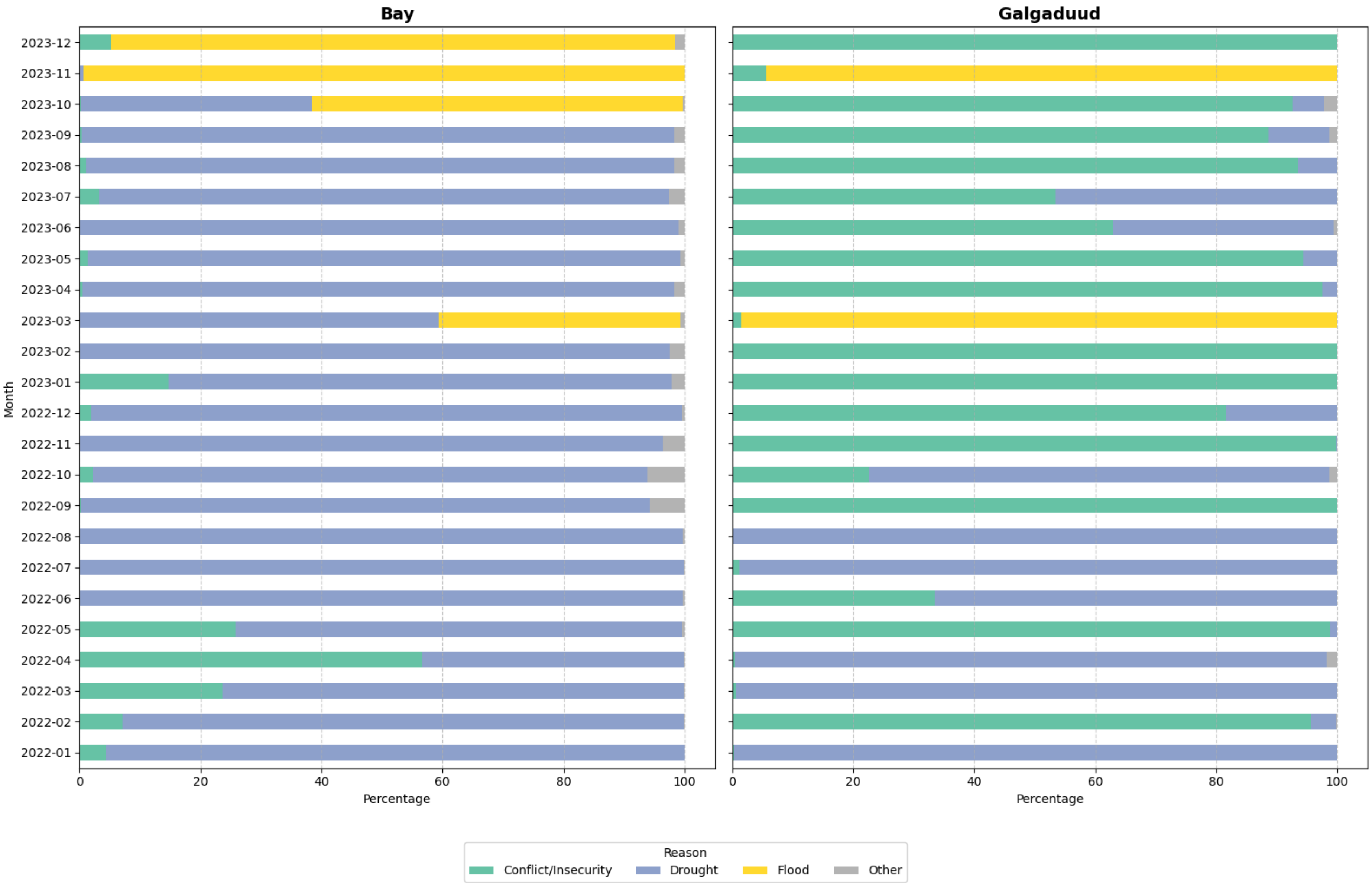
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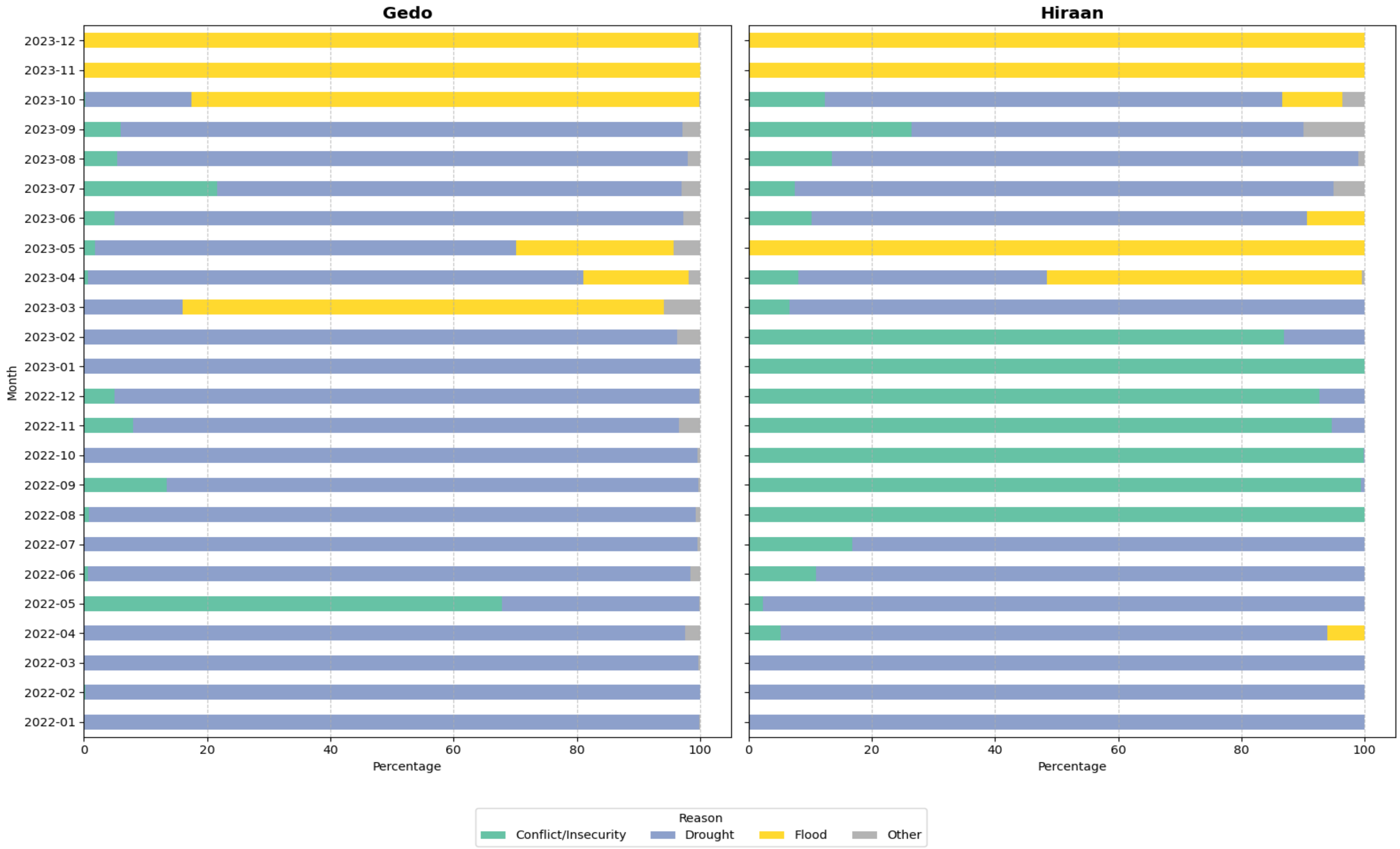
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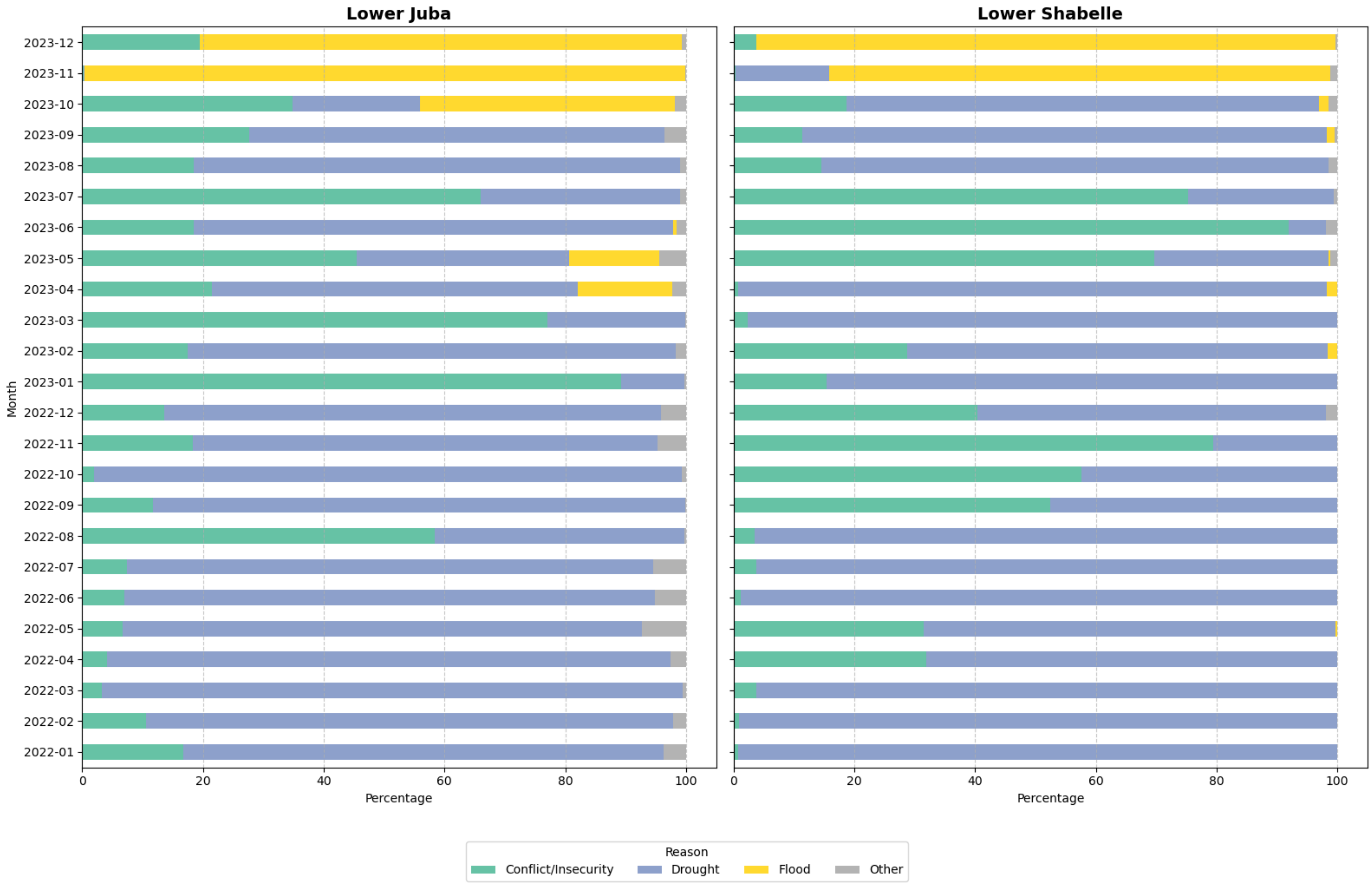
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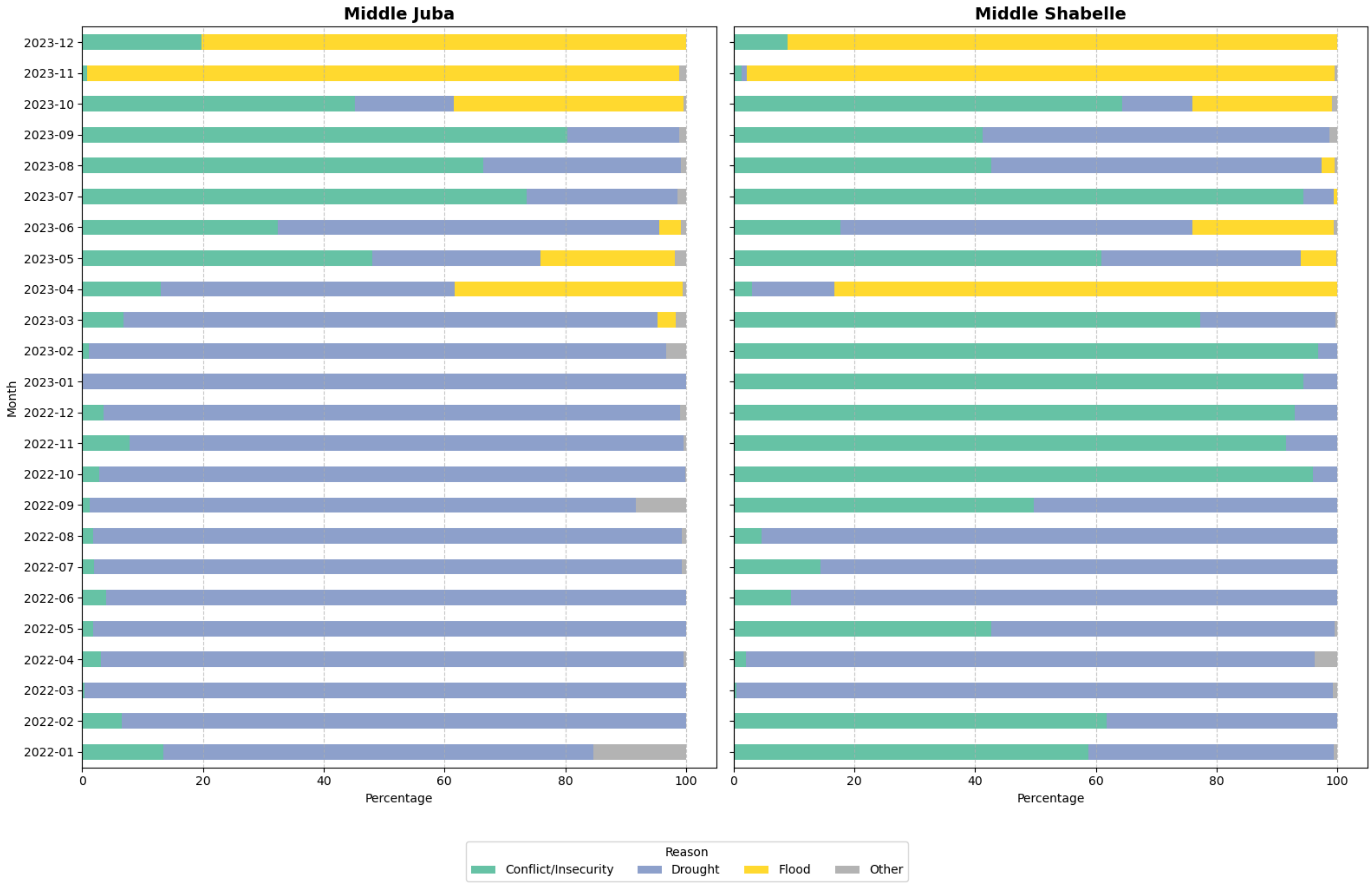
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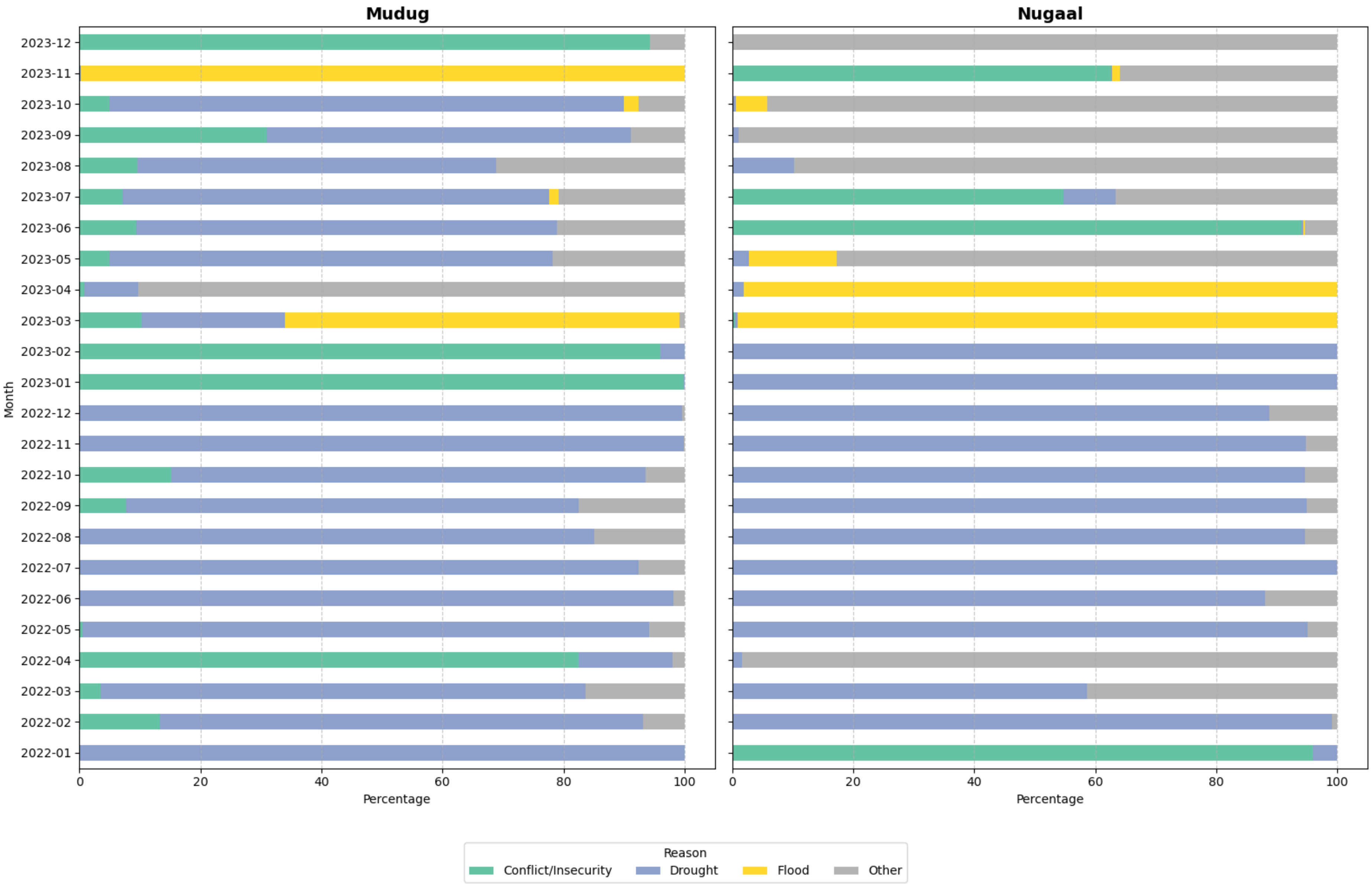
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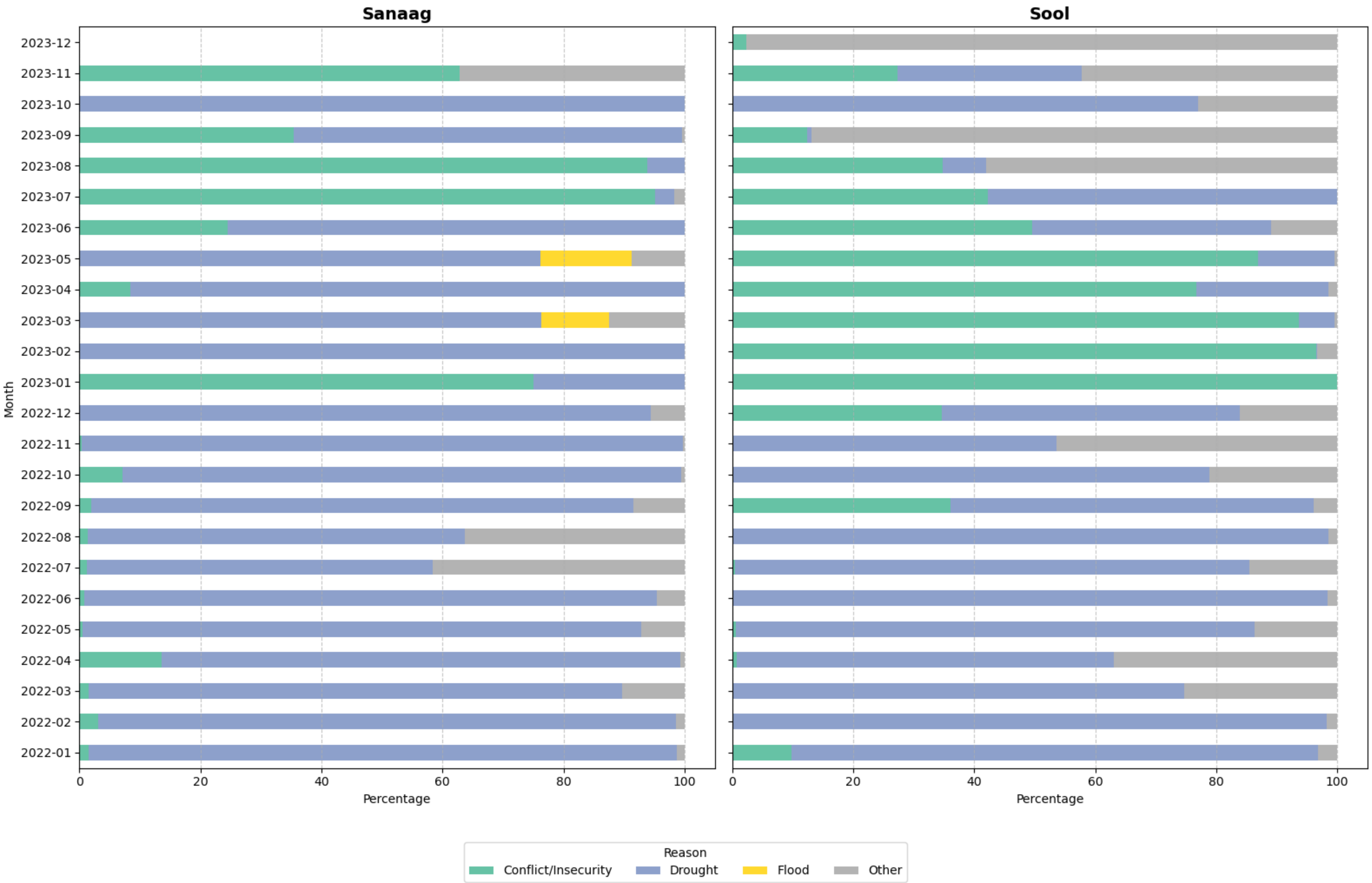
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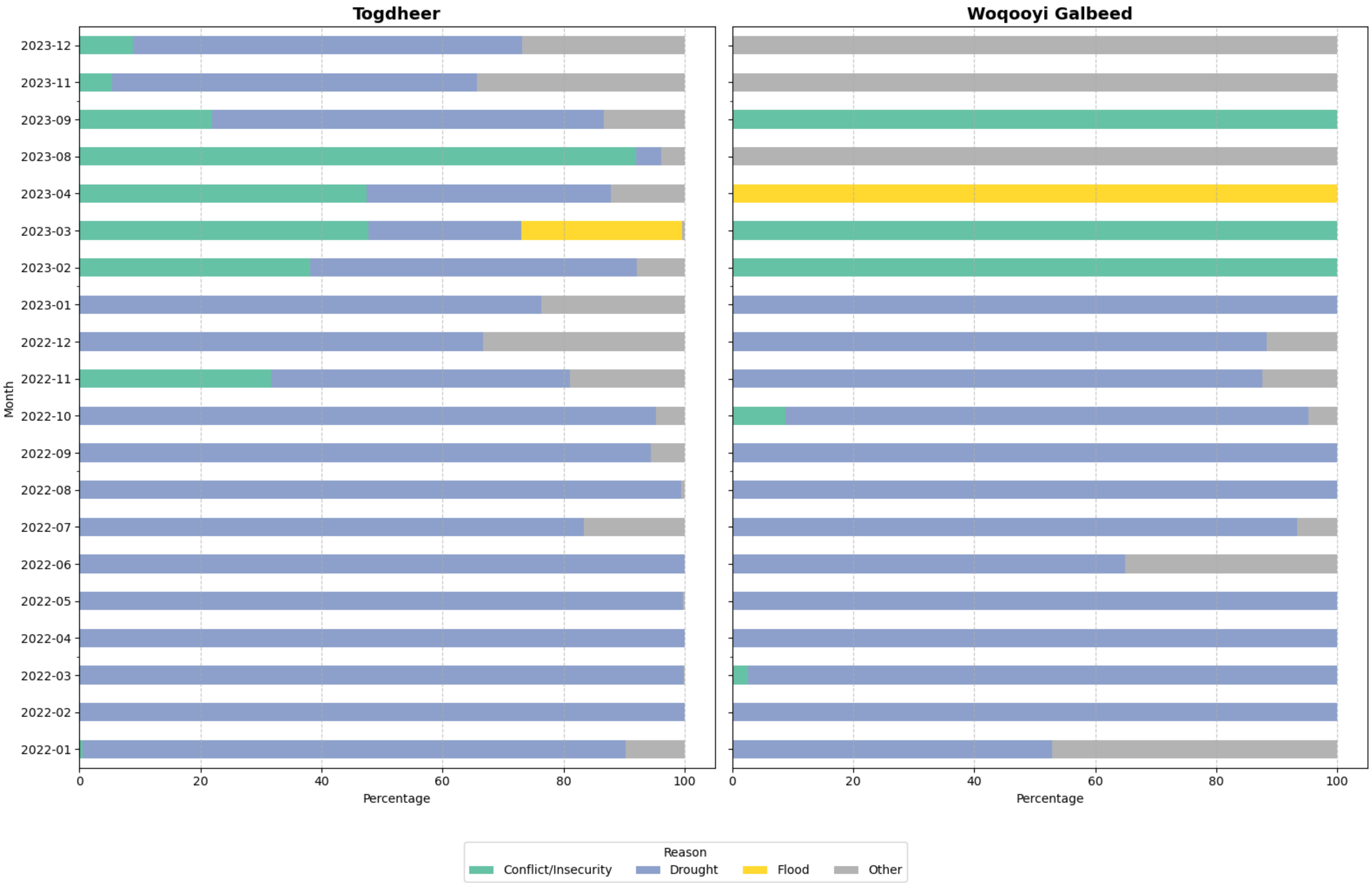
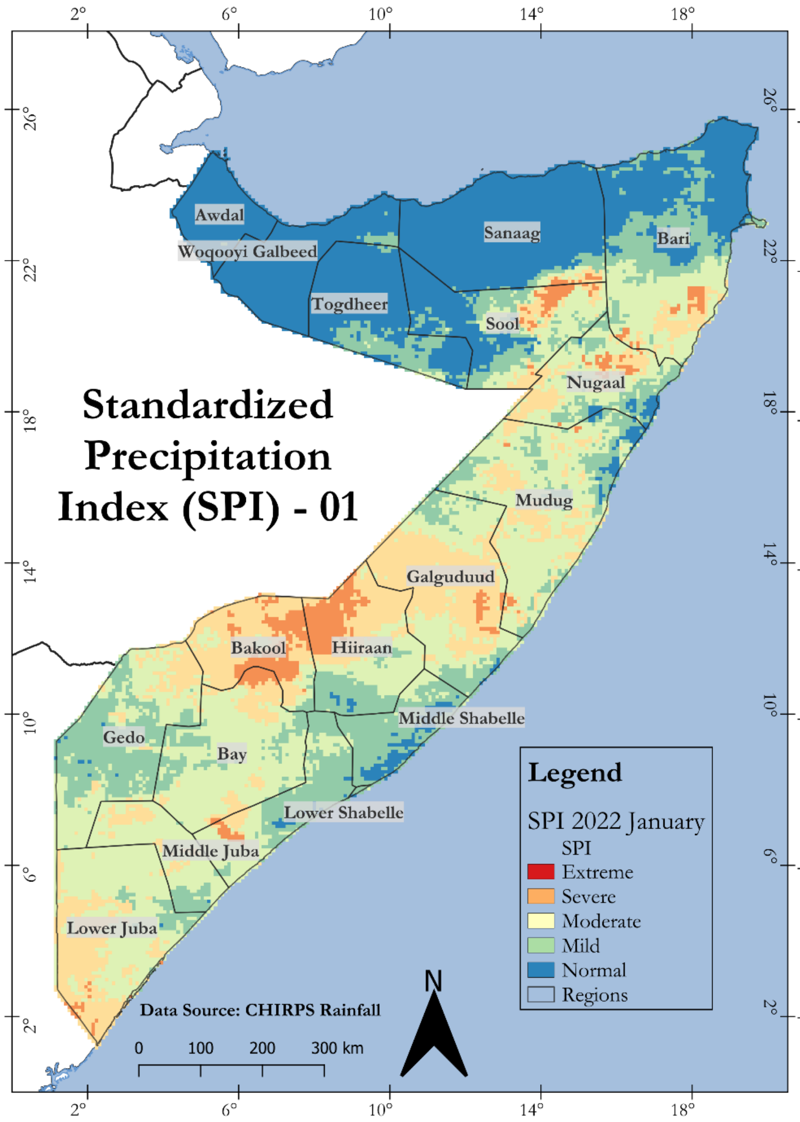
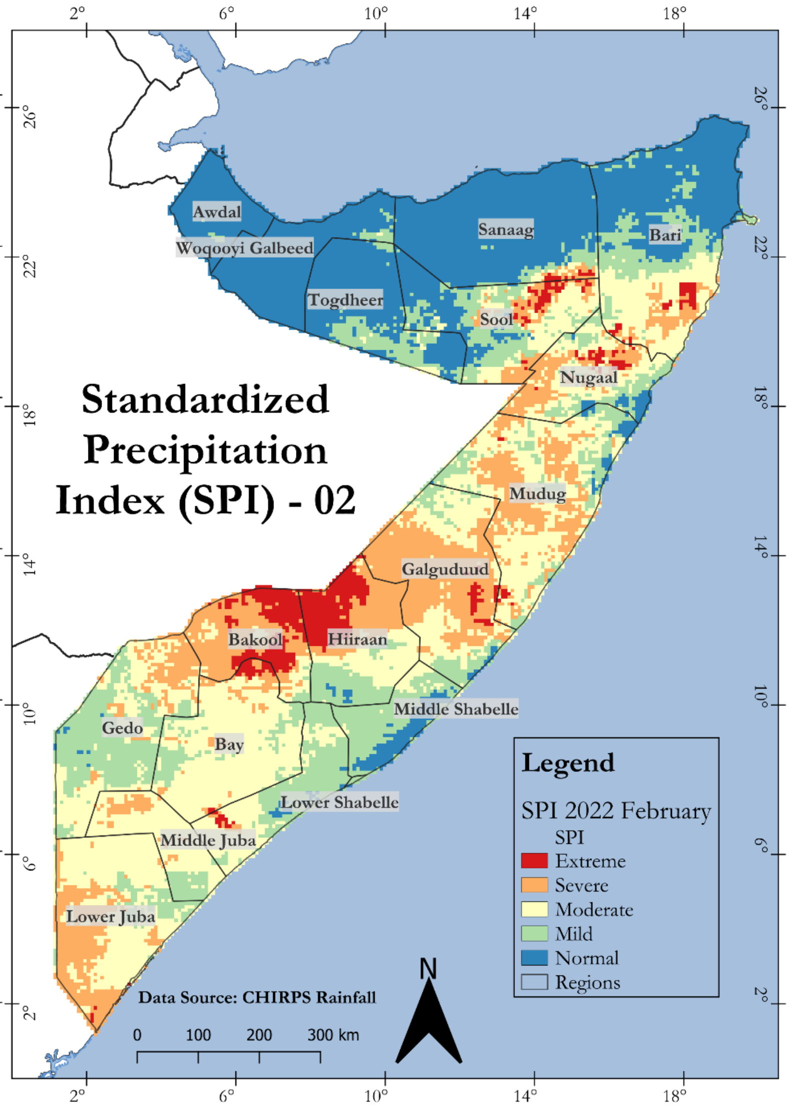
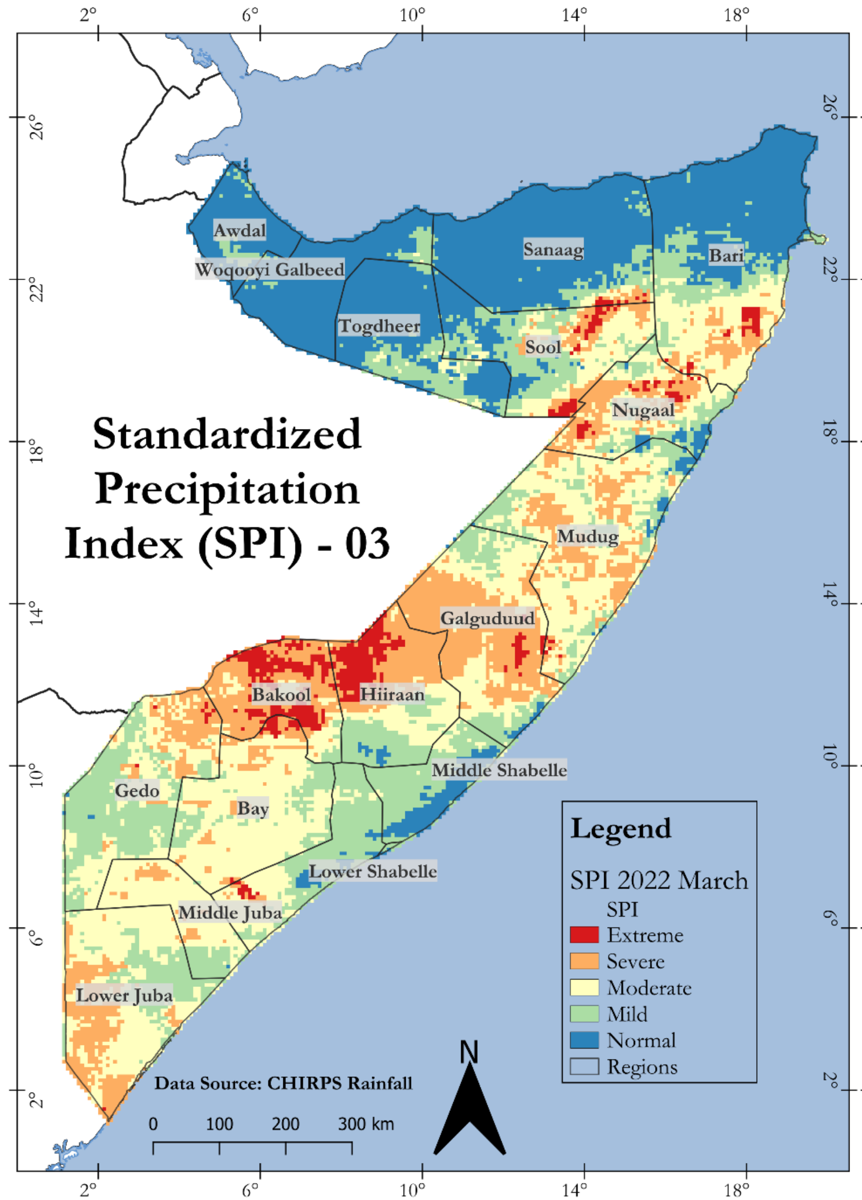
Percentage
2023-12
2023-11
2023-10
2023-09
2023-08
2023-07
2023-06
2023-05
2023-04
2023-03
2023-02
2023-01
2022-12
2022-11
2022-10
2022-09
2022-08
2022-07
2022-06
2022-05
2022-04
2022-03
2022-02
2022-01
0
20
40
60
80
100
Reason
Conflict/Insecurity
Drought
Flood
Other

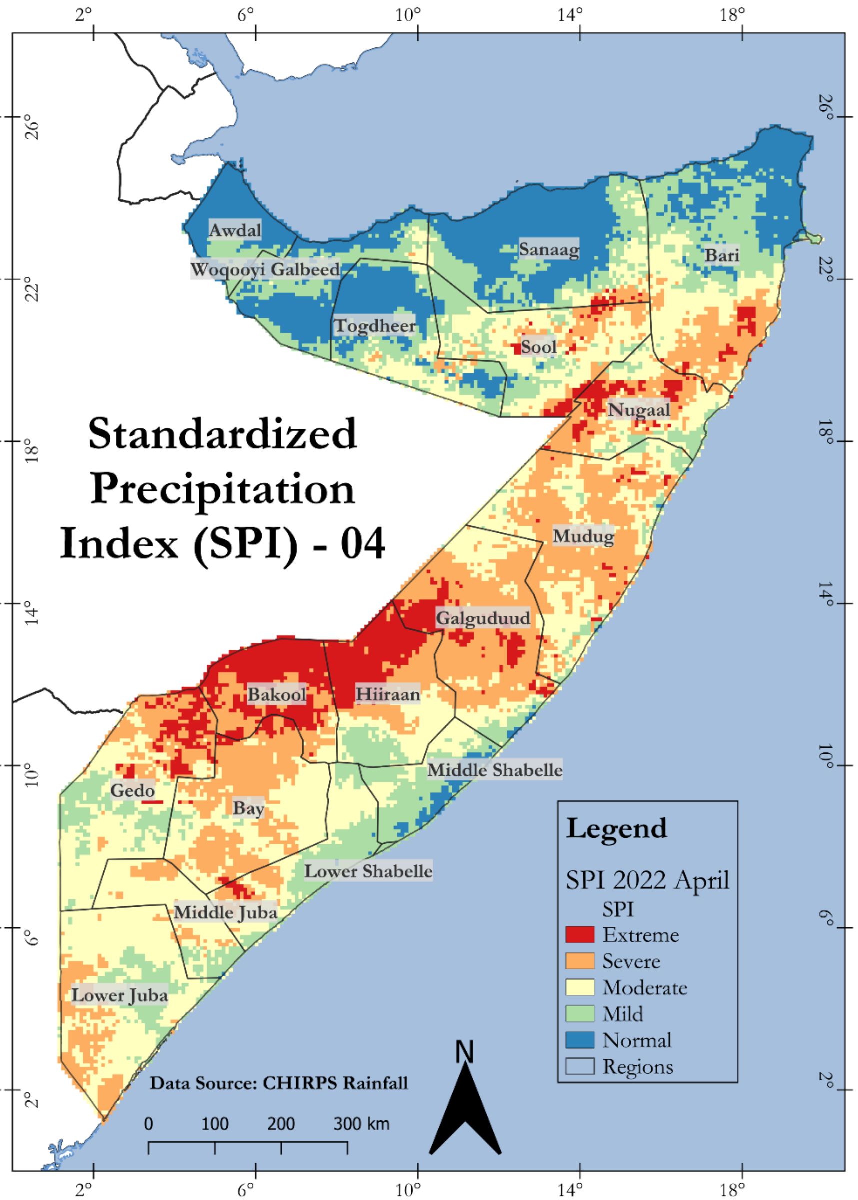

Togdheer
Woqooyi Galbeed
2023-12
2023-11
2023-09
2023-08
2023-04
2023-03
2023-02
2023-01
2022-12
2022-11
2022-10
2022-09
2022-08
2022-07
2022-06
2022-05
2022-04
2022-03
2022-02
2022-01
Month
0
20
40
60
80
100
Percentage
Reason
Conflict/Insecurity
Drought
Flood
Other

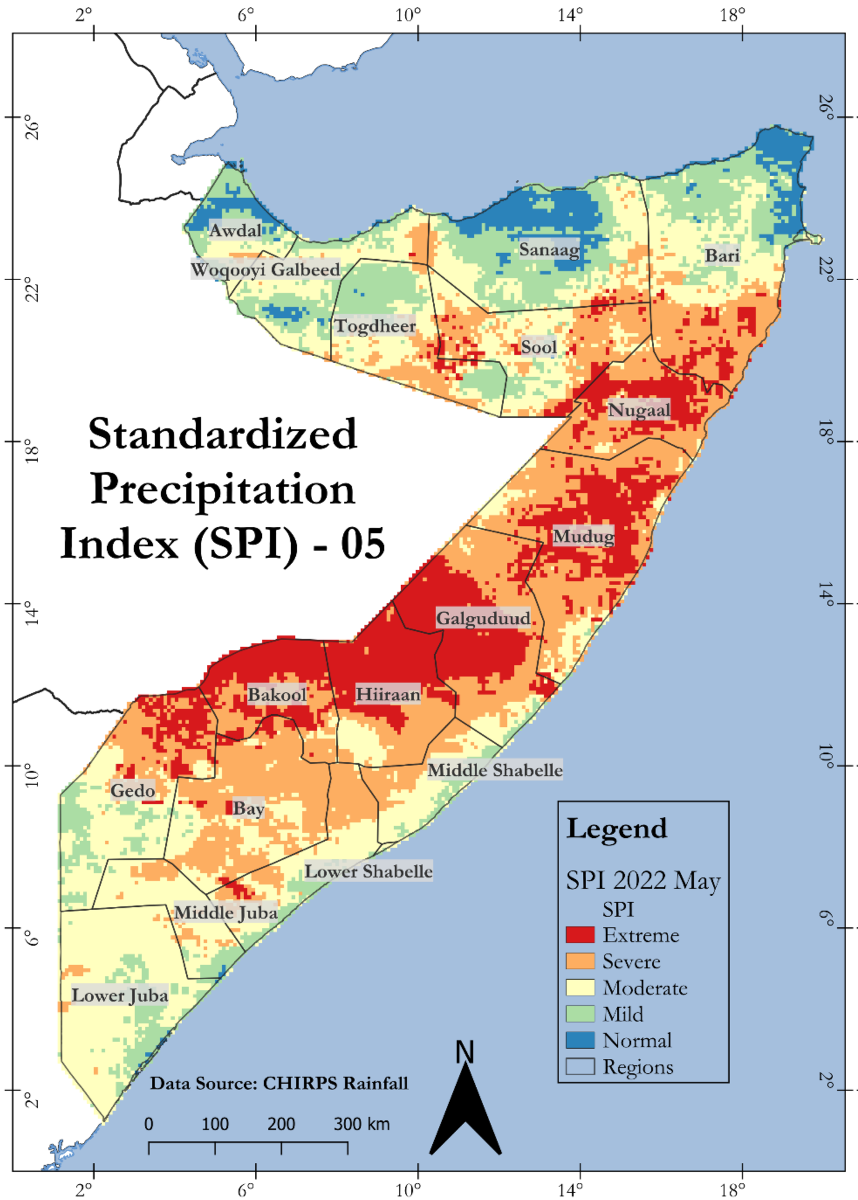
# Appendix E: SPI detailed maps

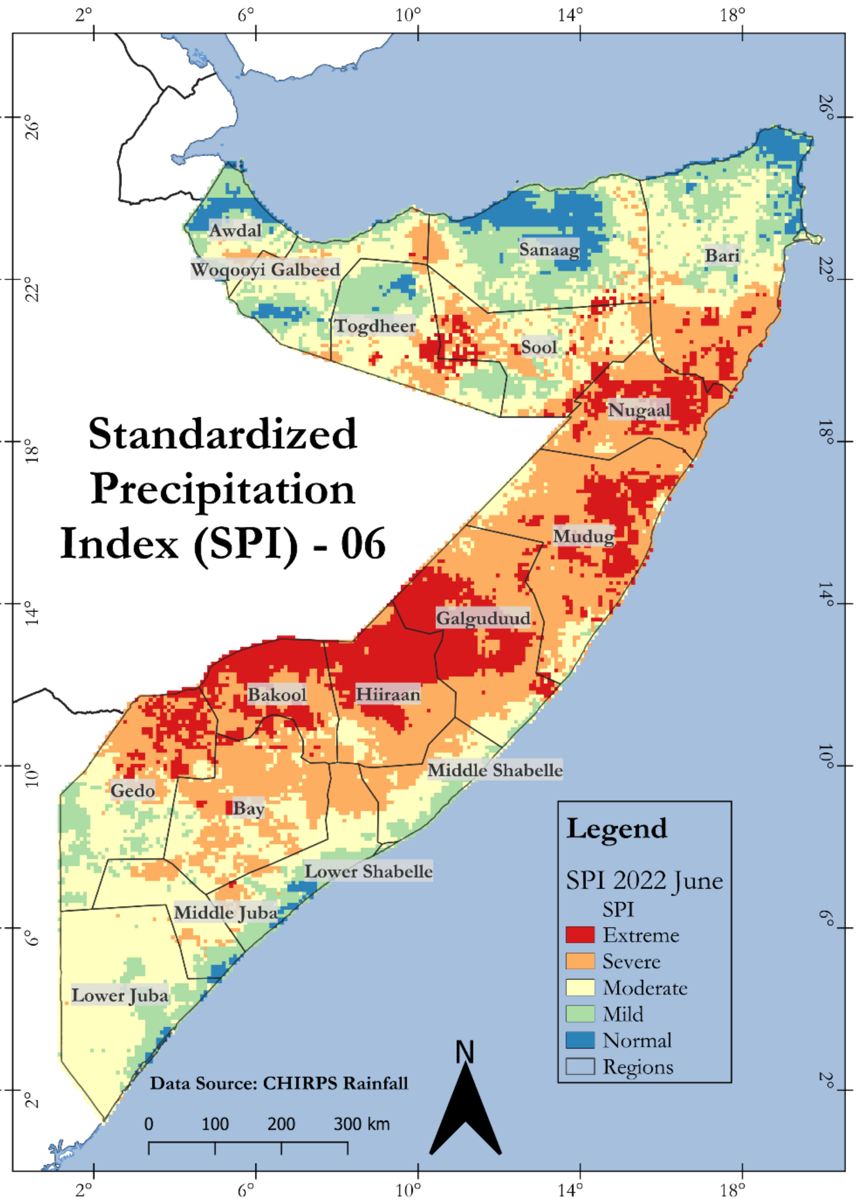


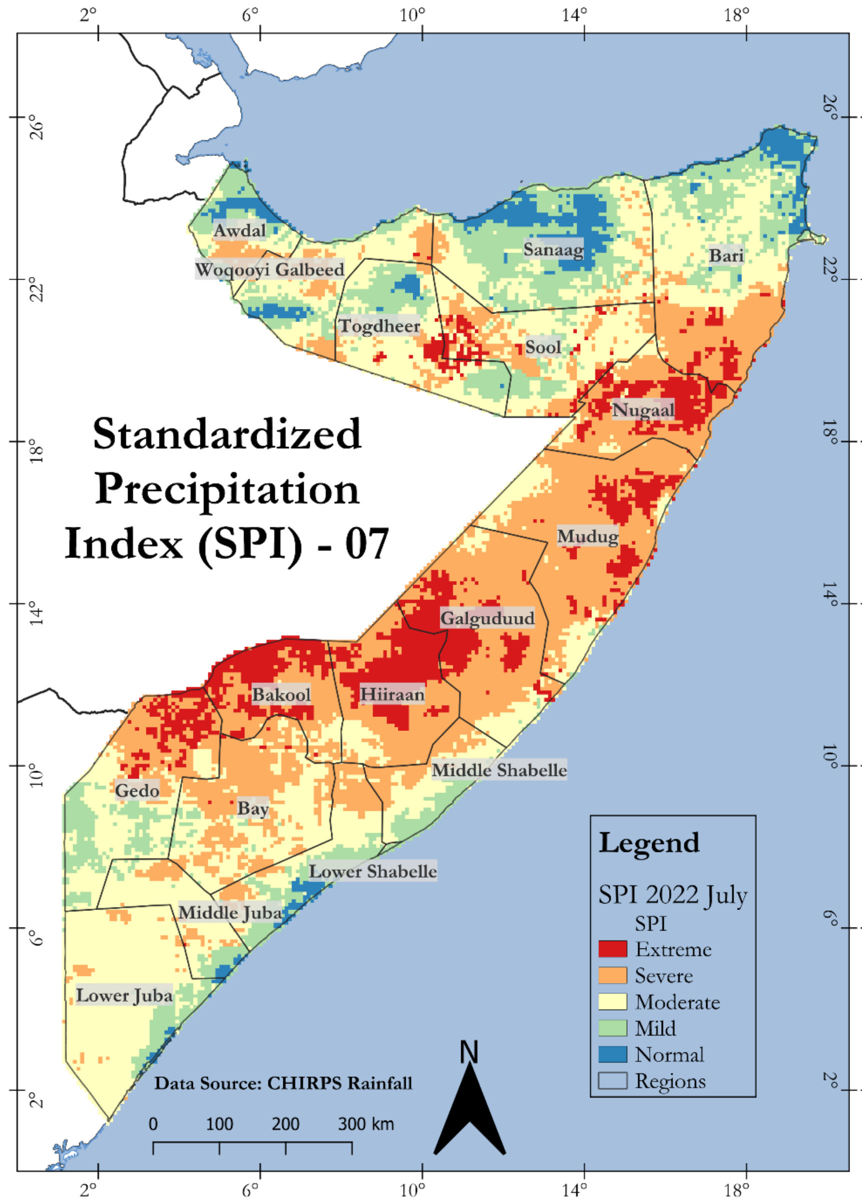



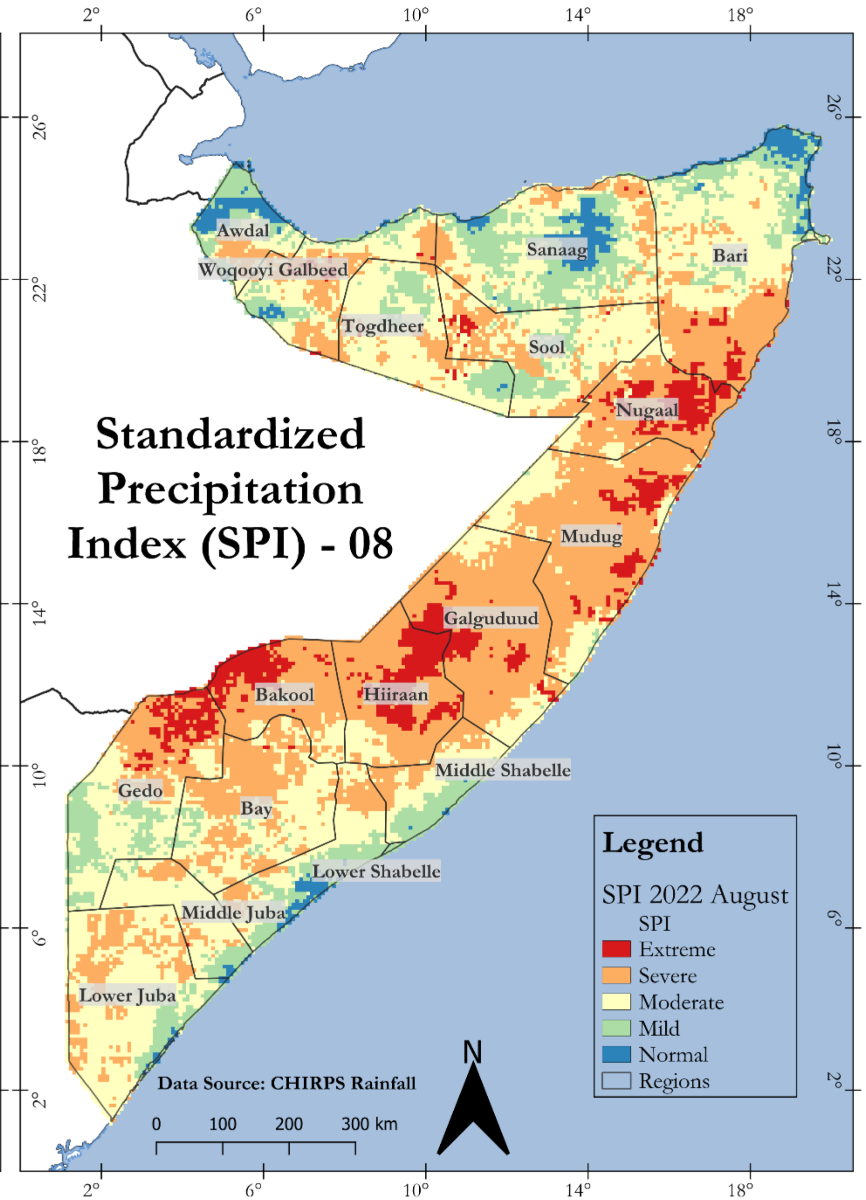

Standardized Precipitation Index (SPI) - 03
Awdal
Woqooyi Galbeed
Sanaag
Bari
Togdheer
Sool
Nugaal
Mudug
Galguduud
Bakool
Hiiraan
Middle Shabelle
Gedo
Bay
Lower Shabelle
Middle Juba
Lower Juba
Legend
SPI 2022 March
SPI
Extreme
Severe
Moderate
Mild
Normal
Regions
Data Source: CHIRPS Rainfall
0 100 200 300 km
N

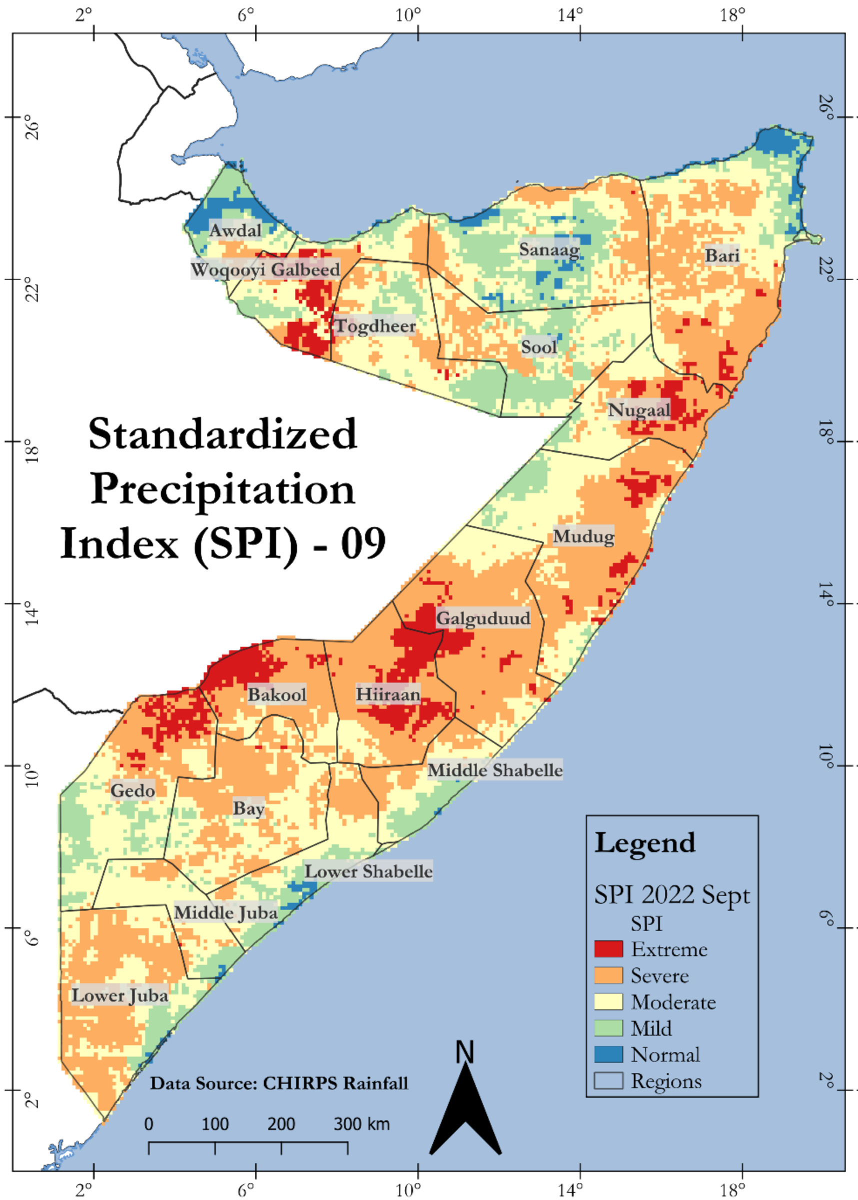

Standardized Precipitation Index (SPI) - 04
Awdal
Woqooyi Galbeed
Sanaag
Bari
Togdheer
Sool
Nugaal
Mudug
Galguduud
Bakool
Hiiraan
Middle Shabelle
Gedo
Bay
Lower Shabelle
Middle Juba
Lower Juba
Legend
SPI 2022 April
SPI
Extreme
Severe
Moderate
Mild
Normal
Regions
Data Source: CHIRPS Rainfall
0 100 200 300 km
N

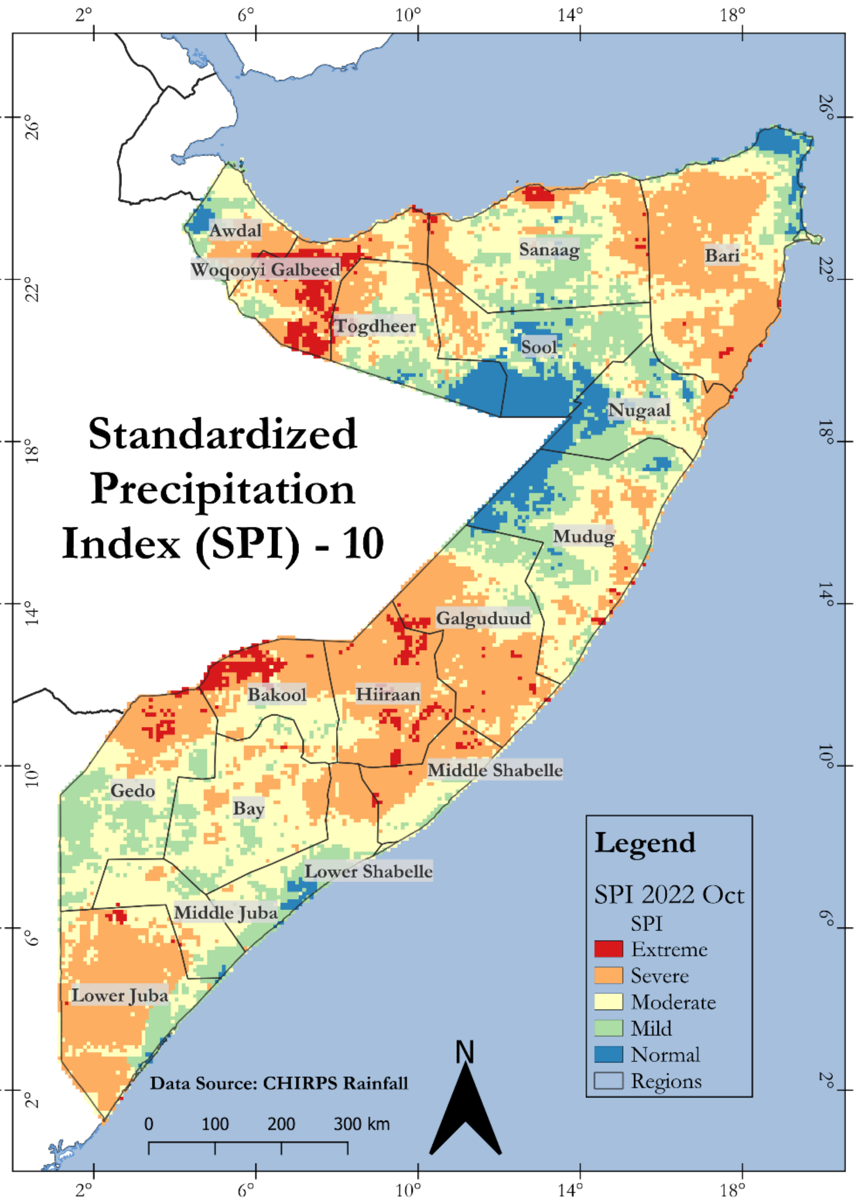

Standardized Precipitation Index (SPI) - 05
Awdal
Woqooyi Galbeed
Sanaag
Bari
Togdheer
Sool
Nugaal
Mudug
Galguduud
Bakool
Hiiraan
Middle Shabelle
Gedo
Bay
Lower Shabelle
Middle Juba
Lower Juba
Legend
SPI 2022 May
SPI
Extreme
Severe
Moderate
Mild
Normal
Regions
Data Source: CHIRPS Rainfall
0 100 200 300 km
N


Standardized Precipitation Index (SPI) - 06
Awdal
Woqooyi Galbeed
Sanaag
Bari
Togdheer
Sool
Nugaal
Mudug
Galguduud
Bakool
Hiiraan
Middle Shabelle
Gedo
Bay
Lower Shabelle
Middle Juba
Lower Juba
Legend
SPI 2022 June
SPI
Extreme
Severe
Moderate
Mild
Normal
Regions
Data Source: CHIRPS Rainfall
0 100 200 300 km
N


Standardized Precipitation Index (SPI) - 07
Awdal
Woqooyi Galbeed
Togdheer
Sanaag
Sool
Bari
Nugaal
Mudug
Galguduud
Hiiraan
Bakool
Middle Shabelle
Gedo
Bay
Lower Shabelle
Middle Juba
Lower Juba
Legend
SPI 2022 July
SPI
Extreme
Severe
Moderate
Mild
Normal
Regions
Data Source: CHIRPS Rainfall
0 100 200 300 km
N


Standardized Precipitation Index (SPI) - 08
Awdal
Woqooyi Galbeed
Togdheer
Sanaag
Sool
Bari
Nugaal
Mudug
Galguduud
Hiiraan
Bakool
Middle Shabelle
Gedo
Bay
Lower Shabelle
Middle Juba
Lower Juba
Legend
SPI 2022 August
SPI
Extreme
Severe
Moderate
Mild
Normal
Regions
Data Source: CHIRPS Rainfall
0 100 200 300 km
N


Standardized Precipitation Index (SPI) - 09
Awdal
Woqooyi Galbeed
Togdheer
Sanaag
Sool
Bari
Nugaal
Mudug
Galguduud
Hiiraan
Bakool
Middle Shabelle
Gedo
Bay
Lower Shabelle
Middle Juba
Lower Juba
Legend
SPI 2022 Sept
SPI
Extreme
Severe
Moderate
Mild
Normal
Regions
Data Source: CHIRPS Rainfall
0 100 200 300 km
N


Standardized Precipitation Index (SPI) - 10
Awdal
Woqooyi Galbeed
Togdheer
Sanaag
Sool
Bari
Nugaal
Mudug
Galguduud
Hiiraan
Bakool
Middle Shabelle
Gedo
Bay
Lower Shabelle
Middle Juba
Lower Juba
Legend
SPI 2022 Oct
SPI
Extreme
Severe
Moderate
Mild
Normal
Regions
Data Source: CHIRPS Rainfall
0 100 200 300 km
N

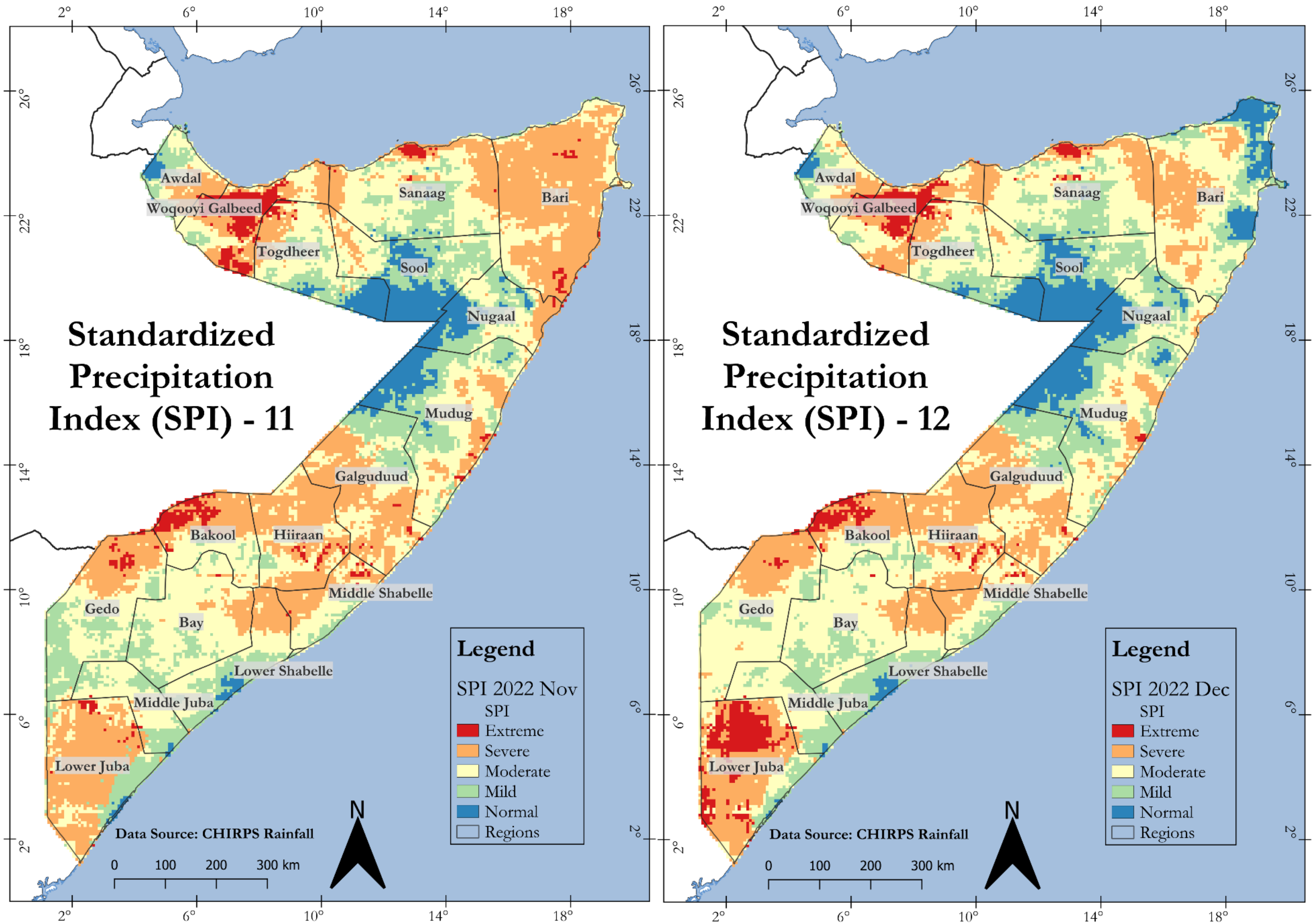
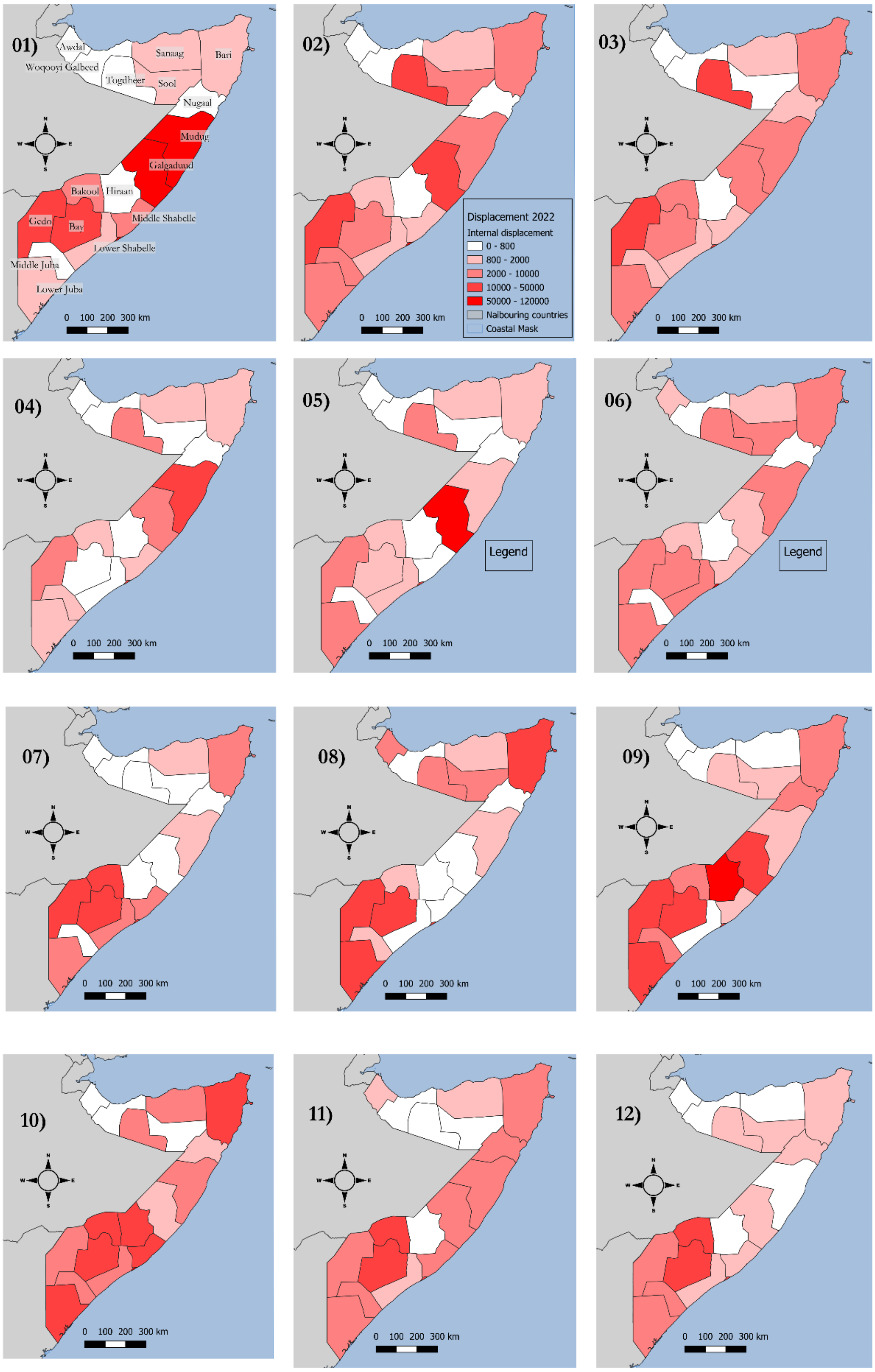



Figure 26: Detailed SPI Maps

# Appendix F: Monthly displacement maps 2022




**Data Source: PRMN (Protection & Return Monitoring Network) survey data on internal displacement in Somalia from UNHCR**

Figure 27: Monthly displacement maps 2022

# Appendix G: Somalia landcover classification

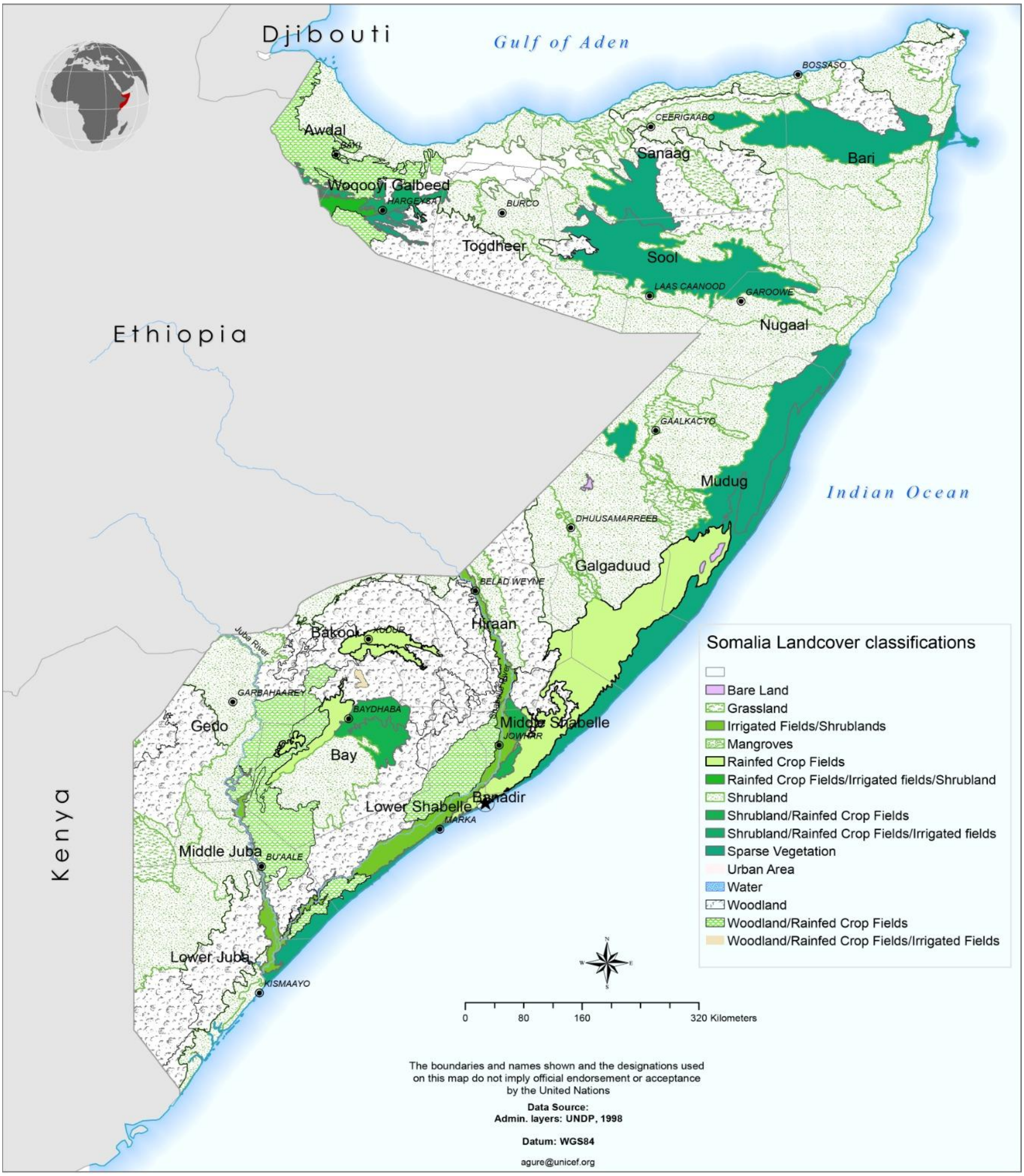



Figure 28: Somalia landcover classification

(Gure, 2021)

# Appendix H: Somalia climate zones

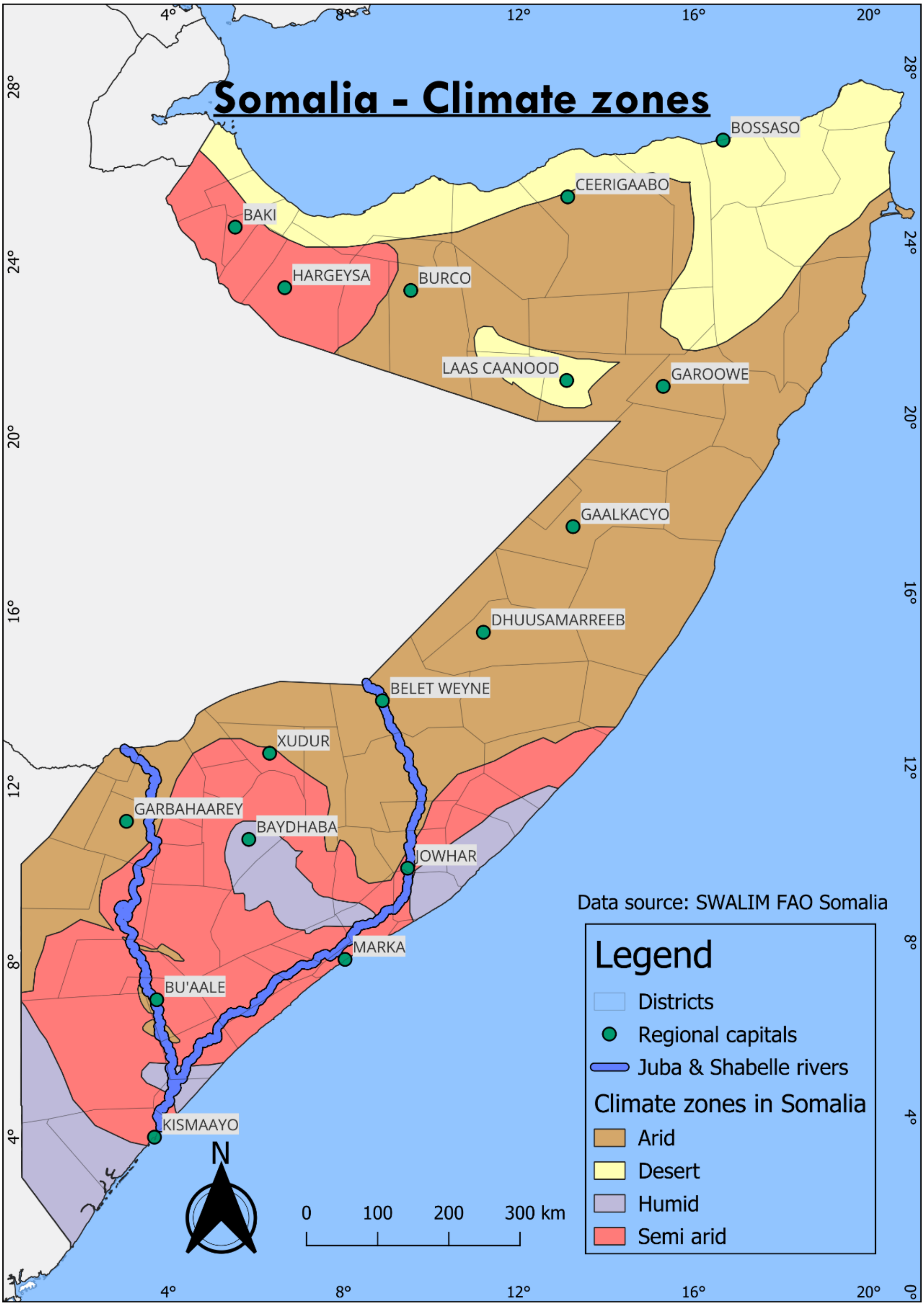



Figure 29: Somalia climate zones

Source: Author

FACULTY OF GEO-INFORMATION SCIENCE AND EARTH OBSERVATION
UNIVERSITY OF TWENTE, ENSCHEDE, THE NETHERLANDS