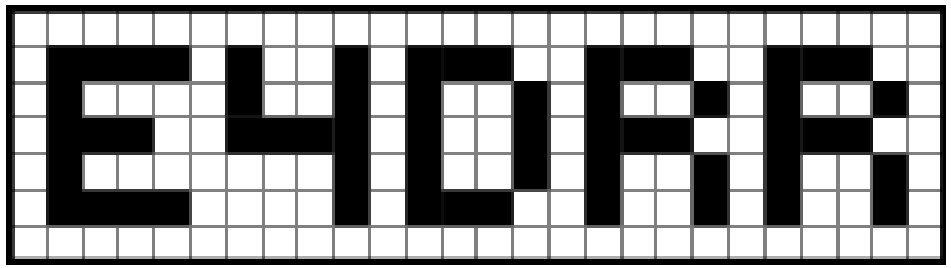
Hazard modeling, impact estimation, event-based climate storylines on drought and flood disasters in the Eastern Africa



Nishadh Kalladath, Hillary Koros, Robert Tucci, Owiti Zablone,
Masilin Gudoshava and Ahmed Amdihun

IGAD Disaster Risk Management Programme, ICPAC
2024/11 to 2026/10

CRAF'd

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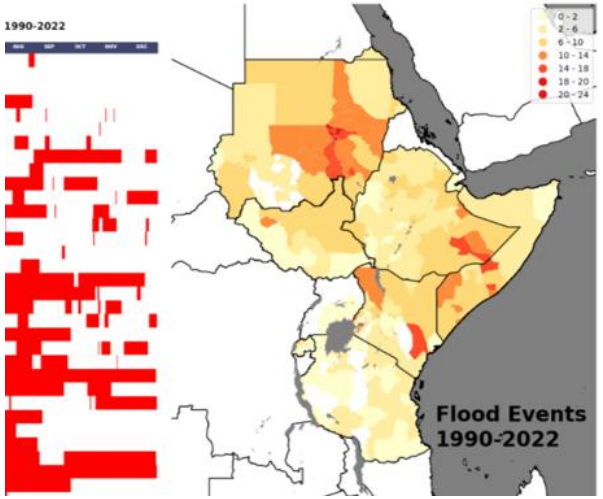
PART OF NORWEGIAN REFUGEE COUNCIL

Agenda

- Project Background
- Concepts
  - IBF
  - Analysis Ready Data Ecosystem
  - Ensemble Prediction System
  - Event Based Storylines
  - Bayesian Networks
  - Co-production: storymaps
  - Hazard modeling
  - Impact modeling
- Project updates

Challenges to be addressed

- Lack of composite data for past disaster events hampering risk Knowledge
- Current early warning system (EWS) based on deterministic forecast, needed probabilistic impact forecast for decision making.
- Hazard modeling computationally complex, there are parsimonious models with ensemble forecasting mode having promising economically cheaper alternative
- There is poor utilization of systematic tools for optimizing risk and decision analysis iteratively, in participatory co-production by including local expert knowledge.
- Long pending operationalization of Impact Based Forecasting



EM-DAT
The International Disaster Database
Centre for Research on the Epidemiology of Disasters

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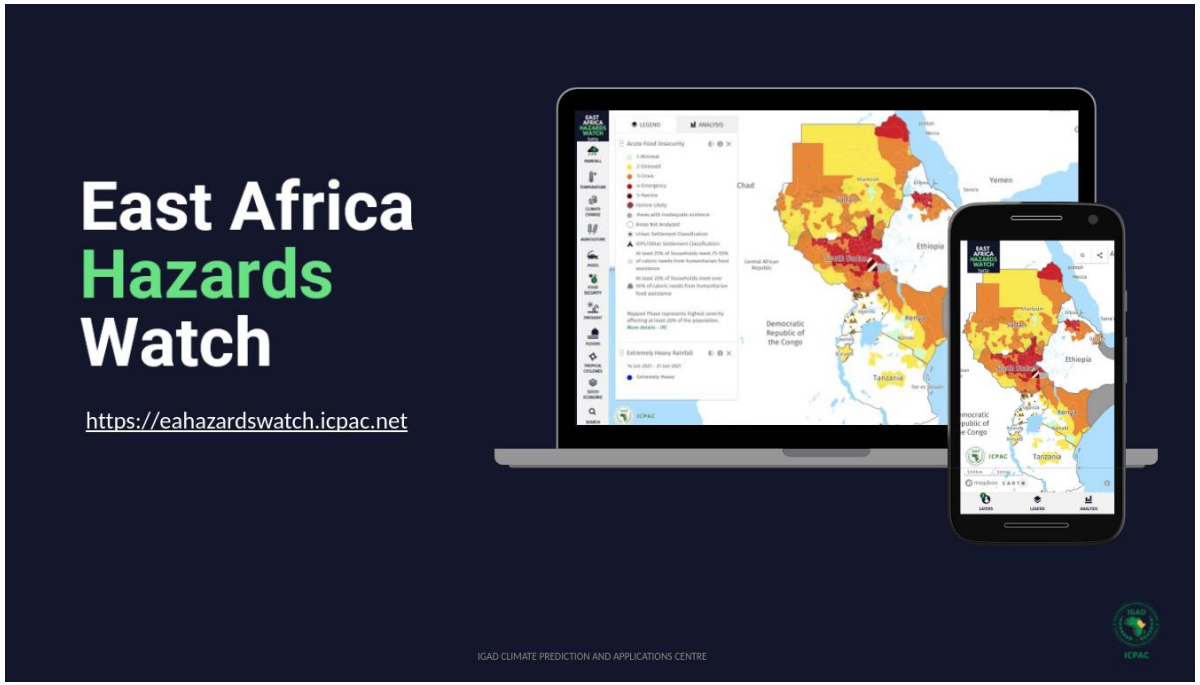
East Africa Hazards Watch



Risk information visualization and Analysis

- Heavy Rainfall
- Food Insecurity
- Pests
- Extreme Temperature
- Drought
- Floods
- Climate Change
- Crops Conditions
- Cyclones

Aim and Objectives

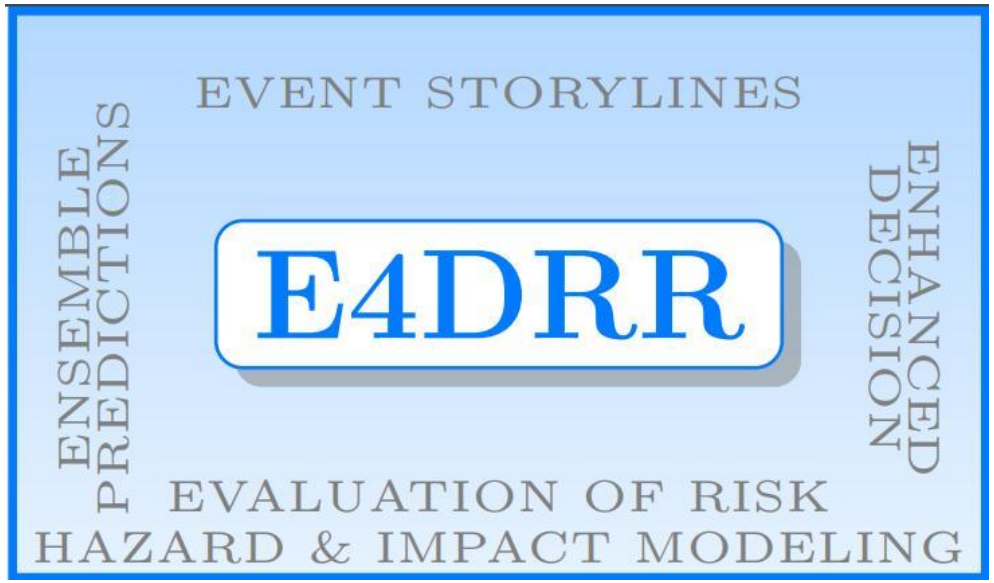
- To enhance the East Africa Hazard Watch Portal as a decision-making and actionable information tool for Disaster Risk Management (DRM) through **impact-based forecasting** based on a chain of auditable evidence synthesised from event-based climate Storylines
- 1. **Enhanced Risk Knowledge and Awareness:** Through the Creation of Event-Based Climate Storylines
- 2. **Operationalizing Impact Based Forecasting:** Exploration of storylines creation processes and applications in Ensemble Prediction System (EPS) Impact Based Forecasting (IBF)
- 3. **Capacity Development:** On the use of methods and tools for storyline creation

Background

1. Ensemble Prediction System
2. Event storylines
3. Evaluation of Risk
4. Enhanced decision support

Project Updates

https://icpac-igad.github.io/e4drr/blog/



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Work Packages

Objective 1

1. Establish Hazard and Impact Modelling for the Region: Setting up of hazard and impact modelling for the region

2. Implement Co-development Method for Event-Based Climate Storylines: Implement a co-development method for event-based climate storylines

3. Consolidate Composite Dataset and Storylines into Story Maps Linked with EAHW: Consolidate the composite dataset and storylines as story maps and link with East Africa Hazard Watch (EAHW) web application

Objective 2

4. Establish an Analysis and Forecast Validation Facility Utilizing Storylines Dataset and Processes for Anticipatory Action: and Processes for Anticipatory Action Develop analysis and forecast validation facility utilising storyline dataset and processes for anticipatory action

5. Demonstrate the Application of Storylines as Bayesian Networks in IBF Risk and Decision Analysis: Demonstrate the application of storylines as a Bayesian network in IBF risk and decision analysis

6. Operationalize EPS IBF with Hazard and Impact Modelling for the Region: Operationalise EPS IBF with hazards and impact modelling for the region

Objective 3

7. Develop Documentation and Training Materials on Methods and Tools Used in Storyline Creation: Prepare documentation and training materials on methods and tools used in storyline creation

8. Conduct Capacity Development Activities in Co-development, Workshops, and Tutorials: Capacity development activities in co-development, workshops, and tutorials

IMPACT-BASED FORECASTING: CURRENT STATUS

Transitioning from Weather - Hazard- to Impact-Based Forecasting

Moving from what the weather will be to what the weather will do

- Impact-Based Forecasting (IBF) bridges the gap between traditional weather forecasts and real-world impacts — enabling decision-makers, communities, and responders to take timely, informed action that saves lives, livelihoods, and resources.
- Implementation of both IbF requires working together with different agencies e.g., climate services, sectors, administrators, donors & communities

Standard Impact Based Risk Measure

Impact communication through risk matrices

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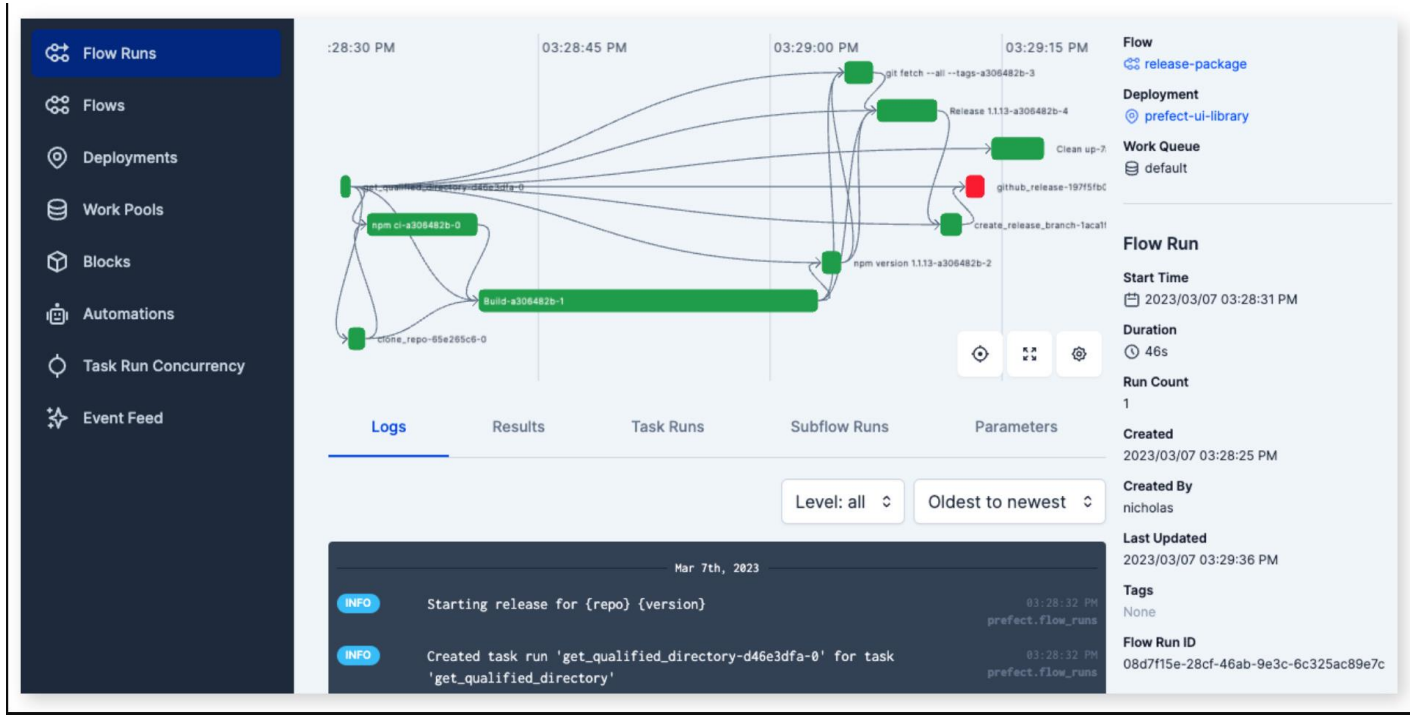
IBF Operations: Challenge of Analysis Ready Data Ecosystem

1. IBF is a merger of Climate data and GIS, sheer size of data involved makes it a technological challenge
2. Need of Analysis Ready Cloud Optimized Dataset and Cloud Native Operations
3. Data Standards and Practices
4. Data Application Programming Interface (API)
5. Web Processing Services (WPS) cloud compute operations, workflow management. Software DevOps.
6. GPU for training



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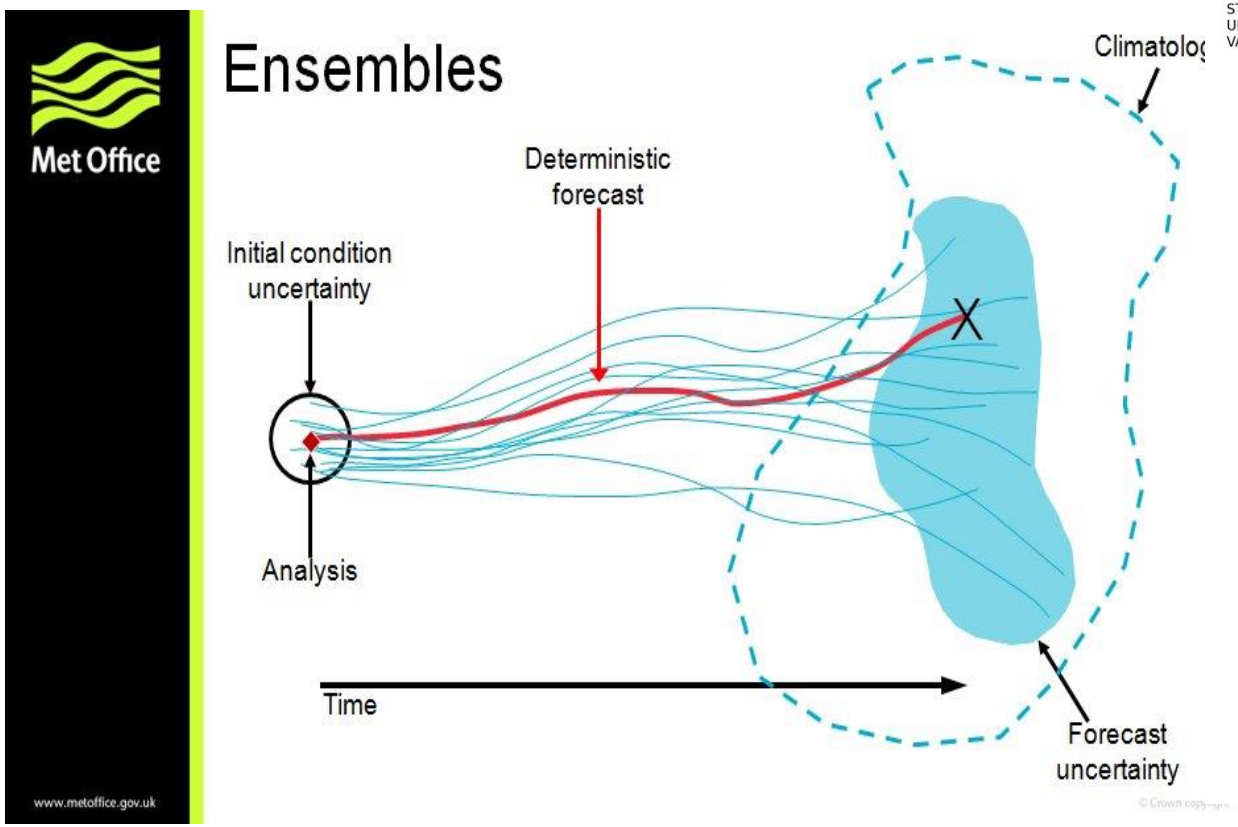
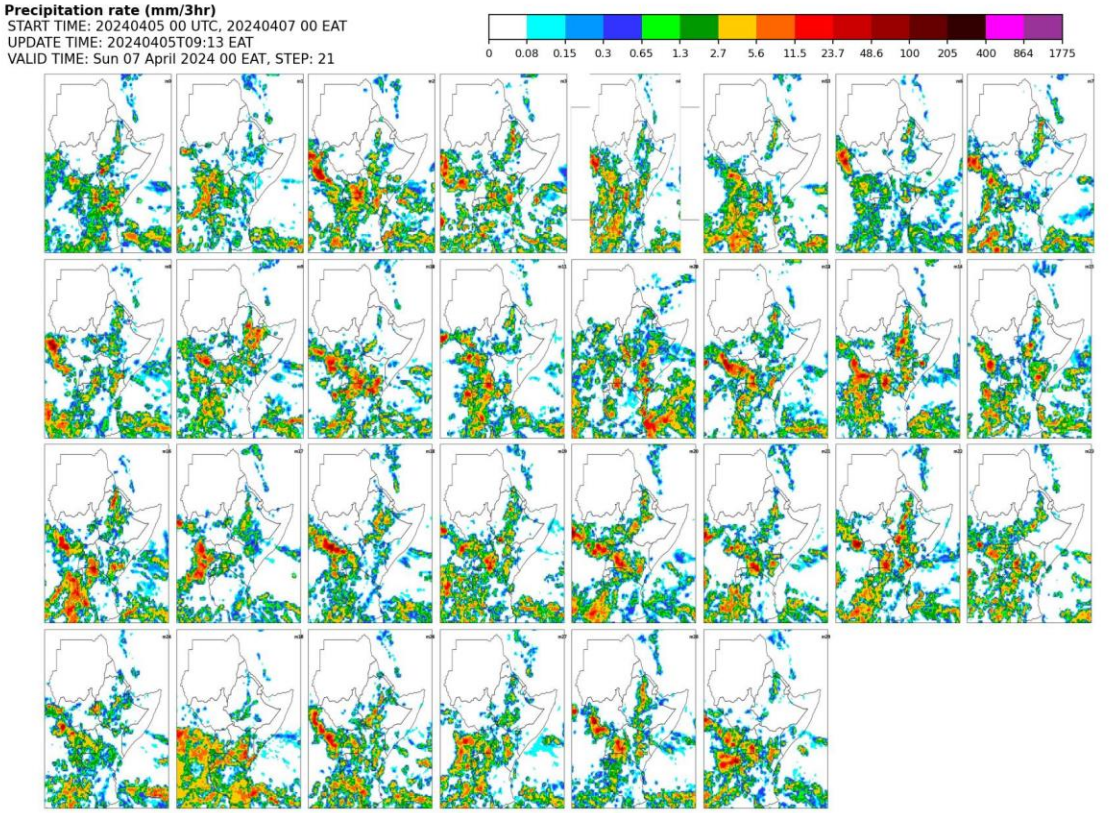
Ensemble Prediction System





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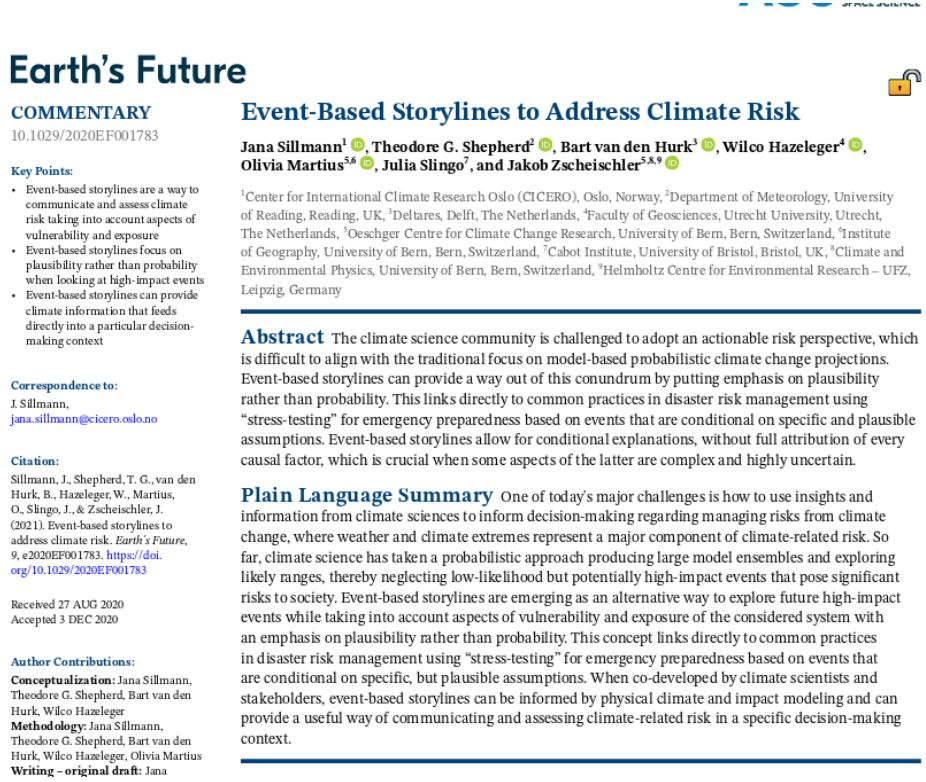
Event Based Storylines

"A physically self-consistent unfolding of past events, or of plausible future events or pathways"

- Event-based climate storylines are narrative reconstructions of historical disaster events using ensemble prediction system members as counterfactuals to generate multiple plausible scenarios, which when combined with hazard modeling, impact estimation, and streamlined data access create evidence-based decision support tools for disaster risk management
- Capacity and tools development on Event-Based climate storylines helps in operationalization of Impact Based Forecasting



Earth's Future

COMMENTARY

10.1029/2020EF001783

Key Points:

- Event-based storylines are a way to communicate and assess climate risk taking into account aspects of vulnerability and exposure
- Event-based storylines focus on plausibility rather than probability when looking at high-impact events
- Event-based storylines can provide climate information that feeds directly into a particular decision-making context

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Citation:

Sillmann, J., Shepherd, T. G., van den Hurk, B., Hazeleger, W., Martius, O., Slingo, J., & Zscheischler, J. (2021). Event-based storylines to address climate risk. *Earth's Future*, 9, e2020EF001783. https://doi.org/10.1029/2020EF001783

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Methodology: Jana Sillmann, Theodore G. Shepherd, Bart van den Hurk, Wilco Hazeleger, Olivia Martius

Writing – original draft: Jana

Event-Based Storylines to Address Climate Risk

Jana Sillmann[1], Theodore G. Shepherd[2], Bart van den Hurk[3], Wilco Hazeleger[4], Olivia Martius[5,6], Julia Slingo[7], and Jakob Zscheischler[5,8,9]

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Abstract The climate science community is challenged to adopt an actionable risk perspective, which is difficult to align with the traditional focus on model-based probabilistic climate change projections. Event-based storylines can provide a way out of this conundrum by putting emphasis on plausibility rather than probability. This links directly to common practices in disaster risk management using "stress-testing" for emergency preparedness based on events that are conditional on specific and plausible assumptions. Event-based storylines allow for conditional explanations, without full attribution of every causal factor, which is crucial when some aspects of the latter are complex and highly uncertain.

Plain Language Summary One of today's major challenges is how to use insights and information from climate sciences to inform decision-making regarding managing risks from climate change, where weather and climate extremes represent a major component of climate-related risk. So far, climate science has taken a probabilistic approach producing large model ensembles and exploring likely ranges, thereby neglecting low-likelihood but potentially high-impact events that pose significant risks to society. Event-based storylines are emerging as an alternative way to explore future high-impact events while taking into account aspects of vulnerability and exposure of the considered system with an emphasis on plausibility rather than probability. This concept links directly to common practices in disaster risk management using "stress-testing" for emergency preparedness based on events that are conditional on specific, but plausible assumptions. When co-developed by climate scientists and stakeholders, event-based storylines can be informed by physical climate and impact modeling and can provide a useful way of communicating and assessing climate-related risk in a specific decision-making context.

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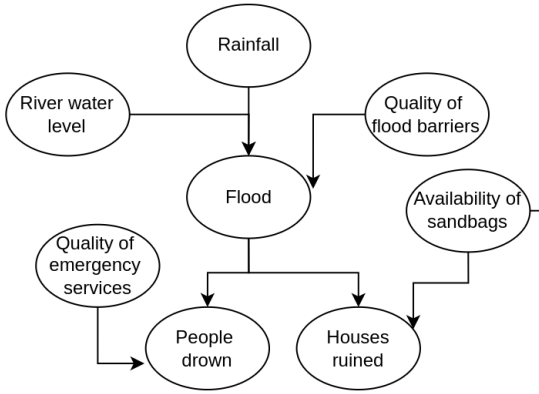
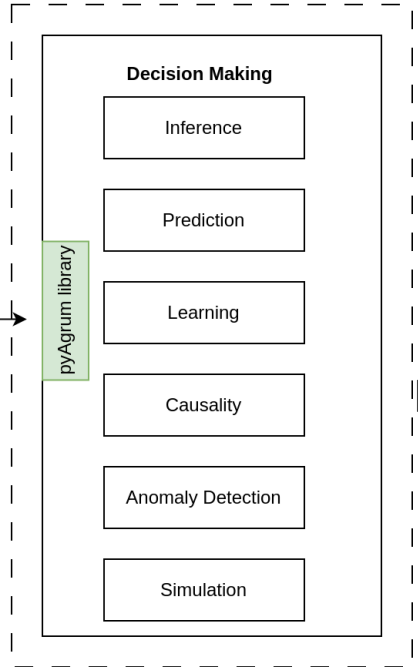
Bayesian Networks

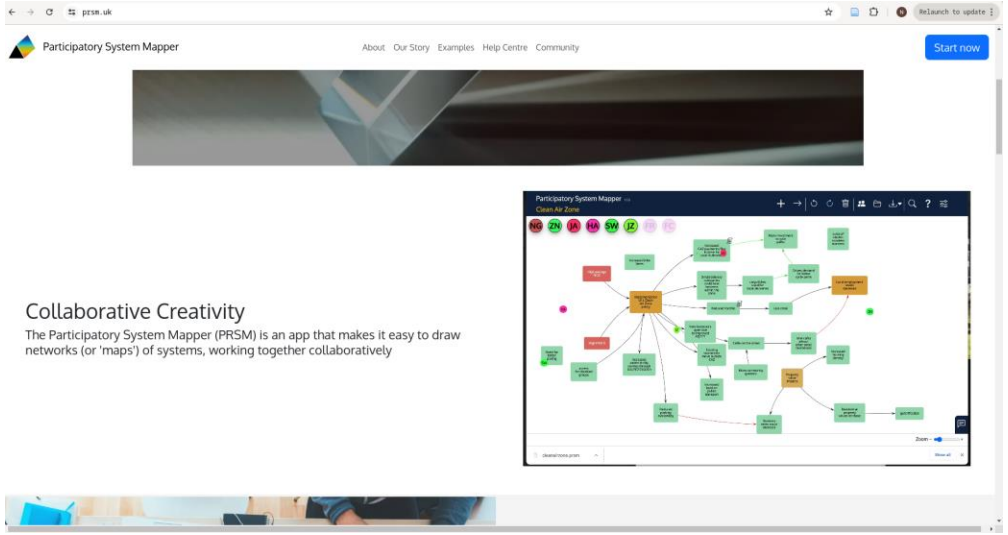




https://github.com/icpac-igad/bn-ibf

Co-Production – Story maps

- Documented hazard for the storymaps creation, the co-production is designed as a recollection, validation, and optimization exercise for the generated storymaps.
- Risk documentation in simplified form and participatory system mapper to knowledge representation

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ELSEVIER

Participatory development of storymaps to visualize the spatiotemporal dynamics and impacts of extreme flood events for disaster preparedness

Lukas Munz [a,b,c,*], Martina Kauzlaric [a,b,c], Markus Mosimann [a,b,c], Anna Fehlmann [b,d], Olivia Martius [a,b,c], Andreas Paul Zischg [a,b,c]

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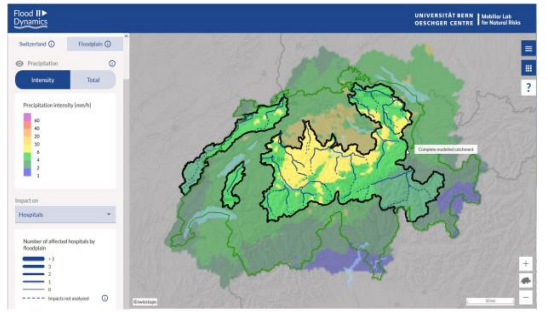
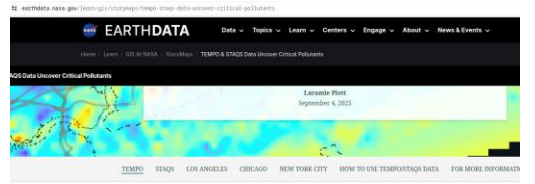
ARTICLE INFO

Keywords:
Storyline
Co-development
Extreme precipitation
Flood
Flood impact
Risk awareness

ABSTRACT

Floods are one of the costliest natural hazards in Switzerland and worldwide. Therefore, society is confronted with questions about protecting people and assets from flood risks. Key instruments are protective measures, land use regulations, spatial planning, and the interventions by civil protection units if flood magnitudes exceed the protection standards. Both prevention and preparedness require risk awareness from professionals, politicians, and the public. Risk awareness is generally high after an event and low after a period without major events. However, the rarity of extreme flood events limits learning from flood events. The training of intervention forces who should manage flood events with magnitudes beyond hitherto observed flood events requires a





By providing clean air, reflecting harmful radiation, and retaining the heat of the Sun, the atmosphere works around the clock in order to keep life as we know it moving forward. While it is a robust system, it is highly dynamic and constantly changing by the second. Sometimes, these changes aren't always for the best. For instance, gases such as Nitrogen Dioxide (NO_2) and Formaldehyde (HCHO) can negatively impact air quality and atmospheric health, creating a host of issues including an increase of respiratory illness, creation of acid rain, and the significant decrease of visibility. Just 0.1 part per million (ppm) of HCHO in the breathable atmosphere can cause nasal/eye irritation, decreased short term memory, and an increased risk of asthma.

Identifying these pollutant gases is critical to determining healthy air quality levels of a given area, but it poses a unique challenge. NO2 and HCHO can form and be broken down in a matter of hours, which makes them difficult to identify at any given time. The TEMPO

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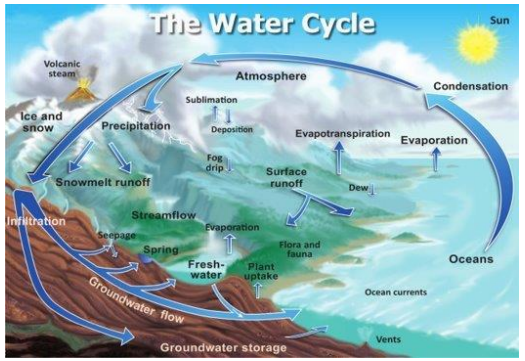
Hazard modeling – impact estimation



- Carried out using ensemble weather reanalysis and hindcast data
- Gridded rainfall data as forcing input for parsimonious hydrologic (wflow.jl) and hydrodynamic (RIM2D-flood) models covering flood and drought event
- The impact of the hazard model output will be assessed using the catastrophic modeling tool CLIMADA
- Generate factual and counterfactual storylines of the events based on output of hazard and impact model output
- This exercise represents the infusion of top-down objective knowledge into risk assessments identifying impact pathway for the complex risk event through modeling

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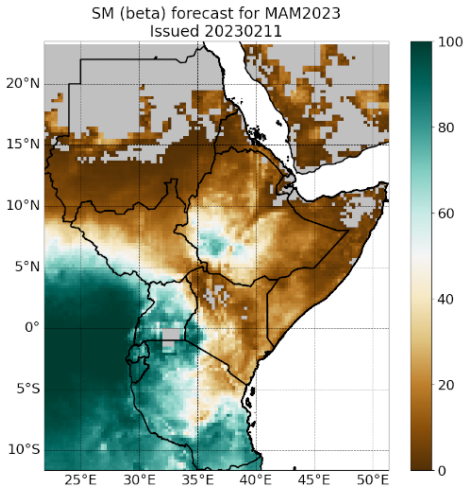
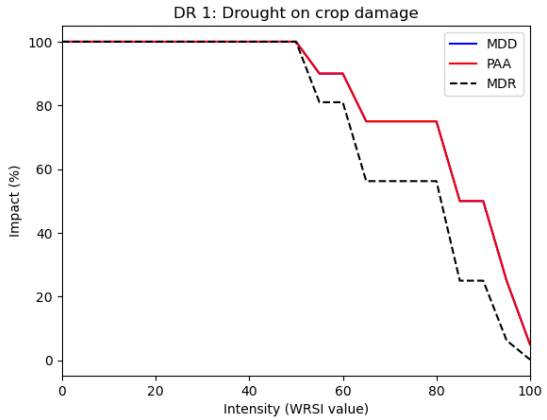
Impact Model workflow



TAMSAT ALERT API

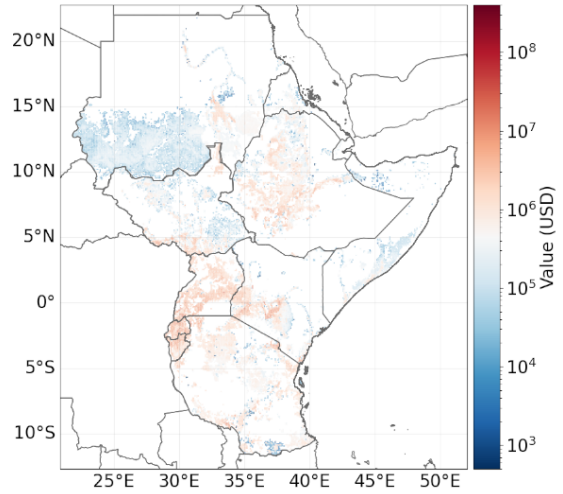
Hazard forecast, MAM 2023 Forecast SPI

+



Impact Function

+



Exposure Data

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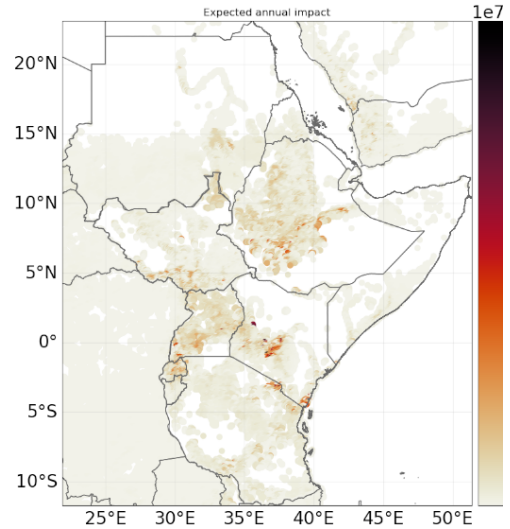

Impact Model/Forecast

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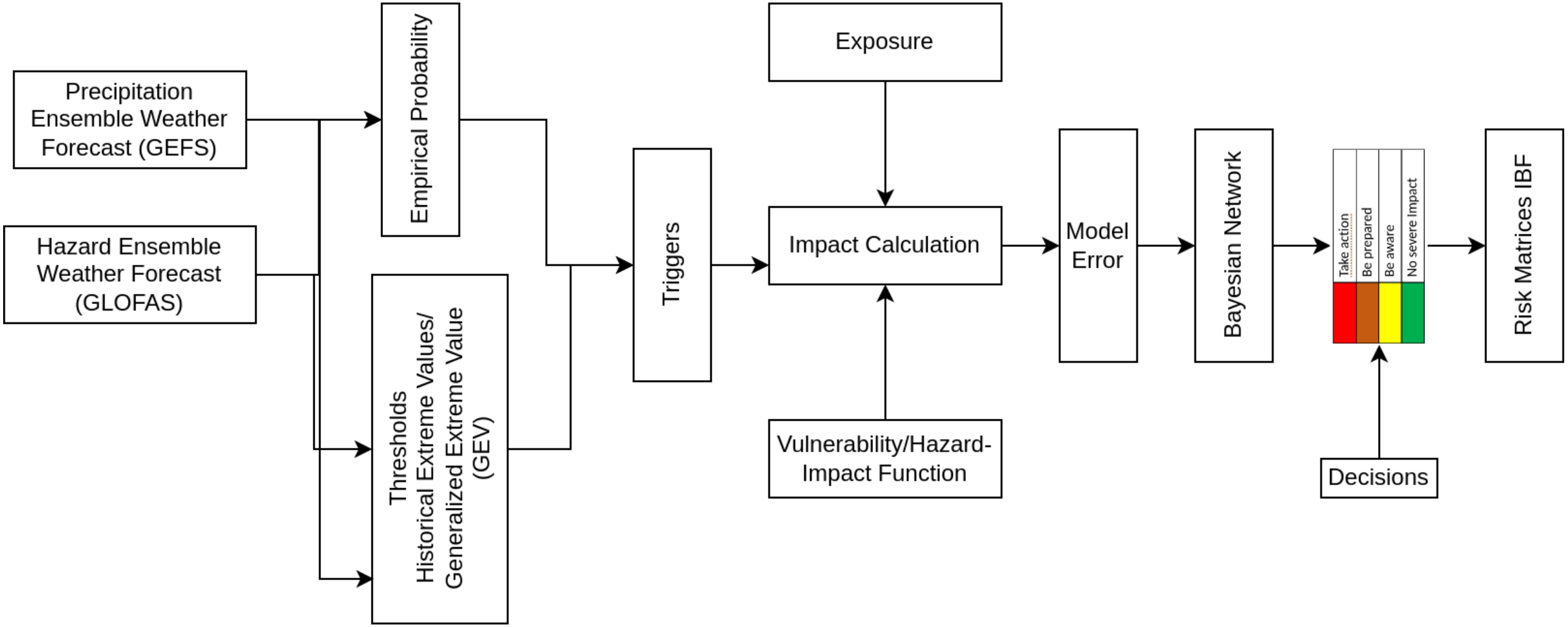
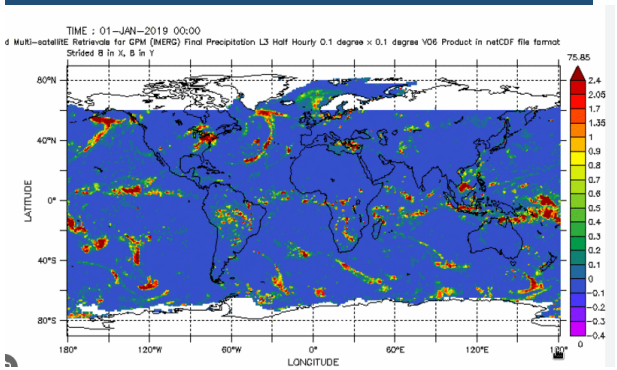
Operationalizing IBF



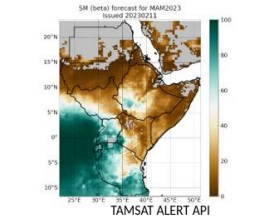
Flood IBF Outlook Bulletin

Recent observations

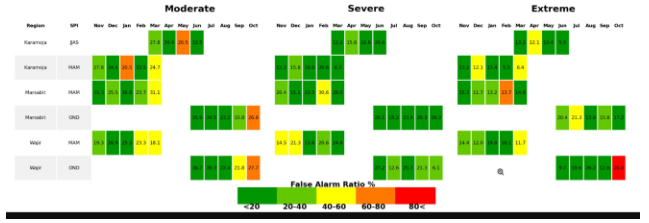


In-site observation, IMERG Satellite observations

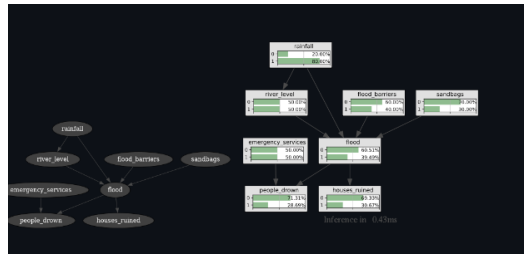
Hazard model



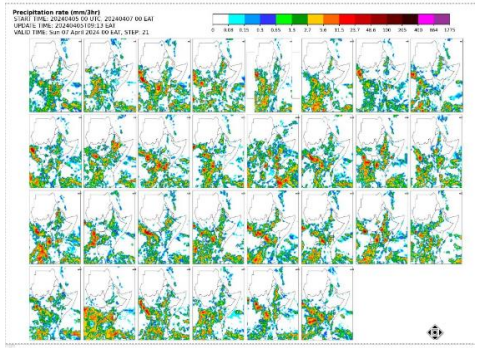
Forecast verification



Quantitative Risk and Reliability Analysis – Bayesian Network

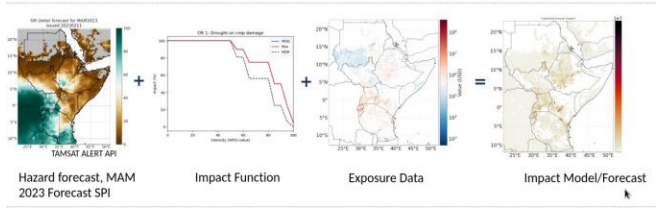


EPS forecast

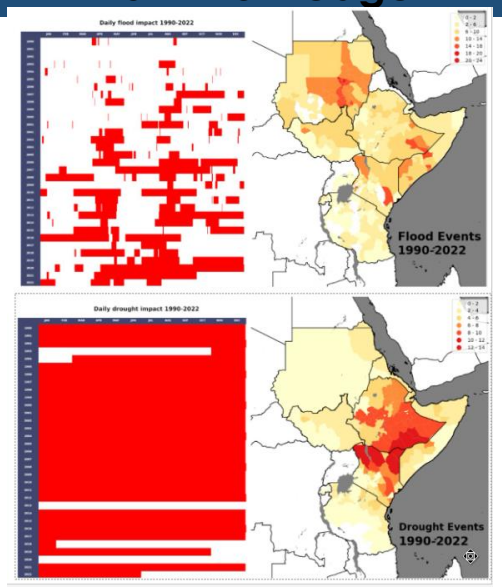


Thresholds and Triggers

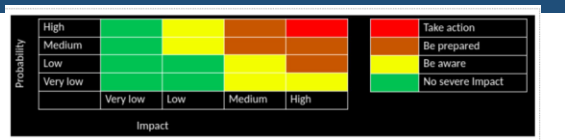
Impact Model



Risk Knowledge



IBF risk map



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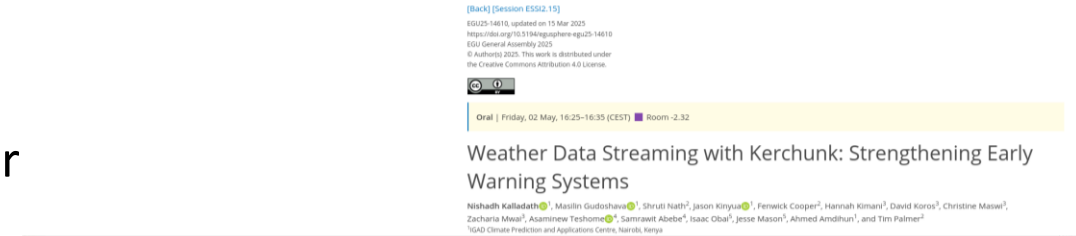
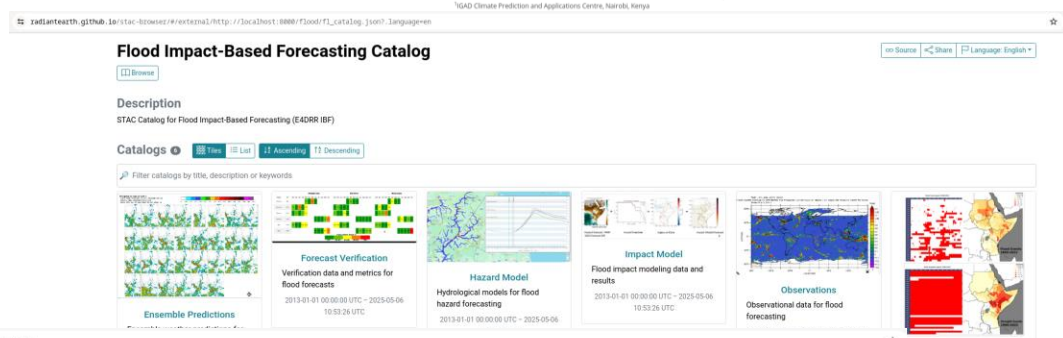
Updates

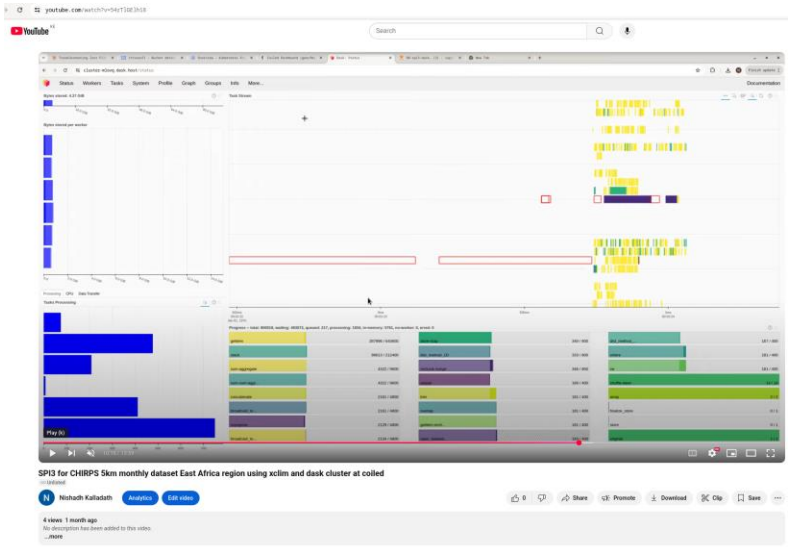
- WP1.1, Hazard modeling with SPI for drought and hydrological model for flood and flood watch system - STAC API, Coiled-K8s WPS
- WP1.2 and 1.3, storylines events selected and development on storymaps and Bayesian Networks
- WP2.1 Method development on AA pilot area validation complete and scaling for region ongoing
- WP2.3 Ongoing work on data pipelines for operational setup
- WP3 Training on AA Karamoja Drought triggers

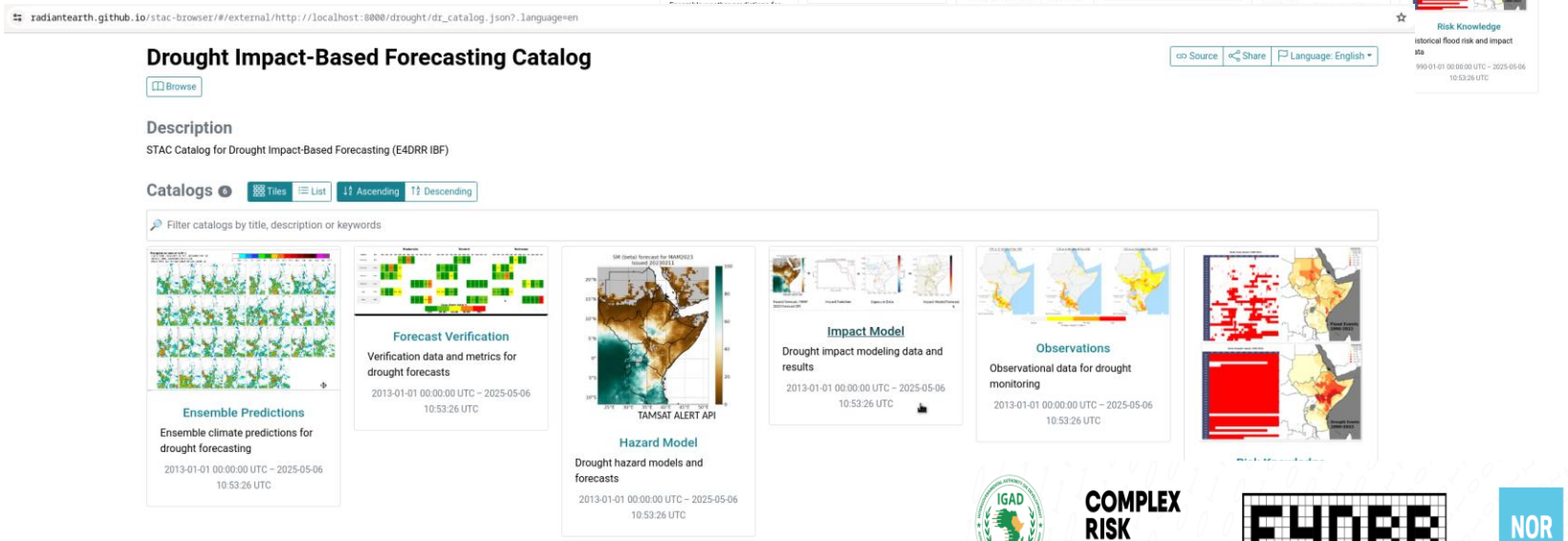
WP1.1 Establish EPS utilization, Hazard-Impact Modelling for the Region

- Analysis Ready Cloud Optimized Dataset and Kerchunk for ARCO generation of EPS
- STAC API to wrap the ARCO dataset and IBF inputs
- Coiled cloud compute for WPS cloud native operations, expanding it with Kubernets
- SPI and flood model in Coiled and cloud compute









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Work package 1 Organize and implement cost-effective programming routines for Ensemble Prediction System use

- Faster processing of hazard information – Rainfall threshold exceedance empirical probability from GEFS 30 members in 5-10 minutes
- Demonstrating the validity of a win–win–win solution among global weather forecasters, open data repositories, and end users.

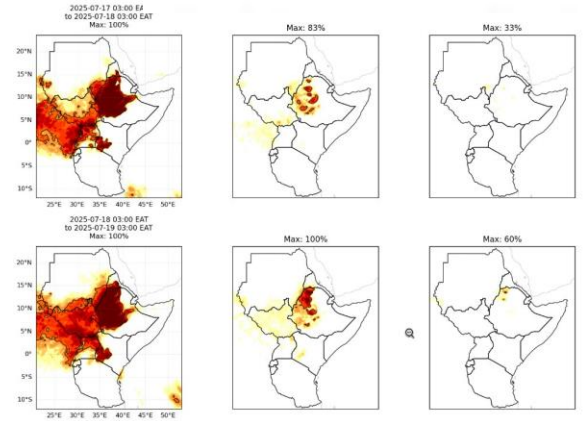
Download: Current Method

Downloading involves transferring an entire file from a server to a local device before it can be accessed or used.

Data streaming: Kerchunk Method

YouTube

NETFLIX



NOAA/ECMWF

4x24/7 - grib output

AWS Data Store

~1 TB per day, petabytes data storage

User

Instead of download/copying - Datastream!

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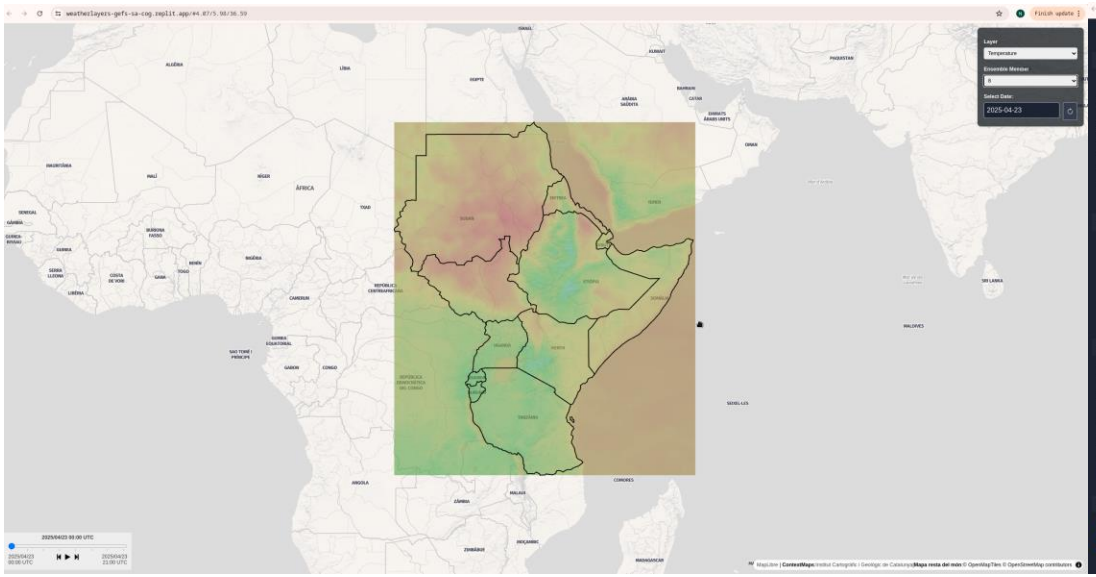
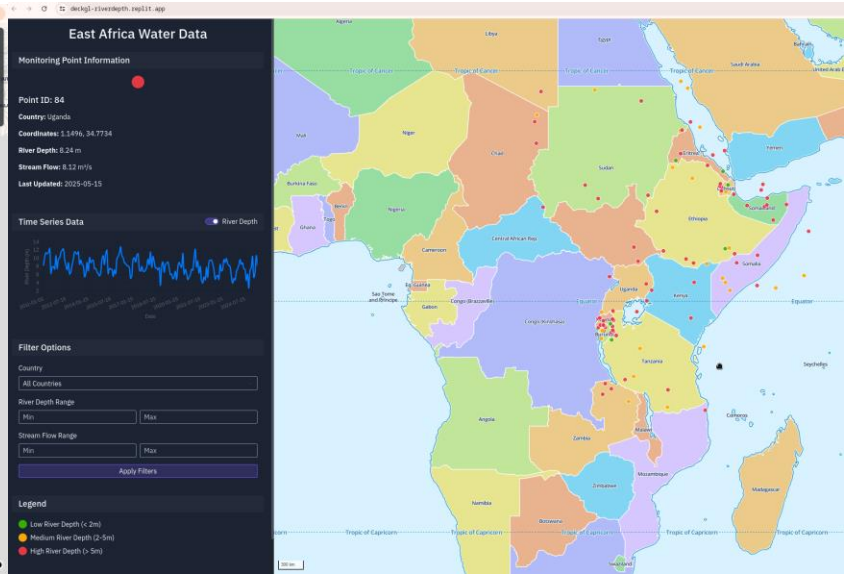
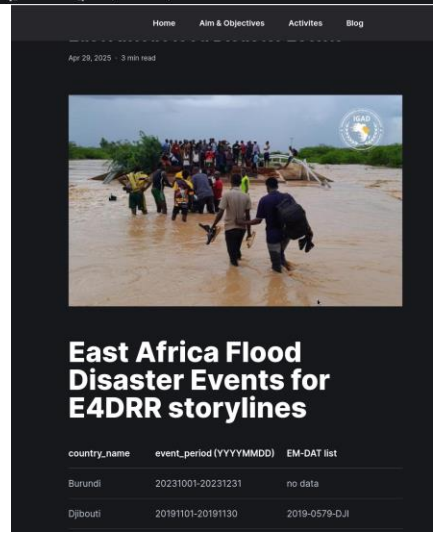
WP1.2 Implement Co-development Method for Event-Based Climate Storylines
WP1.3 Consolidate Composite Dataset and Storylines into Story Maps Linked with EAHW

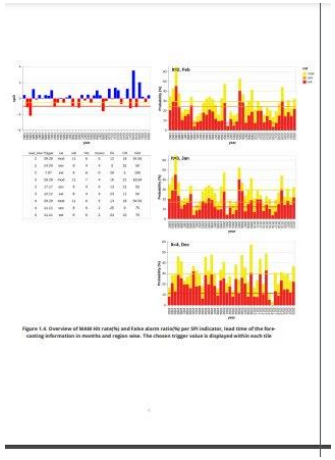
- Storyline events for drought and flood selected
- Bayesian networks implementation and East Africa Flood watch system development started through hired consultants.
- WebGL based application development and exploring tools such as eoAPI and Titiler for storymaps
- Analysis-ready cloud-optimized datasets and STAC API usage as paradigm for cloud-native and web-based GIS for disaster risk assessment. First round of discussion complete with the Development Seed team working on impact catalogue as STAC API from Montandon crisis database by IFRCGo and.







WP2.1 Establish an Analysis and Forecast Validation Facility Utilizing Storylines Datasets and Processes for Anticipatory Action



- ARCO dataset based routine for forecast verification using xarray and dask
- Method developed for scaling to the region
- Ongoing development on region wise Admin1 threhsold calculation for flood and drought

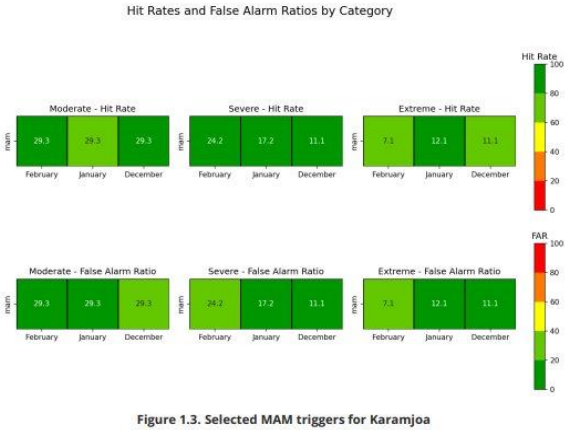


Figure 1.3. Selected MAM triggers for Karamjoa

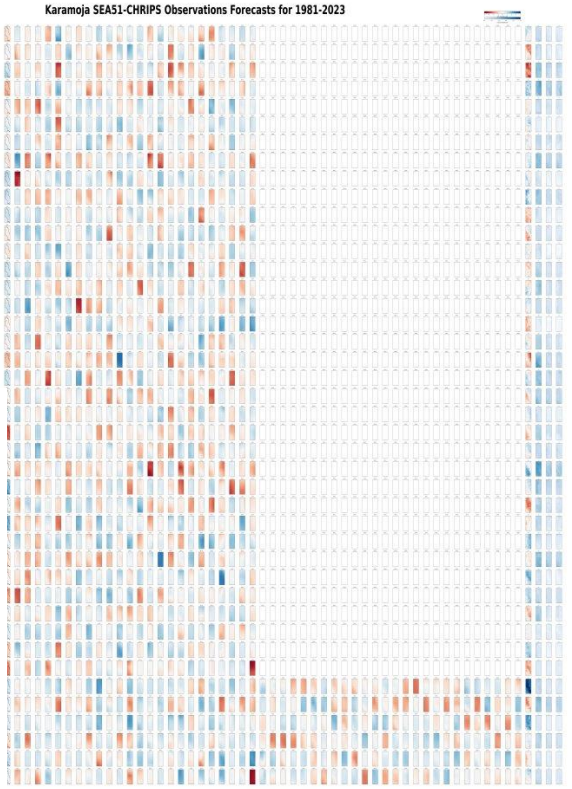
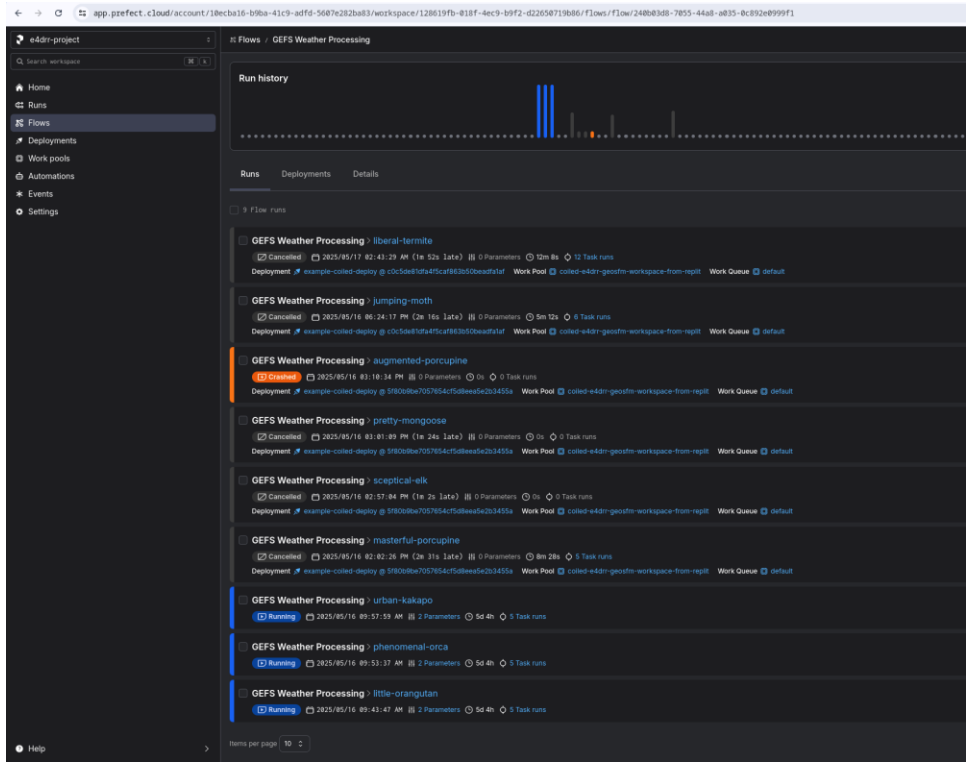
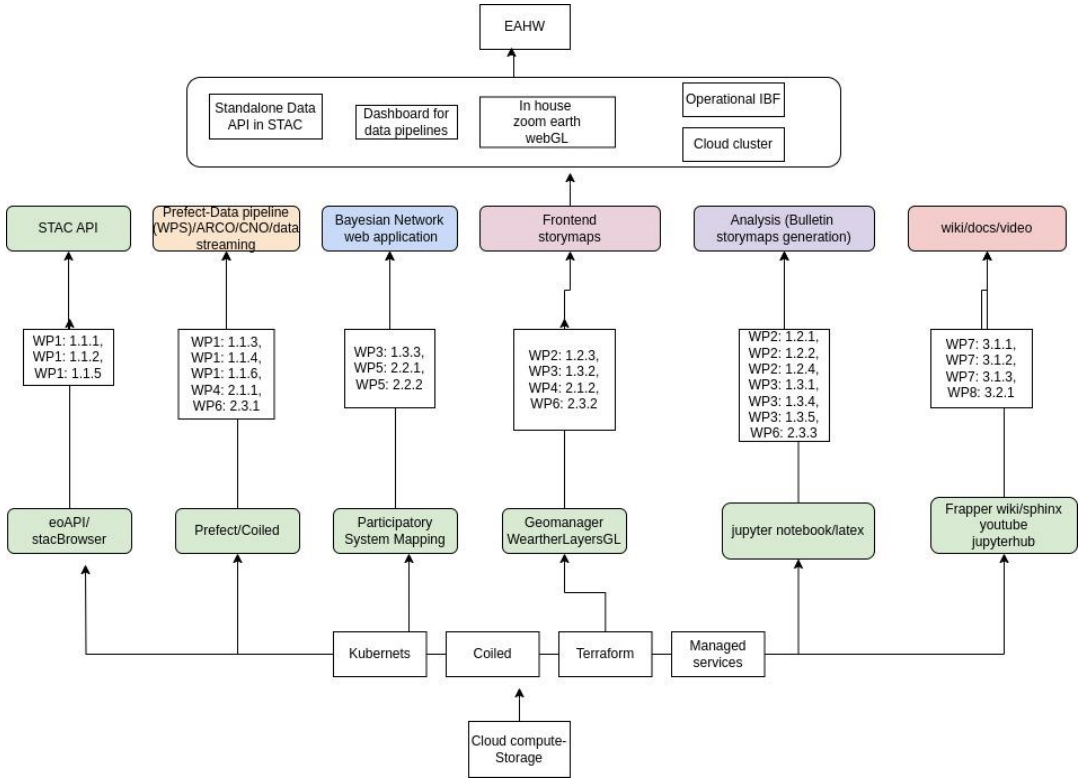


Figure 1.5. Time series map plot of MAM for Karamoja region for the lead time 3

WP2.3 Operationalize EPS IBF with Hazard and Impact Modelling for the Region

- Prefect data pipelines and workflow management system for operational IBF
- Tech stack design complete and based on STAC API

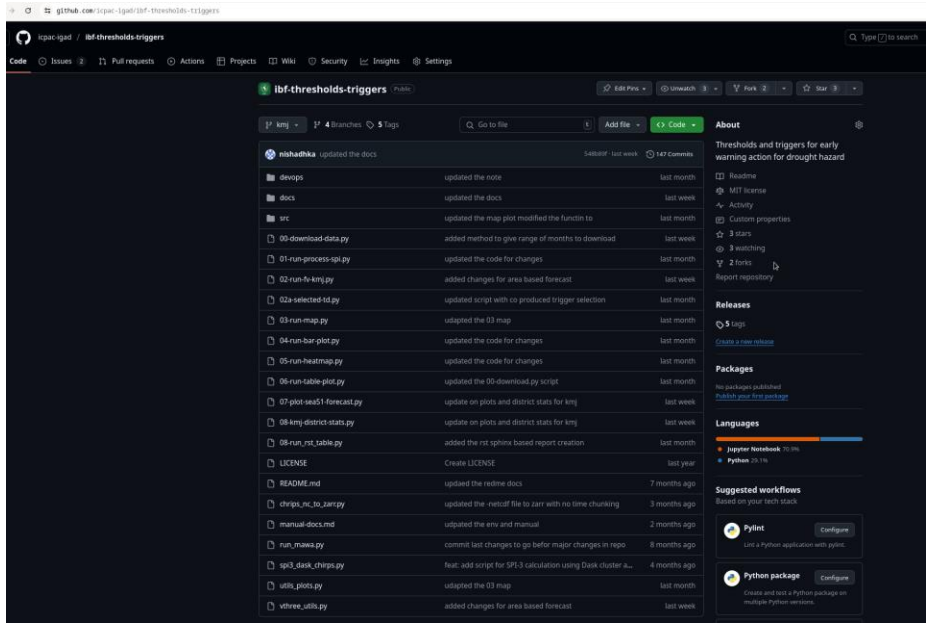




WP3 Capacity Development

- Training conducted on AA on forecast verification, trigger selection and operational SPI calculation
- Training documents, videos and open source code base

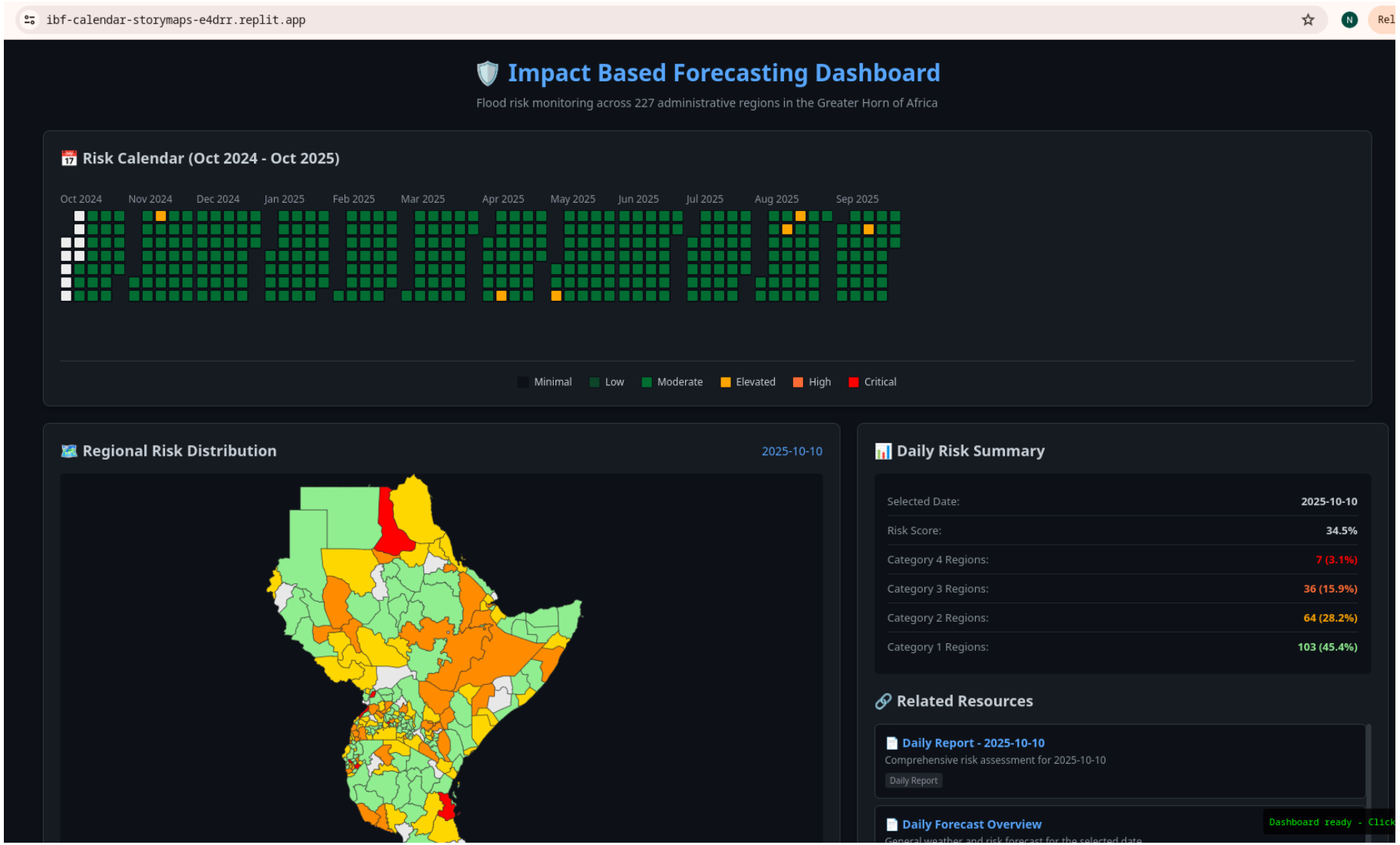
May 15, 2025



IBF as a continus risk assessment and monitoring tool

- **Risk-Informed Decisions:** Impact-Based Forecasting and Anticipatory Action jointly enable proactive, risk-informed decisions by translating forecast data into actionable early warnings.
- **Threshold-Based Continuous Risk Assessment and Monitoring:** Ensemble forecasts are continuously assessed against observation-derived extreme value thresholds to detect potential exceedances and trigger anticipatory actions.
- **Forecast-to-Impact Modeling:** Hazard models and impact functions—grounded in vulnerability, exposure, and socio-economic assessments—translate forecasted extremes into expected sectoral impacts, guiding timely and targeted anticipatory measures.
- **Learning from History:** Historical disaster impact catalogs strengthen model calibration and communication by connecting past extremes to their realized consequences, enhanced by tools such as event based storylines

Demo on IBF -


ibf-calendar-storymaps-e4drr.replit.app
Impact Based Forecasting Dashboard
Flood risk monitoring across 227 administrative regions in the Greater Horn of Africa
Risk Calendar (Oct 2024 - Oct 2025)
Oct 2024
Nov 2024
Dec 2024
Jan 2025
Feb 2025
Mar 2025
Apr 2025
May 2025
Jun 2025
Jul 2025
Aug 2025
Sep 2025
Minimal
Low
Moderate
Elevated
High
Critical
Regional Risk Distribution
2025-10-10
Daily Risk Summary
Selected Date: 2025-10-10
Risk Score: 34.5%
Category 4 Regions: 7 (3.1%)
Category 3 Regions: 36 (15.9%)
Category 2 Regions: 64 (28.2%)
Category 1 Regions: 103 (45.4%)
Related Resources
Daily Report - 2025-10-10
Comprehensive risk assessment for 2025-10-10
Daily Report
Daily Forecast Overview
Dashboard ready - Click

Summary

- Project Background
- IBF Concepts
- IBF as a Continuous Risk Assessment and Monitoring tool

Thank you

COMPLEX
RISK
ANALYTICS
Fund

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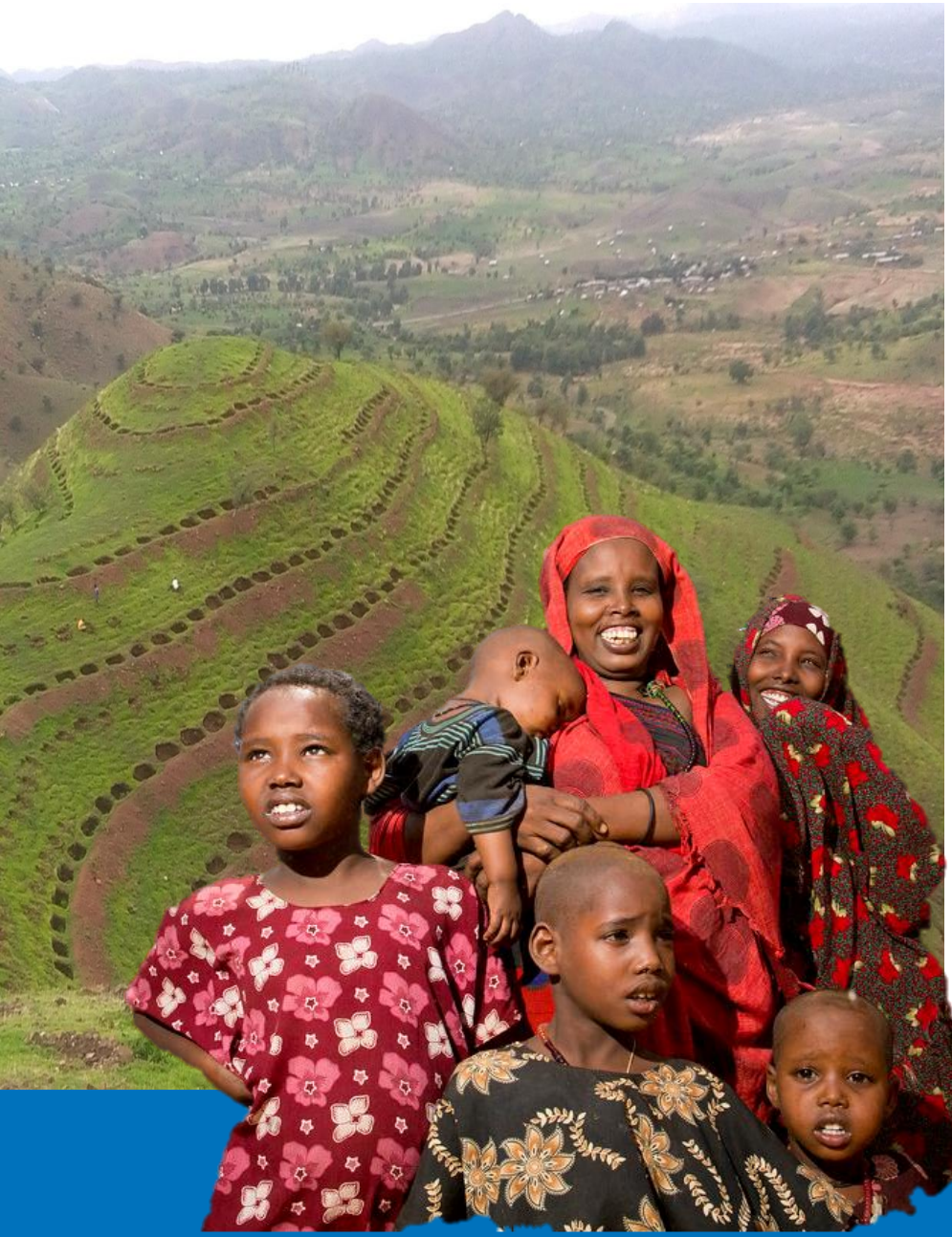
Refugees and Returnees Service



Initiatives for Building Climate-Resilient Communities in Ethiopia's Refugee-Hosting Areas:

An overview of the current NRM development

Climate and Displacement Workshop:

IGAD CPAC, Nairobi, Kenya,
4-5 November 2025

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Global Displacement Trend

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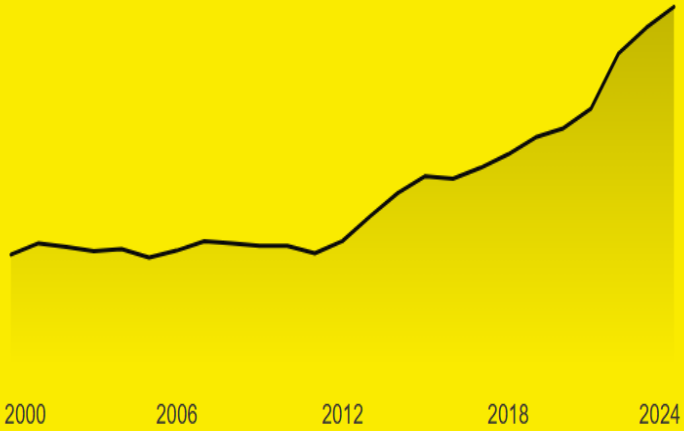
Refugees and Returnees Service

123.2 MILLION

Forcibly displaced people worldwide

at end-2024 as a result of persecution, conflict, violence, human rights violations or events seriously disturbing public order.



73.5 MILLION

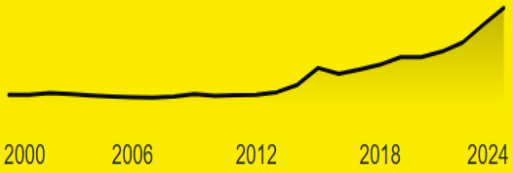
are internally displaced people (Source: IDMC)

36.8 MILLION

are refugees

8.4 MILLION

are asylum-seekers



5.9 MILLION

are other people in need of international protection

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UNHCR
The UN Refugee Agency

REGIONAL BUREAU FOR THE EAST, HORN OF AFRICA AND THE GREAT LAKES

OVERVIEW - FORCIBLY DISPLACED AND STATELESS PERSONS

as of 30-Jun-2025

EHAGL REGION

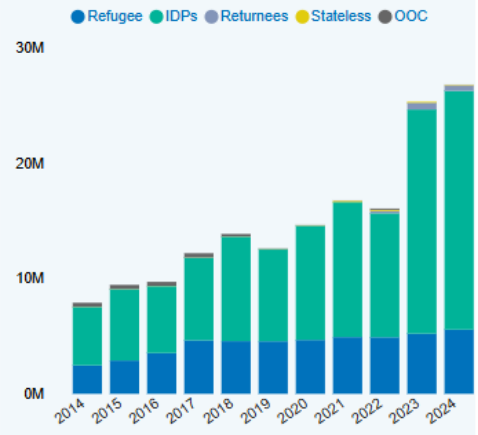
23.9M
PEOPLE WITH AND FOR WHOM UNHCR WORKS

5.9M	17.6M	376K
Refugees and Asylum seekers	Internally Displaced Persons	Refugee Returns in 2025

53K	25K
Stateless Persons**	Others of Concern**

***Stateless persons and Others of Concern population figures coming from Annual Statistical Report 2024*

Population Trends | 2014 - 2024



IGAD REGION

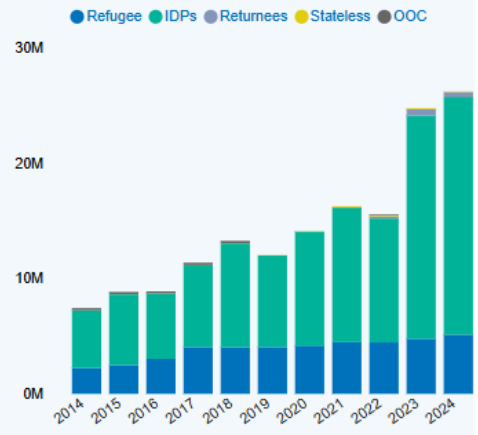
23.3M
PEOPLE WITH AND FOR WHOM UNHCR WORKS

5.4M	17.5M	368K
Refugees and Asylum seekers	Internally Displaced Persons	Refugee Returns in 2025

38K	4K
Stateless Persons**	Others of Concern**

***Stateless persons and Others of Concern population figures coming from Annual Statistical Report 2024*

Population Trends | 2014 - 2024



EAC REGION

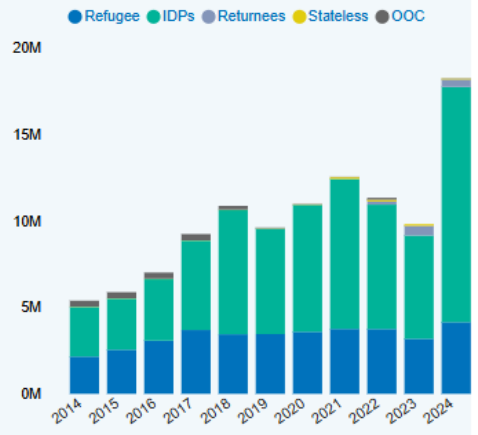
16.1M
PEOPLE WITH AND FOR WHOM UNHCR WORKS

4.4M	11.5M	127K
Refugees and Asylum seekers	Internally Displaced Persons	Refugee Returns in 2025

53K	21K
Stateless Persons**	Others of Concern**

***Stateless persons and Others of Concern population figures coming from Annual Statistical Report 2024*

Population Trends | 2014 - 2024



Source: Government; UNHCR; IOM

Hover your mouse to the respective region and click to go to the resepctive dashboard

Feedback: dimaehagl@unhcr.org

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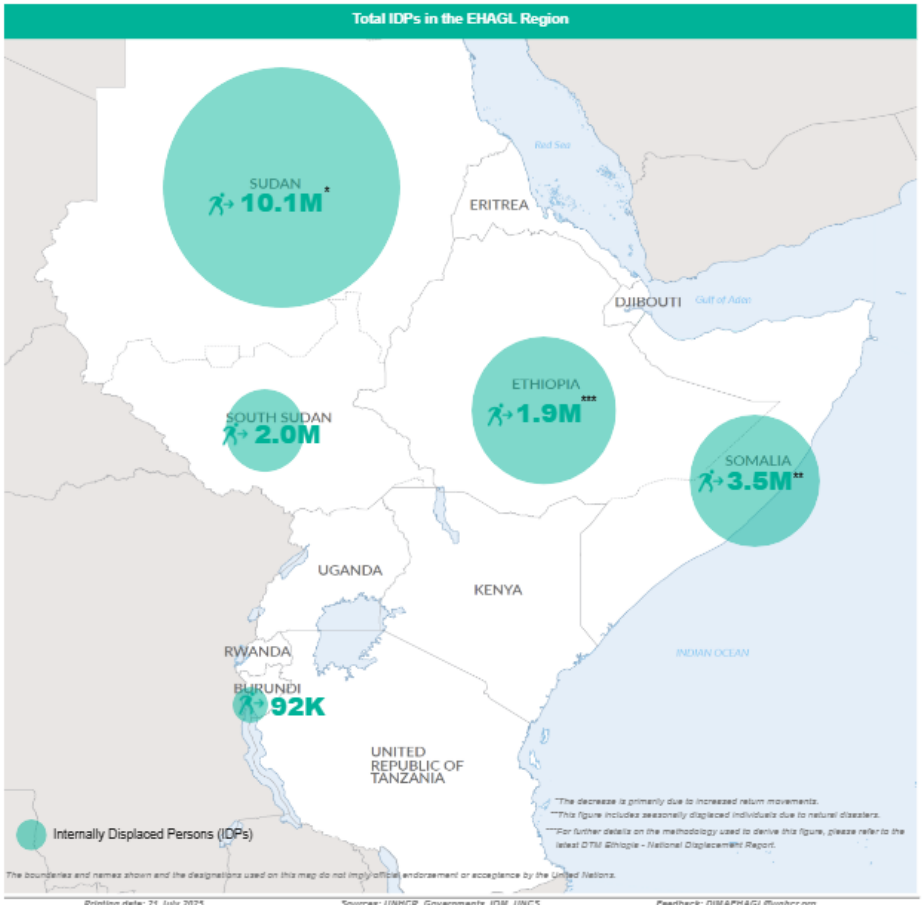
REGIONAL BUREAU FOR EAST HORN OF AFRICA AND GREAT LA
Internally Displaced Persons (II
as of 30-Ju

17.6M
Total IDPs in the EHAGL Region

16.3M
Conflict induced IDPs

1.3M
Natural disaster IDPs

IDPs by host country



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Back to Home

REGIONAL BUREAU FOR EAST HORN OF AFRICA AND GREAT LAKES

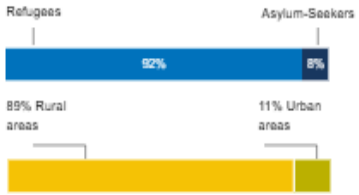
Refugees and asylum seekers by country of asylum

as of 30-Jun-25

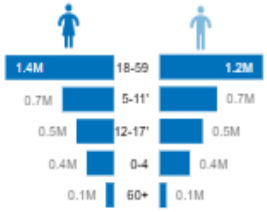
5.9M

5.4M Refugees

483K Asylum- Seekers

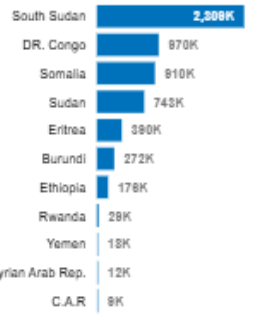


By Age and Gender

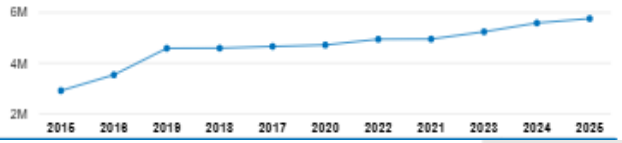


Refugees by Country of Asylum

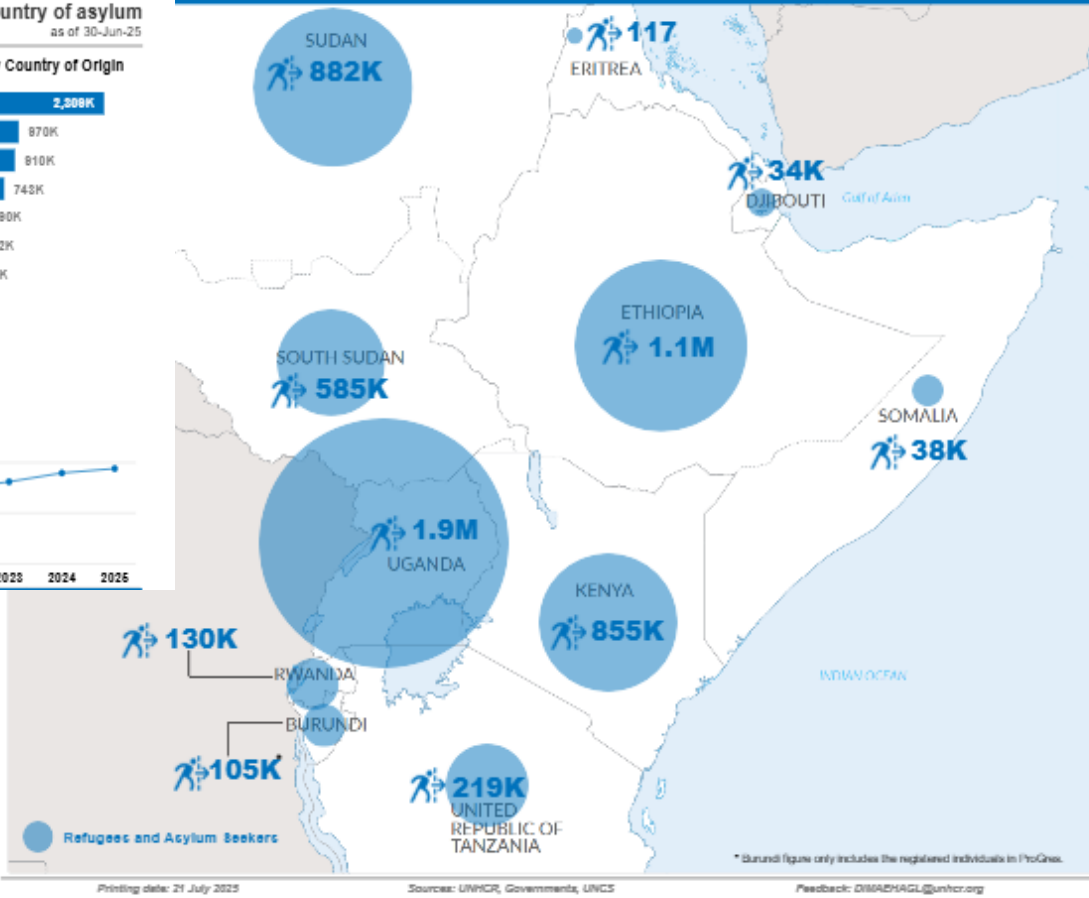
Refugees by Country of Origin



Annual Trend of Displacament | 2015- 2025



Population of Refugees and Asylum-Seekers by Countries of Asylum



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Overview of Displacement Dynamics

- Ethiopia has a long **history** of generously **hosting refugees**.
- Home to **+ 1.1 million refugees** and asylum seekers
- **26** established camps and sites
- 15% of refugees live in **urban and settlement** areas
- Refugees live in camps for **15 years** on average
- **80%** are women and children, often residing in **fragile, climate-vulnerable** border zones.
- Border regions face **limited infrastructure, weak services, and exposure to droughts, floods, and environmental degradation**.
- Displacement pressures are compounded by **conflicts and climate shocks** across the Horn of Africa.

Challenges in Refugee-Hosting Areas

- **Environmental degradation** due to deforestation, biomass dependence, and land pressure.
- **Limited access** to energy, water, health, education, and livelihood opportunities.
- **Fragile social cohesion** arising from competition over scarce resources.
- **Fragmented service delivery** due to parallel humanitarian systems.
- **Declining external aid** and funding sustainability risks.
- **Climate shocks** increasing vulnerability and poverty traps in border regions.

Policy and Institutional Framework

Ethiopia's Progressive Policy Milestones:

- **Comprehensive Refugee Response Framework (CRRF)** – 2017
- **Global Compact on Refugees (GCR)** – 2018
- **Refugee Proclamation No. 1110/2019** – granting rights to education, work, and mobility
- **Global Refugee Forum (GRF) Pledges – 2019 & 2023**
- **Makatet Roadmap** – A government-led, inclusive framework for sustainable refugee response and resilience

The Global Compact on Refugees (GCR)

- Adopted: December 2018 by UN General Assembly

Key Principles:

- Burden and responsibility-sharing
- Strengthening international solidarity
- Non-binding but represents political will

Objectives

1. Easing Pressure on Host Countries
2. Enhancing Refugee Self-Reliance
3. Expanding Third-Country Solutions
4. Supporting Conditions for Safe, Voluntary Repatriation

Government of Ethiopia Pledges

Climate Action

Private Sector Engagement

Human Settlement

Access to Land

Inclusion into National Systems

Connectivity & Documentation

Ethiopia's INCLUSION Model

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Vision

All refugees and host communities live **peacefully**, attain **self-reliance**, build **resilience** and enjoy a **decent** life.

Refugees will not only receive **aid** but also actively shape their **destinies**, drive **innovation**, and enrich the **cultural** and **economic** landscape of Ethiopia.

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Objectives

- To enhance the **resilience** and **socio-economic inclusion** of refugees in Ethiopia
- To ensure **coherence** and **alignment** between the various laws, policy frameworks, area-based plans, and programming
- To establish an efficient **implementation** and **coordination** framework for Ethiopia's policy commitments
- To secure **support from the international community** to share the burden of inclusion of refugees into national systems.

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Guiding Principles

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Refugees and Returnees Service

Humanitarian, Development and Peace (**HDP**) Nexus	**Whole of Society** Approach	**Government Led**
Burden and **Responsibility** Sharing	**Sustainable** and **long-term** programming	**Environmental** and **Climate-Sensitive**
Context-sensitive and tailored	**Gender** mainstreaming	**Protection** Mainstreaming

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Strategic Pillars

1. Capacity and System Development

- Strengthen institutional capacity
- Improve systems including data management
- Enhance **human resources**
- Develop infrastructures such as **schools** and **health** facilities
- ugmenting **resource obilization**

This pillar has 4 high level results with 20 strategic activities

2. Environmental Protection and Climate Resilience

- Addressing household and institutional level **energy requirements**
- Biological and **physical soil and water conservation**
- Foster **sustainable development**
- Enhance refugees and hosting community **resilience**
- Mitigations and adaptations to **climate change**

This pillar has one high level result with 6 strategic activities

3. Economic Inclusion

- Increase access to **economic opportunities** (self-employment, wage employment and joint projects)
- Expand **entrepreneurship**, skills development, agricultural value chains, financial inclusion etc
- Execute refugees' **right to work** provisions under the existing legal frameworks
- Promote **private sector** engagement
- Creating an enabling environment for **housing, land and property**
- Enhance **self-reliance**

4. Protection Mainstreaming and Durable Solutions

- Ensure **centrality of protection** in the Humanitarian-Development-Peace Nexus (HDPN)
- Support **inclusion of refugees** into national protection services (child protection, GBV, access to justice including legal services, vital events registration etc)
- Promote **durable solutions** (local integration, voluntary return, and third country solutions including complementary legal pathways)

5. Access to Basic and Social Services

- Include the refugees from the start of emergencies
- Ensure refugees have access to education, health and nutrition services
- Include selected group of refugees in community-based health insurance schemes
- Ensure access to WASH Services
- Ensure access to adequate, safe and affordable housing
- Facilitate the provision of targeted humanitarian assistance
- **This pillar has one high level result with 5 strategic activities**

6. Partnerships and Coordination

- Strengthen partnership with **state** and **non-state** actors
- Establish comprehensive **governance** structures for the roadmap at all levels
- Promote **whole-of-government** approaches
- Improve **communication**, **collaboration**, and **coordination** among the relevant multi-stakeholders towards realizing the Government's vision under the Makatet roadmap

Environmental Protection & Climate Resilience (Pillar 1)

Goal: Enhance environmental sustainability and build climate resilience among refugees and host communities.

Key Actions:

- **Sustainable Energy Access:** Grid and off-grid (solar) electrification solutions.
- **Clean Cooking Solutions:** Energy-efficient stoves, briquettes, and biogas systems.
- **Reforestation & Watershed Management:** Community-based land rehabilitation and tree planting.
- **Climate Finance Mobilization:** Access carbon credits and green funds.
- **Inclusion in Nationally Determined Contributions (NDCs):** Integrating refugee settings into Ethiopia's climate targets.
- **Joint Environmental Governance:** Refugee-host collaboration on conservation and resource management.

Initiatives on Climate action

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HDP Nexus–Green Climate Fund Projects

Enhancing Climate Resilience of Displacement-Affected Communities in High Climate Risk Areas of Ethiopia

Beneficiaries: >1 million people (refugees, IDPs, host communities)
Target Areas: Regional states with high displacement and climate vulnerability – Somali Region, Gambella Region and Borenza Zone in Oromia Region

Objective

Build resilience and adaptive capacity to climate impacts among displacement-affected communities, while advancing durable solutions and reducing aid dependency.

Climate Finance Relevance

- Catalytic GCF investment in fragile humanitarian settings.
- Model for replication across fragile and crisis setting in the Africa region and globally.
- Supports Ethiopia's CRGE, NAP, NDCs, Global Refugee Forum and IDP Solutions national commitments.

Strategy, Outcomes & Impact

Approach (HDP Nexus + Ecosystem-based adaptation)

- Mainstream climate adaptation into humanitarian response.
- Integrated watershed-based and nature-based solutions.
- Gender-responsive, inclusive livelihoods & climate-resilient infrastructure.
- Strengthen local governance, institutions & community-led planning.

Strategic Outcome Areas

- **Resilience & Governance** – Early warning, DRR plans, climate-proof infrastructure, decentralized O&M.
- **Ecosystem Restoration** – Watershed management, flood control, land rehabilitation, climate-smart agriculture.
- **Livelihoods & Green Jobs** – Value chains, vocational training, eco-enterprises, climate insurance, women/youth empowerment.

Capacity Building

- Strengthen national and local authorities to integrate displaced and host communities into NDCs, NAPs, and the CRGE strategy.
- Strengthen governance and technical systems to sustain inclusive, climate-resilient planning.

Expected Impact

- Stronger institutional & community capacity for climate adaptation.
- Restored ecosystems mitigating droughts & floods.
- Resilient, low-emission livelihoods & reduced aid dependency.
- Inclusion of displaced communities in national climate/development planning.
- Replicable paradigm shift model for adaptation–displacement programming.

Artificial Intelligence Predictive Modelling for Forced Displacement

Objective. The objective of this proposal is to prepare an Artificial Intelligence, machine learning model to predict flows of forcibly displaced populations into Ethiopia from Somalia, South Sudan, Sudan and Eritrea.

- The model would be used to inform anticipatory action to ensure that resources (human, financial, material and information) are prepared and in place to support responses to forced displacement surges *before* they occur.
- This is expected to increase the efficiency of resource allocation, to strengthen preparedness and to minimize strains on host communities, reducing the potential for social tension.
- The proposal will also support the preparation of a contingency financing mechanism within the Government of Ethiopia's Development Response to Displacement Impacts Project Phase II (DRDIP-II) that can provide funds for *woredas* (districts) that receive large inflows of refugees.
- The plan is to connect the AI model to the contingency mechanism, enabling funds to be distributed to districts before inflows take place. This approach aims to improve preparedness and support development and humanitarian responses.

AI, Forced Displacement, Refugees, Anticipatory Action

Some good examples of NRM practices in Ethiopia's Refugee-Hosting Areas

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WB-DRDIP:

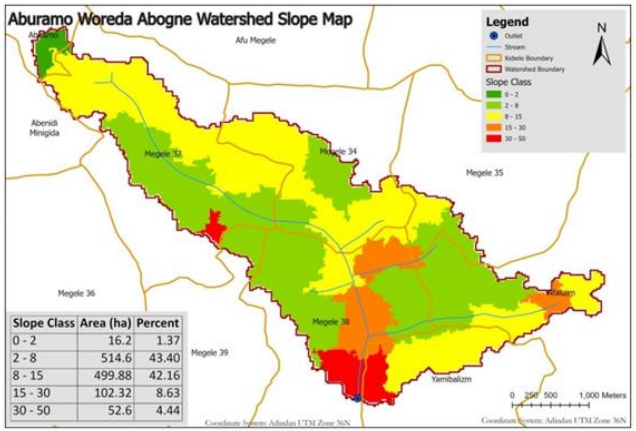
2. Sustainable Environmental Management Component

Objective

- To ensure environmental and natural resources are carefully and sustainably managed to support current and future needs and livelihoods of the project beneficiaries.
- The component will support the implementation of
  - **Integrated Natural Resource Management**
  - **Promotion of Efficient Alternative Energy Source**.

Steps followed to Implement INRM at the Watershed Level

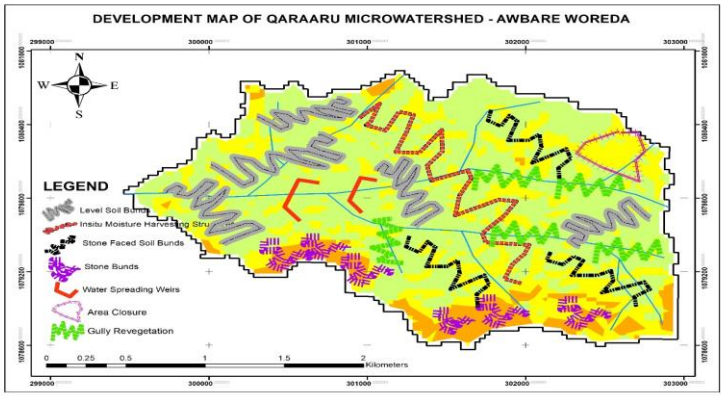
- Participatory Resource Mapping - Identify water sources, land types, degraded areas.
- Stakeholder Engagement & Capacity Building
- Watershed Management Plan Development- Aligned community goals with technical assessments
- Climate Resilience Measures Integration- Address risks from erosion, floods, etc.



Slope Class	Area (ha)	Percent
0 - 2	16.2	1.37
2 - 8	514.6	43.40
8 - 15	499.88	42.16
15 - 30	102.32	8.63
30 - 50	52.6	4.44

107 community watershed was delineated.

- Afar – 12
- Amhara – 30
- B/gumuz – 14
- Gambella – 8
- Somali – 6
- Tigray -- 37

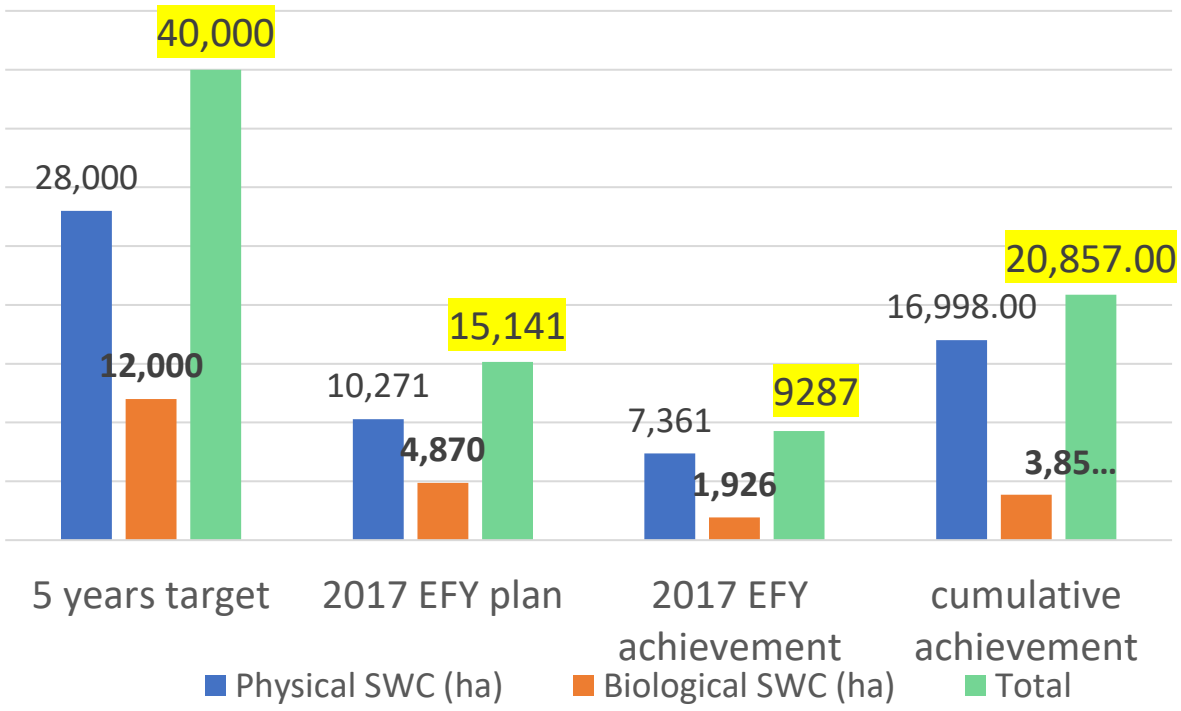


Soil & Water Conservation

Achievement

Achievement of physical and biological soil & water conservation

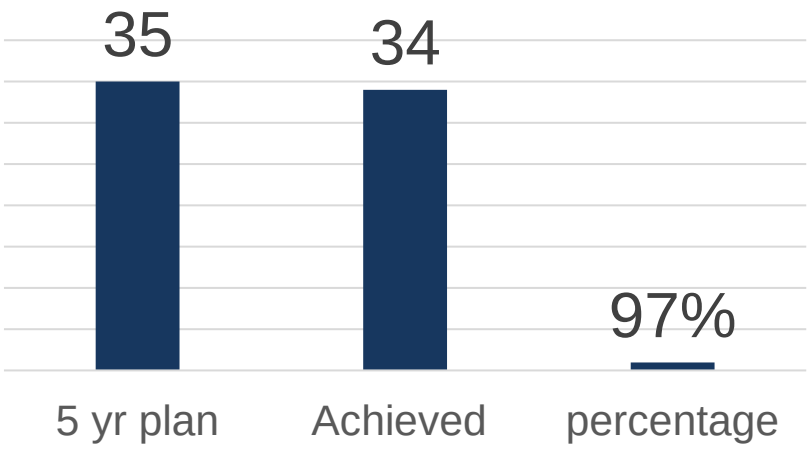
- A total of 1,631,179 persons are participated, including 545,737 females & 78,322 refugees



Number of forest nursery sites strengthened.

.

Achievement



Note

Seedling production

- 5 years targeted 11.2 million
- Achieved to date 6,219,427 (55.5%).

Nursery development

Cont'd


Latitude: 14.106025
Longitude: 38.144683
Elevation: 1552.32m
Accuracy: 2.2m
Time: 04-06-2025 01:44
Note: MaySiyeNursery2017

Practical training of community watershed committee

Training

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Sample pictures of physical SWC implementation - Tigray & B/gumuz

SWC activities
- Tigray, Gambella & Somali

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SWC practices _ Trenches for runoff harvesting

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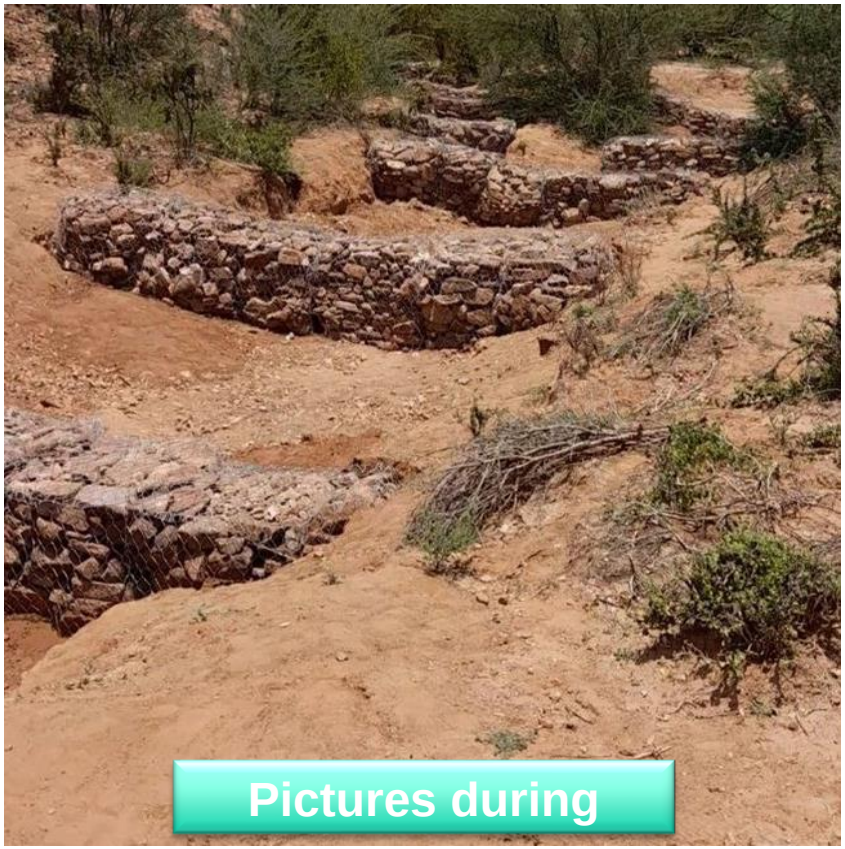
Latitude: 14°14'31"
Longitude: 38°10'37"
Elevation: 1800.68m
Accuracy: 0.9m
Time: 19-07-2024 10:50
Note: AdiDaero,AAbagi-Hindb@DRDIP2016


Pictures during


After Intervention

Rehabilitated land

Recovered plant species via area closure

Pond

Onion production using ponds

Biogas production

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Biogas production

Energy Saving stoves

Achievements and Progress

- **23,000 refugees** using **alternative cooking fuels**.
- **9,000 households** accessing **solar mini-grid electricity** in Melkadida.
- **1.7 million trees planted** for reforestation and land restoration.

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Key Insights & Recommendations

- Conflict remains dominant driver
- Climate shocks require preparedness
- Integrated policies promote resilience
- Funding gaps hinder response capacity

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