Technical brief

Recommendations for Improved Flood Forecasts and Early Action Plans in Dolo Ado and Bokolmayo, Somali Region, Ethiopia

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Summary

In an increasingly fluctuating climate, effective flood disaster preparedness hinges on the ability to understand and utilize reliable flood forecasting information. Flood modeling and forecasting are crucial tools for managing and preparing for extreme flood events. However, without a clear workflow from monitoring to communicating predictions, these forecasts cannot achieve their full potential for implementing appropriate early action that can prevent damaging flooding impacts. This brief provides key recommendations for improving flood forecasting, communication, and response in the Dolo Ado and Bokolmayo districts, flood-prone areas in the lowlands of Ethiopia that host refugees. It can serve as a guide for humanitarian aid organizations operating in the districts, local government bodies, and disaster management agencies, informing their strategic planning and resource allocation.

Key messages

- Improving hydrometeorological data systems is critical due to insufficient existing data and monitoring infrastructure.
- The lack of a dedicated flood forecasting model for Dolo Ado and Bokolmayo districts necessitates either the development of a site-specific model or the adaptation of an existing global flood model to local conditions.
- For a comprehensive understanding of existing flood risks at local scale, flash flood modeling should be taken into consideration in addition to riverine floods.
- Adopt Impact-Based Forecasting approach that combines flood hazard forecasts with community's vulnerability and exposure to floods.
- More effective flood warning alerts require establishment of a coordinated system that delivers clear and timely messages with simple, actionable language that are co-created with the community.
- For effective flood forecasts and early actions that prevent damaging flood impacts, it is crucial to conduct targeted, hands-on training for local stakeholders, including district officers, humanitarian agencies, and community members.

Introduction

The Dolo Ado and Bokolmayo districts, located in the Somali region of Ethiopia, are home to five refugee camps established between 2009 and 2011 along the Genale River. According to data from the United Nations High Commissioner for Refugees (UNHCR) as of January 2024, these camps host approximately 216,721 refugees (Mekuria et al., 2024). These districts are located within the Genale Dawa river basin and are particularly prone to riverine floods from the Genale and Dawa rivers, as well as flash floods originating locally (IFRC, 2021).

Major floods were recorded in April 2012 and November 2023, with the most recent one forcing over 5,300 students out of school and putting more than 200,000 refugees at risk of being displaced again (OCHA, 2025). The April 2012 flood also damaged an estimated 700 tents in Dolo Ado and flooded the access road to Hilaweyn refugee camp, hindering the delivery of services, including water provision (OCHA, 2012). The 2023 floods occurred paradoxically after consecutive years of drought. The historical drought conditions in the region, compounded by recurrent and severe flooding, place both the host communities and the refugee population at significant risk (COOPI, 2024). These risks include displacement, loss of human lives and livestock, infrastructure damage, and agricultural land destruction, impacting food security and livelihoods (Haile et al., 2024; Mabumbo et al., 2024; Mekuria et al., 2024).

A critical challenge limiting the ability for early preparedness and response to floods is the limited availability of flood risk information, the low trust in the data and the way it is communicated. The challenge is largely due to the absence of location-specific early warning systems and the remote nature of the districts. While the Ethiopian Meteorological Institute (EMI) and the Intergovernmental Authority on Development (IGAD) Climate Prediction and Application Centre (ICPAC) provide seven-day forecasts for extreme rainfall, these rainfall forecasts are insufficient for effective flood preparation (Mabumbo et al., 2024). This is because rainfall forecasts alone do not account for runoff and the time it takes for floodwater to travel from distant highlands to low-lying areas, such as Dolo Ado and Bokolmayo.

In addition to improving the flood forecasts to be trustable, communicating the early flood warning to users has its own limitations. Technically, other than floods from the rivers, flash floods during rainfall are also poorly understood, and existing global flood models fail to capture these short-lived events (Mabumbo et al., 2024). Therefore, there is a critical need to translate rainfall forecasts into actionable and trustable flood information that includes areal coverage, flood depth, duration, lead time, and potential flood impacts such as damages to the refugee and Internally Displaced People (IDP) camps and residential areas of the host communities (Haile et al. 2024). Moreover, establishing effective "last-mile" communication systems to ensure local communities can prepare in time is paramount. With this background we evaluate the existing process from creating rainfall and flood forecasts up to taking early action for the Dolo Ado and Bokolmayo districts.

Objectives

The objective of this brief is to provide agencies (governmental and humanitarian organizations) operating in the region with contextualized and actionable recommendations to improve the process of issuing flood forecasts and implementing early action in Dolo Ado and Bokolmayo districts.

The specific objectives are as follows:

- To assess existing workflows from rainfall and flood forecasting up to designing early action and to identify gaps in the process.
- To identify current process gaps in translating rainfall forecasts into early flood warnings.
- To provide recommendations for the improvement of the process of generating hydro-meteorological data, flood forecasts, forecast dissemination and designing early action.

Study area

The Dolo Ado and Bokolmayo districts are located in the Liben zone of the Somali Regional State of Ethiopia (Figure 1). Geographically, these districts lie between 3°30’ and 7°20’ N and 37°05’ and 43°20’ E, covering an area of 8,135 km^2. The elevation varies from 167 to 974 m above sea level. Shrublands and grasslands are the dominant land cover types. These districts are home to five refugee camps: Bokolmayo, Melkadida, Kobe, Buramino, and Hilaweyn, which were established along the Genale River between 2009 and 2011, and host around 216,721 people (Mekuria et al., 2024). Because the districts are in a remote area, their infrastructure is limited. The annual rainfall in the districts ranges from 106 to 609 mm spatially. Rainfall in this region follows a bimodal pattern, with the primary rainy season occurring in April and May, followed by a shorter rainy season from October to November. Inter-annual rainfall variability is common, leading to both droughts and floods. According to data from the Climate Hazards Group InfraRed Precipitation with Station data (CHIRPS), the region has experienced several years of above-average rainfall in the last four decades, specifically in 1997, 2006, 2013, 2019, and 2023 (Figure 2).

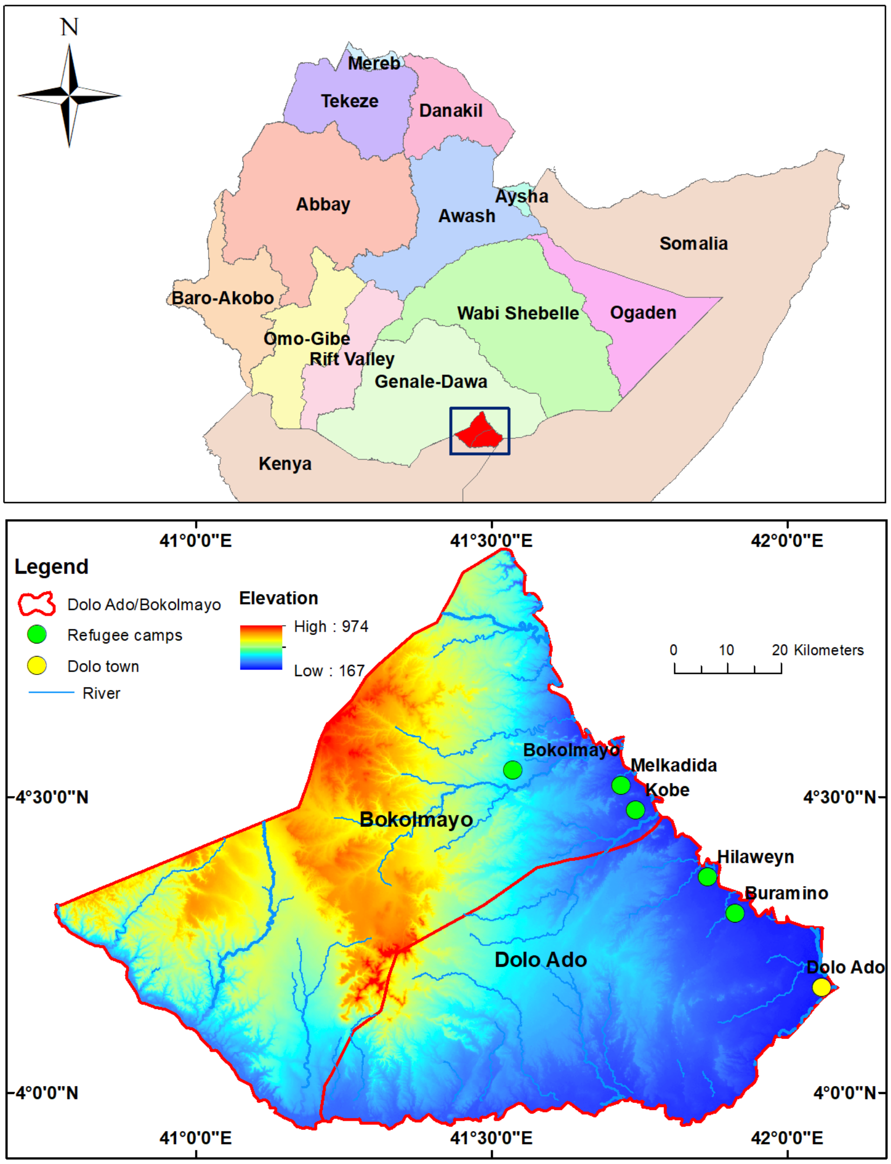

Figure 1: Dolo Ado and Bokolmayo districts in the Genale-Dawa River basin (source: Authors)

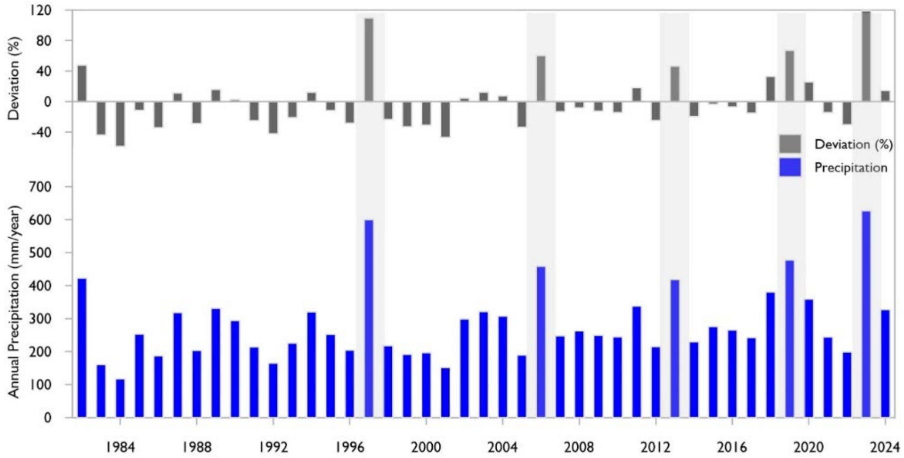

Figure 2: Annual rainfall over the Dolo Ado region and deviation from the long-term mean annual rainfall (Data Source: CHIRPS)

The people of Dolo Ado and Bokolmayo have historically practiced pastoralism, a way of life centered on livestock herding and mobility. However, many are now transitioning to farming (Dessalegn et al., 2024), a shift supported by organizations like the World Food Programme (WFP) and UNHCR. This investment is due to the organizations shift of focus from emergency response to resilience building and one of the mechanisms is to utilize the available river water for irrigation so that they produce food in a region where there is very low rainfall. This shift towards more sedentary farming, particularly along the Genale River, has increased their vulnerability to floods. The Dolo Ado and Bokolmayo districts, bordered by the Genale River to the east and the Dawa River to the west, are highly susceptible to severe riverine flooding. This is mainly due to heavy rainfall in the highland areas. Flash floods from localized rainfall that quickly drains through small streams are also a threat. Therefore, both riverine and flash floods pose a significant threat to these districts.

Methods

This study used various qualitative data collection approaches, such as key informant interviews, two workshops focusing on strengthening resilience and effective flood response design using advanced technology (Haile et al., 2025; Mekuria et al., 2025) and literature reviews. Key informants and participants of the two workshops were stakeholders in government and humanitarian agencies. The participants were 32 with 5 female participants. The key discussion point with the key informants and participants of the workshop was focused on understanding the current workflow practiced for the Dolo Ado and Bokolmayo districts and evaluating the process that is being followed to provide flood forecast information and proposing ways of improvement. Additionally, a literature review was conducted to obtain information on historical flood events, early warning practices, available hydrometeorological data, currently applied modeling and flood simulation tools, alert and warning dissemination methods, the vulnerability context of communities, and institutional roles.

While discussing with the key informants and participants of the workshop, we used a checklist covering five key elements of flood forecasting and designing a solution (Figure 3). The checklist covered (i) the processes followed during data acquisition and processing, (ii) the runoff, water level and flood extent modeling aspect, (iii) the processes of flood forecasting, (iv) the dissemination of flood alerts and warnings, and (v) the implementation of early actions. We used this approach based on the assumption that such detailed information on the process enables the identification of strengths and weaknesses at different stages of the process from initial flood forecasting up to early action.

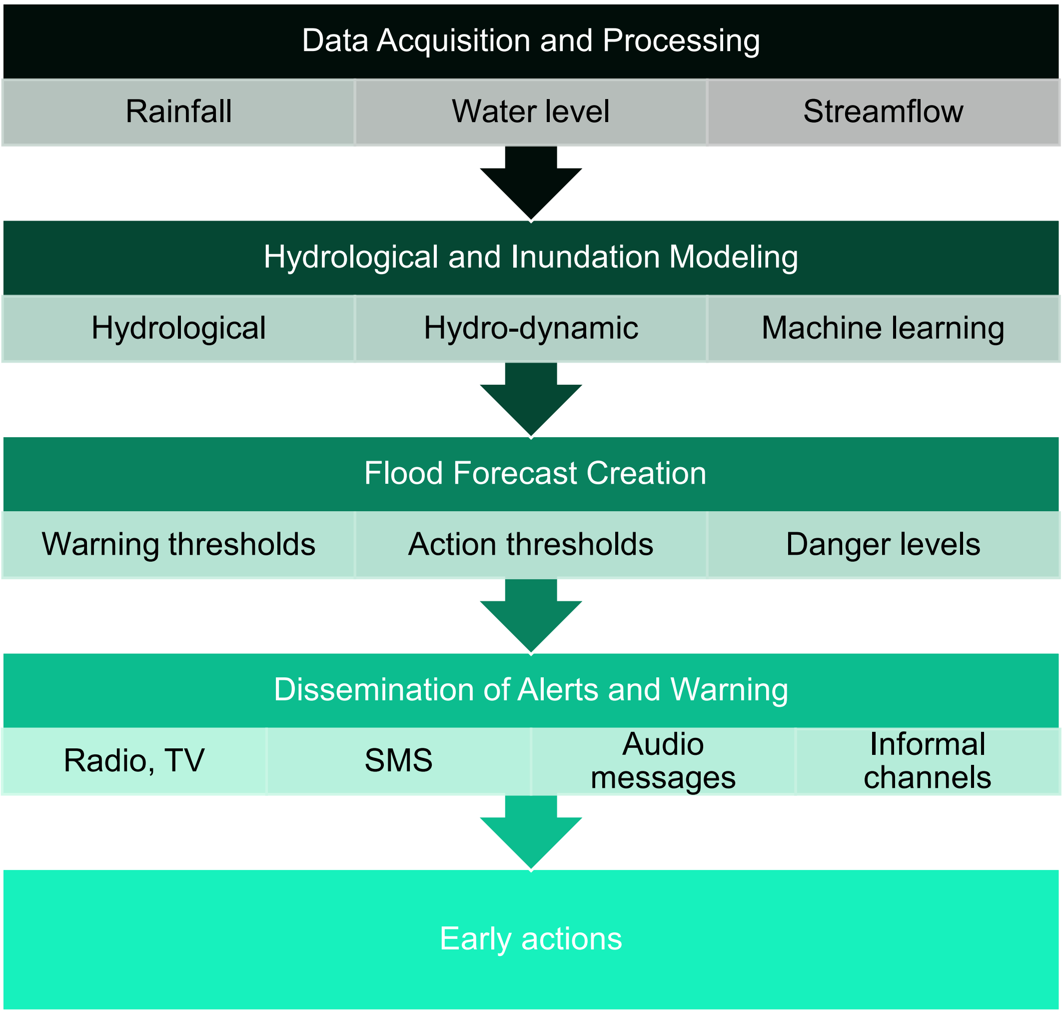

Figure 3: General workflow to provide useful flood forecasts and early actions (Source: Authors' creation)

Key findings

There is lack of standardized workflows for generating and disseminating accurate flood forecasts

The current early warning system for floods in Ethiopia is a multi-agency process. The EMI collects meteorological data and provides rainfall forecasts, including warnings for exceptional rainfall events. The Ministry of Water and Energy (MOWE) converts these rainfall forecasts into riverine flood warnings using the ET-HYPE[1] hydrological model (SMHI, 2023; 2024a; 2024b), but currently only for the Awash and Omo-Gibe basins where there are major reservoirs. The Ethiopian Disaster Risk Management Commission (EDRMC) is responsible for disseminating these warnings up to the local levels. The current practice shows that for the refugee settings in the Dolo and Bokolmayo districts, there are no clear workflows that can provide useful flood forecasts for both riverine and flash floods. There are fragmented efforts by diverse range of actors from governmental and non-governmental agencies. In the

[1] ET-HYPE is a hydrological forecasting model, which is an adaptation of the Hydrological Predictions for the Environment (HYPE) model originally developed by the Swedish Meteorological and Hydrological Institute (SMHI). Specifically tailored for the Ethiopian context, its primary function is to generate streamflow forecasts and issue flood warnings when predefined discharge thresholds are exceeded.

Somali region, while there is a regional technical working group who are responsible for providing preparedness and response measures during disasters, there is a lack of systematic data sharing and collaboration process that creates disconnect between regional systems and the communities affected by floods.

Insufficient existing data and monitoring infrastructure hinder effective flood forecasting system

In the Genale Dawa River Basin, there are only 17 meteorological stations spread over an area of 172,889 km² (Figure 4). This results in a low station density of about one station for every 10,170 km². Additionally, most of these stations are clustered in the highland areas, the upstream part of the river basin, leaving the lower parts and the eastern side of the basin largely unmonitored. In the districts, there is only one meteorological station, located in Dolo town at the southern edge of the study area. Furthermore, there is a notable lack of recent streamflow data. The data from the Hilaweyn station in the Dolo district is outdated as the station is no longer operational, with continuous records dating back to the 1980s (Assefa et al., 2024). Hilaweyn is the most downstream gauging station on the Genale River, approximately 40 km from the river's outlet. As a result, any hydrological model built using data from the Hilaweyn station would miss a large part of the Dolo and Bokolmayo districts. The sparse station distribution, limited data accuracy, and incomplete records all undermine the effectiveness of flood forecasting models, urging the need for mobilizing resources and investing in data. The lack of data reduces the reliability of flood modelling outputs and constrains the planning, design, and implementation of early actions in flood risk management.

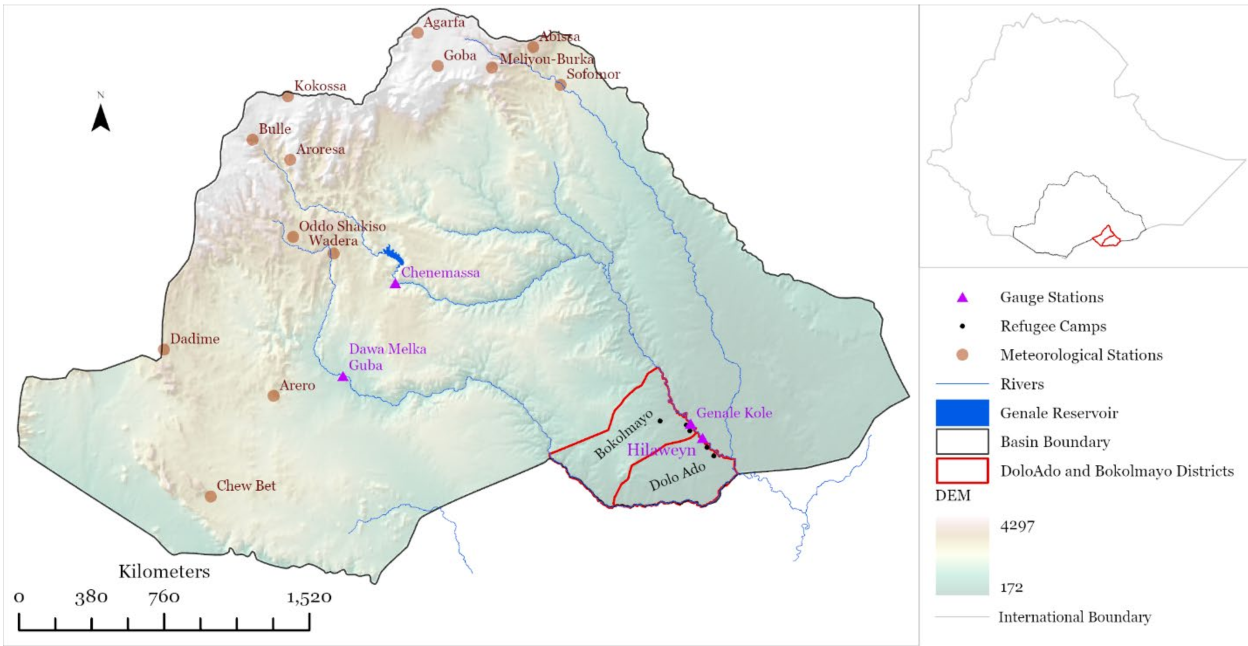

Figure 4: Location of hydrometeorological stations within the Genale-Dawa basin (Source: Authors' creation)

The absence of a site-specific flood forecasting model significantly affects the accuracy of flood forecast creation.

In the Dolo Ado and Bokolmayo districts, there are no operational hydrological modeling and flood simulation tools set up for the context of these locations. The lack of site-specific flood forecasting model forces agencies operating in the area to rely on their own provisional systems. For instance, WFP has an internal provisional system they currently use to inform their flood preparedness according to our key informant from WFP. They use flood forecast data from the Global Flood Awareness System (GLoFAS[2]) and rainfall forecasts from EMI and ICPAC. They monitor the rainfall forecasts and water levels from GloFAS to inform them of their preparedness actions. This system involves three steps, a No-Regret Actions phase (when floods are forecasted with 15-day lead time), a Readiness Phase (when floods are forecasted with 7-day lead time), and an Activation Phase (when floods are forecasted with 3-day lead time). With a 15-day lead time of flood forecasts, WFP identifies at-risk areas, alerts the community, and takes preventive measures, such as dike maintenance. If the 7-day forecast still indicates a flood and a specific threshold is met, WFP activates its early action plans. When a flood is anticipated within a three-day lead time, WFP declares a danger level and takes all necessary actions.

However, the 2023 floods exposed a critical flaw in this approach and the GLoFAS flood forecasting system for the Shebelle Basin, an area adjacent to the Genale Dawa Basin. Although the ICPAC provided accurate rainfall forecasts (Figure 5), GLoFAS failed to issue a timely flood warning for the Shebelle basin, meaning the floods came before the forecasted dates. This created a "fail to act" scenario (WFP, 2023). This is partly due to the dependence of the forecast on the global GLoFAS model, which lacks site-specific calibration. To provide context on lack of local calibration, out of 1,226 global gauging stations used to calibrate GLoFAS, only 102 are in Africa, and just six are in Ethiopia, none of which are located in the Genale Dawa or Shebelle basins. This highlights that GLoFAS, being a global model, lacks the necessary localization to effectively trigger timely flood actions in the Somali region. Thus, this highlights the need for contextualizing global flood forecasting models before applying them to local conditions.

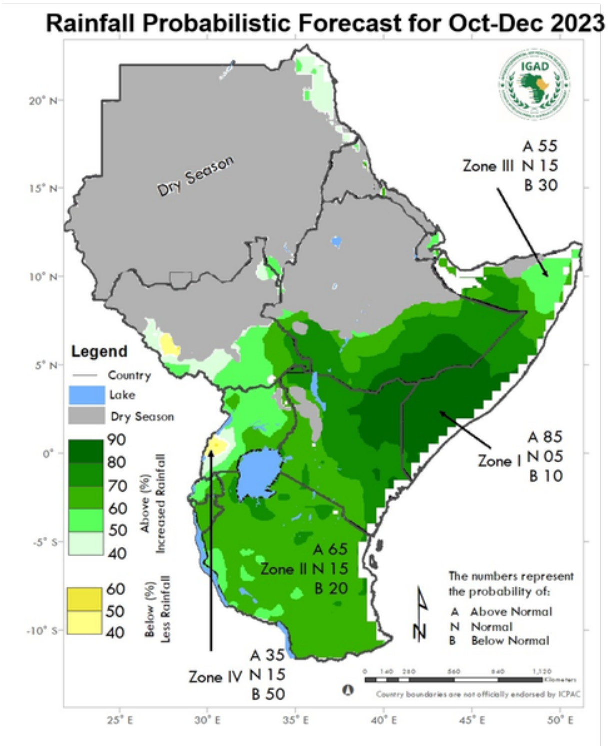

Figure 5: Rainfall probabilistic forecast for Oct-Dec 2023 issued by ICPAC (Source: ICPAC website, accessed July 2025)

[2] GLoFAS is a free, operational web service that provides daily global hydrological forecasts, along with probabilistic flood-risk maps, for up to 30 days. GloFAS produces daily flood-risk maps with three lead time categories: 1-3 days, 4-10 days, and 11-30 days.

Therefore, the key limitation of the current practice is the absence of hydrological and inundation or hydraulic models, which are crucial for predicting the spatial extent and depth of flooding in the districts. This gap makes it difficult to provide a visual extent of the flooded area, the depth of water with the potential impact of riverine floods on properties and the lead time when these floods would occur. Moreover, emerging methods such as the Impact-Based Forecasting (IBF) are not yet practiced for the districts. This approach focuses on assessing the potential impacts of flooding on individuals, property, livelihoods, and infrastructure, blending hazard data with information on exposure and vulnerability providing more comprehensive information for flood risk preparedness (Haile et al., 2024; IFRC, 2023; Schindler et al., 2023).

The absence of clear and coordinated communication pathways for flood warning alerts hinders effective and life-saving responses.

Given the lack of dedicated flood forecasting system for the Dolo Ado and Bokolmayo districts, flood warnings are issued based on rainfall forecasts, which are not processed through hydrological and hydraulic models. EMI's rainfall forecasts are shared through both official and unofficial channels. The official channels include the EMI's website (https://www.ethiomet.gov.et/), emails, phone calls, local FM radio, and text messages. Informal communication occurs via traditional methods such as mosque microphones, megaphones, drums, and word-of-mouth networks led by traditional leaders. All local alerts are delivered in the Somali language. However, there are several challenges in the communication process (Schindler et al. 2023). First, the dissemination of flood warnings is often slow, inconsistent, and fragmented. In interviews in Dolo Ado, officials reported receiving alerts from the EMI website, email, and phone calls within 24 to 48 hours. However, the subsequent relay of these warnings to communities through methods like word of mouth, local radio, or text messages is often delayed or fails to reach those most at risk due to factors such as limited infrastructure. During the 2023 floods, some residents reported receiving no flood warning at all, only realizing the danger when floodwater arrived in their locality (Save the Childern, 2023).

Second, even when flood alerts do reach communities, they may not be effective. The warnings often use technical terms—such as "significant probability of heavy rainfall"—that are difficult for local residents to understand. Local experts and communities tend to rely more on information from humanitarian organizations, such as the World Food Program (WFP) and Ethiopian Red Cross Society (ERCS) as they are better trusted. These agencies have a stronger presence on the ground and often use their own internal procedures to issue warnings based on data from national and regional systems. For example, the WFP's "Last-Mile Early Warning System" sends alerts to refugee camp managers, while the ERCS uses volunteers and loudspeaker vans to reach remote areas. Despite these efforts, some pastoral communities that rely on oral and radio communication may still be missed.

Furthermore, due to a lack of specific, numerical evacuation thresholds for the Dolo Ado and Bokolmayo districts, decisions to evacuate are based on anticipated impact scenarios rather than clear, pre-defined triggers. Evacuation decisions in Dolo Ado and Bokolmayo are made by the district Disaster Risk Management Committees, guided by regional and national advisories, it is the responsibility of the district level authorities (Flood Task Force, 2023). Humanitarian organizations such as ERCS have specific protocols to activate their Early Action Protocols (EAPs) when there is a significant flood risk. They activate their early action plan when GloFAS forecasts predict a 10-year return period flood with high probability and 7-day lead time (IFRC, 2023). However, these numerical thresholds are not part of the standard public warning system. This ambiguity that can come from different information sources can further hinder the timely and effective implementation of community action.

Flash flood modeling requires attention.

Specific to flash floods, rapidly developing storm hazards that can lead to flooding within hours are poorly understood in these districts. While EMI issues warnings for potential flash flood areas based on historical flood prone regions, there is no established method to assess the direct flood hazard from this information and set up an early action trigger mechanism. Therefore, it is essential to establish a clear method and assign responsibilities for issuing flash flood early warnings for these districts as flash floods are also events that risk lives in the region.

Flood forecasting and dissemination efforts are limited by a lack of technical capacity.

There is a lack of expertise with the necessary skills to properly calibrate and validate hydrological and hydraulic models for site-specific conditions. Technical skills are required to understand antecedent soil moisture conditions of the catchment, water propagation in the rivers, and the magnitude of water flow to obtain accurate flood forecasts. A distinct set of skills, including expertise in high-resolution models and the ability to account for surface processes such as soil moisture and topography is required to forecast flash floods. These technical skills require capacity strengthening trainings.

Lack of capacity in communication and dissemination of warnings to the public, especially to the most vulnerable communities, require specific skills and training. Even when forecasts are available, experts often struggle to convey technical information to local communities in a manner that is easily understandable. The reliance on informal channels means that life-saving information often does not reach those who need it most, preventing them from taking timely action to protect themselves and their assets.

Key recommendations

Invest in data to improve flood forecasting and the design of anticipatory actions.

It is important to improve rainfall data collection in the upstream part of the basin and estimating the time required for flood waters to reach the refugee camps. Increasing the spatial density of rainfall stations by strategically placing new gauges in various locations, such as tributary sub-basins, different elevations, and flood-prone areas, will more effectively capture local variations in rainfall. Simultaneously, it is recommended to install streamflow gauging stations along the main river and its tributaries for assessing water levels and associated flood risks. The development of real-time transmission of data for flood monitoring through expanding the spatial coverage of hydro-meteorological stations and upgrading the current quality and timeliness of the information is part of EDRMC roadmap for Ethiopia (EDRMC, 2022) that should be implemented.

Site-specific contextualization of flood forecasting models is needed.

Adapt hydrological and hydraulic models to local conditions and rigorously calibrate and validate with site-specific data. Such models, which accurately reflect unique catchment features such as topography, soil, and land use, as well as river channel properties like geometry and roughness, are critical for making precise predictions of flood volume, timing, depth, and extent.

Adopt the Impact-based forecasting system

Advancing IBF systems in the Somali Region to bridge the gap between forecasted events and their potential impacts, facilitates more precise and actionable warnings. Since this approach requires detailed data on population distribution (especially in refugee camps), infrastructure (e.g., shelters, roads, health facilities), and livelihoods and properties (e.g. number of camels, livestock) investing in such data is also critical for translating hazard forecasts into anticipated impacts.

Establish and maintain a clear communication system for flood alerts to mitigate risks.

Dissemination of flood alerts and warnings requires improvements, as the current method is fragmented and does not always reach the most vulnerable communities. Therefore, the need to improve the alert system to be clear and fast is paramount. Establishing a multi-channel system or process using SMS, local radio, and community-based systems is key. Warnings should be simplified with actionable information and leveraging trusted local humanitarian organizations like the WFP and ERCS for dissemination. Finally, there needs to be better institutional coordination between government agencies and humanitarian organizations to ensure a unified and clear message is delivered to all at-risk populations.

Capacitate local actors with skills for improved flood forecasting and dissemination.

Given that extreme rainfall and flood forecasting and translating this information to actionable plans require various kinds of technical capacities, capacity building of the local stakeholders, such as district officers, humanitarian agencies, and community members, various technical skills is important for the appropriate delivery of an effective and life-saving flood warning system for the region. Additionally, there is a need to strengthen and capacitate actors to build an effective communication and dissemination system that reaches the last-mile users.

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Disclaimer

Front cover photo: Flooded road making it difficult for trucks to cross the road, Dolo Ado, Somali Region, Ethiopia (*photo*: Girma Yimer Ebrahim)

Back cover photo: Irrigated farms affected by the 2023 floods in Dolo Ado, Somali Region, Ethiopia (*photo*: Wolde Mekuria)

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