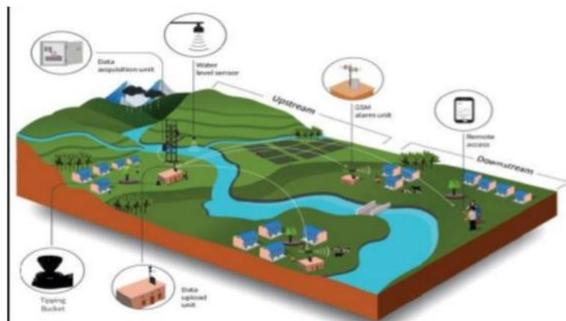# Integration of GEOGloWS-ECMWF Streamflow Forecasting into the Community-Based Flood Early Warning System (CBFEWS): flood warning information in Malawi.

By Calvince Wara, Felix Kasiti, Anastasia Wahome, Ted Nyekanyeka, Fedson Chikuse, Robinson Mugo, Phoebe Oduor, Angelica Gutierrez, and Sara Venturini

In January 2022, Malawi was hit by Cyclone Ana which caused severe flooding across the country. Thanks to the resources that included the deployment of the GEOGloWS-ECMWF streamflow forecast service, and in cooperation with local authorities and international partners, losses and damages were limited. Further work needs to be done to secure the country against disaster risk.

Malawi, one of the least developed countries in Africa, is highly dependent on its agricultural sector where about 85 percent of the country's population lives in rural areas and primarily depends on smallholder farming as their source of livelihood. These communities, however, are time and again rendered vulnerable to frequent flood occurrences that not only affect their land but also lead to losses of lives and livelihoods. Long-term shifts in weather patterns have exacerbated extreme rainfall and flooding events. These events have increased in occurrences, frequency, extent and are more intense. On 24 **January 2022**, Cyclone Ana lashed the Southern and Central Districts of Malawi, bringing strong winds and heavy rains to an area already suffering from floods due to the ongoing rainy season. The Southern districts of Chikwawa, Phalombe, and Nsanje were the worst affected with over a million of the population at risk. According to

the Government of Malawi, the Department of Disaster Management Affairs (DoDMA), about 37 people were reported dead, 22 missing and 158 injured as of 31 January. The flooding affected over 193,558 households and destroyed over 740 hectares of croplands hence pushing the already vulnerable communities into food insecurity in the coming months.

In response to the perennial climate shocks such as floods, the Regional Centre for Mapping of Resources for Development (RCMRD), with financial support from the United Nations Development Programme (UNDP), partnered with the International Centre for Integrated Mountain Development (ICIMOD); the Sustainable Eco Engineering Pvt. Ltd (SEE) of Nepal to support the Government of Malawi through DoDMA in establishing a satellite and telemetric Community-Based Flood Early Warning System (CBFEWS) in eight flood-prone districts in Malawi (Figure 1). The project aimed at supporting the government efforts on Scaling up the Use of Modernized Climate Information and Early Warning systems (M-CLIMES) launched in 2017, with support of the Green Climate Fund (GCF) through UNDP. The CBFEWS project targeted the flood-prone districts of Karonga, Rumphi, Nkhata-Bay, Nkhotakota, Salima, Dedza, Zomba, and Phalombe in Malawi. This project is part of the DoDMA initiative and responds to its mandate and efforts towards disaster risk reduction and building community resilience to climate shocks.

The project has been implemented in close collaboration with local institutions such as DoDMA, Department of Water Resources (DWR), the Department of Climate Change and Meteorological Services (DCCMS), and the Red Cross Society (MRCS) of Malawi. RCMRD established and operationalized the hybrid system using telemetric data from 21 rivers and the GEOGloWS-ECMWF streamflow forecast (bias-corrected) for the eight flood-prone districts.

http://malawi.cbfews.com/#

AfriGEO, which supports the regional implementation of the Group on Earth Observations (GEO) initiatives, has been engaging with the GEO Global Water Sustainability (GEOGloWS) that provides a global service on streamflow forecasts using global hydrometeorological models enabled by Earth Observation (EO) data. Conversations that had initially taken place had highlighted the need to improve global models with in situ data. This compensates for locations where there is no information, and enriches where local observations do exist. Through the SERVIR network, one of the GEOGloWS team members had done some training on the GEOGloWS-ECMWF streamflow forecasting service for staff of the SERVIR implementing partners at RCMRD and AGRHYMET. AfriGEO was able to connect the CBFEWS work being done by the RCMRD in Malawi and the GEOGloWS implementing team. This timely opportunity was a win-win to enhance the work that was being undertaken by the RCMRD team and GEOGloWS. This global to local integration has helped to improve lead time on early warning, making the community and the response teams better prepared for a forthcoming event. This reduces the effects of risk and also gives them time to position the necessary resources to support the local communities, such as was the case for the occurrence of Cyclone Ana.

The integrated CBFEWS system combines real-time data from telemetry sensors and forecasted data obtained from the GEOGloWS-ECMWF streamflow services to provide timely and reliable forecasts and flood warning information to the vulnerable communities across the eight flood-prone districts. Through an application programming interface (API), the CBFEWS system uses python scripts to automatically harvest the 15-day ensemble forecast data from the GEOGloWS-ECMWF Streamflow Services (https://geoglows.ecmwf.int/) into the CBFEWS system. Telemetric-based water level sensors, many installed in bridges and cross drainage structures with controlled sections in the upstream reaches of the river system, provide flood warning information via alarms and SMS to the downstream community with a lead time of at least 1 hour. The integration of telemetric data with the GEOGloWS-ECMWF Streamflow forecast service has increased the warning lead time from hours to days which enhances community preparedness and leads to early action that significantly reduces the flood disaster risks as demonstrated during Cyclone Ana. The global forecast also complements the telemetric sensor during downtime.
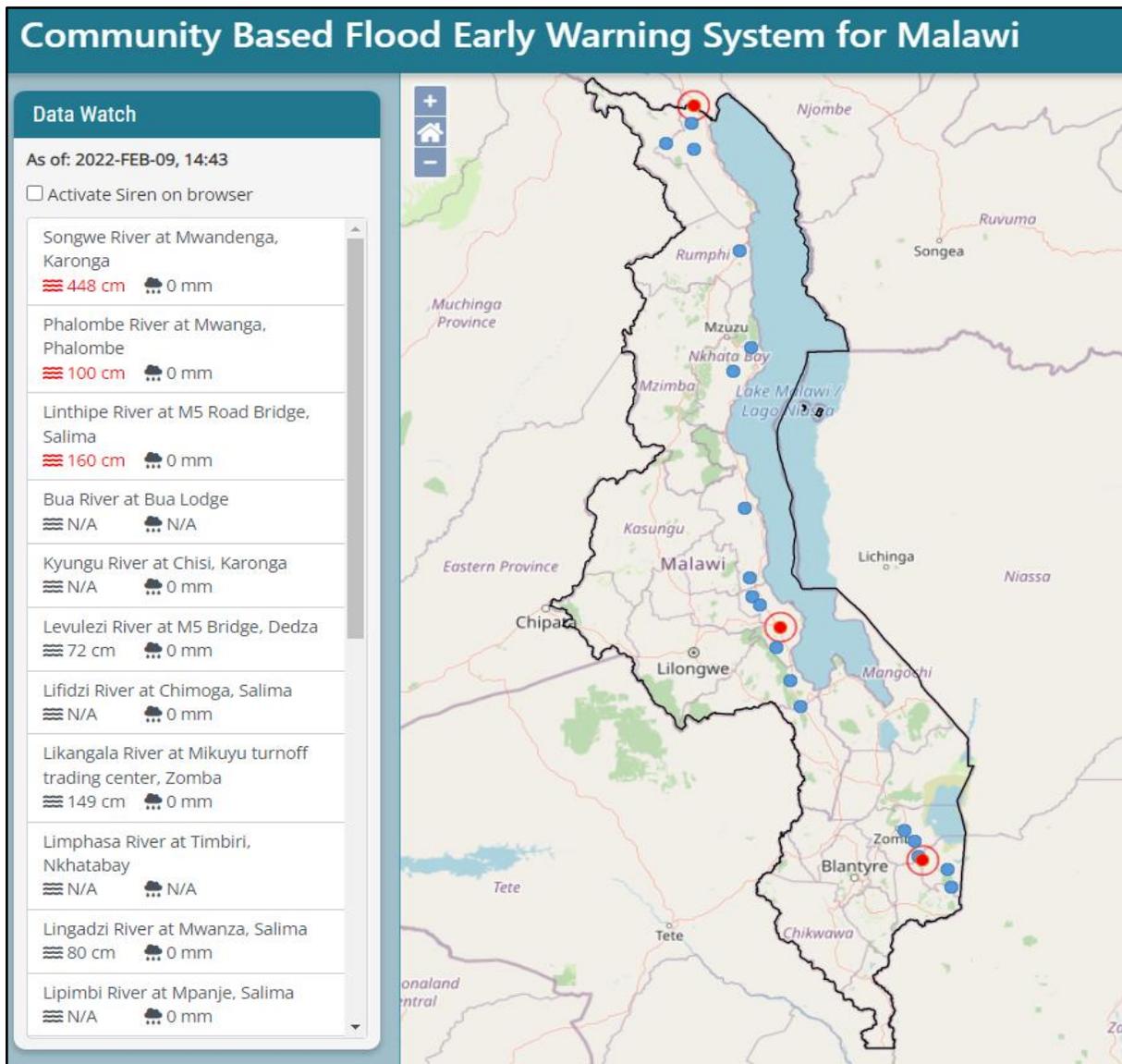
Figure 1: CBFEWS issuing flooding warning on the 9th February 2022 in Songwe, River in Karonga District, Phalombe river in Phalombe districts, and Linthipe River in Salima District.

The CBFEWS system automatically generates flood early warning information verified by the community member (Caretaker) based on pre-set thresholds and flood levels in the upstream and triggering loud alarm sirens installed within the downstream communities within the floodplain. The alarm siren is complemented with a bulk SMS distribution system that enables the community to take action that reduces their risk and vulnerability to flood disaster, saving lives, livelihood, and enhancing community preparedness. RCMRD and SEE have provided training in the use of the system to national and local stakeholders. The second training and capacity-building training to operationalize the system (Standard Operation Procedure (SoP) workshop) was conducted on January31 - February 4, 2022 in Salima, Malawi.

During the arrival of Cyclone Ana in January 2022 in the southern parts of Malawi, the

integrated CBFEWS system captured the increase in water levels in real-time and forecast mode, elaborated in figures 2 and 3, respectively. As indicated in figure 3, the GEOGloWS-ECMWF forecast accurately predicted peak flows in the Phalombe river, which was also recorded by the water level sensors on the same day and forecasted by the GEOGloWS-ECMWF streamflow forecast. The national and district government authorities and the humanitarian organization, such as the Malawi Red Cross Society (MRCS), were simultaneously alerted via SMS and email for emergency response and coordination. According to the DoDMA, more than half of the country's 28 districts were affected by the floods. Malawi's government declared a national disaster in areas hit by Cyclone Ana and more than 40 emergency camps have been set up to deal with thousands of displaced and injured.
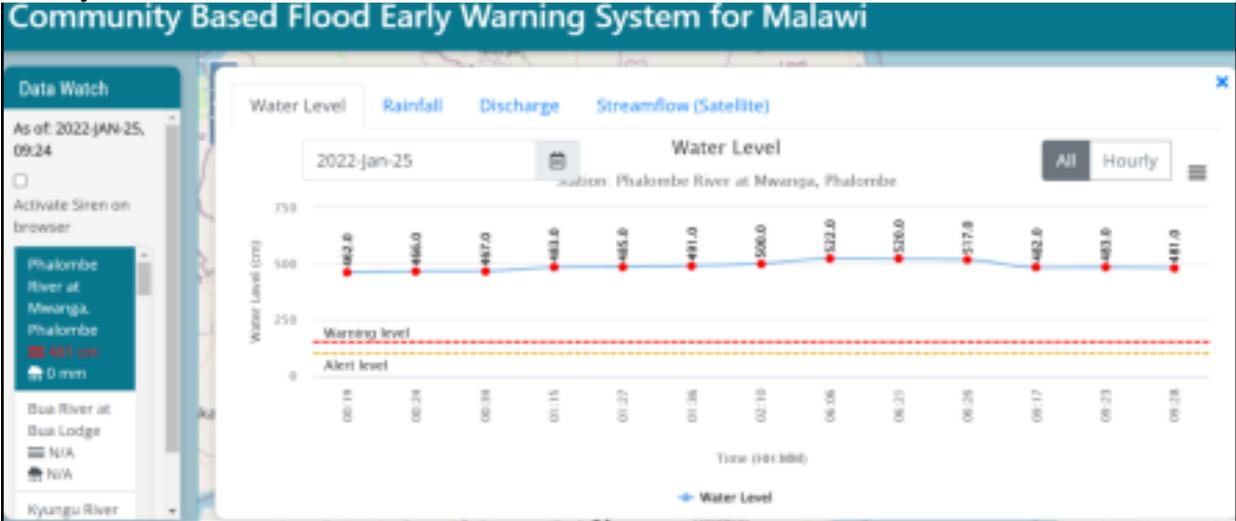

Figure 2: Status Water level in Phalombe river passed the warning level for the warning that was issued 24 hours ago (24th January at 08:00am).
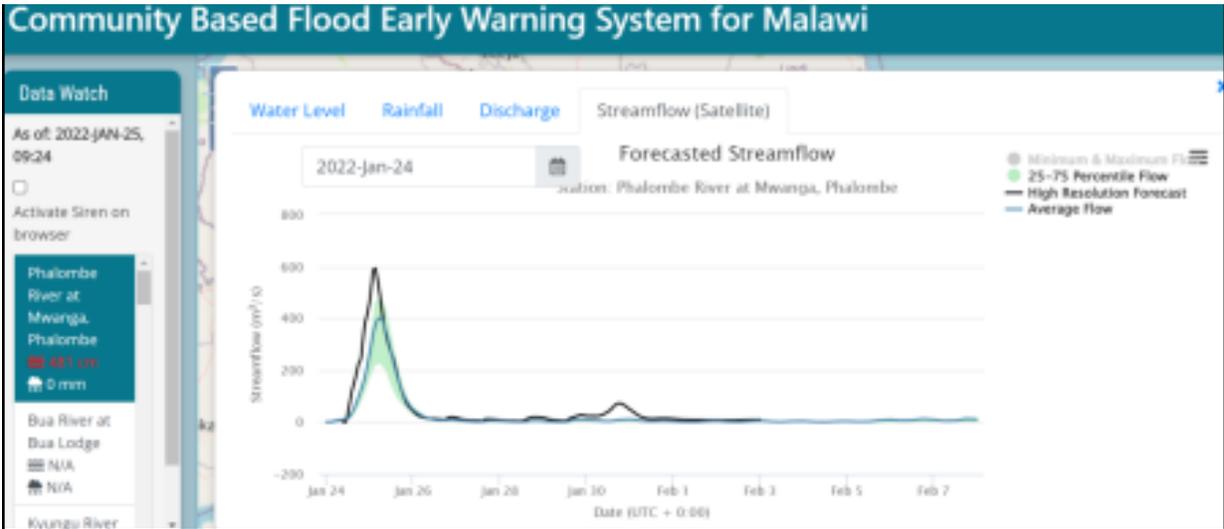

Figure 3: Phalombe River flooding events pick up by the satellite 6 days ago (19th January 2022) from GEOGloWS
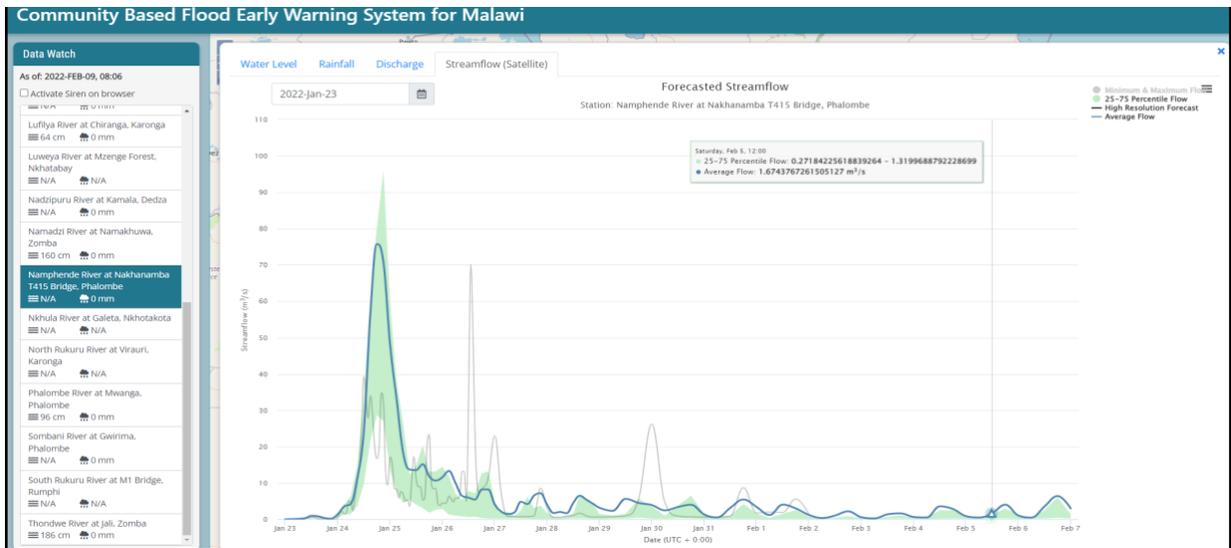
Figure 4: Namphende River flooding events on 24th January pick up by the satellite 5 days ago (19th January 2022) from GEOGloWS
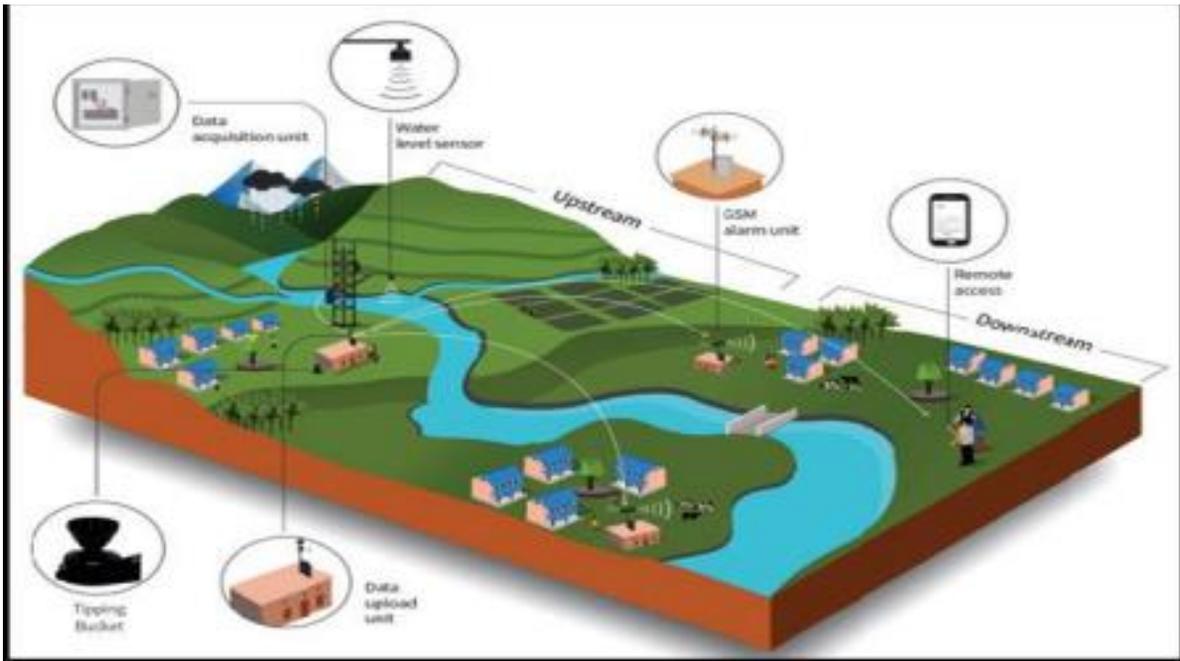

Figure 4: Working principle of the established CBFEWS instrumentation & layout.

All the Data Acquisition (sensor installed in the river), Data Upload Unit (Installed at the Caretaker house) and Alarm Unit (Siren) installed within the most affected downstream communities are managed by the community members commonly referred to as Caretakers. The integrated CBFEWS system equally considered gender participation and involvement for the early warning generation and dissemination as means for building community resilience to disasters, with the potential to save lives and livelihoods. Women and marginalized gender groups face unique barriers in disaster risk reduction hence must be involved and streamlined into the CBFEWS system operations (Figure5 and 6).

Figure 5: Caretaker at Levulezi River Data Upload Unit (DU) in Dedza District

Figure 6: Caretaker at Linthipe River Data Upload Unit (DU) in Salima (L) and Lipimbi Alarm installation ® in Salima District

Figure 8: DoDMA Deputy Director Risk Reduction providing opening remarks during the CBFEWS SOP training Workshop held on the 31st January - 4th February 2022 in Salima, Malawi..

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