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**Report on the Technical Training and Knowledge Exchange Workshop**

**on the BuPuSa Flood and Drought Monitor**

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1. **Background**

Hydrometeorological hazards (pluvial and fluvial floods including flash floods, droughts, heatwaves, landslides, and wildfires) are perennial challenges across southern Africa, and expected to become more severe and frequent under climate change and human influences such as land use change. Use of early warning (EW) information is crucial to addressing these challenges, alongside robust mitigation and adaptation measures to reduce the impacts of hazards. Collectively there is wide experience and expertise across institutions in the region in climate and hydrological monitoring, forecasting and early warning. There is an opportunity in the context of the “A community focused flood early warning system for the Buzi, Pungwe and Save (BuPuSa) transboundary river basins” project to bring this experience and expertise together to co-develop improved methods for EW of hydrometeorological hazards. Sharing of expertise would be beneficial to identifying best practice, and gaps in the implementation and use of EW, as well as technical deployment related to data development, modelling approaches, back-end architecture, and analytical and decision support interfaces, as well as open science principles. Specifically, there is potential to leverage from the design and implementation of a pilot BuPuSa high resolution basin-scale flood and drought monitoring system (BuPuSa-FDM) developed by PCI, University of Southampton (UoS) and the University of Montana (UMT), to progress EW for the region.

1. **Aim and Objectives of the Workshop**

To progress this, a 2-day workshop was developed and delivered to bring together relevant stakeholders from Zimbabwe and Mozambique to exchange knowledge, enable collaboration, and build capacity and ambition in the implementation of EWS, based on the BuPuSa-FDM.

***Objectives***

1. To exchange knowledge on the development, implementation and use of early warning of hazards.
2. To provide technical training in the new basin scale flood and drought monitoring system (BuPuSa-FDM).
3. To co-develop a way forward for potential technology transfer and implementation for early warning in the region.
4. **Workshop Agenda**

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| **Date** | **Time** | **Session** |
| **Knowledge exchange** | | |
| Day 1 AM | 9:00-9:30 | Opening remarks |
|  | 9:30-10:00 | Overview of objectives and proposed outcomes of the workshop. |
|  | 10:00-11:30 | Introductions and background to each represented institution, including overview of current approaches and needs. |
|  | 11:30-13:00 | Discussion of strengths and gaps in current approaches to EWS, including technical methodologies and capacities. |
| Lunch | 13:00-14:00 |  |
| **Training in the BuPuSa-FDM** | | |
| Day 1 PM | 14:00-14:15 | Introduction to the FDM and its potential use. |
|  | 14:15-14:45 | Flood monitoring forecasting – methods/data, validation, utility |
|  | 14:45-15:15 | Drought monitoring and forecasting – methods/data, validation, and utility |
|  | 15:15-15:45 | Overview of data, models and methods. |
| **Training in the BuPuSa-FDM** | | |
| Day 2 AM | 9:00-9:30 | Tour of the system |
|  | 9:30-12:00 | Exercises in the use of the FDM, including historic case studies for flood and drought events |
|  | 1200:13:00 | Feedback and initial validation of the system |
| Lunch | 13:00-14:00 |  |
| **Way forward** | | |
| Day 2 PM | 14:00-14:30 | Discussion on principles of a multi-hazard system (e.g. open, inter-operable, modular, sustainable, …). |
|  | 14:30-15:00 | Identification of barriers and opportunities to developing a multi-hazard system, and options for technology transfer and ownership. |
|  | 15:00-16:00 | Way forward including opportunities to leverage from the FDM and other approaches |

1. **Participants**

Representatives from the following institutions participated in the workshop.

Zimbabwe:

1. The Zimbabwe Meteorological Services Department (ZMSD),
2. The Department of Civil Protection (DCP)
3. The Zimbabwe National Water Authority (ZINWA)

Mozambique:

1. INAM: Instituto Nacional de Meteorologia (Mozambique National Institute of Meteorology); INAM Sofala, INAM Manica, INAM Inhambane
2. INGD: Instituto Nacional de Gestão e Redução do Risco de Desastres (National Institute for Disaster Risk Management and Reduction)
3. ARA Centro (Water Administration Institute for the Central Region of Mozambique), Buzi
4. ARA Centro, Pungwe
5. ARA-Sul (Water Administration Institute for the Southern Region of Mozambique)
6. ICS: Instituto De Comunicacao Social
7. **Training Materials**

The following training materials formed the basis for the training and are available as attachments.

1. Introduction to the workshop (PowerPoint file)
2. Lecture 1 – Introduction to the BuPuSa-FDM and its potential use (PowerPoint file)
3. Lecture 2 – Overview of data, models and methods, validation (PowerPoint file)
4. Lecture 3 – Flood and drought monitoring concepts and methods (PowerPoint file)
5. Lecture 4 – Flood and drought forecasting concepts and methods (PowerPoint file)
6. Self-guided exercise in how to use the system (pdf file)
7. **Summary of Discussion on Feedback and Way Forward**
8. **Participant Feedback on the System**

This is a summary of key points and suggestions from individual participants regarding the system's functionality and potential improvements.

*General Observations and Desired Functionality*

The system was widely regarded as very useful and a valuable complement to existing work and systems.A strong desire was expressed for the system to incorporate and visualize real-time data for current conditions and future forecasts. This includes:

* Understanding what's happening now and in the coming days.
* Complementing existing real-time data visualization systems.
* Integrating observations to observe the real-time behavior of rivers.

*Specific Suggestions and Areas for Improvement*

1. User Experience & Data Accessibility

* Interactive Display: Participants suggested implementing a feature to click on a point or shape to view information on current conditions and forecasts.
* Layman's Understanding: The system needs to be made understandable to a non-technical audience, as the underlying data is perceived as very technical.
* Low Bandwidth Access: Concerns were raised about system accessibility in low-bandwidth environments or with slow computers. A suggested solution is to generate automatic updates of static maps and figures for easier access.

2. Data and Model Enhancements

* Hydrological Data:
  + Meteorological data generally appeared reasonable.
  + While precipitation forecasts aligned with observed MSG data, a discrepancy was noted with expected increased streamflow. This was attributed to errors in the streamflow modeling.
  + It would be beneficial to include Evapotranspiration (ET), particularly noting its peak in relation to expected precipitation peaks.
  + Historical data was considered highly useful.
  + A "dream" was expressed for integrating real-time station data directly into the system for visualization.
  + The ability to show the hydrological evolution over an event and view this from an office was highlighted as useful.
  + Questions arose regarding how to determine water volumes from tributaries, given that most hydrometric stations are on main river courses.
  + The need for river profiles of flows (indicating whether levels are rising or falling) was mentioned.
* Forecasts and EW:
  + The system can enhance EW by providing streamflow forecasts.
  + Forecast Timeliness: While 1-day forecasts are acceptable, 3-hour forecasts would be preferred. There's a strong need for up-to-date information, ideally matching the frequency of river level readings during events (e.g., 5 times a day).
  + Daily data updates are valuable for advisories, including for the Ministry of Agriculture (e.g., streamflow and drought forecasts).
* Validation and Calibration:
  + Frequent suggestions were made to validate the system by comparing its outputs against observations.
  + Participants noted that numerous gauges could be integrated or used for validation purposes.
  + A formal calibration/validation step was recommended.

3. Existing Systems

* Zimbabwe already utilizes a similar system (the Pitman Model, developed by the Centre for Humanitarian Analytics), which could be compared with.

1. **Way Forward: Addressing Key Challenges**

Several potential next steps were suggested to address the feedback and ensure the system's effectiveness and sustainability.

1. Validation Strategy

* Approach: The primary approach should be comparison with existing observational data.
* Data Availability:
  + Mozambique: Extensive historical station data is available. The "Central" district has multi-decade data with gaps for the Buzi and Pungwe basins. "Arusul" has data on precipitation, Epan/temperature data (3 stations) from 2000 to present for the Save and other districts, including 20 stations in Save for 20 years. Water levels are also shared daily by districts from the energy agency managing dams.
  + Zimbabwe: Data sharing agreements are already in place through the BuPuSa project, providing daily precipitation, discharge, temperature, and pan evaporation from the 1960s. The National Water Authority (NWA) holds streamflow and water level data back to the 1920s and can also provide operating rules.
* Responsibility: Collaboration between the project team and in-country experts with access to the historical datasets will be crucial.

2. Integrating Real-Time Observational Data

* Mozambique: Real-time data can be sent daily via email. Some automatic stations use a chatbot for access (AcroNet).
* Zimbabwe: Some automatic stations are accessible via institutional contacts.
* Technical solutions should be explored for automated ingestion of these real-time data streams into the system.

3. System Sustainability and Accessibility

* Sustainability agreement: An agreement could be established between UNESCO and the two countries to maintain the system's operation.
* Increased ownership:
  + Mirroring: Hosting a mirrored version of the web interface within each country could increase local ownership.
  + Training: Providing training for technicians on system operation and updating processes would be beneficial.
  + Open-source pilot: Piloting an open-source version of the system with the countries could foster collaboration and local development.
* Hosting: The Flood Centre in the BuPuSa basin, which already hosts several other models, could potentially host the system.
* Accessibility solutions:
  + Low-bandwidth version: Develop a version with less data and lower resolution to accommodate low-bandwidth environments.
  + Static version: Create a static version of the system for easier access where real-time interaction isn't feasible.
* Communication: Establish clear communication channels for updates and feedback to ensure ongoing relevance and support.