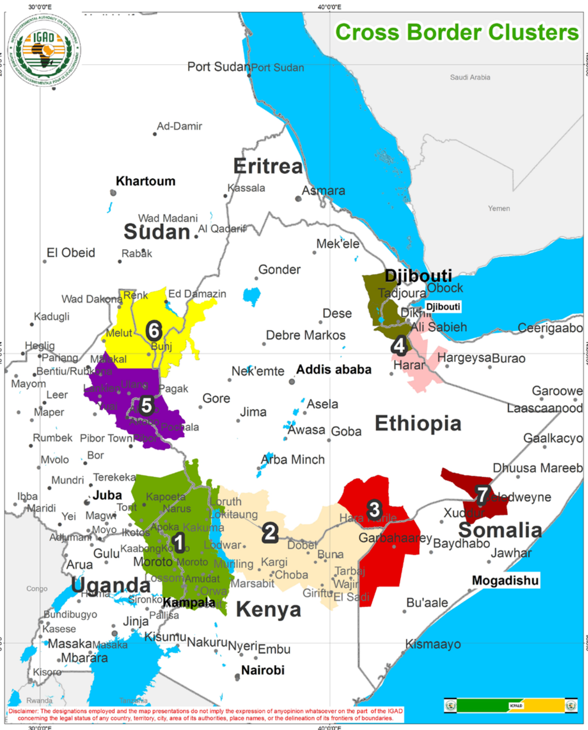
Training Module

IGAD
ICPAC

Strengthening Multi-Hazard Early Warning Systems (EWS) and Disaster Risk Management in Karamoja, Moyale — Moyale and Mandera Triangle; A Cross-Border Setting

September 2025 - February 2026



1 IGAD Cluster 1 (AKA Karamoja Cluster)
2 IGAD Cluster 2 (AKA Somali Cluster)
3 Proposed new areas in Somalia
4 IGAD Cluster 4 (AKA Dikhil Cluster) plus proposed new areas in Somaliland
5 Proposed cross border cluster: Ethiopia and South Sudan
6 Proposed cross border cluster: Ethiopia, Sudan and South Sudan
7 Proposed cross border cluster: Ethiopia and Somalia

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Strengthening Multi-Hazard Early Warning Systems (EWS) and Disaster Risk Management (DRM) in Karamoja, Moyale-Moyale and Mandera Triangle; A Cross-Border Setting

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About ICPAC and the IGAD DRM Unit

IGAD Climate Prediction and Applications Centre (ICPAC)

The IGAD Climate Prediction and Applications Centre (ICPAC) is a specialized institution of the Intergovernmental Authority on Development (IGAD), based in Nairobi, Kenya, mandated to provide timely climate early warning information and support specific sector applications to enable the region cope with risks associated with climate variability and change including providing climate applications for poverty alleviation, environment management and sustainable development. ICPAC also hosts the Disaster Risk Management Unit and the IGAD Food Security, Nutrition and Resilience Analysis Hub (IFRAH).

The specialized IGAD Centre started as a Drought Monitoring Centre (DMC) in 1989, in response to the devastating drought that occurred in eastern Africa in the 1980s. A Protocol that fully integrated the institution into IGAD was signed on 13 April 2007. The Centre serves eight IGAD member countries namely: Djibouti, Eritrea, Ethiopia, Kenya, Somalia, South Sudan, Sudan and Uganda as well as three non-IGAD member countries, namely Burundi, Rwanda and Tanzania.

ICPAC is responsible for climate monitoring, prediction and early warning, applications, climate change, Disaster Risk Management and capacity building for its member countries to cope with extreme climate events and adapt to future climate changes in support of climate sensitive sectors for sustainable development. Furthermore, it is tasked with providing support on disaster risk management within the region, thus strategic for addressing IGAD's climate variability and change and disaster risk management efforts.

The vision of ICPAC is to be a world-class Centre of excellence in climate services for sustainable development in the Greater Horn of Africa. The mission of the Centre is to foster climate services and knowledge to enhance community resilience for prosperity in the Greater Horn of Africa. ICPAC was designated as a World Meteorological Organisation (WMO) Regional Climate Centre (RCC) for eastern Africa in 2016 and also has an observer status with the United Nations Framework Convention on Climate Change (UNFCCC).

ICPAC Core Values are to:

- **Uphold the virtues of integrity, professionalism, teamwork and meritocracy Promote creativity and innovativeness**
- **Encourage openness and transparency in all dealings and operations Promote social responsibility**
- **Espouse a strong concern for the preservation and protection of the environment**
- **Ensure reliable and timely provision of services**
- **Ensure a regional approach to issues**
- **Promote the use of all knowledge (including indigenous knowledge)**

The Objectives of the Centre are to:

- **Enhance preparedness and mitigation of climate risks and adaptation to climate change and to strengthen disaster preparedness, mitigation and resilience in the IGAD Region.**
- **Provide timely climate early warning information and sector specific products for the mitigation of the impacts of climate variability and change;**

- **Improve the technical capacity of producers and users of climatic information to enhance the input to and use of climate monitoring and forecasting products;**
- **Develop proactive, timely, broad-based systems of information and product dissemination and feedback, at both sub-regional and national scales through partners;**
- **Expand the knowledge base within the sub-region in order to facilitate informed decision making on climate risk reduction related issues;**
- **Maintain quality controlled databases and information systems required for detection and attribution of regional climate hazards and changes; risk/vulnerability assessment, mapping and general support to the national and regional climate risk reduction strategies;**
- **Monitor, assess, detect and attribute climate change and associated impacts, vulnerability, adaptation and mitigation options;**
- **Develop relevant tools required to address the regional climate challenges through research and applications in all climate sensitive socio-economic sectors including addressing linkages with other natural and man-made disasters; and**
- **Network and exchange of information regarding the disasters in the sub-region.**

IGAD Disaster Risk Management (DRM) Unit

The IGAD Disaster Risk Management (DRM) Unit was initiated in 2004 (as a programme), to advance Disaster Risk Reduction (DRR) efforts within the IGAD region. In line with the evolving priorities and global frameworks, the Unit has undergone revisions to align with the four core priorities of the Sendai Framework. These priorities encompass enhancing risk knowledge, fostering effective disaster risk governance, promoting investment in DRR for building resilience, and strengthening preparedness mechanisms

The overarching objective of the Unit is to reduce the adverse impacts of disasters, particularly minimizing the number of people affected and damage to infrastructure by such events. To achieve this goal, the Unit focuses on the implementation of improved multi-hazard early warning systems, enabling timely and accurate dissemination of critical information to the focal institutions of member states. Through the "Strengthening the Capacity of IGAD to Enhance Drought resilience within the Horn of Africa (SCIDA) III" project and similar initiatives, and partnerships with other donors and partners, the Unit aspires to enhance the disaster response capabilities of Member States and communities in cross-border areas to effectively anticipate, prepare for, and respond to disaster events essentially manage risks before they become disasters. Moreover, the Unit places a strong emphasis on promoting climate-resilient livelihoods across the region, ensuring that vulnerable communities are better equipped to adapt and withstand the challenges posed by a changing climate. By aligning with international frameworks and prioritizing proactive measures, the IGAD DRM Unit is well-positioned to make a tangible difference in disaster risk reduction and community resilience. As it continues to evolve and adapt to emerging challenges, the Unit remains committed to its mission of safeguarding lives, livelihoods, and ecosystems in the face of disasters.

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List of Abbreviations and Acronyms

AOI	Area of Interest
CDI	Combined Drought Index
CHIRPS	Climate Hazards Group InfraRed Precipitation with Station
DRM	Disaster Risk Management
EWS	Early Warning System
EADW	East Africa Drought Watch
EM-DAT	Emergency Events Database
FAPAR	Fraction of Absorbed Photosynthetically Active Radiation
ICPAC	IGAD Climate Prediction and Applications Centre
LST	Land Surface Temperature
MODIS	Moderate Resolution Imaging Spectrometer
NDVI	Normalized Difference Vegetation Index
PA	Protected Area
PDF	Portable Document Format
SMA	Soil Moisture Anomaly
SMI	Soil Moisture Index
SMS	Short Messaging System
SPI	Standard Precipitation Index
SST	Sea Surface Temperature
VCI	Vegetation Condition Index
XML	Extensible Markup Language

Training Module on Early Warning Systems (EWS) and Disaster Risk Management (DRM)

Module Objectives

By the end of this course, the participants will be able to:

- Explain various concepts related to EWS and Disaster Risk Management (DRM) in a cross-border setting
- Properly understand operational mechanisms and procedures for the prediction, forecasting, downscaling, monitoring and response to warnings in a cross-border setting
- Examine the kinds of tools and products that are available or could be developed to integrate information into forms most useful for them to make decisions at various levels
- Generate/adopt and use tools for early warning, identify current gaps in existing early warning systems
- Undertake risk mapping/assessment and design of multi-hazard early warning systems for managing and reducing (drought) disaster risks
- Assess strategies to institutionalize early warning systems into the process cycle of disaster risk reduction and development planning, emergency response, and preparedness activities
- Design and implement community based, people centered and cross-border early warning systems

Trainees and stakeholders will be introduced to various aspects of early warning systems and disaster risk management. This training is designed to increase the participant's awareness of the process of Early Warning System, leading to better performance in disaster preparedness and response. The major objective of this training is to increase awareness about early warning mechanisms for different hazards, their potential benefits, challenges in taking decisions during such early warning, and capacity building in interpreting and taking suggested protective measures.

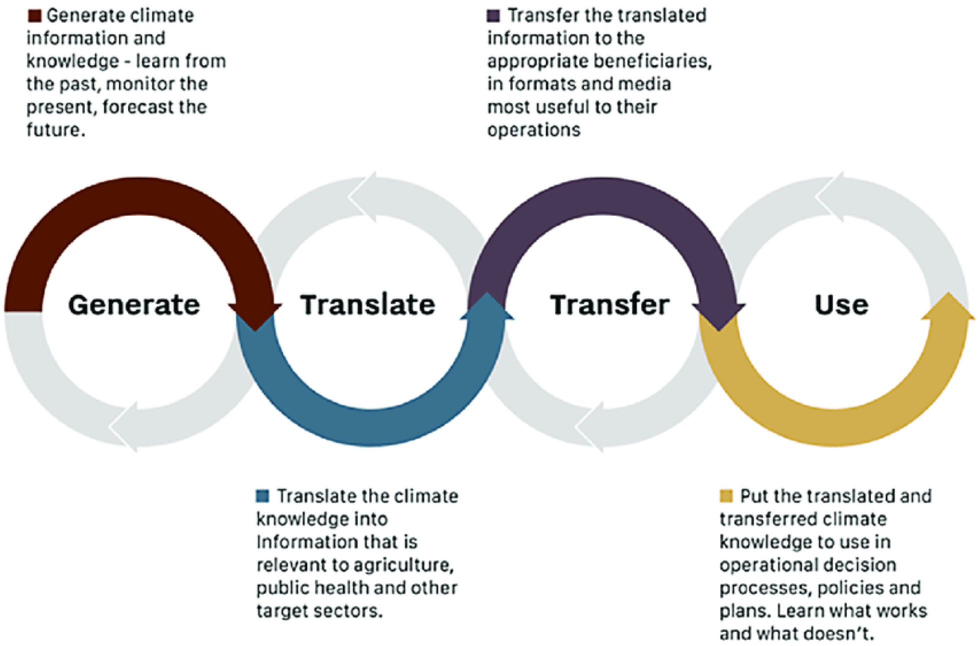
Early Warning Systems (EWS)

Introduction

Background and Context

Climate-related hazards including droughts have significantly increased in the recent past particularly in the Horn of Africa (HoA) where most landscapes are characterized by semi-arid to arid lands. **Karamoja cluster** covering part of Kenya, Ethiopia, South Sudan and Uganda; **Moyale-Moyale cluster** covering borderlands in Ethiopia and Kenya and **Mandera Triangle** covering borderlands of Ethiopia, Kenya, Somalia have experienced a series of droughts and other hazards leading to significant loss of lives and livelihoods, food insecurity, water and pasture shortage and displacement. Increasing hazards, exposure, vulnerability and low adaptive capacity across communities have amplified disaster risks across various fragile ecosystems driving conflict and displacements. On many occasions, resource-based conflicts have been experienced as communities have moved into new territories, sometimes with large herds of animals in search of water and pasture.

A credible Early Warning System is anchored on provision of timely, understandable and usable climate information service guided by the value chain shown below:



Multi-Hazard Early Warning Systems (MHEWS) have been identified at the highest political level (national, regional, continental and global) as a critical tool for anticipating, preparation and investments ahead of disasters and helped in saving lives and strengthening livelihoods. The United Nations (UN) Early Warning for All (EW4All) initiative emphasizes the need to cover and protect all at-risk communities by EWS. The Global Framework for Climate Services (GFCS) is under implementation by the World Meteorological Organization and emphasizes the establishment of Regional Framework for Climate Services (RFCS) and the National Framework for Climate Services (NFCS). For example, Kenya's NFCS seeks to establish an institutional mechanism to coordinate, facilitate and strengthen collaboration among national institutions to improve the co-production, tailoring, delivery and use of science-based climate predictions and services.

A number of components, sectors, and actors relevant for EWS have been illustrated under GFCS delivery and implementation as shown in Figure 1a below.

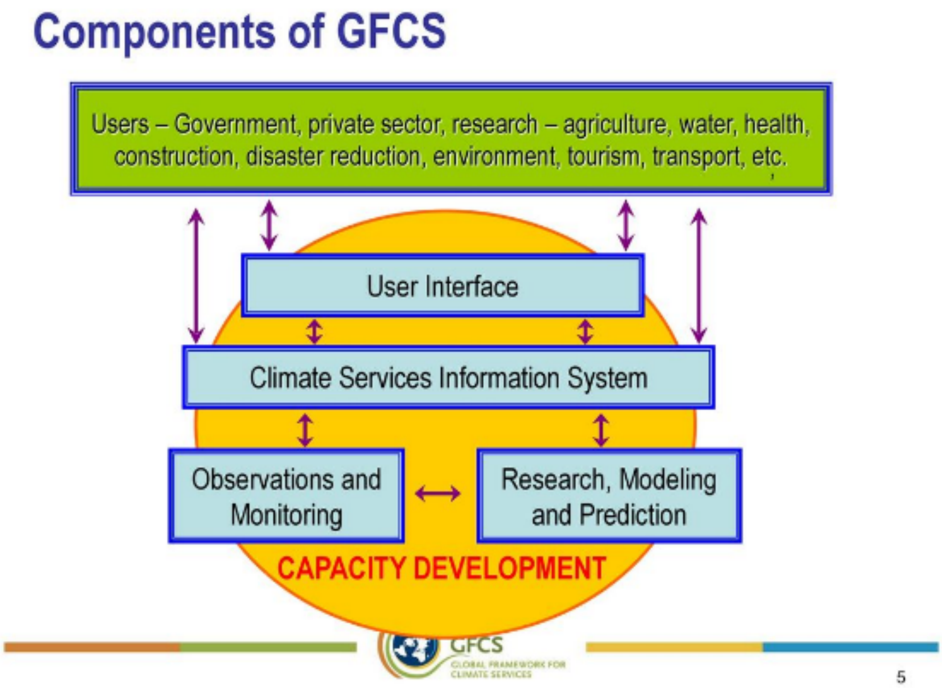


Figure 1a: Global Framework for Climate Services (GFCS)

Figure 1b: Kenya (left) and Ethiopia (right) National Frameworks for Climate Services (NFCS)

The governments, international development agencies and bilateral donors are supporting the development of EWS at the national level. Implementation of EWS with a multi-hazard framework is deemed challenging due to legislative, financial, organizational, technical, operational, training and capacity building constraints. Therefore, this course will help its participants/trainees and stakeholders to develop an early warning system and risk management plans tailored to the needs of the Moyale cluster.

Implementation of the Global Framework for Climate Services (GFCS) requires development and implementation of National Frameworks for Climate Services (NFCS), such as the examples shown in Figure 1b above and the Regional Framework for Climate Services (RFCS).

Task #01a: Which components of the global/regional/national Framework for Climate Services ensure that information is relevant for decision making at the Cluster level?

Task #01b: What are the gaps limiting operationalization of the framework for climate services in any country/county/cluster?

Early Warning System (EWS) Framework and its Elements

An Early Warning System (EWS) includes, on one hand, the gathering, processing and presentation of information in a consistent and meaningful manner to allow the generation of alert messages and, on the other hand, the generation and transmission of alert messages to the end-users at risk by means of warning communication. EWS has necessarily evolved to become more people-centered, in a way that is respectful and recognizant of the participation of communities in the development of an EWS that concerns them at local level.

In addition, people-centered EWS capitalizes on the knowledge, tools and systems within a community. The core idea is that for any EWS to be effective, the message from the 'top level' (e.g. government, research institutions) must reach the populations who stand to be affected by the hazards being monitored. In addition, communities can contribute substantially to EWS from 'the bottom up', in that they can raise initial warnings about changes of key indicators (e.g. rising water levels, increased prevalence of illness symptoms), and convey these messages to centralized systems or information managers who are able to raise the signal within an EWS.

An effective early warning system includes four core elements (see Figure 2 below), and each element must function efficiently for the system to be successful.

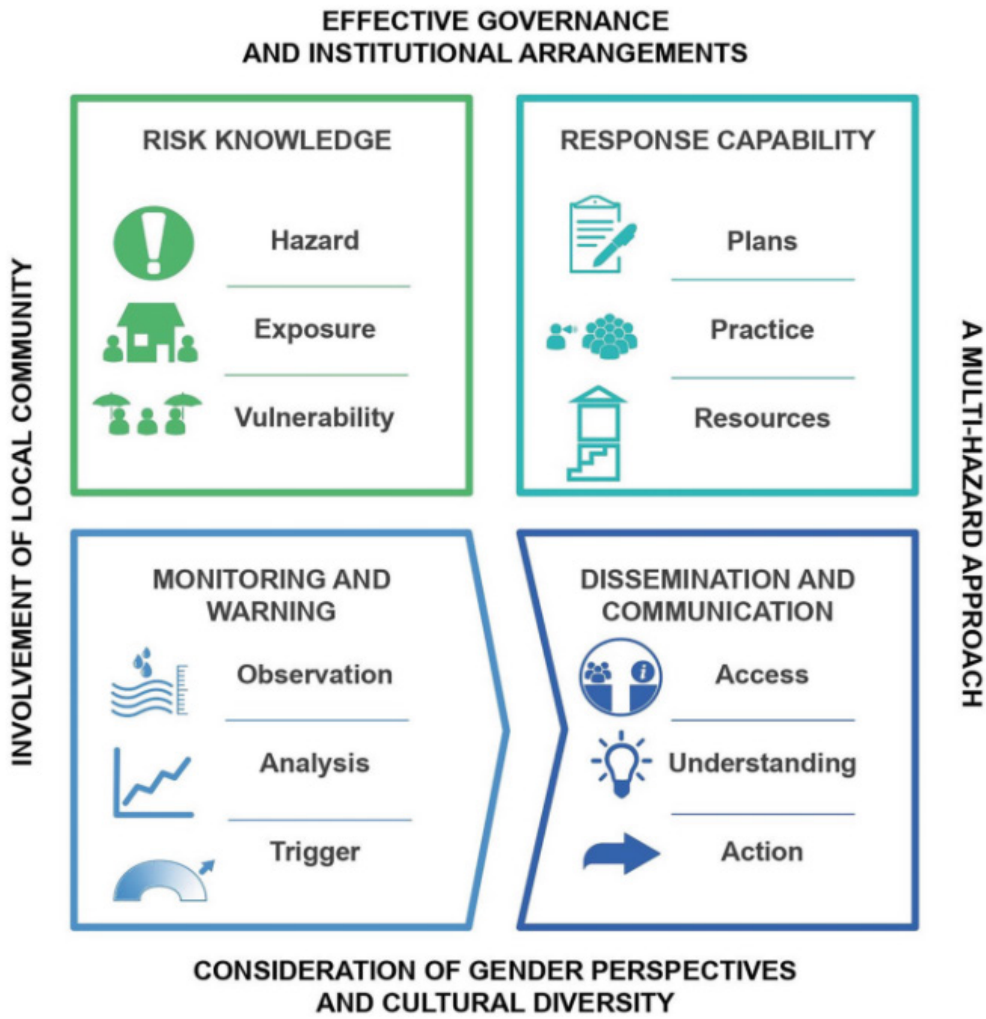


Figure 2: Early Warning System Component

Task #02a: What would you consider as major building blocks for a functional EWS?

Task #02b: Why does an EWS fail sometimes?

Task #02c: How can we promote effective use of an EWS?

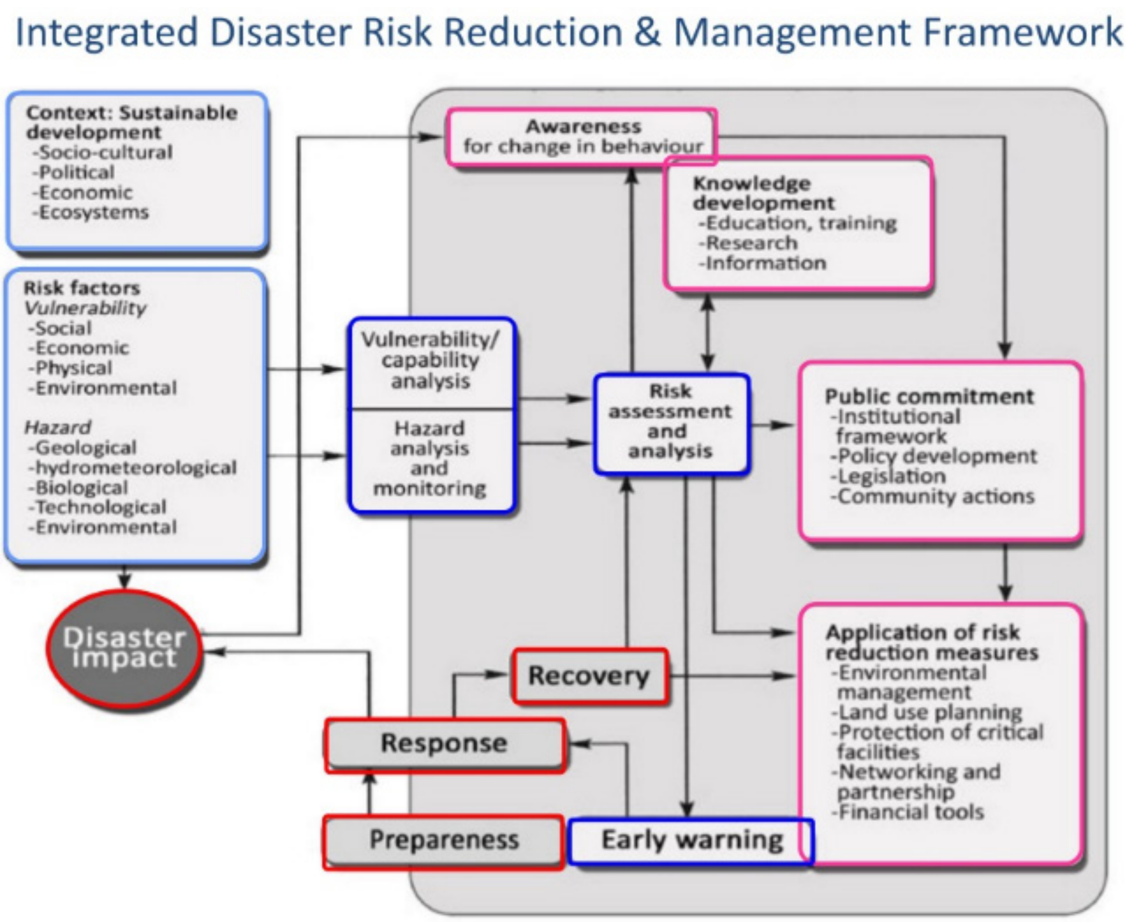
Integrated Disaster Risk Reduction

Integrated disaster risk reduction (IDRR) involves weaving disaster risk reduction (DRR) principles and practices into all aspects of national development and humanitarian planning, an approach actively supported by the United Nations Office for Disaster Risk Reduction (UNDRR). UNDRR oversees the **Sendai Framework,** providing global guidance and country-level support for activities like risk assessments, multi-hazard early warning systems, and capacity development to prevent and reduce disaster risk and promote resilience. This integration helps countries achieve comprehensive risk management by aligning DRR with climate action and other development goals.

IDRR emphasizes three elements:

- **Holistic Approach:** IDRR is a process that connects and coordinates DRR with broader strategies for development and humanitarian aid.
- **Prevention and Reduction:** It aims to prevent the creation of new risks and reduce existing ones, building resilience against disasters.
- **Partnership:** IDRR requires an "all-of-society" approach, with shared responsibility among governments, local authorities, the private sector, and other stakeholders.

In addition, there are several other elements needed to support integrated disaster risk reduction and management as shown in Figure 3 below.



Conceptual Framework for Disaster Risk Reduction, UNISDR

Figure 3: Integrated Disaster Risk Reduction and Management Framework in the context of EWS

Furthermore, the Sendai Framework establishes four pillars for Disaster Risk Reduction (DRR):

1. **Understanding disaster risk:** This priority involves taking measures to increase the availability and accessibility of data on hazards, vulnerabilities, and disaster risk information to better understand risk.

2. **Strengthening disaster risk governance:** It focuses on establishing and reinforcing the legal and institutional framework for disaster risk management, which includes enhancing the roles and capacities of different stakeholders at all levels.

3. **Investing in disaster reduction for resilience:** This involves investing in disaster risk reduction measures to build resilience and reduce losses to the physical, social, cultural, and environmental assets of communities and countries.

4. **Enhancing disaster preparedness for effective response:** This priority calls for strengthening preparedness to enable effective response and to implement "Build Back Better" strategies in the recovery, rehabilitation, and reconstruction phases after a disaster.

The EWS framework, therefore, is designed to enhance disaster risk reduction as described in the Sendai Framework.

EWS Component 1: Risk Knowledge

This component refers to systematic data collection and undertaking risk assessments to build baseline understanding about risks (hazards and vulnerabilities) and priorities at a given level as shown in Figure 4 below. Risk knowledge ensures that:

- Key hazards and related threats are identified and well-known;
- Exposure, vulnerability, capacities and risks are assessed;
- Risk maps, patterns and trends are widely available;
- Roles and responsibilities of stakeholders are identified; and
- Risk information is consolidated.

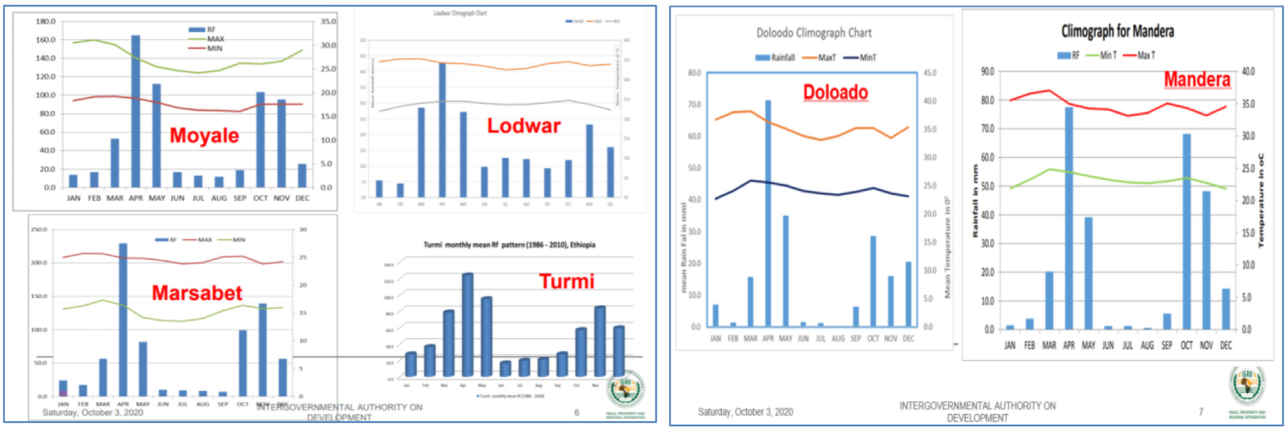


Figure 4: Integrated Disaster Risk Reduction and Management Framework

Guiding principle 1.1: Although risk knowledge exercises may not lead to early warning, all early warning must be founded on risk knowledge.

Guiding principle 1.2: Accept that a community's priorities may not be your own.

EWS Component 2: Detection, monitoring, analysis and forecasting of the hazards and consequences

This component requires development of hazard monitoring and early warning services to help to keep up-to-date on how those risks and vulnerabilities change over time as shown in Figure 5. It is based on sound scientific foundation for making forecasts. This component ensures that:

- Hazard monitoring systems are in place;
- Accurate and timely forecasts and warning services are accessible; and
- Institutional mechanisms are readily available.

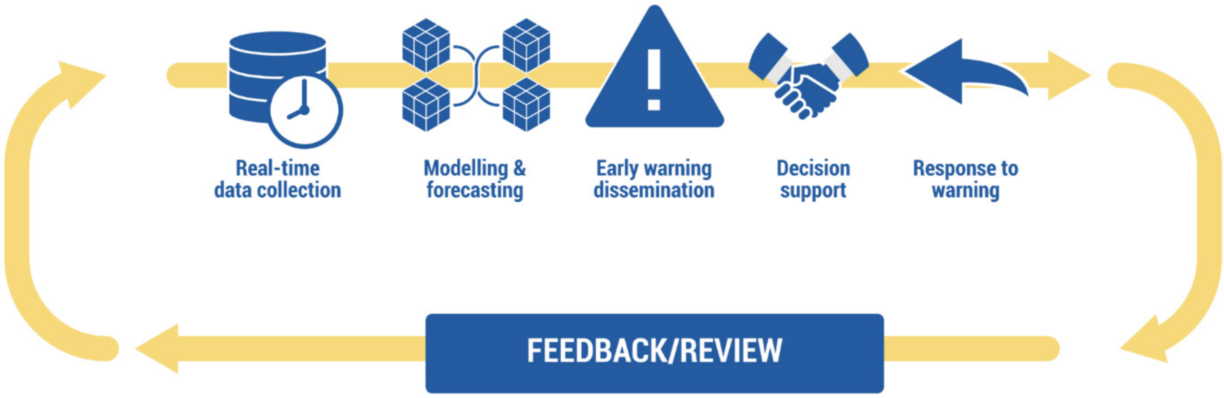


Figure 5: Specialized hazard monitoring, analysis and forecasting cycle

Guiding principle 2.1: Passive receivers of information do not save lives.

Guiding principle 2.2: Some communities will need to drive their EWS.

Guiding principle 2.3: When hazards evolve, so must their monitoring.

EWS Component 3: Preparedness and response capability

This component of EWS supports national and community response capabilities to reduce risk once trends are spotted and announced as illustrated in Figure 6 below. This may be through pre-season mitigation activities, evacuation or duck-and-cover reflexes, depending on the lead-time of a warning.

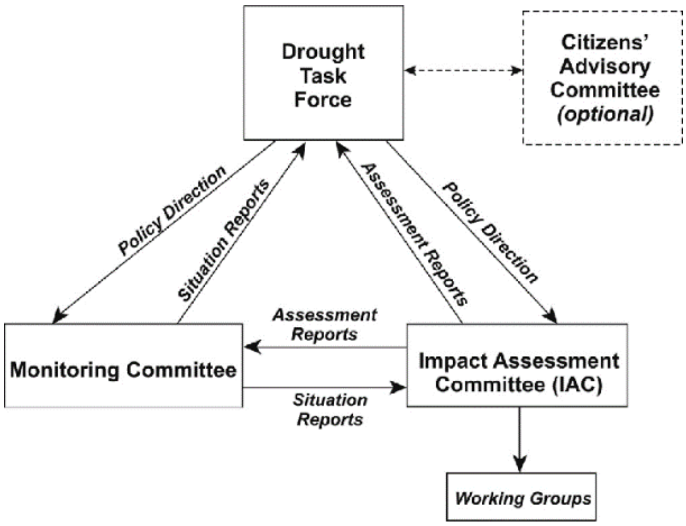


Figure 6: Committees for Drought preparedness and Response

It ensures that:

- Disaster preparedness measures, including response plans are developed and operational;
- Public awareness and campaigns are conducted;
- Local capacities and knowledge are made use of;
- Public awareness and response are tested and evaluated; and
- People are prepared and ready to react to early warnings.

Guiding principle 4.1: In EWS, we respond to warnings, not to disasters.

Guiding principle 4.2: Strive to organize robust 'no-regrets' response actions.

Guiding principle 4.3: Embed response options in annually updating contingency plans with links to funding.

Guiding principle 4.4: 'Practice makes perfect': test drive your response actions.

EWS Component 4: Warning dissemination and communication

This component focusses on packaging the monitoring information into actionable messages understood by those that need, and are prepared, to hear them as shown in Figure 7 below. This ensures that:

- Organizational and decision-making processes are in place and operational;
- Communication systems and equipment are accessible and functional;
- Risks and warnings are clear, understandable, and useable; and
- Impact-based early warnings are communicated effectively to prompt action by target groups.

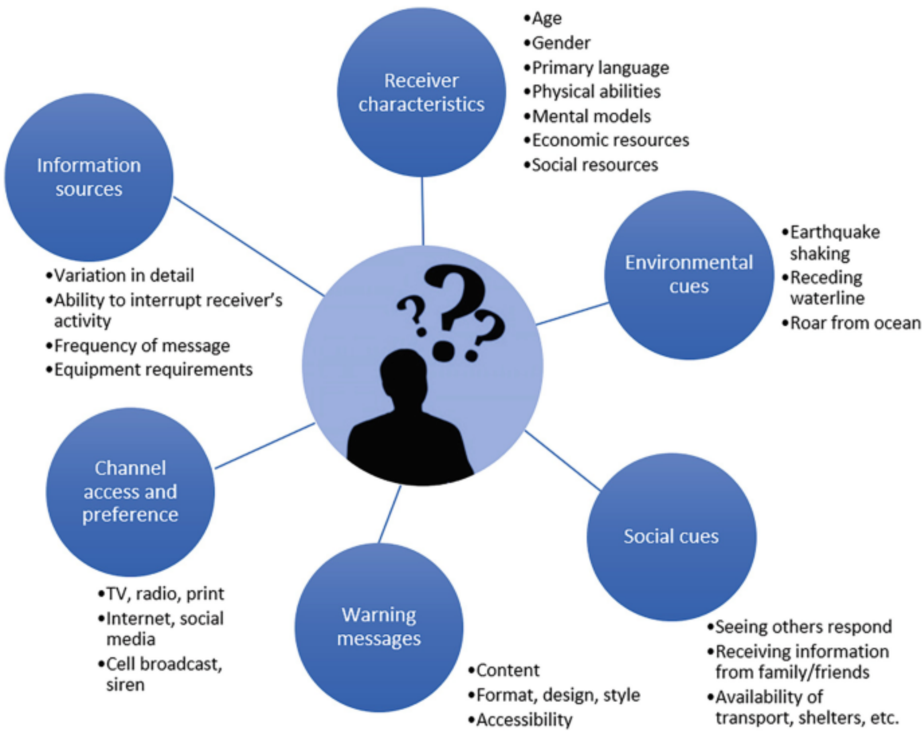


Figure 7: Components for warning dissemination and communication

Guiding principle 3.1: Clearly delegate responsibility to alert or mediate.

Guiding principle 3.2: Do not fall into the 'sophistication trap' for warning devices.

Guiding principle 3.3: Use staged warnings (levels and colors) in dissemination.

The effectiveness of any EWS depends upon political will, the administrative and technical capacity of a given country/county/district and the degree of acceptance and awareness of rules by the population. EWS, therefore, requires a people-centered approach where formal mechanisms like laws, protocols and standards complement informal mechanisms, such as the engagement and participation of communities. EWS becomes effective and sustainable when end-users can easily access credible information on hazards and on the performance of EWS, and when they realize their own rights and duties in early warning.

In all levels, there are four core elements for the development of a complete and effective EWS. These are: risk knowledge; monitoring and warning service; dissemination; and response capacity (i.e. action on the early warnings received). Failure in any one of these elements could mean failure of the whole system. When looking to build resilience at community level through early warning systems, it is essential that all the four elements be considered. While the source of one of the elements is not found within the community (e.g. meteorological services), the importance lies in a community's access to relevant information. Notably, local indigenous knowledge systems exist in some communities that allow detection and traditional forecasting. Figure 8 below shows the roles of different practitioners in the EWS value chain.

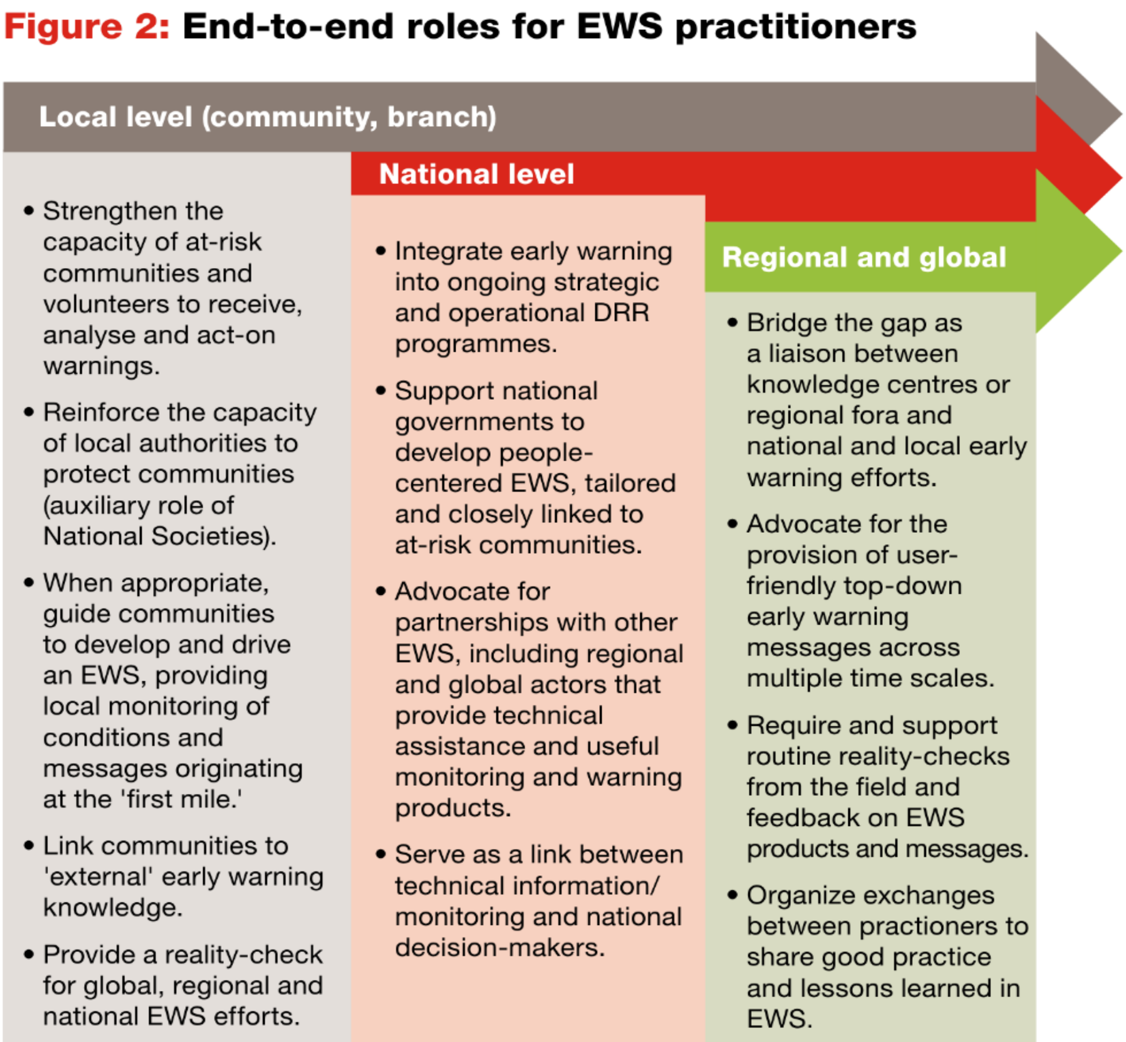


Figure 8: Roles of Early Warning Practitioners / Stakeholders

Governance and Institutional Arrangements

This aims at the development of national institutional, legislative and policy frameworks that support the implementation and maintenance of effective EWS. Indicators of good institutional and legal systems for EWS are related to:

Indicator 1: **Gender equality** - EWS considers the needs of women and men, girls and boys, and protects the most vulnerable groups including those living with disabilities.

Indicator 2: **Policy priorities and commitment** - National policies, plans and legislations assigns clear mandates and adequate resources to undertake early warning activities.

Indicator 3: **Multi-sector responsibility** - The EWS is shared across all relevant sectors, levels of governance and society, and addresses all hazards that threaten the population.

Indicator 4: **Accountability for warning** - The design and coverage of the EWS matches transparent criteria of vulnerability, prioritizing most at-risk areas. Clear roles and responsibilities are defined.

Indicator 5: **Resources** - The level of resources allocated is appropriate and available resources are used efficiently.

Indicator 6: **Application** - The EWS functions as part of EWS incorporated into longer-term development planning and practice, including land use, human settlement development, environmental protection, etc.

Indicator 7: **Civil society and private sector participation** - Civil society and the private sector are mobilized to participate in the design, implementation and monitoring of the system.

Indicator 8: **Decentralization of EWS** - Resources are decentralized to support early warning activities, and decision-making is devolved, and local actors have the necessary knowledge and tools to carry out their roles in EWS.

Sub-Module 2: Climate Related Hazards and Associated Risks

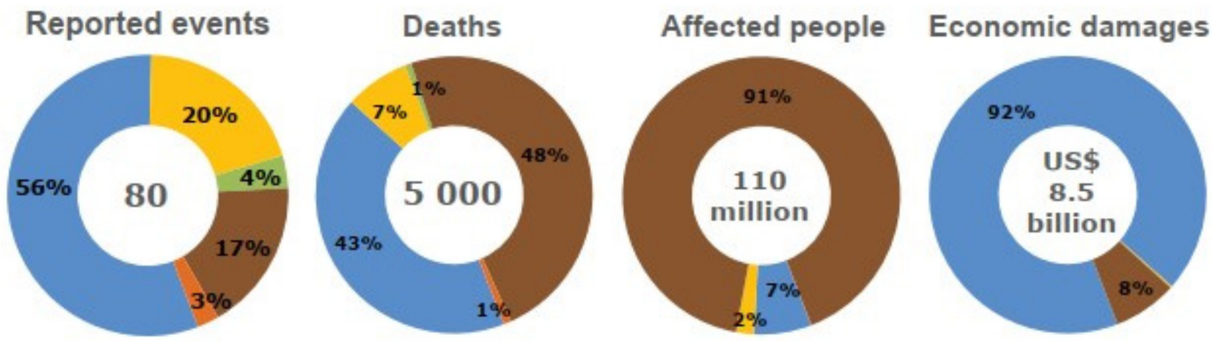
Introduction to Climate Related Hazards and Associated Risks

Hazards

Climate-related hazards are events that have a variety of direct and indirect consequences for society. Hazards are defined as "a process, phenomenon or human activity that may cause loss of life, injury or other health impacts, property damage, social and economic disruption or environmental degradation" (UN 2016). Climate-related hazards impact a vast range of sectors and as countries nowadays depend on the global economy, there are also several potential pathways for transboundary impacts. Compound events occur when multiple events (climate and even non-climate related) overlap.

The increasing occurrence and intensity of extreme weather and climate events (hazards) is reducing agro-pastoral productivity, driving agricultural expansion, and threatening biodiversity and ecosystems. Climate change and the diminishing natural resource base could fuel conflicts for scarce productive land, water, and pastures, where farmer-herder violence has increased over the past 10 years due to growing land pressure, with geographic concentrations in many sub-Saharan countries. Based on data provided in the Emergency Event Database (EM-DAT) 20 in Africa, 80 meteorological, hydrological and climate-related hazards were reported in 2022; of these 56% were flood-related events.

These natural hazard events resulted in around 5,000 fatalities, of which 48% were associated with drought and 43% were associated with flooding. Overall, more than 110 million people were directly affected by these disaster events, causing over US$ 8.5 billion in economic damages. While drought was the leading cause of death and people affected, flooding was the leading cause of economic damages (see Figure 9 below). The true figures related to the impacts of extreme events are presumed to be greater because of underreporting.



Weather-, climate- and water-related disasters in Africa in 2022. Note: The economic damages of some disaster occurrences are not presented in the figure due to data unavailability.
Source: Data as of June 2023 from EM-DAT

Figure 9: Weather, climate and water related disasters in Africa

Major climate-related hazards (need to be ranked in order of severity by stakeholders) include:

- Drought
- Heavy rainfall events
- Floods
- Landslides

- Cyclones
- Strong winds
- Extreme temperatures
- Heatwaves
- Forest and wild fires
- Pests

Task #03: Identify any three major hazards, exposure and sources of vulnerabilities in your location and propose capacities and resources needed to address related challenges.

Hazard	*Exposure*	*Sources of Vulnerabilities*	*Capacities/ resources*	*Gaps in capacities /resources*	*Actors*
#1					
#2					
#3					

The consequences resulting from these hazards have increased in the recent past, resulting in huge losses of lives, property and livelihoods. There is also a tendency for these hazards to be compounded with other existing vulnerabilities. Factors, such as environmental degradation from drought, over-grazing and land resource exploitation, such as deforestation have escalated the impacts and hazards.

With regard to these climate-related hazards, several systems and platforms that help monitoring, analysis, prediction and communication, and provision of feedback for the use, reliability and versatility of the systems have been developed. Figure 11 shows the East Africa Hazards Watch, a one-stop shop platform that has information on various risk elements including rainfall, temperature, climate change, agriculture, pests, food security, flood, drought, tropical cyclones, etc.

Climate-related Risks

The term, risk is used to refer to probability of an event/hazard causing disruptive and harm effect to a system, community or infrastructure with a potential to disrupt the functioning of that system.

What is the opposite of risk?

Risk is relative and is measured as a function of hazard (occurrence, frequency, duration and intensity), exposure (structures, crop or grassland, settlement, people / population, animals, etc.), vulnerabilities and coping capacities of the affected/exposed unit.

Therefore Risk = f(H,E,V,C); H = Hazard characteristics; E = Exposed unit characteristics; V = Vulnerability characteristics; and C = Coping capacity (see definitions at the back of module).

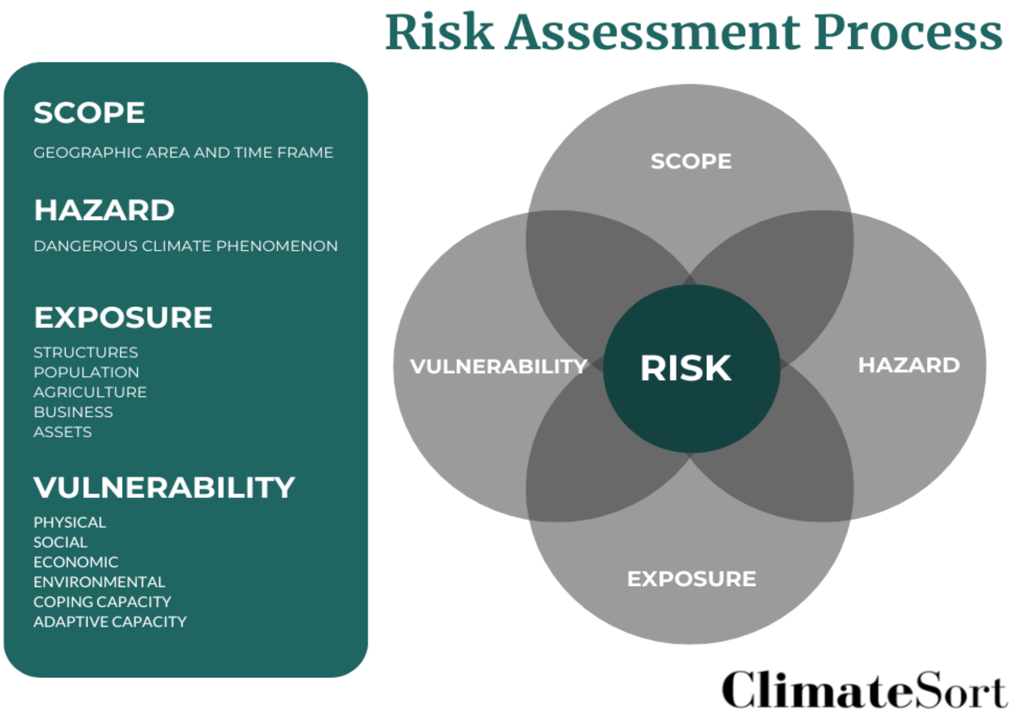


Figure 10: Risk components and assessment process

Hazards Analysis and Mapping

ICPAC has developed data and information on a number of hazards and also developed an East Africa Hazards Watch as shown in Figures 11 – 13.

Figure 11: East Africa Hazards Watch

Specialized watches for specific hazards have also been developed to monitor the respective hazards. The East Africa Drought Watch as shown in Figure 12 is designed to monitor drought and issue warning information at different levels, including watch, warning and alert.

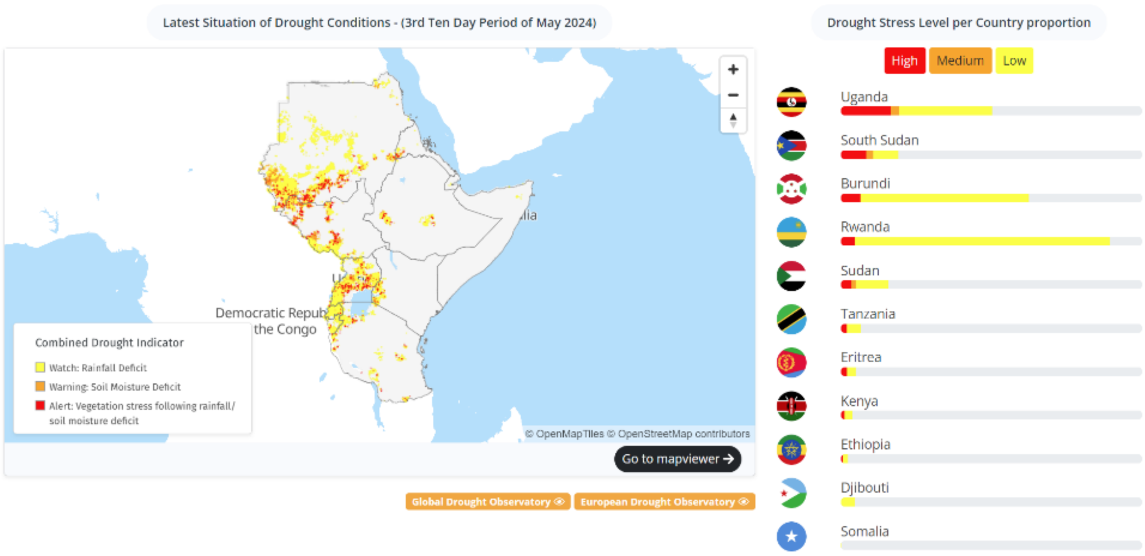


Figure 12: East Africa Drought Watch

The East Africa Agriculture Watch as shown in Figure 13 below monitors agricultural performance and issues/indicates various levels for stress on agricultural and rangeland.

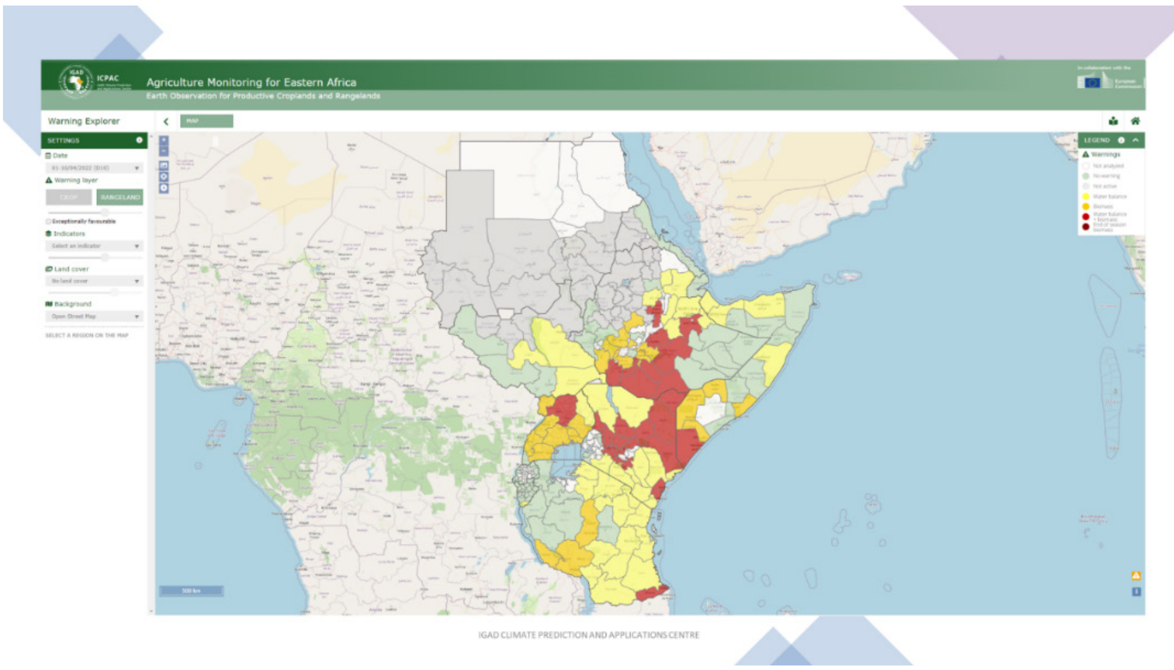


Figure 13: East Africa Agriculture Watch

Task #05: What components of risk are missing from the hazards watch?

Sub-Module 2.1: Overview to the East Africa Drought Watch

Introduction

The East Africa Drought Watch (EADW) is a regional drought monitoring and early warning system publicly accessible online at https://droughtwatch.icpac.net/. Hosted and maintained by IGAD Climate Prediction and Applications Centre (ICPAC), EADW provides periodic monitoring of actual drought conditions and developing drought conditions across 11 eastern Africa countries, namely: Burundi, Djibouti, Eritrea, Ethiopia, Kenya, Rwanda, Somalia, South Sudan, Sudan, Tanzania and Uganda.

This section will focus on the East Africa Drought Watch (EADW) as basis for customization of cross-border multi-hazard Watch (hands-on Exercises – see separate guide)

East Africa Drought Watch provides 3 classifications of drought conditions every 10 days; watch, alert and warning based on a Combined Drought Indicator (CDI). Areas under Watch category indicate areas where relevant rainfall deficit is observed, warning indicates areas with soil moisture deficit caused by the precipitation deficit, and areas classified as alert indicates areas where the deficit in both precipitation and soil moisture have caused negative vegetation anomalies.

EADW is developed at ICPAC in collaboration and with the support of the Joint Research Centre of the European Commission through the Intra-ACP programme. This user-manual describes the EADW interface, the indicators and methodology used to develop the CDI, and the functionality available in the system, including report generation for administrative boundaries and user-defined boundaries.

Accessing East Africa Drought Watch – Homepage

The EADW is publicly available online via this website url: https://droughtwatch.icpac.net/.

To access the EADW:

a) Open internet browser i.e., chrome, Firefox, or Microsoft Edge on your device (laptop, tablet or phone)

b) Copy and paste the following link https://droughtwatch.icpac.net/ into the browser's address bar and press "Enter", or search using the following words, "East Africa Drought Watch"

c) The homepage will open

The homepage

The EADW homepage gives a quick snapshot of the current drought conditions across the region. The severity and geographic extent of the drought is shown on the map. The bar charts on the right shows the country ranking of the 11 countries based on percentage area of each country under the three drought categories. For example, in the Figures 14 and 15 showing snapshot of drought conditions as of mid-August 2023, Somalia has the largest percentage area under drought conditions followed by Uganda and Kenya, with Djibouti having the least area under drought conditions.

The ranking is based on severity level as well, thus a country with the highest percentage of area under drought category "High" will be ranked higher.

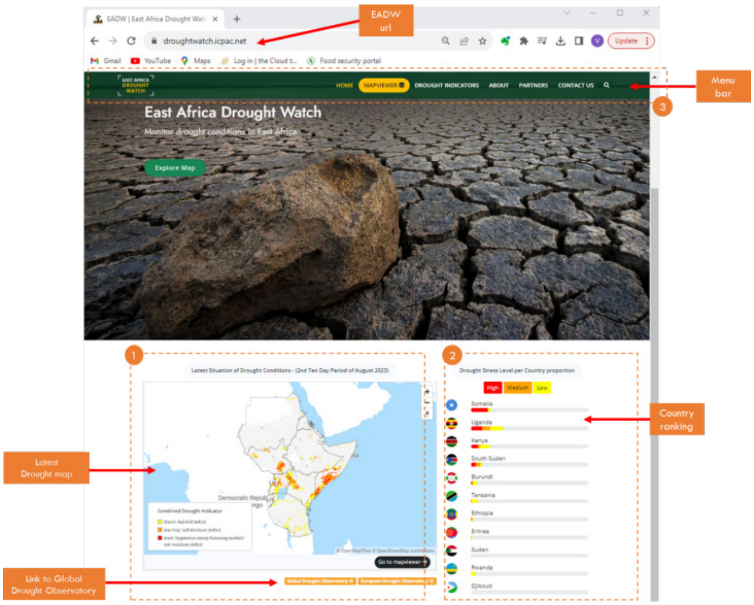


Figure 14: Homepage of the East Africa Drought Watch

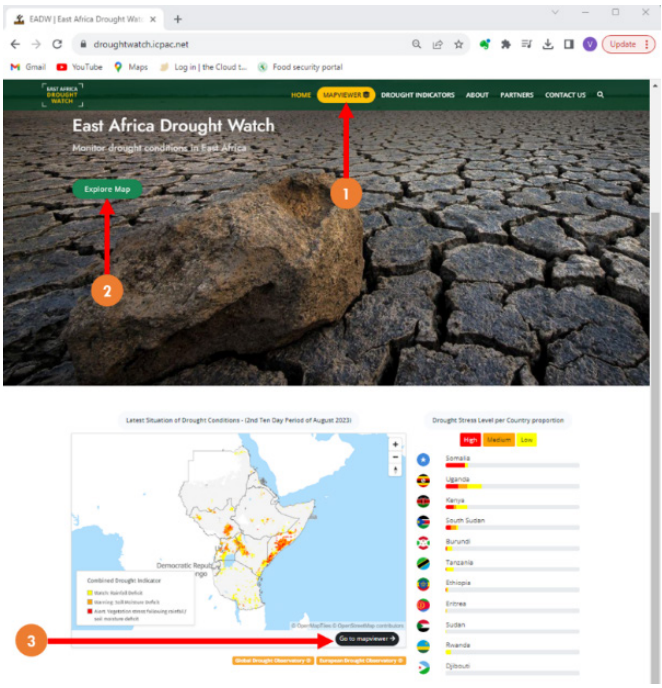


Figure 15: Accessing the Mapviewer for drought analysis

The mapviewer is an interactive interface providing map visualization of all the data layers available on the EADW including the combined drought indicator (CDI). The mapviewer is the main interface for users for monitoring and understanding drought conditions as shown in Figure 16.

To access the map viewer:

1. Click on this link https://droughtwatch.icpac.net/mapviewer/

OR

2. There are three ways you can access the mapviewer from the homepage as shown in Figure

16 below. Click on:

i) *the mapviewer* tab on the menu bar at the top

ii) *Explore Map*

iii) Go to *Mapviewer* on the bottom-left of the map inset

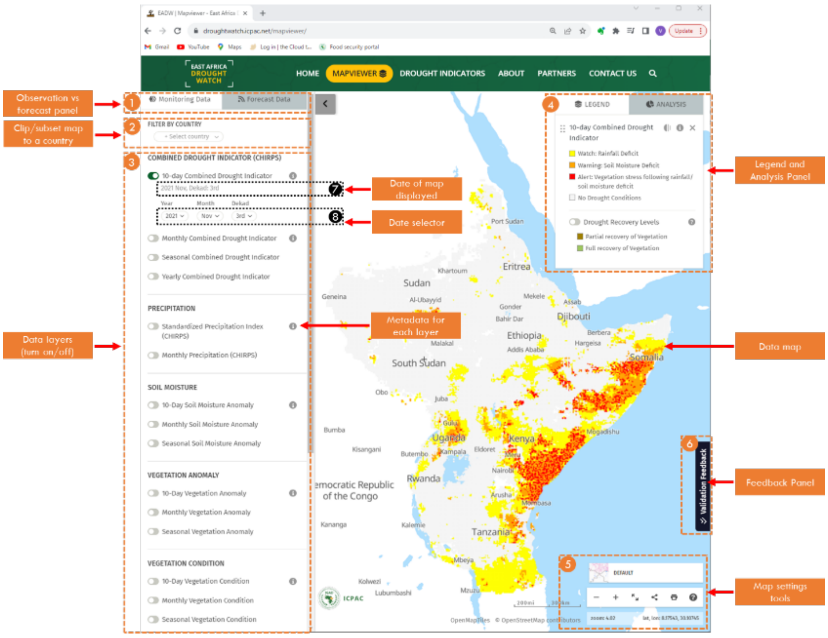


Figure 16: Sections and functionality on the mapviewer

The mapviewer has the following sections:

1. ***Observation vs Forecast panel:*** These are two tabs at the top left, that allows the user to switch between Observation data layers vs Forecast data layers.

2. ***Filter By Country:*** It allows user to subset/clip the map and zoom into the selected country, i.e. by selecting a particular country, the data layer maps are clipped to only show the country.

3. ***List of data layers:*** User can turn on and off layers displayed on the map panel.

4. ***Legend and Analysis panel:*** The legend panel displays the legend of active (turned on) layers. The analysis panel provides an interface to perform areal analysis on a user-defined boundary by drawing a polygon on the map or uploading a shapefile or GeoJSON file.

5. ***Map settings:*** They provide map manipulation tools, such as zoom in/out, share, print and a map-guide. Users can also change the background map from the default OpenStreetMap to either 'dark' or satellite. Users can turn labels on/off.

6. ***Feedback panel:*** On the right side of the interface, it allows users to provide feedback on the data products on EADW

7. ***Date of map displayed:*** Available for each layer, it acts as a label for the date of the layer displayed on the map panel

8. ***Date selector:*** Available for each data layer, it allows the user to visualize maps of different dates. For example, in order to display the CDI map of the 2nd dekad of October 2010, the user selects "year=2010", "month=October" and "Dekad=2nd"

9. ***Information icon, "i":*** It is available for each data layer and provides detailed information (metadata) about the layer.

Displaying data layers SPI, Soil moisture on the map

22 data layers are available on the EADW, the list on the Data Layer Panel on the left of interface. Each layer can be visualized on the map-viewer. For a layer to be visualized, it must be turned on, and the corresponding legend is available on the Legend panel.

a) To display a data layer on the map, use the layer switch button on the left of each layer on the data layer panel. Active layers are indicated by the switch button being green while deactivated layers have the button as grey.

b) Use the date-selector to change the time of the data layer displayed on the map-viewer. This is available for the dynamic layer.

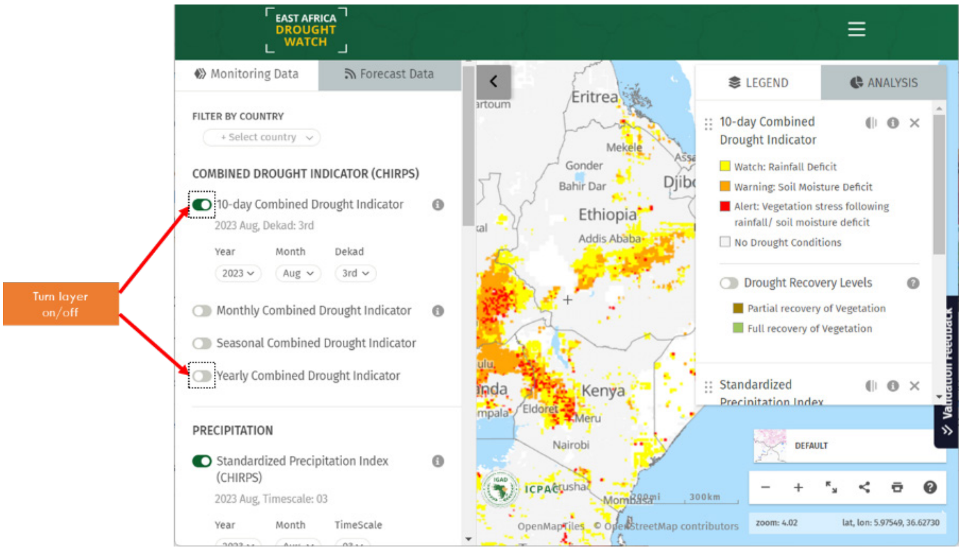


Figure 17: Turning a data layer on/off on the mapviewer

Changing the opacity of a layer

A layer's opacity determines how see through a layer is and how much of the layer beneath is obscured or revealed.

The ***"Opacity"*** tool is available in the legend panel, on the right of each layer's legend next to the i icon. To change the opacity of a layer, turn on the layer, on the legend locate the opacity tool and slide the button to desired percentage

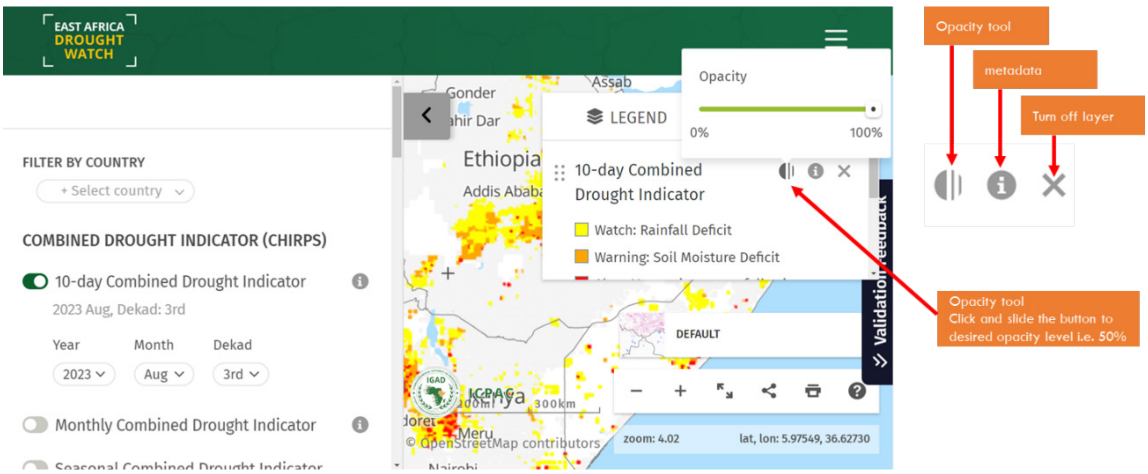


Figure 18: Changing the opacity of a layer

Changing the date/time-period of the map displayed

The date-selector is used to select the time-period of the map that is visualized on the map-viewer. By default, the latest CDI map is visualized, but a user can change this using the date-selector tool available for each dynamic layer.

The date-selector is available whenever a layer is activated (turned on) and it allows the user to specify the year, month and dekad for CDI, soil moisture and vegetation conditions. Upon the user's selection, the layer map for the specified date is displayed on the map-viewer.

For SPI, instead of the dekad, the user specifies the timescale as either 1, 3, 6, 9, 12, 24, or 48 months. For the static data layers, the date-selector is not available.

Zooming in/out and panning the map

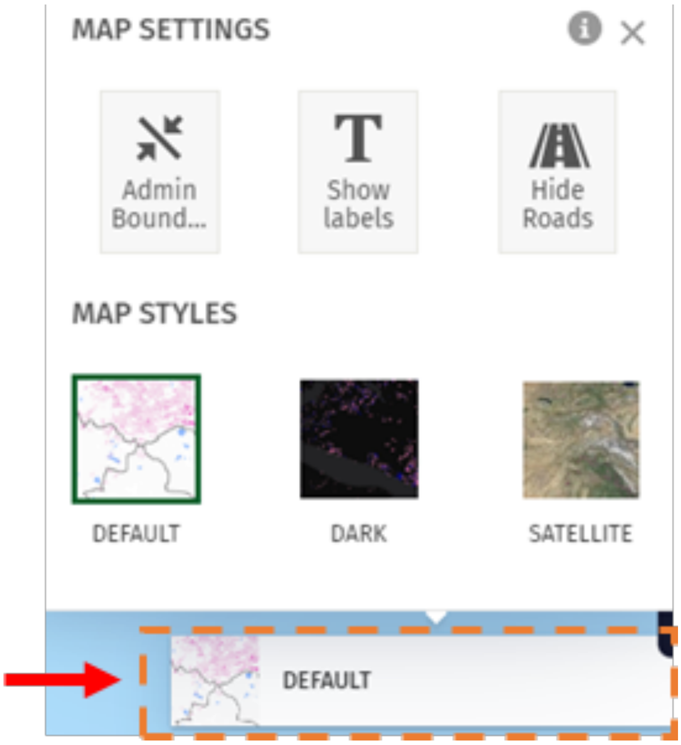
The default map zoom on EADW is the 11 countries covered by the system. EADW provides basic web map functionality like zoom and pan to allow user to focus on user's area of interest.

To pan across the map from one area to another, click and hold the mouse anywhere on the map and while holding the mouse move the map up/down left/right to your desired location.

Panning allows us to move the map on the screen positioning it to our preferred area
There are two ways to zoom in/out:

a) Use the zoom in/out elements on the mapviewer shown as plus and minus signs (- and +) at the bottom right of the map-viewer shown below.

b) Use the mouse scroll-wheel to zoom in and out. Front motion zooms in while back-motion on the scroll-wheel zooms out.



Changing background layer

The default background is OpenStreetMap, but the user can change the background to either satellite or dark.

Click on the button **"DEFAULT"** on the bottom-right of the screen to access the different map styles.

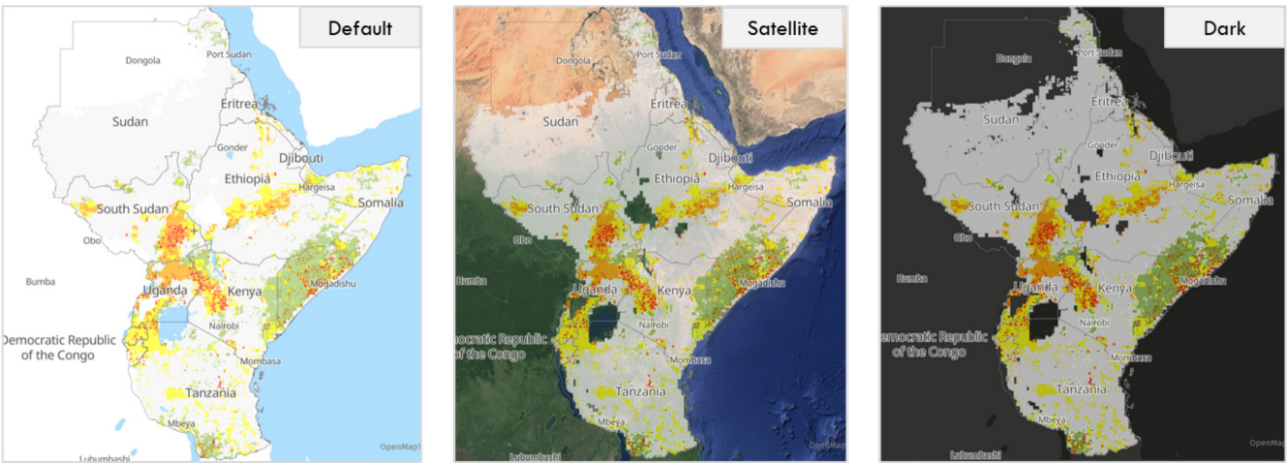


Figure 19: Changing the background map on the mapviewer

Accessing the metadata

The layer's metadata (more info) is accessed through the "i" tool. The tool can be accessed in two ways: a) on the layer list panel and b) on the Legend panel. To access the metadata, click on "i" tool next to the layer of interest. Figure 20 shows the metadata for the layer 10-day Combined Drought Indicator. Metadata provides information like description, spatial resolution, coverage, temporal resolution and sometimes the URL link for source data.

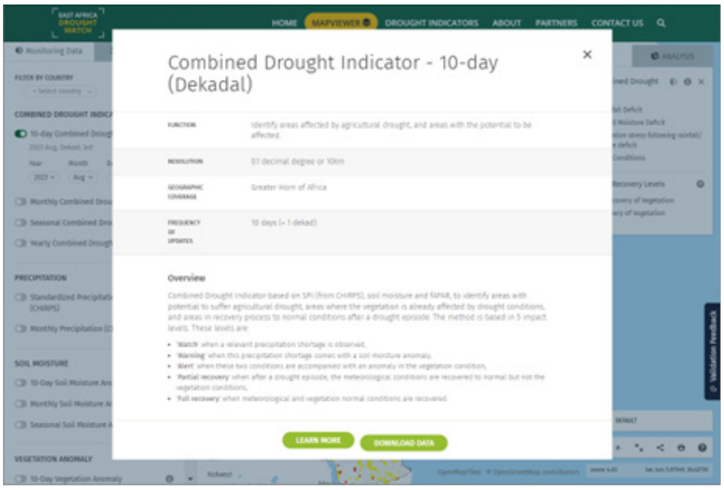


Figure 20: Accessing metadata for each data layer

Accessing the legend

The legend for each layer is available on the Legend Panel. The map legend is visible whenever the layer is activated (turned on). The legend panel also provides metadata and opacity tools.

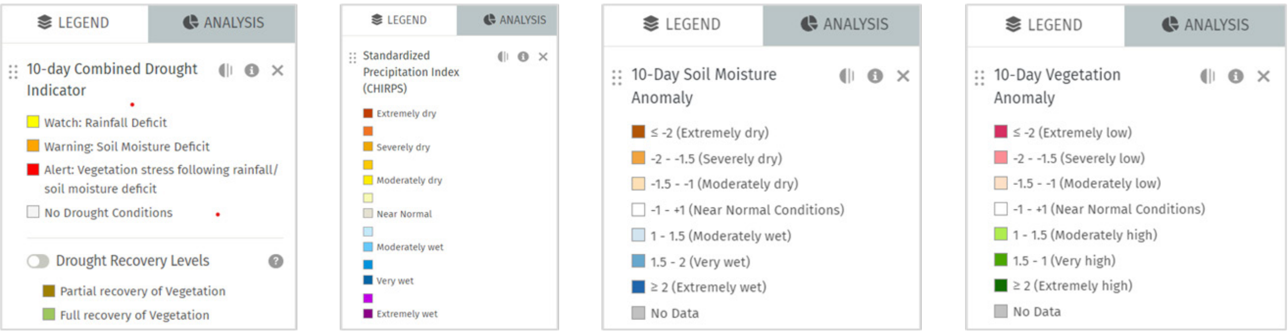


Figure 21: Accessing the legend for each layer

Exercise 1 – Defining a Study Area by Choosing Different Administrative Boundaries

i) Navigate to the Mapviewer and select a country of your choice.

ii) Scroll down to the Boundary data layer and turn on the Admin Level 1 layer. Zoom to Admin Level 1 that would like to analysis.

iii) If you would like to further narrow down your analysis to a smaller area, turn on the Admin Level 2 data layer.

Exercise 2 – Defining a Study Area by Drawing on the Map the Area You Want to Analyze

i) Navigate to the Mapviewer and select a country of your choice.

ii) Zoom to the location that you would like to analyze (Or follow the steps in exercise one to navigate to your preferred administrative boundaries).

iii) Click on the Analysis icon on the upper right side of your screen to reveal the ANALYZE DATA LAYER properties.

iv) Click on START DRAWING and a polygon drawing tool (+) will appear.

v) Right click your mouse with the polygon drawing tool (+) on the Mapviewer to draw your study area. Once done, left click the mouse to complete the drawing. Your defined boundary will appear under the USER DEFINED BOUNDARY data layer where you can switch it on and off.

Exercise 3 – Defining a Study Area Using a Shapefile

i) Navigate to the Mapviewer.

ii) Click on the Analysis icon on the upper right side of your screen to reveal the ANALYZE DATA LAYER properties.

iii) To define your study area, you can either:

a. Drag and drop your shapefile to the "Drag and drop your file (s) or click here to upload" section.

b. Or click on the "Drag and drop your file (s) or click here to upload" section and navigate to the folder with your shapefile and select the shapefile.

Drought Indicators on EADW

Combined Drought Indicator – CDI

Overview

Combined Drought Indicator based on SPI (from CHIRPS), soil moisture and vegetation anomalies, is used to identify areas with potential to suffer agricultural drought, areas where the vegetation is already affected by drought conditions, and areas in recovery process to normal conditions after a drought episode. The method is based on 5 impact levels.

These levels are:

- ***'Watch',*** when a relevant precipitation shortage is observed.
- ***'Warning',*** when the precipitation shortage comes with a soil moisture anomaly.
- ***'Alert',*** when these two conditions (precipitation shortage and soil moisture anomaly) are accompanied by an anomaly in the vegetation condition.
- ***'Partial recovery',*** when after a drought episode, the meteorological conditions are recovered to normal, but not the vegetation conditions.
- ***'Full recovery',*** when meteorological and vegetation normal conditions are recovered.

What the indicator shows:

Agricultural drought, which is one of the three main types of droughts (the others being meteorological and hydrological) that are defined according to the affected variables of the hydrological cycle, is characterized by a reduced crop production due to insufficient soil moisture.

The CDI identifies areas with the potential to suffer agricultural drought, areas where the vegetation is already affected by drought conditions, and areas in the process of recovery to normal conditions after a drought episode. The indicator is based on the cause-effect relationship for agricultural drought, whereby a shortage of precipitation leads to a soil moisture deficit, which in turn results in a reduction of vegetation productivity. Furthermore, the indicator is computed by combining anomalies of precipitation, soil moisture and satellite-measured plant growth - as measured by Standardized Precipitation Index, Soil Moisture Anomaly, and FAPAR Anomaly, respectively – using a classification scheme consisting of five drought levels (corresponding to the various stages of the cause-effect relationship for agricultural drought).

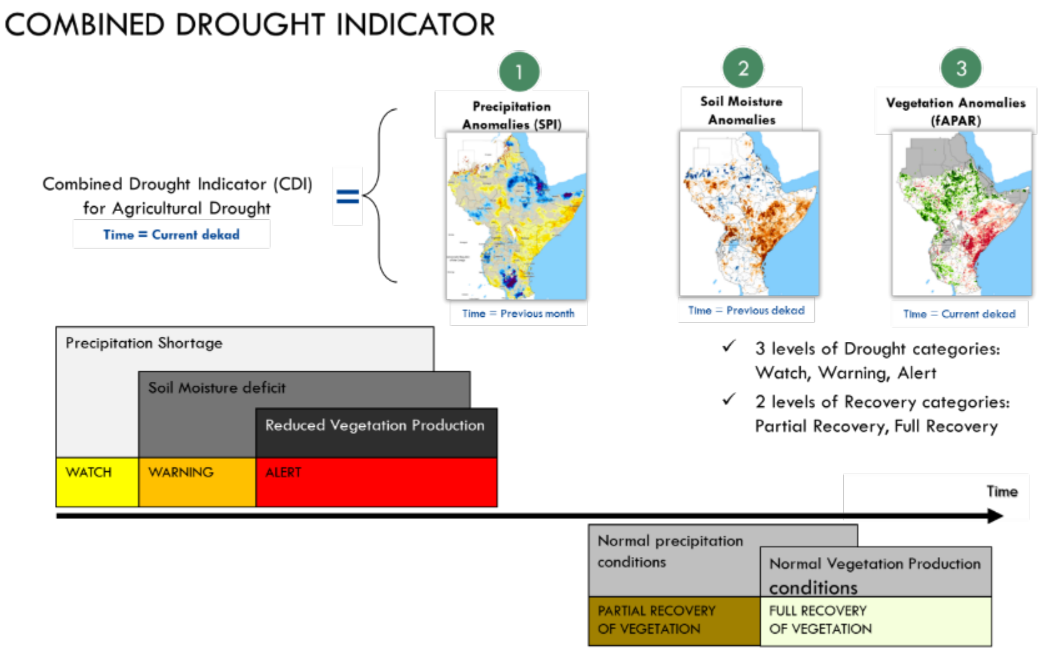


Figure 22: Combined Drought Indicator methodology

How the indicator is computed:

The Combined Drought Indicator (CDI) is derived by integrating the following three main drought indicators, which are implemented operationally within the system:

Standardized Precipitation Index (SPI): The SPI indicator measures precipitation anomalies at a given location, based on a comparison of observed total precipitation amounts for an accumulation period of interest (e.g. 1, 3, 12, 48 months), with the long-term historic rainfall record for that period (McKee et al., 1993; Edwards and McKee, 1997).

Soil Moisture Anomaly (SMA): The SMA indicator is derived from anomalies of estimated daily soil moisture (or soil water) content - represented as standardized soil moisture index (SMI) - which is produced by the JRC's LISFLOOD hydrological model (de Roo et al. 2000), and which has been shown to be effective for drought detection purposes (Laguardia and Niemeyer, 2008).

FAPAR Anomaly: The FAPAR Anomaly indicator is computed as deviations of the biophysical variable Fraction of Absorbed Photosynthetically Active Radiation (FAPAR), composited for 10-day intervals, from long-term mean values. Satellite-measured FAPAR represents the fraction of incident solar radiation that is absorbed by land vegetation for photosynthesis and is effective for detecting and assessing drought impacts on vegetation canopies.

The one-month, three-month, nine-month and twelve-month Standardized Precipitation Index (SPI-1, SPI-3, SPI-9 and SPI-12) are used for computing the CDI. Several studies have shown that SPI-3 has the strongest correlation with the vegetation response and is therefore the most suitable for identifying agricultural drought, whereas SPI-1 can detect extreme short-term dryness that can dramatically affect the vegetation condition depending on its stage of development.

For SPI-3, SPI-9, SPI-12, FAPAR Anomaly and Soil Moisture Anomaly (SMA) indicators, a threshold of minus one (-1) standard deviation is used, which equates to a return period of 6.3 years, and corresponds to "moderate drought", according to the SPI classification of McKee et al. (1993). In the case of SPI-1, a threshold of minus two (-2) standard deviations is used, corresponding only to cases identified as extreme drought. The classification scheme that is used to assign areas to one of the five drought classes is summarized below as well as the colour scheme used for depiction in the CDI maps.

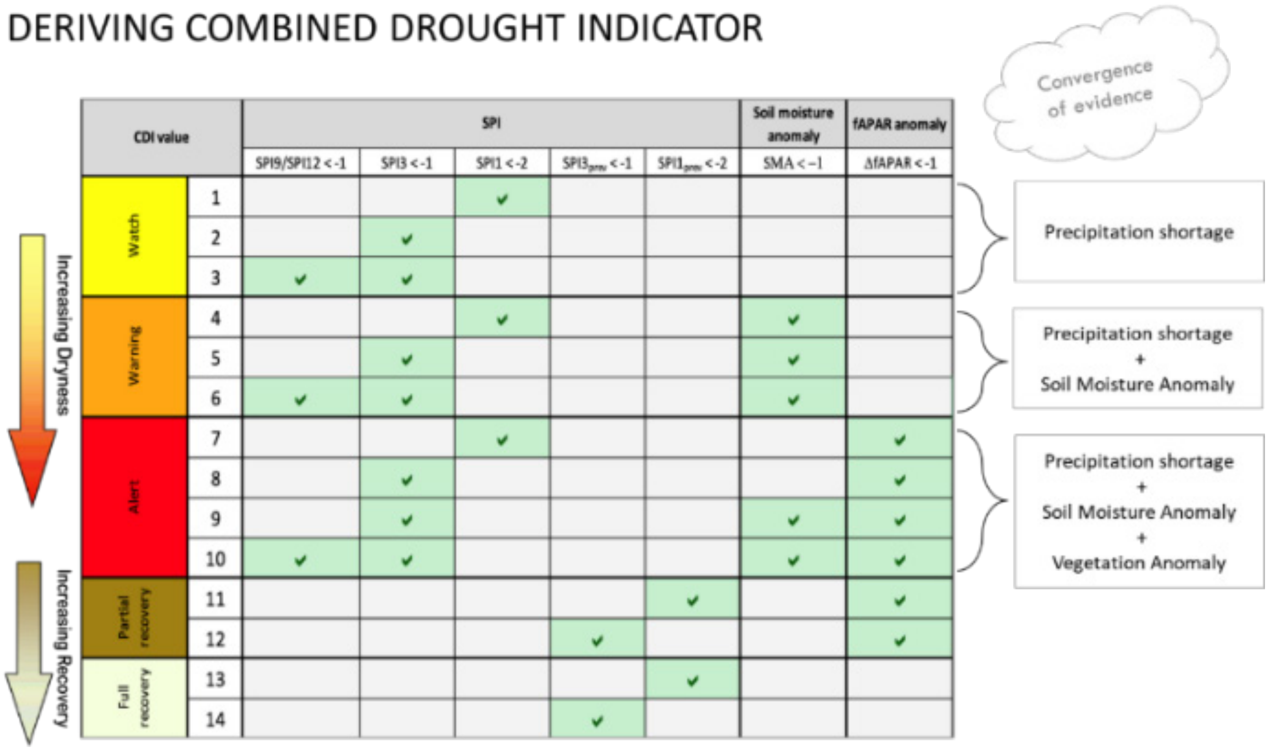


Figure 23: Deriving the Combined Drought Indicator

In applying the classification scheme, a temporal lag between the three components of the CDI is implemented. Thus, SPI of a given month is contrasted with soil moisture anomalies of the 2nd and 3rd dekads of that month, and with the 1st dekad of the following month, and with FAPAR anomalies of the 3rd dekad of that month and the 1st and 2nd dekads of the following month. Each month is assumed to have three dekads (days 1-10; days 11-20; day 21 to the end of the month)

How to use the indicator

CDI provides two categories of information a) geographic extent of drought conditions and b) severity of drought conditions. The 3 drought classes are useful in interpreting drought conditions.

An assessment of the behavior of the Combined Drought Indicator (CDI) for the main droughts between 2010 and 2021 demonstrated the CDI's capability to discriminate the areas where the drought impacts were most severe. The CDI layer is classified into 5 impact levels as listed below:

- 'Watch', when a relevant precipitation shortage is observed.
- 'Warning', when this precipitation shortage comes with a soil moisture anomaly.
- 'Alert', when these two conditions are accompanied with an anomaly in the vegetation condition.
- 'Partial recovery', when after a drought episode, the meteorological conditions are recovered to normal but not the vegetation conditions.
- 'Full recovery' when meteorological and vegetation normal conditions are recovered.

Colour	Level	Classification description
	Watch	A relevant precipitation deficit is observed
	Warning	The above precipitation deficit is accompanied by soil moisture deficit
	Alert	The above two conditions are accompanied by a negative anomaly of vegetation growth
	Partial recovery	When after a drought episode, the meteorologivcal conditions are recovered to normal but the vegetation conditions are yet to recover
	Full recovery of vegetation	When after a drought episode both the meteorological and vegetation conditions have recovered to normal
	No drought conditions	

Figure 24: The 5 classes of drought and drought recovery of the CDI

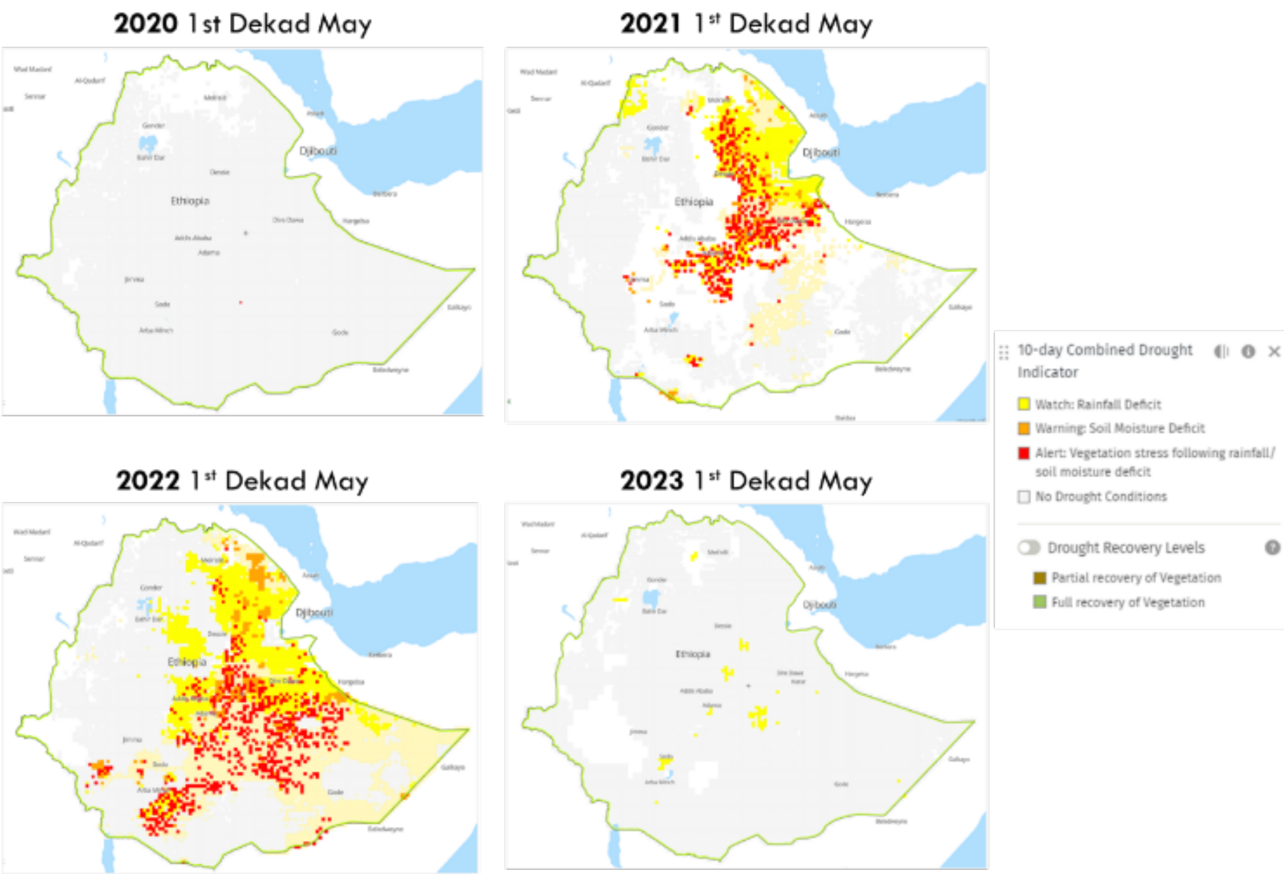


Figure 25: Comparing CDI map of 1st dekad of May in 2020, 2021, 2022 and 2023

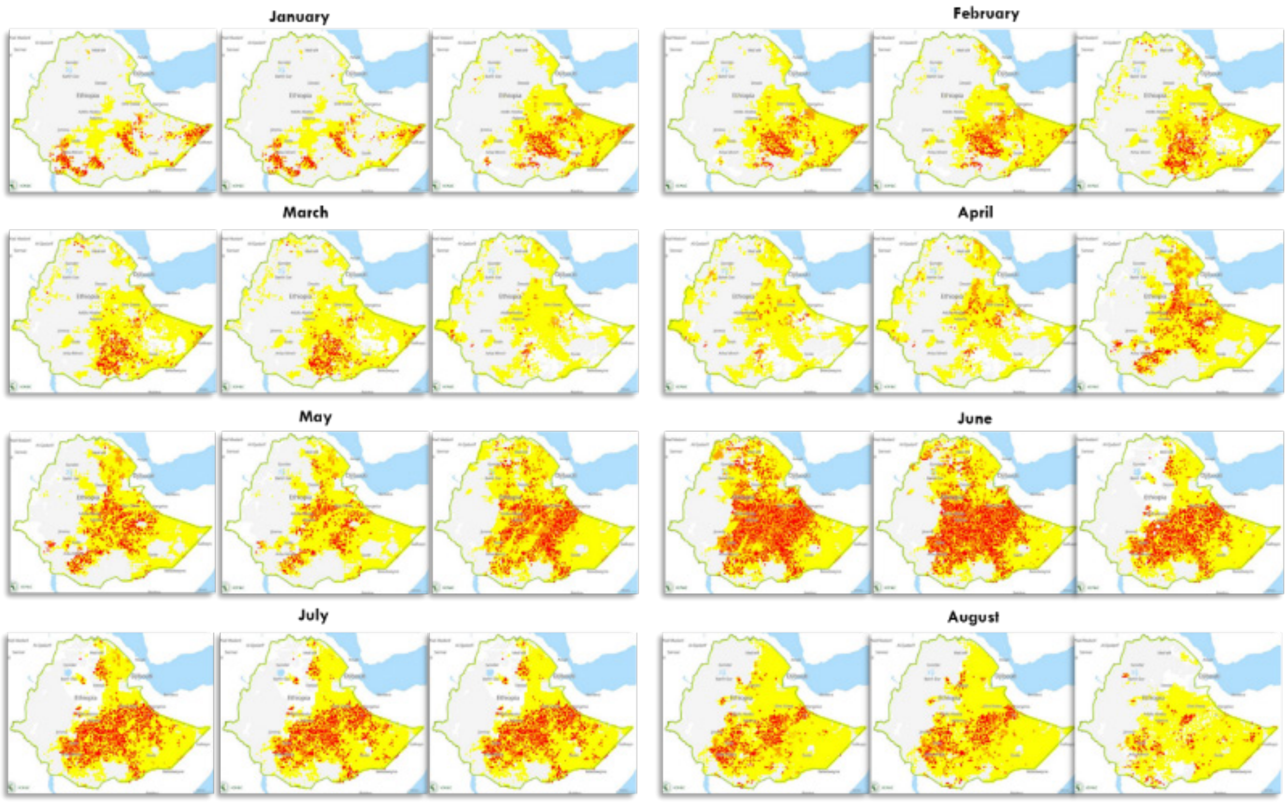


Figure 26: Time-series maps of drought conditions over Ethiopia in 2022

Standardized Precipitation Index – SPI

Standardized Precipitation Index is the most commonly used drought index based only on precipitation. It is widely used to characterize meteorological droughts on a range of timescales.

This means that SPI can be used to monitor conditions on a variety of timescales thus useful for both short-term agricultural and long-term hydrological drought applications. EADW provides SPI at the following timescales: 1, 3, 6, 9, 12, 24 and 48 months. SPI quantifies observed precipitation as a standardized departure from a selected probability distribution function that models the raw precipitation data. The SPI values can be interpreted as the number of standard deviations by which the observed anomaly deviates from the long-term mean. SPI values therefore show both rainfall deficit (dry events) and excess (wet events). Above zero values indicate wet conditions while below zero values indicate dry conditions. SPI can be displayed either as maps or as time-series graphs as shown in Figures 27 – 28.

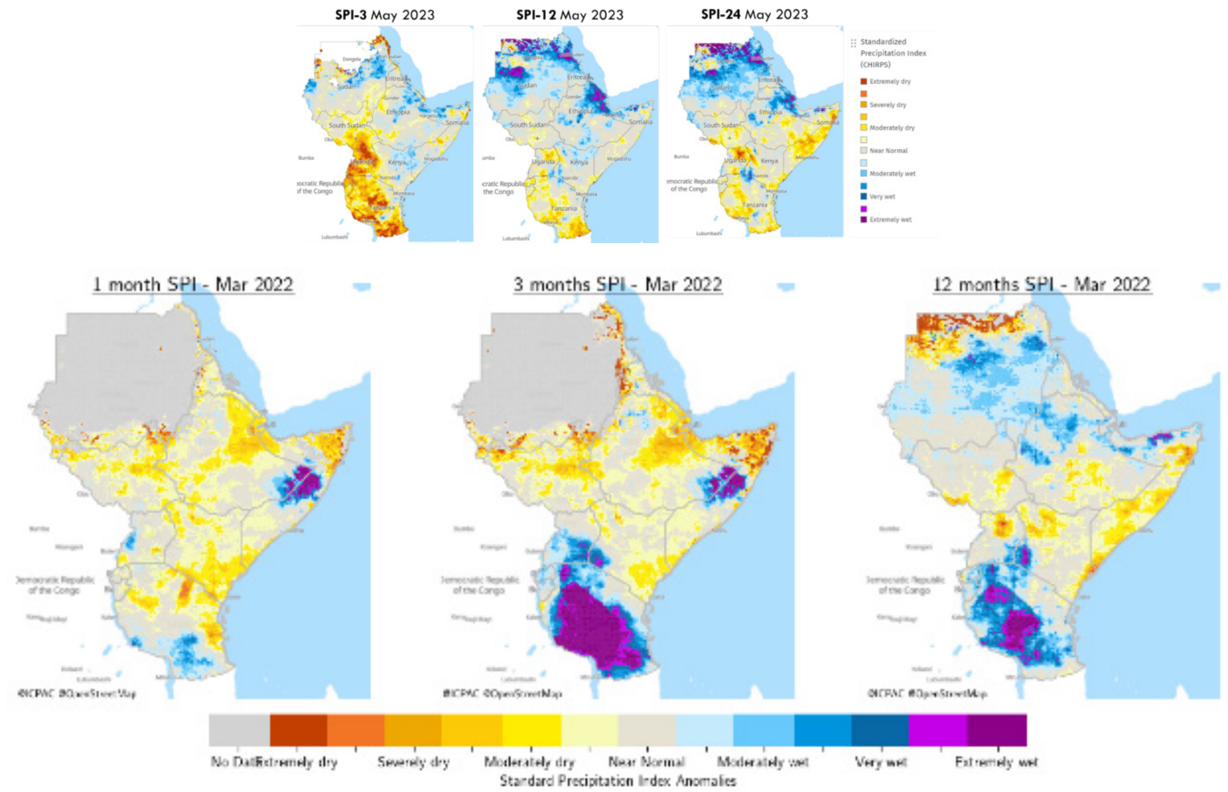


Figure 27: SPI maps on EADW

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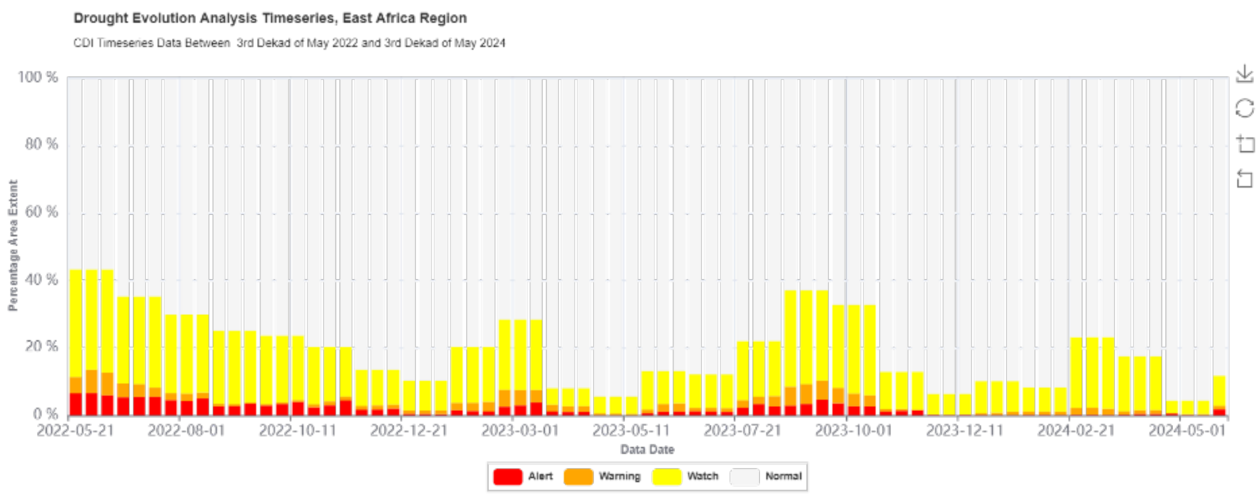


Figure 28: Alternative SPI visualization as time-series graphs

The EADW implements two SPI products, generated from their respective sources computed using the same procedure. These are:

- CHIRPS based SPI: spatial resolution 0.05 decimal degree or 5km
- GPCC based SPI: spatial resolution 1 decimal degree or 100km

Increasingly, severe rainfall deficits (i.e., meteorological droughts) are indicated as SPI decreases below – 1.0, while increasingly severe excess rainfall is indicated as SPI increases above 1.0. In EADW, the SPI indicator can be displayed in maps or as time series graphs in a report. The legend used on EADW is presented below.

Symbol	Values	Class Definition
	<= -3.0	Extremely dry
	-3.0 - -2.5	
	-2.5 - -2.0	Severely dry
	-2.0 - -1.5	
	-1.5 - -1.0	Moderately dry
	-1.0 - -0.5	
	-0.5 - 0.5	Near Normal
	0.5 - 1.0	
	1.0 - 1.5	Moderately wet
	1.5 - 2.0	
	2.0 - 2.5	Very wet
	2.5 - 3.0	
	>= 3.0	Extremely wet

Figure 29: SPI legend on EADW

Soil moisture anomaly

Soil moisture anomaly is useful in indicating the start and duration of agricultural drought conditions which arise when soil moisture availability to plants drops to such levels that it adversely affects crop yield and hence agricultural production.

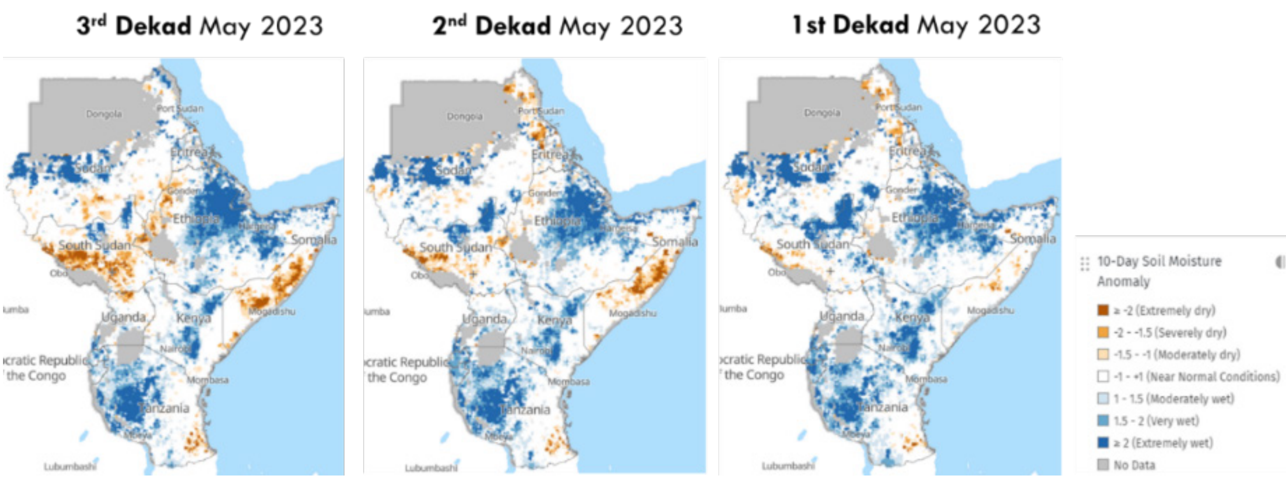


Figure 30: Sample Soil Moisture Anomaly Maps from EADW

Symbol	Values	Class definition
	>=-2	**Extremely dry**
	-2 to -1.5	Severely dry
	-1.5 to -1	Moderately dry
	-1 to +1	Near normal conditions
	1 to 1.5	Moderately wet
	1.5 to 2	Very wet
	>=2	Extremely wet
		No data

Figure 31: SPI legend

In EADW, the index is computed as a weighted average of three standardized variables: 1) LISFLOOD root zone soil moisture, 2) MODIS Land Surface Temperature, and 3) ESA CCI remote sensing skin soil moisture. All three variables are standardized on the same baseline period 2001-2016 and the weighting factors are computed. Comparing soil moisture anomalies from multiple independent sources over different regions across the globe. Hydrology and Earth System Sciences, 21(12), 6329.

The full ensemble of the three models is provided up to the second-to-last dekad, whereas the last dekad is a 'first-guess' estimate based only on LISFLOOD and MODIS LST data. SMA is made available every ten days sourced from the Global Drought Observatory. Read more (GDO factsheet)

Vegetation anomaly

The Fraction of Absorbed Photosynthetically Active Radiation (FAPAR) is a biophysical variable, derived from satellite observations. It represents the fraction of incident solar radiation that is absorbed by land vegetation for photosynthesis.

The FAPAR Anomaly indicator is computed as deviations of the satellite-measured biophysical variable Fraction of Absorbed Photosynthetically Active Radiation (FAPAR, sometimes written as fAPAR or FPAR), composited for 10-day intervals, from its long-term mean values. FAPAR is one of the 50 so-called "Essential Climate Variables" (ECVs) that have been defined by the Global Climate Observing System (GCOS) as being both feasible for global climate observation, and important to support the work of the United Nations Framework Convention on Climate Change (UNFCCC) and the Intergovernmental Panel on Climate Change (IPCC). (Of the 50 ECVs, 26 are listed as being significantly dependent on satellite observations).

FAPAR values and their anomalies have been shown to be good indicators for detecting and assessing drought impacts on plant canopies, such as agricultural crops and natural vegetation, and thus provide information that is potentially useful for water and agricultural management purposes.

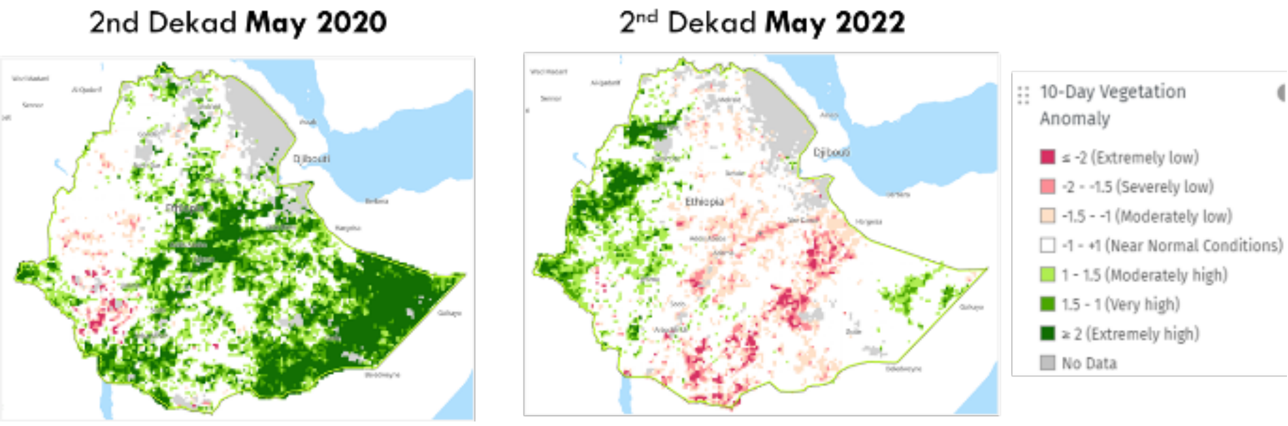


Figure 32: Vegetation anomaly maps over Ethiopia

Symbol	Values	Class definition
	>=-2	Extremely low
	-2 to -1.5	Severely low
	-1.5 to -1	Moderately low
	-1 to +1	Near normal conditions
	1 to 1.5	Moderately high
	1.5 to 2	Very high
	>=2	Extremely high
		No data

Figure 33: Vegetation anomaly legend

Both fAPAR and fAPAR Anomalies are made available every ten days sourced from the **Global Drought Observatory**.

Read more (GDO factsheet)

Exercise 4 – Characterizing a Recent Drought Event

a) Select a region and carry out drought analysis.

b) From your analysis, determine the following:

   i) When was the peak of the drought?

   ii) How many people were exposed during the peak?

iii) What was the greatest extent of the drought?

iv) What was the greatest extent of the drought?

c) Produce the following outputs from your analysis:

i) Time-series maps

i) Time series maps

Functionality available on EADW

The EADW provides several functionalities in addition to visualization of maps to support analysis and better understanding of drought conditions at varying geographical scales; regional, national and sub-national scales.

The following are some of the functionalities provided:

a) Automatic analytical report generation: The analytical report is generated over a bounded area i.e. country boundary, administrative boundaries within the country, protected areas, user-defined boundary.
b) Subscription service:

c) Analysis dashboard – the analysis dashboard provides users with an interface to perform advanced analysis beyond the generic analysis generated automatically

Generating Drought Analysis Report

Generating the automatic report within EADW is simple. The automatically generated report provides the user with an overview of the current ($time_x$) drought conditions as well as the conditions over a specific time-period preceding the current drought conditions. $time_x$ is defined by the user, by default it is the latest CDI map available but by changing the CDI layer to an earlier date ($time_x$) the report generated is for the drought conditions during $time_x$. For instance, to generate a report for mid-October 2010, change the CDI map to 2nd dekad October 2010 using the date-selector tools.

The automatic report contains 4 important information listed below and shown in Figure 34:

i) Maps

ii) Time-series graphs

iii) Population estimates

iv) Ranking of most affected areas by extent/severity

The maps and time-series graphs are available for the 4 variables used in drought monitoring: CDI, SPI, soil moisture anomaly, vegetation anomalies. The population estimates are aggregated for the different cdi categories. The ranking functionality ranks the "lower" administrative areas within the area-of-analysis based on extent/severity so that the lower administrative area with the highest area under the highest severity level is ranked top.

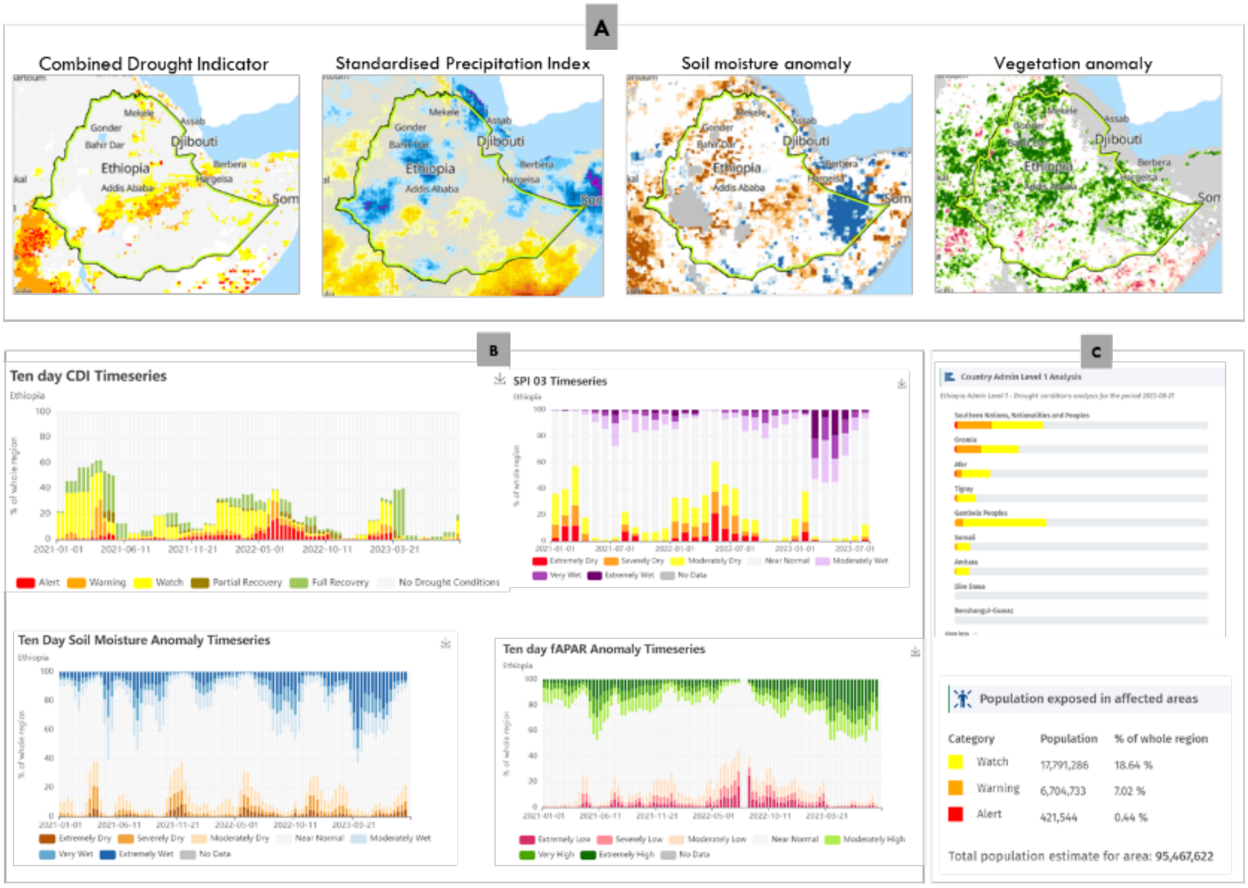


Figure 34: Maps and graphs output on the report

Reports can be generated for the following bounding areas:

a) National level based on country boundary (Admin0; source GAUL)

b) Sub-national level based on lower administrative boundary (Admin1, Admin2; source GAUL)

c) Protected area (source WDPA)

d) User-defined area based on a) user drawing a shape on the map or b) user uploading a shapefile

Generate an Automatic Report

Generating the automatic report is simple. On the map-viewer, click on any point within the boundaries of the area-of-analysis i.e., within the country, protected area, or user-defined shape/ polygon.

a) Using the date-selector, select the date of analysis for which the report is to be generated, by default the report for the latest drought conditions (CDI) available on the system is generated

b) Zoom to desired area of interest (the desired boundary should be visible)

   i) For sub-national level analysis, zoom until the desired boundary is visible.

c) Click on any point within the area-of-analysis, a pop-up as shown in Figure 35 will appear

d) Click ***generate report*** (confirm that desired area-of-analysis level is selected i.e. Ethiopia – country level)

e) A new webpage with the report is opened as shown in Figure 35 below.

f) The time-series graphs can be downloaded by clicking on the down-arrow on the right of each graph

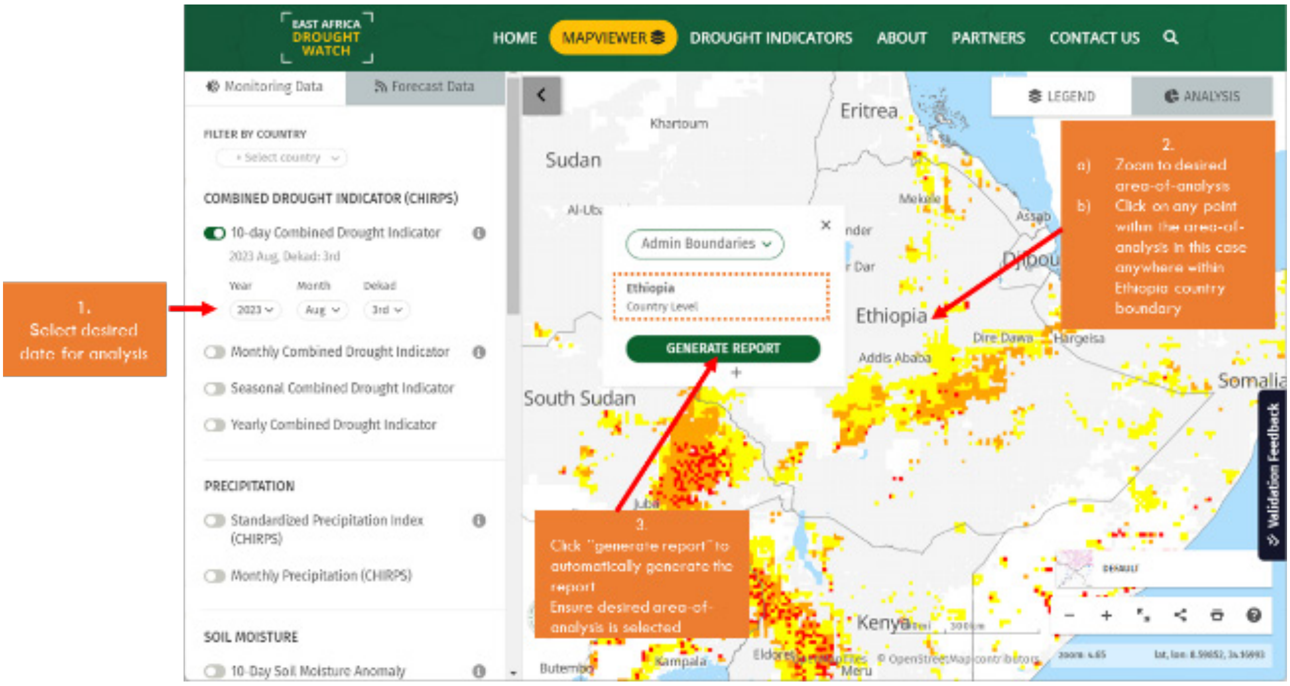


Figure 35: How to generate a report on EADW

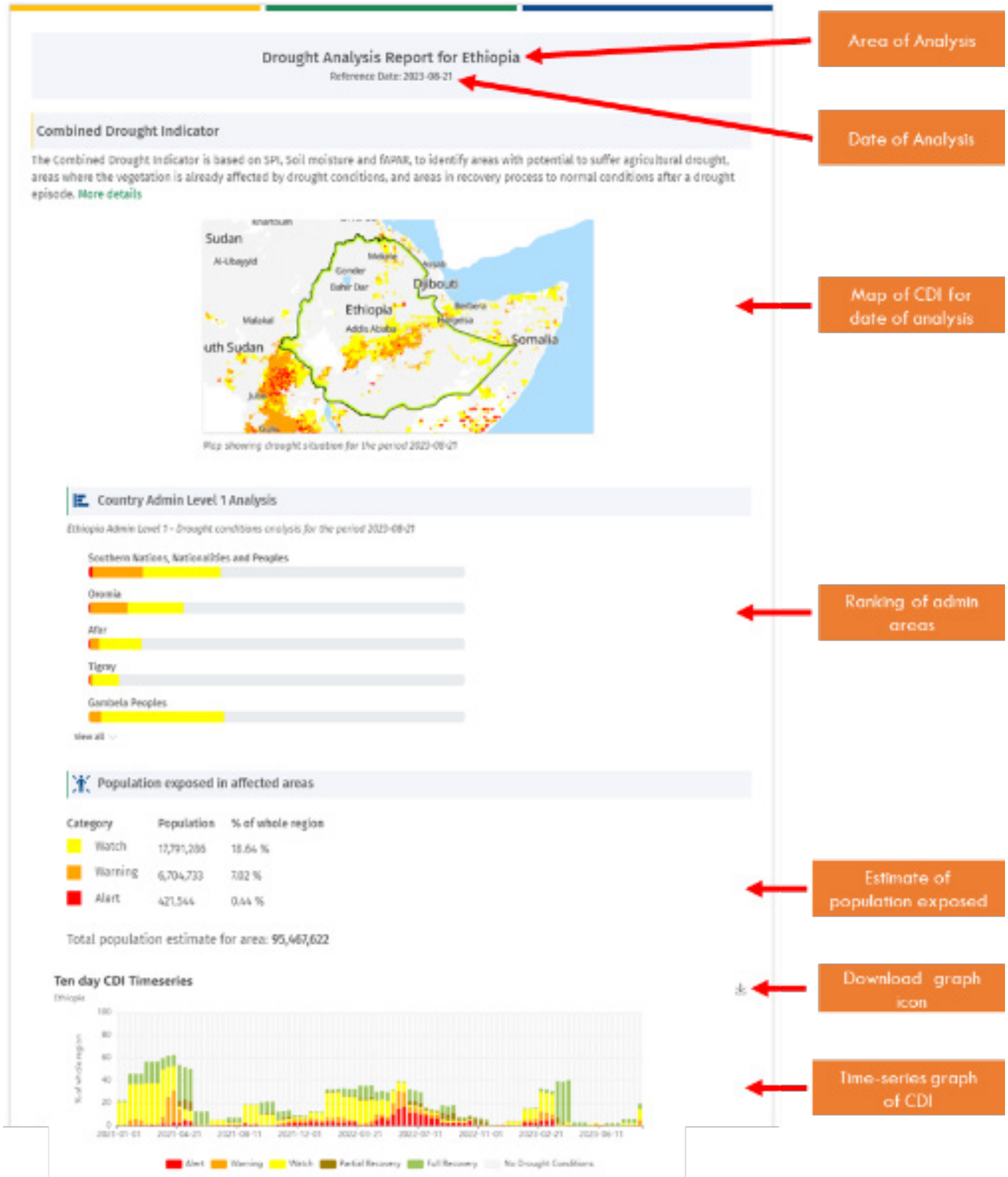


Figure 36: Drought report for Ethiopia as of end of August 2023

Download report as pdf

Scroll to the bottom of the report page to download the full report as a pdf

Download report graphics

To download the graphics available in the report as separate elements for use in a report or presentation, click on the down-arrow on the right of graphics i.e., right of the time-series graph.

Generate report for Sub-national administrative area & Protected Area

EADW allows you to generate reports based on national, sub-national administrative boundaries and Protected Areas. Protected Areas were included in EADW due to the understated impact of drought on wildlife. The Protected Area functionality aims to support national park managers in monitoring drought within the protected areas and generating early warning information to support park management before and during drought.

Sub-national report

The steps to generate reports are similar regardless of the unit of analysis. To generate a report at Admin 1 or Admin 2, zoom in until the desired boundary either Admin 1 or Admin 2 is visible and then click anywhere on the map within the boundary of your desired are-of-analysis to get the "generate report" pop-up.

a) Zoom to desired Admin1 or Admin2 i.e. Somali region of Ethiopia as shown on Figure 37 below.

b) Select desired date-of analysis using the date-selector of the CDI layer

c) Click anywhere within desired area-of-analysis i.e. the Somali region boundary

d) On the pop-up window Confirm the desired area-of-analysis is selected

e) Click generate report to get an automatic report over Somali region

Protected Area report

The steps for generating analysis over a Protected Area are the same as above, the only difference is the user will have to turn on (activate) the Protected Area boundary shapefile for it to be visible on the map-viewer.

a) Turn on the Protected Area layer on the Layer-list panel on the left (scroll down to find the PA layer)

b) Pan and zoom to the desired Protected Area i.e. Tsavo West national park in Kenya

c) Select desired date-of analysis using the date-selector of the CDI layer

d) Click anywhere within desired Protected Area i.e. Tsavo West

e) On the pop-up window Confirm the desired area-of-analysis is selected i.e. Protected Area, if this is not the selected, click on the drop-down and select Protected Area

f) Click generate report to get an automatic report over Tsavo West

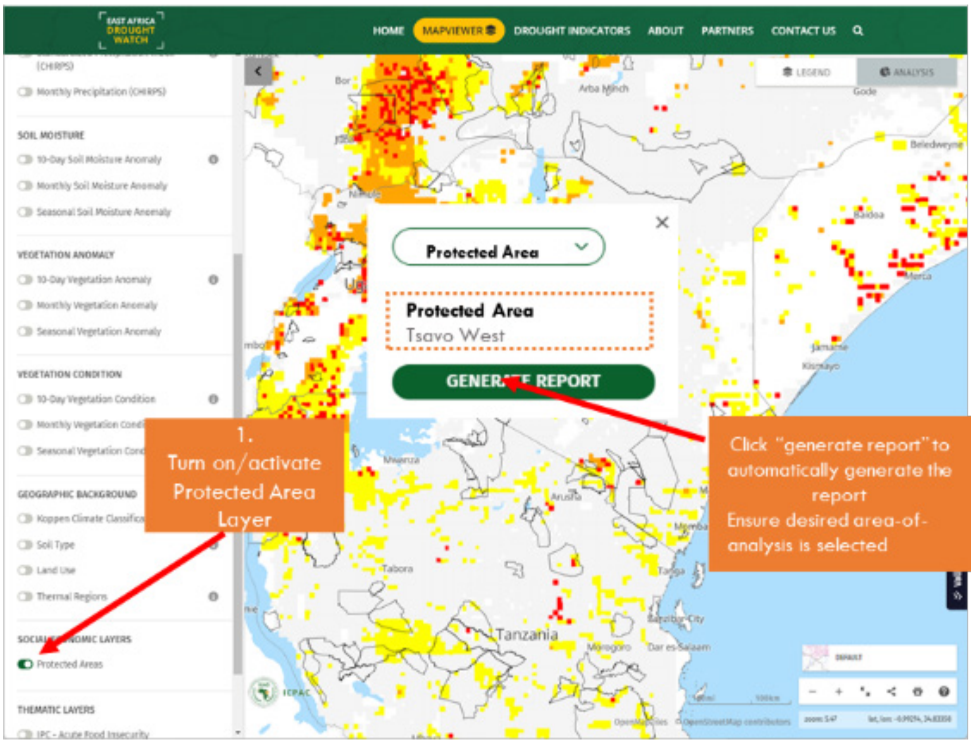
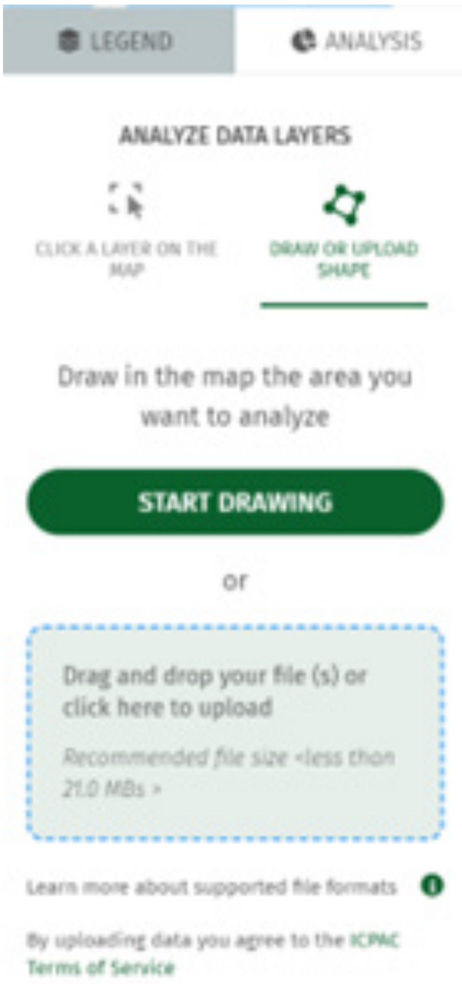


Figure 37: Generate report over Protected Area or user-defined boundary

Upload shapefile or draw boundary for analysis



In addition to pre-loaded boundary layers available on the EADW, the EADW allows users to generate analysis for user-defined boundaries. This functionality allows users to monitor drought conditions beyond administrative boundaries and protected areas.

To generate the analysis report on user defined boundaries, EADW provides two options:

i) Draw the boundary shape on the mapviewer

ii) Upload boundary file as shapefile or geojson

To access the user-defined functionality, open the Analysis Panel by clicking on the **Analysis** Tab. The Analysis tab is found next to the **Legend** tab as shown on the figure on the right.

Draw AOI (shape) on the map

a) Click the Analysis Tab to open the Analysis window

b) Zoom to your area of interest (you can use the mouse to zoom in and out)

c) Click ***"Draw or upload shape"***

d) Click the button ***"Start Drawing"***

e) To start drawing click on the map in your area of interest and then click successively to draw your shape of interest

f) To stop drawing or to close the polygon double click

g) Once you create a polygon (AOI) a layer is added on the data layer panel under the category User-Defined Boundary as shown below, each polygon/shape is named layer-1, 2, 3 and so-forth. Shapes covering cross-border areas are highlighted in Figure 38 below.

h) You can turn on/off the AOI layer using the switch on the data layers panel

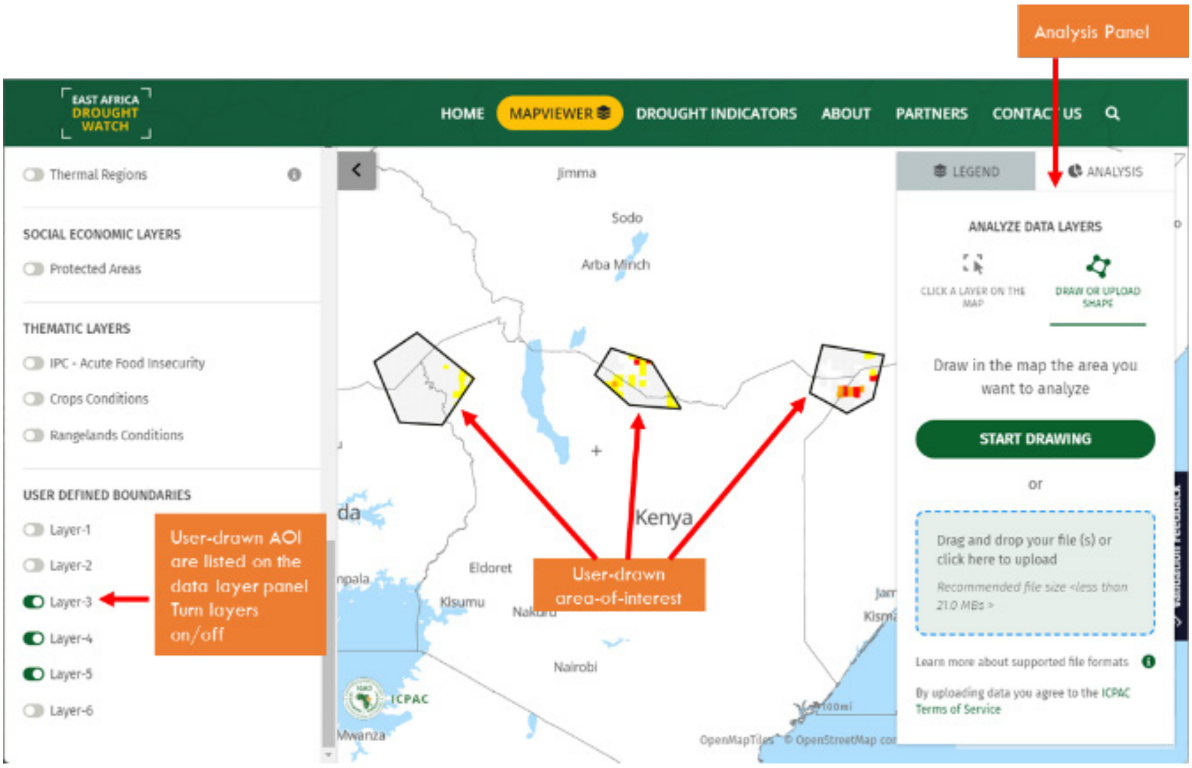


Figure 38: Draw user-defined shape on mapviewer and generate drought report

Generate report on user-drawn shapes (AOI):

To generate a report on the user-defined shapes, once, you have drawn the shape you want to analyze, click within the shape as previously described in section "Generate Report". The process is similar to when generating reports for admin or protected area boundaries.

Upload AOI shapefile or geojson

In addition to drawing shape/polygon on the map, the user can upload GIS files to be used for analysis. The file formats accepted by the system are ESRI shapefile or geo-json

To upload the files, the user has two options: drag and drop or upload as shown in Figure 39. Follow the steps below to upload your file(s):

a) Click the Analysis Tab to open the Analysis window

b) Click on the light green box labelled ***"Drag and drop your files or click here to upload"*** as shown below

c) In the open "directory navigator window" navigate to the location of the desired shapefile and select the shapefiles to use for analysis. (make sure to select all the relevant ESRI shapefile files i.e. .shp, .dbf, .prj and .shx)

d) Click "Open" on the pop-up window;

e) The shape/polygon is visualized on the map as shown in Figure 40 below, showing the regional boundary.

f) The shape/polygon is also added to the layer list panel on the left as Layer-1,2,3 and so-forth under the "User Defined Boundaries" section to allow you to turn the polygon layer on and off as shown in Figure 9x.

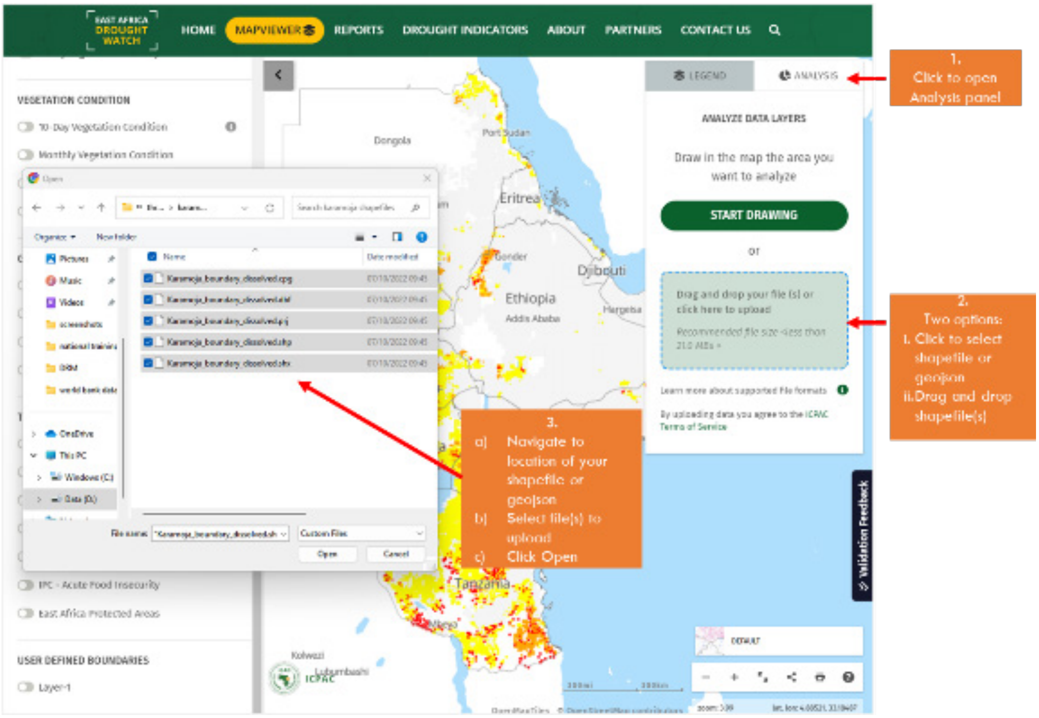


Figure 39: Uploading a shapefile for drought analysis and report generation

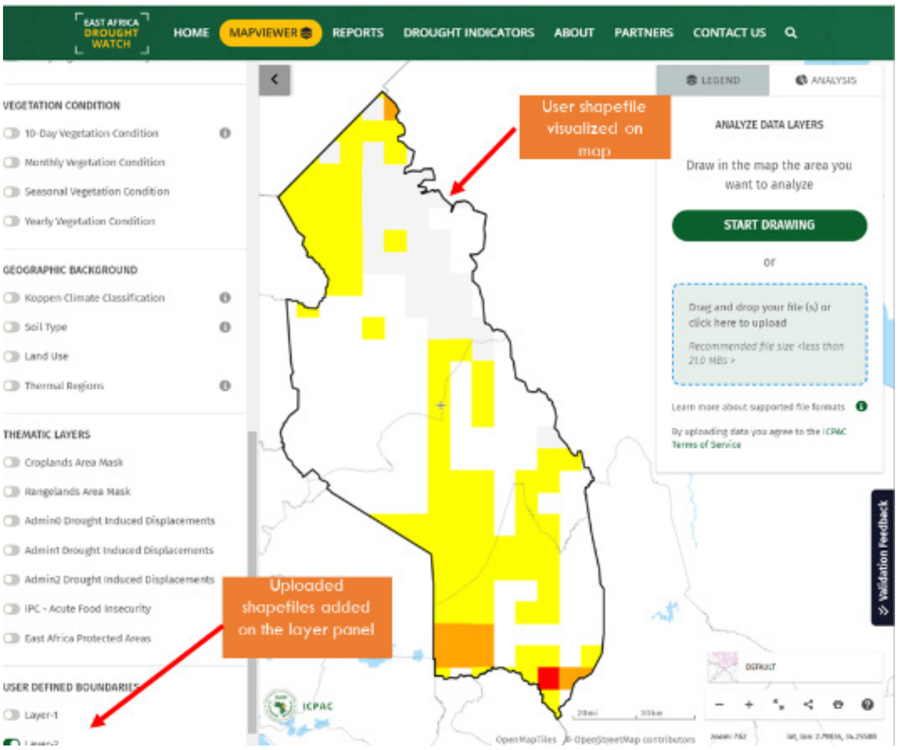


Figure 40: Turning user-defined boundary on/off

Sub-Module 4.1: EWS Component 2 - Detection, monitoring, analysis and forecasting of the hazards and consequences

Detection, monitoring and analysis

Introduction:

Drought, a period of abnormally dry weather that severely affects hydrology, agriculture, and ecosystems, is a major environmental threat. To have a full grasp of the severity and extent of the drought a lot of data is required. This could be biophysical, social and economic data. GIS (Geographic Information Systems) and Remote Sensing technologies provide powerful tools for detecting and monitoring drought hazards, allowing for proactive measures to be taken. Monitoring and detection involve the integration of spatial data and satellite imagery to assess and manage the impacts of drought. This process includes the collection, analysis, and interpretation of data to understand the extent, severity, and effects of droughts.

1. Data Acquisition

Many ways exist to data acquisition for drought detection and monitoring as illustrated in Figure 41 below. They include:

- **Remote Sensing:** Satellites collect data on various Earth surface characteristics relevant to drought. Use of various satellite sensors (e.g., MODIS, Landsat, Sentinel) to gather data on vegetation, soil moisture, temperature, and precipitation.
  - » The satellite data can be used to:
    - **Monitor Precipitation:** Rainfall estimates and forecasting
    - **Vegetation Monitoring;** measure the health and greenness of vegetation, with lower values indicating drought stress.
    - **Land Surface Temperature (LST):** LST data helps identify areas with elevated temperatures, often associated with increased drought severity.
    - **Soil Moisture:** Microwave sensors can estimate soil moisture levels, which are crucial indicators of drought conditions.

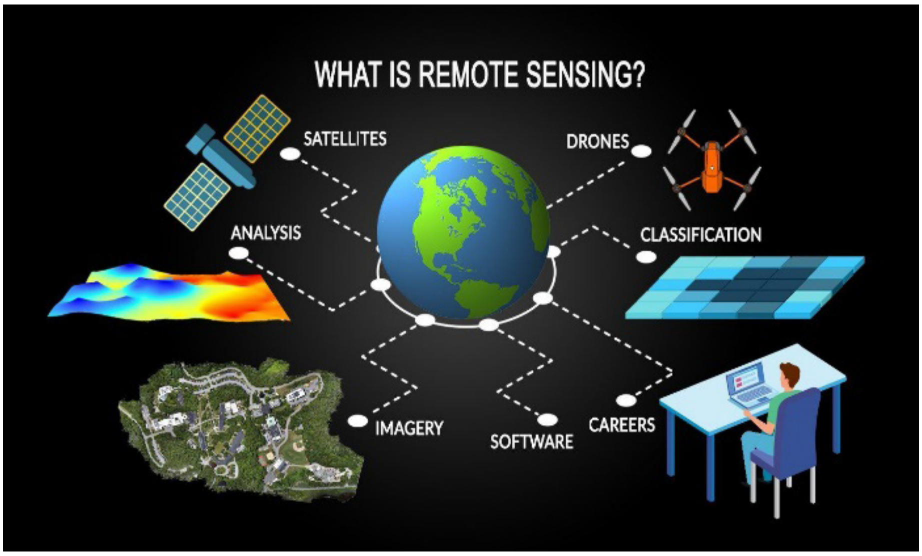


Figure 41: Different components linking up to remote sensing

- **Ground-Based Data:** Collection of meteorological data from weather stations, including rainfall, temperature, and humidity.
- **Historical Data:** Compilation of historical drought data for trend analysis. Mostly recorded by governments. The international disaster database is an example of such data.

2. Data Processing and Analysis in GIS

» **GIS software** integrates remote sensing data with other geospatial information like:

- **Precipitation data:** Rainfall records from weather stations are crucial for understanding drought severity.
- **Land cover data:** Differentiating between forests, agricultural land, and urban areas helps tailor drought assessments.
- **Soil data:** Soil types influence water holding capacity and drought vulnerability.

» **Satellite based drought mapping and monitoring**

- These satellite-based indicators are proxies to drought events. They include:
  - **Normalized Difference Vegetation Index (NDVI):** Measures vegetation health and density, indicative of drought stress.
  - **Standardized Precipitation Index (SPI):** Quantifies precipitation deficit over various time scales.
  - **Vegetation Condition Index (VCI):** Assesses vegetation condition relative to long-term norms.
  - **Temperature Condition Index (TCI):** Evaluates temperature anomalies affecting vegetation.
  - **Soil Moisture Index (SMI):** Indicates soil moisture levels and deficits.
  - **Palmer Drought Severity Index (PDSI)**
  - **Combined Drought Indicator (CDI)**

These datasets are then combined with other datasets through overlaying and further analyzed: Spatial relationships between factors like NDVI, LST, precipitation, and soil data are explored to identify areas experiencing drought. To understand the past drought and predict future scenario, the time series data is analyzed as shown in Figure 42 and 43. Changes in drought indicators over time helps identify trends and predict potential future droughts and facilitates timely interventions. Based on the analysis, the generated drought maps, using the drought indices like the SPI, PDSI or CDI are categorized based on drought severity levels for decision making.

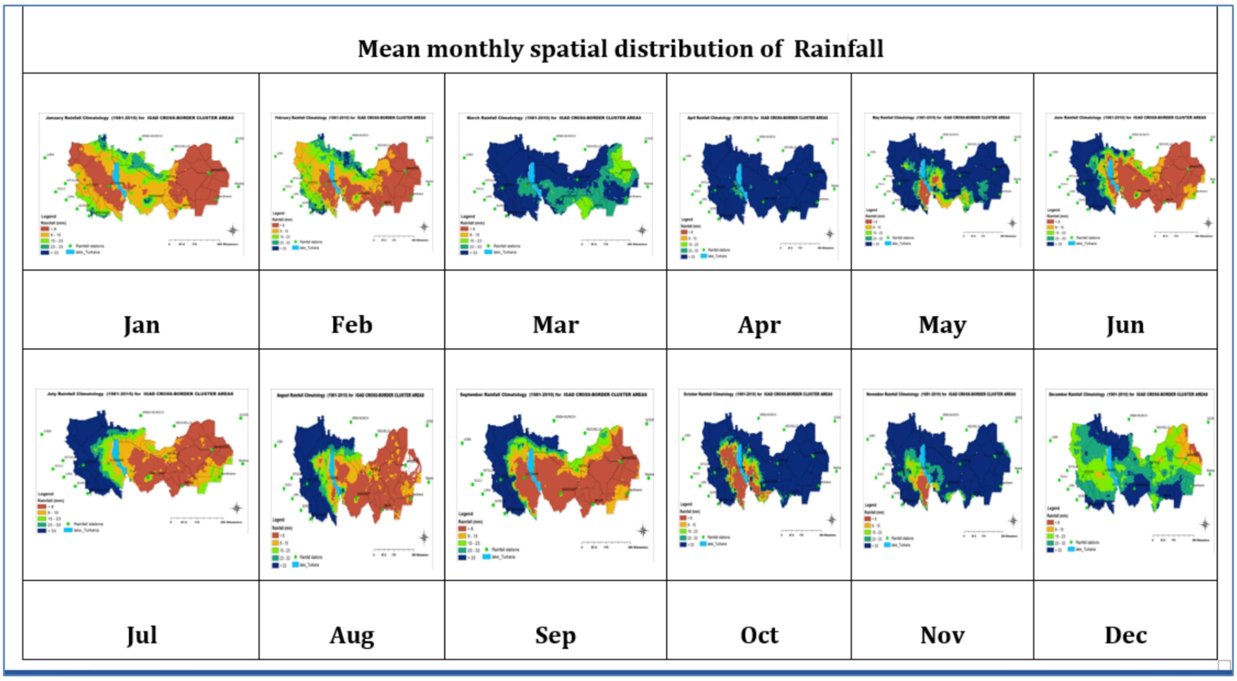


Figure 42: Rainfall climatology 1990-2020

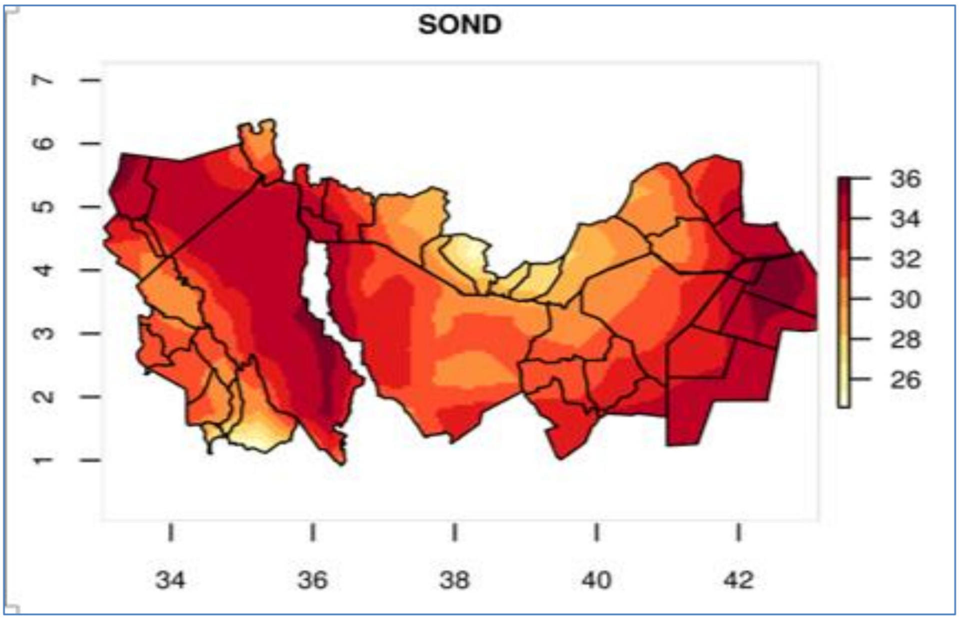


Figure 43: Maximum Temperature Distribution

Benefits of using GIS and Remote Sensing:

- **Large-scale Coverage:** It provides data for vast areas, overcoming limitations of ground-based monitoring.
- **Objective and Consistent Data:** It offers standardized data collection, reducing human error and bias.
- **Timely Information:** Satellites offer frequent data collection, allowing for near real-time monitoring.
- **Improved Decision Making:** Accurate and timely drought information helps authorities implement effective mitigation strategies.

Limitations:

- **Cloud cover:** Clouds can obscure satellite data acquisition (RADAR options exist)
- **Data Interpretation:** Expertise is needed to interpret complex remote sensing data.
- **Ground Validation:** Field observations are still necessary to validate remotely sensed

More Indicators

https://www.droughtmanagement.info/literature/GWP_Handbook_of_Drought_Indicators_and_Indices_2016.pdf

Data Access via ICPAC GeoPortal

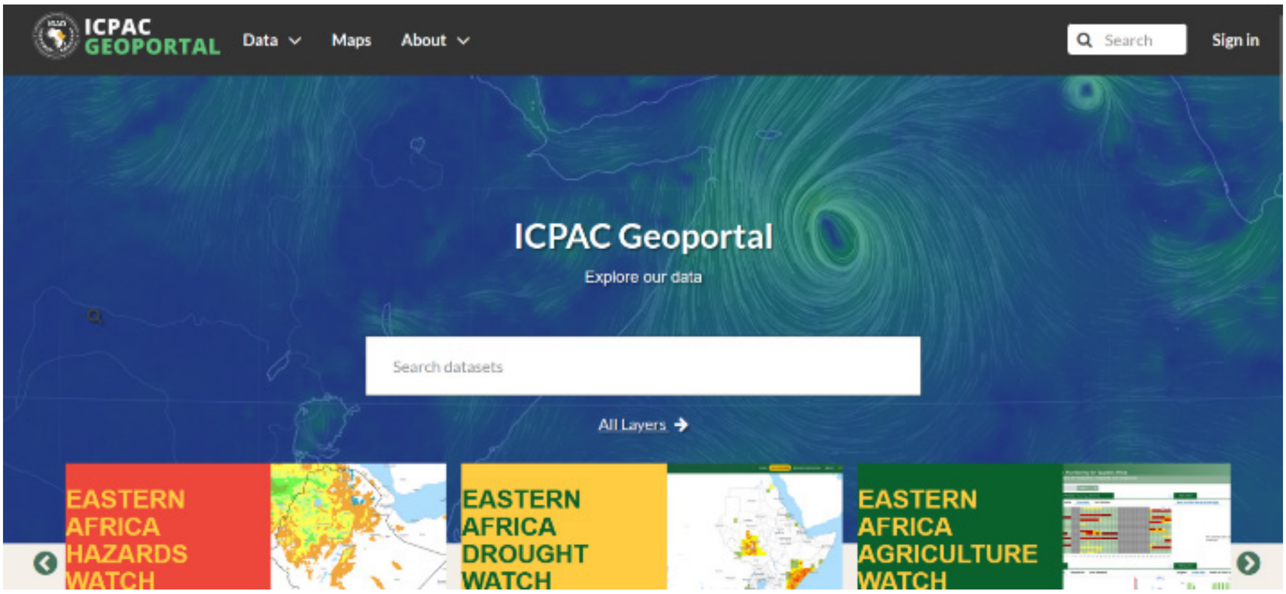


Figure 44: ICPAC Geoportal

ICPAC GeoPortal is a geospatial content management system, a platform for the management, visualization and analysis of geospatial data as shown in Figure 44. It provides a consistent and easy-to-use interface allowing non-specialized users to share data and create interactive maps. Data management tools built into the GeoPortal allow for integrated creation of data, metadata, and map visualization. Each dataset in the system can be shared publicly or restricted to allow access to only specific users.

Data Types

GeoPortal welcome page shows a variety of information about the current GeoPortal instance.

You can explore the existing data using many search tools and filters or through the links of the navigation bar at the top of the page.

There are three main types of resources contained in the Geoportal:

1. Documents
2. Layers
3. Maps

Documents and layers can be accessed from the Data menu of the navigation bar. Whereas, the Maps menu, lets you view maps.

Documents

GeoPortal allows you to publish tabular and text data and to manage metadata and associated documents. Through the detailed document page, it is possible to view, download and manage a document.

Layers

Layers are a primary component of GeoPortal. Layers are publishable resources representing a raster or vector spatial data source. Layers also can be associated with metadata, ratings, and comments. By clicking the Layers link, you will get a list of all published layers.

Finding Data

This section will guide you to navigate GeoPortal to find layers, maps and documents by using different routes, filters and search functions. In homepage, you can find some quick search tool.

The Search box in the navigation bar as shown in Figure 45 below, allows you type a text and find all the data, which have to deal with that text.

Figure 45: Search tool

When you trigger a search, you are brought to the Search page, which shows you the search result through all data types.

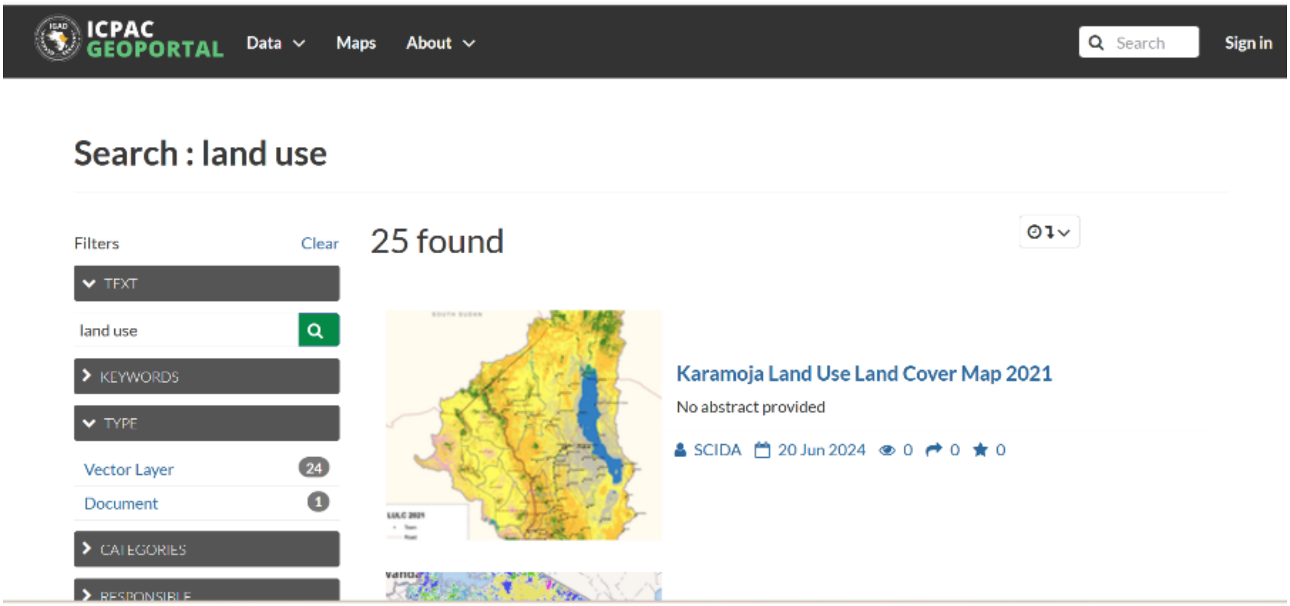


Figure 46: Search page

This page contains a wealth of options for customizing a search for various information on GeoPortal. This search form allows for much more fine-tuned searches than the simple search box is available at the top of every page. It is possible to search for data by Text, Categories, Type, Keywords, Owners, Date, Regions or Extent.

Try to set some filter and see how the resulting data list changes accordingly. Data can be ordered by date, name and popularity.

Documents

When you are searching for *Documents,* you can click on the *Documents link* of the Data menu in the navigation bar as shown below:

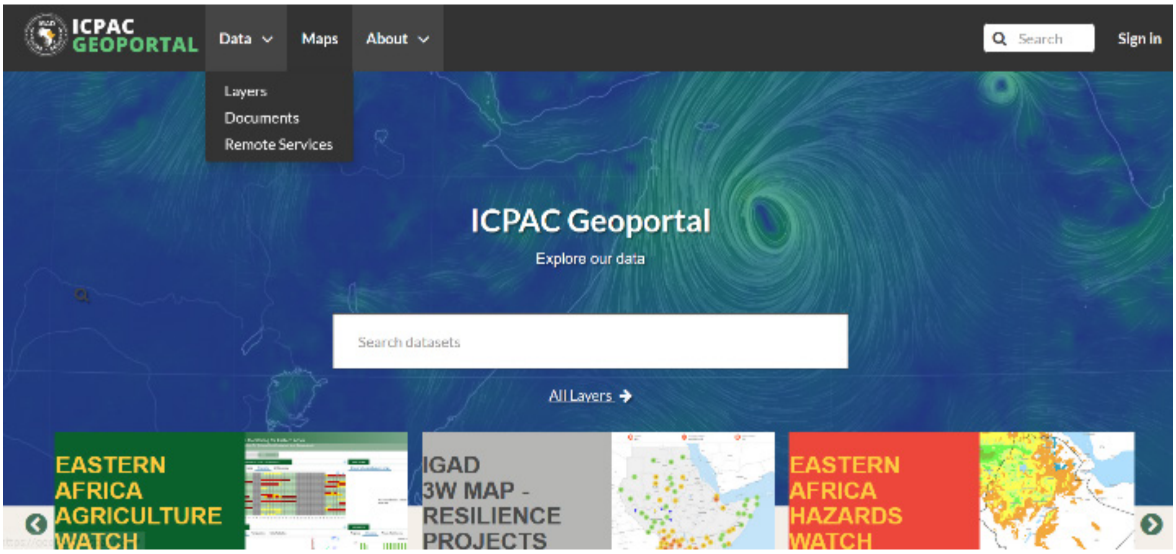


Figure 47: Link for documents

The *Documents* search page looks like the generic one but only Document is considered as data type. You can filter documents by CATEGORIES, as in the example below, or by TEXT, KEYWORDS and so on. You can also use more than one filter at the same time.

Document Information

From the *Documents Search Page* you can select the document you are interested in and see some basic information about it. You can access the document details page by clicking on its name. That page looks like the one shown in the picture below

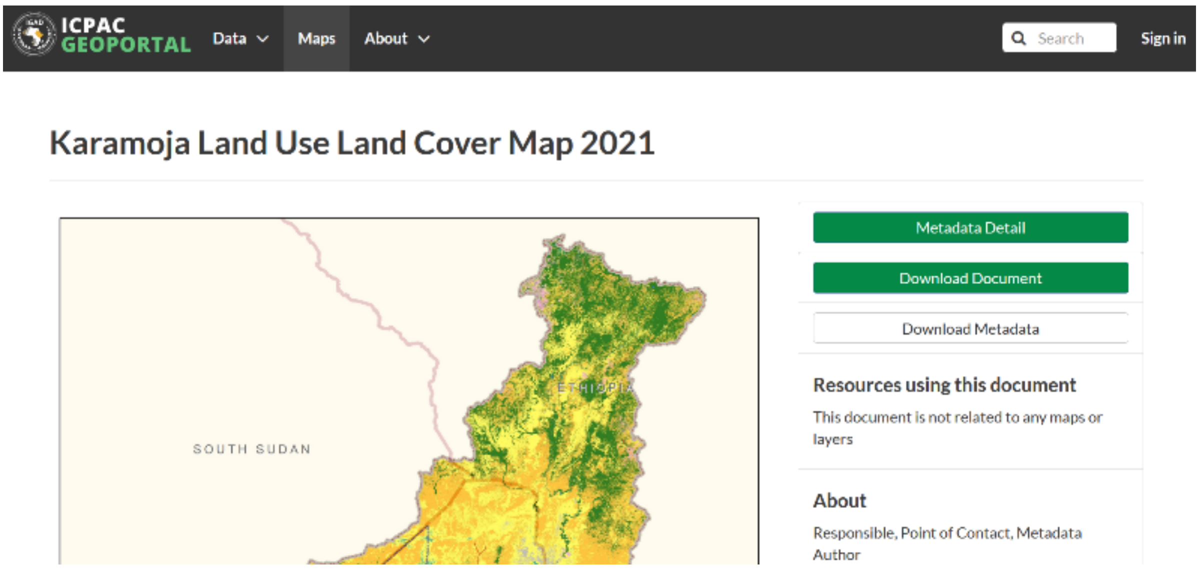


Figure 48: Document information page

Exploring the Tabs Sections

There is a Tab Section below the document, where you can first view Info about the document
.

Figure 49: Tab section

The **Info Tab** section shows the document metadata such as its title, abstract, date of publication etc. The metadata also indicates the user who is responsible for uploading and managing this content, as well as the group to which it is linked.

The **Share Tab** provides the social media links for the document to share. There is also a link to share the document through email.

You can **Rate** the document through the *Ratings system*

In the **Comments Tab** section, you can post your comment. Click on *Add Comment,* insert your comment and click *Submit Comment* to post it. Your comment will be added next to the last already existing comment. If you want to remove it click on the red *Delete* button.

The Tools Section

On the right side of the *Document Page* you can see other useful information such as the links to the resources linked to the document, the document *Owner,* the *Point of Contact* and the *Metadata Author*.

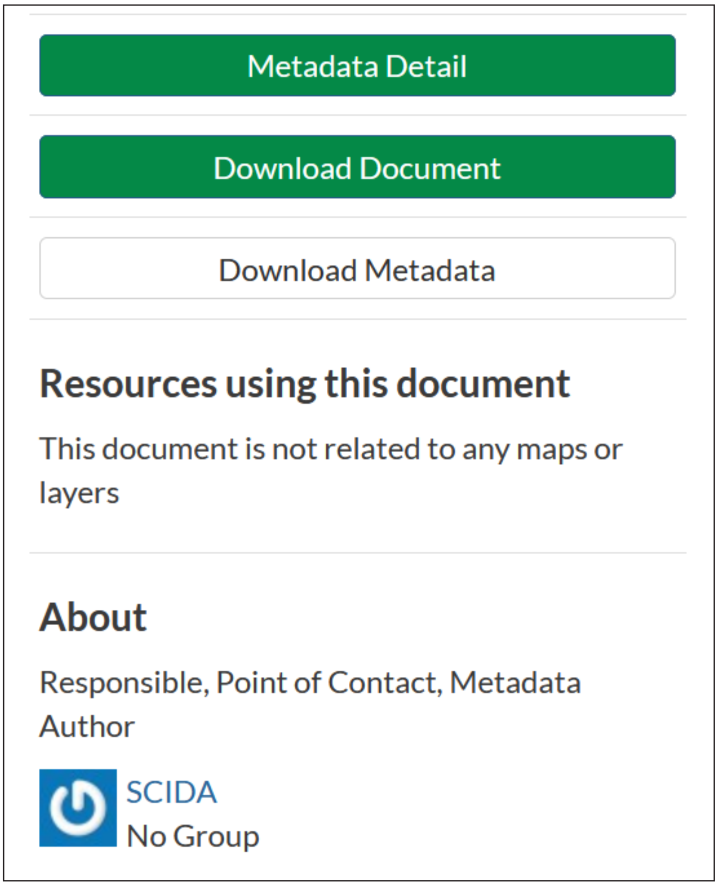


Figure 50: Tools section

In the same section of the Document Page, you can find the following useful tools:

- *Metadata Detail* to explore in detail the document metadata
- Download Document to download the document
- Download Metadata to download the whole set of metadata in various formats

Exploring Metadata Details

When clicking on the Metadata Details button, a page like the one shown in Figure 51 below, will open.

Figure 51: Document Metadata details page

It displays the whole set of available metadata about the document. Metadata are grouped to show the following types of information:

- *Identification,* to uniquely identify the document
- *Owner,* the user who own the document
- *Information,* the identification image, the Spatial Extent, Projection System and so on
- *Features,* Restrictions, Language and so on
- *Contact Points,* the user available to have a contact
- *References,* various links to the resource information
- *Metadata Author,* the metadata author information

Layers

To find Layers you can click on the Layers link of the Data menu in the navigation bar

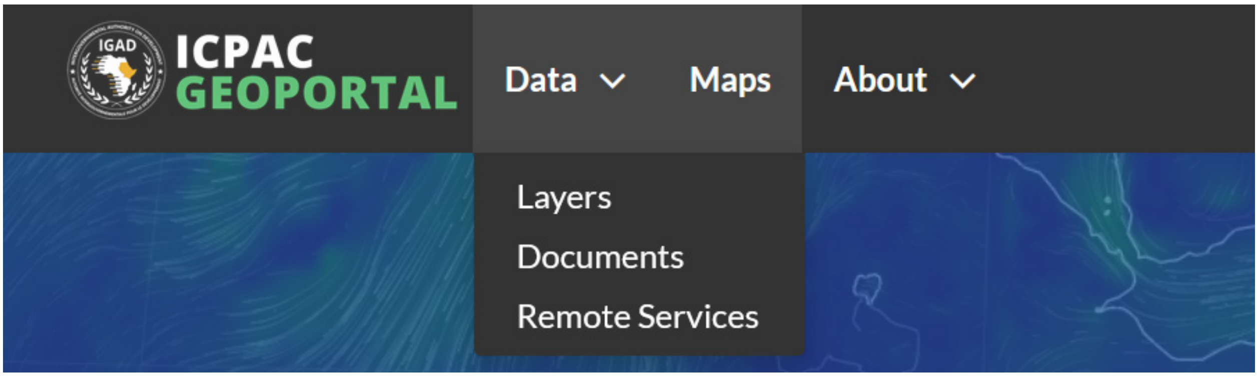


Figure 52: Finding Layer

In the Layers search page, only Layer will be considered as data type. You can set one or more filter to refine the search. In the example below the layers have been filtered by EXTENT and CATEGORIES.

Layer Information

From the layers list page, click on the layer you are interested in. The Layer Page like the one shown in Figure 53 below will open.

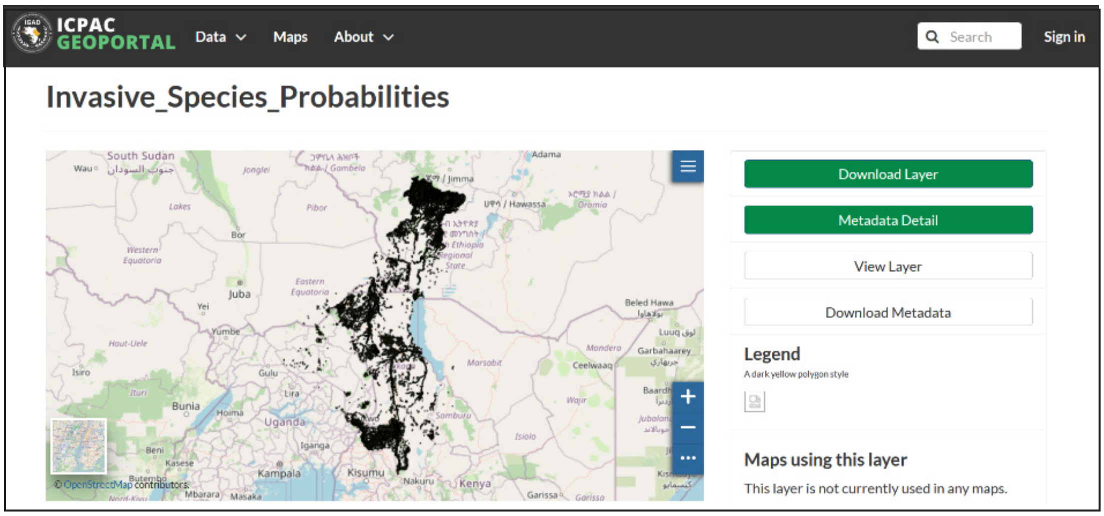


Figure 53: Layer Information

As shown in the picture above, the Layer Page is divided into three main sections:

1. Layer Preview section, under the title
2. Tabs section, under the layer preview
3. Tools section, on the right side of the page

Layer Preview

The Layer Preview shows the layer in a map with very basic functionalities:

- The *Base Map Switcher* that allows you to change the base map;
- The *Zoom in/out* tool to enlarge and decrease the view;
- The *Zoom to max extent* tool for the zoom to fit the layer size;
- The *Query Objects* tool to retrieve information about the map objects by clicking on the map; and
- The *Print* tool to print the preview

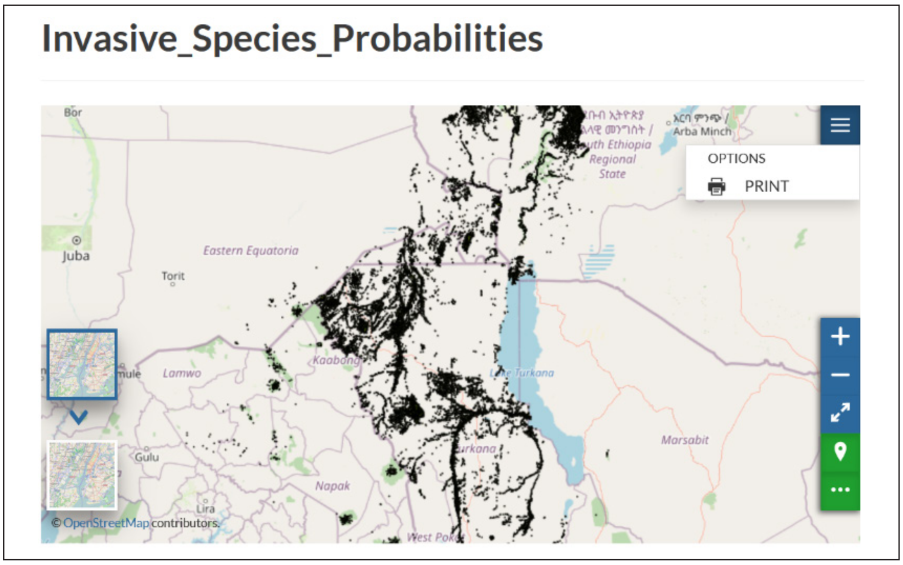


Figure 54: Layer Preview

Tabs Sections

Figure 55: Tabs section

The Layer Page shows some tabs sections containing different information about the layer:

- The tab *Info* is active by default. This tab section shows some layer metadata such as its title, the abstract, date of publication etc. The metadata also indicates the layer owner, what are the topic categories the layer belongs to, and which regions are affected.
- The *Attributes* tab shows the data structure behind the layer. All the attributes are listed and for each of them some statistics (e.g. the range of values) are estimated (if possible).

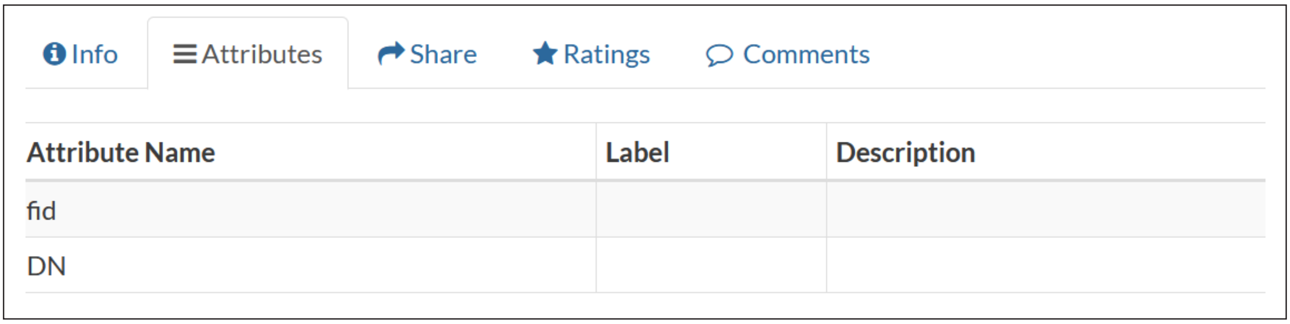


Figure 56: Layer Attributes tab

The Share tab provides the links for the layer to share through social media or email

Figure 57: Layer Sharing

- You can Rate the layer through the Rating system.
- In the *Comments* tab section, you can post your comment. Click on Add Comment, insert your comment and click Submit Comment to post it.

Layer Tools

In the right side of the Layer Page, there are some buttons and tools that show layer information:

- Through the *Download Layer button*, you can download your layer with some options;
- The *Metadata Detail* button to see the layer metadata;
- The View Layer button opens the layer loaded in a map, see the *Map Information* for more details;
- The *Download Metadata* button allows you to download the layer metadata in various formats;
- The *Legend* shows what the symbols and styles on the map are referring to;

- In the *Map using this layer* section, all the map that uses the layer are listed;
- The *Styles* section shows all the styles associated with the layer. Click on the checkbox corresponding to one of the styles listed to apply it the preview;
- The *About* section shows you the layer Owner, the Contact user and the Metadata Author.

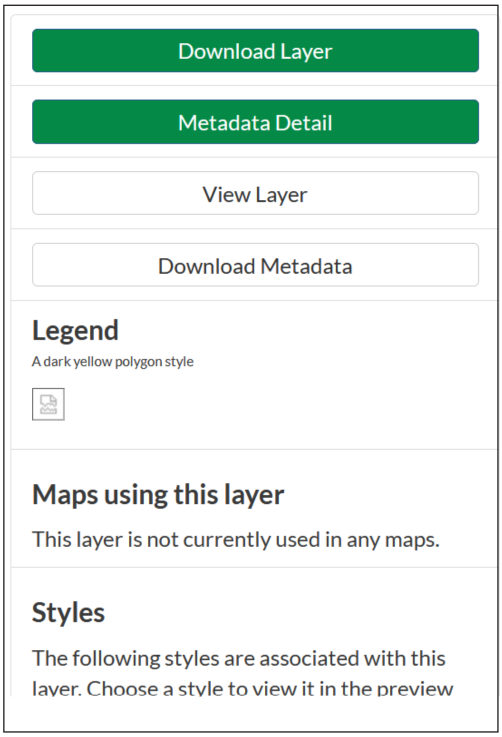


Figure 58: Tools section

Downloading Layers

At the top of the *Layer Page* there is the Download Layer button. It provides access to the ability to extract geospatial data from within Geoportal. You will see a list of options of the supported export formats. You can choose the Images formats PNG, PDF, JPEG if you want to save a "screenshot-like" image of the layer

Figure 59: Download Layer as Images

You can also download the layer data; the supported export formats will be listed in the Data tab. Click on your desired format to trigger the download.

Figure 60: Data Download tab

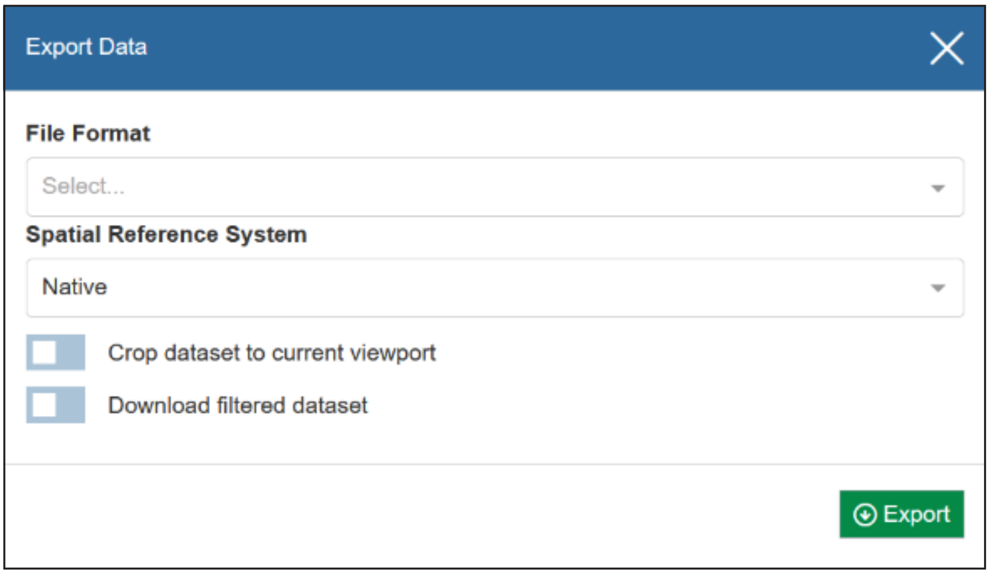


Figure 61: Export Data options

Layers Metadata

In the Geoportal special importance is given to Metadata and their standard formats. You can explore the Metadata of a Layer by clicking the Metadata Detail button from the Layer Page. The Layer Metadata page will be displayed

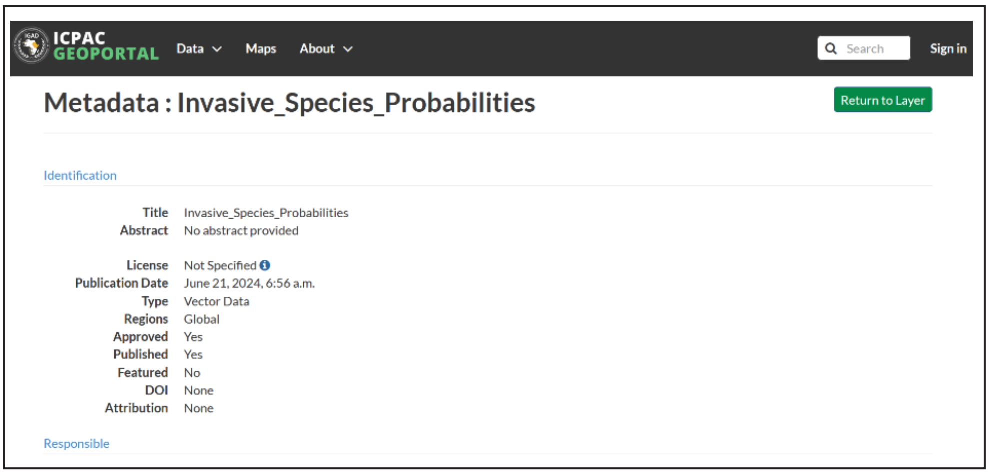


Figure 62: Layer metadata page

In that page you can see the whole set of available metadata about the layer. Metadata are grouped in order to show the following types of information:

- *Identification* to uniquely identify the layer (Title, Abstract, Publication Date etc.);
- *Owner,* the user who owns the layer;
- *Information,* the Identification Image, the Spatial Extent, Projection System and so on;
- *Features,* Language, Supplemental and other Information;
- *Contact Points,* the available user to get in contact;
- *References,* various links to the resource information and data;
- *Metadata Author,* information about the author of the metadata

Downloading Metadata

The *Download Metadata* button of the Layer Page allows you to download the layer metadata in various formats.

The available download formats are grouped in three categories:

- *Full metadata*
- *Standard Metadata - XML format*
- *Attribute Information*

Click on the format name that you prefer to start the download

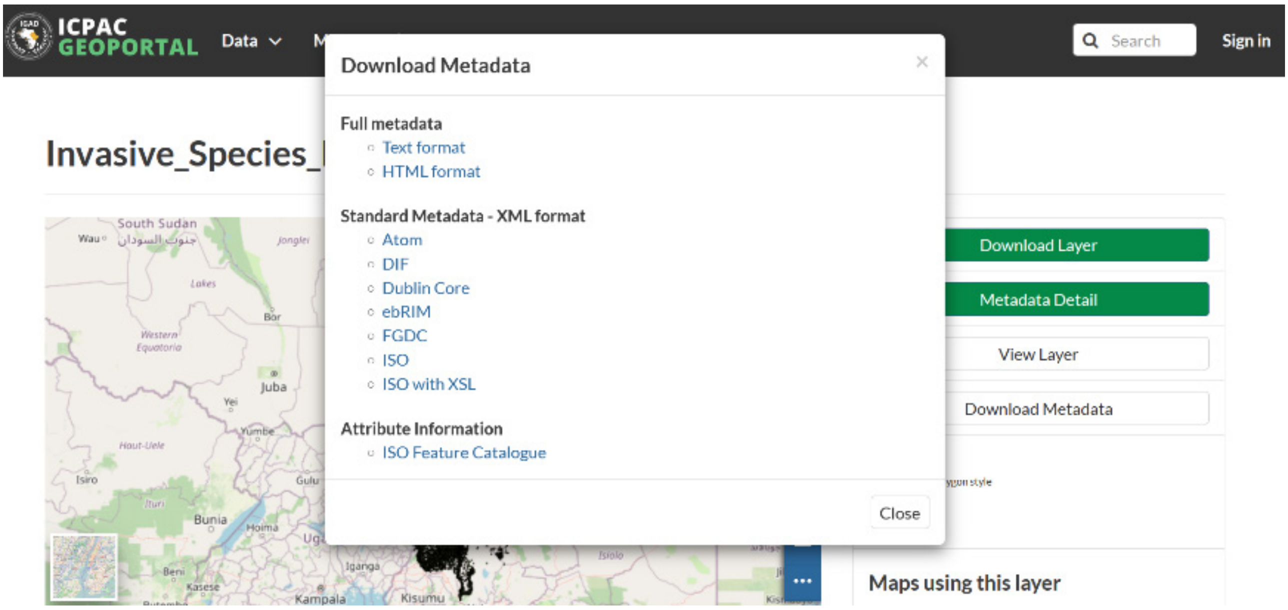


Figure 63: Download Metadata panel

Forecasting of the hazards and consequences

Weather and Climate

We are all familiar with the progression of the weather. Every few days, the temperature changes, rain comes and goes, or a severe storm hits. Climate is the statistics of weather averaged over a time period that contains many weather events, usually at least a month.

Understanding hazards and their potential impact is central to promoting early action. Climate forecasts predict weather averages and other climatic properties from a few weeks to a few years in advance. Forecast information comes in many forms, from raw data to qualitative statements such as bulletins from regional climate centers and national meteorological services. Table 1 represents various approaches and methods used for forecasting.

Comparative Issue	Traditional Knowledge Methods	Contemporary Seasonal Forecast Methods
Context	Often Embedded with cultural context, e.g. can include behavioral messages / morale. Part of a wholistic world view built upon generations of experience	Numerical simplification of real-world processes generated using models and empirical meteorological data
Scale - Spatial	Generally localized knowledge, e.g., relevant to a particular village. Full extent of spatial applicability is often unknown.	Generally broad, e.g., El-nino Southern Oscillation for large spatial scales. Seasonal forecasts by National Meteorological services, often apply only to province level, occasional to smaller number of villages for which meteorological observations exist.
Scale - Temporal	Forecast generated when indicator /sign (biophysical or spiritual) is seen. Timing can vary.	Forecasts generally coincide with calendar months.
Forecast generation	Ability of individuals to understand the forecast process varies, e.g., ability to generate forecast may be limited to the position of individual in community (e.g., rain prophet) or may be part of community's general knowledge.	Larger meteorological centers may be able to generate their own forecasts, or they may be reliant on forecasts from other centers.
Communication	Knowledge typically communicated through non-written methods, such as stories. Rarely documented.	Computer generated forecasts. Forecasts generated by external agencies generally communicated via internet. Regional / national forums for discussion of forecast generation and verification may occur, e.g., Greater Horn of Africa Climate Outlook Forum (GHACOF) and national/sub-regional COFs.
Verification	Informal verification. Continued use dependent on cultural constraints and/or continued usefulness	Formal mathematical verification, e.g., skill scores

Table 1: Forecasting procedures and major approaches

Probabilistic forecasts and statistical methods

Weather forecasts are usually accurate for hours or a few days ahead, but it might not be possible to predict exact conditions at precise times. Nevertheless, it is possible to make forecasts of the statistics of atmospheric conditions over an extended period (a month or a season), with a longer lead of up to many months, e.g. a forecast of monthly or seasonal rainfall totals a few months ahead.

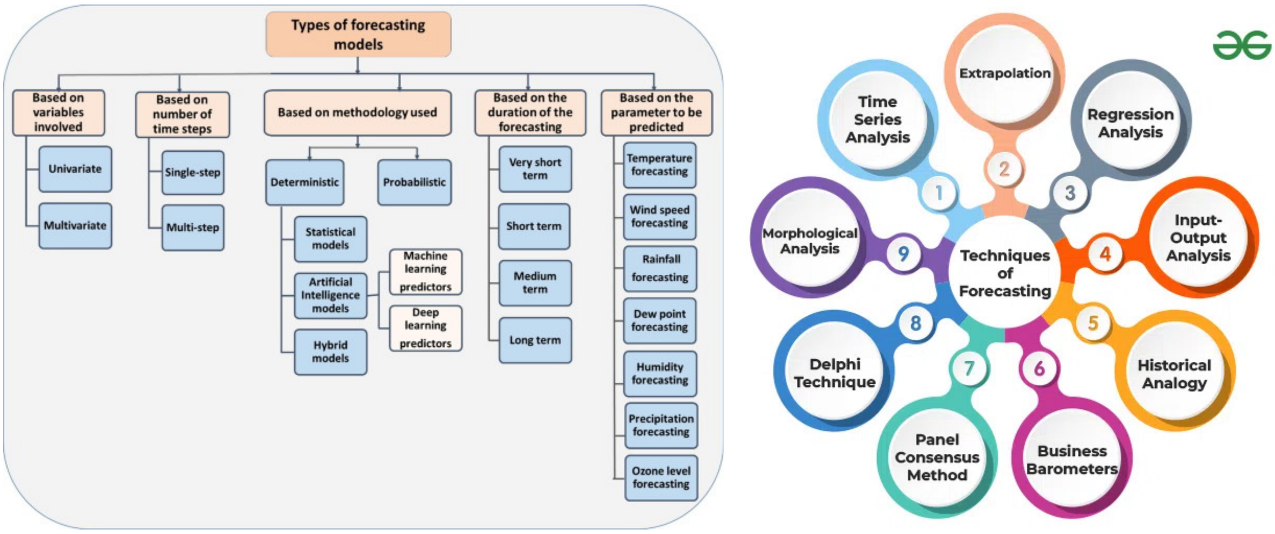


Figure 64: Types of Forecasting Models (left) and Techniques (right); only a few apply for climate forecasting

These monthly/seasonal forecasts from models are probabilistic (Figure 65), meaning that they typically come from multiple runs of the model (an 'ensemble'). Ensemble forecasting is now the standard approach used in major modelling centers and accounts for inherent uncertainty in both the climate system and the models themselves.

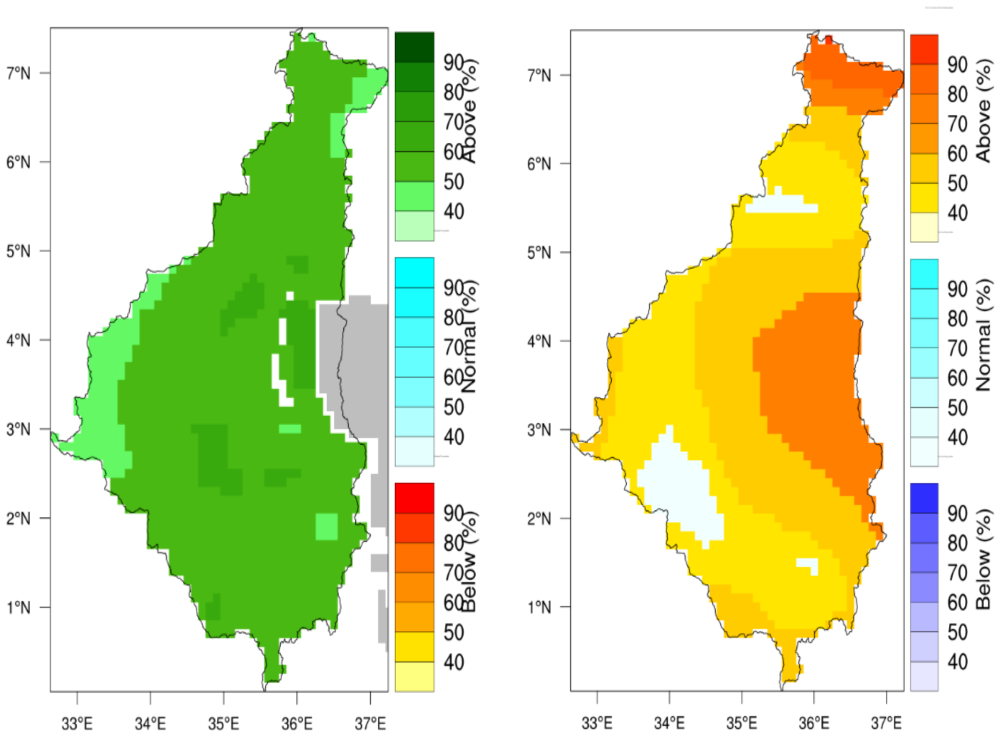


Figure 65: Seasonal probabilistic forecast of rainfall (left) and temperature (right)

Probabilistic forecasts provide an estimate of the likelihood of some event occurring, e.g. a 30% chance of rainfall greater than some value. Monthly/seasonal forecasts can also be derived using statistical approaches such as regression equations, predicting climate some months ahead, and Sea Surface Temperatures (SSTs), where a strong relationship exists in historical data. This is a standard method used by many African national meteorological services. This type of local approach is more appropriate for the context and can have greater skill (i.e., get it right more often) than global models.

The forecasts are often expressed as probabilities, reflecting uncertainty in the statistical relationships. Statistical 'calibration' of numerical models can improve forecast skill. Multiple forecast products can also be merged using an 'expert judgement' system, e.g. the consensus products of the Regional/National Climate Outlook Forums.

The operations component is the creation of forecast and other products, while service is the delivery of these products to stakeholders and customers. Note that each sector can make contributions to the various components (i.e., research and development, operations, and service).

Traditional Forecast Approaches:

Traditional forecasts are generated through experiences transmitted from one generation to another with ancestral connections and is based on indicators or signs of the environment. These include:

- behavior of plants, animals, humans and insects;
- cloud formations, wind direction, and the moon's/stars alignment; and
- dream interpretation to predict weather patterns and environmental changes.

(1) Environmental and Biological Indicators

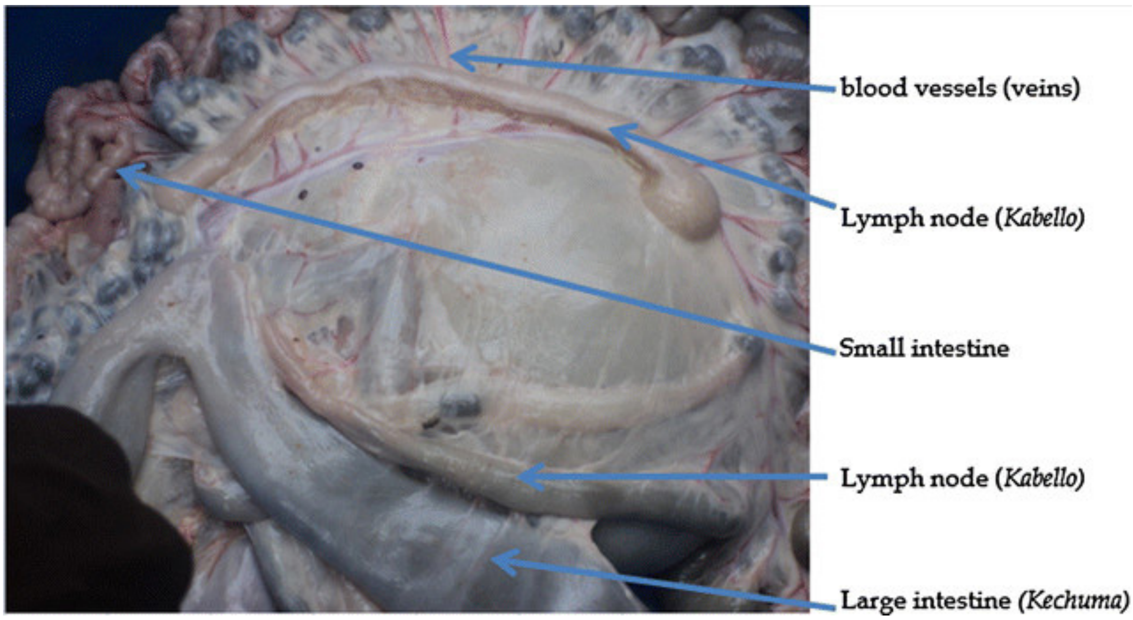
- **Plants:** The flowering of specific plants or the types of vegetation present can signal changes in seasons or potential drought.
- **Animals:** The behavior of animals and birds, such as the appearance of migratory birds like cattle egrets, their calls, or even the sounds made by frogs, are observed to predict rain or changes in weather patterns.
- **Insects:** The appearance and movement of insects, including winged termites, are used as indicators for the start of the rainy season.
- **Livestock:** In some cultures, the colour of slaughtered domestic animals' intestines is interpreted to forecast weather.

(2) Meteorological and Astrological Indicators

- **Clouds:** The type and formation of clouds are observed to forecast upcoming weather.
- **Wind:** The direction and strength of winds, such as winds blowing from east to west, are used to predict rainfall.
- **Stars and Moon:** The alignment and apparent movement of stars and the phase of the moon, such as the crescent's direction, are observed for weather forecasting.
- **Sky Color:** The colour of the sky, particularly at sunrise or sunset, can indicate approaching rain.

(3) Other Indicators

- **Dreams:** In some communities, the interpretation of dreams serves as an early warning sign for weather changes.
- **Lightning and Thunder:** The presence of lightning and thunder is a direct indicator of imminent storms and rain.



Use of Goat intestines for weather forecasting

Task #06: Assume that you have been provided with a seasonal forecast indicating that most parts of the cluster are likely to receive depressed rainfall accompanied by dry spells and hotter than usual temperatures.

(1) What are the likely consequences of this forecasted event on your major livelihood?

____

____

____

____

(2) What mitigation measures will you put in place to address the expected challenges

(3) What stakeholders are required to achieve results on resilience to the climate shocks in the cluster?

Sub-Module 5: EWS Component 3 - Warning dissemination and communication

In this context, ICPAC plays a vital role by rigorously and accurately providing climate information to its member states in the Greater Horn of Africa. Its mission is to leverage this information in forms such as seasonal forecasts, climate outlooks, and early warning systems, which are used by government agencies, civil society organizations, and other stakeholders to design and implement climate-resilient development programs and policies.

How we utilize Spatial data for Disaster Operation Centre situation room, on supporting the DRM activities using the East Africa Hazard Watch for flood and drought monitoring, and transboundary pests, forecasting, early warning and early action services, anticipatory actions including analyses of data from the climate services into weekly and monthly bulletins as shown in Figure 66 below.

Flash Flood Update and Tropical Cyclone Update and Monitoring

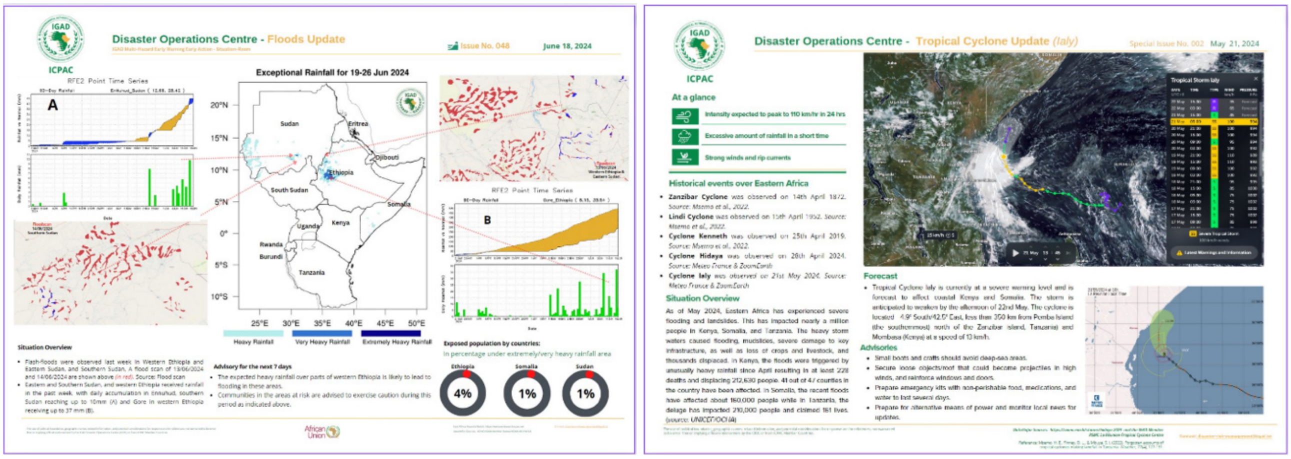


Figure 66: Flash Flood Update (left) and Tropical Cyclone Update and Monitoring (right)

Warning Dissemination and Communication Frameworks and channels

Figure 67 below shows a communication and dissemination framework to support emergency response. Whereas communication and dissemination of information can be done through a large number of channels, radio and SMS seem to be the most widely used channels. These popular channels still suffer from language barrier and high illiteracy levels among end users, requiring translation of information and creation of audio messaging for effective communication.

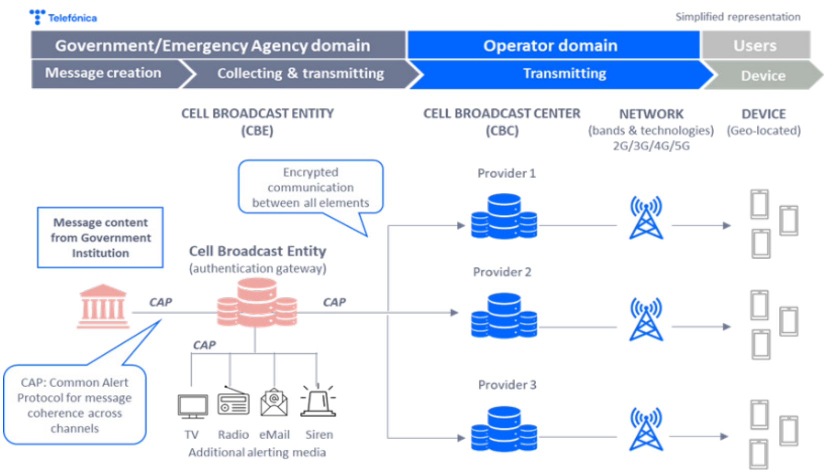


Figure 67: Communication and Dissemination Framework

HUSIKA Multi-layered Information Management System App

For this purpose, ICPAC uses the "Husika" App as shown in Figure 68 below for moving information from the cross-border drought watch (system) to end-users for decision making. The Husika App, provides well-curated information and alerts through a Short Messaging Service (SMS). The information could be early warning messages, e.g. weather forecast, drought updates or any other information, which keep users in the know about what is happening around them and how to avert risks if any of the events happening around them pose any kind of danger.

A user can also reply to the messages they receive as feedback to the early information/alerts provided. The messages sent can be used to further assess the situation on the ground or fetch more information regarding the issue at hand. This forms a basis of crowd sourcing of data and enhances collaboration. The end-users are added by the various organizations, which subscribe to Husika MIMS.

Figure 68: Husika App Levels for Early Warning

Sub-Module 6: Introduction EWS Component 4 - Preparedness and response capability

Preparedness and response form a strong part of the disaster risk management cycle as shown in the figure below.

DRM Cycle – Adopted from the Disaster Risk Management Handbook for Malawi (Draft – DODMA)

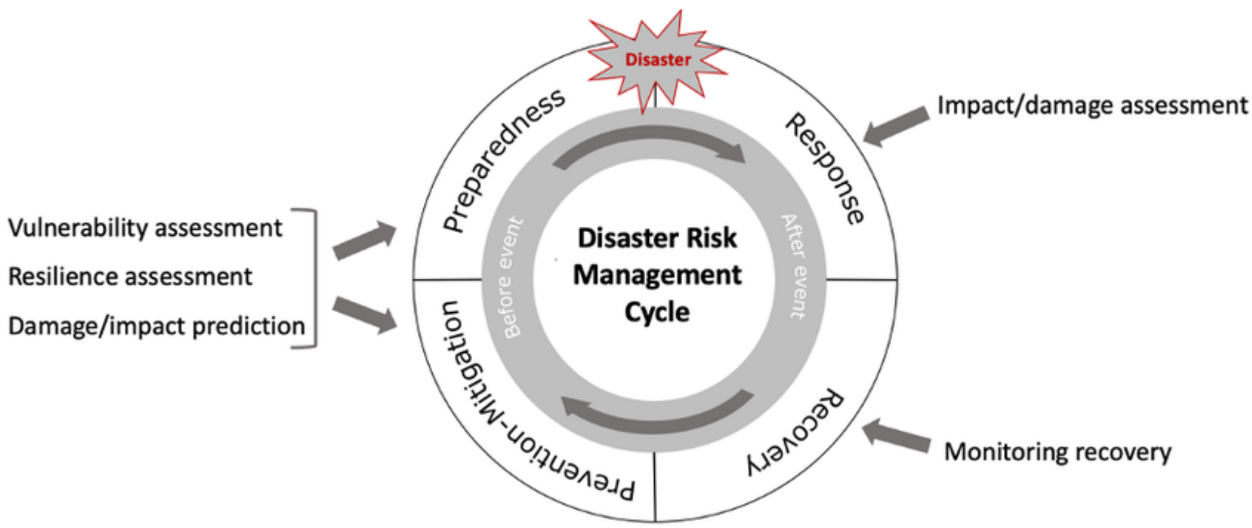


Figure 69: Disaster Risk Management Cycle

Preparedness Actions and Contingency Planning (CP) are two sets of complementary activities that should be initiated together to plan for specific risks when risk analysis and monitoring indicate moderate or high risk.

Preparedness Actions are designed to advance readiness to respond to specific risks. Some preparedness actions are risk specific. They build on the minimum preparedness already in place.

The checklist includes essential preparedness actions that complement and support the contingency planning process.

A contingency plan sets out the initial response strategy and operational plan to meet the humanitarian needs during the first three to four weeks of an emergency. A contingency plan addresses what could happen and what might be needed; actions to take and resources required and gaps to be bridged. it lays the ground for a flash Appeal, if required.

Key principles of the Preparedness and Response Approach/ Capability

- The preparedness and response approach should be practical. It should focus on needs; what we have and how to bridge the gaps. It looks like now we might reach affected people with assistance. In other words, the Preparedness and Response approach is a process of asking and answering a set of critical operational questions.
- The preparedness and response approach should be flexible. Countries/clusters should prioritize actions considering capacity within the country to undertake preparedness.
- Risk analysis and monitoring are key to dynamic and responsive preparedness.
- Simulations and other such tools should regularly be applied to ensure the emergency readiness of the cluster/country to carry out the action plans developed through the Preparedness and Response capability process. in this way problems can be anticipated, sources for relief items can be identified in advance and roles and responsibilities of different actors can be better understood. The chances of good coordination will be greatly improved.
- The preparedness and response approach should be participatory. Planning is most effective when all those who will be required to work together are engaged in the process from the start.
- Strategic leadership by the government and strong commitment from heads of Agency at country level to making staff and resources available to support the process are vital to the success of a Preparedness and Response Plan. The success of the preparedness and response process depends on each and every member of the cluster/country.

Figure 70: Development process of the preparedness plans

Preparedness and Response Strategies for the Likely Case Scenario

After defining the scenarios using the risk analysis result, the next step is to identify response strategies. A response strategy in this sense refers to what we want to achieve in our response intervention (objective of the response) and how we want to achieve this objective. The response strategy in a contingency plan serves this purpose and also acts as a bridge between the scenario and the plan that follows.

The Participatory Disaster Risk Analysis (PDRA) and other data sources complement each other to provide in-depth situational analysis and guide in formulation of response objectives and capabilities. It ensures a clear focus of interventions directed at saving human lives and livelihoods. The early warning system should be reliable and provide timely and efficient information to trigger a response. The early warning thresholds guide in triggering timely response thus minimizing the responding at the point of destitution. Communities have their traditional early warning systems as well as the conventional early warning systems that provide information.

There are currently several studies underway that identify which benchmark EWS should activate the contingency plans. The result of this is critical for the effectiveness of drought management. In established drought early warning system in Kenya, for example, contingency plans are activated in between the alert/alarm stage of the drought cycle where all monitored indicators reflect worsening trends. At the community level, pastoral communities have their early warning indicators with respective thresholds guiding the contingent coping mechanisms. For example, utilization of certain water sources like the strategic dry season boreholes are only utilized when the water distances have exceeded 10km plus watering hours of livestock going beyond eight hours. At this point, the rangelands user association in conjunction with water user associations institute measures to utilize dry season grazing areas and strategic boreholes with a clear management function.

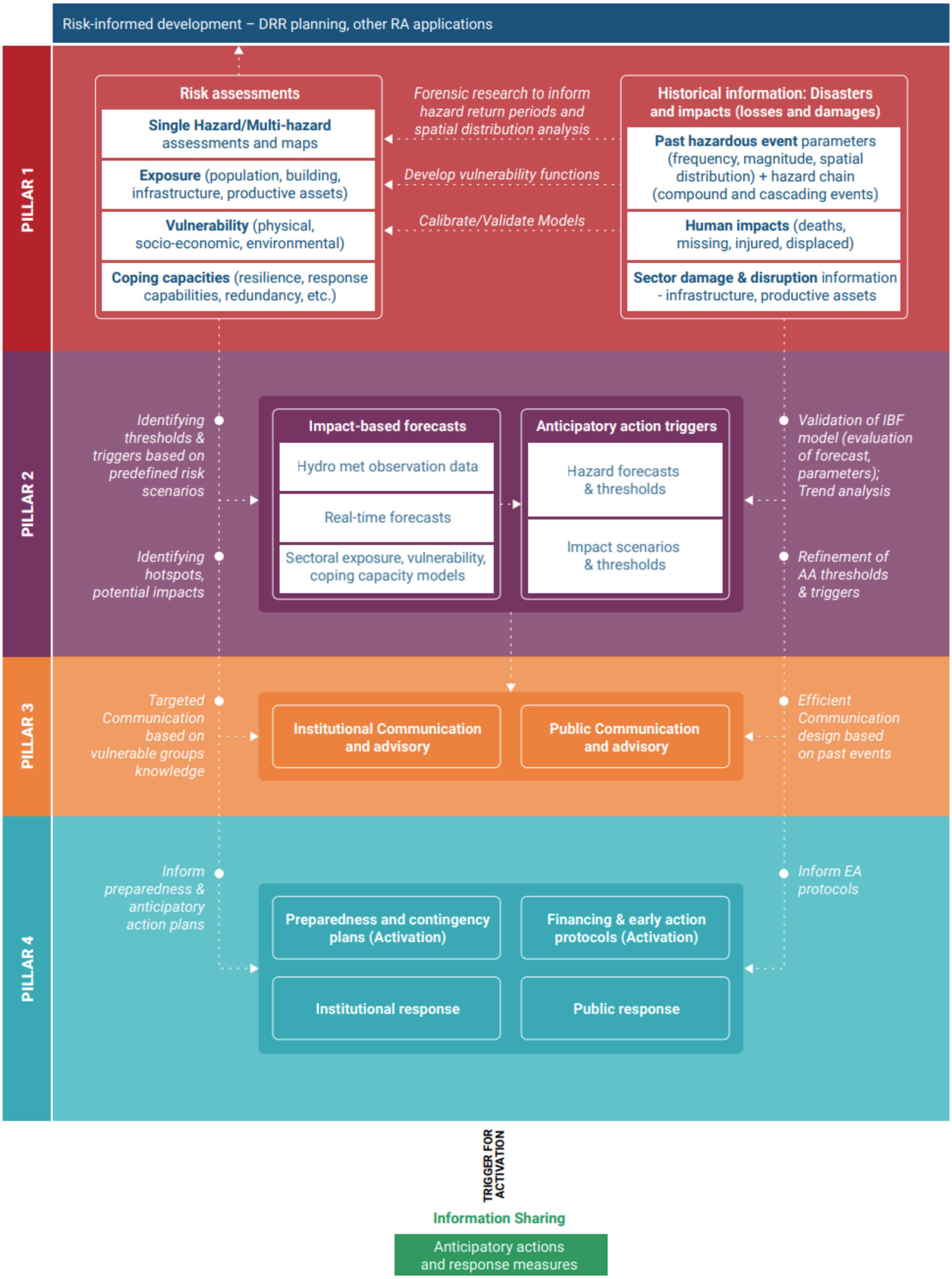


Figure 71: EW4All supports Risk-informed development and Anticipatory Action (AA)

Figure above illustrates the importance of risk knowledge (assembled from historical disaster loss and damage information) for the EW4 All pillars and development of impact-based forecasts and anticipatory actions (modified by UNDRR).

Needs Assessment and Target Levels

From the **Post Disaster Rapid Assessment (PDRA)** and other data collection instruments, especially from early warning systems and scenario building, the emergency needs assessment is informed on the level of vulnerability for human beings and animals. What are the eminent gaps that require sound planning? Emergency needs assessment will facilitate proper situational analysis by actual review of the existing local capacities that cope with the hazard.

It also takes stock of the functions and critical facilities, while projecting the emerging demand for the utilization and the facilities' ability to absorb the pressure. Therefore, needs assessment and the identification of targeting levels, require a multi-stakeholder participation with clear objective of determining the hazard and vulnerability levels comparing them against the local coping capacities. Generated PDRA information in combination with the emergency needs assessment instruments shall be developed and used to guide the assessment.

A checklist to guide and ensure the assessment is focused shall be developed upfront before embarking on the assessment.

Frequently, emergency needs assessment and targeting levels assessments have been driven by external forces, especially political influences. But if the objectives and frameworks are developed in advance, then such isolated incidences may be overcome. The assessment should therefore take advantage of the available primary and secondary data sources with clear instruments to collect the relevant data.

Data collection, collation and analysis should be thorough, and the assessment report developed prior to emergency response implementation, such that the needs assessment and targeting levels are clear and agreed upon across all the stakeholders.

Development of Preparedness and Response Plans

While planning for emergency response, it is important to take stock of the kind of partnership required to operationalize the response plan. Identification of partners and aligning each partner's roles and responsibility in the preparedness and emergency response plan is an important undertaking.

Stakeholders' analysis that should have been done during the PDRA process informs the stakeholders or partners for the community. Review and update of the same is crucial with an update on each partner's current roles and the actual expected roles in the preparedness and emergency response. Determining roles ensures agreements on specific tasks that may be assigned to each partner, and this is where leadership of the emergency response plan also takes shape with the support of the rest of partners. Clear communication needs to be instituted across the identified partners to ensure that the latest information in regard to the emergency response is accessible to all partners.

It is from the identified partnership that the coordination roles during the implementation of preparedness and response plans are shared across the partners with specific roles being defined. Local leadership, especially at the community level, should be instrumental in strengthening local community institutions by empowering them in decision making. Administration representation at the local level, for example, is key in providing link between the community institutions and other partners especially the Government agencies. While at the district level, the experience has shown that it is important for the leadership of emergency response to be entrusted on the local administration available for purposes of facilitating a lead role in decision making as well as providing link with high Government authorities. Other partners thus play facilitatory roles with communities and their leaders being at the forefront in implementation of emergency response plan.

Preparedness and Response Plan Template

<table>
<tr><th colspan="9">Sector Preparedness and Response Objective(s)</th></tr>
<tr><td colspan="9"></td></tr>
<tr><td colspan="9">Planning Assumptions:</td></tr>
<tr><td colspan="9">*</td></tr>
<tr><td colspan="9">Strategic Action:</td></tr>
<tr><td colspan="9"></td></tr>
<tr><td colspan="9">Drought Preparedness and Response Plan</td></tr>
<tr><td>Objective:</td><td colspan="8"></td></tr>
<tr><td>Strategic Action</td><td>Activity</td><td>Where</td><td>Timeframe</td><td>Indicator</td><td>Cost Estimate</td><td>Funds source</td><td>Coordination</td><td>Comments</td></tr>
<tr><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
</table>

Table 2: Drought preparedness and response plan Template

Additional Reading:

Rokhideh, Maryam, Carina Fearnley, and Mirianna Budimir. **"Multi-Hazard Early Warning Systems in the Sendai Framework for Disaster Risk Reduction: Achievements, Gaps, and Future Directions."** *International Journal of Disaster Risk Science 16, no. 1 (2025): 103 - 116.*

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Hermans, Thirze DG, Robert Šakić Trogrlić, Marc JC van den Homberg, Hannah Bailon, Rebecca Sarku, and Anuszka Mosurska. **"Exploring the integration of local and scientific knowledge in early warning systems for disaster risk reduction: a review."** *Natural Hazards* 114, no. 2 (2022): 1125 - 1152.

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Annex I: Key Definitions

Capacity: The combination of all the strengths, attributes and resources available within a community, society or organization that can be used to achieve agreed goals

Climate service: This refers to the provision of climate information to help end-users make climate smart decisions

Co-production: This is when an individual/user influences the support and services received, or when groups of people get together to influence the way that services are designed, commissioned and delivered.

Data: This is defined as a value or set of values representing a specific phenomenon, concept or system.

Disaster: A disaster is a serious disruption of the functioning of a community or a society involving widespread human, material, economic or environmental losses and impacts, which exceeds the ability of the affected community or society to cope using its own resources. Disasters are often described because of the combination of the exposure to a hazard; the conditions of vulnerability that are present; and insufficient capacity or measures to reduce or cope with the potential negative consequences.

Disaster Risk: The potential disaster losses, in lives, health status, livelihoods, assets and services, which could occur to a particular community or a society over some specified future period. The definition of disaster risk reflects the concept of disasters as the outcome of continuously present conditions of risk. Disaster risk comprises different types of potential losses, which are often difficult to quantify. Nevertheless, with knowledge of the prevailing hazards and the patterns of population and socioeconomic development, disaster risks can be assessed and mapped, in broad terms at least.

Disaster risk reduction: The concept and practice of reducing disaster risks through systematic efforts to analyze and manage the causal factors of disasters, including through reduced exposure to hazards, lessened vulnerability of people and property, wise management of land and the environment, and improved preparedness for adverse events.

Early warning system: 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.

Forecast: A statement of what is judged likely to happen in the future, especially in connection with a particular situation, or the expected weather conditions.

Framework: This refers to a supporting structure around which something can be built.

Hazard: A dangerous phenomenon, substance, human activity or condition that may cause loss of life, injury or other health impacts, property damage, loss of livelihoods and services, social and economic disruption, or environmental damage.

Information: This is the output that results from analyzing, contextualizing, structuring, interpreting or in other ways processing data.

Mitigation: The lessening or limitation of the adverse impacts of hazards and related disasters. Mitigation measures encompass engineering techniques, hazard-resistant construction, and improved environmental policies and public awareness.

Uncertainty: Refers to the inability to foretell consequences or outcomes because there is a lack of knowledge or bases on which to make any predictions.

Preparedness: Preparedness action is carried out within the context of disaster risk management and aims to anticipate, respond to, and recover from the impacts of likely, imminent or current hazard events or conditions and builds on the capacities needed to manage all types of emergencies efficiently and effectively.

Prevention: The outright avoidance of adverse impacts of hazards and related disasters, prevention expresses the concept and intention to completely avoid potential adverse impacts through action taken in advance. Because it is not possible to avoid all losses, prevention often is transformed into mitigation (the terms are often interchanged in casual use.

Public awareness: The extent of common knowledge about disaster risks, the factors that lead to disasters and the actions that can be taken, individually and collectively, to reduce exposure and vulnerability to hazards.

Resilience: The ability of a system, community or society exposed to hazards to resist, absorb, adapt to and recover from the effects of a hazard in a timely and efficient manner, including through the preservation and restoration of its essential basic structures and functions; the positive side of vulnerability.

Response: Providing emergency services and public assistance during or immediately after a disaster to save lives, reduce health impacts, ensure public safety and meet the basic subsistence needs of the people affected. Disaster response is focused on immediate and short-term needs and is sometimes called 'disaster relief.' The division between this response stage and the subsequent recovery stage is not clear-cut. Some response actions, such as the supply of temporary housing and water supplies, may extend well into the recovery stage.

Risk: The combination of the probability of an event and its negative consequences.

Vulnerability: A set of prevailing or consequential conditions arising from various physical, social, economic and environmental factors which increase the susceptibility of a community to the impact of hazards Vulnerability also comprise various physical, social, economic, political, and environmental factors that affect the ability of communities to respond to events.

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