Using simple mobile technologies to scale up digital collection & processing of climate observation for adaptation actions in Malawi

UNEP CTCN Project: 2022000048

Assessment of Needs and Requirements

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ADAPTATION FUND

UN environment programme

CTCN UN Climate Technology Centre & Network

1. Scope

In the UNEP CTCN technical assistance project, "Using simple mobile technologies to scale up digital collection & processing of climate observation for adaptation actions in Malawi", Output 3 plays a key role. Comprehensive and foundational feasibility knowledge and guidance is generated, both for the project as a whole, and for Malawi and broadly for countries facing similar challenges with closing the observation data gap.

Output 3 is "Diagnosis & pre-feasibility of using simple mobile technologies as a solution to comprehensively collect and digitise weather & climate observations for application in impact modelling and developing climate futures for purposes of adaptation and disaster risk management".

Under Output 3, Activity 3.2 entails the assessment of needs and requirements by users and administrators to digitise manual observation data of water and weather at Malawi's Department of Climate Change and Meteorological Services (DCCMS) and Department of Water Resources (DWR). The activity emanated in three deliverables:

- Deliverable 3.2.a Workshop minutes & presentation materials
- Deliverable 3.2.b Client needs summary list (ToR & system architecture)
- Deliverable 3.2.c Matrix - comparing available versus requested data and systems

This document contains deliverables 3.2.b and 3.2.c. The minutes and workshop materials are presented in separate documents.

The findings of the activities were discussed and validated by the consultant team during the Workshop (3.2.a) in Dedza, Malawi on April 29, 2024, as well as in-person meetings and interviews with DCCMS and DWR staff in Blantyre and Lilongwe Respectively April 30 - May 03, 2024).

Additional information on hydro-meteorological information and data management system needs were gathered from meetings with the Malawi National Water Resources Authority and international donors, including USAID and the World Food Programme.

The needs listed in the summary and in the illustrated matrix below will form the basis of a ToR/system architecture design, developed in subsequent activities and deliverables in Output 3:

- Deliverable 3.3 Report: preliminary analysis on the use of simple mobile phones
- Deliverable 3.4 Report on challenges, barriers, risks, opportunities & strengths
- Deliverable 3.5.a Draft system architecture with user manual (summary report)
- Deliverable 3.5.b Matrix: explaining needs reached (i.e., 3.2) or not reachable

2. Client needs summary

The set of requirements and needs of the future technology, prototype and system are presented as separate lists under the sub-sections below.

Data collection - manual water & weather observation

Equipment

- Replacement and repairs needed to equipment due to vandalism, theft, and damage during floods.

  This entails equipment for:

  - River gauge stations (iron angles, gauge plates, cement).
  - Rainfall cylinders (cylinders of adequate volume capacity and material - preferably copper, with funnel and removable container, measurement cylinders).
  - Maximum and minimum thermometers (replacement with dry and wet bulb equipment in accordance with WMO directive to move away from mercury-based equipment).
- Protecting the measurement equipment, ensuring the measurement equipment and supporting infrastructure installations (e.g., fence) are safe from theft or damage is needed. To strengthen the protection of equipment, engagement with the gauge readers and observers is needed (e.g., phone calls, sms etc.). Engaging the gauge reader and observer in the protection and maintenance of simple measurement equipment helps ensure alignment of incentives - from the department seeking to sustain physical measurement equipment investments, through to gauge readers and observers seeking to fulfil their task and duty in the long-run.
- Easy reporting methods to document changes and loss of station equipment (as part of national inventory), in turn improving cost-effectiveness and efficiencies in government budgeting and maintenance operations.
- Easy interface to understand, analyse and iteratively manage equipment.

Site management

- Robust and durable tools to gauge readers and observers:
  - Personal Protective Equipment (rain coats, gum boots)
  - Sickles (short handle, hook-like blade), scythes (long handle, curved blade), and spade for removing vegetation and sedimentation at the site of the equipment, ensuring measurement is reliable.

	• Community sensitisations to raise awareness of the importance of the observation station and equipment, and to mitigate vandalism. • Easy interface to understand, analyse and iteratively manage observation sites. • Sites need to be safe for gauge readers and observers, in particular during extreme rainfall and floods, and gauge readers and observers need to be informed that they should not take observations during such events. The same applies during sightings of dangerous animals, such as crocodiles and snakes, at the monitoring site.
Mobile phone assets & technologies 	• Mobile technologies used for transferring manual observation data need to be secure and reliable so that the data can be processed for verification. • The method of sending observation data needs to be simple, building on conventional communication methods (SMS, WhatsApp etc.). • Communication must allow for 2-way communication and interaction, and not be limited by time. • Communication methods must be reversely billed (at no cost to the user), or at a very minimal cost to the user that can easily be compensated (e.g., using minimum airtime/data transfers). • All types of phones, from simple-feature to smart phones, should be able to use operationally and financially optimal method(s) of mobile communication. • For smartphone users, the gps-location of the gauge reader and observer should be transmitted. • Minimal training should be required for users to learn how to send observations of optimal quality. • Communication methods should work with minimum connectivity, i.e., GSM/2G networks at a minimum. • Mobile technologies should support safe and secure transmission of messages with data and ability to engage in near real-time communication between gauge readers and observers, and government staff working on data transmission and management at district to HQ - depending on the institutional set up.

Individual skills and incentives 	• Financial cash-for-work/government volunteer honorarium for river level gauge readers has proven to be a prerequisite for sustained, long-term submission of gauge readers at the WMO standard level of frequency for manual in-situ observations (from previous testing and research). • Incentives and directives are needed for rainfall observers and station meteorologists to adopt using their phones to transmit manual observations (in addition to logbooks or for a period of transition, depending on government protocol). Incentives in the form of training, monthly airtime and data bundles, and repaired equipment can boost incentives for long-term adoption. • Additional non-financial incentives needed include encouragement, two-way communication and training. The need for and impact of gamification needs to be tested. • Adequate (re)training for existing and new gauge readers and observers is needed to ensure use of equipment and data collection processes meet standards (e.g., schedule). • Skills in using the phone's keyboard to enter observation numbers in a standardised format is needed, regardless of the individual's language and level of literacy.
Gender 	• Gender-sensitive approaches and support mechanisms (in the form of guidance to NGOs or similar) are recommended to be conveyed to women gauge readers or observers, to ensure additional honorarium income or access to higher-valued phones results in household tension and a greater risk of gender based violence. Available services in the community e.g. social welfare, gender based violence response available in the community to link gauge readers whenever required. • Communication on support mechanisms targeting women need to be conveyed in a socially and culturally appropriate manner. • Any recruitment of new gauge readers or observers should provide equal chances to women and men, to attain greater gender balance and access to opportunities to learn and use mobile technologies and to receive financial remuneration. • Prevent gauge readers delegating observation tasks to children under the age of 18 so as not to expose him/her to unsafe conditions. • Potential additional gender barriers can be identified in discussion with female gauge readers.

Data formats, processing & visualisation - manual water & weather observation

Data format and trust

- Gauge Readers and Observers need to use a standardised format for sending measurements to make sustained submission viable for the individual, and to ensure compatibility and ease of data integration and use by government and applications.
- Standardised formats for sending observations should adhere to. Below, compliance with the WMO standard schedule and format for manual observations is needed (i.e. the The WMO No. 544 - *Manual on the Global Observing System*). For the DWR and DCCMS in Malawi, the WMO-compliant timing and format for observations are as follows:
    - River levels measured in metres, to the level of two decimals (cm) for river level depths. Observations are taken and recorded at 8h00 am and 16h00 local time (e.g., format of data sent is "2.32"). The observation data corresponds to metres depth, with level estimated based on depth above gauge zero m.asl).
    - Total rainfall in mm over 24 hrs, to the level of one decimal measurement taken and recorded at 08h00 am local time (e.g., "10.5" recorded and transmitted).
    - Minimum temperature in celsius to the level of one decimal sent at 08h00 am local time (e.g., "15.7")
    - Maximum temperature in celsius to the level of one decimal sent at 08h00 am and 14h00 local time (e.g., "27.5").
- Data format needs to be easy to learn and use, and easy to repeat over time.
- Trustworthiness of data sent using phones needs to be strengthened, as observations are not considered official (particularly for meteorological observations) and are not submitted in the existing step-wise process of logbooks (i.e., log books are sent by post, verified and validated through quality control, transferred to data entry and management staff, stored and quality controlled in Climsoft).
- Lessons should be captured on DCCMS and DWR efforts to use mobile communication and technologies, from DCCMS capturing observations from individual phone calls and WhatsApp groups, to DWR using individual mobile communication during the rainy season to collect information on river levels reaching green, yellow and red levels at flood monitoring sites.

Data transmission 	• Data must be transmitted efficiently and reliably from remote locations to central systems, using robust communication networks. • Transmission needs to leverage 2G to 4G capacities, and enable real-time, rapid transfer of raw data to online cloud-based databases. • Cloud technologies should automatically integrate and transmit data from various collection end points of the gauge readers and observers' phones, to a centralised, secure database online (and with replication at local server). • Data transmission needs to be cost-effective, secure and sustainable with limited points of vulnerability to outages or external access.
Data storage, cleaning and integration 	• Multiple data formats from various sources must be handled. • Data must be cleaned for human error or formatting consistency, removing outliers and repetition, and flagging data that requires additional verification. • Need for robust validation processes to ensure data accuracy and reliability (using a multi-pronged and exploratory approach, such as validation against satellite observations, gps locations, automatic sensor comparisons, statistical analysis, outlier detection, etc.). • Data storage needs to ensure access and protection over the long-run, with online storage and replication at local servers of DWR and DCCMS (as requested and possible). This respects the need for centralised databases that the government has in place. • Data storage needs to handle large volumes of data efficiently and securely. • Robust backup solutions are needed to prevent data loss and ensure data recovery capabilities. • Data storage needs to be scalable to accommodate increasing volumes of data from historical to future records. • Seamless integration is needed with diverse data sources, including manual and automated sensor data, to uncover comprehensive access and analysis of collective observation data.

Data access, visualisation & interactive dashboards 	• Data needs to be accessible in CSV formats that can be manually pulled or automatically transferable via APIs. • Data formats must be easily malleable or tailored for database systems HYDSTRA/HYDATA and Climsoft. • User-friendly interfaces are needed for intuitive interaction with data via dashboards (e.g., filtering, selection by parameter, geographic scale, timeframes etc.). • Dashboards should be customisable, to the extent possible, to user needs and accessible to tiered, different users (with profiles and access control). • Visualisation of observation data based on basic needs for hydro-meteorological interpretation (e.g., presentation of rainfall in monthly or seasonal averages, inter-annual comparison etc.). • Specific visualisation formats need to be based on information available and complexity of modelling involved. • Need for visualisation can be identified using UX/UI methodology. • Visualisation and analytical features should be complementary to more advanced modelling, such as forecasting and hydrological modelling - that have separate software capabilities and purposes. ○ For example, river levels can help derive discharge estimates from cross section measurement and rating curves. In the absence of cross section measurement, the discharge can be mistaken. In such cases, there is a need to test analysis of displayed graphs at select stations for assessing the value-add.
Decision making 	• For decision-making purposes, there is a need to enable data-driven insights that respond to the decision and knowledge gap at hand. Therefore, there is a need to identify and articulate the common and/or critical question that the data shall help answer. • Data needs to be in the required, correct format and be effectively transferable into analytical processes/software in order to help in forecasting and strategic planning, especially in sectors sensitive to climate variability such as agriculture and water management.

Value of climate information services 	• Building robust solutions to close the water and weather observation gap need conjunctive investment and strengthening of application and use of the data (forecasting, hydrological, flood modelling etc.) so as to build the entire value chain of climate information services. • Closing the observation gap through innovative approaches and new data sources from manual in-situ observations needs to be valued and supported financially and politically, as it provides evidence-based insights that facilitate policy decisions and planning, particularly in response to climate change and disaster risk management. • Economic and Social Benefits: Highlighting the economic and social benefits derived from accurate and timely climate information, which aids in better resource management and disaster preparedness • Private sector opportunities derived from improved and accurate observation data are growing, for example in weather insurance derivatives. Government agencies can evolve to generate revenue from selling analytical products that enables cost-recovery of operations and finances for developing capabilities. Analytical services and products have notably higher market value than selling raw data.

3. Matrix - comparing available versus requested data and systems