FEDERAL GOVERNMENT OF SOMALIA MINISTRY OF ENERGY AND WATER RESOURCES

COMPREHENSIVE ASSESSMENT OF EXISTING CENTRALIZED AND DECENTRALIZED EARLY WARNING SYSTEMS IN SOMALIA

FINAL REPORT

31st November 2021

Empowered lives.
Resilient nations.

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List of Abbreviations

AWS	Automatic Weather Station
CBEWS	Community-based Early Warning System
CDI	Combined Drought Index
CORDEX	Coordinated Regional Downscaling Experiment
DRM	Disaster Risk Management
DSS	Decision Support System
ENSO	The El Niño Southern Oscillation
EWS	Early Warning Systems
FAO	Food and Agricultural Organization
FEWS NET	Famine Early Warning System Network
FRRMIS	Flood Risk and Response Management Information System
FSNAU	Food Security and Nutrition Analysis Unit
GDACS	Global Disaster Alerts and Coordination System
GIEWS	Global Information and Early Warning System
GIS	Geographic Information System
HADMA	Humanitarian Affairs and Disaster Management Authority (Puntland)
ICPAC	IGAD Climate Prediction and Applications Centre
IGAD	Intergovernmental Authority on Development
INDC	Intended National Determined Contribution
IOD	Indian Ocean Dipole
ITCZ	Inter-Tropical Convergence Zone
MoEWR	Ministry of Energy and Water Resources
MoHADM	Humanitarian Affairs and Disaster Management
MoU	Memorandum of Understanding
NADFOR	National Disaster Preparedness and Food Reserve Authority
NAPA	National Program of Action
NDP	National Development Plan
NDRMP	National Disaster Risk Management Policy
NDSS	Somalia National Durable Solutions Strategy
NDVI	Normalized Difference Vegetation Index
NGO	Nongovernmental Organization
NHMS	National Hydro-Meteorological and Monitoring service
NOAA	National Oceanic and Atmospheric Administration
NWRS	National Water Resource Strategy
PET	Potential evapotranspiration
RCP	Representative Concentration Pathway
SDGs	Sustainable Development Goals
SOP	Standard Operating Procedure
SPI	Standardized Precipitation Index
SWALIM	Somalia Water and Land Information Management
UN	United Nations
UNDP	United Nations Development Program
UNFCCC	United Nations Framework Convention on Climate Change
UNISDR	United Nations International Strategy on Disaster Reduction
UNOCHA	United Nations Office for the Coordination of Humanitarian Affairs
UNSPIDER	United Nations Platform for Space-based information for Disaster Management
USAID	United States Agency for International Development
USGS	United States Geological Survey
WASH	Water, Sanitation and Hygiene
WHO	World Health Organization
WMO	World Meteorological Organization

Executive Summary

Early Warning System is an approach adopted by the governments, communities and societies to reduce the risk of potential hazards and enhance resilience. Effective early warning systems must be people-centered and must integrate the following four inter-related key elements: Risk Knowledge; Monitoring and Warning; Dissemination and Communication and Response Capability. The communities and involved institutions: should have a good knowledge of the risks that are threatening them; should monitor the changes in risks and vulnerabilities of the communities; should disseminate and communicate the information and risks provide early warnings, and should have the response capability to reduce the risk once they receive the alerts.

Somalia has been devastated not only with the long-lasting civil war but also by hydro-meteorological hazards including drought, floods, cyclones, and other climate-related disasters that have adversely affected the lives, property, and livelihoods of the Somali people for centuries and it's ranked among the most vulnerable countries in the world to climate change and has a low capacity to adapt to climate change because of its poor socioeconomic development.

Observational data for the 1985-2018 period show that drought, floods, cyclones, and climate-related diseases and epidemics, whose frequency, occurrence, and impacts have increased in recent years, already pose a significant risk to the country's vulnerable population. In recent decades, this has led to massive problems of food insecurity and population exodus from the worst-hit areas. In the time periods of 1961–1990 and 2002–2018, there were six severe flooding events along the Jubba and Shabelle Rivers. The major floods took place in the Deyr of 1961, Deyr of 1977, Gu of 1981, Deyr of 1997, Gu of 2005, and Deyr of 2006 and Gu of 2018. The floods of 1997/1998 and 2018 were the worst seen in the riverine areas in living memory. During the period between 1960 and 2018, the country has experienced several massive droughts. The droughts that occurred in 1973/1974, 1984, 1991, 2010/2011 and 2016/2017 were most intense and widespread. On top of that, over the past several years, drought has been occurring virtually once every two years in most parts of the country. It starts in some zones and slowly spreads to the rest of the country because of seasonal shifts and increased dryness. Cyclones also have particularly been active in Somalia in the past two decades as the country has experienced more than 5 major cyclones during the 2010s than in the 1980s, 1990s, or 2000s. In recent years, major storms such as Cyclone Gati in 2020, Cyclone Sagar in 2018 and Cyclonic Storm Pawan in December 2019 have killed dozens and displaced thousands across northern Somalia.

The country's low level of socioeconomic development makes it extremely vulnerable to disaster, with several notable contributing factors. Decades of disasters have undermined the country's coping mechanisms and protective capacity; this increases the likelihood that hazards turn into disasters with large humanitarian and economic consequences. A considerable amount of the loss and damage could be avoided if the people to be affected are warned in advance. The absence of such a warning system using modern forecasting and dissemination systems is a major issue to be addressed in Somalia.

Hydrological and meteorological data collection and observation in Somalia started in the late 1894 by installation of first weather station in Kismayo. The hydrometric network expanded rapidly in the 1960s and 1970s. Before 1990, Somalia had one of the best meteorological monitoring systems in the region, when the civil war in Somalia intensified, the whole weather recording system collapsed and this saw the loss of valuable data and unfortunately, most equipment were rendered non-

functional or destroyed. In 2002, FAO-SWALIM project in collaboration with some NGOs and UN agencies started efforts to rehabilitation of non-functional weather stations network and installation of new stations throughout Somalia. This has been a welcome initiative which will generate essential ground data to supplement satellite predictions. The network is still extremely sparse with no river level radar sensors and groundwater sensors functioning in the south. Since then, SWALIM has been reinstated and is the lead agency in collecting, processing and reporting of weather data including temperature, precipitation and weather forecasts. Currently, there are four types of hydro-meteorological monitoring stations some of them are not functional including 13 automatic weather stations, 110 manual rain gauges, 9 synoptic stations. For the past 5 years, the FAO-SWALIM, IGAD-ICPAC and USAID's FEWSNET initiatives have focused on improving regional forecasting for Somalia, making use of the rehabilitated network of monitoring stations in addition to stations abroad.

Somalia lacks a systematic and defined Early Warning System at the national level. EWS is included in most of the national disaster-related policies and relevant plans, although there is still lack of a long term strategic early warning system plan. Currently, FAO-SWALIM with its historical data is considered as the central entity for risk knowledge. Since the collapse of the government the risk monitoring and warning services are done by the donor-driven FEWSNET, FSNAU, FAO-SWALIM, IGPAC programs for drought, floods, cyclones and other climate-related diseases and epidemics.

A systematic network of Early Warning System does not exist in Somalia. In the current arrangements, MoHADM (Federal level), HADMA (Puntland) and NADFOR (Somaliland), Hydro-meteorological Department under MoEWR, National Multi-Hazard Early Warning Center and Somali WASH Cluster are the main providers of early warning and climate information and are at the forefront of the risk reduction system in the country through provision of the required information and warnings are disseminated to the public through their websites and social media accounts and sometimes through mass media channels. However, responsibility for different elements of an effective EWS is divided between various institutions in Somalia as well as lacking technical and institutional capacity to disseminate timely early warnings and accurate hydrological information to enable the efficient and economic management of water resources.

There is limited capacity to systematically access, process, and integrate remote sensing products into hydro-meteorological services and EW systems. It is obvious that a community-based early warning system is much more effective than a system at the national level. Given that there is no systematic EWS and a clearly defined Standard Operation Procedure (SOP) for early warnings in Somalia, the issued warnings do not follow a previously defined communication way to reach to the communities at risk.

Overall, EWS in Somalia requires extensive attention and improvement. There is no doubt that the application of an early warning system is the most cost-effective and efficient measure for disaster prevention. The current setup for EWS faces numerous challenges that need to be addressed. The identified challenges are related to institutional arrangements, technical and technological capacity and financial resources. Each element of the EWS faces several specific challenges that are highlighted in the relevant sections.

1. Introduction

1.1 Background

The Federal Republic of Somalia is highly vulnerable to hydro-meteorological disasters and is ranked among the most vulnerable countries in the world to climate change. The climate of Somalia is considered either arid or semi-arid due to the fact that mean precipitation is less than potential evapotranspiration across most parts of the country (Muchiri, 2007). The country experiences different types of hazards such as floods, drought, stormy rains, accidents, and disease epidemics. Severe floods regularly overflow the river systems, displacing hundreds of people and impoverishing them with failed crops and livelihoods. Droughts periodically affect the country, negatively impacting on food security for many people. The impacts of disasters are enormous and have hindered the country's socio-economic development of the country. Establishing accurate and timely hydro-meteorological, early warning and climate information services is very critical for Somalia to minimize human and economic losses and to safeguard the economic gains that the country has achieved this far.

After many years of civil strife, Somalia is making progress towards rebuilding its hydro-meteorological and early warning institutions and recognizes the importance of quality public services. In addition to reducing loss of life and damage to assets, the productivity of key economic sectors in the country, such as agriculture, water resources management depends on the availability and access to quality weather, water, and climate information services. Ministry of Energy and Water Resources (MoEWR) takes issues of hydro-meteorological and early warning systems serious with goal to reduce the social, economic and environmental impact of hydro-meteorological disasters.

One way to effectively reduce hydro-meteorological disasters risks and adapt to climate change is by improving weather and climate information and early warning systems in Somalia. Monitoring climate, weather forecasting and climate change, impacts and using early warning systems to disseminate information to a wide range of stakeholders from national to local level are important components of successful long-term adaptation to climate change and disaster risk reduction. Currently, there are multiple ongoing early warning projects being implemented in Somalia, but there is little horizontal or vertical coordination between existing projects as well as national, district and community levels.

In 2020 the Federal Government of Somalia signed an agreement with UNDP to implement project entitled: Support for Integrated Water Resources Management to Ensure Water Access and Disaster Reduction for Somalia's Agro-Pastoralists. The main objective of the project under component two of the project "***Transfer of technologies for enhanced climate risk monitoring and reporting on water resources in drought and flood prone areas***" is to support the mitigation of climate shocks, and strengthen the weather, climate and hydrological monitoring capabilities, early warning systems and delivery of through precise and timely hydro-meteorological forecasts responding to extreme weather and planning adaptation to climate change in Somalia. The Global Environmental Facility is providing financial support for the project. As a way of providing baseline information on the current status, MoEWR conducted this comprehensive assessment of existing centralized and decentralized early warning systems in the country, including existing weather and climate information exchange mechanisms, communication channels and dissemination mechanisms between authorities, user agencies and end-users in order to recommend a way forward and standardize existing and future of Early Warning Systems (EWS) in Somalia.

1.2 Objectives of the assessment

The main objective of this assignment is to undertake a comprehensive assessment of existing centralized and decentralized early warning systems as part of transfer of technologies for enhanced climate risk monitoring and reporting on water resources in drought and flood prone areas, with aim to support the mitigation of climate shocks, and strengthen resilience through precise and timely hydro-meteorological forecasts.

- ***Specific objectives:***

1. Review of existing FRISC-DIGNIIN early warning systems and document their strengths and weaknesses, and propose areas of improve these systems to enable Somalia to have an effective and strong warnings observation network covering all the country based on standard of WMO.
2. Provide solid recommendations regarding potential impacts of climate change on Somalia and play critical role on raising the awareness of the community on climate change at different levels in the Somali society.

1.3 Methodology Adopted in the Study

On the basis of the evolved concept of EWS, a methodology was developed to accomplish the main objectives of the assessment. These objectives included the development of an assessment and analysis of existing EWS covering all the country, and the analysis of its adequacy according to the recommendations of international initiatives.

For the inventory, a systematic approach was followed supplied by different sources of information. The starting point was the work done on the Role of Climate information and Early Warning Systems in Supporting Disaster Risk Reduction in Somalia (Gure, 2021). Local experts and practitioners (including the authors of this study) have developed this work. Through literature reviews, interviews, and focus group discussions, these documents allowed to identify key stakeholders related to disaster risk management that may strengthen EWS and understand the existing policies, initiatives, and actions on EWS. In addition, local experts and practitioners were consulted to identify specific systems and operating initiatives currently in use by means of a short survey. It addressed the following issues: elements of the EWS to which the system is better related with (following the definition applied, explained above); the supporting agency for each system discerning between public and private; the geographical coverage of the system (national, regional, global); and the type and number of hazards that the system addresses. This allowed to develop the assessment and to analyze the currently available EWS. The next analysis, focused on the assessment, at the national level, of the adequacy of these systems according to guiding principles of global initiatives.

A comprehensive questionnaire has been developed, applied and completed by key stakeholders of the EWS currently operating in Somalia with focus on some issues related to standardization, updating and accessibility of information related to hazard, vulnerability and risk; technical modeling, automation and validation of processes; differentiation between hazard-based and impact-based approaches; the private sector; issues on technologies, on understandable and suitable warning systems and communications; and, on the EWS planning in the preparedness and response capabilities. Based on the questionnaire, face-to-face interviews were held to receive responses from the main stakeholders related to EWS currently operating in Somalia. Geographical Information Systems (GIS) with other powerful tools used in this study.

1.4 Structure of the Report

This report provides overview of Early Warning Systems (EWS) for the climate-induced natural hazard in Somalia, in order to identify past achievements and current and future entry points for further improvement of the system, with the ultimate goal of reducing disasters risks. The report is divided into four chapters.

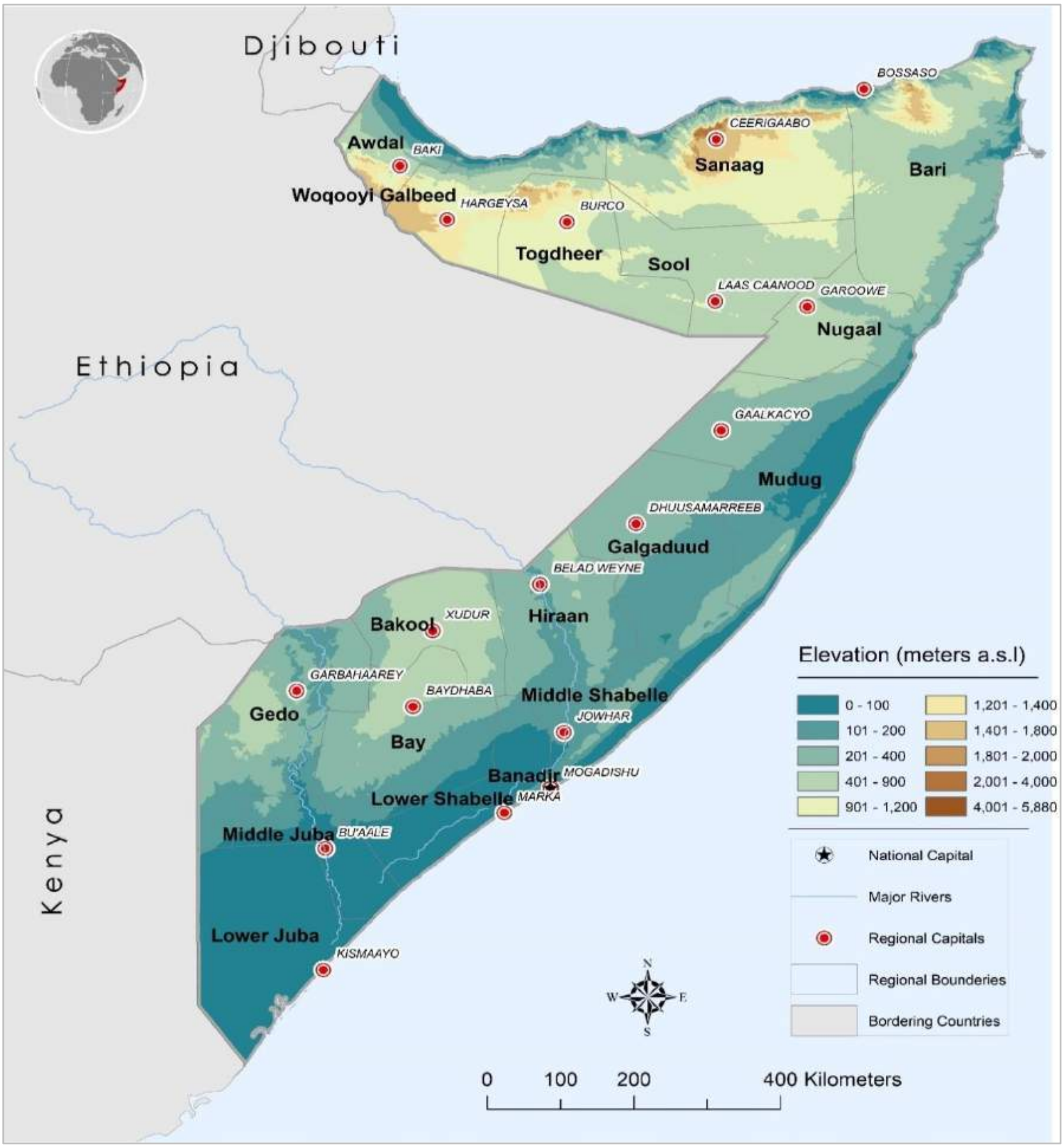
The first chapter of the report provides background about the assignment and the methodology adopted to conduct this study. The second chapter of the report provides an overview of geographical features, weather and climate of Somalia, the chapter also presents the historical background of climate-induced disasters in the country. The third chapter of the report provides an overview of the basics of a EWS and the CBEWS. The fourth chapter of the report provides an overview of the current state of EWS in Somalia. The chapter focuses on the current legal framework of EWS, the institutional arrangement of EWS, and the current status of EWS, highlighting its major challenges and provides recommendations. The fifth and last chapter of this report is conclusions and recommendation includes the key findings and critical issues, the way forward and annexes.

This report identifies that, despite having no systematic EWS at the national level, the relevant legal documents recognize the importance of having an effective EWS in order to reduce disaster risks. Somalia has the foundations for the establishment of an efficient institutional arrangement for application of a EWS network at the national level.

2. Geographical Features, Weather and Climate Risks

2.1 Study area

Federal Republic of Somalia is an arid and semi-arid land located in the Horn of Africa. Its 637,700 km^2 are bordered by Ethiopia to the west, Djibouti to the northwest, the Gulf of Aden to the north, the Indian Ocean to the east, and Kenya to the southwest. The country is divided into seven states Somaliland, Puntland, Galmudug, Hiirsabelle, Jubaland, Southwest and Banadir each subdivided into districts, and the largest city, Mogadishu, is also the capital. Somalia's terrain consists mainly of arid and semi-arid plateaus, plains, and highlands[1] (Fig 2.1).



[1] World Bank. (n.d.). Somalia Country Metadata

Figure 2. 1 Elevation Map of Somalia

Within such an arid environment, the most prevalent livelihood of livestock rearing is constrained by the increasingly limited resource base. With average rainfall of <500mm and high evapotranspiration, rain-fed forage production is limited. Somalia's predominant natural resource-based livelihoods are extremely vulnerable to the impacts of climate change, particularly high mean surface temperatures, floods and droughts. Recurrent devastating droughts and irregular rainfalls that vary according to location and season pose a serious and growing threat to Somalia's sustainable development.

2.2 Geographical Features

Distinct geographical areas in the country include: the northern coastal plain of Guban comprised of semi-arid terrain; the northern highlands which are rugged mountain ranges that rise from the Guban region and contains the country's highest peak (2407m); the Ogaden region which descends southwards from the highlands and consists of shallow plateau valleys, wadis and broken mountains which continue until the Mudug plain in central Somalia (Federico and Giovanni, 2000). The northern region of Somalia also contains the Golis Range Mountains, which run parallel to the Gulf of Aden and ends at Cape Gardafui. The southern part of the country hosts the only two permanent rivers (Jubba and Shabelle) which support the country's agricultural area; and supplies water to the largest city, Mogadishu. Somalia lies downstream of nine river basins including Gulf of Aden, Tug Der/Nugaal, Daroor basins in the north, and Jubba, Shabelle, Lag Badana and Lag Dera river basins in the south, central costal and Ogaden basin in central areas (Fig 2.2). Its topography generally slopes in a south-eastern direction towards the Indian Ocean (Awise, 2009 cited in SWALIM, 2012). The highest elevations are in the northeast along the Golis Mountains in the Gulf of Aden. South of the Golis range of mountains the topography of Somalia can be classified as gently sloping with average slopes of less than ~ 1-2% (Kammer, 1989 cited in SWALIM, 2012).

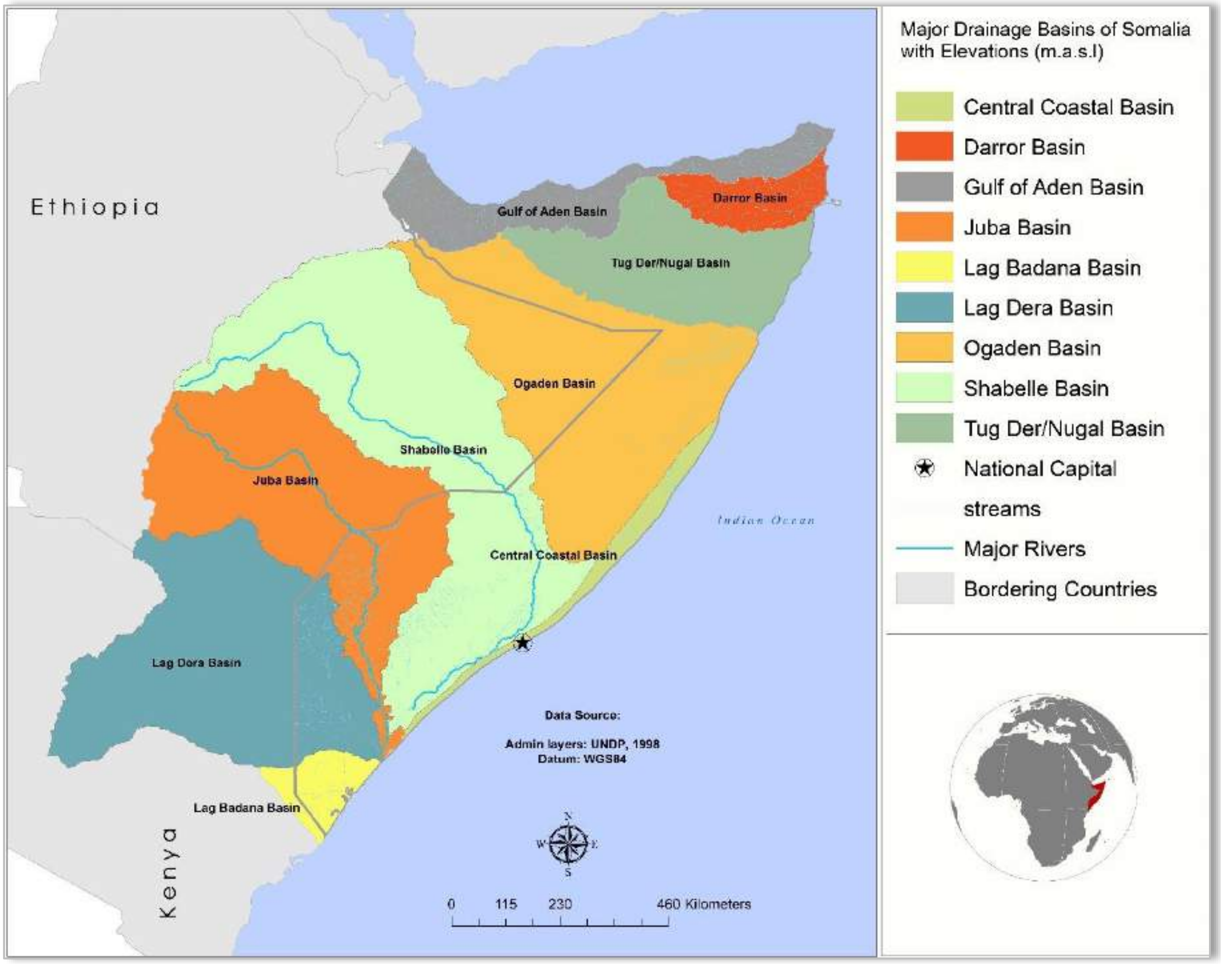


Figure 2. 2 Major River Basins of Somalia

The Jubba and Shabelle are the main and only permanent rivers, both located in the south. Due to the soft valley and ridge topography in large parts of the basins these river basins are the two major catchments contributing to surface flow in southern Somalia. These rivers have large catchment area that contribute to high peak floods during the wet seasons. The Laag Dheera catchment joins the Jubba basin in the lower reaches of southern Somalia (SWALIM, 2012).

The Jubba and Shabelle river basins are shared with Ethiopia, and Kenya, with the most parts of both basins lying outside of Somalia's border. Approximately 30% of the Jubba river basin lies within Somalia, and only 25% of the Shabelle basin lies in Somalia. Originating in the Ethiopian highlands the Jubba and Shabelle traverse the gently sloping terrain in Somalia. At its confluence with the Jubba River, the Shabelle River Basin is 297,000 km^2, of which two-thirds are in Ethiopia and the rest in Somalia. After its confluence with the Shabelle, the Jubba River flows downstream through to the Indian Ocean. Somaliland and Puntland are incised with significant dry river valleys (wadis) that flow only during the wet seasons. Groundwater is usually abundant in quaternary aquifers along all major river valleys. In most of the country, groundwater is frequently saline or brackish and not usable for drinking water or irrigation, and exacerbated by overconsumption in large agricultural areas.

2.3 Land use and Land cover

Approximately 50% of Somalia's land area can be considered as permanent pasture, while 13% is suitable for cultivation (UNDP, 2010). Much of the country is arid and semi-desert making it relatively unproductive for agriculture, with nomadic pastoralism a prevailing livelihood among rural communities (Fig 2.3). Pastoralism is the predominant landuse in Somalia and consists of nomadic pastoralism with a growing private sector livestock export industry (Shaie, 1997). This industry provides the greatest source of revenue in Somalia, surpassing crop production fourfold in value. The livestock industry employs over 60% of the population and livestock earnings account for over 80% of Somalia's foreign exchange earnings (GTZ, 1990).

The country comes second in global sheep exports after Australia. Goats, sheep, camels, and cattle are the predominant animals reared by pastoralists. Other types of landuses include rain-fed agriculture, irrigated agriculture and forestry. Most of the northern part of Somalia is dry and cannot support rain-fed agriculture except for small pockets of land in the areas around Hargeisa, Gebiley and Borama. In the rest of the region, sparse rainfall means that agriculture is only possible where there are alternative groundwater sources to support irrigation. This is common within the alluvial plains where shallow wells and permanent springs provide supplementary water for irrigated Pastoralism in Northern Somalia agriculture.

In the South, rain-fed agriculture is practiced in the Shabelle and Jubba river basin. There are two crop growing seasons, coinciding with the Gu and Deyr rain seasons. The crops grown include sorghum, millet, maize, groundnuts, cowpeas, mung beans, sesame, cassava and vegetables. These crops are produced for both human consumption and animal fodder. Crop production is limited by factors such as shallow and stony soil, low soil moisture, rainfall variability, soil erosion and low soil fertility. Irrigated agriculture is practiced in the floodplains along the permanent rivers in south Somalia (Jubba and Shabelle) and along the seasonal streams and springs. In northern Somalia, water is available within pockets of deep soil for irrigated orchards, or from shallow wells and springs, which are the major sources of water for crop irrigation, with water pumped to the fields. Irrigated crops grown on a small scale include maize, sesame, fruit trees and vegetables, while crops such as bananas, guava, lemon, mango and papaya are grown on a large scale for domestic consumption.

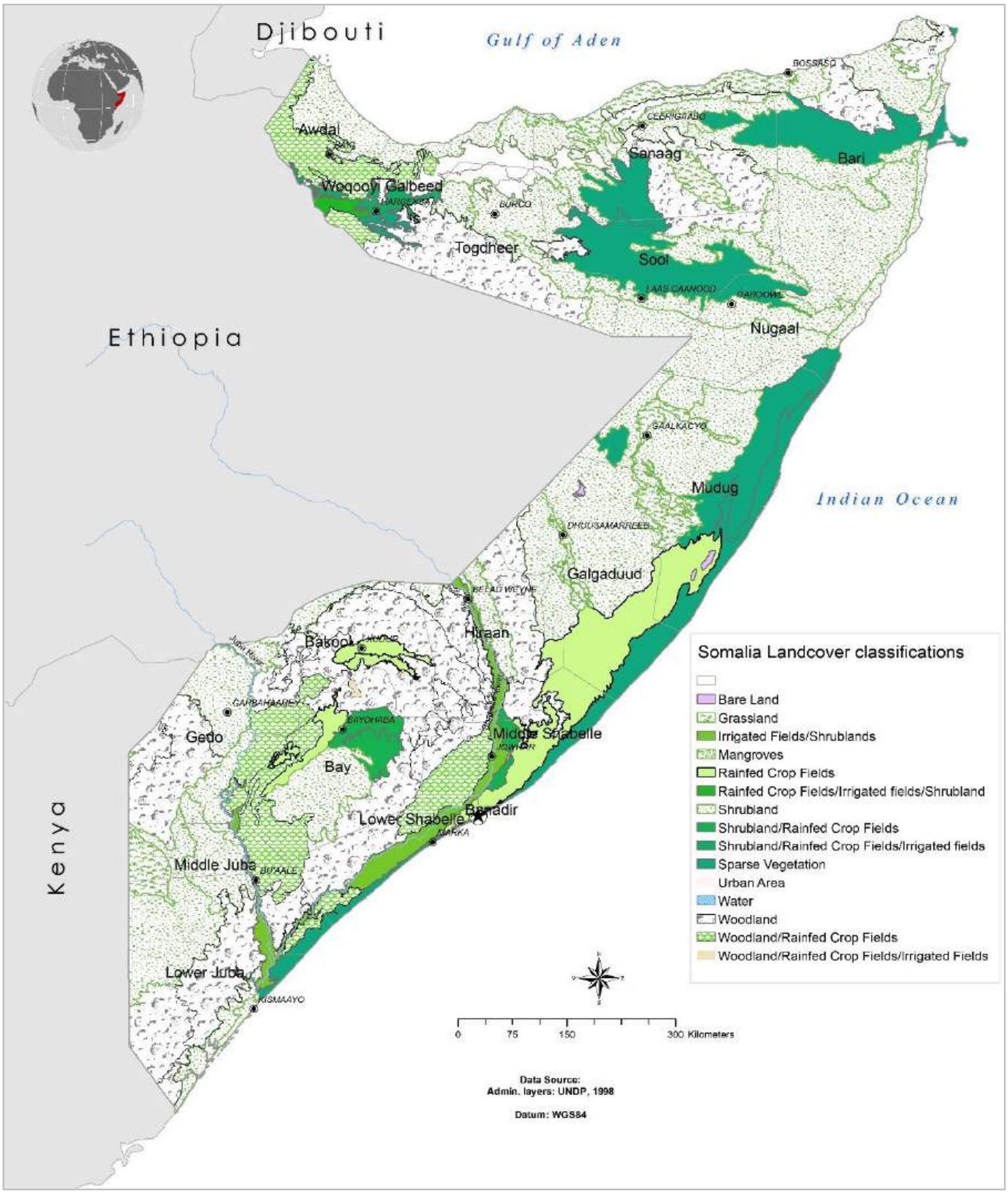


Figure 2. 3 Economic Activity and Land Use in Somalia

The vegetation in Somalia is varied and ranges from the forests of the Golis mountains in the North to the bush land in the Lag Badana ecosystem of the South (Mumuli, et al 2010). Patches of mangroves are found in Zeylac, Berbera and Calula on the northern coastline and in Kismayo on the southern coast Expansive the vegetation in Somalia is varied and ranges from the forests of the Golis Mountains in the North to the bush land in the Lag Badana ecosystem of the South (Mumuli, et al 2010). Patches of mangroves are found in Zeylac, Berbera and Calula on the northern coastline and in Kismayo on the southern coast Expansive grasslands are found in Puntland and sparsely covered sand dunes cover a band of several kilometers along the coast. Inappropriate land use has led to the original vegetation cover being heavily degraded, especially in northern Somalia, and in various places it has been entirely destroyed. According to Mumuli, et al 2010, the spatial distribution of vegetation in Somalia is as follows:

1. The coastal plains vegetation consists mainly of herbaceous plants. The vegetation in this region extends to the feet and slopes of the Golis Mountains. Close to the mountains, the predominant vegetation is sparse bushy Acacia, Balanites aegyptiaca, and Commiphora associations including Boswellia species.
2. In the hinterland plateaus, vegetation is dominated by open shrubs and woody plants of Acacia bussei, Acacia etbaica, Boscia spp, Cadaba spp, and Acacia mellifera. Some herbaceous plants (mainly Chrysopogon aucheri and Sporobolus spp.)
3. In the northern Golis mountain range the vegetation consists of evergreen trees of Junperus procera and Juniperus excelsa and open shrubs of Buxus hilderbrandtii, Dodonea viscose and Terminalia brownii, etc.
4. In the central plains, vegetation varies from extensive grassland along the fixed dune areas to shrubby bushland with scattered trees in the west toward the Ethiopian border. Plants and bushes include Andropoon kelleri, Chrysopogon aucheri, Soporobolus ruspolianus, Indigofera ruspolii, Acacia spp., Commiphora spp., Cordeauxia edulis, Delonix elata, Terminalia orbicularis and Dobera glabra etc.
5. In the southern regions (especially in the floodplain), the vegetation type is mainly low deciduous bushland of Acacia spp. which extends to the coastal dunes. At certain points along Jubba River there are sections of riparian forest.

2.4 Weather and Climate

Somalia generally can be divided into two climatic zones with an arid zone in the northernmost and central regions, and a semiarid zone in small area in northwest, northern mountains and most of southwest, with two seasonal rainfall seasons. Climate in Somalia is influenced by a number of factors, including the Inter-Tropical Convergence Zone (ITCZ), monsoonal winds and ocean currents, jet-streams including the Somali Jetstream or Somalia Current, easterly waves, tropical cyclones, neighboring Indian Ocean and Red Sea conditions. The climate also varies across the country with the topography and the country can be divided into different physio-geographic zones: northern coastal zone which has the highest variation in temperature and the driest zone in Somalia (Fig 2.4).

The Karkaar Mountains in the north occurs close to the Gulf of Aden and extends from east to west. Interior Plateaus cover most of the central and southern part while plains border the coastline and widest in the south. In the south, there are two perennial rivers: Jubba and Shabelle Rivers which come from the Ethiopian Plateau and flood in some years when there is a heavy rainfall in Ethiopia. The plain between the rivers in the south has the highest agriculture potential in Somalia and frequently affected by flood.

Annual mean temperature is close to 30°C throughout the country except in the northern highland, with an average annual daytime temperature of 27°C. Average monthly temperatures reach their maximum during the months of April through June. June to September is the hottest months in the north, while December to March marks the hottest weather for the south (Fig 2.5).

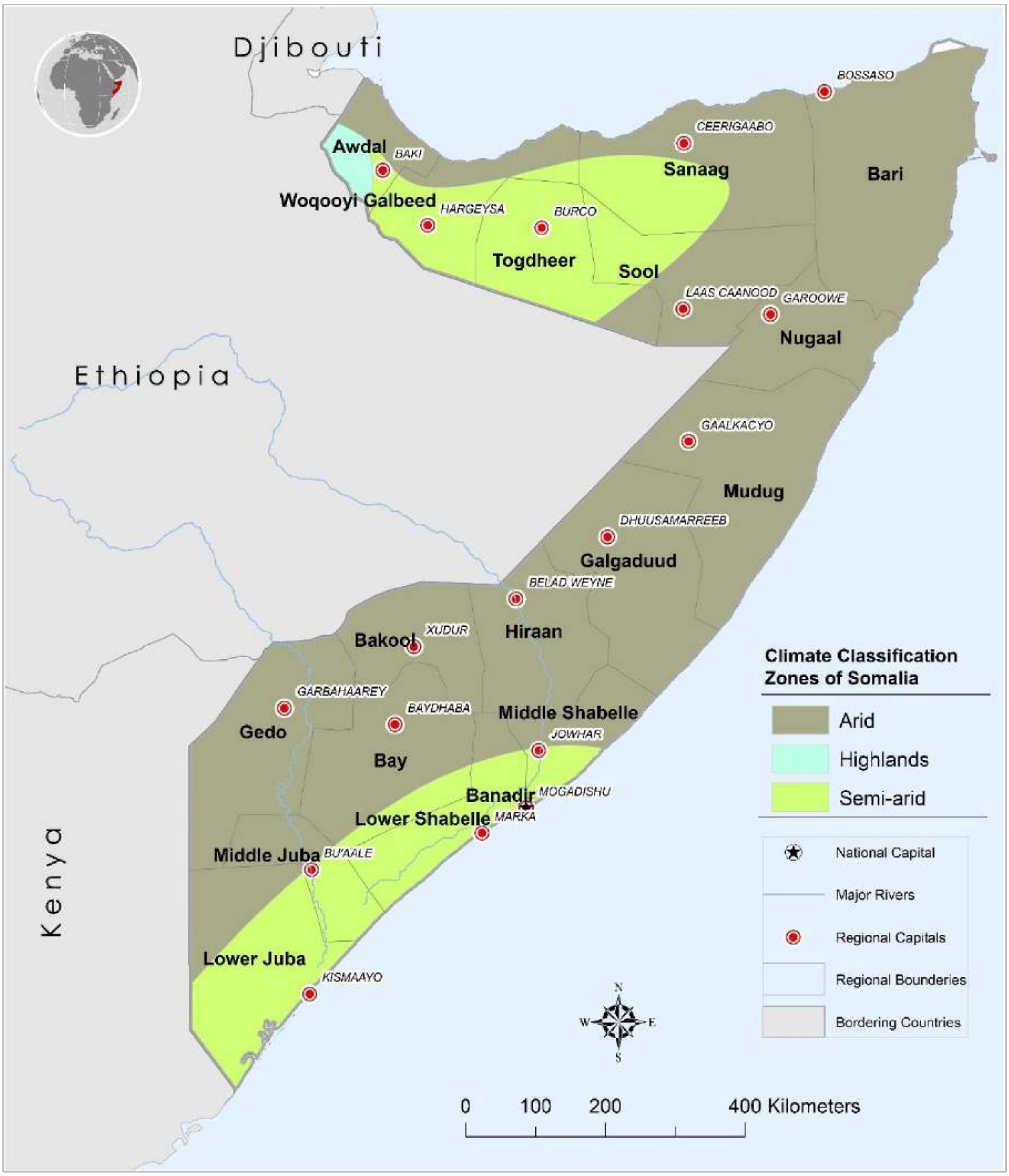


Figure 2. 4 Climate Classification Zones of Somalia

Precipitation is generally low across the country and takes the form of showers or localized torrential rains, subject to high spatial and temporal variability. The average annual rainfall is about 200mm in most parts of the country. Only the northern coastline receives significantly less rainfall (only up to 50mm), 500mm in the northern highlands, about 150mm in the interior plateau. Rainfall in the south is higher at approximately 400mm and highest in the southwest with around 600mm rainfall on an annual average (Fig 2.6).

The Gu rain season starts as early as the second half of March. Precipitation intensifies in April across the country, except for the north-eastern coastline which receives the least amount of rainfall during this season. In June, rainfall starts to reduce in most parts of Somalia. The southern coastline continues to receive little rainfall. Significant rains occur in July through August. The second rainy season (Deyr) is characterized by a shorter duration and less amounts of precipitation in the months of October to the end of November. Annual potential evapotranspiration (PET) is more than 2000 in the north especially in north coast of Gulf of Aden with 2900mm. In south, it is about 1500-2000 near the coast (IUCN, 2006). PET increases from south to north due to increasing of temperature which make PET greater than precipitation in most of the country. The El Niño Southern Oscillation (ENSO) influences Somalia's climate variability in several ways, bringing more rainfall and flooding during El Niño and droughts in La Niña years (UNDP/ICPAC, 2013).

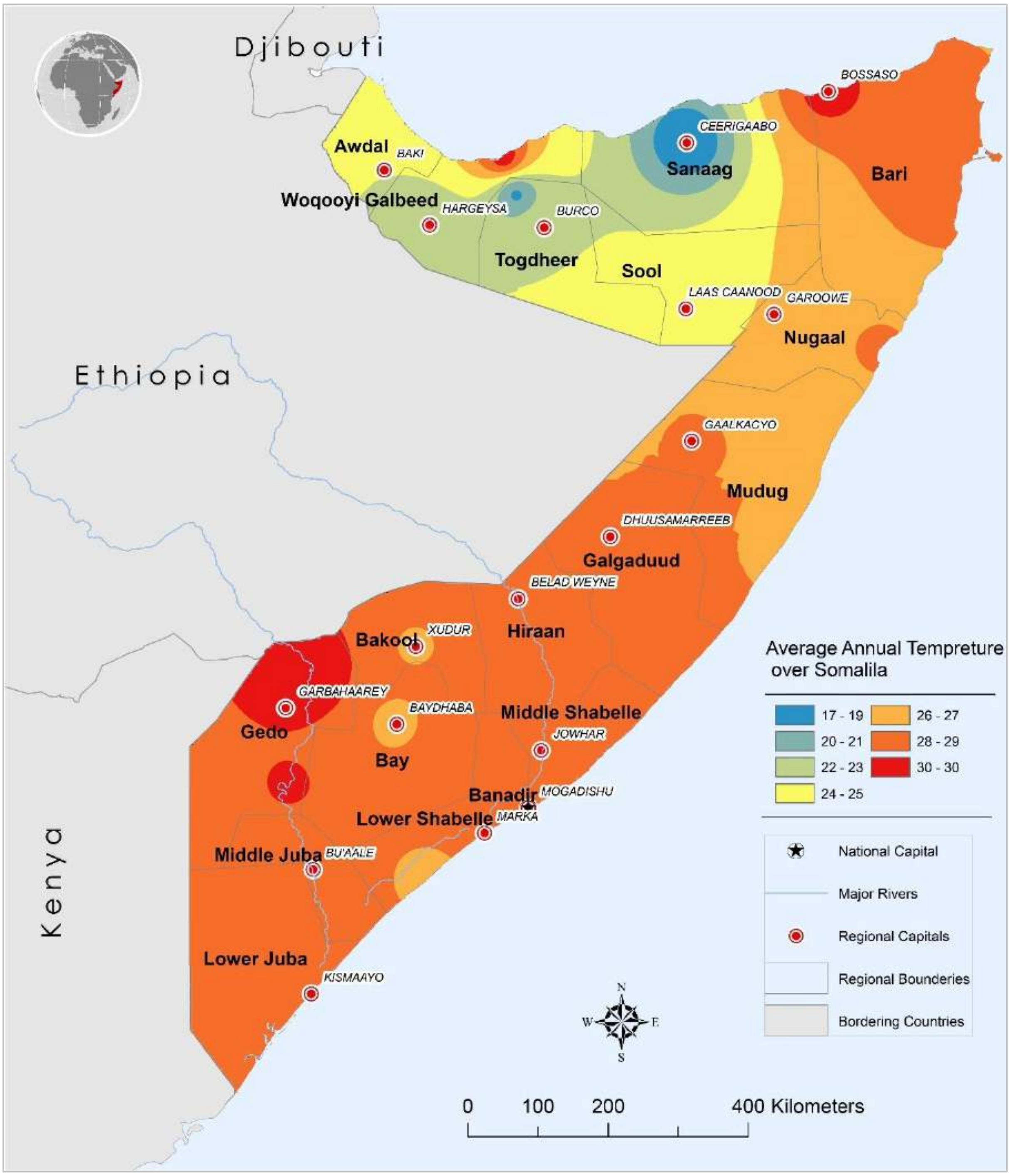


Figure 2. 5 Average Monthly Temperature and Rainfall, Series 1901–2020

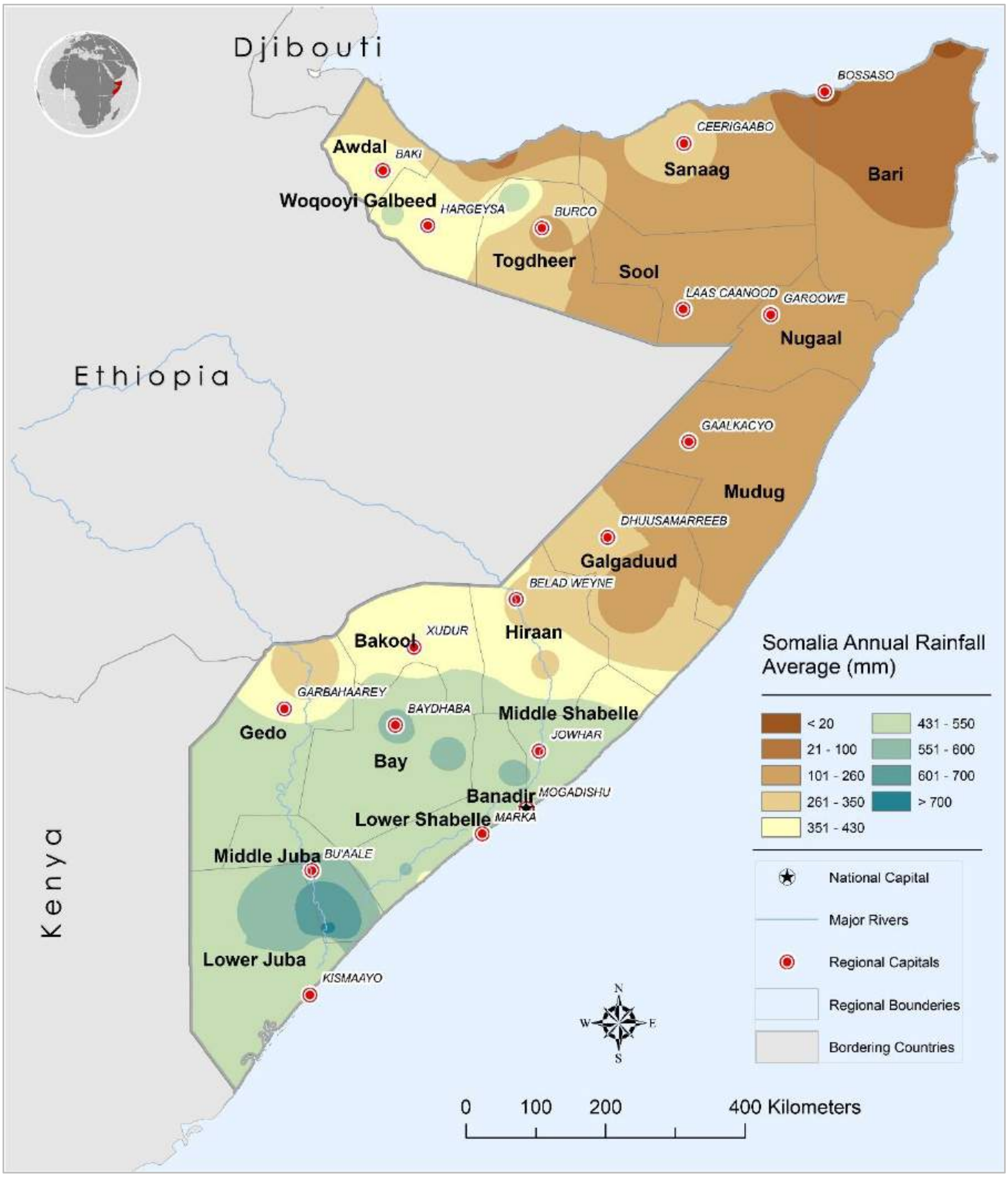


Figure 2. 6 Spatial Variability of Mean Annual Precipitation in Somalia

2.4.1 Recent Climate Trends

Climate variability and change already strongly affected population food security, drinking water supply and irrigation, public health systems, environmental management, and lifestyle across Somalia. The following is key historical climate trends are summarized for the country (since 1960, unless otherwise noted):

- Since the 1960's, a warming trend has been observed in Somalia.
- All average temperatures in the past decades have been higher than normal, and the period between 1991 and 2016 was one of the warmest periods on record.

- An increase of between 0.5°C and 1.5°C has been observed in the absolute maximum monthly temperatures in the past three decades. The average increase in minimum temperature is 1.5°C and the increase is most significant in April and May.
- Rainfall is increasingly erratic, with marked seasonal deficits when compared to long term past averages. The changing dynamics are associated decreases in crop and livestock production and increasing food deficits.
- Significant increase in rainfall has been registered for the months of April – May and October – November and the period between 1991 and 2016 was recorded high rainfall rates.
- Heavy rainfall events appear to be increasingly frequent, with changes in rainfall patterns, including decreased reliability and less predictability.
- The number of extreme events is likely to increase and droughts appear to be increasingly frequent.

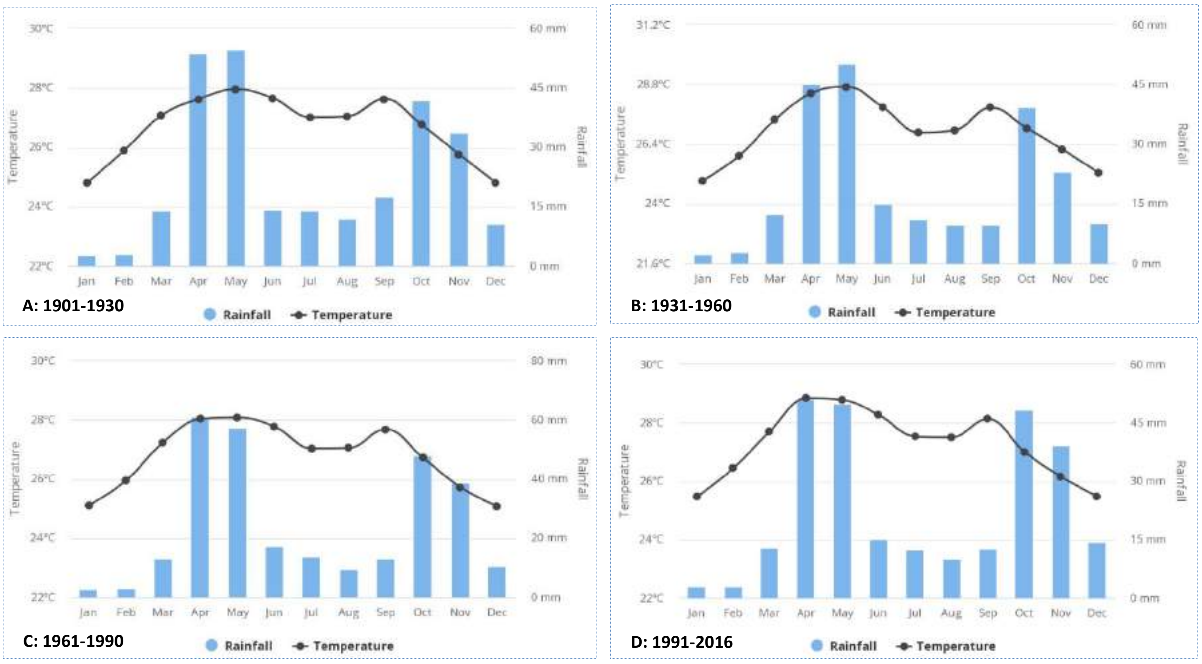


Figure 2. 7 Average Monthly Temperature and Rainfall of Somalia for 1901-1930, 1931-1960, 1961-1990 and 1991-2016[2]

2.4.2 Future Projections for Rainfall and Temperature

The simulated temperature and rainfall data derived from the Coordinated Regional Downscaling Experiment (CORDEX) RCMs of three models HadGEM-ES, MPI-ESM-LR and GFDL-ESM2M were compared with the observed data from 50 stations, some with pre-war data and others with both pre-war and post war data (SWALIM, 2019).

The models have been run for historical period covering the period from 1981 until 2005 and future projection 2006 up to 2100. The results for future projections of rainfall and temperature are given for IPCC sub periods 2031 – 2060 in the near future, and 2071-2100 in the far future, relative to a reference period of 1981-2010. Analysis of the projected rainfall indicated a decreasing trend in rainfall leading up to 2030 followed by an increase in the near (2031-2060) and far future (2071-2100) compared to the reference period (1981-2010).

[2] Somalia water and land Information Management project (SWALIM), 2021

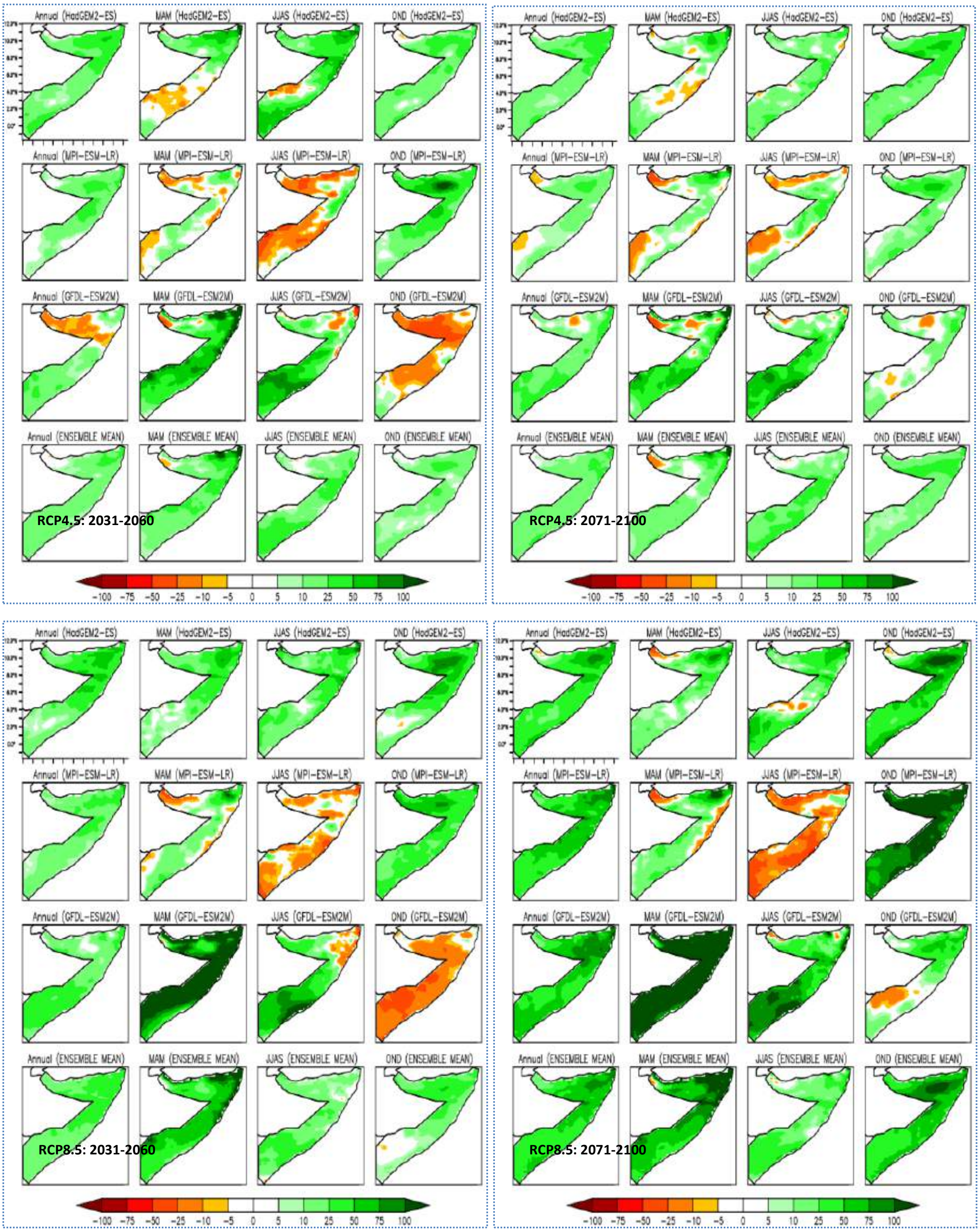


Figure 2. 8 Projected rainfall changes (%) over Somalia in near future (2031-2060); far future (2071-2100) from different models for different seasons during RCP4.5 and RCP8.5 scenario respectively

Under RCP4.5 and RCP8.5 scenarios, mean annual rainfall is expected to increase by between 5% and **10%** over much of Somalia. Future plans should therefore focus in areas and seasons where substantial changes are expected to occur.

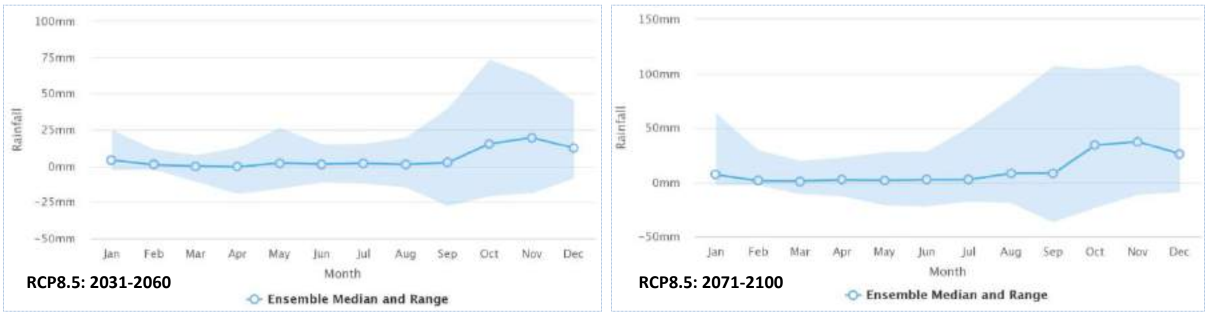


Figure 2. 9 Projected change in monthly precipitation for Somalia for near future (2031-2060); far future (2071-2100) during RCP8.5 scenario[3]

Figure 2.10 shows the recorded number of days with very heavy rainfall (20mm/day) each year for 1986-2005, and projected values for 2020-2100 and recorded 5-Day Cumulative Rainfall for 1986-2005 and projected 5-Day Cumulative Rainfall 10-yr Return Level by 2050 under all RCPs of CIMP5 ensemble modeling. Note, the shaded ranges illustrate the inter-model differences.

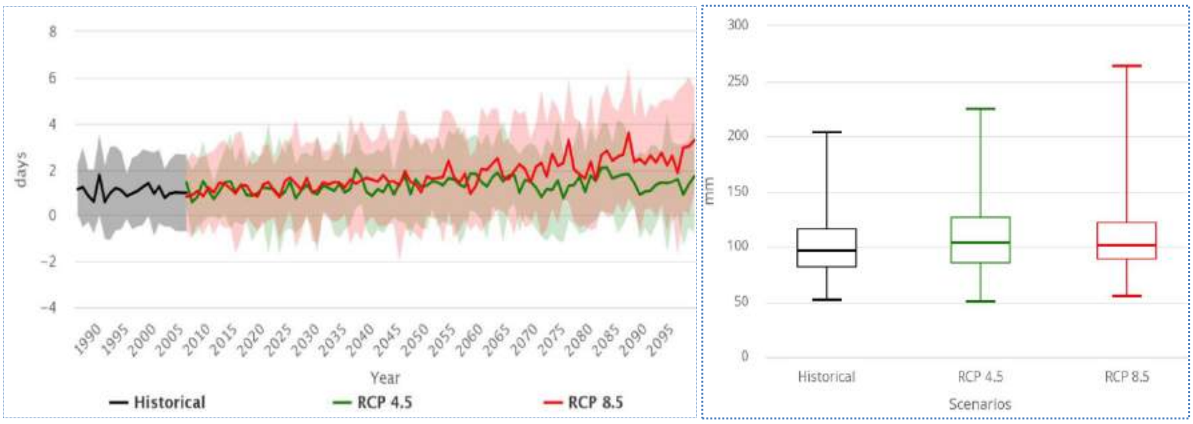


Figure 2. 10 Number of days with very heavy precipitation in Somalia for period: 1986-2099 (left) and 5-Day Precipitation: 10-yr Return Level in Somalia for period: 2040-2059 (right)[4]

In the case of temperature, the projections from all the models showed increase in minimum and maximum temperatures under both scenarios with RCP8.5 and RCP4.5 in the near (2031-2060) and far future (2071-2100) compared to the reference period (1981-2010), like being observed by temperature projection over other parts of the world.

The projected temperature change scenarios show that Somalia future development and livelihoods will in future face increased threats of climate extremes unless effective climate smart adaptation systems form integral components of national development strategies. Results however show that projected change in temperature will vary from season to season and district to district. The northern parts of the country are more likely to be warmer compared to the southern parts. Under RCP4.5 scenario, the temperature increase by the end of the century relative to the reference period (1981-2010) is expected to be between 1.5 and 2.5°C.

[3] Mean or change in monthly precipitation compared to the reference period (1981-2010). In general, the value of monthly precipitation change varies between -100 and +200 mm.
[4] EM-DAT: The OFDA/CRED International Disaster Database

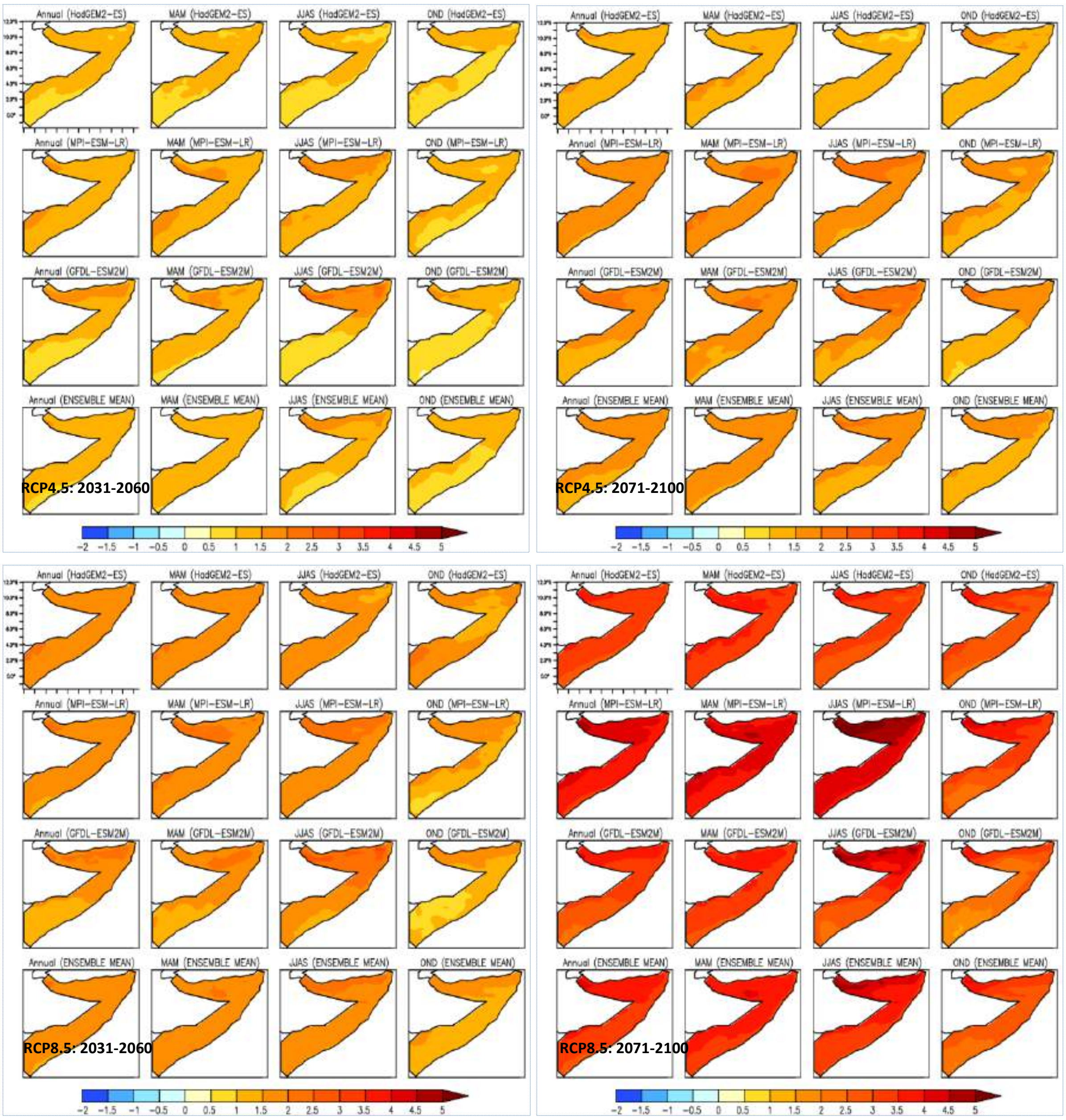


Figure 2. 11 Projected changes in mean temperature over Somalia in near future (2031-2060); far future (2071-2100) from different models for different seasons during RCP4.5 and RCP8.5 scenario respectively

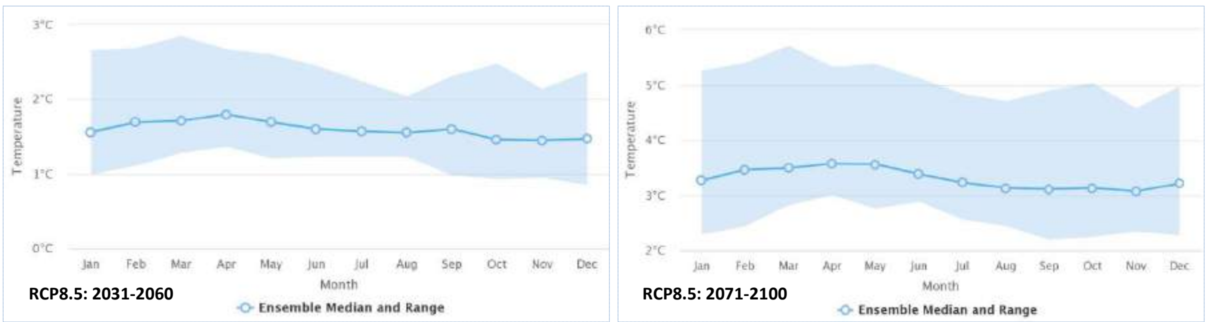


Figure 2. 12 Projected Change in Monthly Temperature for Somalia for near future (2031-2060); far future (2071-2100) during RCP8.5 scenario[5]

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[5] Mean or change in monthly temperature compared to the reference period (1981-2010). In general, value of monthly temperature change varies between 0 and 4 degrees.

The spatial patterns of temperature changes in the far-future (2071-2100) were similar to those in the near future despite the changes are much bigger under RCP8.5. The warming is likely to be less in the southern parts of the country compared to the northern parts. The northern parts are expected to experience up to 3°C under RCP4.5 scenario compared to 5°C under RCP8.5 scenario. Results from the temperature time series (Fig 2.13) show an increasing temperatures in both the near to long term future. This is in line with global and regional reports that project an increase in the average temperature by 2060 and a further increase by 2100[6, 7,8.]

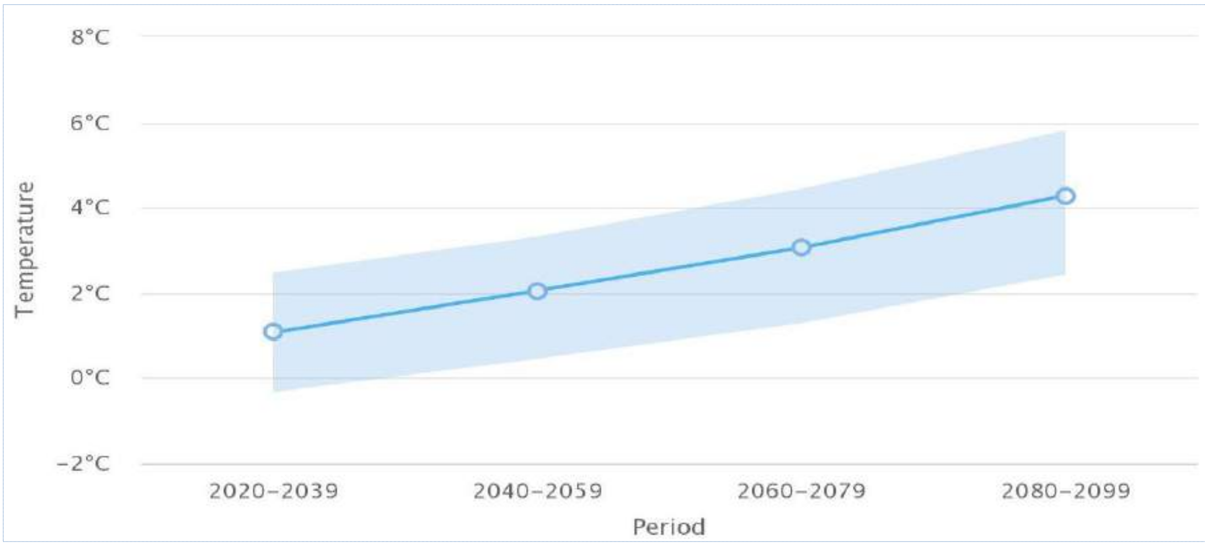

Figure 2. 13 Projected change in average temperature 2020 -2099

2.5 Historical Background of Climate-Induced Natural Disasters in Somalia

Somalia has faced severe challenges linked to climate variability, which has been exacerbated by conflict and limited governance that persisted for decades. Somalia, a member of the World

[6] IPCC. (2014), Africa. In: *Climate Change 2014: Impacts, Adaptation, and Vulnerability. Part B: Regional Aspects.*

[7] Few, R., Seytal, P., McGahey, D., Leavy, J., Budd, J., Assen, M., Bewket, W., et al. (2015) Vulnerability and Adaptation to Climate Change in Semi-Arid Areas in East Africa. ASSAR Working Paper, 111

[8] Anyah, R.O. and Qiu, W. (2012) Characteristic 20th and 21st Century Precipitation and Temperature Patterns and Changes over the Greater Horn of Africa. International Journal of Climatology, 32, 347-363. https://doi.org/10.1002/joc.2270

Meteorological Organization (WMO), is classified as the least developed country by the UNFCCC, has been devastated not only with the long-lasting civil war but also by the natural disasters.

Many of the hazards affecting Somalia that originate from hydro-meteorological events such as heavy precipitation prolonged dry spells or extreme temperatures that have adversely affected the lives, property, and livelihoods of the Somali people for centuries. These are primary hazards which lead to secondary and tertiary hazards, including floods and flash floods, drought, cyclones and other climate-related diseases and epidemics. Floods and flash floods follow weather events, either heavy rain. While droughts could result in heat waves and water scarcity, both droughts and frosts will result in damage or loss of crops and important impacts on human and animal health. Pest and disease outbreaks may be triggered by drought or excess precipitation. The distinction of hazards in such a cascading manner is the first step in progressing from weather forecasts and warnings to multi-hazard, impact-based forecasts and warnings (Table 2.1).

Table 2. 1 Primary, Secondary and Tertiary Hazards Cascading from Hydro-meteorological Events

Event	Primary Hazard	Secondary Hazard	Tertiary Hazard
Thunderstorm	- Heavy rainfall - Strong winds - Lightning	- Flash floods - River floods	- Damage to structures, embankment, irrigation and drainage facilities, pumping facilities - Submerging fields - Loss of infrastructure systems and services (shelter, energy, transport, schools, hospitals, communications) - Widespread economic losses - Infectious disease - Insect and pest problems - Sand and silt deposition - Waterborne diseases - High sediment runoff into reservoirs
Drought	- High temperatures - Heat waves - Less rainfall	- Water scarcity - Low flow - Less inflow - Crop damage	- High evaporation loss in reservoirs - Shortage of storage water in reservoirs - Insufficient diversion in channels - Salt-affected soil - Salt-affected soil - Energy shortages - Pumping system difficulties
- **Extreme** - **Temperature**	- Heat waves - Heat-related complications with livestock and animals	- Heat stroke - Biological hazards - Stress on vegetation - Water insecurity	- Socioeconomic impacts - Hydropower shortage - Changes in groundwater level - Waterborne diseases - Food shortages

Climate change in Somalia is not an uncertain, “potential” future risk but a genuine, present threat whose impacts have already been felt by the Somali people across the country. Somalia has a low capacity to adapt to climate change because of its poor socioeconomic development. The vast majority of Somali’s rural population is highly susceptible to climatic uncertainty – they live in deserts or marginal and infertile areas, often with highly erodible soils, poor ground cover, and limited water supplies where food security is a serious concern. During the past 28 years, Somalia has been affected by six moderate-to-strong El Niño events in which floods of different magnitudes were reported (Fig 2.14). These floods led to the collapse of virtually all large irrigation schemes and damaged the major flood relief channels, roads and other major infrastructure. The flood recurrence at the Jubba and Shabelle Rivers pose significant flooding risks along the two rivers, mainly in the middle and lower reaches. Observational data for the 1985-2018 period show that drought, floods, cyclones, and climate-related diseases and epidemics, whose frequency, occurrence, and impacts have increased in recent years, already pose a significant risk to the country's vulnerable population. In recent decades, this has led to massive problems of food insecurity and population exodus from the worst-hit areas.

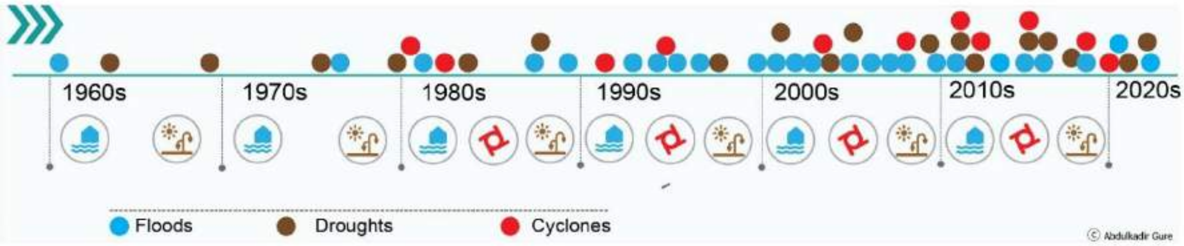

Figure 2. 14 Historical natural disasters (droughts, floods and cyclones) in Somalia (Source: Gure, 2021)

The country is home to a large pastoralist population, living on poor quality pasture lands, and the impact of climate-related changes on livestock production could be significant. According to the World Bank's Natural Hotspots Study, 43% of Somalia's land area is exposed to flooding and droughts which entails that 54% of the population is highly exposed to climate extremes. The charts below (Fig 2.15) provide overview of the most frequent natural disaster in a given country and understand the impacts of those disasters on human populations.

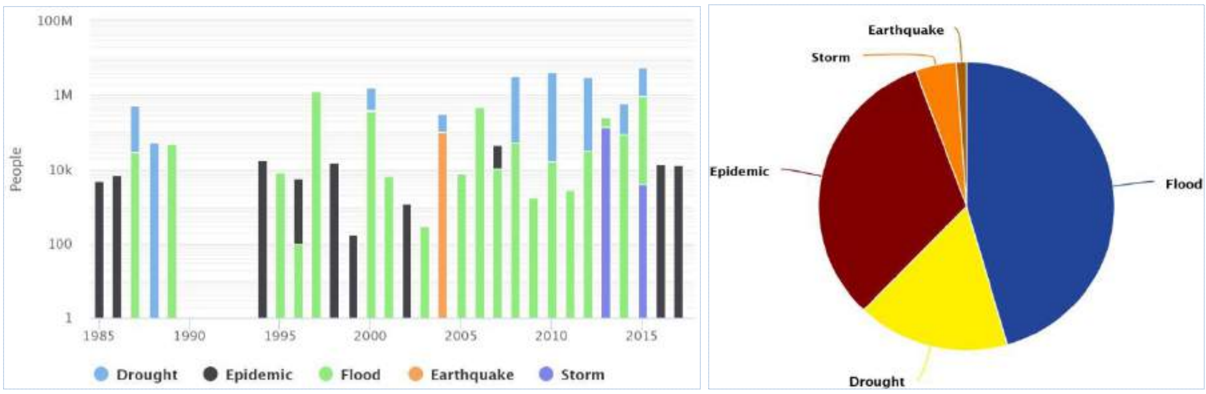

Figure 2. 15 Key Natural Hazard Statistics for Somalia 1985-2018 (Left); Average Annual Natural Hazard Occurrence for 1900-2018 (Right)[9]

2.5.1 Floods

During the rainy season, the Jubba and Shabelle river basins in southern Somalia are often impacted by extreme flooding in the riparian zones. Flash floods are frequent in the seasonal rivers in the north (SWALIM, 2015; Roba et al, 2013; Guleid et al, 2007). Temporal patterns of high rainfall variability exacerbate flood events (UNDP/ICPAC, 2013).[10] When mild and frequent droughts occur, they are often followed by devastating floods (Roba et al, 2013; SWALIM, L-14, 2009). Intense rainfall and flash flooding contribute to sedimentation of the river channels and deterioration of the riverine bunds. Flood diversion schemes are often required (e.g., Duduble Flood Relief Channel (DFRC) and Jowhar Off stream storage Project (JOSP)). However, the topography in the lower reaches of the Shabelle River is particularly unfavorable to containing the river, with the riverine areas being raised above the surrounding flood plain. This means that even a minor breach in the river embankment can result in widespread flooding as the river escapes from its perched position into the surrounding floodplain. Damages from low return period flooding are therefore significantly

[9] EM-DAT: The OFDA/CRED International Disaster Database, Université Catholique de Louvain, Brussels, Belgium.
[10] Somalia National Action Programme (NAP) to the United Nations Convention to Combat Desertification (UNCCD)

higher than one might expect when compared to areas where the extent of flooding is confined by topography rising away from the river.

The river system in the Middle Shabelle has now declined to the point where some flooding is expected during each high flow season (i.e. twice per year). This has become the expected course of events during a typical year and causes significant hardship through destruction of infrastructure, inundation of crops, loss of livestock, loss of life and in some cases the relocation of many thousands of people. Scarce human and physical capitals are directed to implementing prevention measures against the flooding. Severe climatic events, such as heavy rainfall during an El Nino year, would add another layer of hardship and would undoubtedly be catastrophic for the region, as was the case during the 1997 floods.

Floods are annual phenomena with the most severe occurrence during the months of March-May and September-November in the riverine areas along the two rivers, Jubba and Shabelle. Riverine and flash floods occur in areas around the Jubba and Shabelle river valleys every year between April to June and October to December (*See* Fig 2.16). Limited infrastructure, including flood-bank retaining walls and water catchment or redirection systems, expose the communities to the effects of floods annually, often with disastrous results on small-holder farmers and rural economies. The regions of Lower Shabelle & Middle Shabelle are most affected, with croplands, houses and infrastructure like feeder roads periodically destroyed, besides affecting the livelihood of pastoralist population.

In the time periods of 1961–1990 and 2002–2018, there were six severe flooding events along the Jubba and Shabelle Rivers. The major floods took place in the Deyr of 1961, Deyr of 1977, Gu of 1981, Deyr of 1997, Gu of 2005, and Deyr of 2006 and Gu of 2018. The floods of 1997/1998 and 2018 were the worst seen in the riverine areas in living memory. Major floods that usually affect most of the riverine areas are due to heavy rainfall over the Ethiopian highlands. Before the 1997/1998 floods, the worst floods to hit the areas along the upper Shabelle in Somalia were the 1981 Gu floods; along the Jubba, the floods of the Deyr of 1977 were the worst.

The Gu 2018 floods are some of the worst that has ever seen in the riverine areas, and the water level exceeded a 50-year return period in most locations. In 2018, the Gu floods, for instance, 215,000 people have been displaced and over 630,000 affected by floods (UNOCHA, 2018). The Gu 2018 rainy season started off well in advance (two to four weeks earlier than normal) in many parts of the country during the month of March and significant rainfall continued to spread spatially in the first and second decades of April and persisted through early May. The season was generally good in most parts of the country, with many places recording normal to above normal rains. However, the heavy rains seen within the Jubba and Shabelle river basins inside Somalia and in the Ethiopian highlands translated to increased river levels of Jubba and Shabelle in Somalia. The subsequent flooding caused by these heavy rainfalls has led to fatalities, massive displacement, and damage to infrastructure and cropland. The Jubba which enters Somalia approximately 70Km from the border with Ethiopia (near the town of Luuq in the Gedo Region) runs through a mountainous terrain to Somalia; but as it reaches near the town of Baardheere, floods do occur affecting farming, animals and homes.

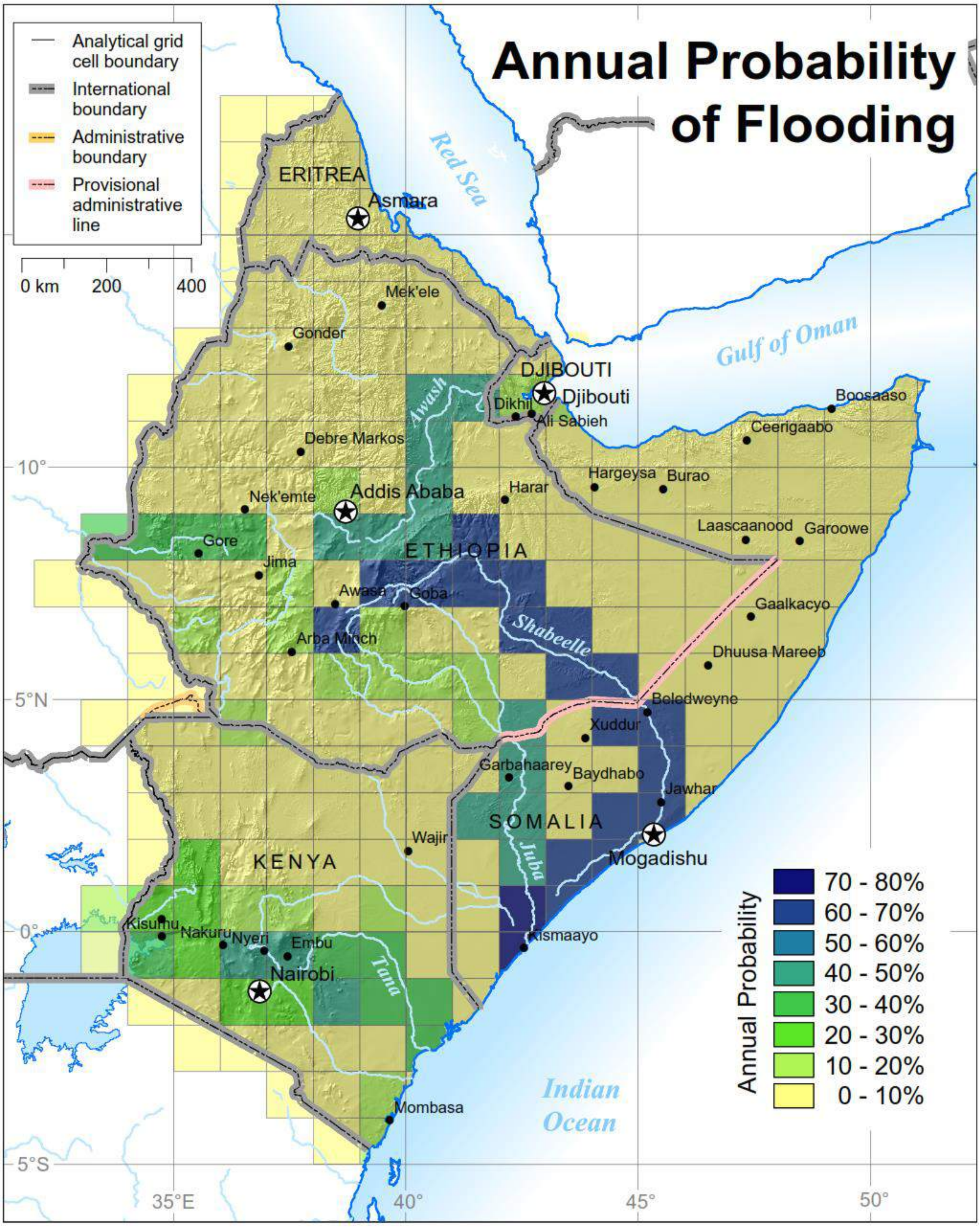

Figure 2. 16 Annual Probability of flood in Somalia[11]

Starting from Bardheere which is in Gedo region up to the point where it runs into the Indian Ocean, the Jubba River causes floods over a significant area of land inhabited by a large number of people. On the other hand, Puntland and Somaliland usually experience serious flash flood disasters during the heavy rains that results in damage to property and loss of lives. They both have a hot and arid climate and a short rainy season with occurrences of intense rainfall events that can result in flash floods. Flash flood events frequently trigger disasters because of the lack of warning and prevention measures in place.

[11] source: UNISDR, 2009

2.5.2 Droughts

Failure of rains in either season (Gu and Deyr) is very common causing crop losses and drying up of pastures with persistent dry conditions. Somalia's Arid and Semi-Arid Lands (ASALs), which make up more than 80% of the country's landmass and house the greatest national proportion of pastoralists in Africa are particularly vulnerable to extreme weather conditions (*see* Fig 2.17). Nearly 70% of Somalis are dependent on climate-sensitive agriculture and pastoralism. The pastoralists depend upon rain-fed rangeland grazing for their livestock and tend to have very few fixed assets.

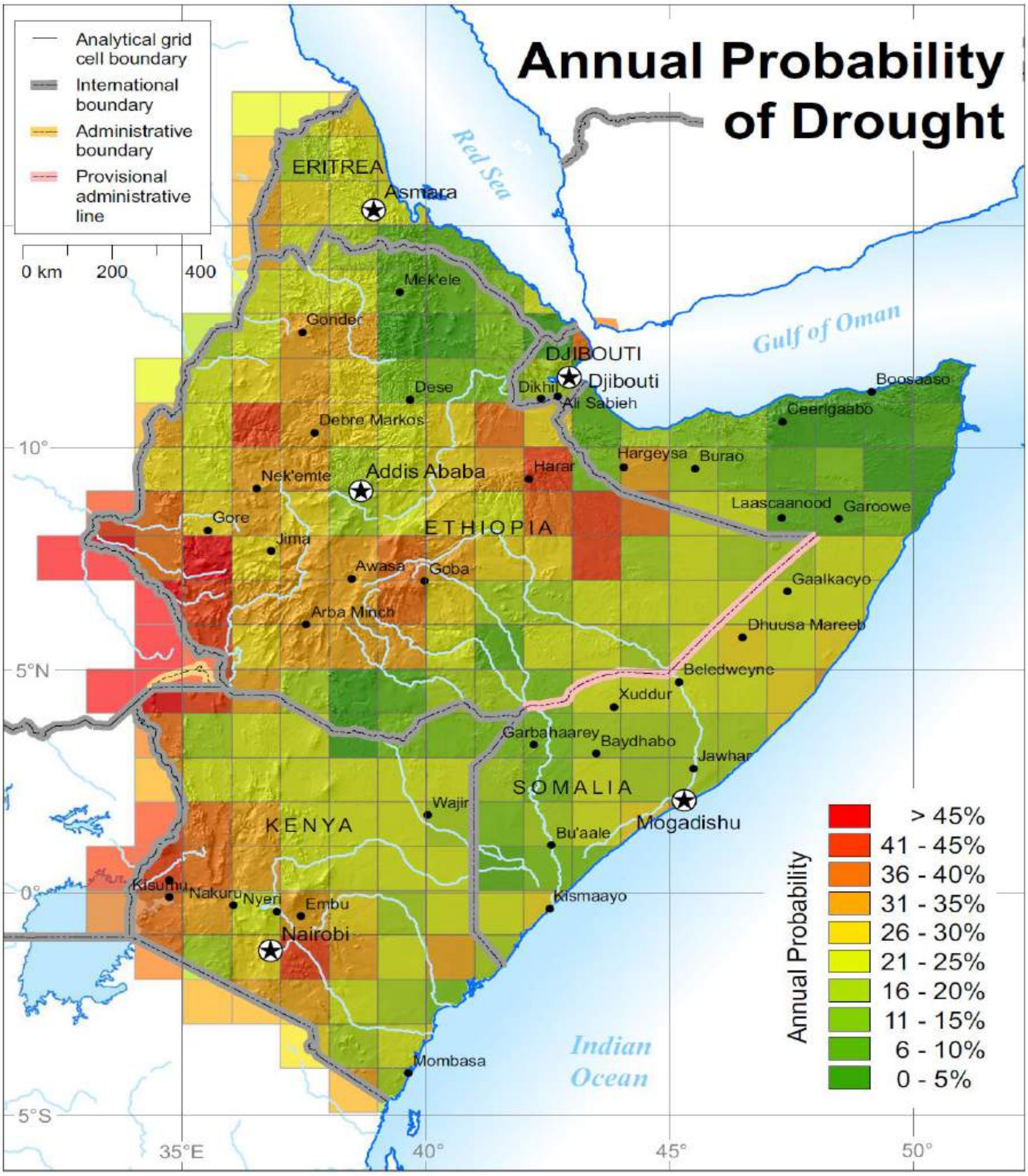

Figure 2. 17 Annual Probability of Drought in Somalia[12]

Throughout the course of history of Somalia, drought has been a problem affecting its welfare and food security as well as other water dependent sectors. During the period between 1960 and 2018,

[12] source: UNISDR, 2009

the country has experienced several massive droughts. The droughts that occurred in 1973/1974, 1984, 1991, 2010/2011 and 2016/2017 were most intense and widespread. On top of that, over the past several years, drought has been occurring virtually once every two years in most parts of the country. It starts in some zones and slowly spreads to the rest of the country because of seasonal shifts and increased dryness. The main underlying causes of most droughts in Somalia can be related to changing weather patterns manifested through the excessive buildup of heat on the earth's surface, meteorological changes which result in a reduction of rainfall, and reduced cloud cover, all of which results in greater evaporation rates. Poor water resource management and governance as well as population growth pressures on natural resources have also accelerated the impact of droughts. As a result, droughts usually affect most parts of the country, leading to livestock deaths, and increasing food and water prices, which makes it increasingly difficult for poor families to feed themselves. Drought produces a complex web of impacts that extents many sectors of the economy and reaches well beyond the area experiencing physical drought. The drought hazard differs from other natural hazards such as floods and its effects often take long to appear because of its creeping nature.

Over the past three decades, Somalia has experienced a cycle of protracted droughts including two famines. A famine in 1992 killed nearly 300,000 people and displaced 1 out of 5 people whereas the 2011 famine has claimed the lives of 260,000 people following several seasons of very low precipitations. Somalia was the country hardest hit by extreme drought in 2011 that affected over 13 million people across the Horn of Africa region. Famine was first declared in July 2011 in Somalia's Southern Bakool and Lower Shabelle regions, but later spread to other areas, including Middle Shabelle, and inside camps for displaced people in the Mogadishu. In recent years, the Shabelle River has had some sections of the channel getting dry. While there are many reasons behind the drying riverbed, the main driver to this could be attributed to failed rainy seasons both in the Ethiopian highlands and inside Somalia. The drying of the Shabelle River has also caused a major displacement of riverine farming communities due to reductions in river flows to seek new employment opportunities in urban areas where they can more easily receive both aid and remittances.

The humanitarian situation in Somalia for example has become increasingly fragile in 2016, especially in the northern regions. Drought conditions were deepened in Puntland and Somaliland, and have expanded to southern and central regions, including Gedo, Hiraan, Galgaduud and Lower Jubba. The Deyr rainy season, which usually extends from October to December, had been poor, and high temperatures combined with limited amounts of rain in October 2016 that have led to drought conditions in most of parts of Somalia, ranging from moderate to extreme. The impact of drought in Somalia is compounded by climate change and the ongoing conflict and insecurity facing large parts of the country. Significant parts of southern Somalia continue to be contested or controlled by Al Shabaab, and the conflict impacts directly on people in terms of displacement and disruption to livelihoods and severely restricts the ability of aid organizations to access large parts of the country.

2.5.3 Cyclones

In Somalia, although the country is rarely affected by tropical storms, the northeastern and northwestern regions are occasionally hit by severe weather systems during the Northern Indian Ocean cyclone season. Such storms can cause significant flooding and devastate coastal communities, as well as bring an increased risk from water-borne diseases. Cyclones have particularly been active in Somalia in the past two decades as the country has experienced more than 5 major cyclones during the 2010s than in the 1980s, 1990s, or 2000s (Fig 2.14).

In recent years, major storms such as Cyclone Gati in 2020, Cyclone Sagar in 2018 and Cyclonic Storm Pawan in December 2019 have killed dozens and displaced thousands across northern Somalia. Cyclone Gati is widely believed as country's strongest storm on the past 50 years to make landfall in Somalia. Tropical Cyclone Gati made landfall on 22 November in Somalia and its impacts were felt primarily in parts of Bari and Sanaag regions of northern parts of Somalia but extended also into Yemen and western Oman. The heavy rains and strong winds triggered flash floods along coastal and inland areas.

In total, an estimated 70,000 people have been affected and significant portion of these populations have been displaced to higher grounds within their neighborhoods. In addition, shipping and fishing activities along the coastal areas of Bari and the Gulf of Aden have been disrupted. It is obvious that in the past few years, there has been a considerable increase in the frequency of such cyclones at the end of the Deyr season in Somalia. Tropical cyclones are fueled by available heat, and during the positive phase of the Indian Ocean Dipole (IOD), sea surface temperatures in the tropical western Indian Ocean are above average. In addition, climate change is contributing to sea surface temperature increases in the Indian Ocean and warming seas means more frequent or stronger cyclones.

2.5.4 Others

As a consequence of climate change, Somalia will be increasingly at risk of vector- and water-borne diseases (malaria, cholera, etc.). According to The World Health Organization (WHO), in 2017 the limited access to safe drinking water and poor sanitation and hygiene conditions led to a surge in diarrhea and cholera cases, 17,000 cholera cases and 388 deaths were reported. For the past two years, desert locusts have been a serious threat to food security and agriculture in parts of Somalia as a result of favorable climate and environmental conditions. Sea level rise poses significant threats to already declining water quality, particularly with respect to saltwater intrusion into the coastal aquifer. Saltwater intrusion into the aquifer from projected sea level rise poses a severe risk to the country's urban areas such as Mogadishu, Barbara and Bosaso due to the excessive pumping of groundwater, as well as overexploitation of surface and groundwater for municipal use. This is especially critical during the monsoon season when the predominant tides flow from the sea, bringing high salinity levels.

Climate change risks undermine the sustainability of basic livelihoods, threatening food security, health among other socio-economic impacts. Without proper adaptation measures, the projected increase in frequency and severity of weather and climate extremes will undermine the safety of ecosystems and health. The need to strengthen Somalia's capacity to deal with disasters, such as the protracted droughts and floods that it continues to face, is critical.

3. Early Warning System (EWS)

3.1 Introduction

Early Warning System (EWS) is an approach adopted by the governments, communities and societies to reduce the risk of potential hazards and enhance resilience. The United Nations International Strategy on Disaster Reduction (UNISDR) defines the Early Warning System as: “The set of capacities needed to generate and disseminate timely and meaningful warning information to enable individuals, communities and organizations threatened by a hazard to prepare and to act appropriately and in sufficient time to reduce the possibility of harm or loss.” (UNISDR, 2009)

Early Warning Systems are one of the most important elements for effective disaster risk reduction. They should provide, in their more holistic understanding, a comprehensive scheme from the upstream detection and analysis of hazards to the downstream warning communication and response actions. An estimated 90% of recorded major disasters caused by natural hazards were linked to climate and weather, including floods, storms, heat waves, and droughts. Governments are becoming aware that a paradigm shift from crisis management to risk management is necessary if the finite resources available are spent in the most efficient way to assist the populations at risk to prevent or mitigate disasters.

Over the past few years, international initiatives have focused on enhancing the effectiveness of EWS and strengthen cooperation among the various agencies involved. While much attention has been given to the upstream phase, less emphasis has been placed on the study of the downstream phase and in the significant and delicate linkage between both phases. The importance of these phases is highlighted by the specific objective of EWS, a risk reduction measure mainly focused on reducing the exposure of the population to different hazards, thus contributing to the reduction of the impacts faced by communities and to ensure public safety.

EWS is considered as one of the priority actions in the Hyogo Framework for Action (2005-2015). The framework encourages the development of the community-based (people-centered) EWS. With the adoption of the Paris Agreement on climate change, the Sustainable Development Goals (SDGs) and the Sendai Framework for DRR, the links between climate change adaptation, disaster risk reduction and sustainable development became clearer and internationally recognized. All three global frameworks have specific reference to EWS and recognize the importance of monitoring and early warning in reducing climate and risks vulnerabilities and enhancing resilience. Considering the adverse impacts of climate-induced natural hazards, the world recognized the importance of the early warning system to the safety and wellbeing of human beings. During the past two decades, EWS have gradually received more attention in the framework of the regional and international agreements, conferences, cooperation and action plans. The application of an effective EWS as a measure for disaster risk reduction and climate change adaptation can save lives and avoids economic losses. Therefore, there has been a global movement in integrating EWS into the global and national policies, strategies and action plans.

3.2 Elements of EWS

Early warning is a strategy adopted by many societies to reduce the impacts of disasters. EWS are often based on interconnections between visual observations, past experience, and cooperation to mitigate losses from upcoming hazards (Brazzola N, 2018). If correctly implemented, EWS can help to reduce losses of lives and property and to minimize environmental damage. All this coheres in a favorable cost-benefit ratio while also increasing safety. Effective early warning systems must integrate the following four inter-related key elements (EWC, 2006):

3.2.1 Risk knowledge

The knowledge of risk could be increased by systematically collecting data and undertaking risk assessments. The knowledge of risk could be increased by systematically collecting data and undertaking risk assessments.

- Are the hazards and vulnerabilities well known?
- What are the patterns and trends in these factors?
- Are risk maps and data widely available?

3.2.2 Monitoring and warning services

A climate-induced monitoring and warning system has to be in place considering the findings from the first element. For predicting and forecasting hazards there is a need for a reliable forecasting and warning system that operates 24/7 using sound scientific basis. Continuous monitoring of hazard parameters and precursors is essential to generate accurate warnings in a timely fashion. Warning services for different hazards should be coordinated where possible to gain the benefit of shared institutional, procedural and communication networks. Before issuing an accurate warning, the following questions should be answered:

- Are the right parameters being monitored?
- Is there a reliable scientific basis for forecasting?
- Can accurate and timely warnings be generated?

3.2.3 Communication and dissemination

Effective early warnings have to be communicated and disseminated to people to ensure communities are warned in advance of impending hazardous events and to facilitate national and regional coordination and information exchange. To communicate effective warnings, the message should be clear, simple, and critical. To ensure widespread dissemination of warning to endangered people, we should not stick to only one communication channel. To ensure that adequate warnings received by the public about the potential risk, the followings questions have to be answered:

- Does warning reach all of those at risk?
- Does the public understand the risks and warnings?
- Is the warning information clear and useable?

3.2.4 Response capability

The fourth key element of EWS is the response capability. This element is the most important part in EWS circle to safeguard the people being at risk. Communities must understand their risks, respect the warning and know how to react. For this part, education and public awareness are essential for vulnerable communities. For a successful response capability, the following questions should be answered regularly:

- Are response plans up to date and tested?
- Are the local communities trained on the use of the response plan, and is their traditional knowledge of the communities integrated into the plans?

- Are people prepared to react to warnings?

Nowadays, the global focus is on people-centered early warning systems. The objective of this approach is to enable individuals and communities prone to hazards to act in sufficient time and a convenient way to reduce the contingency of people injury, losses of lives, damage to property and the environment. For the efficiency of the people-centered EWS, the inclusion and interaction between four key elements: risk knowledge, monitoring and warning services, dissemination and communication and the response capability is essential (Fig 3.1).

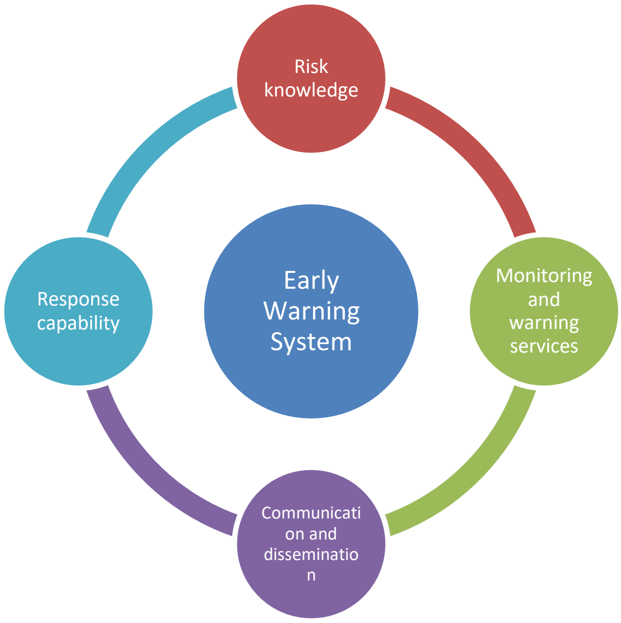

Figure 3. 1 Key elements of an early warning system

3.3 Community-Based Early Warning Systems

Community-based Early Warning System (CBEWS) is implemented in communities using a "people-centered" approach. CBEWS empowers individuals and communities to use and manage an integrated system of tools and plans that provide early warnings on hazards to reduce risks (Jack, 2010).

This system disseminates advance information to vulnerable communities, practitioners and involved organizations, on natural hazards in order to serve for prevention, preparedness, and response efforts. The system plays an important role in enhancing the resilience of hazard prone communities. For an effective CBEWS, it is crucial to consider all four elements defined for an Early Warning System. The communities and involved institutions: should have a good knowledge of the risks that are threatening them; should monitor the changes in risks and vulnerabilities of the communities; should disseminate and communicate the information and risks provide early warnings, and should have the response capability to reduce the risk once they receive the alerts.

"People-centered" approach is the main feature of a CBEWS. It is important that all members from the vulnerable communities and relevant actors are involved in planning, implementing, monitoring and dissemination of early warning information. Moreover, the community should take ownership of the system for its better functionality and sustainability. Efforts should be made to employ affordable and easily accessible technologies in a CBEWS. People from the community should be trained on how to use and maintain the technologies used in a CBEWS.

4. Current State of the EWS In Somalia and Stakeholders

4.1 Institutional and Organizational Analysis

4.1.1 Brief History of Hydro-Meteorological services in Somalia

Meteorological and hydrological observations constitute the first step in producing high-quality weather and flood forecasts with proper lead time, as well as providing baseline data for water resources management, drought forecasting, and a long-term climate trend. Depending on their purpose, stations record temperature, precipitation, pressure, humidity, evaporation, wind speed, solar radiation, soil moisture, depth, and density, and hydrological regime parameters (water levels, discharges, and reservoir storages) as well as agromet parameters (soil temperature and soil moisture). Monitoring and observation systems consist of observation stations as well as data transmission, telecommunication networks, and data processing and storage systems, that is, data management systems (WB 2018).

Hydrological and meteorological data collection and observation in Somalia started in the late 1894 by installation of first weather station in Kismayo. The hydro-meteorological network expanded rapidly and other stations were located in the coastal areas where Italian and British colonizers settled at the turn of the twentieth century. In the 1920s a more concerted collection of rainfall data began. Despite lack of data collection continuity at some stations, most of Somalia was covered with rainfall stations. The two oldest hydrometric stations are the uppermost stations of Luuq, in Jubba, and Belet Weyne in Shabelle, river basins respectively. Records of water level readings for the two stations are dated back to 1951. After independence in 1960, many of the old stations were strengthened. Direct river flow measurements were carried out between 1963 and 1989 by all agencies that were involved in hydrometric activities. Before then, no direct discharge measurements were carried out (Muchiri, 2007).

The Ministry of Agriculture then took over responsibility for the national weather monitoring network. Substantial amounts of data have since been located, especially rainfall data. There is evidence that the documentation was not up to date because the data that had been traced so far was obtained from different, not always reliable sources. Organizations that were involved in weather data collection included: The International Civil Aviation Organization (ICAO), British Meteorological Office (BMO), and other then existing development foreign-aided projects. Before 1990, Somalia had one of the best meteorological monitoring systems in the region, when the civil war in Somalia intensified, the whole weather recording system collapsed and this saw the loss of valuable data and unfortunately, most equipment were rendered non-functional or destroyed. The civil war and its aftermath led to degradation of traditional observation networks, prevalence of outdated and inefficient technologies, and lack of modern instruments and ICT. The absence of forecasts and weather information reversed years of development gains in farming and civil aviation operations.

In 1997 FAO-Food Security and Nutrition Analysis Unit (FSNAU) in collaboration with some NGOs and UN agencies re-established a few more rainfall stations in Somalia with the hope of reviving the network of weather observations. Unfortunately this network did not last long due to lack of maintenance and prevailing insecurity. Since the civil war and especially at the times when Somalia was particularly hard-hit by drought and famine early warning activities in Somalia relied heavily on satellite data for rainfall estimates.

In 2002, FAO Somalia Water and Land Information - SWALIM project started efforts to rehabilitation of non-functional weather stations network and installation of new stations throughout Somalia. This has been a welcome initiative which will generate essential ground data to supplement satellite predictions. The network is still extremely sparse with no river level radar sensors and groundwater sensors functioning in the south. Since then, SWALIM has been reinstated and is the lead agency in collecting, processing and reporting of weather data including temperature, precipitation and weather forecasts.

All hydro-meteorological data that have been recovered is archived in HYDATA, which is dedicated database software that has the capability to store and analyze hydro-meteorological data developed by the Institute of Hydrology. The database contains both historical and current river level data. The parameters of the rating equations for all of the stations are also included in the HYDATA database. For the past 5 years, the FAO SWALIM, IGAD-ICPAC and USAID's FEWSNET initiatives have focused on improving regional forecasting for Somalia, making use of the rehabilitated network of monitoring stations in addition to stations abroad. Currently, there are four types of hydro-meteorological monitoring stations some of them are not functional (SWALIM, 2021) including 13 automatic weather stations, 110 manual rain gauges, 9 synoptic stations (Fig 4.1 and 2) which collect a variety of data as explained here;

1. Automatic Weather Station (AWS): This is a station that automatically transmits or records observations obtained from measuring instruments. In an AWS, the measurements of meteorological elements are converted into electrical signals through sensors. The signals are then processed and transformed into meteorological data which is then stored in a database.
2. Manual Rainfall Station (MRS): This is a station that a rain gauge is used to gather and measure the amount of liquid precipitation over an area in a predefined period of time. It is used for determining the depth of precipitation (usually in mm) that occurs over a unit area and thus measuring rainfall amount. The measurements or readings are done manually.
3. Synoptic Station (SS): These are instrument which collects meteorological information at synoptic time 00h00, 06h00, 12h00, 18h00 (UTC) and at intermediate synoptic hours 03h00, 09h00, 15h00, 21h00 (UTC). The common instruments of measure are anemometer, wind vane, pressure sensor, thermometer, hygrometer, and rain gauge.

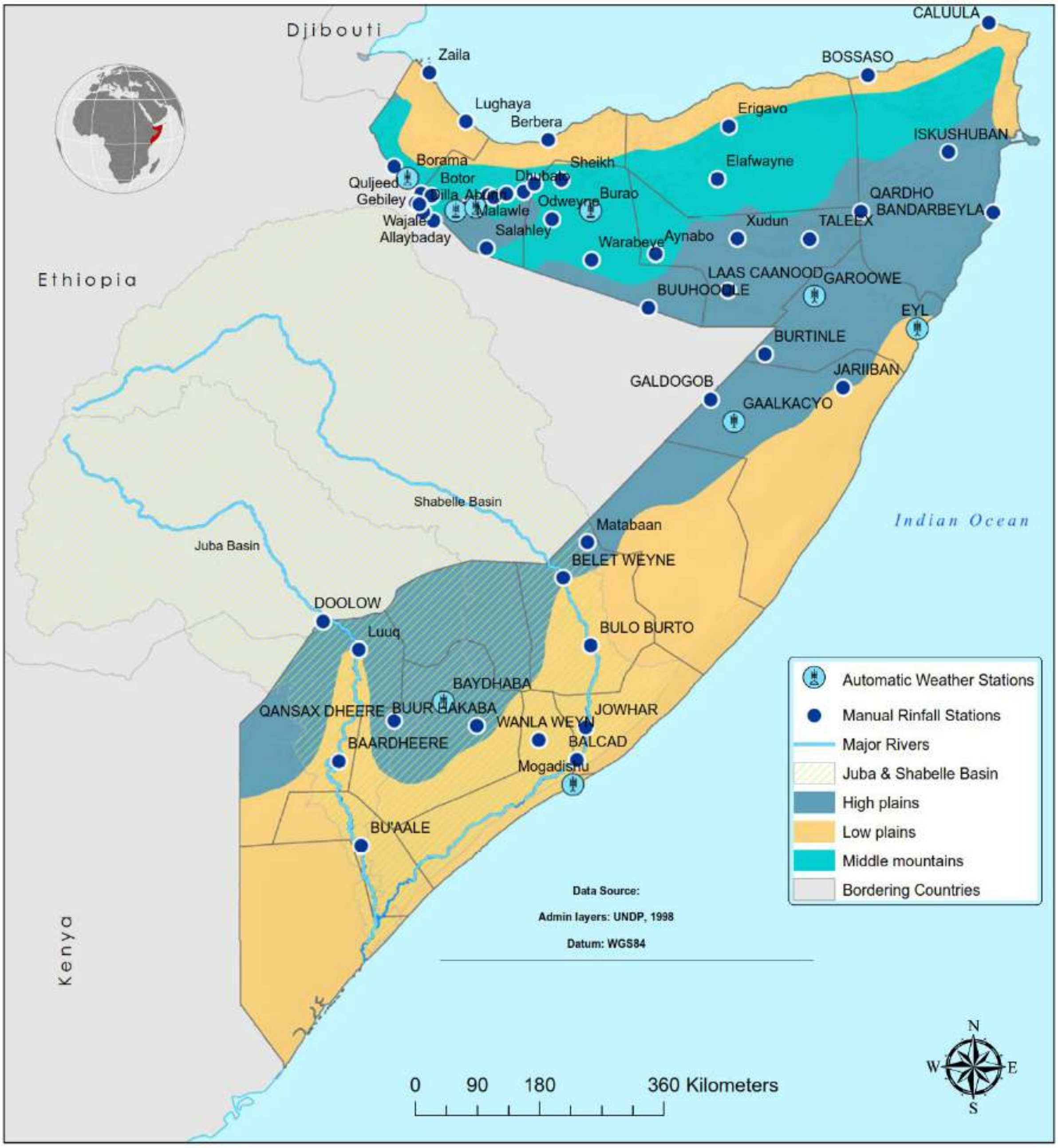

Figure 4. 1 Locations of Rainfall Stations in Somalia

Hydrological data collection and analysis started in Somalia with the installation of hydro-meteorological stations in Jubba and Shabelle Basin. In total 16 River Gauging stations installed along Jubba and Shabelle River (SWALIM, 2021), some of them are not functional, and albeit at different levels of data reliability and latency (see Table 4.1).

Table 4. 1 Location and operation status of river gauging stations in Somalia

#	Station Name	River	Longitude	Latitude	Operation Status
1	**Luuq**	Jubba	42.54264	3.79172	Functional
2	**Bardhere**	Jubba	42.28115	2.33989	Functional
3	**Bualle**	Jubba	42.57317	1.24477	Functional
4	**Dollow**	Jubba	42.07938	4.18777	Functional
5	**Mareere**	Jubba	42.70000	0.45000	Non-Functional
6	**Kaitoi**	Jubba	42.66667	0.78333	Non-Functional
7	**Kamsuma**	Jubba	42.77392	0.25111	Non-Functional
8	**Mogambo**	Jubba	42.73333	0.15000	Non-Functional

9	**Jamamme**	Jubba	42.68333	0.01944	Non-Functional
10	**Belet Weyne**	Shabelle	45.20596	4.73598	Functional
11	**Bulo Burti**	Shabelle	45.56727	3.85702	Functional
12	**Mahadey Weyne**	Shabelle	45.53038	2.97098	Functional
13	**Jowhar**	Shabelle	45.50486	2.77872	Functional
14	**Balad**	Shabelle	45.39167	2.35000	Non-Functional
15	**Afgoi**	Shabelle	45.12500	2.14444	Non-Functional
16	**Audegle**	Shabelle	44.83333	1.98611	Non-Functional

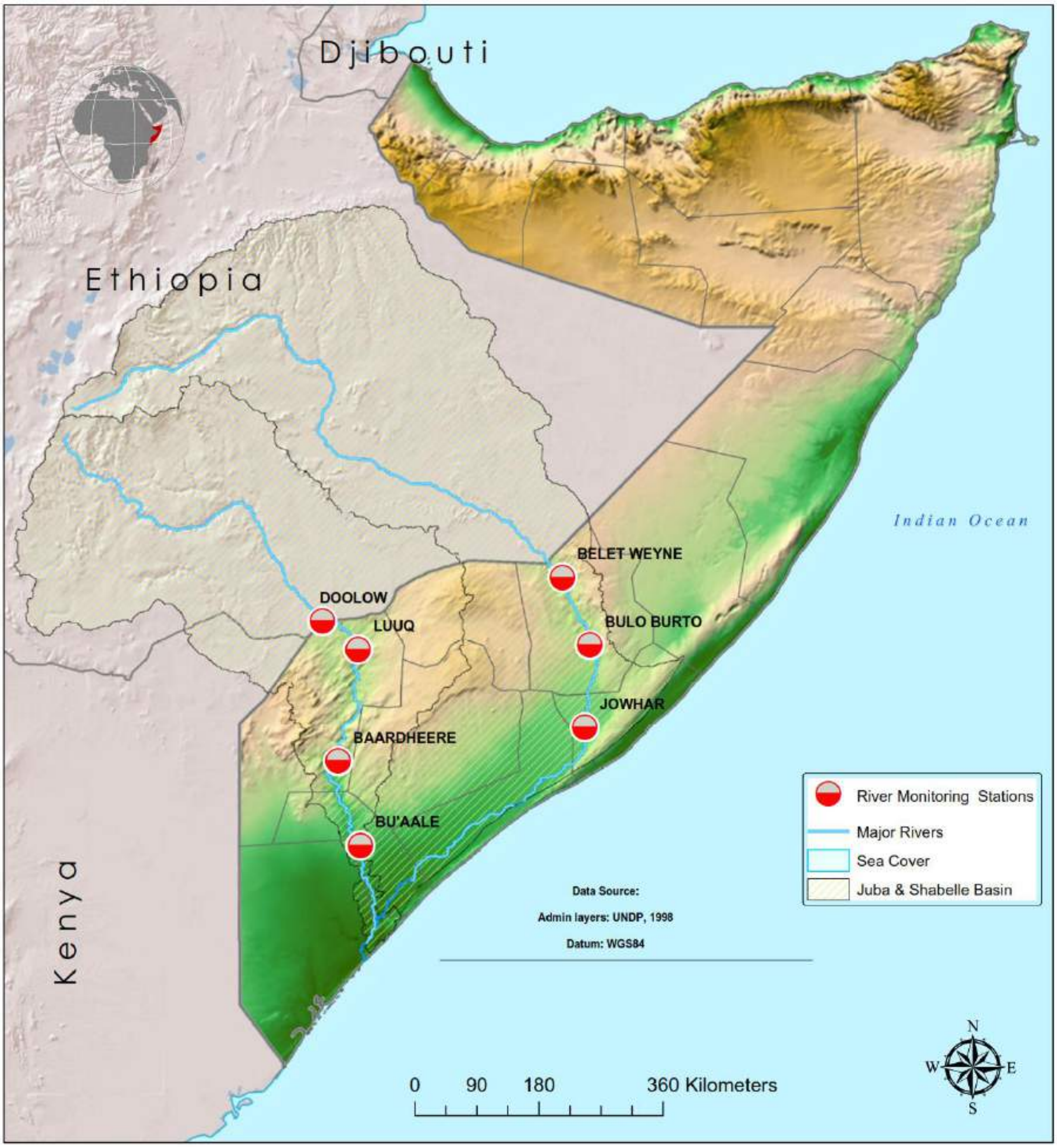

Figure 4. 2 Locations of Main River Monitoring Networks

These gauges were rehabilitated previously by the SWALIM, CEFA, CARE and World Vision International. An effort was made by IGAD-ICPAC to fix new staff gauges at the same level datum of the gauges that were maintained before the war. Data from these stations is transmitted on a weekly basis or as requested by SWALIM via e-mail or telephone to its Nairobi office where the Somalia Climate archive is maintained comprising of the pre-war and post war climate data. Regular update is also maintained. The network will continue to expand subject to certain constraints and the willingness and presence of other partners in this field. SWALIM indicated that there is plan to hand over the climate data to the Somali Government.

As mentioned in the previous chapters, Somalia is classified as a least developed member of the WMO, whose journey of hydro-meteorological data collection and analysis has been just restarting. This is while the country is one of the most vulnerable from the adverse impacts of climate change and still suffers from a constantly increasing poverty. The absence of accurate forecasting and weather information resulted losses of economic and thousands of lives in the past two decades. One of the most affected sectors was the agriculture and livestock sector, which is the foundation of Somalia's economy and livelihoods, supporting some 80% of the country's population, either directly or indirectly.

4.1.2 Institutional Arrangements for Hydro-Meteorological Services and EWS

Somalia is lacking technical and institutional capacity to disseminate timely early warnings and accurate hydrological information to enable the efficient and economic management of water resources. Alerts and early-warnings are produced by the donor-driven FEWSNET, FSNAU and FAO-SWALIM programs. FAO-SWALIM provides early warning information through regular updates on water resources with a focus on drought and flood risk early warning. There are currently over 110 manual rainfall stations, 16 river gauging stations, 9 manual synoptic stations, and 13 automatic weather stations in Somalia run by SWALIM. It has also developed the Flood Risk and Response Management Information System (FRRMIS) to assist flood management in Somalia. This allows SWALIM to provide early warnings to vulnerable communities, well ahead of flood occurrence and has been effective in managing flood disasters in Somalia. Real-time flood information provided during a flood event includes daily flood observations (water level) compared to moderate and high-risk flood levels for major locations. SWALIM also developed a drought monitoring tool (CDI) which was used effectively during the 2010-2011 infamous famine in Somalia to show the magnitude and duration of the drought event.

The other sources of early warning systems in Somalia include the Famine Early Warning Systems Network (FEWS NET). FEWS NET is a leading provider of early warning and analysis on food insecurity. It was created by USAID in 1985 in partnership with NASA, National Oceanic and Atmospheric Administration (NOAA), USDA, and USGS currently provides evidence-based analysis for 34 countries including Somalia. The FEWS NET information is publicly available, however, is too general and covers too large of a geographical area to be useful. More location specific and higher resolution information is needed to allow better planning and decision making.

Food Security and Nutrition Analysis Unit (FSNAU), a project managed by Food and Agriculture Organization (FAO), is the primary source for early warning information on food security, nutrition, and livelihoods in Somalia. However, despite some progress has been made in the development of early warning systems in Somalia, very little has been achieved in its mainstreaming into national development plans due to the relatively late introduction of measures for disaster risk reduction in Somalia.

Community-level efforts in establishing early warning systems and services or assessing disaster risk exist. For example, the community-based early warning initiative relies on a group of people to disseminate early warnings in the community. However, it should be assessed to what extent this initiative is fully operational in the communities in which it has been set up. Likewise, it is not clear where the warnings will originate, whether from their own operation, or from other sources.

Ministry of Energy and Water Resources has the role of managing hydro-meteorological activities and monitoring at the federal level as well as its standard ministerial roles. The Ministries of Energy and Water Resources have similar roles for their respective states. None of these ministries have specialized personnel trained in hydrogeology, hydro-informatics and meteorology. New Climate Information/Early Warning Centers were recently established in Mogadishu, Hargeisa and Garowe, however, they are lacking the technical and operational capacities to analyze and present data.

The Hydro-meteorological Department is one of the most critical and important departments of MoEWR and is responsible for provision of nationwide hydro-meteorological services; information to decision makers about the water (or hydrological) cycle and the status and trends of a country's water resources. Most typically, this focuses on assessing water resources, including drought monitoring and outlooks and flood forecasting and warnings; monitoring weather and collecting data; providing forecasts and early warnings; archiving and providing climate data; collection and analysis of hydrological data and forecast of floods, droughts and cyclones. Such information may be required, among others, for the following purposes:

- Assessing the status of a country's water resources (i.e., quantity, quality, and distribution in time and space), the potential for water-related development and the resource's ability to meet actual or foreseeable demand;
- Planning, designing, and operating water projects; assessing the environmental, economic, and social impacts of existing and proposed water resources management practices and planning sound management strategies;
- Providing security for people and property against water-related hazards, particularly floods and droughts;
- Allocating water among competing users, both within the country and across borders; and
- Meeting regulatory requirements.

Currently the Hydro-meteorological Department is lacking technical and institutional capacity to analyze, forecast, develop and disseminate timely early warnings messages for floods and flash floods, drought, cyclones and accurate hydrological, hydrogeological and meteorological information to enable the efficient and economic management of water resources. The analysis of the department operational systems reveals low capacity, including:

- limited accessibility of data and information to meet user needs;
- lack of electronic historical data;
- limited IT and data transmission infrastructure for the majority of data providers;
- limited capacity in data analysis, quality control, interpretation, modeling, forecasting, and product development;
- insufficient human resources both in number and skills;
- lack of integration of meteorological, hydrological, and DRM services;
- lack of weather and hydro-meteorological hazard forecasting services;
- low capacity in EWS and appropriate DRM;
- inadequate hydro-meteorological service delivery system;
- Absence of effective communications and engagements between the users and producers of hydro-meteorological data and products.

In terms of Disaster Risk Management (DRM), MoHADM (Federal level), Humanitarian Affairs and Disaster Management Authority - HADMA (Puntland) and National Disaster Preparedness and Food Reserve Authority - NADFOR (Somaliland) are the responsible agencies. MoHADM has only been operational for one and a half years. With limited institutional memory, it is practically impossible to promote and sustain monitoring and forecasting technologies. Furthermore, technical and operational flood and drought preparedness capacities are extremely weak in all states of Somalia.

National Multi-Hazard Early Warning Center established in 2020 in Mogadishu and tasking it with the coordination of disaster risk management activities in the country. The center has taken the lead in state emergency management and local emergency management committees. One of the main tasks of the center is produce regular information products on climate such as rainfall and temperature forecasts, early warning on floods and droughts, cyclones, as well as projections on desert locust movement and diseases. It is also important to note that the Ministry of Energy and Water Resources has committed itself to minimize the impacts of recurrent droughts and floods by taking the lead of Flood and Drought Task Force (Fig 4.3).

In Somaliland, the National Disaster Preparedness and Food Reserve Authority (NADFOR) received its mandate through a disaster management law/policy passed in 2007. NADFOR is supported at the national level by the National Disaster Council (NDC) and the Disaster Management Steering Committee (DMSC). At the regional and district levels, Regional Disaster Management Committees (RDMC) and District Disaster Management Committees (DDMC) respectively will form part of the DRM system. NADFOR carries the key functions of disaster preparedness and disaster response in Somaliland. The goal of NADFOR is to prevent frequent occurrence of disasters and reduce vulnerability of communities by improving sustainable coping capacities to decrease the overall impact of disasters on lives and livelihoods of Somaliland communities. Given that the frequency of both floods and droughts are expected to increase across Somalia due to global climate change, NADFOR will be a key institution for enhancing resilience of Somaliland communities. However, NADFOR suffers from serious capacity gaps including inadequate qualified staff; inadequate staff recruitment; low level of staff skills and knowledge on disaster management; limited access to information due to inadequate skills on Information Communication Technology (ICT); lack of adequate physical assets/infrastructure and transport; and lack of capacity building for Disaster Preparedness and Management Committees (DP&MCs) at all levels. With regards to climate change, there is little or no knowledge on even the basics of climate change and its impacts, particularly with regard to disasters such as droughts and floods.

In Puntland, Humanitarian Affairs and Disaster Management Authority (HADMA) is the focal agency for Disaster Risk Management. It is an autonomous organization under the auspices of the presidential office, supporting the Puntland communities in time of humanitarian need and disaster management. Line Ministries are required to work closely with HADMA to ensure the effectiveness of all humanitarian assistance provided by the different stakeholder during the occurrence of disasters. With assistance from UNICEF, in September 2012 a Puntland Disaster Preparedness Contingency Plan was developed. This Contingency plan makes several references to climate change and its impacts on disasters. Recommendations put forward in this plan are supported by the Puntland government and international community. With support from UNOCHA, in June 2011 Puntland developed a Disaster Risk Reduction Framework, which set the foundation for development of a comprehensive policy. Subsequently, a Puntland Disaster Risk Reduction and Management Policy were developed. Legislation to implement key provisions of the policy, including contingency funding for disaster response, funding for preparedness and the formalization of disaster response structures, needs also to be drafted and enacted.

MoEWR has also launched the National flood and drought task force, it believed that this task force will enhance collaboration and partnerships and running a credible flood and drought management system among all relevant stakeholders and collectively address flood and drought impacts on the country's socio-economic development. The Flood and Drought Task Force will be incorporated within the water sector coordination structure and it is a government owned and managed by national unit. Some of the functions of the task force include:

- Coordinate the Flood and Drought related plans and activities
- Facilitate national, district and community level Flood/Drought Management contingency mechanism.
- Enhance collaboration and partnerships through trust-building and running a credible Flood and Drought Management system among all relevant stakeholders
- Operate a functional and effective Monitoring & Evaluation system for programming and managing activities on Flood and drought.

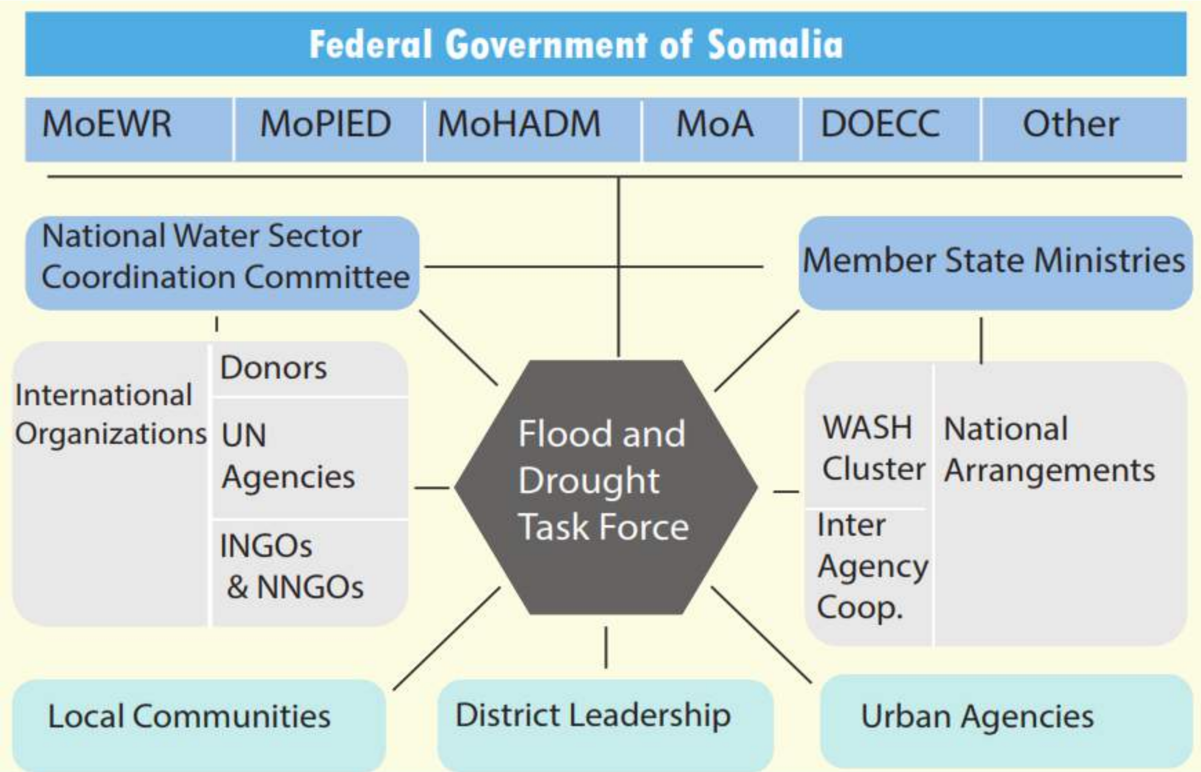

Figure 4. 3 The structure of Flood and Drought Task Force (MoEWR, 2021)

Non-governmental organization and relevant UN Agencies are involved in the Flood and Drought Task Force as technical supporting and engage directly with the respective executing agencies of the Federal Government of Somalia. The Flood and Drought Task Force group had several meetings in 2019 and 2020; however, due to the COVID19 pandemic, the meetings of the committee did not happen as per usual, except for a few meetings in 2021. The current intuitional arrangement for EWS divides responsibilities among various institutions. This division of responsibilities raises some coordination and communication challenges among and between the involved institutions, which adversely impacts on the effectiveness of the EWS in the country.

MoEWR is currently responsible for policy formulation, setting direction and coordination of national water resources but there is uncoordinated management of water resources between the Federal Line Ministries and Federal Member States. Thus, the leadership being provided by the Ministry of Energy and Water Resources in the development of a National Water Resource Strategy (NWRS) to strengthen coordination among relevant role players and stakeholders is timely and much needed.

Under the Strategic Objective 13b of NWRS states that a national hydro-metrological service center, based in Mogadishu and bridging the access to data and the utilization of information by users, will be established. The strategy aims to improve the levels of monitoring that produce hydro-meteorological and environmental data and information and to strengthen the systems and approaches that make this data and information accessible (Gure, 2021).

4.1.3 Policy Context of Hydro-Meteorological Services and Early Warning Systems

According to the existing laws and strategic plans, the institutional responsibilities for some of the disaster risk management and hydromet related areas (e.g., data collection and exchange and early warning services) are not clear. The MoEWR is planning to develop a comprehensive National Hydrological and Meteorological services Policy and its implementation plan of Somalia hereafter (Hydromet Policy) is underpin one of the National Water Resources Strategic Plan's Flagship Projects. Flagship 7: Establishing a monitoring and information management system. The development of the policy and the implementation plan is expecting to: (i) identify the needs and priorities of the potential hydromet services users ii) analyses all relevant sectoral policies to align the proposed hydromet policy with existing policies and avoid inconsistencies; (iii) elaborate on how various actors in the public, private, NGOs, CBOs, and academic sectors can be involved in the hydromet value chain (as producers or users) to maximize socio-economic benefits through innovative engagement and partnership, and to define the scope of hydromet services, (iv) Develop policy objectives, guiding principles and policy statements into an integrated policy; and (vi) Develop an implementation plan for the policy.

This policy will also formulate an appropriate mechanism for properly accessing and sharing of hydro-meteorological and hydrogeological data. The policy will provide the groundwork for cooperation and coordination between data producing organizations and data users. It also will facilitate ease of access to data and information for national, regional, and international institutions. It has been proposed to widen the scope of this policy to also include meteorological data produced by other institutions and to adopt it as a national policy for data sharing.

The National Hydro meteorological and Monitoring services (hydromet) services policy will set policy principles, to define the roles of the actors involved in the provision and use of hydromet services, along with rights and responsibilities, and will Establishing a robust coordination framework at various levels (federal, state, district and local) is vital for achieving climate-proof development.

Defining and streamlining the institutional responsibilities and other relevant stakeholders entails the establishment of a national institutional framework for hydro-meteorological and EWS in Somalia that defines the roles and responsibilities for each institution from observation, data management, modeling, and forecasting to early warning and service delivery. Currently, there is no user-driven, long-term national strategy for weather, climate, and hydrological services. The absence of such a strategy is reflected in the ad hoc approach and proliferation of independent observational networks and incomplete coordination of activities related to weather, climate, and hydrology. Improving the legal and regulatory framework, will confirm and strengthen MoEWR's responsibility and mandate for issuing warnings of meteorological hazards. Regulation will also codify the responsibilities of other government agencies and organizations, which are affected by meteorological and hydrological hazards, ensuring more timely and effective responses that will help mitigate weather related disasters.

The operational management status of hydro-meteorological department needs to be significantly strengthened in terms of hiring and retaining qualified staff, improving capacity building and professional development programs, offering appropriate salaries and incentives, mainstreaming gender and providing effective services. Overall, however, the current meteorological and hydrological services in Somalia have limited capacity and capability to provide quantitative information to guide timely decision making.

- **Existing National Strategies and Plans**

Somalia has the following policies, strategies and plans with regard to environment, development, disaster risk reduction, climate change adaptation relevant to hydro-meteorological services:

The Constitution Federal Government of Somalia (FGS) 2012; which places a strong emphasis on restoration, protection and safeguarding of the environment the care of natural resources, land rights and natural resources. Furthermore, Somalia´s 'Six Pillar Policy' (2012), which mandates i) enacting laws that preserve and protect the environment and ii) incorporating environmental education in the formal and informal education systems in the country.

Somalia National Development Plan (NDP-9) 2020-2024; contains multiple references to human mobility and to the nexus between conflict, disasters and displacement. It recognizes throughout that 'climate disasters have led to substantial population displacement, creating pressures within IDP camps and their host communities, and high rates of IDP unemployment.' The NDP-9 guides all development activities in Somalia and provides the nation with a path leading to economic growth and reduction of poverty within the next five years. Its goal is to reduce poverty and inequality through inclusive economic growth and employment, improved security and rule of law, and strengthened political stability. The NDP-9 outlines an extensive poverty analysis diagnosing many of its root causes, including conflict, political instability, climate-related disaster and a still weak economy. Finally in the risk management section of the plan makes clear the FGS intention to collect data related to disasters and displacement. It encourages the development of 'Early warning systems where possible, particularly for drought, flood and conflict/displacement signals.' It also calls for the clear mapping of movement patterns when displacement does occur.

National Water Resource Strategy (NWRS) and Roadmap 2021-2025; The NWRS has been intentionally designed to provide synergy with NDP-9's four pillars. The NWRS targets to unlock key actions and align with the Constitution (2012), Sustainable Development Goals and sectorial policies and laws to manage Somalia's water resources to reduce poverty, increase sustainable economic and social development, improve the quality of life for all Somalis, and ensure an adequate supply of water for future generations. Operationalizing Integrated Water Resources Management is one of the goals of the Strategy. Plan and respond to climate variability and its impacts on water resources management and development (adaptation, mitigation and recovery) through developing expertise in weather forecasting, warning, and preparedness is one of the sub-objectives. Climate and hydrological data and information provides the basis for climate and resilience adaptation planning

The National Disaster Risk Management Policy (NDRMP) 2017; Sets out institutional, legal and policy context, as well as mechanisms for preparing for and responding to disasters includes chapter on 'policy outcomes and institutional mechanisms for delivery', and on monitoring and evaluation. The policy also provides a robust framework for flood and drought risk management which serves as the foundation for water sector flood and drought response actions. The policy clearly identifies the lack of a centralized data management system, coordination among agencies, and the absence of an effective EWS as the main challenges affecting the establishment of an effective DRM system in Somalia. The MOHADM has made significant progress in developing the current suite of policies, protocols and early warning systems that guide current disaster responses. This will require MoEWR support to provide the necessary hydrological data and information that is needed to support decision making and early response. So MoEWR in need for strengthening the monitoring networks and information management to provide this support to disaster risk management.

NDRMP details how the MoHADM will review implementation of the policy through an annual consultation process involving all relevant Member State agencies. The MoHADM and its local equivalents are given the task of, 'Arranging and directing local population at risk of being hit by floods and cyclones which may be life-threatening to evacuate to safer locations/relief camps as soon as alerts are issued, ensuring that safe centers/relief camps/emergency shelters set up in the district are managed to prevailing local guidelines and Sphere standards of humanitarian response in terms of provision of protection and meeting minimum basic needs of the displaced.

The DRM strategy also encourages a decentralization of responsibilities, and the building of disaster-response capacity at the district level. It requires that the MoHADM 'facilitate capacity building of local responders and provide appropriate support during response, particularly for prioritized evacuation and care of women, children, older persons, and children and adults with disabilities. District municipalities are also encouraged to promote the building of resilience before a disaster strikes.

Somalia National Durable Solutions Strategy (NDSS) 2020-2024; its act as an operational roadmap setting out a collective vision to guide the implementation of durable solutions programing over a five- year period in Somalia. The NDSS has closely aligned its priorities with the direction set forth by NDP-9 and Recovery and Resilience Framework (RRF). Invest in early and long-term solutions to reduce and prevent displacement caused by drought and floods are one of the strategic priorities in NDSS.

National Program of Action (NAPA) 2016 and Intended National Determined Contribution (INDC) 2015: After detailing the climate change risks facing Somalia, the NAPA provides a 'framework for an adaption program', outlining possible adaption initiatives, and implementing a monitoring structure. Somalia's Intended National Determined Contribution sets out policies for mitigating the effects of climate change, highlighting especially water use management and the use of indigenous knowledge.

Other Policies and Plans: Somalia has made also progress in the development of other policies, plans and institutional frameworks relevant to climate change, Natural Resource Management and overall National development. Below are some of the other policies and plans:

1. Draft of National Policy for Hydrometeoerological services (Hydromet)
2. Draft of Strategy plan for National hydrometeorloical and monitoring services
3. Draft of National Environmental Management Bill, 2020
4. Draft of Environmental Social Impact Assessment Regulations, 2020
5. The Somalia National Climate Change Policy, 2020
6. The National Environment Policy, 2019
7. National Voluntary Land Degradation Neutrality Targets, 2020
8. National Drought Plan, 2020
9. Somalia National Water Policy and National Water Resource Law, 2019
10. Water, Hygiene And Sanitation (WASH) Policy, 2019
11. Draft Somalia livestock sector development strategy

The existence of policies and regulatory frameworks are steps in the right direction although implementation challenges still exist at both the Federal and State levels.

4.2 Flood and Drought Early Warning System

Weather-related events such as floods, droughts and storms are substantially increasing in the last decades. Severe flooding 2018 made thousands homeless, and destroyed agricultural land, livestock and infrastructure. The needs of the public for services are not well-understood by the service providers and the end-users themselves have little or no knowledge of (and thus capacity to demand for) hydro-meteorological and early warning system. Thus, an urgent component is building the capacity and capabilities of the end-user community. By developing the understanding of hydro-meteorological data and products, the end-user community can benefit from hydro-meteorological services for disaster risk reduction. Reducing the risks of disasters can improve the productivity of socioeconomic sectors and raise wellbeing.

Efforts have been made in recent years, jointly by the Federal Government of Somalia and the supporting international and non-governmental organizations to implement some pilot early warning systems. However, the early warning system in Somalia requires a significant amount of investment and technical support. Currently, there are various institutions involved in the EWS, which require a better institutional arrangement, continuous communication and strong coordination among and between themselves.

4.2.1 Existing Flood and Drought Early Warning Systems

A considerable amount of the loss and damage could be avoided if the people to be affected are warned in advance. The absence of such a warning system using modern forecasting and dissemination systems is a major issue to be addressed in Somalia. Hydrological services are dependent on meteorological data in the form of quantified estimates of observed and forecasted precipitation and temperature, as well as such environmental variables as dew point, wind speed and direction, and solar radiation. Floods, flash floods and drought are a major source of death and property loss in Somalia. Large part of the country is exposed at a considerably high risk to flash floods.

The prolonged civil war in Somalia saw the collapse of the climate monitoring network which has recorded data between 1963 and 1990. The data gap post 1991 makes accurate flood and drought forecasting challenging. For the past 5 years, the FAO SWALIM, IGAD ICPAC and USAID's FEWSNET initiatives have focused on improving regional forecasting for Somalia, making use of the rehabilitated network of monitoring stations in addition to stations abroad. Furthermore, the centralized agency for Disaster Risk Management (DRM) in the south has only been operational for one year. Technical and operational flood and drought preparedness capacities are extremely weak in all zones of Somalia. Currently, if early warning information is provided to communities, it is usually passed on in a very ad-hoc, uncoordinated manner by leaders to others through text messages or word of mouth.

FAO-SWALIM provides early warning information through regular updates on water resources with a focus on drought and flood risk early warning. There are currently over 110 manual rainfall stations, 16 river gauging stations, 9 manual synoptic stations, and 13 automatic weather stations in Somalia run by SWALIM and its planning to install additional automatic weather station in Dhusamareb and three more groundwater monitoring stations in central Somalia. The installed AWS stations provide data for parameters that include; rain gauge, temperature, wind speed and direction, and humidity.

The system also has the ability of 24-hour forecasting. The existing operating procedure for the river flood forecast starts from the gauge men observations of the water level at the river gauging stations installed along Shabelle, Jubba Rivers. On daily basis, the gauge men collect the data two times from river. In special occasions when there is a sudden increase in river water level, the gauge men collect the data and share it with the HQ in Nairobi, Kenya. The experts of the SWALIM review the data and compare it with historical data of the same river and decide about the warning threshold level considering the weather forecast and geographical local of the area.

Large parts of Somalia do not have insufficient in-situ hydro-meteorological observing stations to support the reliable provision of EW and hydro-meteorological services. This is especially in sparsely regions where satellite data can be particularly useful as a complementary data source to in-situ systems and should be well integrated into the country's hydro-meteorological observing network to ensure maximum benefit and cost-effectiveness. The current security concerns and geographic features in Somalia lend themselves for using remote sensing systems for data collection. Indeed, such systems may be the only source of information in some areas of Somalia, due to either the limited or lacking in-situ systems or the prevailing security issues or hazards. Most stations tend to be located in more secure areas around major cities due to the difficult security issues in Somalia. Integrating remote sensing data with those obtained from in-situ stations can be accomplished by using the latter as a validation or calibration point; by providing complementary maps of areas that are not observed by in-situ stations; or by blending the in-situ data with the remote sensing data using models or data assimilation techniques.

There is limited capacity in MoEWR to systematically access, process, and integrate remote sensing products into hydro-meteorological services and EW systems, and no formal requirements have been identified for remote sensing products and services. The development of capacity in this area, however, will allow the use of remote sensing data to produce precipitation, floods, drought, extreme temperature, soil moisture, evapotranspiration, and land cover maps of Somalia in support of agriculture, and to support weather and hydrological forecasting and EW services.

There is a plan for Strengthening Hydromet and Early Warning Services in Somalia through the ***Somalia Crisis Recovery Project (SCRP)*** funded by World Bank, The SCRP project can accelerate progress on hydromet and early warning services, through fundamental investments, and in doing so, directly "*strengthen capacity for disaster preparedness nationwide*". The support could embrace a mixture of goods (including monitoring equipment and IT hardware), physical works, and consultancies that could advance warning capabilities. Technically sound, reliable and trusted hydromet services will allow actors in Somalia to plan for extreme events, and respond appropriately as they develop, resulting in reduced losses and damages.

The Ministry of Energy and Water Resources with support GIZ is developing a data requirement analysis and an assessment of the current hydrological monitoring network in the Shebelle river basin regarding a cost-effective and improved water resources monitoring of the Shebelle river basin by identifying and implementing cost-effective priority measures and capacity development". Specifically MoEWR will analyses the information requirements for the decision-making processes in water resources management in the Shabelle Basin, prepare recommendations to improve the existing water resources monitoring (data acquisition/collection, data flow, quality control, analysis), develop skills of the technical staff by trainings on the use of hydrological techniques of data collection, analysis and monitoring, and prepare and implement targeted measures to improve the existing water resource monitoring network. In summary, this project will assist the MoEWR in the activities related to the entire chain of data collection, transfer, processing and storage, and the analysis and information collation and dissemination.

UNDP is planning for installation of 13 AWS, 10 manual rain gauges, 9 synoptic stations and 4 radar river level sensors. IGAD-ICPAC is also planning to install 10 hydrological stations, 5 along Shabelle River, and other 5 along Jubba River. These stations are able to provide data on parameters that include; water level, air temperature, wind speed and direction, water conductivity, water salinity, total dissolved solid materials, pressure, precipitation intensity and accumulation, and air relative humidity.

FAO-SWALIM and partners have taken the lead in placing early warning systems on high alert and encouraging other preparedness activities. As an early measure, SWALIM has developed a unique mobile phone-based alert and early warning system called DIGNIIN. It facilitates early detection of flood situations in the Jubba and Shabelle rivers and enables timely warnings to be communicated to vulnerable communities, allowing evacuation and response. During the flood period, SWALIM is also issues "Flood Preparedness and Safety" materials that contain key messages for local communities on what to do before, during and after a flood. They also provide advice on riverbank protection and placement of sandbags. SWALIM has also developed and use Flood Risk and Response Management Information System (FRRMIS) which is a web-based approach mainly designed to provide information sharing platform or Decision Support System (DSS) to assist in guiding lead agencies and cluster responses to plan and embark on interventions. FAO-SWALIM also provides regular updates on water resources with a focus on drought and flood risk. Real-time flood information provided during a flood event includes daily flood observations (water level) compared to moderate and high-risk flood levels for major locations.

The FRISC-DIGNIIN alert system, which gathers and sends flood and rainfall information, fails to reach pastoral communities directly. Due to their remoteness, 100% of the targeted agro-pastoralists are not forewarned about and prepared for extreme events. Rather information is provided by mobile phone, email and cluster reports to donor and civil society organizations and Ministry focal points. Furthermore, FAO-SWALIM is dependent on funding replenishment by donors. The funds are not renewed consistently. The system needs to be expanded to collect and disseminate early warning and contingency planning information covering the whole country.

On the other hand, SWALIM has developed a remote monitoring system using remotely sensed data to observe large swathes of territory in Somalia on a regular basis though much of it inaccessible due to insecurity. SWALIM routinely monitors riverbank breakages and areas of potential flooding along the Jubba and Shabelle Rivers in Somalia. It uses satellite images, combined with field observations, to identify weak points along the rivers and shares this information with development partners, local authorities and communities. SWALIM also developed a drought monitoring tool (CDI) which was used effectively during the 2010-2011 infamous famine in Somalia to show the magnitude and duration of the drought event. Somalia WASH cluster is also periodically issuing short-range of rainfall forecasts updates and flood extent maps and shares with cluster partner to facilitate preparedness of potential responses.

These systems achievement are promising in terms of relief oriented short term objectives, but the developmental long term objectives have a long way to go in Somalia. The systems have a characteristic of generic EWS which is difficult to manage the features of all hazards at a time. These systems have a shortage of experts beside lack of permanent responsible persons at local levels. The systems are found not suitable for rapid onset hazards. Early warning messages do not include all important components of a quality messages, and false messages are usual leading majority of the people not to respect the warning. The existing early warning systems are problematic across the four components of UNISDR effective early warning framework.

USAID, USGS, NOAA, NASA, the U.S. Department of Agriculture (USDA), work with FAO to assess the risks of food shortages in Somalia through FEWS NET. The Standard Precipitation Index (SPI) is used. The second drought index that may be suitable for Somalia is the Normalized Deficit Vegetation Index (NDVI), which is based on satellite observations and assessment of vegetation health. FEWS NET produces both observations and forecasts and relies heavily on satellite-based observations, which makes it particularly suited for Somalia, given the sparsity of ground-based observations in the country. These products, however, do not provide the necessary resolution. Observations are provided by NASA (SWE), NOAA (rainfall, temperature) and the USGS (NDVI).

It is essential to build the technical capacity of the MoEWR staff so they can use and build on this information. Relying on other forecast providers does not enable national ownership and capacity development within the ministries to sustain national hydrological and meteorological monitoring and forecast development independently and in coordination with all states.

- **Community-based Flood Early Warning System**

In some of the riverine areas, people use numerous river level marks to monitor the onset of floods while the color of the river water have been used as an indicator of the onset of large-scale surface runoff generation. When the water level in a river approaches warning levels, the news is disseminated by word of mouth and runners. For example, at Jowhar, when the Shabelle River staff stage gauge reaches 5.25m, the Middle Shabelle Authorities send messengers to the villages to warn the communities about the potential for floods. At Jowhar they also make contacts with authorities at Belet Weyne and Bulo Burti for river levels information at those locations. Using this primitive method is however no longer sufficient for using as early warning systems in Somalia to reduce disaster risk, because hazard characteristics are changing as a result of climate change.

- **Global and Regional Hydro-Meteorological Services and Early Warning Systems**

There are a number of ongoing initiatives that aim at strengthening early warning systems and hydromet services in Somalia. It is therefore crucial that planned initiatives will build upon the activities and achievements of ongoing projects such as those being implemented through FAO SWALIM, IGAD ICPAC and USAID's FEWSNET initiatives.

There are also a number of ongoing international initiatives for remote sensing that offer potential benefits for Somalia hydro-metrological and EW systems and services:

- The United Nations Platform for Space-based information for Disaster Management and Emergency Response (UN-SPIDER) was established in 2006 to provide information for humanitarian aid and emergency response, with a particular focus on assisting developing countries to gain access to satellite data for emergency preparedness and response needs.
- The FAO Global Information and Early Warning System (GIEWS), established in the wake of the world food crisis of the early 1970s, provides information on food production and food security and consists of a worldwide network including 115 governments, 61 nongovernmental organizations (NGOs) and numerous trades, research, and media organizations.

- The Global Disaster Alerts and Coordination System (GDACS), developed by the Joint Research Centre of the European Commission and used jointly by the European Commissions and the United Nations Office for the Coordination of Humanitarian Affairs (OCHA) is a fully automatic 24/7 alert system which gathers data about natural severe events (earthquakes, tsunamis, tropical storms, floods, and volcanoes). GDACS collects near-real time hazard information and combines this with demographic and socioeconomic data to perform an analysis of the expected impact. This is based on the magnitude of the event and possible risk for the population. The result of this risk analysis is distributed by the GDACS website and alerts are sent via e-mail, fax and SMS to subscribers in the disaster relief community and all other persons that are interested in this information.
- Additional initiatives include UNOSAT, DLR-ZKI, SERTIT, the Dartmouth Flood Observatory, the Global Monitoring for Environment and Security (GMES) of the European Commission and the European Space Agency (ESA), PREVIEW (Prevention, Information and Early Warning pre-operational services to support the management of risks), LIMES (Land and Sea Integrated Monitoring for Environment and Security), GMOSS (Global Monitoring for Security and Stability), SAFER (Services and Applications For Emergency Response), and GMOSAIC (GMES services for Management of Operations, Situation Awareness and Intelligence for regional Crises).

Clearly, guidance is required for officials in Somalia to identify relevant information and application for specific needs of the country.

4.2.2 Risk Knowledge

The development of an effective EWS requires accurate knowledge and understanding of existing and potential risks. A better understanding of risk scenarios allows estimating the potential impacts of hazards on vulnerable communities and ecosystems.

Efforts have been made by the governmental and non-governmental organizations, for better understanding of the existing and potential risks of natural hazards throughout the country. The Somali WASH Cluster published report on the role of climate information and early warning systems in supporting disaster risk reduction in Somalia, which maps major natural disasters in Somalia, including the flood, flash flood, drought, and cyclones. This document provides a nationwide overview of natural hazards' risks, which can be used for risk reduction interventions by different involved organizations. Despite the multidimensional development in the area of DRR during recent years, significant challenges remain that restrain the process to better understand the existing natural hazards and their associated risks. Some of the major challenges to be addressed in future are briefly presented below:

- Insecurity in the majority parts of the country remains as the most significant challenge for all elements of EWS. Currently, most of the hazard maps rely heavily on remote sensing products, which do not include too much on-the-ground data and information due to inaccessibility to the remote and insecure areas. Insecurity will not be repeated as a challenge in the following sections.
- A better understanding of hazards and their potential future risks require quality data. Lack of data due to insecurity, low technical and technological capacity and financials issues, is one of the major challenges for risk knowledge. In addition to satellite imageries and GIS data, multidimensional and on-the-ground data is essential for better projecting the impacts of potential risks.

- Variability in the nature of hazards is another challenge that is observed, with influence from different factors that includes natural and human interventions, such as the climate change impacts. This phenomenon poses a barrier for better understanding of impacts and risks that a natural disaster could cause.
- The current knowledge of risks remains at a larger scale, which cannot support an efficient EWS. For an efficient EWS, it is crucial to understand the impacts of a risk at the local level. Risks assessments and analysis are needed to be undertaken at the local level, for a better understanding of the potential impacts that could be imposed by a risk.
- For acquiring a better knowledge of the impacts of a risk, it is important to undertake inclusive risks assessments, where the community people are involved in the process. A people-centred and participatory risk assessment will not only support the data collection process but also allow integrating traditional knowledge in the process.
- The Federal Government also lacks enough financial resources to improve the current status of EWS and to cover the hazard-prone areas with the network of people-centered EWS.

4.2.3 Monitoring and Warning Services

Monitoring and warning services is another critical element of EWS. This element is the foundation for observing and monitoring various sets of parameters which helps us issue warnings about potential future risks. In order to appropriately respond to potential natural hazards, it is essential to have continuous monitoring of the associated risks and provide on time warnings to the vulnerable communities.

In Somalia, the responsibility for flood and drought risk monitoring is divided between MoEWR and other institutions. Currently forecasting flood and drought is provided by SWALIM. All these institutions, using their operated monitoring stations and remote sensing products, monitor potential risks and issue warnings through their respective webpages and social media platforms. The forecast experts decide the threshold for different levels of risk in each entity. In some communities, natural hazards have been monitoring using the traditional knowledge of the experienced elders of the communities. This is one of the prevalent and practical methods in remote areas of the country where the aged people play an essential role in monitoring potential natural hazards and issuance of warnings.

- **Major Challenges in Monitoring and Warning Services**

While governmental and non-governmental organizations have made efforts to improve the hydro-meteorological monitoring services in Somalia, many significant challenges still exist that harness the efficiency of the services. These challenges are briefly presented below:

- **Insufficient Monitoring Coverage Area:** The existing stations for hydrological and meteorological monitoring services are not enough to provide adequate coverage for the whole country. This issue is much more significant in the case of weather monitoring services. MoEWR has identified a need for more hydro-metrological stations to cover the whole country. Though it is reported that hydrological monitoring network covers some parts of the country and gaps remain for some parts. Insecurity and inaccessibility to these areas are reported to be the main reasons for the coverage gap.
- **Inadequate Data Transfer Technologies:** Absence of real-time data transfer remains as a major challenge that compromises the efficiency of the EWS.
- **Weak Data Management:** It is crucial to develop an efficient data management system that ensures data quality assurance, data archiving and data sharing processes. Quality control

and assurance (QA/QC) and access to available data remain as critical challenges for the data management processes.

- **Insufficient Technical Capacity:** Establishment of a professional and technical workforce is a major challenge for MoEWR and other stakeholders. To enable the country to move in parallel with the globe, investment is much needed on importing new technologies and building the capacities of the national experts to use and maintain these technologies.
-

4.2.4 Dissemination and Communication

The third key element of EWS is the dissemination and communication of the warnings to the endangered people. The warning messages should, one, forecast a potential future risk, second, include a clear message of what certain people do should. For disseminating the warnings, different communication means and channels should be used to ensure receiving the warning by the communities in risk. In the meantime, it is essential to warn the public early in advance to help them take action.

- **Current State of Dissemination and Communication**

Given that there is no systematic EWS and a clearly defined Standard Operation Procedure (SOP) for early warnings in Somalia, the issued warnings do not follow a previously defined communication way to reach to the communities at risk.

At the current arrangements, the issued warnings by SWALIM, ICPAC and Somali WASH Cluster are shared through email or their respective webpages and social media accounts. In addition to social media, the government shares the warnings with mass media as well for broadcasting. However, there is no formal agreement between the government and mass media. SWALIM and ICPAC do not have a formal communication with MoEWR or Somali WASH Cluster about the issued warning. Once a warning is issued, MoEWR has to find it out and share it forward. Recently, after the incident of the flood in Gu 2018, in MoEWR and other relevant government institutions and NGO's have created Flood and Drought Task Force group, through which they communicate the forecasted risks between themselves.

Somalia should streamline the dissemination of early warnings to ensure that all agencies communicate in a timely manner with the lead early warning agency and that warning messages reach users without alteration. Each agency should have its own service delivery system for data and information products. Although multiple dissemination channels are recommended, it would be advisable to route all agencies' warning messages through a single delivery mechanism. In complement, each institution should have its own method of dissemination (e.g., posting the warnings—and any additional explanations—on its website). That way, the public becomes active consumers of the warnings, knowing where to look for and how to use the information.

Upon the reception of warnings, MoEWR informs their State directors to get ready for any emergency, also to share the warnings with NGOs and other relevant states departments. Somali WASH Cluster role is just coordinating the emergency response processes when a hazard happens. Given that flood and flash flood are not forecasted at the community or district levels, government staff and NGO's at the district level relies on the risk history of each community and hazard maps, for identification of vulnerable villages and communities.

For the community-based early warning systems, community members are involved in the dissemination of the warning. Upon the declaration of warning by forecast experts the responsible person will be informed for further dissemination of the warning. Usually, they inform the community members using either the loudspeakers of the mosques or using hand-carry loudspeaker previously donated to them for this particular purpose. Historically, in Somalia, different means have been used for disseminating warnings such as phone calls, shooting bullets, or shouting louder. Some of these means of communication are still used in some remote areas which should be considered as a traditional and practical knowledge at the local level.

- **Major Challenges in Dissemination and Communication**

Despite the efforts made by various governmental and non-governmental organizations, warning messages do not reach to all communities at risk. Some of the major challenges for the dissemination of warnings to community members are briefly described as bellow:

- **Inadequate Institutional Arrangements:** For disseminating the warnings to people at risk, lack of clear roles and responsibilities between the line ministries and agencies remains a big gap.
- **Lack of Clarity in Warning Messages and Inaccuracy:** The issued warning lacks impact information about the risk and instructions for users to support them in taking action on the ground, the warning threshold level is always a question. This gap leads to a considerable intensification in the inaccuracy of warnings. Dissemination of unclear warning messages decreases the value of warning and is associated with the risk of being ignored by communities and people.
- **Inadequate mobile communication courage area**
- **No Assessment of Previous Early Warnings:** There is no assessment undertaken to identify the effectiveness of the issued warnings. Currently, no lessons-learned are captured from the dissemination of warnings and its effectiveness. A formal feedback process could support to improve the current state of the EWS and its accuracy in the country.
- **Short Notice Time:** Basically, EWS detects a flooding condition upstream and warns inhabitants downstream of the impending flood. The longer the time between the warning and the actual arrival of the flood, the better the residents can prepare by bringing their belongings and themselves to safe places or take other precautions.

4.2.5 Response Capability

Response to early warnings includes the activation of the coping mechanisms before a disaster happens. This includes the preparedness strategies and plans of the communities at risk. For an effective EWS, the concerned communities must possess a functional response capacity. It usually takes some time to bring certain items to safety or protect them otherwise. This depends much on the circumstances of the location (e.g. proximity of a safe place).

With the warning declaration, different institutions that are involved in disaster preparedness at the national and local level are triggered for coordinating their preparedness and emergency plans, including the community that is threatened by the risk. Therefore, hazard warnings must come from reliable sources and include explicit instruction that allows individuals to take appropriate actions. Preparedness and response plans for hazard warning are always associated with an efficient EWS.

With the absence of a systematic EWS and standard operation procedure at the national level, the current response plans and strategies focus on post-disaster emergencies. There are potential governmental institutions and non-governmental organizations that could support response strategies at the national and local levels before disaster strikes.

- **Major Challenges in Response Capacity**

At the national level, EWS is limited to the forecast, issuance of warning and dissemination of the issued warning. The country lacks an extensive plan for response to the issued warnings. Based on the three levels of risk, the action required is limited to: No Action, Be Prepared and Take Action (or Evacuation). Some of the major challenges for an adequate response capacity to issued warnings are briefly presented below:

- The country lacks a response plan for the issued warnings. Currently, no SOP is developed for EWS at the national level, and the issued warnings also do not provide adequate information on the action required.
- Inadequate and unclear warning messages remain as key challenges against enhancing the response capability. The current forecasts and warnings do not include information on the impact of the risks and guidance of what should a particular community or group does, when and how.
- The current institutional arrangement throughout the country is mostly engaged with post-disaster response interventions. Coordination among the different organizations is not yet established to support response interventions to early warnings. However, the national and state disaster management commissions are able to intervene if needed, for the community response to warnings issued.

4.2.6 Strengthening Existing Flood and Drought Early Warning Systems

As indicated previously, currently, the Hydro-meteorological Department under Ministry of Energy and Water Resources has the role of managing hydro-meteorological activities and monitoring at the federal level as well as its standard ministerial roles. But currently the department need to strength technical and institutional capacity to analyze, forecast, develop and disseminate timely early warnings messages for floods, drought, cyclones and accurate hydrological, hydrogeological and meteorological information to enable the efficient and economic management of water resources.

In order to Strength the existing flood and drought early warning systems in Somalia, first and foremost, it is required to upgrade the Hydro-meteorological Department or establish a National Hydro-Meteorological and Monitoring service (NHMS) unit to be responsible for all monitoring and forecasting and to provide information on weather, climate, and hydrological conditions; to mitigate natural disasters and to support national development. NHMS should perform these functions by acquiring:

- Comprehensive, high-quality and robust observational networks;
- Efficient data collection and management and rapid information exchange;
- Improved understanding of meteorological and hydrological phenomena through ongoing scientific research;
- Effective dissemination systems using multiple channels to assure the widest dissemination of warnings, forecasts, and advisory information;
- Capacity building across the entire NHMS and for the users and stakeholders; and

- Improved methodologies and algorithms for use of meteorological, hydrological, and related information in decision making.

NHMSs focus on understanding the user value chain to better understand users, the decisions they must make, and how information related to weather, climate, and hydrology is applied to minimize risk and to benefit the society as a whole. As a result of improved service delivery, users will gain confidence in the capability of the NHMS. The operation of a NHMS in any country is based on observations and data collection; data processing; telecommunications; preparation of forecasts, warnings, and climate advisories; and dissemination of forecasts and other specialized information through the media and other channels to users. No country is alone in undertaking these tasks; the combination of many networks, centers, and hubs on global, regional, and national scales form the intricately interconnected world of global hydrometeorology. The three components of observations, telecommunications, and data processing and forecasting together comprise the WMO World Weather Watch Program. The generation of meteorological and hydrological value can be depicted in a “value chain” linking the production and delivery of services to user decisions and the outcomes and values resulting from those decisions (Fig 4.4).

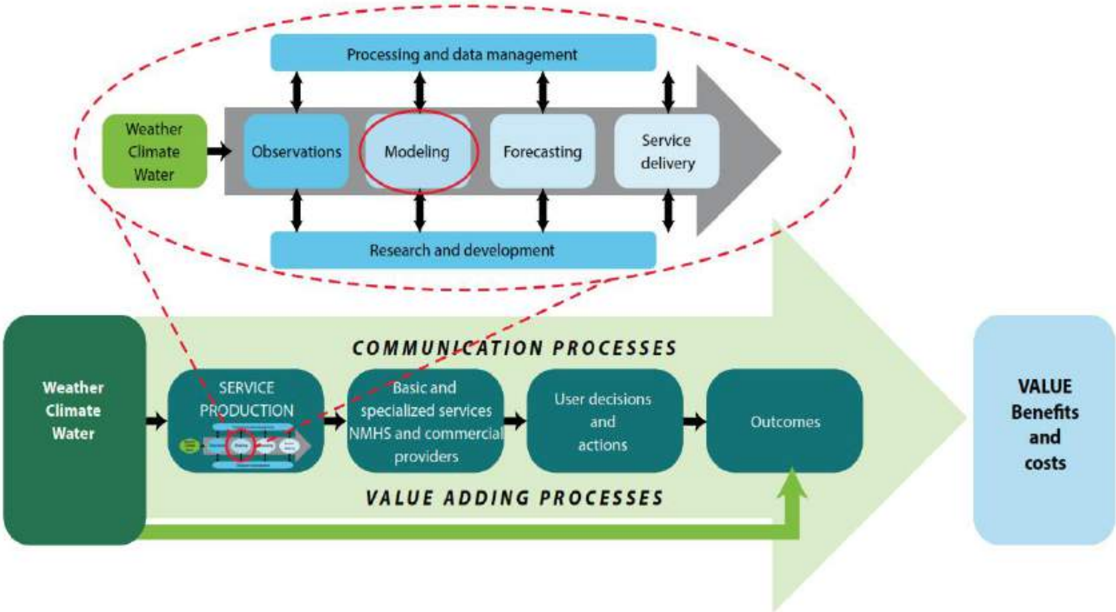

Figure 4. 4 Hydro-Meteorological Production Value Chain (Source: WMO, 2015)

In well-functioning NHMS, every link in this chain is strong, helping to deliver value to the society at the end of the chain. Significant improvement of interrelated elements of meteorological and hydrological monitoring networks, forecasting, and service delivery is necessary. This includes new technologies for data sensing and recording, data validation and archiving, and modern scientific-based tools for forecasting, dissemination, and communication of products and services (Fig 4.5).

Such improvement requires the integration of five essential elements in the monitoring program of an NHMS, as follows: quality management system, network design, technology, training, and data management.

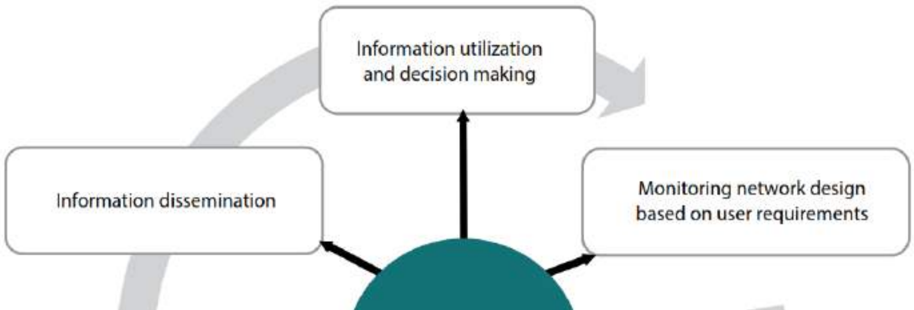

Figure 4. 5 Schematic for strengthening of National Hydro-Meteorological and Monitoring Services

Figure 4.6 gives an overview of the flow of data and information in National Hydro-Meteorological and Monitoring Services.

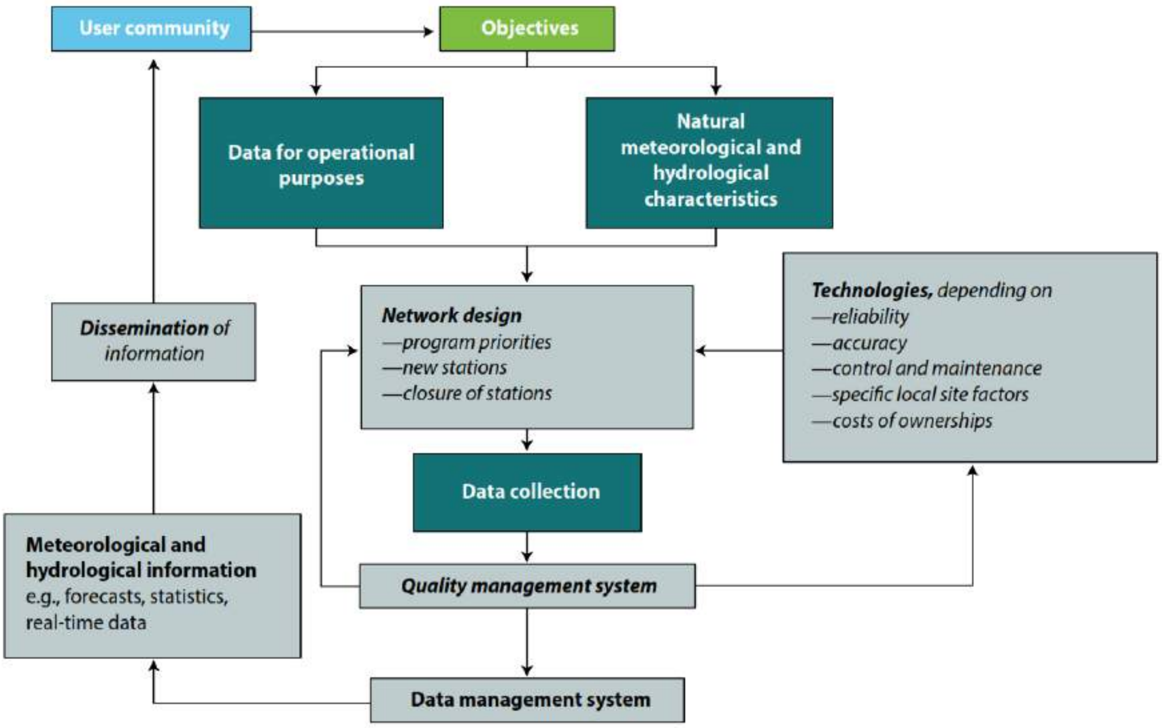

Figure 4. 6 Data Flow in National Hydro-Meteorological and Monitoring (Source: Andreas Schumann, 2017)

The socioeconomic benefits of NHMS will be manifested in managing risk and aiding decision making in (i) weather-related disasters and (ii) economic development. This is especially the case for floods, which have the biggest impact on the poor and vulnerable populations. Improving the forecasting and early warning of hydro-meteorological hazards will contribute to building resilience for communities and sectors at risk. Any strengthening for NHMS should typically include three components, namely: (i) enhancement of service delivery systems; (ii) institutional strengthening and capacity building; and (iii) modernization of observation, ICT, and forecasting infrastructure. The activities proposed in the subsequent sections are in line with this principle. They aim to strengthen the MoEWR's institutional basis: to enhance a legal and regulatory framework and to develop the capacity of staff; to technically modernize the observation, ICT, data management, and hydro-meteorological forecasting infrastructure and facilities; and, most importantly, to improve the delivery of hydro-meteorological and EWS to the Somali people and weather-dependent sectors.

The upcoming National Hydro-meteorological and Monitoring service policy will clearly establish the mandate of the service for all the states and the FGS. The most important aspect of the policy should be the effective coordination at the national level to ensure the services are authoritative, credible, and dependable, and used to inform better decision making by the end-users. Combine all the exiting EWS's including FRISC-DIGNIIN alert system and transfer them to the NHMS; enhance and expand their capacity to collect and disseminate early warning and contingency planning information covering the whole country. Standard operating procedures should be developed and implemented by NHMS in partnership with key stakeholders for producing and communicating fit-for-purpose services. This is especially important in the case of warnings to ensure that such information is consistent among partners and stakeholders, permitting clear decision making and timely action.

The wide dissemination of hydro-meteorological data, forecasts, and warnings to all users is a key element of modern delivery of public and hydrological services. An essential tool will be the NHMS and MoEWR websites for access to important meteorological and hydrological information needed by the user community. The websites should be managed on an operational basis and kept up to date. Consideration should be given to developing color-coded information and pictograms, which are often the most effective way of communicating warnings.

4.3 Stakeholders and Consultations

4.3.1 Stakeholders analysis

The following key stakeholder groups have been identified with responsibility for delivery of services relevant to EWS in Somalia:

1) State actors (national/regional/district levels);

1. Ministry of Energy and Water Resources
2. Ministry of Planning and International Cooperation
3. Office of Environment at the Office of the Prime Minister
4. National Disaster Preparedness and Food Reserve Authority (NADFOR)
5. Humanitarian Disaster Management Authority (HADMA)
6. Ministry Transport and Civil Aviation
7. Ministry of Agriculture
8. Ministry of Livestock, Forestry and Range
9. Ministry of Health
10. Ministry of Public Works and Reconstruction
11. Ministry of Labour and Social services
12. Ministry of Interior and Federal Affairs
13. Ministry of Fishery and Marine Resources
14. Ministry of Internal Security
15. Ministry of Finance
16. Educational Institutions Ministry of Education, Somaliland, Galmudug, Puntland, Hir-Shabelle, South West, and Jubaland
17. Communities (traditional leaders, pastoralists, youth groups, CBOs)
18. District disaster committees

2) Non-State Actors

1. Non-governmental organizations/Community Based Organizations
2. Academic Institutions
3. Impacted communities; and vulnerable groups (women, elderly, youth, nomadic pastoralists and other mobile groups/informal settlers, people with disabilities) include:
    - Traditional clan leaders/elders, and Religious leaders
    - Cooperatives (Pastoral cooperatives formed with the support
    - Farmers associations
    - Business organizations (local chamber of commerce)
    - women and youth -based groups
    - District Disaster Management Committees

4.3.2 Initial consultations and workshop

Due to the security situation in Somalia, opportunities to conduct comprehensive stakeholder consultations in the country are limited. In-depth interviews with government officials, local and international NGO representatives working in Somalia, climatologists and sector specialists with expertise on Somalia, academics, former government officials, and other stakeholders. The results of these discussions provided critical insights about the most pressing institutional strengthening and capacity development needs, lessons learned from previous projects, as well as information about technical feasibility of various approaches to strengthening climate information and early warning systems in Somalia.

Several of the participants emphasized the urgent need for capacity building and awareness-raising activities at the subnational (state and district) level with respect to early warning systems and climate change. Participants also pointed to the need to establish effective vertical coordination between government institutions through which information generated at local levels can be effectively integrated into national level strategic planning processes. These consultations informed the design of a feasible and coherent set of recommended activities that is consistent with the institutional realities present in Somalia. Below are the main points that were identified as the way forward by the participants for the strengthening of the national EWS and long term planning for climate change:

- Modernization of observation infrastructure, data management systems, and forecasting
- Institutional strengthening and capacity building
- Rehabilitation/ Upgrading of existing hydro-meteorological stations and data rescue and addition of stations in strategic areas
- Expansion of automatic weather stations
- Enhance data management, communication, use of ICT and weather forecasting based on remote sensing;
- Developing a comprehensive national EWS system
- Enhance the CBEWS
- Global data exchange, submit and retrieve data from the WMO Global Telecommunication System (GTS)
- Coordination and collaboration with key government stakeholders at the subnational (state and district) level
- Strong collaboration between information producers, research society, user community
- Accuracy, timeliness, availability, usefulness, compatibility - high priority
- Research
- Manpower development and computation skills - capacity building

- Knowledge transfer

5. Conclusions and A Way Forward

5.1 Key Findings and Critical Issues

Somalia, a member of the World Meteorological Organization (WMO), is classified as the least developed country by the UNFCCC, has been devastated not only with the long-lasting civil war but also by natural hazards. Somalia lacks a systematic and defined Early Warning System at the national level. No EWS exists in the country for issuing warnings of severe weather events. No agro-meteorological forecasts or flood forecasts are produced, and assessment of the water resources of the country are lacking.

In the current arrangements, MoHADM (Federal level), HADMA (Puntland) and NADFOR (Somaliland), and Somali WASH Cluster are the main providers of early warning and climate information in Somalia and are at the forefront of the risk reduction system in the country through provision of the required information. MoHADM is responsible for all pre-during and post-stages of disaster risk reduction and management in the country. MoHADM has only been operational for four and a half years. Hydro-meteorological Department under MoEWR and is responsible for the provision of nationwide hydro-meteorological monitoring services; information to decision makers about the water (Hydrological and Meteorological services) and the status and trends of a country's water resources. The newly established National Multi-Hazard Early Warning Center in Mogadishu is responsible on coordination of disaster risk management activities in the country and produce regular information products on climate such as rainfall and temperature forecasts, early warning on floods and droughts, cyclones, as well as projections on desert locust movement and diseases. However, a responsibility for different elements of an effective EWS is divided between various institutions in Somalia as well as lacking technical and institutional capacity to disseminate timely early warnings and accurate hydrological information to enable the efficient and economic management of water resources. There is limited capacity to systematically access, process, and integrate remote sensing products into hydro-meteorological services and EW systems. EWS is included in most of the national disaster-related policies and relevant plans, although there is still lack of a long term strategic early warning system plan.

Currently, FAO-SWALIM with its historical data is considered as the central entity for risk knowledge. Since the collapse of the government the risk monitoring and warning services are done by the donor-driven FEWSNET, FSNAU, FAO-SWALIM, IGPAC programs for drought, floods, cyclones and other climate-related diseases and epidemics. Both, FAO-SWALIM and IGPAC operate hydro-meteorological stations in Somalia and have access to global platforms. There are currently over 110 manual rainfall stations, 16 river gauging stations, 9 manual synoptic stations, and 13 automatic weather stations in Somalia run by SWALIM.

Warnings are also reached out to people through government institutes, Somali WASH cluster, NGO's websites and social media platforms and sometimes through mass media channels. Given that there is no systematic EWS and a clearly defined Standard Operation Procedure (SOP) for early warnings in Somalia, the issued warnings do not follow a previously defined communication way to reach to the communities at risk. It is obvious that a community-based early warning system is much more effective than a system at the national level. Focusing on community-based (People-centered) EWS is also in line with the existing disaster risk reduction frameworks of Somalia.

During the past five years, a significant amount of efforts are made in the field of disaster risk reduction in Somalia. Today, the government institutes with support from national and international partners have a better knowledge of natural hazards and its relevant risks, than ever. Though further improvements are needed, the government monitors different parameters associated with flood and drought and provides forecast and warning services. Warnings are disseminated to a bulk of people through mass media channels. However, there is still need for further efforts to be made to improve the current state of risk knowledge to the village and watershed levels; to extend the coverage area of hydro-meteorological monitoring stations; to improve forecasting and warning issuances; to strengthen the warning dissemination processes and channels, and to establish and improve an effective response plan to issued warnings.

For effective EWS, it is vital to achieve and improve all four elements of early warning system including the risk knowledge, monitoring and warning services, dissemination and communication and the response capability. With the current institutional arrangement, each of the four elements of the EWS is not achieved at the national level, and in a disconnection way from each other. Coordination and continuous communication among the involved institutions need more attention and improvements. At some point, there is a need for joint and inclusive efforts to be made among the involved institutions.

5.2 Recommendations

Low-cost, high-priority activities are needed to achieve critical minimal capabilities to provide weather, climate, and hydrological services (focused on improving basic public services based on strengthening MoEWR capacity in the use and interpretation of available and accessible tools and technologies and introducing basic affordable new technologies). The following recommendations are based on the findings of this report and are intended to address some of the existing challenges against the EWS in Somalia.

- MoEWR, in collaboration with SWALIM and MoHADM, should establish a methodology for the establishment of a EWS and a CBEWS supplement with a clear SOP that explains different stages for the establishment and implementation of EWS, including the type of technologies to be used. Having clear SOPs will allow other practitioners in the sector to follow the same methodology and use the predefined and unified type of technologies.
- Upgrade the Hydro-meteorological Department under MoEWR or establish a National Hydrological and Meteorological and Monitoring service (NHMS) unit to be responsible for all monitoring and forecasting and to provide information on weather, climate, and hydrological conditions.

- Combine all the exiting EWS's including FRISC-DIGNIIN alert system and transfer them to the NHMS; enhance and expand their capacity to collect and disseminate early warning and contingency planning information covering the whole country.
- The current institutional arrangement requires an inclusive and consultative discussion among the involved stakeholders to clarify each institution's responsibilities and terms of references.
- Communication among the involved institutions needs to be strengthened, both at the national and local levels. Stakeholders need to communicate rapidly and have shorter of communication. An efficient approach would be to rely on Information Technology products, such as the establishment of a platform that is accessible by all key stakeholders. Effective communication among and between the stakeholders is crucial throughout the achievement of all four elements of EWS.
- In line with the adopted frameworks of the country, the establishment of new EWS needs to be people-centered and at the same time technically sound systems that include traditional approaches and systems.
- As disaster is managed through different development and ecological plans and programs, it is important to integrate EWS establishment in relevant national and local frameworks and action plans.
- Given that the implementation of EWS falls under the responsibility of various institutions, coordination among the key involved institutions should be strengthened. This coordination is required throughout the achievement of all four elements of EWS. Some of the processes, such as the issuance of a warning require the involvement of more than one institution, which not only requires coordination but even joint delivery. This might require signing a Memorandum of Understanding among different institutions.
- Several rounds of training to build on current capabilities of forecasters to enhance the understanding and as full a use of data. The following list is indicative of areas for which training is generally required based on current capabilities and gaps in the knowledge of the relevant staff:
    - Project management;
    - Management training;
    - Technical skills to support meteorological and hydrological observing networks;
    - Instruments and sensors maintenance;
    - Enhanced skills in weather forecasting using numerical models on all timescales from nowcasting to long-range forecasting;
    - Enhanced skills in weather forecasting based on remote sensing;
    - Enhanced skills in flood forecasting using numerical models;
    - Enhanced skills in deterministic seasonal forecasting using models;
    - Understanding of the end-to-end early warning production and delivery;
    - Impact-based forecasting and warning services including for hazards such as floods, droughts…etc
    - Verification and statistics methods for model evaluation;
    - Data base management;
    - IT management skills;
    - Skills in the delivery of public weather and hydrological services, including user/stakeholder consultation, communication, negotiation, and feedback gathering;
    - Enhanced skill in climate prediction using numerical methods; and

    - Public education and outreach.
- Strengthening the application of GIS, either by introducing QGIS software (freeware), if no GIS system exists, or by using an already existing system such as ArcGIS;
- Raising public awareness is a key to the efficiency of the EWS. To raise awareness of the general public, it is essential to develop and deliver outreach and awareness activities at the national and sub-national levels.
- To the extent possible, efforts should be made to extend the number of CBEWS throughout the country. If not high-technologies, basic and low-cost early warning equipment should be distributed in the most vulnerable communities.
- To overcome financial challenges, the government needs to allocate an annual budget for the improvement of the current status of the EWS as well as to extend the coverage of EWS throughout the country. The government should also focus on accessing global climate funding mechanisms for this purpose.
- The government should also maintain and improve its collaboration FAO-SWALIM, IGAD-ICPAC and USAID to benefit from their technical and technological assistance.
- To have a better knowledge of hydro-meteorological hazards risks:
    - Risk and vulnerability assessments need to be undertaken at the village and watershed levels, in order to allow better monitoring of risks, which will result in issuing accurate warnings and disseminating to the communities at risk;
    - Strengthen the data management system on risk knowledge. Risk and vulnerability assessment conducted by various organizations using on-the-ground surveys or through remote sensing approaches, need to be stored in a central data repository for further analysis and uses. The system should ensure quality assurance and quality control procedures.
    - Risk and vulnerability assessments need to be conducted in an inclusive, participatory and community-based manner, in order to involve all stakeholders and capture traditional knowledge for risk management.
- To overcome the risk monitoring and warning services challenges:
    - The current hydro-meteorological monitoring station networks should be extended to cover all vulnerable areas of Somalia. However, in case the plan is to bring new technology, the feasibility study of the concerned technology should be undertaken to avoid functionality failure at later stages as it is evident in some cases;
    - Monitoring stations need to be equipped with telemetry and other adequate technologies that facilitate real-time data transfer. This will allow enough lead-time for the people at risk to get to a safe location, in case of flood and flash flood risks.
    - The current inter-governmental institutional arrangements for EWS need to be reviewed; an ideal situation would be to decide on the warning levels jointly. For this purpose, all the institutions involved in EWS need to compare their data and conduct a joint analysis of data for warning issuance.
    - Risk levels threshold needs to be adjusted according to the vulnerability level of each location. On-the-ground risk and vulnerability data for deciding on warning levels and adjusting the threshold is fundamental beside monitoring and forecasting of other hydro-meteorological parameters.
    - A capacity needs assessment should be undertaken to identify the capacity need for the relevant institutions, to improve the risk monitoring and warning services. Informed by the mentioned assessment, capacity enhancement programs should be

planned and delivered for professional working on both risk monitoring and warning services.

- To overcome the gaps in dissemination of the warnings:
  - The issued warning messages should be very clear and include information on the risk impacts, and provide decision-making advice that could support people at risk to take action.
  - It is important to route all early warnings through a single delivery mechanism. This will allow building trust, ensuring timely dissemination of warnings and using a standard language for all messages.
  - The states offices of relevant institutions involved in EWS need to be proactive for the dissemination of warnings to ensure widespread of the warnings to all concerned people and communities.
  - At the state level, there is a need for joint collaboration between relevant institutions involved in EWS. This joint engagement requires an official Memorandum of Understanding or any other official binding agreement.
  - MoEWR should undertake an assessment of the effectiveness of the warning messages. This will allow evaluating the effectiveness of warnings delivered and capture the lessons-learned for further improvement of the process.
- For overcoming the gaps in response capability:
  - The government needs to establish a standard response plan for issued warnings. Currently, there is no clear guidance for how people should react to the issued warnings and how to ensure that the targeted people react to the warnings.
  - Warning messages need to be targeted to the people and communities at risk. This will allow the message to follow a specific route to reach out to the targeted audiences and will acquire them to take action.
  - Strengthen people’s knowledge on the response plans through conduction of training sessions, outreach materials and undertaking simulation exercises and drills.
- Establish and strengthen coordination mechanism among different institutions that could potentially support the response plan to the warnings. This might require and official MoU among different organizations to engage on the occasions of need.

References

1. Anyah, R.O. and Qiu, W. (2012). Characteristic 20th and 21st Century Precipitation and Temperature Patterns and Changes over the Greater Horn of Africa. International Journal of Climatology, 32, 347-363. https://doi.org/10.1002/joc.2270
2. Brazzola N, H. S. (2018). Five approaches to build functional early warning system. United Nations Development Programme.
3. EM-DAT. (2018). The International Disaster Database. http://www.emdat.be/
4. EWC. (2006). Developing early warning system: a checklist. Geneva: UN Inter-Agency Secretariat of the International Strategy for Disaster Reduction. Retrieved September 2, 2020, from https:// www.unisdr.org/files/608_10340.pdf
5. Few, R., Seytal, P., McGahey, D., Leavy, J., Budd, J., Assen, M., Bewket, W., et al. (2015). Vulnerability and Adaptation to Climate Change in Semi-Arid Areas in East Africa. ASSAR Working Paper, 111
6. Giovanni Federico. Feeding the World (2005). An Economic History of Agriculture, 1800–2000. Princeton Economic History of the Western World. Princeton, NJ: Princeton University Press, 2005. Pp. 416.
7. Gure, A. M. (2021). The Role of Climate information and Early Warning Systems in Supporting Disaster Risk Reduction in Somalia, Technical Report No. WC-007.
8. GTZ. (1990). Masterplan for Jubba Valley Development. Main Report. Somali Democratic Republic.
9. ICPAC (2016). IGAD Climate Prediction and Application Centre. http://ftp.chg.ucsb.edu/pub/org/chg/products/GeoCLIM/Geoclim_archives/
10. IPCC. (2014). Africa. In: Climate Change 2014: Impacts, Adaptation, and Vulnerability. Part B: Regional Aspects.
11. IUCN (2006). Country Environmental Profile for Somalia. The European Commission Somalia Operations Office, Nairobi. https://europa.eu/capacity4dev/file/33006/download?token=OUsVfuq

12. Jack E, D. J. (2010). Guideline on Early Warning Systems and Application of Nowcasting and Warning Operations. Geneva: World Meteorological Organization.
13. Kammer, D., 1989. A Brief Description Major Drainage Basins Affecting Somalia. Prepared by. National Water Centre, Mogadishu. Project Field Document No. 14. SOM/85/008
14. Muchiri, P. W. (2007). Climate of Somalia, Technical Report No. W-01.
15. Mumuli, S. O, Alim, M. and Oduori, G., (2010). Monitoring of Mangroves in Somalia (Puntland, Somaliland and South Central Somalia). FAO-SWALIM. Project Report No. L-19. Nairobi, Kenya.
16. Shaie, A.M. (1997). Inventory Report Somalia. FAO Report. Rome, Italy. Vargas, R., Paron, P., Monaci, L., Shaie, M. Oduori, S. Downie, M. and Nduby, A. 2007. Field Survey Manual. Project Report L-01. FAO-SWALIM. Nairobi, Kenya.
17. United Nations/International Strategy for Disaster Reduction (UN/ISDR). 2003b. Information Systems and disaster risk reduction. Geneva, Switzerland: United Nations. [Online]. Retrieved from: http://www.unisdr.org/news/WSIS/WSIS. pdf [2008, July 12].
18. UNISDR, (2009). Global Assessment Report on Disaster Risk Reduction, Geneva: United Nations.
19. UNDP/ICPAC (2013). NAPA Report for Somalia – Climate Variability and Projections. Produced by the InterGovernmental Climate Predictions and Assessment Centre (ICPAC) on behalf of the United Nations Development Programme for Somalia, using (inter alia) data obtained from the Somalia Water and Land Information Monitoring (SWALIM) database.
20. UNDP, (2010). World Environment Day, Biodiversity in Somalia. http://www.so.undp.org/WED/bio_diversty.html
21. UNOCHA. (2017). Horn of Africa: Humanitarian Impacts of Drought. https://reliefweb.int/report/somalia/horn-africa-humanitarian-impacts-drought-issue-11-3-november-2017
22. World Bank Group/GFDRR (2018). Assessment of the State of Hydrological Services in Developing Countries. Washington DC.
23. World Health Organization (2003). Climate Change and Human Health: Risks and Responses. World Health Organization, Geneva.
24. World Meteorological Organization/WMO, World Bank/GFDRR and USAID (2015). Valuing Weather and Climate: Economic Assessment of Meteorological and Hydrological Services, WMO No. 1153. Geneva, Switzerland.