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Enhance Response to Climate Change Challenges: CENTAUR's Integrated Approach to Climate Security and Early Warning Systems

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01. Introduction

Climate change is an undeniable reality, and its effects on human lives and global security are steadily increasing. Over the past five decades, the number of natural disasters has grown **fivefold**.
Within EU's comprehensive security strategy, climate change is gaining greater recognition as a **critical factor**. Already today, environmental changes are forcing people to migrate. While migration itself is not typically viewed as a direct security threat, it is often linked to rising societal tensions and growing competition for limited resources (Schaik L., Bakker T., 2017)[1].

02. Objectives

CENTAUR (Copernicus ENhanced Tools for Anticipative Response to Climate Change in the Emergency and Security Domain) is a research and development initiative funded under the Horizon Europe programme, aimed at addressing contemporary societal challenges. The project seeks to develop and validate innovative service components within the frameworks of the **Copernicus Emergency Management Service (CEMS)** and **Support to EU External and Security Actions (SESA).** CENTAUR is a three-year project that commenced in December 2022.

05. Use cases

CENTAUR explores various use cases related to the two thematic areas:

- **Cold cases:** Well-documented crisis events from the past.
- **Hot cases:** Ongoing or upcoming events that will occur during the course of the project.

03. Domains

Urban Flood (UF)[2]

- Boost the capabilities of the existing **CEMS** urban flood detection system by identifying key indicators and tracking their performance, using EO data and downscaled city-level meteorological forecasts.
- Establish an **early warning system** that triggers alerts when predefined crisis thresholds are met.

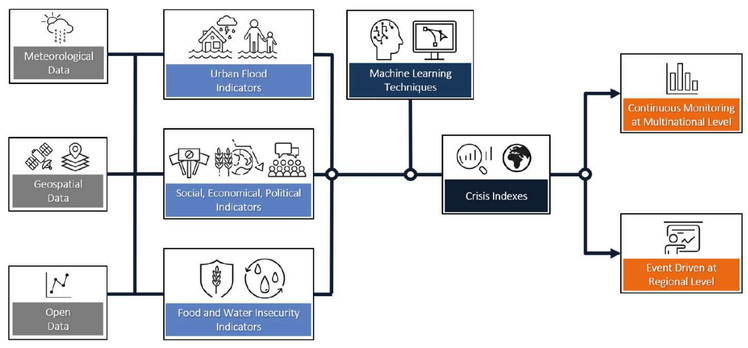
Water and Food Security (WFS)[3]

- Expanding the **CSS – SESA** portfolio by incorporating new vulnerability and fragility indices.
- Strengthening early warning capabilities for **continuous monitoring** of indicators and drivers of social unrest, population displacement, and conflicts related to food and water insecurity.

04. Methodology

CENTAUR employs a structured, multi-layered approach to enhance crisis understanding and response:

- **Data:** A foundation built on multidimensional datasets.
- **Indicators:** Thematic insights extracted from time series data and model-based combinations.
- **Crisis Indexes:** Advanced integration of flood, food, and water insecurity data alongside socio-economic and political indicators.



Urban Flood - Lombardy

CONTEXT & BACKGROUND

- Severe flooding occurred on 22 Sept - 2025
- Requested CEMS activation (EMSR843)
- Exposed population: over 1.3 million
- Caused extensive damage to infrastructure and buildings
- Overall cumulative impacted area: 59.6 ha

INDICATORS

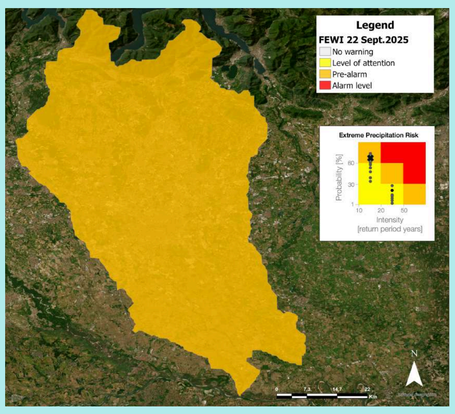
UF-ID-1: Static map of precipitation associated to return period
UF-ID-2: Forecast of return period
UF-ID-3: High-resolution urban flood risk maps for various return periods
UF-ID-4: Inferred InSAR urban flood extent
UF-ID-5: Enhanced urban flood damage assessment
UF-ID-6: Social/Traditional media indicators for Urban Flooding Map
UF-ID-9: Assets and financial resources
UF-ID-10: Public services and government support
UF-ID-13: Ability to evacuate
UF-ID-14: Economic impact of floods

INDEXES

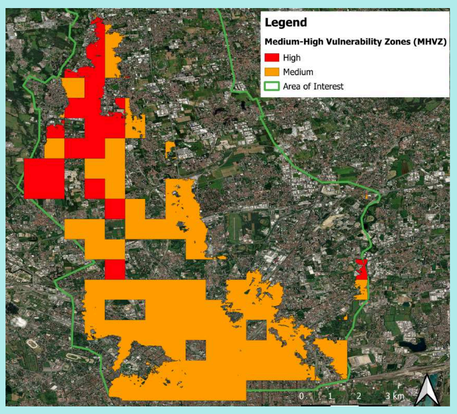
UF-IX-01: Flood Early Warning Index
UF-IX-02: Flood Impact Index
UF-IX-03: Medium High Vulnerability Zones

Early Warning

Flood Early Warning Index (FEWI): The meteorological component of the index leverages UF-ID-2 probability maps to build an alert system that, using fuzzy logic and a risk matrix, triggers an alarm up to 3-day lead time. Consequently, the indicator UF-ID-3 is employed to obtain high-resolution flooding maps for 10, 20 and 50 years return period.



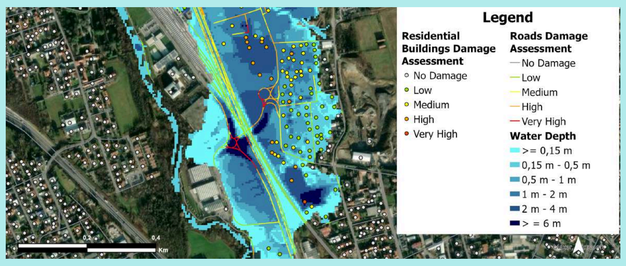
Medium-High Vulnerability Zones (MHVZ): This early-warning index combines crisis (UF-ID-3) and socio-economic indicators (UF-ID-9,10,13) to delineate the most vulnerable areas that are predicted to be flooded in the affected urban area. The vulnerability stems from a combination of the expected flood-impact, average income and accessibility to roads and emergency services.



Post - Event

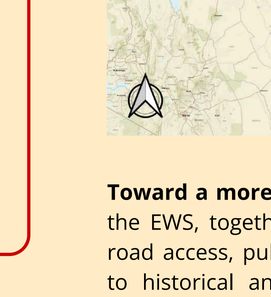
UF-ID-5: This product delivers an improved flood-extent and depth delineation as well as rapid post-event damage assessment, comprising three main components:

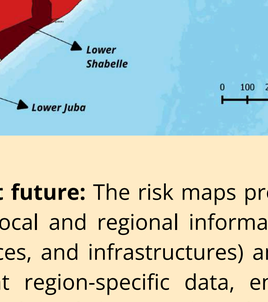
- Geomorphological model with SAR/optical inputs: converts the initial raw flood mask into an urban-aware, drainage-consistent outline.
- Water depth: Reconstructs a plausible water surface from the DTM and subtracts terrain to yield a smooth, GIS-ready depth raster.
- Damage assessment: Applies global depth-damage curves with country max values to compute per-asset damage factor, €/m², and impact class (Low–Very High).



Flood Impact Index (FII): After the occurrence of the flooding event, the FII estimates the potential impact over the Area of Interest by distinguishing into physical, human and asset impact. Therefore, the index is partitioned into the following components:

- **General-FII:** It quantifies the impact of flooding by integrating Corrected Flood Depth (CFD) measurements and land-use characteristics
- **Human-FII:** It calculates the impact of flooding on people by combining physical flood parameters with socio-economic and demographic indicators
- **Asset-FII:** It computes the impact on critical infrastructures and assets





Water Food Security - Somalia

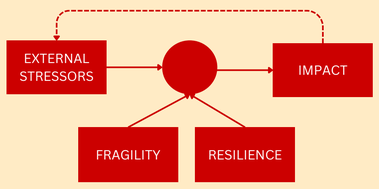
CONTEXT & BACKGROUND

- Ranked 2° most climate-affected country globally
- Hit by prolonged droughts and failed rainy seasons
- Over 70% of the population in poverty, reliant on rainfed agriculture and pastoralism
- Crisis worsened by political instability, extremism, and civil unrest
- High risk of displacement, conflict, and food insecurity from environmental shocks

INDICATORS

WFS-ID-1: Current precipitation deficits
WFS-ID-2: Future precipitation deficits
WFS-ID-3: Probabilities of drought aggravation and recovery
WFS-ID-4: Current drought impact on vegetation productivity
WFS-ID-5: Future drought impact on vegetation productivity
WFS-ID-6: Agricultural drought risk zone map
WFS-ID-7: IDPs camps status indicator
WFS-ID-8: Populations at risk of food insecurity
WFS-ID-9: Populations at risk of water insecurity
WFS-ID-10: Number of people living in conflict-affected areas
WFS-ID-11: Food insecurity
WFS-ID-12: Economic insecurity
WFS-ID-13: Displaced persons
WFS-ID-14: Violent conflict
WFS-ID-15: Radicalisation and polarisation
WFS-ID-17: Humanitarian aid
WFS-ID-18: Resource capture
WFS-ID-19: Climate sensitivity of agrifood systems
WFS-ID-21: Public services and infrastructures
WFS-ID-23: State-citizen relations
WFS-ID-24: Dispute resolution mechanisms
WFS-ID-25: Social cohesion and trust

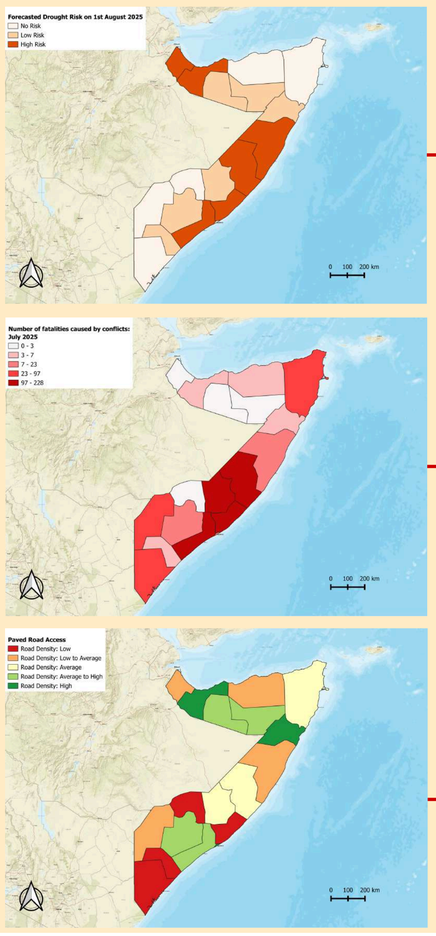
DCPI/DDPI: The Drought Conflict Prediction Index and the Drought Displacement Prediction Index estimate respectively the number of conflicts and of displacement resulting from periods of prolonged meteorological and agricultural drought. To adopt an holistic approach, the models encompass indicators of external stressors, fragility and resilience to forecast the expected impacts on a region of interest monthly.



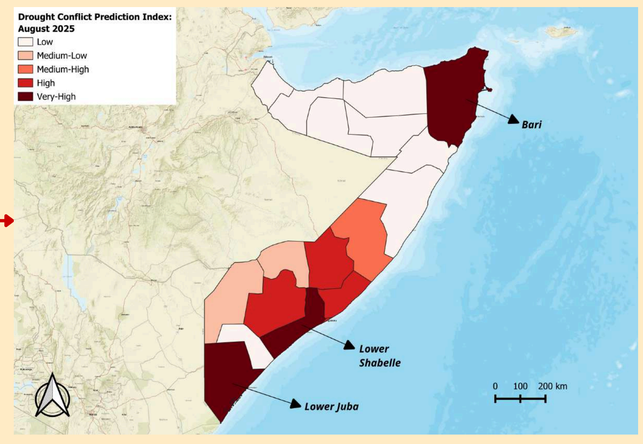
External stressors: These represent any factor external to a system, region, or population that can cause volatility, disorders, or shocks, such as natural disasters or human-made crises. An example is WFS-ID-3, which evaluates the risk of encountering a meteorological droughts in the coming 6 months over the region of interest

Fragility: It encompasses all the inherent weaknesses of a system, region, or population that make it susceptible to disruptions. Among all the influencing factors, one of the most dramatic drivers of population displacement and rising tension is the number of casualties caused by disorders, as measured by WFS-ID-14 on a monthly basis

Resilience: It refers to the capacity of a system, region, or population to cope with stressors and recover quickly, returning to its pre-stressor state. The presence of infrastructures is certainly a sign of resilience, as they enable essential services to continue functioning and support rapid recovery after disturbances.



CENTAUR's Early Warning System (EWS): By integrating environmental, economic, and societal factors, CENTAUR automatically generates alerts and identifies regions at risk of increased food insecurity, violent conflict, and displacement. As illustrated in the example below, during July 2025, an alert would have been issued for August 2025, indicating that the regions of Lower Shabelle, Lower Juba and Bari were at high risk of conflict escalation.



Toward a more resilient future: The risk maps provided by the EWS, together with local and regional information (e.g., road access, public services, and infrastructures) and access to historical and current region-specific data, enable the preparation of targeted and timely interventions that support smarter, context-aware responses.

6. Consortium

7. Acknowledgements

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