PHI: BAGUIO CITY SMART FLOOD WARNING, INFORMATION AND MITIGATION SYSTEM

CONSOLIDATION PHASE
PRE-MONSOON ASSESSMENT REPORT

OCTOBER 2023

ASEAN AUSTRALIA SMART CITIES TRUST FUND
Asian Development Bank

Australian Government
Department of Foreign Affairs and Trade

ADB

Source: Ramboll

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ABBREVIATIONS

AASCTF	ASEAN Australia Smart Cities Trust Fund
ADB	Asian Development Bank
API	Application programming
ASEAN	Association of Southeast Asian Nations
CAR	Cordillera Administrative Region
CDRRMO	City Disaster Risk Reduction and Management Office
DA	Data Assimilation
DFAT	Department of Foreign Affairs and Trade (Australia)
DHI	Danish Hydraulic Institute
DOST	Department of Science and Technology (Philippines)
DOST-ASTI	DOST Advanced Science and Technology Institute
DOST-CAR	DOST Cordillera Administrative Region
DRR	Disaster Risk Reduction
DRRM	Disaster Risk Reduction and Management
EWS	Early Warning System
FEWS	Flood Early Warning System

HD	Hydrodynamic
ICT	Information and Communications Technology
LGU	Local Government Unit
MITD	Management Information Technology Division
MO	Mike Operations
MoA	Memorandum of Agreement
NAM	Rainfall Runoff
OTJ	On-the-job (Training)
O&M	Operations and maintenance
PAGASA	Philippine Atmospheric Geophysical and Astronomical Services Administration
RR	Hydrological Rainfall-Runoff
SOP	Standard Operating Procedures
TOF	Time of Forecast
WL	Water Level
WRF	Weather Research Forecasting

EXECUTIVE SUMMARY

In April 2019, the Asian Development Bank (ADB) approved the establishment of the ASEAN Australia Smart Cities Trust Fund (AASCTF or the Fund) under the Urban Financing Partnership Facility, with financing provided by the Government of Australia, through its Department of Foreign Affairs and Trade (DFAT). Through this mechanism, the ADB is supporting Baguio City in implementing the Smart Flood Early Warning, Information and Mitigation System project.
Following the completion of the pilot project in April 2023, the Baguio FEWS Consolidation Phase kicked off in May 2023. The activities of the consolidation phase build on what has been achieved and delivered under the pilot project. It covers activities supporting the Baguio Local Government Unit (LGU) with continued technical assistance throughout the 2023 monsoon, which includes testing, running, troubleshooting throughout the monsoon, as well as fine-tuning the system during the post-monsoon phase. The 2023 monsoon will be the first full-scale test of the Baguio FEWS during real-time operation. The aim of this report is to provide an overview of the pre-monsoon model and system updates as well as the preparation and plan for the first full-scale test of the FEWS.

During the pre-monsoon phase, the project has successfully upgraded the network of real-time stations by replacing five stations which were not operational. The station equipment and construction works were procured, civil works repairs completed, platforms constructed, and the new station equipment installed by early April 2023. The five upgraded stations have been operational since May 2023 with DOST-ASTI and DOST-CAR continuously supporting in trouble-shooting of any technical issues that may arise.
In close collaboration with the LGU, efforts in enhancing FEWS governance has been continued in 2023. As a result, the partnership with crucial stakeholders has been strengthened. Furthermore, the project team has facilitated the establishment of two Memoranda of Agreements with neighboring municipalities La Trinidad and Tuba. The MOAs formalize the collaboration on maintenance of the network of monitoring stations and knowledge and data-sharing on the Baguio FEWS between the three municipalities. A targeted training program building on the 2022 training activities kicked off in end-April 2023. The aim of '2023 Baguio FEWS training program' is to strengthen local capacity for independent operation and maintenance of the FEWS in parallel with implementing, testing and refining the system.

In the pre-monsoon phase, efforts have been made enhance the FEWS by improving bias correction, data assimilation and implementing model upgrades. The performance of the model benefits significantly from a larger dataset, resulting in increased model reliability. It is essential to emphasize that the entirety of the collected data holds potential for further model improvements and improvement of FEWS. Therefore, in this project stage, the acquisition of additional data is pivotal.

The plan for the 2023 real-time test of the FEWS has been prepared and is currently being executed. Three main aspects of the system will be tested: technical performance, effectiveness of procedures, and team performance. The need for testing is not limited to one single monsoon season, as any FEWS requires proper validation (several monsoons) before it's publicly launched. Launching a FEWS without proper testing and troubleshooting time can have serious consequences on the credibility of the LGU and ultimately on the confidence in the system itself.

1. INTRODUCTION

Source: Ramboll

1.1 AASCTF PROGRAMME

In April 2019, the Asian Development Bank (ADB) approved the establishment of the ASEAN Australia Smart Cities Trust Fund (AASCTF or the Fund) under the Urban Financing Partnership Facility, with financing provided by the Government of Australia, through its Department of Foreign Affairs and Trade (DFAT). The Fund's envisioned impact aligns with ADB's Strategy 2030, as well as ASEAN's Sustainable Urbanization Strategy which aims to promote high quality of life, competitive economies, and sustainable environments. The expected outcome of the Fund will be that through the adaptation and adoption of digital solutions, across three core functional areas (planning systems, service delivery and financial management), systems and governance in participating ASEAN cities are improved, in particular by way of:

- Strengthening city planning processes by enhancing the collection, storage, analysis and utilization of data on geospatial platforms.
- Promoting the use of integrated and smart network management systems to strengthen operational systems and to improve quality and efficiency of service delivery.
- Introducing integrated financial management information systems to improve institutional credit worthiness and fiscal standing.

AASCTF acts as a mechanism for facilitating and channeling resources and financing for eligible projects, as well as activities agreed between DFAT and ADB for project preparation, implementation, and capacity development.

1.2 PREVIOUS PROJECT ACHIEVEMENTS

The ADB, through the AASCTF, supported Baguio City in implementing the Smart Flood Early Warning, Information and Mitigation System project. The project assisted the city with both the planning for flood mitigation and the delivery of the services of flood early warning and responses, using smart technologies. The project outcome has been improved flood early warning system, responses, and mitigation measures of Baguio City. The project has three key outputs:

- Smart flood early warning information system (FEWS) established and operational;
- Real-time data capture system established in four river basins in Baguio City;
- Flood Mitigation Action Plan prepared.

Furthermore, the project enhanced local technical capacities through the implementation of a Targeted Capacity Building Program to enhance the sustainable delivery of FEWS. The FEWS has been developed with Baguio Local Government Unit (LGU) and other key stakeholders to improve community disaster preparedness, raise awareness, and ensure ownership.

The activities and achievements of the project have been documented in the twelve (12) deliverables produced. The Final Report from December 2022 summarizes the project achievements, findings, and outputs. The pilot project under the AASCTF came to an end in April 2023 concluding in the preparation of a Final Roadmap for the Baguio FEWS Consolidation Phase.

1.3 CONSOLIDATION PHASE

Following the completion of the pilot project in April 2023, the Baguio FEWS Consolidation Phase kicked off in May 2023.

The activities of the consolidation phase build on what has been achieved and delivered under the pilot project. It covers activities supporting the Baguio LGU with continued technical assistance throughout the 2023 monsoon, which includes testing, running, troubleshooting throughout the monsoon, as well as fine-tuning the system during the post-monsoon phase. The 2023 monsoon will be the first full-scale test of the Baguio FEWS during real-time operation.

Furthermore, the technical capacities within the Local Government Unit (LGU) will continue to increase through on-the-job (OTJ) training and implementation and testing of the prepared FEWS standard operating procedures (SOPs). Enhancement of system governance and support for partnership agreement will strengthen the foundation for effective and sustained operation and maintenance of the system. The activities will further enhance the LGU's capacity to utilize the FEWS as an active risk-mitigation tool serving as an integral element within the overall vision of Baguio City to become a truly resilient, dynamic, and smart city.

The main activities are divided in three phases following the operational phases of the FEWS: pre-monsoon, monsoon, and post-monsoon. The main activities and deliverables of the Consolidation Phase are outlined in Table 1-1. The roadmap for the consolidation phase is seen in Figure 1-1.

Table 1-1 Activities and deliverables for Baguio FEWS Consolidation Phase

Delivareble	Activities	Timeline
D1 Pre-Monsoon Assessment and Report (this report)	• Development of bias correction factors for weather and rainfall (WRF) forecast data and update FEWS • Improvement of model data assimilation and error calculation in real-time operation • Online capacity building sessions in SOPs • In-person OTJ training for SOPs to prepare the FEWS O&M team for real-time operation	September 2023
D2 Monsoon Assessment of FEWS operation and post-monsoon system updates, city graduation and SOP updates report	• Daily operation, maintenance, and troubleshooting of FEWS, and training in real-time monsoon SOPs • Conduct system performance assessment based on real-time operation and complete system updates including data adjustments of rainfall-runoff (NAM) parameters and other required system updates • Complete updates to SOPs and operation and maintenance framework based on learnings from real-time operation • In-person OTJ training in SOPs for assessment of system performance and completion of post-monsoon system updates • Post-monsoon operation coordination including gold city graduation and scale-ups as necessary • Assessment of additional technical support required	December 2023
D3 Training Report for real-time operation of the FEWS	• Documentation of training activities • Assessment of team performance and program effectiveness • Assessment of local ability to operate the system beyond 2023	November 2023

Source: Ramboll

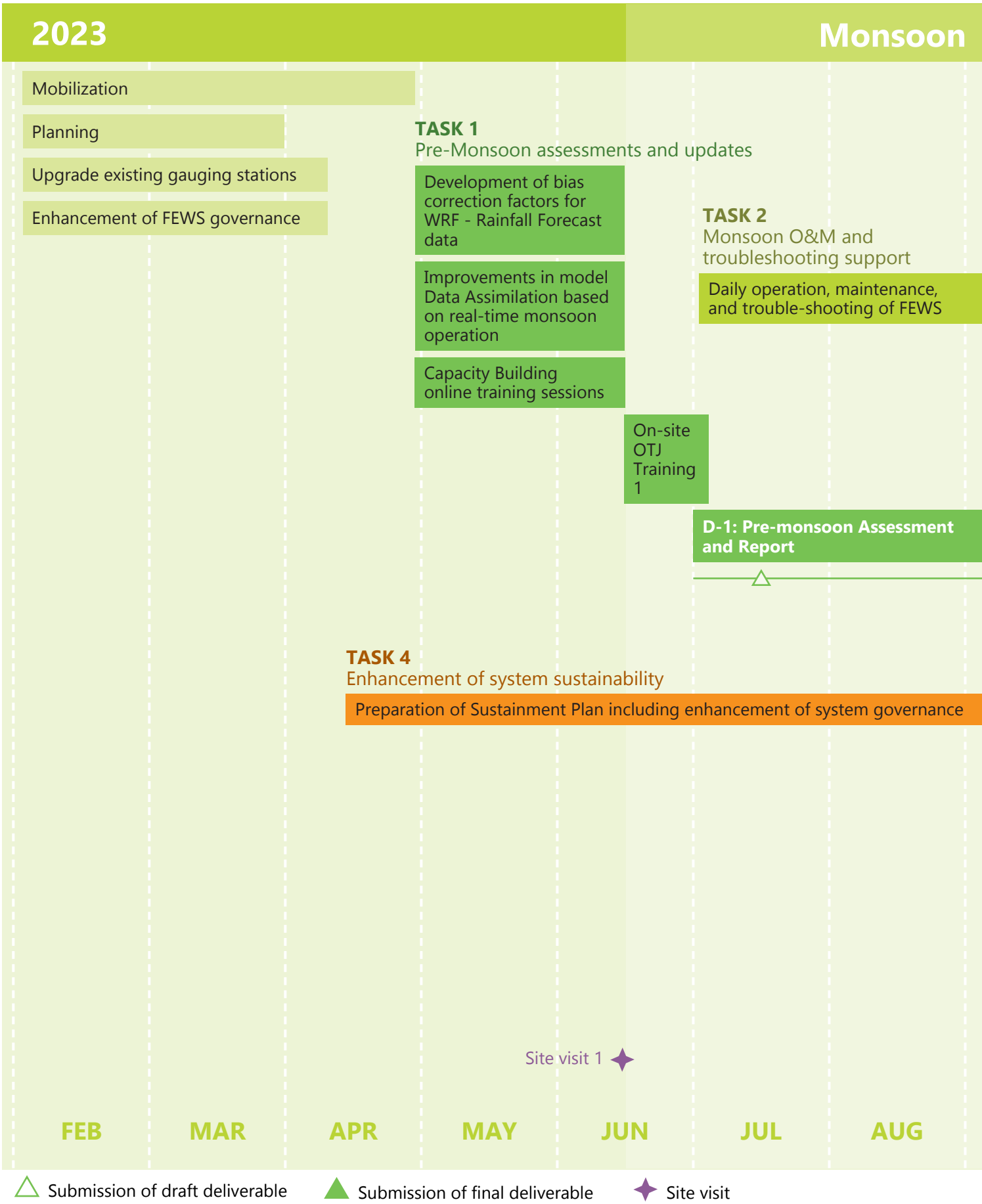
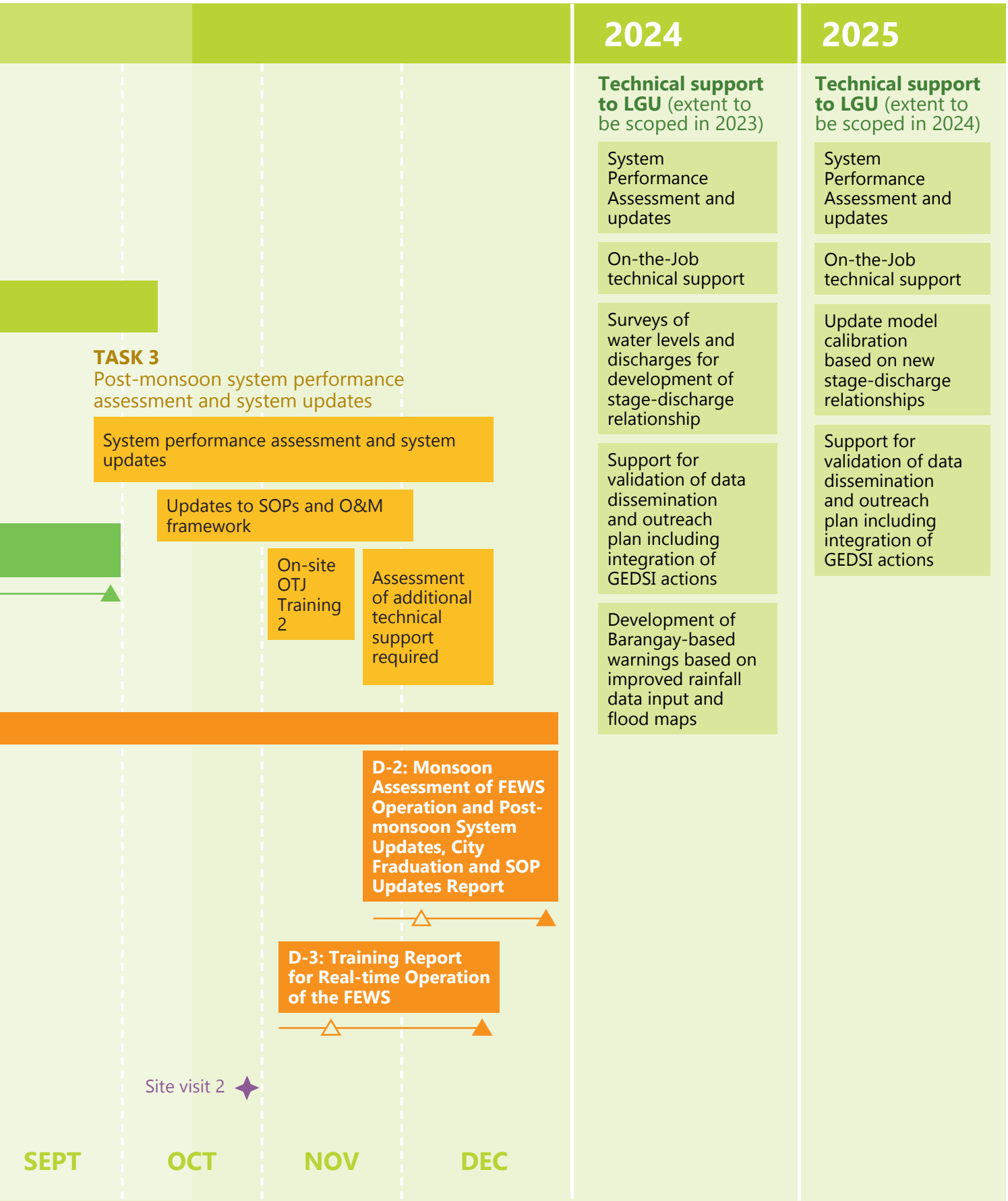


Figure 1-1 The roadmap for the Consolidation Phase
Source: Ramboll


2024
2025
Technical support to LGU (extent to be scoped in 2023)
System Performance Assessment and updates
On-the-Job technical support
Surveys of water levels and discharges for development of stage-discharge relationship
Support for validation of data dissemination and outreach plan including integration of GEDSI actions
Development of Barangay-based warnings based on improved rainfall data input and flood maps
Technical support to LGU (extent to be scoped in 2024)
System Performance Assessment and updates
On-the-Job technical support
Update model calibration based on new stage-discharge relationships
Support for validation of data dissemination and outreach plan including integration of GEDSI actions
TASK 3
Post-monsoon system performance assessment and system updates
System performance assessment and system updates
Updates to SOPs and O&M framework
On-site OTJ Training 2
Assessment of additional technical support required
D-2: Monsoon Assessment of FEWS Operation and Post-monsoon System Updates, City Fraduation and SOP Updates Report
D-3: Training Report for Real-time Operation of the FEWS
Site visit 2
SEPT
OCT
NOV
DEC

1.4 REPORT STRUCTURE

This Pre-monsoon Assessment Report is the first report out of three reports to be produced in the Baguio FEWS Consolidation Phase. The report builds on the achievements documented in the twelve reports produced in the Baguio City Smart Flood Early Warning, Information and Mitigation System pilot project. The primary intended audience comprises technical personnel from the LGU and ADB. Other intended audiences comprise policymakers, city planning officials and the broad general audience with knowledge and/or interest in smart flood early warning systems, real-time monitoring systems, city resilience, data storage and management.

The aim of this report is to provide an overview of the pre-monsoon model and system updates as well as the preparation and plan for the first full-scale test of the FEWS.

- Section 1 introduces the AASCTF programme, describes the project rationale and overall activities.
- Section 2 presents the overall FEWS framework.
- Section 3 presents the upgrades of the real-time monitoring network
- Section 4 summarizes a review of the data utilized in the FEWS.
- Section 5 presents the bias correction and data assimilation assessment and improvements.
- Section 6 outlines the model updates implemented during the 2023 pre-monsoon phase.
- Section 7 outlines the FEWS IT infrastructure updates implemented during the 2023 pre-monsoon phase.
- Section 8 describes the main activities of the 2023 Baguio FEWS Capacity Building Programme including an evaluation of the program effectiveness.
- Section 9 presents the efforts to enhance FEWS governance.
- Section 10 presents the plan for the 2023 monsoon test of the FEWS.
- Section 11 summarizes the main conclusions.

Source: Adobe Stock

2. THE FEWS FRAMEWORK

Source: Ramboll

The end-goal of the Flood Early Warning System (FEWS) development for Baguio City is to improve the city's resilience to flooding and facilitate early preparedness. The value added by the FEWS is an increase in reaction lead time by way of forecasting future water levels in the main rivers, with linked risk of flooding in Baguio. At the core of its design, the FEWS is an IT system, composed of a back-end and front-end development. The FEWS essentially hosts calibrated hydrological and hydraulic models based upon historical data and measurements which take in real-time and forecasted inputs to predict time series of flows and water levels in a river system. The FEWS is a dynamic system to be continuously improved as more data is collected and as further needs are identified. The FEWS is developed, operated, and maintained in close collaboration with the LGU and other key stakeholders to ensure ownership.

The FEWS framework including its main components are presented in Figure 2-1 and briefly described below. The FEWS technical design and system governance is detailed in the Flood Early Warning System Report.

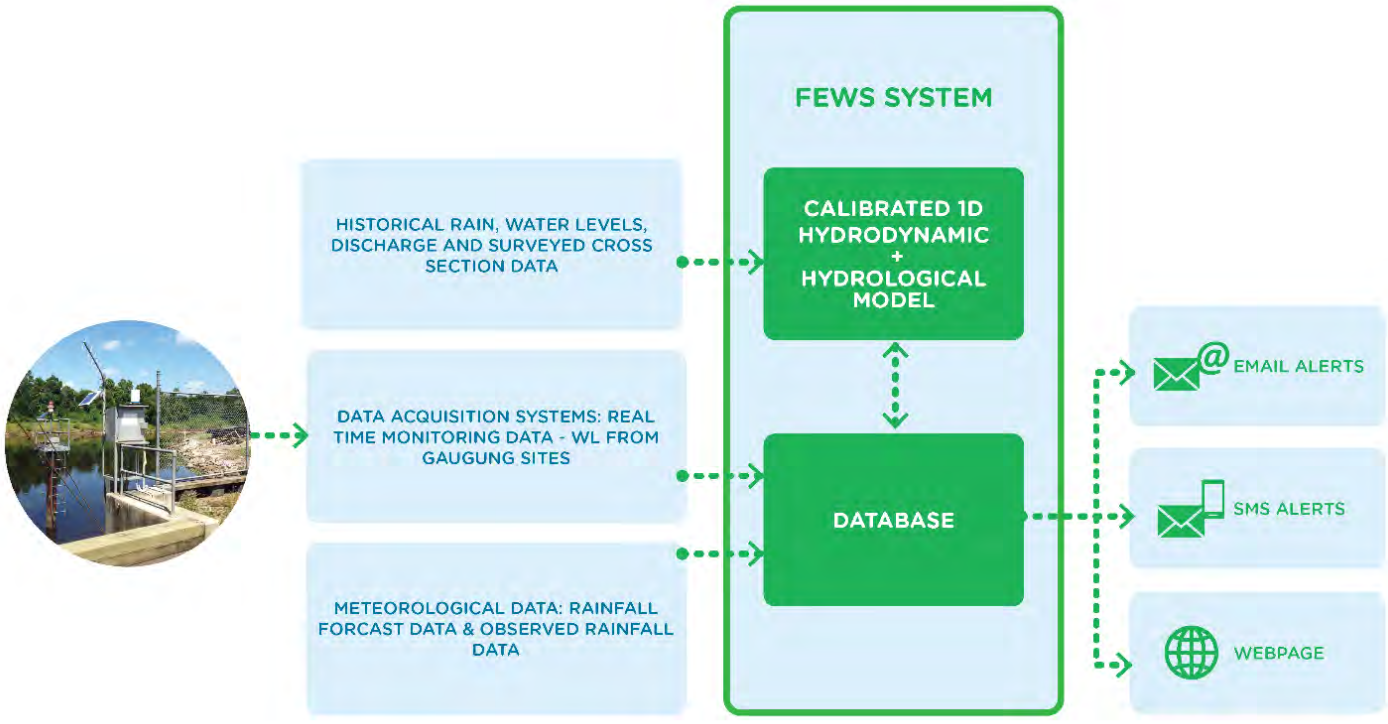


Figure 2-1 The framework for the FEWS
Source: Ramboll

Hydraulic and hydrological models calibrated with respect to recorded water level data and discharge data provides the foundation for the FEWS to replicate expected routing in the rivers and the hydrological response of the catchments to rainfall events. The rainfall forecast is the main input for the calibrated coupled Hydrodynamic-Rainfall Runoff (HD-RR) model along with real-time rainfall and water level data for data assimilation. The models are setup using the MIKE HYDRO River software, a state-of-the art modelling tool by DHI.

The FEWS IT system is designed and built using the MIKE OPERATIONS product by DHI. The real-time flood forecasting domain within MIKE OPERATIONS is configured for LGU's specific forecasting and warning requirements. The Baguio FEWS dashboard as well as the daily system logs allows the FEWS O&M team to easily monitor observed and forecasted water levels ensuring efficient operation and timely response.

The FEWS is configured to run automated Jobs to acquire all the required real-time data and information from external data sources, perform data checking for timeseries analysis and visualization, run forecast models and issue automated alerts. All processes such as downloading real-time and forecast data, updating model inputs, triggering model runs, and updating model results are automated.

2.1 OPERATION AND MAINTENANCE

The activities and tasks related to operation and maintenance of the FEWS is divided into three phases:

- Preparation phase: Pre-monsoon period (expected in April-May)
  - This phase includes preparation of the FEWS for operation in the monsoon season. The pre-monsoon system maintenance for a season will essentially be the outcome of the post-monsoon analysis of the previous monsoon.
- Application phase: Monsoon period (expected in May-October)
  - This phase includes operation and maintenance of the FEWS during the monsoon.
- Assessment phase: Post-monsoon period (expected in November-March)
  - This phase includes assessment and updating of the FEWS post-monsoon. In this phase the existing system needs to be assessed to evaluate its performance in the recent monsoon season; this assessment primarily is to be carried out in two areas: Assessment of real-time monitoring station and Updating of FEWS.

To secure effective operation of the FEWS, Standard Operating Procedures (SOPs) have been prepared. The purpose of a SOP is to carry out operations correctly and always in the same manner. The SOPs contribute to enhancing sustainability by outlining specific activities and tasks to be undertaken and serving as a guide throughout the different operation and maintenance phases.

2.1.1 THE FEWS O&M TEAM

To enable effective operation and maintenance of the FEWS for Baguio, the FEWS O&M Team has been formed. The ownership of the FEWS is anchored at the Local Government Unit (LGU) and thus, the O&M core team consists of LGU staff with support from a peer team of representatives from academia and selected relevant agencies (i.e., PAGASA, DOST-CAR). The members of the FEWS O&M team have undergone extensive training to enhance their technical capacities and their ability to operate and maintain the FEWS. The training activities and technical guidance are continuing throughout 2023 (see Section 8).

The organigram for the FEWS O&M team is seen in Figure 2-2. The well-defined team structure provides guidance to all team members by outlining the official reporting relationships that govern the workflow of the team and enhances the foundation for efficient operation and communication. The team consists of 12 people. Overall supervision of the FEWS O&M team is with the Officer-in-Charge (OIC) at the CDRRMO who has the mandate to coordinate directly with high-ranking government officials and guide in decision-making. The O&M team is led by the Team Lead supported by the Deputy Team Lead. The team is sub-divided in three smaller teams: the modelling team, the instrument team, and the IT team. Each team has a team lead and two core team specialists from the LGU. Peer support is defined for each team. The responsibility for a defined SOP will be assigned to one of the three teams.

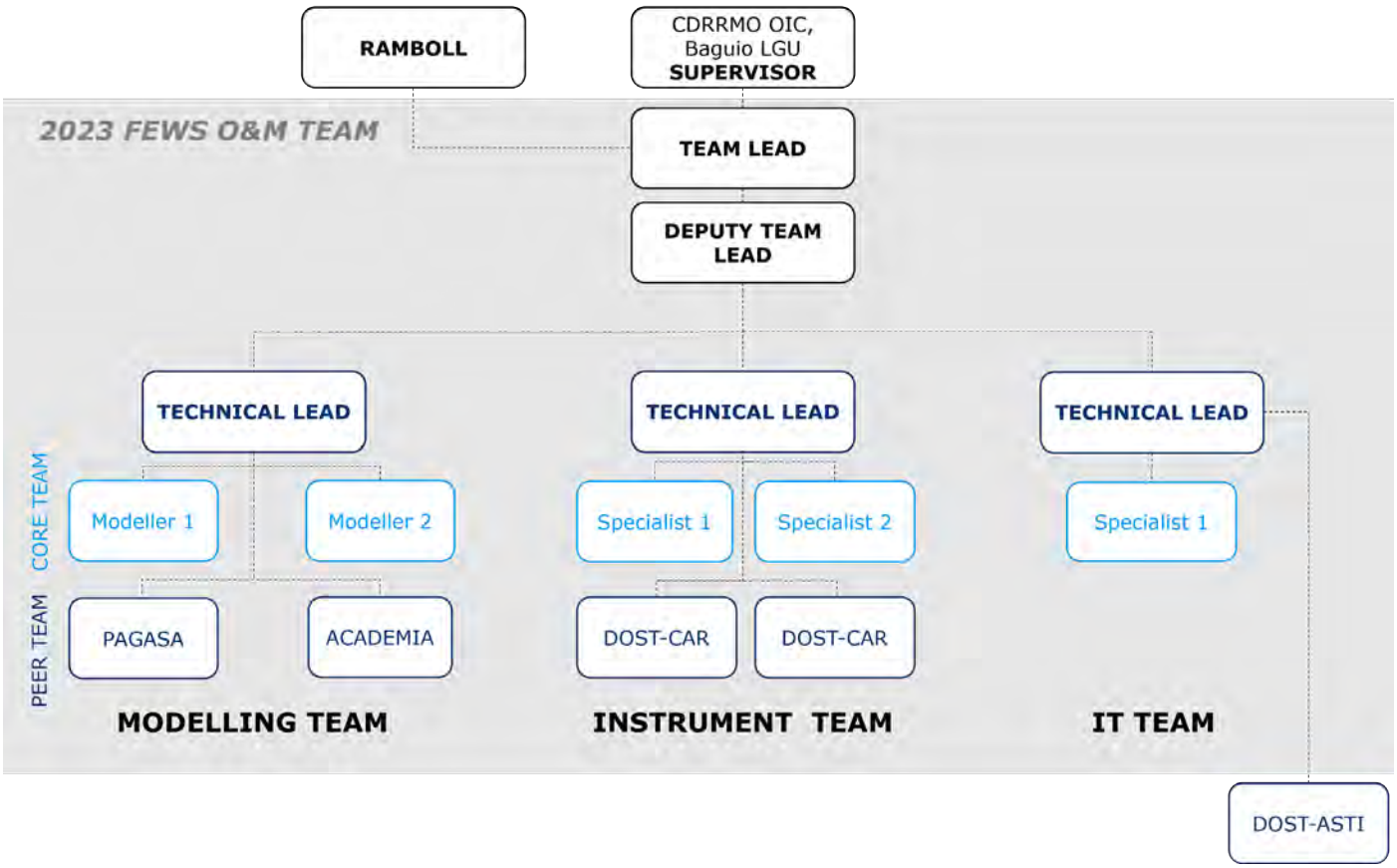


Figure 2-2 The 2023 FEWS O&M Team
Source: Ramboll

2.2 TEST AND VALIDATION OF THE FEWS

To avoid sending flawed warnings to the wrong recipients at a wrong time, the FEWS in Baguio needs to be tested and the quality of the messages need to be validated in several steps, before sending messages to the end-recipients, the affected residents of Baguio.

Launching a FEWS without proper testing and troubleshooting time can have serious consequences on the credibility of the LGU and ultimately on the confidence in the system itself. The need for testing is not limited to one single monsoon season, as any FEWS requires proper validation before it's publicly launched. A test and validation phase will last several years, depending on the number of flood events, their severity and the feedback loops established to review the messages and channels.

The first full-scale test of the system is taking place during the 2023 monsoon as the project enters the initial test phase, as seen in Figure 2-3. During the initial test phase, the FEWS will only be tested by the FEWS O&M team, and the Mayor's office will be informed about the test results on a frequent basis. During the test, the FEWS O&M team are completing SOPs throughout all operational phases to validate their effectiveness. Throughout the monsoon, the system is operated daily by the FEWS O&M team in close collaboration with Ramboll's technical team.

Figure 2-3 Organisational set-up during the expected FEWS test phases
Source: Ramboll

The expected subsequent test phases/years will gradually involve more levels and eventually include the end-users of the information. It will be a political decision when to include the different levels of recipients, as there will always be a risk involved in either disseminating too little or too late information or too broadly and too much information. The real-time operation of the FEWS during the 2023 monsoon period will serve as a basis to determine the FEWS O&M team's needs for further technical support and the need for further testing. The level of confidence in the system will be assessed as part of the post-monsoon assessment but given the limited historical data available for calibration, the system is expected to need multiple years of fine-tuning, updating, and validation.

Source: Adobe Stock

3. UPGRADE OF REAL-TIME MONITORING NETWORK

Source: Ramboll

Real-time data from monitoring stations, rainfall and water level, is used in the real-time operation of the FEWS. It is crucial for the real-time operation of the system that the stations are operating continuously. Unfortunately, the existing stations were not working properly (i.e. they have been intermittently offline) for the duration of the pilot project. Following meetings in December 2022, DOST-CAR recommended replacement of five existing stations. This is also supported by our pre-monsoon assessments of the rainfall and water level data as indicated in sections 4.2.1and 4.3.1 respectively. Thus, the task of upgrading the real-time monitoring network was initiated in early 2023 to ensure completion ahead of the monsoon at the following locations:

- Asin Bridge (Tuba)
- Balili Bridge (La Trinidad)
- City Camp Lagoon (Baguio)
- Camp 6 Bridge (Tuba)
- Irisan (Baguio)

The station equipment and construction works were procured, civil works repairs completed, platforms constructed, and the new station equipment installed by early April 2023. The stations are linked to the national PhilSensors website[1], where real-time data from the existing stations is being published, and data is accessed by the FEWS through an API provided by DOST-ASTI. The five upgraded stations have been operational since May 2023 with DOST-ASTI and DOST-CAR continuously supporting in trouble-shooting of any technical issues that may arise.

1 DOST-ASTI, "PhilSensors," 2023. [Online]. Available: https://philsensors.asti.dost.gov.ph/.

In addition to the existing stations, five new stations, one tandem station (i.e. monitoring rainfall and water level) and four water level stations, that were installed as part of the pilot project in early 2022. Thus, a total of ten (10) water level stations have been installed under the project with the data displayed publicly on the PhilSensor website for all to access. The new stations ensure greater spatial real-time data coverage of the river basins in Baguio. Figure 3-1 provides an overview of the real-time monitoring stations in Baguio City, La Trinidad and Tuba installed under the Baguio FEWS project.

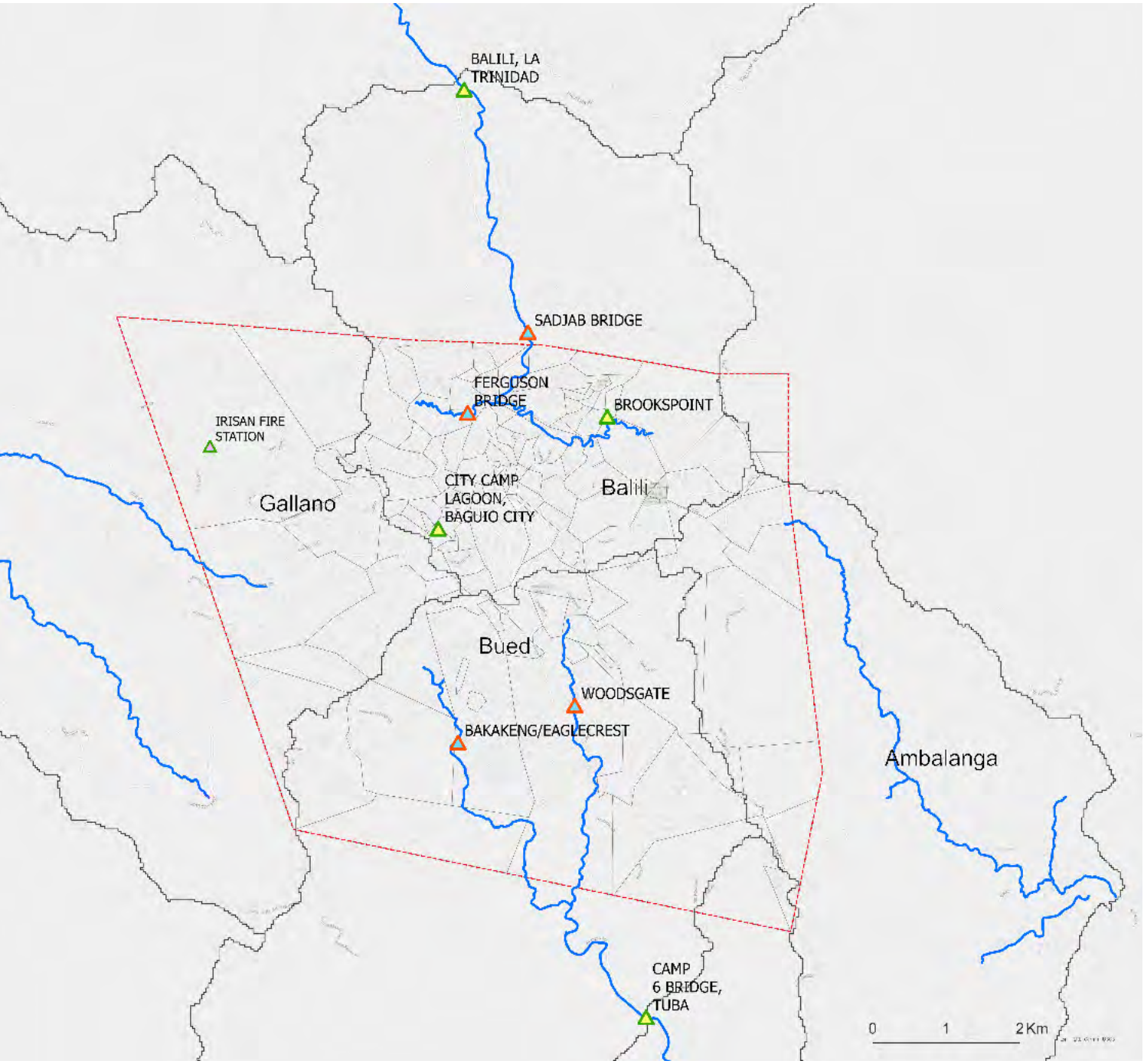


Figure 3-1 Overview of existing and new gauging stations within Baguio City
Source: Ramboll

4. DATA REVIEW

Source: Ramboll

The hydrological and hydraulic models of the FEWS were setup using data from rainfall and water level monitoring stations, rainfall forecasts, surveyed river cross-sections and elevation data. The FEWS is heavily data dependent; hence, reliability and quality are key to ensuring the success of the project. The data from monitoring stations and rainfall forecasts are briefly discussed in this section. For a comprehensive understanding of additional input data used in the model setup, see the Flood Early Warning System Report[2].

This section presents the pre-monsoon data assessment.

4.1 WRF DATA

Countrywide Weather Research and Forecasting (WRF) models are run at PAGASA for Philippines. Initialization and information of boundary conditions of the WRF model is set using GFS data. These models are not yet initialized with the data from the radar stations in the country. This is mainly due to current unavailability of adequate infrastructure for storage and processing of the data in real time from the stations at PAGASA. The outputs for the WRF models are produced every 3 hours and the different resolutions for the available gridded meteorological output is the following:

- Hourly data at a 3 km x 3 km grid and at 12 km x 12 km grid
- 3-hourly data at a 3 km x 3 km grid and at 12 km x 12 km grid
- 6-hourly data at a 3 km x 3 km grid and at 12 km x 12 km grid

The 3 km x 3 km hourly data is produced for 48-hour forecasts and the 12 km x 12 km hourly data is produced for 72-hour forecasts.

4.1.1 PRE-MONSOON REVIEW

The WRF data has been monitored for the period between May 2023 to July 2023. It has been observed that this data is being received consistently without failure by the FEWS.

2 Flood Early Warning System Report Phi: Baguio City Smart Flood Warning, Information And Mitigation System, AASCTF, April 2022.

4.2 STATION RAINFALL DATA

Real-time data from rainfall monitoring stations is used in the setup and real-time operation of the Baguio FEWS. There six stations which measure rainfall in the Baguio City and surroundings as indicated in Table 4-1. Out of these, five are tandem stations and one is a rainfall-only station. The data is observed at 10 minutes interval at these stations.

Apart from these five stations, there is an existing station Irisan PSHS, which is used in setting up the FEWS system. The station is currently inactive and has been inactive throughout 2022. Through close collaboration with the FEWS O&M team, it has recently been understood that the location of the Irisan PSHS station is incorrectly marked on the PhilSensors website. The site for the un-operational station is only approximately 600 m from the newly installed "Irisan Fire Station". The data from this new station will replace the data from the un-operational station in the FEWS setup.

The historical rainfall data i.e., the recorded measurements over a period of time, available at each station is summarized in Table 4-1 and Figure 4-1.

Table 4-1 Summary of historical data for monsoon and non-monsoon period at rainfall stations

ID	Station name	Period of historic data availability	Monsoon period			Non-monsoon period		
			Monthly average rainfall	Average no. of rainy days in a month*	Percentage time station is online	Monthly average rainfall	Average no. of rainy days in a month*	Percentage time station is online
892	Camp 6 Bridge	Jul-2017 til 2022	48.43	18	55.9%	4.6	12	58.4%
460	City Camp Lagoon	Sept-2016 til 2022	232.25	20.25	70.5%	1.5	3.6	16.3%
463	Asian Bridge	Jun-2016 til 2022	650.1	23.25	75.9%	43.8	18	57.7%
2894	Brookspoint	Oct-2022 til 2022	321.1	14	80.75%	2.75	2.7	61.5%
1390	Balili Bridge	May-2016 til 2022	834.75	15.6	56.3%	5.5	5.5	52.7%
3028	Irisan Fire Station	May-2023	497.7	23	83.7%	-	-	-

* Rainy days here are defined as those days where rainfall is more than 1 mm

Source: Ramboll

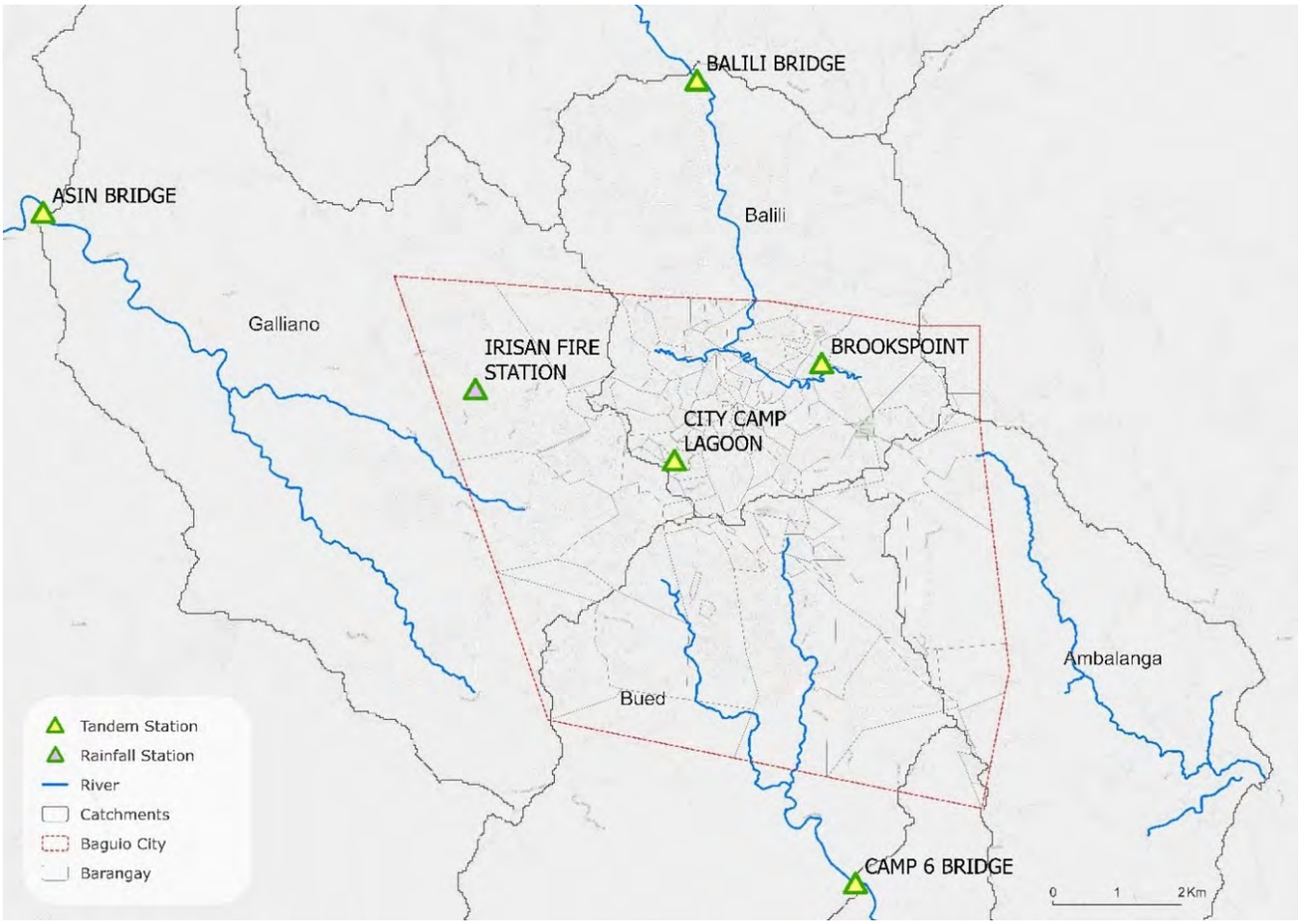


Figure 4-1 Real-time rainfall monitoring stations used in FEWS
Source: Ramboll

4.2.1 PRE-MONSOON REVIEW

The review of station operation was done to identify issues with the stations of the system, if any. It was found that the existing stations are intermittently offline. Table 4-2 summarises the percentage time the stations have been online for the period from October 2022 to April 2023, which is post the last monsoon, and after the station upgrades in May 2023 (presented in detail in Section 3). It is crucial for the real-time operation of the system that the stations are operational and providing data continuously. However, all the stations are online more than 80% of the time after the upgrades were completed, and since the onset of the consolidation phase during which the O&M team has initiated daily monitoring and maintenance of the stations.

Table 4-2 Summary of rainfall stations

ID	Station name	Sensor type	Period of station assessment	Percentage time station is online	
				From Oct-2022 to Apr-2023	From May-2023[a]
892	Camp 6 Bridge	Tandem	Oct-2022 to Jul-2023	60.6%	82.3%
460	City Camp Lagoon	Tandem	Oct-2022 to Jul-2023	20.5%	83%
463	Asian Bridge	Tandem	Oct-2022 to Jul-2023	48.8%	83.3%
2894	Brookspoint	Tandem	Oct-2022 to Jul-2023	64.1%	89%
1390	Balili Bridge	Tandem	Oct-2022 to Jul-2023	44%	86.3%
3028	Irisan Fire Station	Rainfall	Oct-2022 to Jul-2023	-	83.7%
69	Irisan PSHS	Rainfall	Jun-2016 to Oct-2020		Station Inactive

[a] In May 2023, the consolidation phase kicked off and the established FEWS O&M team initiated daily monitoring and maintenance of all stations. Furthermore, the upgrade of monitoring stations was completed in May 2023.

Source: Ramboll

4.3 WATER LEVEL DATA

There are nine water level monitoring stations in the system. These are real-time monitoring stations linked to the PhilSensors website[1], where real-time data from the existing stations is being published and is accessed through an API provided by DOST-ASTI. They monitor water level data at 10-minute intervals. The list of the water level monitoring stations is provided in Table 4-3.

Table 4-3 Summary of historical data for monsoon and non-monsoon period at Water level stations

ID	Station name	Period of historic data availability	Monsoon period		Non-monsoon period	
			Average water level	Percentage time station is online	Average water level	Percentage time station is online
2893	Sadjap Bridge	Sep-2022 to date	1343.99	85.7	1342.4	58.5
460	City Camp Lagoon	May-2016 to date	1420.6	82.1	1417.5	80.2
2896	Camp 7	Sep-2022 to date	1238.5	85.7	1242.2	60.5
463	Asin Bridge	May-2016 to date	219.2	58.5	215.3	53.2
2894	Brookspoint	Sep-2022 to date	1406.4	85.3	1405.6	58.5

1 DOST-ASTI, "PhilSensors," 2023. [Online]. Available: https://philsensors.asti.dost.gov.ph/.

ID	Station name	Period of historic data availability	Monsoon period		Non-monsoon period	
			Average water level	Percentage time station is online	Average water level	Percentage time station is online
892	Camp 6 Bridge	Feb-2017 to date	772.3	64.7	773.4	63.4
1390	Balili Bridge	Jun-2014 to date	1305.1	78.1	1304.5	83.7
2892	Ferguson Bridge	Sep-2022 to date	1368.7	85.7	1367.2	60.3
2895	Eagle Crest	Sep-2022 to date	1317.5	57	1312.8	60.5

Source: Ramboll

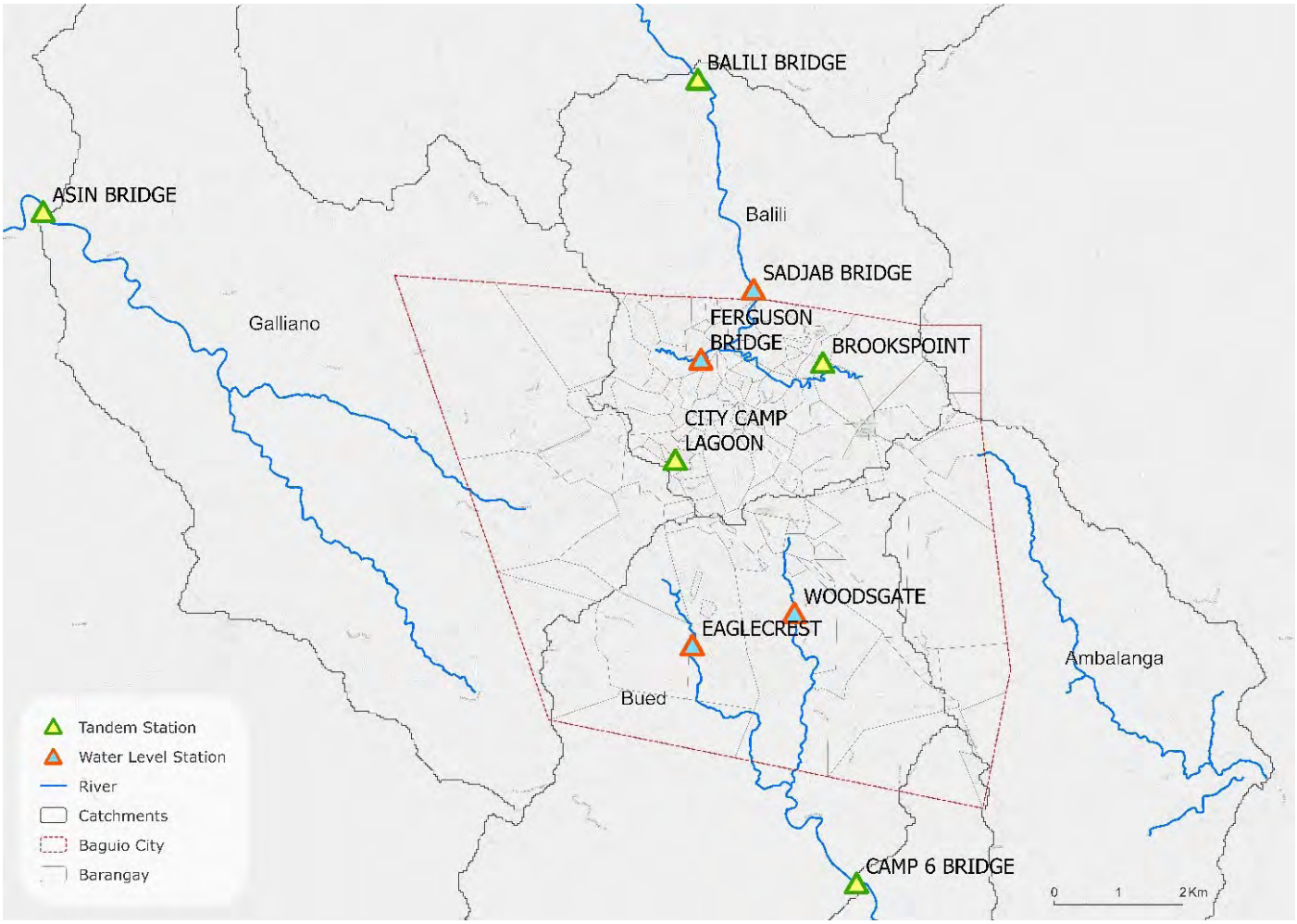


Figure 4-2 Real-time water level monitoring stations used in FEWS

Source: Ramboll

4.3.1 PRE-MONSOON REVIEW

The review of station operation was done to identify the issues with the stations of the system, if any. It was found that the existing stations are intermittently offline. Table 4-4 summarises the percentage time the stations have been operational during the period from October 2022 to April 2023 and after the station upgrades in May 2023 (presented in detail in Section 3). All stations are have been online more than 75% of the times after the station upgrades were completed. It is crucial for the real-time operation of the system that the stations are operating and providing data continuously. The station log will be prepared during the monsoon phase to identify the major causes of station failure and measures to avoid any station failure.

Table 4-4 Summary of water level stations

ID	Station name	Sensor type	Period of station assessment	Percentage time station is online	
				From Oct-2022 to Apr-2023	From May-2023[a]
2893	Sadjap Bridge	Water Level	Oct-2022 to Apr-23	61.1%	85.7%
460	City Camp Lagoon	Tandem	Oct-2022 to Apr-23	19.5%	79%
2896	Camp 7	Water Level	Oct-2022 to Apr-23	62.7%	85.7%
463	Asin Bridge	Tandem	Oct-2022 to Apr-23	46.4%	79.3%
2894	Brookspoint	Tandem	Oct-2022 to Apr-23	61%	85.3%
892	Camp 6 Bridge	Tandem	Oct-2022 to Apr-23	57.7%	78.3%
1390	Balili Bridge	Tandem	Oct-2022 to Apr-23	41.8%	82.3%
2892	Ferguson Bridge	Water Level	Oct-2022 to Apr-23	62.7%	85.7%
2895	Eagle Crest	Water Level	Oct-2022 to Apr-23	62.8%	85%

[a] In May 2023, the consolidation phase kicked off and the established FEWS O&M team initiated daily monitoring and maintenance of all stations. Furthermore, the upgrade of monitoring stations was completed in May 2023.

Source: Ramboll

Source: Ramboll

5. REVIEW OF BIAS CORRECTION AND DATA

Source: Adobe Stock

The reliability and accuracy of a flood forecast model depend on various factors, including the quality and availability of input data, the accuracy of initial conditions, and the data observed at monitoring stations. The quality of the input data used in the flood forecast model is critical. Inaccuracies in these data can lead to discrepancies between the model's forecasts and actual observations. To reduce the errors induced by such discrepancies, bias correction is applied on the input data (i.e., forecasted rainfall). However, the model output is expected to be impacted by model uncertainty due to model parameterization and numerical errors. To further reduce the errors in the model forecasts, the data assimilation is applied to the model. The data assimilation applies appropriate corrections to the water level forecasts and thus, producing more reliable forecasts.

In 2022, preliminary bias correction and data assimilation have been included in the models used for the FEWS setup. Currently in the FEWS, the bias correction is to correct the rainfall forecast data based on statistical correlation with historical rainfall for a period of 12 hours prior to the time of forecast for each model simulation and data assimilation is to correct the simulated water levels in the hydrodynamic model based on actual observations of flows recorded at the stations.

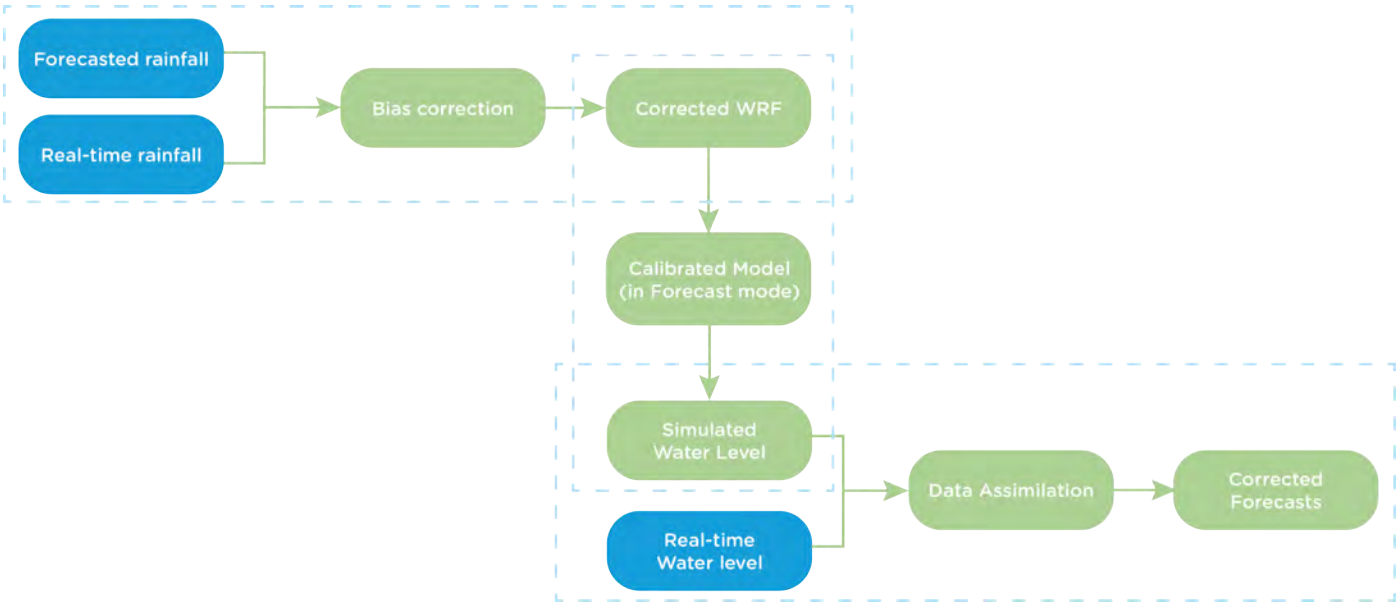


Figure 5-1 Framework of model improvements in consolidation phase
Source: Ramboll

However, due to delays in collection of the historical forecast rain data by PAGASA and persistent challenges related to continuous operation of real-time monitoring stations (see Section 3), the bias correction methods were not validated against historical data analysis and the data assimilation was also not tested during real-time operation in the monsoon period.

Since May 2023, during the consolidation phase, efforts have been made to close this gap and upgrade the FEWS as illustrated in Figure 5-1.

5.1 DATA OVERLAPS AND GAPS

Real-time data from monitoring stations, rainfall and water level, is used in the real-time operation of the system to run the models. The data with timely overlapping periods is a prerequisite for testing and fine-tuning the system, which includes WRF, rainfall and water level data. These periods of overlaps need to include periods with significant rainfall i.e., Monsoon period. At present, the overlapping data is available for only four monsoons (2017 to 2020). And unfortunately, the stations were intermittently offline even during this overlapping period. Therefore, the overlapping data is very limited, and this data is required for testing and progressively improving the model. The model benefits from a larger dataset, leading to improved performance.

It's important to highlight that all the historical data gathered can be utilized in upcoming model revisions, consistently adding value to the advancement of FEWS. Raw data remains irreplaceable and cannot be reproduced or reconstructed. Therefore, in this phase, collection of more data (WRF, rainfall and water level) is an important activity and will support in further improving the model and its other components.

The period of historical rainfall data availability at each station is summarized in Table 4-1. The period of water level data availability at each station is summarized in Table 4-3. The data availability is comparatively large at Balili Bridge, City Camp Lagoon, Asin Bridge and Camp 6 Bridge stations.

Station Name		Camp 6 Bridge		City Camp Lagoon		Asin Bridge		Brookspoint		Balili Bridge		Irisan Station		Sadjap Bridge		Camp 7		Ferguson Bridge		Eaglecrest	
	Data Type	Rainfall	Water lev	Rainfall	Water lev	Rainfall	Water lev	Rainfall	Water lev	Rainfall	Water lev	Rainfall	Water lev	Rainfall	Water lev	Rainfall	Water lev	Rainfall	Water lev	Rainfall	Water level
2016	May												X	X		X		X		X	
	Jun												X	X		X		X		X	
	Jul												X	X		X		X		X	
	Aug												X	X		X		X		X	
	Sep												X	X		X		X		X	
	Oct												X	X		X		X		X	
2017	May												X	X		X		X		X	
	Jun												X	X		X		X		X	
	Jul												X	X		X		X		X	
	Aug												X	X		X		X		X	
	Sep												X	X		X		X		X	
	Oct												X	X		X		X		X	
2018	May												X	X		X		X		X	
	Jun												X	X		X		X		X	
	Jul												X	X		X		X		X	
	Aug												X	X		X		X		X	
	Sep												X	X		X		X		X	
	Oct												X	X		X		X		X	
2019	May												X	X		X		X		X	
	Jun												X	X		X		X		X	
	Jul												X	X		X		X		X	
	Aug												X	X		X		X		X	
	Sep												X	X		X		X		X	
	Oct												X	X		X		X		X	
2020	May												X	X		X		X		X	
	Jun												X	X		X		X		X	
	Jul												X	X		X		X		X	
	Aug												X	X		X		X		X	
	Sep												X	X		X		X		X	
	Oct												X	X		X		X		X	
2021	May												X	X		X		X		X	
	Jun												X	X		X		X		X	
	Jul												X	X		X		X		X	
	Aug												X	X		X		X		X	
	Sep												X	X		X		X		X	
	Oct												X	X		X		X		X	
2022	May												X	X		X		X		X	
	Jun												X	X		X		X		X	
	Jul												X	X		X		X		X	
	Aug												X	X		X		X		X	
	Sep												X	X		X		X		X	
	Oct												X	X		X		X		X	
	Data available																				
	Poor data quality																				
	No data																				
X	Not Applicable																				

Figure 5-2 Historical real-time monitoring station data availability and overlapping period
Source: Ramboll

Figure 5-2 indicates the months for which data is available at the stations. The red dashed box in the figure indicates the overlapping data which is a prerequisite for fine-tuning the system and testing the bias correction and data assimilation. The overlapping data is available for the monsoons from year 2017 to 2020.

5.2 BIAS CORRECTION

The models developed for the FEWS have been calibrated against historically observed water level data using historical rainfall data as input[2]. The historical rainfall used for calibration is from stations in the region, i.e., input rain data is from point sources as indicated in Section 4.2. The forecasted rain that is applied to the model is gridded rainfall data produced by climate models running in real time on Pagasa servers, i.e., WRF data described in Section 4.1. The spatial distribution of WRF data and rainfall monitoring stations is shown on Figure 5-3.

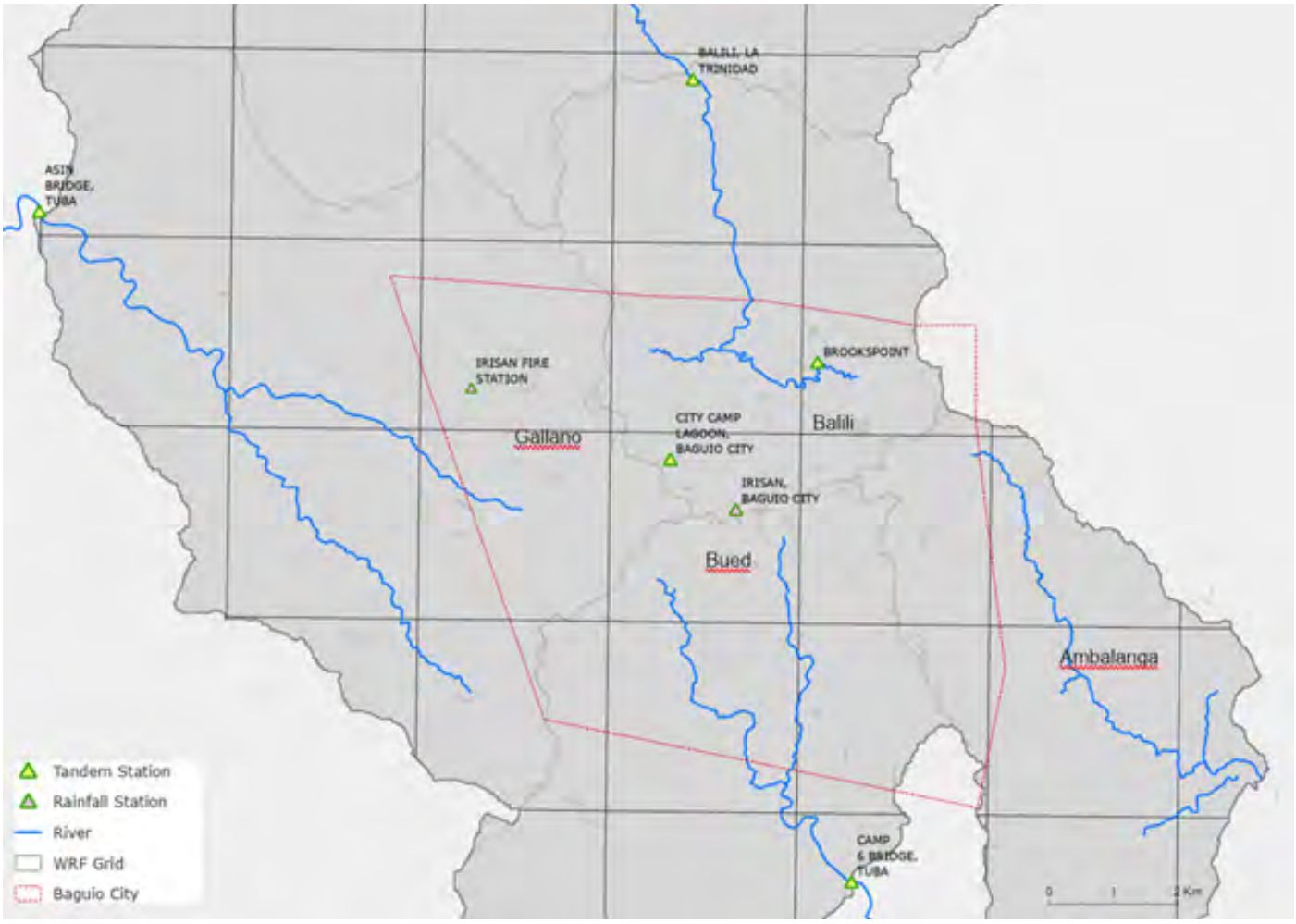


Figure 5-3 Spatial distribution of WRF and real-time rainfall monitoring stations
Source: Ramboll

2 Flood Early Warning System Report Phi: Baguio City Smart Flood Warning, Information And Mitigation System, AASCTF, April 2022.

WRF models are numerical weather prediction models. These models simulate atmospheric processes to predict future weather conditions and can exhibit biases that lead to overestimation or underestimation of the rainfall. Biases can arise due to various reasons, such as uncertainty in input data, uncertainty in initial conditions, parameterization, spatial and temporal resolution, or due to models biases that do not adequately capture the underlying atmospheric processes.

The hourly rainfall forecast from PAGASA, at a resolution of 3 km, is a key input for the FEWS as the rainfall forecasts are primary driver for the flood forecast. The WRF models run on the PAGASA server at 0000, 0300, 0600, 0900, 1200, 1500, 1800, 2100 hours UTC. Philippine time is UTC + 8 hours. 48 hours for the WRF data is used as input in the FEWS currently. For data analysis, each time the forecast is available, it has been segmented into 16-levels, wherein each level is hourly data for 3 hours. The data from PAGASA is received by the FEWS with a delay of 3 hours due to the upload, download and processing times. This implies that the first level of forecast from the PAGASA has already occurred at the time the data is received by the FEWS. Therefore, we have fifteen levels of rainfall forecasts available. The level of forecast and availability of WRF data is illustrated in Figure 5-4.

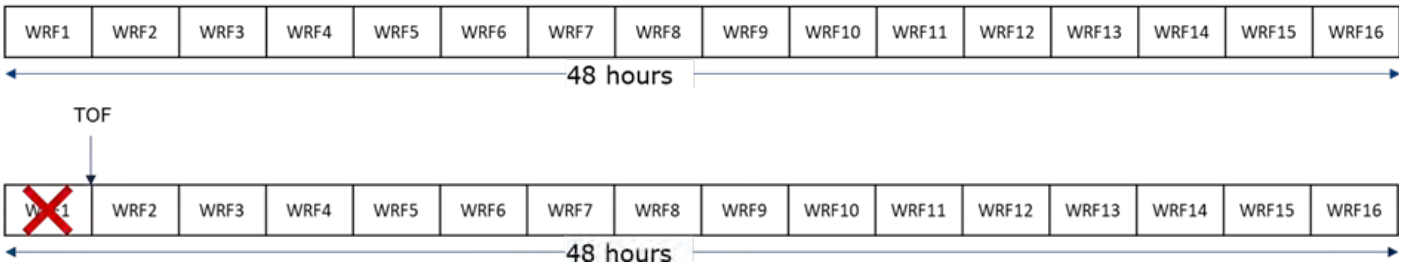


Figure 5-4 Illustration of level of forecasts in WRF data from PAGASA

Here, WRF1 means first level of forecast, WRF2 means second level forecast and so on. TOF - Time of forecast

Source: Ramboll

The accuracy of a forecast in relation to lead time reduces i.e., the forecast shorter lead times tend to be more reliable due to reduced data variability and uncertainty, while longer lead times often lead to diminished accuracy, known as accuracy decay, due to increased unpredictability. The WRF data is grouped in accordance to the level of forecasts for analysis of bias correction and data assimilation.

It is essential to correct the forecasted rainfall input as much as possible to get accurate outputs from the FEWS for which bias correction is applied.

Bias correction is a statistical technique used to adjust biases that may be present in the rainfall forecast data. Thus, aim to improve the accuracy of rainfall forecasts by reducing or eliminating these systematic errors. The concept of biases in rainfall data and bias correction is illustrated in Figure 5-5.

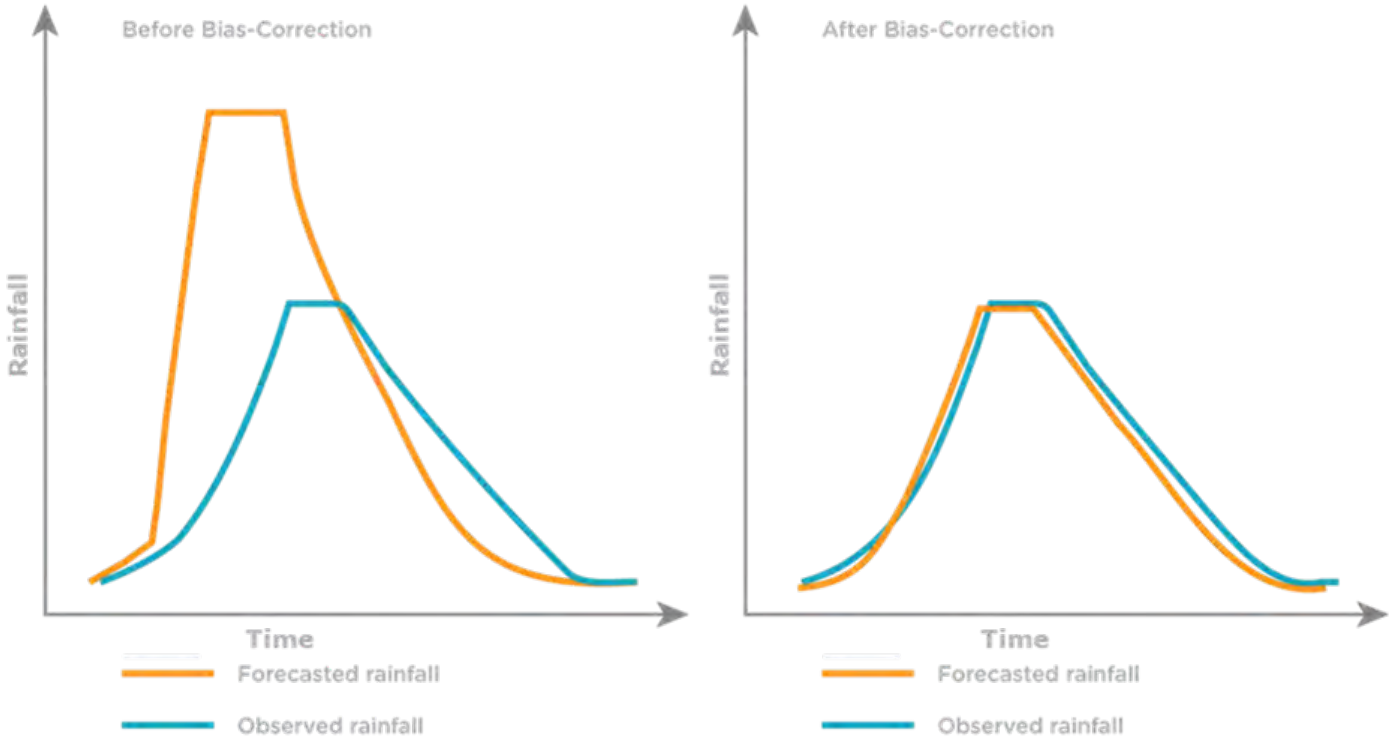


Figure 5-5 Illustration of bias-correction concept
Source: Ramboll

5.2.1 APPROACH

There are numerous methods for bias correction. Bias correction methods can vary depending on the type and source of bias, the available data, and the specific application. Applying an unsuitable bias correction can have adverse impacts on the performance of the system. To ensure that the most suitable method is identified, multiple methods have been assessed.

Techniques considered include:

1. Cumulative Distribution Function (CDF) Matching: CDF matching involves finding the cumulative distribution function of observed rainfall and then matching it with the cumulative distribution function of the forecasted rainfall to correct biases. However, in doing so, it may not preserve the original characteristics of the model output, leading to some loss of information, such as heavy rainfall events, as the focus is on matching the distribution at percentiles, and not at specific extreme values. And therefore, these approaches are not suitable for flood forecasting studies. However, the CDF matching is performed here as an investigatory tool to identify the overall bias in the forecasted rainfall.

2. Ensemble Bias Correction: Ensemble bias correction involves using multiple bias correction methods to create an ensemble of corrected rainfall datasets. This approach can help capture uncertainties in bias correction and improve the overall accuracy of the final results. However, ensemble bias correction can be computationally intensive. Running multiple models in an ensemble requires additional computational resources and time and thus, these are not suitable for forecast models.

3. Error-based approaches: These techniques adjust the forecasted rainfall with real-time observed rainfall data to improve the accuracy of the model output. This approach helps to correct biases in rainfall forecasts and produce more reliable predictions. The method involves analysing the available rainfall observations and comparing them to the forecasted rainfall for the hindcast period and adjusting the forecast rainfall accordingly. This method has been applied to identify and correct the bias in the forecasted rainfall in Baguio FEWS currently. The error in the data is computed for each simulation based on a timespan before the specified time of forecast. This error, which is calculated, is then applied and helps improve the forecasts.

The algorithms for testing the effectiveness have been developed in the system. The testing is being done for historical periods and also in real time during the monsoon of 2023. For the testing on the historical data, simulations are being run during the periods of data availability as indicated in Figure 5-2. For each day during the identified periods, 8 simulations are run for 4 scenarios, wherein the different scenarios have different timespans of error calculation, i.e., 3 hour, 6 hour, 9 hour and 12 hour. These scenarios are illustrated in Figure 5-6.

The difference of the forecasted water level recorded for each simulation is added to the sample for the statistical analysis. For more dependable outcomes, it is recommended to have as large a sample size as possible. The computational run-time of 4 scenarios is 20 minutes and a total of 12 months between 2017 and 2022 have been identified. This run time has been computed based on the simulation period from 5 days in hindcast to 42 hours in forecast. Considering the significant computational time required for the total runs, partial assessment based on limited simulations (approximately 3500 out of 11500 simulations run in May and June 2023 of the consolidation phase) has been carried out in the pre-monsoon period. This has been done to ensure that the real time testing of the overall FEWS in the monsoon of 2023 is not delayed. The simulations are being continued and the final outputs will be reflected in the updated models in the post-monsoon phase. The section 5.2.2 elaborates our findings from the pre-monsoon assessments.

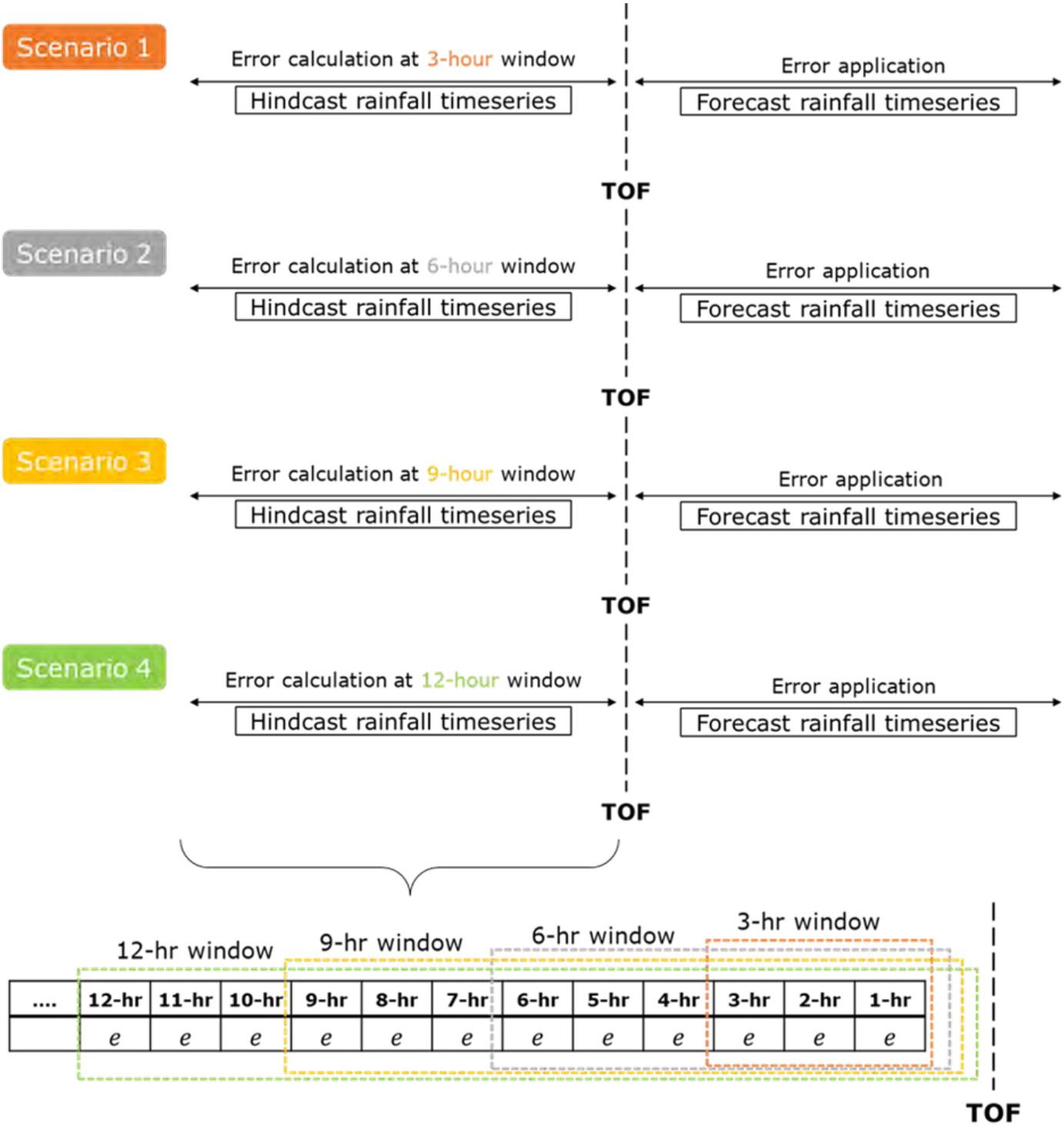


Figure 5-6 Different scenarios of bias error estimation

TOF - Time of forecast

Source: Ramboll

5.2.2 OUTCOME

The completed simulations were reviewed to understand which bias correction scenario/strategy is performing better. The model performance review has been done on the basis of the difference between the simulated water level for each scenario and the observed water level, which is the estimated error. The primary objective is to identify the scenario which is giving the lowest error. Lower error indicates lesser divergence from observed, implying better performance of the scenario.

Another statistical parameter to observe is the variation of the error in each scenario. A larger variation implies that model can give larger deviations in the forecasts from actual on-ground situations. A model giving larger deviations is less reliable.

The performance of the scenarios is presented using the box-plots for the model errors, as shown in Figure 5-7 and Figure 5-8. These show the mean, quartiles, and potential outliers in the error distribution for four levels of forecasts at shorter lead times and four levels of forecasts with larger lead times respectively and effectively capture the central tendency (mean) and variability of errors for each scenario. The plots for the remaining levels of forecast are included in Appendix A.

The simulations for various scenarios performed have been categorized based on the level of forecast (refer section 5.2), wherein each level of forecast is hourly data for 3 hours. Since, the model runs for 42 hours in forecast mode, there are fourteen levels of water level forecasts. These fourteen levels of forecasts are analysed to identify the suitable time-span for bias correction.

The following are main observations from the analysis:

1. The mean error (indicated by the horizontal lines) for all scenarios are very close and small indicating that all scenarios perform well for most runs.

2. The deviations in errors of the scenarios 1 and 2 are often larger than that for scenarios 3 and 4 indicating that these 2 scenarios will give smaller errors when there are outliers in the WRF data.

3. The difference in deviations in errors for the 4 scenarios are larger in the levels closer to the time of forecast and become diminished in levels farther from the time of forecast. This indicates that the impact of choosing one scenario over the other will be prominent only for the initial few levels.

4. The scenario 3 performs quite well too. However, as the stations have been seen to not perform intermittently at times during real-time operation, scenario 4, which uses a larger time-span for error calculation, will work more consistently.

Based on these findings, it is concluded that the applied 12-hour timespan for error estimation for real-time bias correction (scenario 4) is overall the best for the system.

It is important to emphasize that the conclusions drawn above are specific to a small sample size of data. The assessment will be further validated using the remaining historical and real-time monsoon data to establish a more robust and confident error time span or scenario. Thus, the confidence in the applied bias correction method is expected to increase throughout the real-time monsoon operation ahead of the planned post-monsoon system updates. More simulations to increase the sample size is currently ongoing.

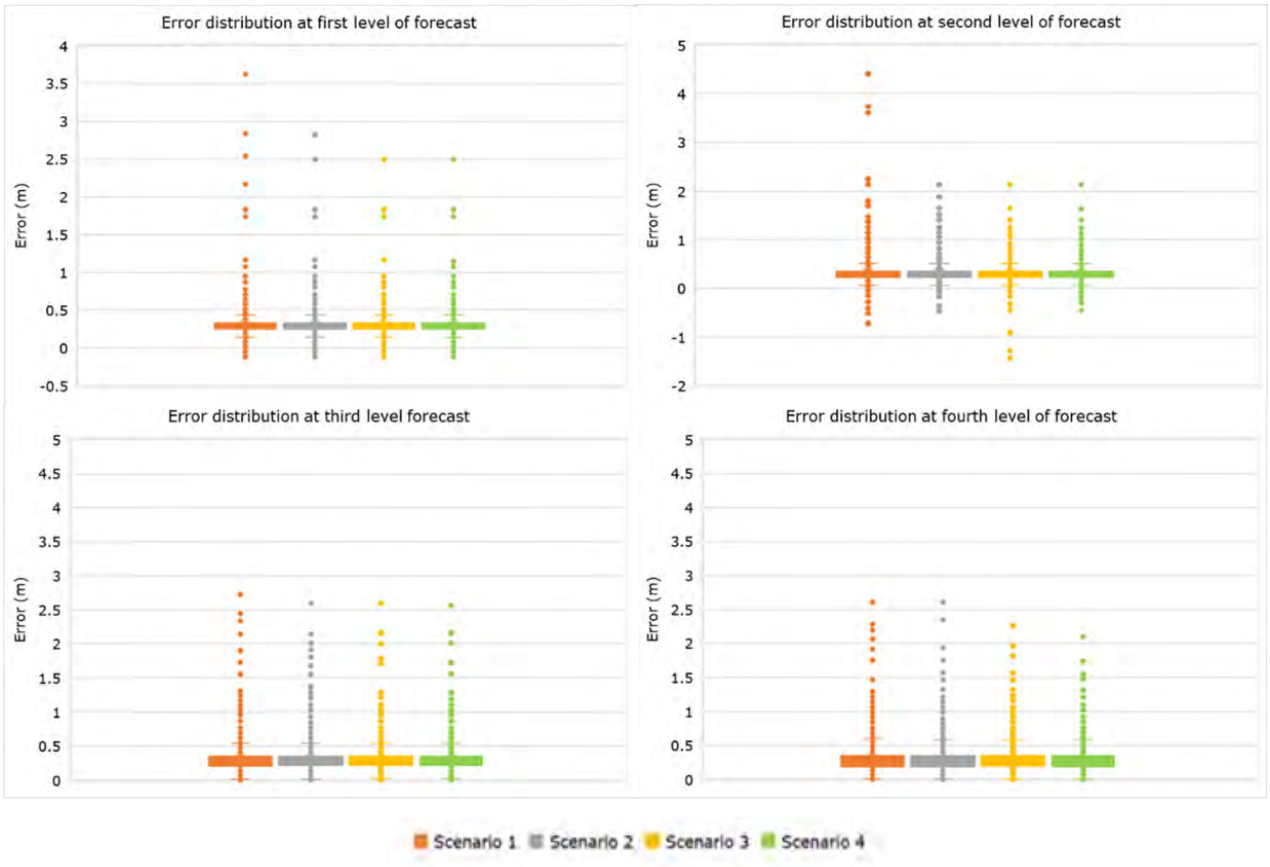


Figure 5-7 Error distribution for the four scenarios at shorter lead times

Defined as different levels of forecast. The lower the level of forecast, the shorter the lead time.

Source: Ramboll

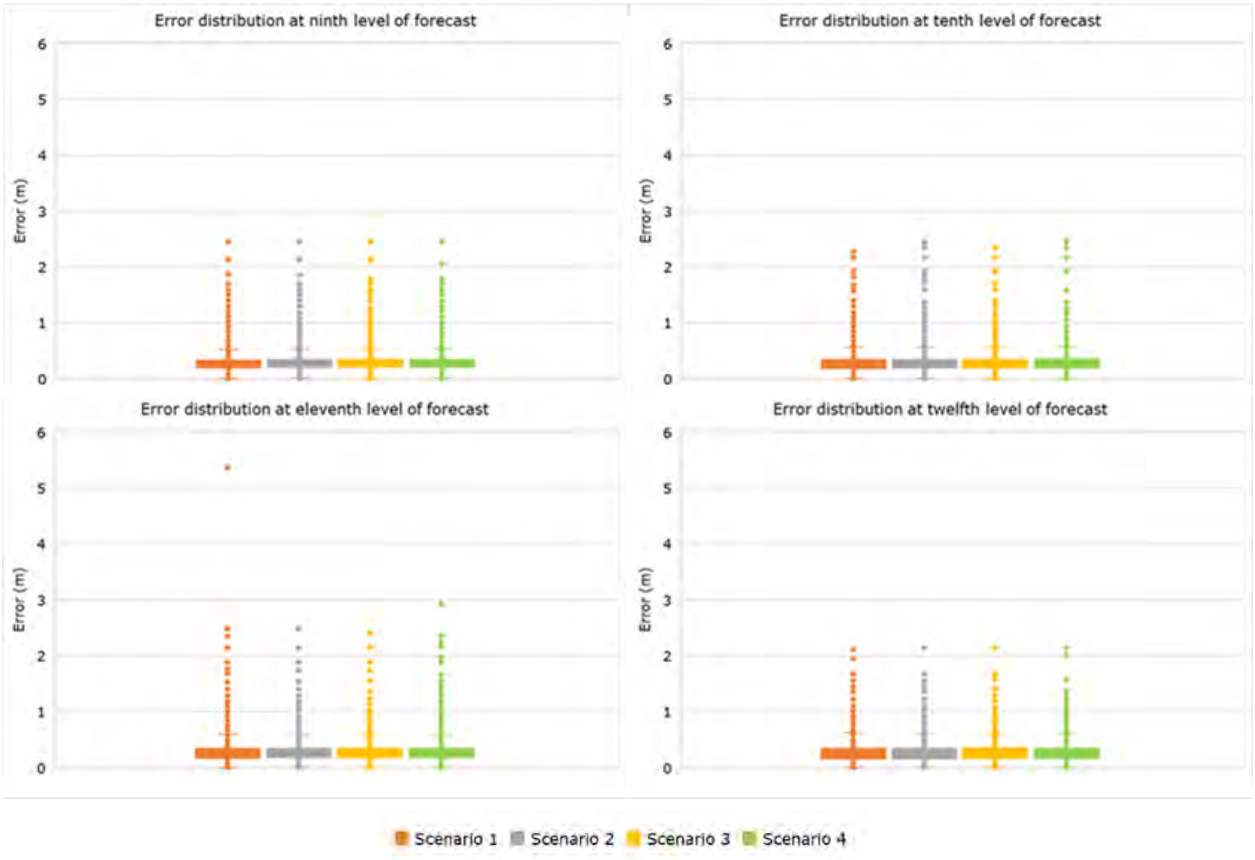


Figure 5-8 Error distribution for the four scenarios at larger lead times

Defined as different levels of forecast. The higher the level of forecast, the larger the lead time.

Source: Ramboll

5.3 DATA ASSIMILATION

Data assimilation is a process that combines observations and model estimates in an optimal manner, considering the uncertainties associated with both and the correlation between the modelled and observed measurements. The concept of data assimilation is depicted in Figure 5-9.

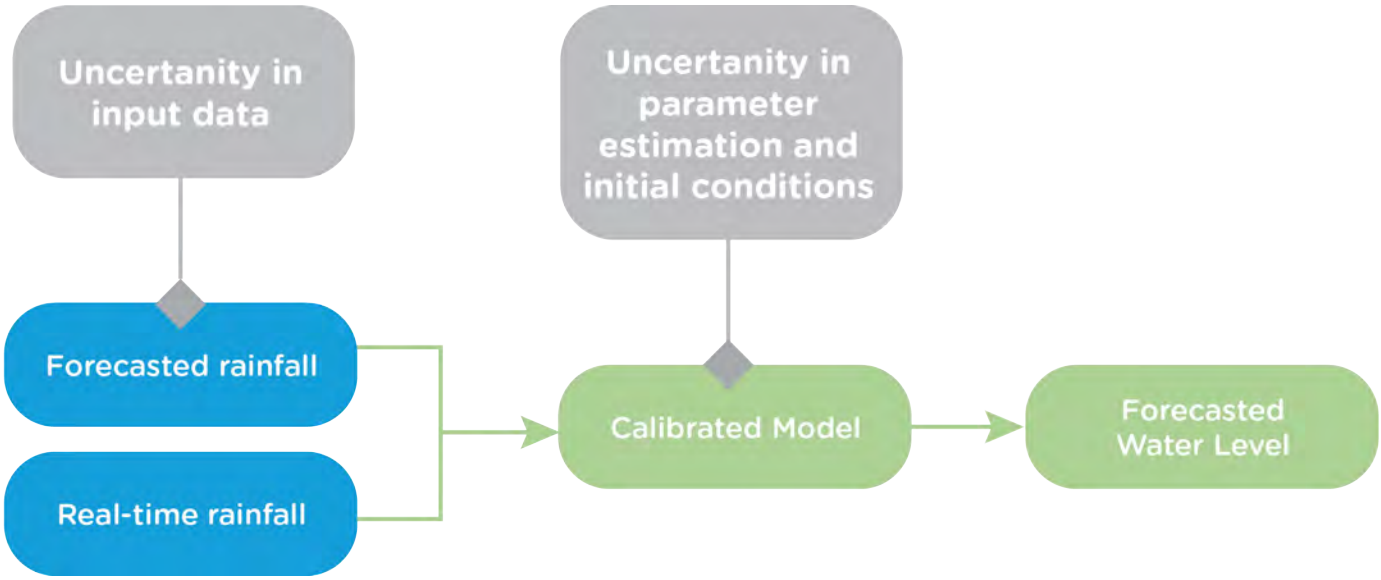


Figure 5-9 The concept of data assimilation.
Source: Ramboll

The objective is to obtain the most accurate and reliable forecasts by effectively merging the information from both observations and model simulations. This is particularly important because observations may be limited in spatial coverage, time resolution, or measurement accuracy, while models may have inherent biases or errors. By accounting for uncertainties and correlations, data assimilation helps to reduce biases and improve the overall accuracy of the model.

5.3.1 APPROACH

Observed water level data in the hindcast period is used to compute the error in the previously forecasted water levels. This error is then used to apply appropriate corrections to the water level forecasts for a specified period post time of forecast in the next model run. The application of the error correction has been setup such that it reduces gradually at each timestep post time of forecast till it gets nullified.

The process involves analysing the available water level observations, comparing them to the model results for hindcast period, and adjusting the model predictions accordingly. In-built Data Assimilation (DA) module of MIKE Hydro River has been used to accomplish the objective. The DA is defined using error function.

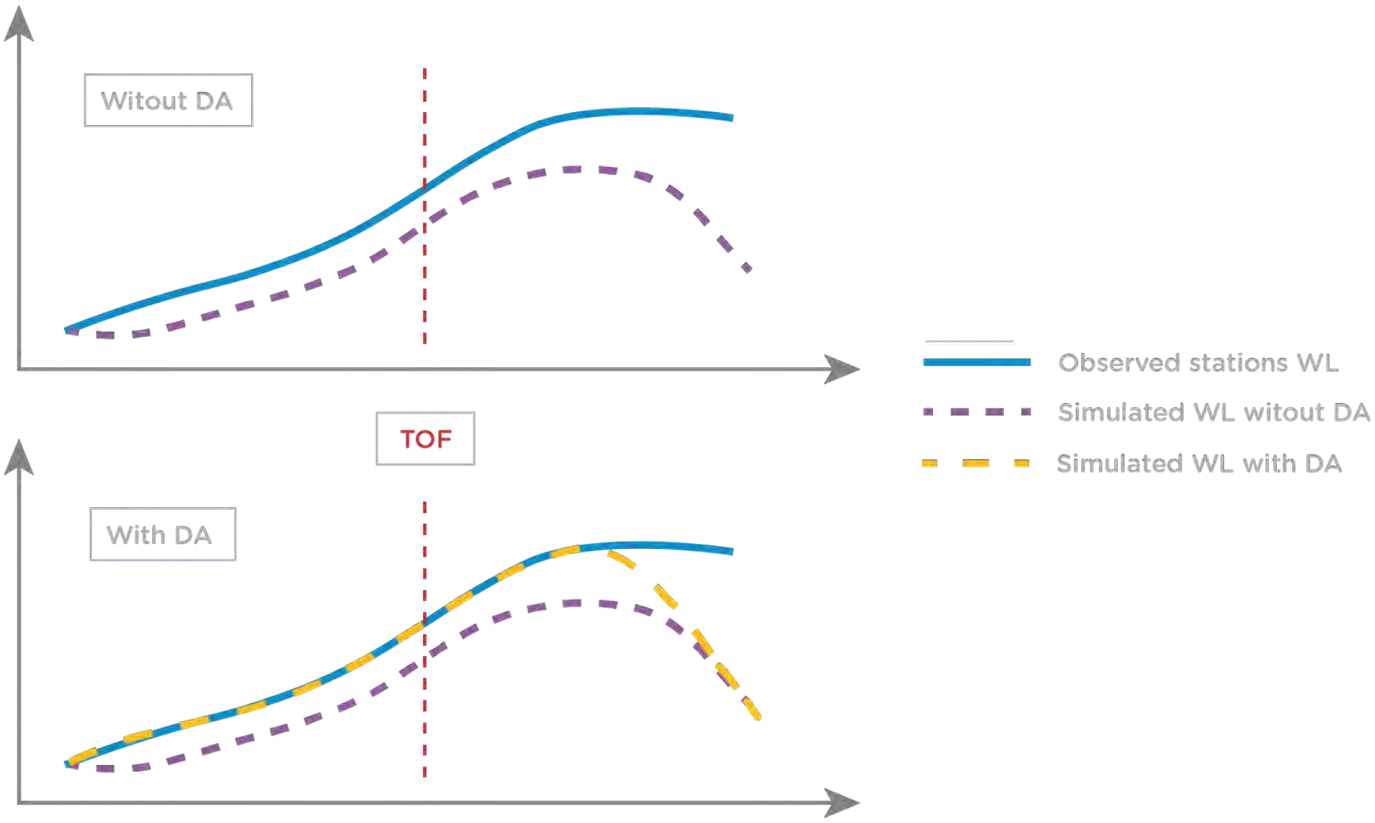


Figure 5-10 Illustration of data assimilation concept
TOF - Time of forecast, DA - Data assimilation, WL - Water level
Source: Ramboll

The error in the data is computed based on a "time-span" before the time of forecast. The time-span for which this error is calculated and then applied makes a difference to how the forecasts improve.

5.3.2 OUTCOME

To validate the appropriate time-span for error calculation at each water level station location, algorithms have been developed to run repeated simulations in automation during the real time operation in 2023 monsoon, to generate results for four DA-strategies with time-spans at 6 hours, 12 hours, 24 hours and 36 hours, respectively. All four DA-strategies are being tested through the 2023 monsoon real-time operation.

The data collected during the full-scale test of real-time operation will be assessed and appropriate changes to DA will be applied in the post-monsoon period.

6. MODEL UPDATES

Source: Adobe Stock

It is necessary to ensure the Baguio FEWS is robust and fail-proof during its real-time operation in the monsoon season. Failure to do so could result in inadequate warning (and thus response) to the flood events. Ensuring stable and resilient operation of the FEWS has been a key priority during the pre-monsoon activities. Therefore, the pre-monsoon phase has been finalised by ensuring that the overall model framework is in stable operation and ready for real time testing during the monsoon.

In the pre-monsoon phase, various activities have been completed to improve the performance of FEWS by increasing the reliability as well as stability of the models. The model was calibrated in 2022 using the available historical data. The model set-up is described in the Flood Early Warning Report [1]. It is important to ensure that the model is able to withstand the storm events/flood events of larger magnitude experienced by the city, which are not available in the historical data. Therefore, updates have been implemented in the models to enhance the stability of the existing models during monsoon operations.

The specific improvements made to the models in the pre-monsoon phase are as follows:

1. Model 1: Balili - The model has been enhanced by decreasing the HD calculation time step to 1 second from 5 seconds. This adjustment allows for more precise simulations. By employing a smaller time step, the model can effectively capture rapid changes and provide a more accurate representation of the river system's dynamics during monsoon events. This also improves model stability.

2. Model 3: Bued, Ambalanga and Galiano - The model for the three river systems has been strengthened by incorporating extended Qh tables. The addition of these extended Qh tables ensures model stability, particularly during periods of higher observed flows. By incorporating more comprehensive and accurate Qh data, the model can handle and simulate extreme flow conditions with greater reliability, minimizing the risk of instability or model failure. The Qh tables were extended by extending the Qh relations applied as downstream boundary condition and by adding the Qh relations for a higher h-levels in the downstream boundary.

Overall, these updates demonstrate a focused effort to improve the stability of the models during monsoon operations.

These actions were performed thorough testing and validation of these updates and corrections to the FEWS. Different scenarios were tested using historical data to assess how well the system responds.

6.1 EXPECTED 2023 POST-MONSOON MODEL UPDATES

During the monsoon period, team will ensure smooth operation of the FEWS system. This includes debugging of any model stability issues whenever it arises. Also, continues data harvesting to increase the period with available historical records. This will furthermore allow more data and stations to be included in updating during the post monsoon period and thus strengthening the efforts made for model improvements.

The hydraulic model has not been fine-tuned during the pre-monsoon phase. The fine-tuning of the model, if deemed necessary, will be performed during the post-monsoon phase.

The envisaged sequence for model updates during the post monsoon period is as follows:

- Fine-tuning of NAM model
- Fine-tuning of HD model
- Verify and readjust Bias Correction
- Verify and readjust Data Assimilation

Source: Adobe Stock

7. FEWS CHECKS AND UPDATES

Source: Ramboll

In preparation for the monsoon season in 2023, significant improvements were made to the IT infrastructure of the Baguio FEWS. In 2022, under the pilot project, the project team successfully developed a system capable of collecting real-time data on rainfall and water levels, as well as generating flood warnings, however, it was not possible to test the real-time performance of the system infrastructure. The system set-up and IT infrastructure is described in the Flood Early Warning System Report[2].

To enhance efficiency, end-user experience, and resiliency ahead of the full-scale test, the system has been reviewed extensively in the pre-monsoon phase and several updates have been implemented. These updates aimed at enhance the system's functionality and effectiveness. This section of highlights the updates made to the FEWS in preparation for the upcoming monsoon season in 2023, as shown in Figure 7-1.

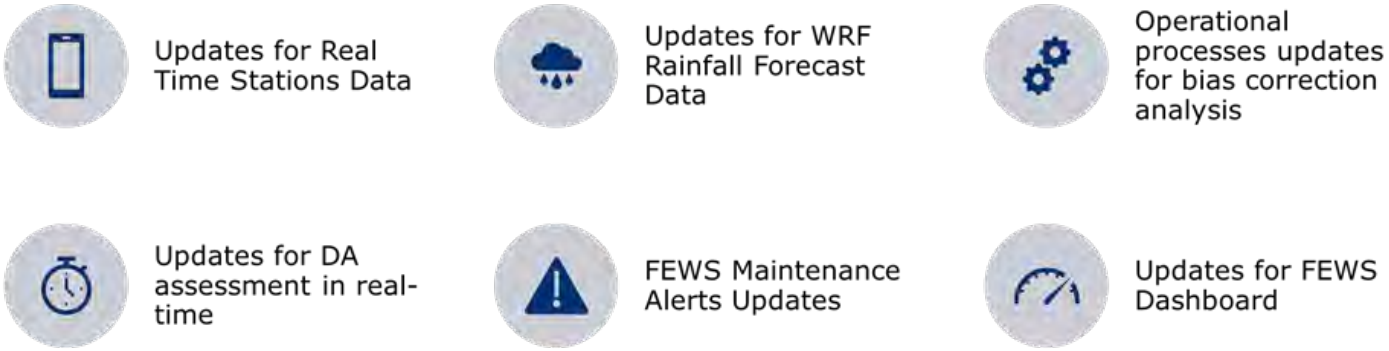


Figure 7-1 Overview of FEWS Updates
Source: Ramboll

A summary of updates made to the back-end scripts in the FEWS is included in Appendix B.

2 Flood Early Warning System Report Phi: Baguio City Smart Flood Warning, Information And Mitigation System, AASCTF, April 2022.

7.1 UPDATES TO REAL-TIME DATA ACQUISITION AND MONITORING OF STATION DATA

In response to the insights gained from pre-monsoon data checks, several enhancements were made to the Python scripts responsible for collecting real-time data to minimize system failure in case of data issues.

The following updates have been made to the FEWS data acquisition and monitoring approaches in the pre-monsoon period:

1. A new rainfall-only station, Irisan Fire Station, has been constructed as indicated in Section 3. Data acquisition in real-time to MIKE OPERATIONS from this new station has been enabled. The data from the un-operational station, Irisan PSHS, is now replaced by data from the new station in the FEWS.

2. To enhance the monitoring of real-time stations and improve data acquisition, a comprehensive assessment and de-bugging exercise of the python scripts has been undertaken. During the previous monsoon season, the project team diligently monitored station data on a daily basis to assess the individual station performance based on the data received from the APIs provided by DOST-ASTI. However, during the pre-monsoon checks of the system, it has been observed that an incomplete log of the total data captured by each station was being recorded by the FEWS. It was identified that this was due to the MITD server losing connection to the MIKE licenses intermittently which interfered with the real time data acquisition by the FEWS from the PAGASA servers. As a mitigation measure, an API introduced by DOST-ASTI that enables the system to update station data with the latest information, covering a span of up to the past 24 hours has been included in the FEWS setup which mitigates this issue of any missing station data prior to each model simulation run.

3. The existing system functionality, whereby a job is triggered at midnight to analyse the real-time data input into the MIKE OPERATIONS has been tested and optimised. The job triggers an email to be sent to the FEWS O&M team daily, with a dedicated report that encompasses the water level and rainfall stations' activities over the past 24 hours. The process has been modified and upgraded following feedback from the FEWS O&M team to allow the inclusion of a comprehensive summary of the total rainfall recorded at each rainfall station in the report. An example of daily automated station logs from the system are shown Figure 7-2.

4. Additionally, a tool has been developed for downloading historical station data from all monitoring stations. This has been completed keeping in mind that this process may be required multiple times for analysis work in the future. It is ensured that the download includes the most recent station information, whenever the tool is used.

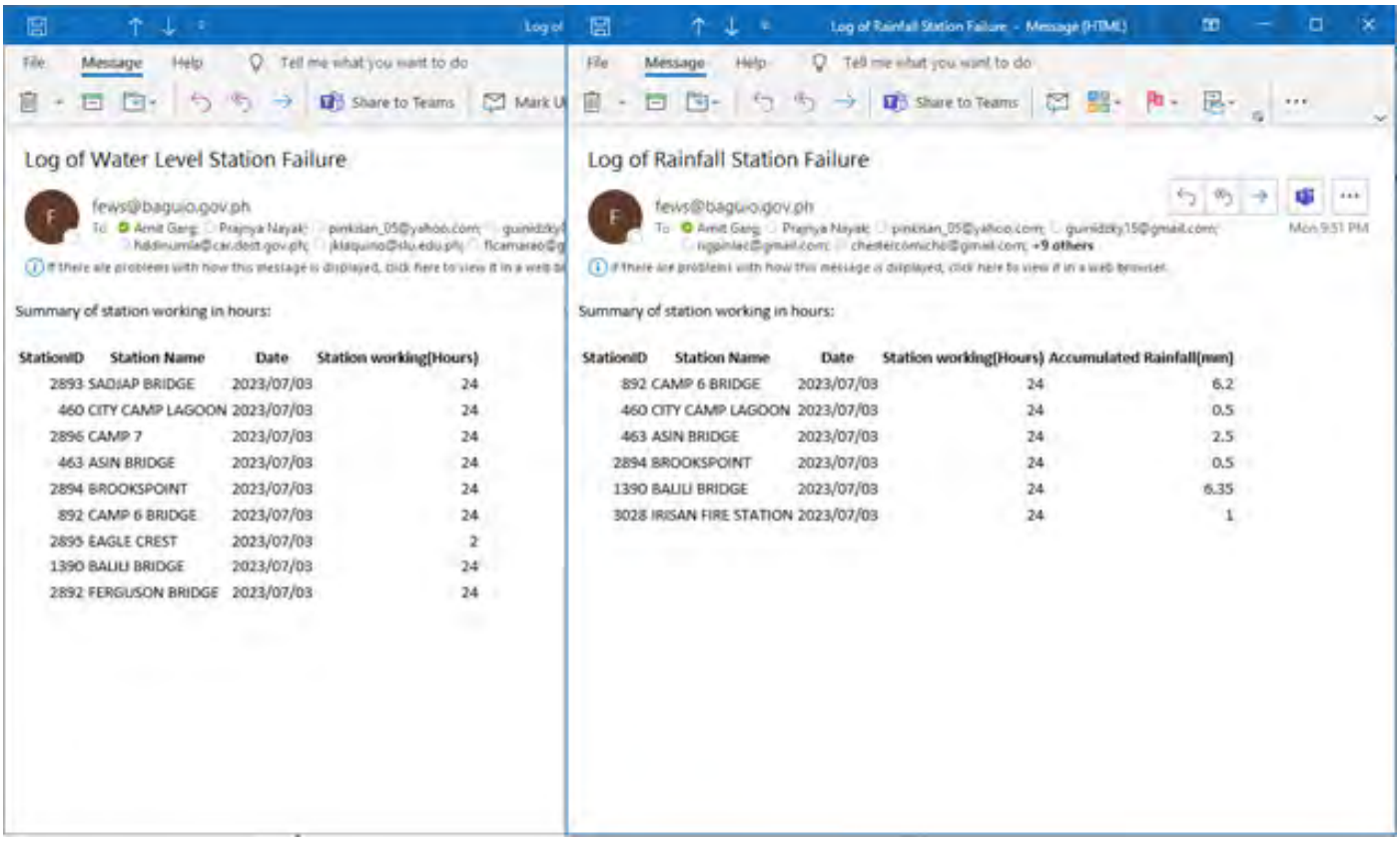


Figure 7-2 The system generates daily emails summarizing the operational hours of stations within the last 24 hours

Source: Ramboll

7.2 UPDATES TO REAL-TIME WRF DATA ACQUISITION

The script to check the status of the WRF data input into the FEWS has been updated. The logic of this script has been updated so that it now examines the folders on the MITD server where the WRF data gets uploaded in real-time and checks for the data and their respective timestamps to determine the timing of each upload.

The script to generate a status email for the monitoring of WRF data upload has been updated and is operational.

7.3 OPERATIONAL PROCESSES UPDATES FOR BIAS CORRECTION ANALYSIS

In addition to the updates made to real-time data downloading and bug fixes, several enhancements have been implemented in the operational processes. These operational processes refer to the sequence of tasks executed for the preparation of WRF data, including bias correction for model simulation, as well as the simulation of all back-end models. These updates aim to streamline and optimize the overall workflow, ensuring more accurate and reliable model simulations. By refining the operational processes, we anticipate less system failures and a more efficient utilization of resources.

In order to enhance the model results and ensure greater reliability of the bias correction applied to the model (refer section 5) processing and analysis of historical WRF data spanning from 2017 to 2020. To carry out this comprehensive data processing, a separate clone of the existing database has been undertaken to ensure that the integrity of the operational system remains intact. A separate copy of all the code and batch files specifically designed to run the system in historical mode, for generating data for bias correction analysis, has been developed. This dedicated historical system enables analysis of the available data from 2017 onwards and modification of the necessary input files to correspond with the specific times of forecast, for each historical simulation while the FEWS parallelly operates in real-time.

The process involves creating time series files that capture the historical data for each respective date. Subsequently, the start and end dates as well as the forecast time are adjusted, to align with the historical time period being simulated. By implementing this approach, accurate replication and analysis for past conditions, providing valuable insights and more reliable results for retrospective analyses and comparisons, can be performed.

7.4 UPDATES FOR DA ASSESSMENT IN REAL-TIME

Scripts have been written and implemented in the FEWS to accommodate the developed algorithms for running repeated simulations in automation during the real time operation in 2023 monsoon, to generate results for 4 scenarios with time-spans at 6 hours, 12 hours, 24 hours and 36 hours (refer to Section 5.3).

7.5 FEWS MAINTENANCE ALERTS UPDATES

Throughout the pre-monsoon phase, several scripts have been developed to ensure and strengthen the system's performance and the applicability of its results. These scripts allow for generation of daily/monthly reports and ensures timely updates on the station and system's status to the FEWS O&M team. Thus, these scripts contribute to effective operation and ensures minimal manual analysis for the O&M team members.

A complete list of the scripts developed, and their use, can be seen in Appendix B.

7.5.1 MONTHLY REPORT GENERATION FOR LONG TERM ANALYSIS OF STATION PERFORMANCE

This report provides an overview of the daily reports generated under "Real-time data updates" section for station data. In addition to these daily reports, the system also produces comprehensive reports through a long-term analysis of station data. These reports offer valuable insights, showcasing the maximum water levels in correlation with the daily rainfall. Moreover, they facilitate flow balance checks when compared across different parameters, which are useful in the post-monsoon assessment of system performance.

To ensure easy access and viewing, the system utilizes FEWS to create relevant tables, which are then saved into the Document Manager under the "MonthlyReport" group as CSV files. This format allows users to conveniently download and view the reports using popular tools like Excel or Notepad. For a more detailed overview, Appendix C contains examples of monthly generated reports.
Table 1 – Monthly Rainfall

- Year
- Month
- Monthly accumulated rainfall (mm)
- Number of rainy day per month (>1mm within 24 hours)
- Total time of down time / no data / lost connection / errors

Table 2 -Daily Rainfall

- Year
- Month
- Date
- Daily rainfall (mm) for each day
- Highest one hour precipitation (mm/hour) within the day + time stamp for its beginning
- Time stamp for the first observed rainfall
- Time stamp for the last observed rainfall
- Duration between first- and last-time stamp

Table 3 – Daily Water level

- Year
- Month
- Date
- Daily maximum recorded water level
- Time stamp for the maximum recorded water level within the day
- 90% percentile of daily water level
- 50% percentile of daily water level

Table 4 – Monthly Water level

- Year
- Month
- Maximum recorded water level within the month
- Time stamp for the maximum recorded water level within the month
- Total time of down time / no data / lost connection / errors

7.5.2 DAILY JOBS FOR MODEL SIMULATION STATUS

A daily report has been created, which delivers the daily status of Jobs and simulations for the model. FEWS generates a comprehensive report that encompasses the status of all jobs, which include information such as successful completion, error, or extended runtime for model simulations. This report highlights any jobs in red if any of their targets have failed as shown in Figure 7-3 and Figure 7-4.

This report also presents the status of the last three runs of each job which enables users to monitor the Job's performance over time, identifying patterns of success, failure, or improvement. It further allows users to determine if there is an improvement to jobs that have been encountering issues, post troubleshooting activities. Furthermore, the report includes an overview of all the models currently running in FEWS. This aspect offers critical information on the status of the data preparation process and the model's execution

phase. By observing this status, users can quickly identify whether a job is facing challenges during data preparation or model execution.

In summary, this report consolidates crucial information to help the FEWS O&M team understand the performance and reliability of jobs and models in FEWS. It enables users to take informed decisions and actions based on the historical job runs and model statuses, facilitating efficient decision-making and troubleshooting.

After the report generation, it is distributed to all members of the FEWS O&M team through an automated email process. The system is configured to initiate this process at a specified time, ensuring timely delivery of the report to relevant recipients. The responsibility of assessing the need of response based on the system reports is with the IT team lead, who will coordinate with the other teams to ensure proper action is taken.

Simulation

last 4 simulations in the past 24 hours

scenario	at	status	tof
Scenario of Model 1 OK: 42/57	2023-07-21 22:54:48	OUTPUT_DATA_OK	2023-07-21 22:00:00
	2023-07-21 19:57:20	OUTPUT_DATA_OK	2023-07-21 19:00:00
	2023-07-21 16:54:43	OUTPUT_DATA_OK	2023-07-21 16:00:00
	2023-07-21 13:55:12	OUTPUT_DATA_OK	2023-07-21 13:00:00
Scenario of Model 2 OK: 39/39	2023-07-21 23:36:48	OUTPUT_DATA_OK	2023-07-21 23:00:00
	2023-07-21 20:40:17	OUTPUT_DATA_OK	2023-07-21 20:00:00
	2023-07-21 17:41:48	OUTPUT_DATA_OK	2023-07-21 17:00:00
	2023-07-21 14:44:39	OUTPUT_DATA_OK	2023-07-21 14:00:00
Scenario of Model 3 OK: 35/44	2023-07-21 23:40:08	OUTPUT_DATA_OK	2023-07-21 23:00:00
	2023-07-21 20:43:30	OUTPUT_DATA_OK	2023-07-21 20:00:00
	2023-07-21 17:45:06	OUTPUT_DATA_OK	2023-07-21 17:00:00
	2023-07-21 14:48:15	OUTPUT_DATA_OK	2023-07-21 14:00:00

Figure 7-3 Status of last 4 simulations of all the models in the system
Source: Ramboll

Jobs

last 3 job instances per jobhost in the past 24 hours

job	At
Database Backup	WIN-IDRUS25I459 @ 2023-07-21 01:00:27 - FinishedSuccess - 00:36:57.9741430 WIN-IDRUS25I459 @ 2023-07-20 01:00:44 - FinishedSuccess - 00:35:45.9113370 WIN-IDRUS25I459 @ 2023-07-19 01:00:24 - FinishedSuccess - 00:34:05.2394510 OK:8/8
Log Email	WIN-IDRUS25I459 @ 2023-07-22 00:20:27 - Running - 00:00:16.9375522 WIN-IDRUS25I459 @ 2023-07-21 00:20:30 - FinishedSuccess - 00:00:31.8908590 WIN-IDRUS25I459 @ 2023-07-20 00:20:28 - FinishedSuccess - 00:00:44.0469820 OK:9/10
OperationProcess	WIN-IDRUS25I459 @ 2023-07-21 22:50:26 - FinishedSuccess - 01:01:33.6489020 WIN-IDRUS25I459 @ 2023-07-21 19:50:24 - FinishedSuccess - 01:05:16.2372980 WIN-IDRUS25I459 @ 2023-07-21 16:50:25 - FinishedSuccess - 01:07:58.5725300 OK:31/68
RealTimeData	WIN-IDRUS25I459 @ 2023-07-22 00:20:25 - FinishedSuccess - 00:00:11.8906550 WIN-IDRUS25I459 @ 2023-07-22 00:10:27 - FinishedSuccess - 00:00:07.3438310 WIN-IDRUS25I459 @ 2023-07-22 00:00:27 - FinishedSuccess - 00:00:10.3127370 OK:387/441
RealtimeStation_log	WIN-IDRUS25I459 @ 2023-07-22 00:10:30 - FinishedSuccess - 00:00:10.0626250 WIN-IDRUS25I459 @ 2023-07-21 00:10:24 - FinishedSuccess - 00:00:11.5468840 WIN-IDRUS25I459 @ 2023-07-20 00:10:25 - FinishedSuccess - 00:00:11.3437580 OK:9/9
WaterLevel_Alert	WIN-IDRUS25I459 @ 2023-07-22 00:00:24 - FinishedSuccess - 00:00:05.8437620 WIN-IDRUS25I459 @ 2023-07-21 20:00:27 - FinishedSuccess - 00:00:07.3437670 WIN-IDRUS25I459 @ 2023-07-21 16:00:35 - FinishedSuccess - 00:00:08.2022570 OK:48/48

Figure 7-4 Status of last 3 instances per job in the past 24 hours
Source: Ramboll

7.6 UPDATES IN FEWS DASHBOARD

The dashboard provides users with simulated water levels at flood forecasting sites, as well as the ability to view simulated water levels at the identified vulnerable reaches of the river.

The dashboard has been updated to include the following features:

1. In addition to simulated results, observed water level series have been integrated for better visual comparison.

2. Threshold water levels for all monitoring stations based on the bank levels, aiding in the assessment of potential flood risks have been added.

3. A new ribbon item called "Rainfall Stations" has been added as shown in Figure 7-5, allowing users to access and visualize observed rainfall data recorded at various rainfall stations.

These updates have been prepared in a close feedback loop with the FEWS O&M team who has tested functionalities and provided requests based on their identified needs. The aim of the implemented updates is to improve the overall functionality and effectiveness of the FEWS dashboard.

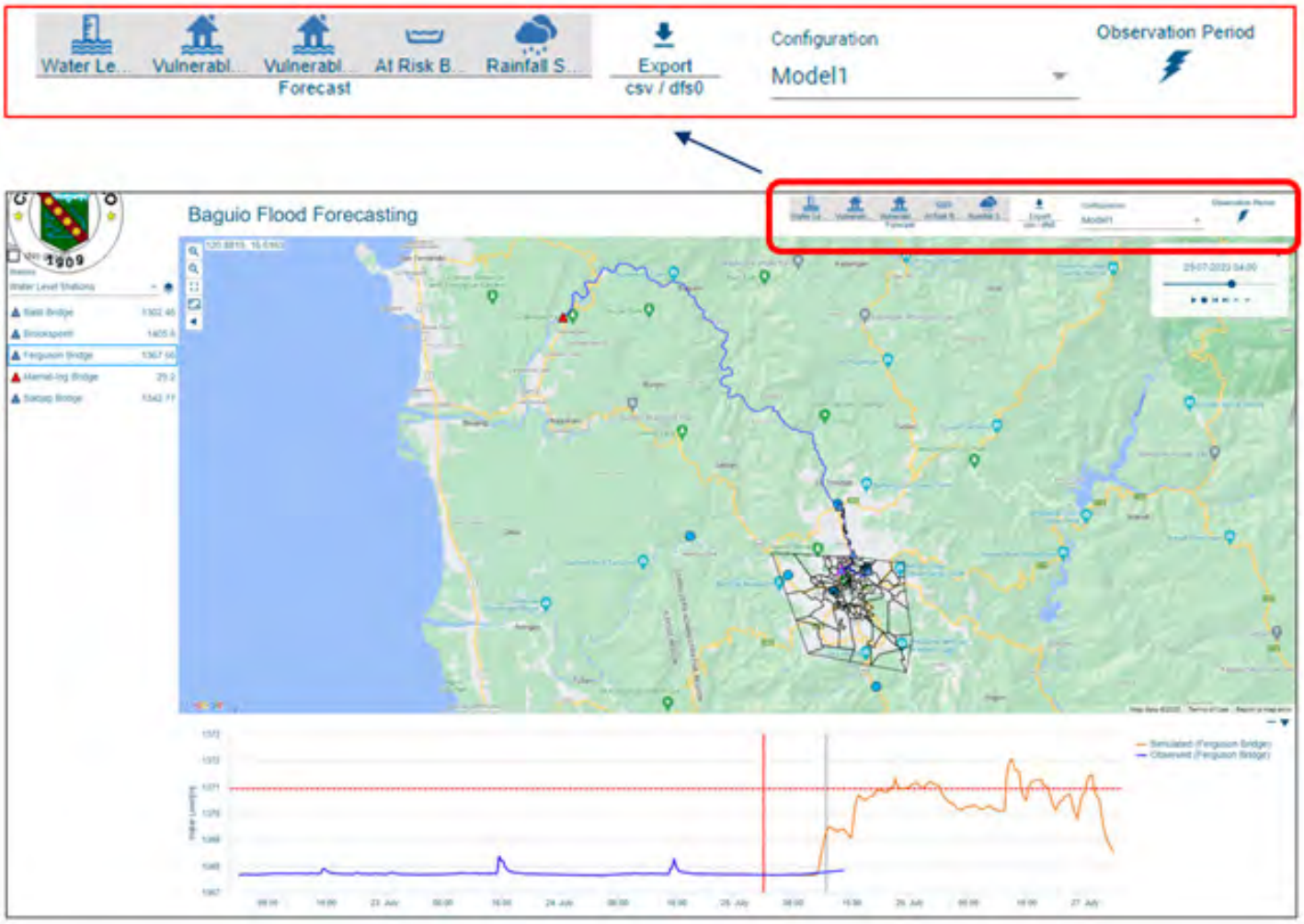


Figure 7-5 Enhanced FEWS dashboard with dedicated menu for rainfall station monitoring
Source: Ramboll

7.7 CHECKS OF STORAGES AND BACKUP

Regular backups of the FEWS database, which contains critical information such as historical data, simulation results, and system configurations must be scheduled. Scheduled backups help prevent data loss and support recovery in case of hardware failure, data corruption, or other issues. The FEWS system executes a nightly script to perform database backups, capturing a snapshot of the database's current state. These backups are retained for a rolling period of seven days, after which the system automatically removes older backups to optimize storage usage.

Checks of this process has been carried out during the pre-monsoon phase so that the same process can be run during the real-time operation as intended.

8. CAPACITY BUILDING AND TRAINING PROGRAM

Source: Adobe Stock

The capacity building and training component of the consolidation phase builds on the Targeted Capacity Building Program to Enhance the sustainable delivery of FEWS and OTJ training completed in 2022.

Towards the end of the pilot project in 2022 it was apparent that there was a need for improved capacity of Baguio City to better utilize the established Flood Early Warning System (FEWS) as an active risk mitigation tool to facilitate appropriate, applicable, and timely early warning through completion of necessary finetuning, troubleshooting, and testing of the system and enhancement of FEWS governance.

The purpose of the '2023 Baguio FEWS training program' is therefore to strengthen local capacity for independent operation and maintenance of the FEWS in parallel with implementing, testing and refining the system.

While the training activities will be documented in D3 Training Report (see Table 1-1), this section provides a brief overview of the training program, focusing on the pre-monsoon activities, and an assessment of the effectiveness of the pre-monsoon training activities completed.

8.1 2023 BAGUIO FEWS TRAINING PROGRAM

In line with the 2022 training activities, the consolidation phase training consists of a mix of online training sessions and on-the-job (OTJ) training aimed at ensuring long-term sustainability of the established FEWS by securing local capacity for operating and utilizing the FEWS as an active rusk mitigation instrument beyond the timeframe of the project.

The goal of the training program is to increase the average confidence level within the locally established FEWS O&M team in operating and maintaining the FEWS. The training consists in the following components:

1. Online training sessions: These sessions has been taking place during the pre-monsoon phase and focused on giving the participants a recap of modelling, data and instruments.

2. On-the-job (OTJ) training: These sessions are taking place during the pre-monsoon and post monsoon phases. The main focus of pre-monsoon session, completed in June 2023, was on standard operating procedures (SOPs) of the FEWS, and the second session will focus on post-monsoon system assessment and updates.

3. Real operation of the FEWS: This will take place during the monsoon season and will consist in applying the knowledge gained during the training to operate the FEWS.

Furthermore, trainees still have access to the DHI ACADEMY eLearning platform, established as part of the 2022 training, and modules from here are used as homework/preparation for the instructor-led training sessions in 2023 and for repetition when suitable for trainees.

The twelve (12) members of the FEWS O&M team are participating in the training program. Most of the team members have participated in the FEWS training activities since the training kick-off in 2022. The selection of training program participants is presented in the Scoping and Training Course Design Report for the Targeted Capacity Building Program to Enhance the sustainable delivery of FEWS.

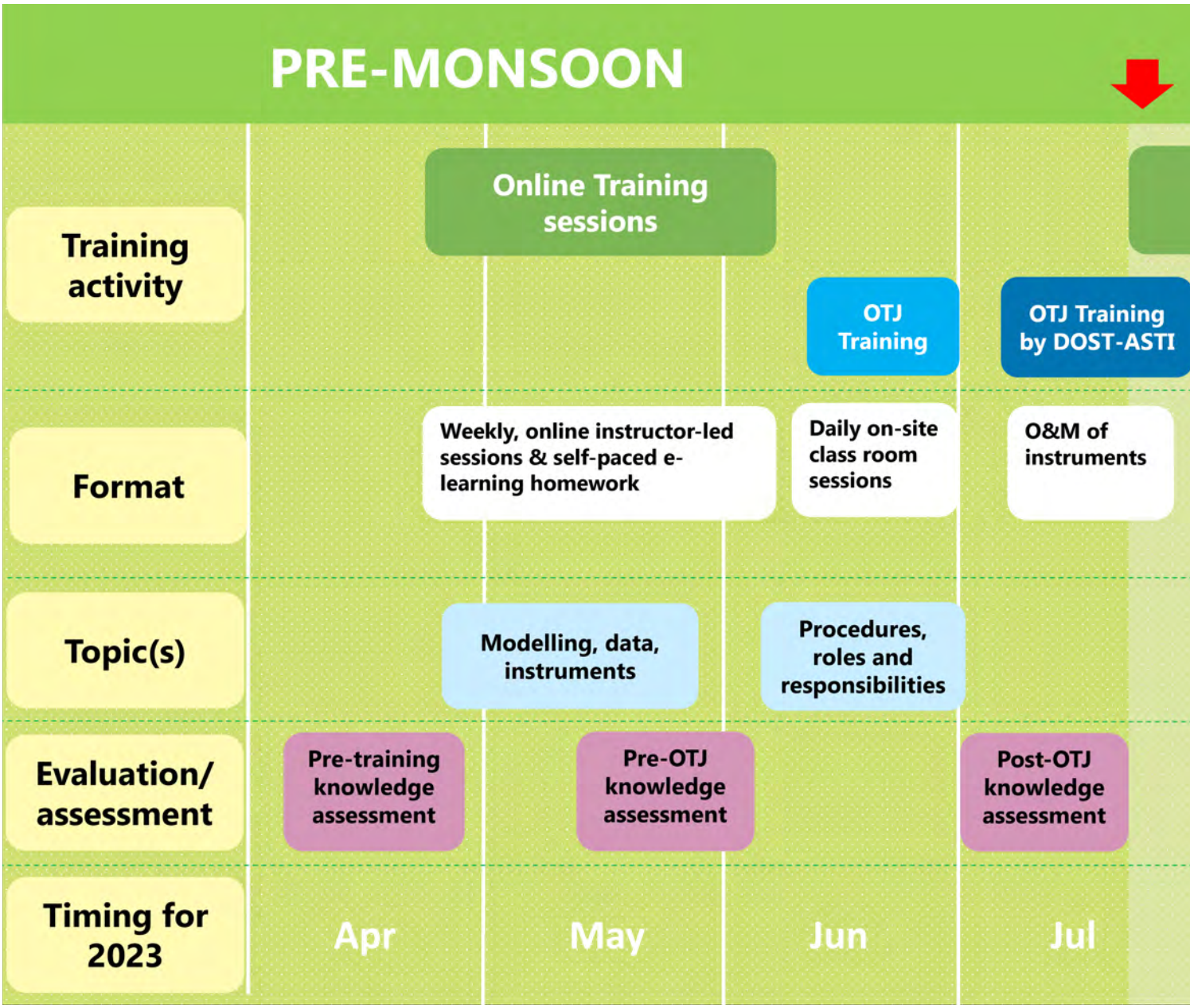
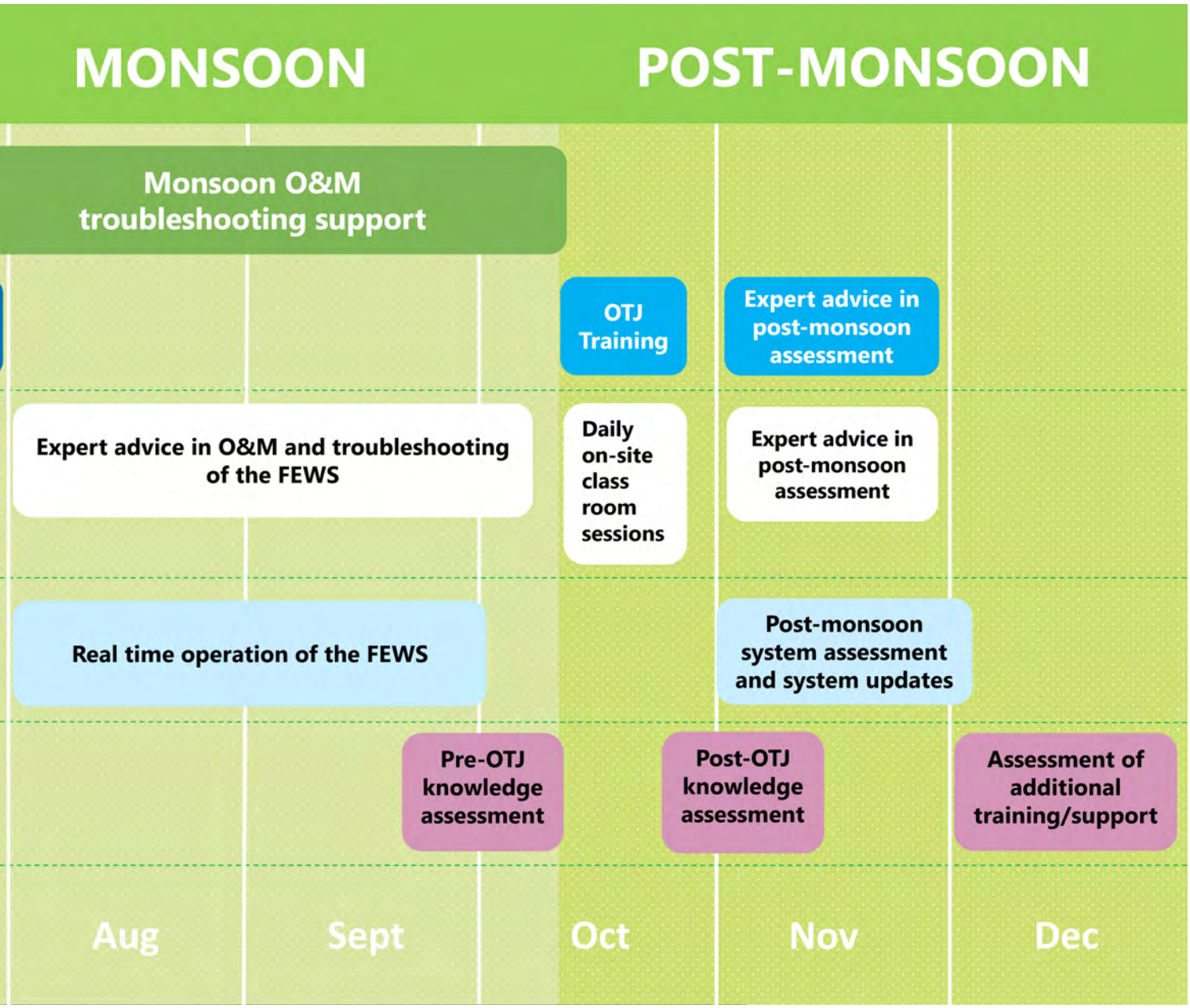


Figure 8-1 Overview of the 2023 Baguio FEWS Training Program

The red arrow indicates the initiation of the monsoon operation and maintenance by the O&M team for the 2023 full-scale test

Source: Ramboll

The training activities of the consolidation phase are aligned with the operational phases of the FEWS to ensure alignment with the full-scale test of the system including the real-time operation and maintenance tasks. An overview of the 2023 Baguio FEWS Training Program is seen in Figure 8-1.



8.1.1 COMMITMENT LETTER

Prior to initiating the training all participants and their direct managers signed a commitment letter. By signing the letter, both participants and managers, agreed to commit to the program for a total amount of training hours as well as to ensure continued time availability/commitment of the participant beyond 2023 to the extent needed to ensure proper and optimal functioning and long-term sustainability of Baguio's FEWS.

Signing the commitment letter was important to ensure the full availability/flexibility of the participant's working time, to accommodate the foreseen level of engagement and to make sure that roles and responsibilities are clear to both participants and direct managers.

8.2 PRE-MONSOON TRAINING ACTIVITIES

The pre-monsoon training activities have been built around three main areas: technical, procedures, and role and responsibilities. While the technical skills have been a key focus the pre-monsoon online training sessions, the primary focus of the OTJ training has been on building an understanding of SOPs and roles and responsibilities as illustrated on Figure 8-2.

The pre-monsoon training activities are described in section 8.2.1 and 8.2.2 below.

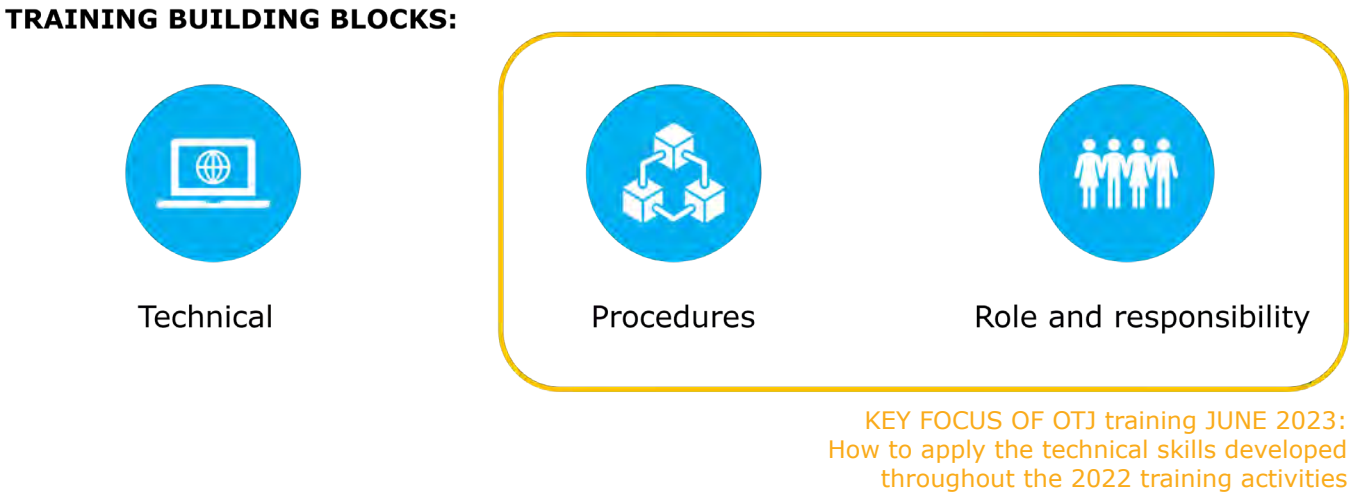


Figure 8-2 The pre-monsoon training components
Source: Ramboll

8.2.1 ONLINE INSTRUCTOR-LED TRAINING SESSIONS

The online training sessions served to prepare the team for the OTJ training, as feedback from the 2022 training activities highlighted enhancement of learnings from the OTJ training due to online sessions.

The online training sessions were divided into two primary tracks: Modelling and IT. Furthermore, a dedicated instrumentation training session focusing on operation and maintenance of the monitoring stations were facilitated in collaboration with DOST-CAR and DOST-ASTI. O&M team members only attended the sessions that were relevant for their responsibilities as part of the FEWS O&M team.

In agreement with the trainees, the online training sessions took place weekly on Thursdays at 3 PM – 5 PM between end-April and mid-June to ensure that the trainees could plan their other work responsibilities around the training sessions.

8.2.2 ON-THE-JOB TRAINING

The pre-monsoon OTJ training was conducted in the last two weeks of June 2023 at CDRRMO. Nine (9) out of twelve (12) OTJ trainees attended all training sessions from 9 AM – 4.30 PM during the eight-day course. Three (3) OTJ trainees from the peer team, were only able to attend some of the planned training program activities.

The training built on the activities of the online training sessions facilitated between April-May 2023 as preparation for the OTJ training. The training provides in-depth hands-on experience in FEWS monsoon standard operating procedures (SOPs), which is expected to build confidence in the team in a more efficient manner than traditional classroom trainings or online e-learning modules.

The training consisted of site visits, presentations, live demonstrations, Q&A discussions, peer-to-peer presentations, live testing of SOPs, and hands-on exercises with the Baguio models and data. Gathering the trainees in-person at the same location allowed for enhanced interaction and collaboration between trainees and for the trainees to work together as a team.

8.3 PROGRAM EVALUATION AND SATISFACTION

To ensure that the content, the technical level, and the format of the training are suitable for the participants, the lead trainers have been engaged in continuous dialogue with the participants to ensure that the training program meets expectations and is adapted to the wishes and suggestions from the participants. Accordingly, participant feedback has been actively encouraged and addressed constructively in all training sessions through open dialogue and discussion. The feedback on the training training sessions has been very positive. Particularly, the trainees expressed that the OTJ training sessions and hands-on in-person exercises, live demonstrations, and live testing of the system are crucial in their learning process.

Three feedback surveys have been completed by the trainees in 2023: Pre-training survey (early-May 2023), pre-OTJ training survey (June 2023), and post-OTJ training survey (June 2023).

The pre-training survey results show that the level of satisfaction among the participants is very high and that the training is well-received. The knowledge acquired during the 2022 FEWS training has been moderately employed, which indicates a potential decrease in knowledge levels. Additionally, the time required for the 2023 training program seems to moderately conflict with prior work commitments. In this sense the submission of commitment letters becomes crucial to clearly outline the expectations from participants before the training commences. Participants also agree that the training is relevant for them and expect the online training to better prepare them for the in-person on-the-job training.

Figure 8-3 Pre-program survey: Assessment of participants satisfaction and expectations before the online training sessions

1= strongly disagree, 2= disagree, 3= neutral, 4= agree, 5= strongly agree

Source: Ramboll

Figure 8-4 Training session facilitated at the CDRRMO in Baguio
Source: Ramboll

Figure 8-5 shows that satisfaction and knowledge levels have increased across all three teams following the competition of the OTJ training sessions. The training successfully achieved its objective of building a comprehensive understanding of testing and operating FEWS, while preparing the participants for the FEWS test during the monsoon season. Additionally, participants are satisfied with the topics covered, the training format and the quality of instruction. They highlighted that the training significantly enhanced their understanding of the FEWS, enabling them to better focus on their respective tasks. They also emphasized the invaluable role of hands-on experience in facilitating the learning process. The practical, experiential aspect of the training played a crucial role in reinforcing their understanding and skills.

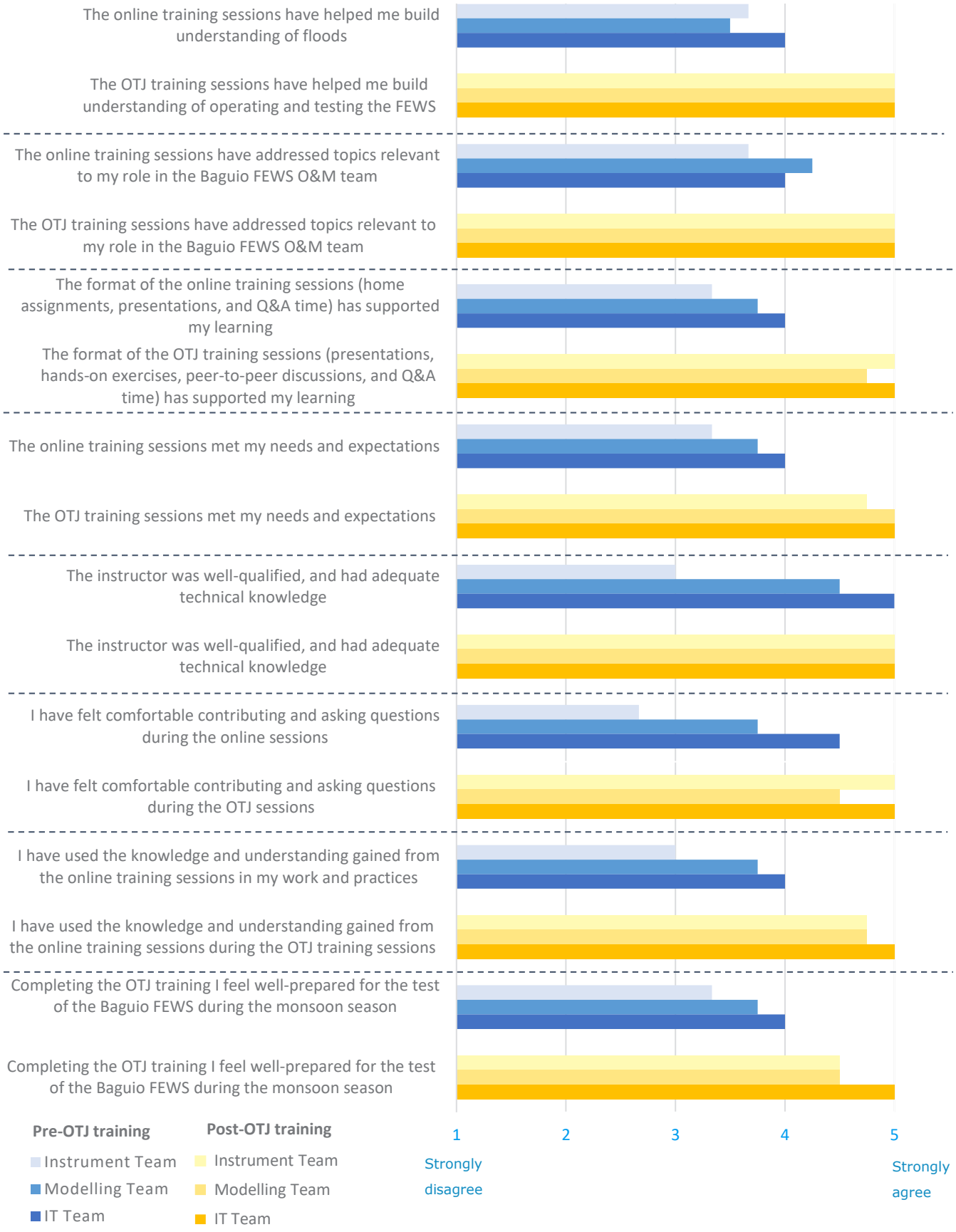


Figure 8-5 Assessment of participants satisfaction before and after the OTJ training sessions

1= strongly disagree, 2= disagree, 3= neutral, 4= agree, 5= strongly agree

Source: Ramboll

8.4 PROGRAM EFFECTIVENESS AND TEAM PERFORMANCE

To monitor the program effectiveness, knowledge assessments are carried out frequently throughout the training program to garner a proper understanding of the participants existing knowledge, and skills related to the topics of the training modules. The knowledge assessments are based on self-assessments. Thus, by comparing the knowledge assessment surveys, it is possible to assess how the trainees have gained knowledge and experience during the training program and thereby measure the Program Effectiveness.

Three knowledge assessments have been completed to date in 2023 in addition to the three knowledge assessments completed in 2022. Figure 8-6 shows the average learning curve for the trainees throughout the entire duration of the FEWS training activities. It is seen that most of the participants prior to the training had 'no knowledge' or 'limited knowledge' within the fields of hydrology, hydraulics, the modelling tools and MIKE OPERATIONS which are core elements of the new FEWS system established in Baguio. Furthermore, the participants, on average, have had a steep learning curve as they have gained 'some knowledge' or 'good knowledge' of most of the topics covered by the program. This is very positive and indicates that the training program has been very effective.

Figure 8-6 2022-2023 learning curve

The assessment of knowledge is based on self-assessment of knowledge within topics covered by the training program
1= no knowledge, 2= limited knowledge, 3= some knowledge, 4= good knowledge, 5= very good knowledge.
Source: Ramboll

Figure 8-6 shows that there was a decrease in knowledge levels from November 2022, where the 2022 training activities came to an end, to May 2023. The decrease in the knowledge levels among participants was expected, considering that they were not actively operating and maintaining the system and using their knowledge. The learning curve in 2023 is seen to be increasing and the average knowledge level among participants is self-assessed to be between 'good' and 'very good' in end-June 2023 post-OTJ training.

One of the main goals of the pre-monsoon OTJ-training was to enhance participants' confidence in following standard operating procedures and understanding their roles and responsibilities. Ensuring a comprehensive understanding of these procedures and responsibilities, is a first step towards the self-sustainment of the FEWS O&M team in the long run.

Figure 8-7 provides a visual representation of the change in confidence levels for each team before and after the OTJ training. Prior to the training, participants had a moderate understanding of the procedures to follow and their respective roles and responsibilities. However, following the OTJ training, there has been a large increase in confidence levels across all teams. Thus, the high confidence levels demonstrate that the OTJ training format and content has successfully contributed towards achieving the training goals.

Figure 8-7 provides a visual representation of the change in confidence levels for each team before and after the OTJ training. Prior to the training, participants had a moderate understanding of the procedures to follow and their respective roles and responsibilities. However, following the training, there was a significant and steep increase in knowledge levels across all teams. Additionally, it is worth noting that the disparity that existed between the modelling team and the Instrument and IT team has considerably reduced, resulting in a much smaller gap between their respective confidence levels.
In addition to the general improvement in knowledge and confidence levels, all teams acknowledge the significance of ongoing support from the technical project team. When asked how technical experts from Ramboll can support the FEWS O&M team during the monsoon phase, their responses emphasized the importance of receiving assistance during this critical period. The team also expresses the need for continuous guidance and training to ensure sufficient team performance.

It is expected that the capacities within the FEWS O&M team will continue to increase through on-the-job training and implementation of standard operating procedures in 2023 throughout the consolidation phase, however, it is very likely, that it will not be possible to bring them to a professional level to enable the team to be fully responsible for the operation and maintenance of the FEWS. Thus, it is expected that further technical support for finetuning, testing, and operating the system will be needed beyond 2023. The extent of the additional technical support required will be assessed as part of the post-monsoon activities when the local capacities to operate and maintain the system as well as the performance of the FEWS are better understood.

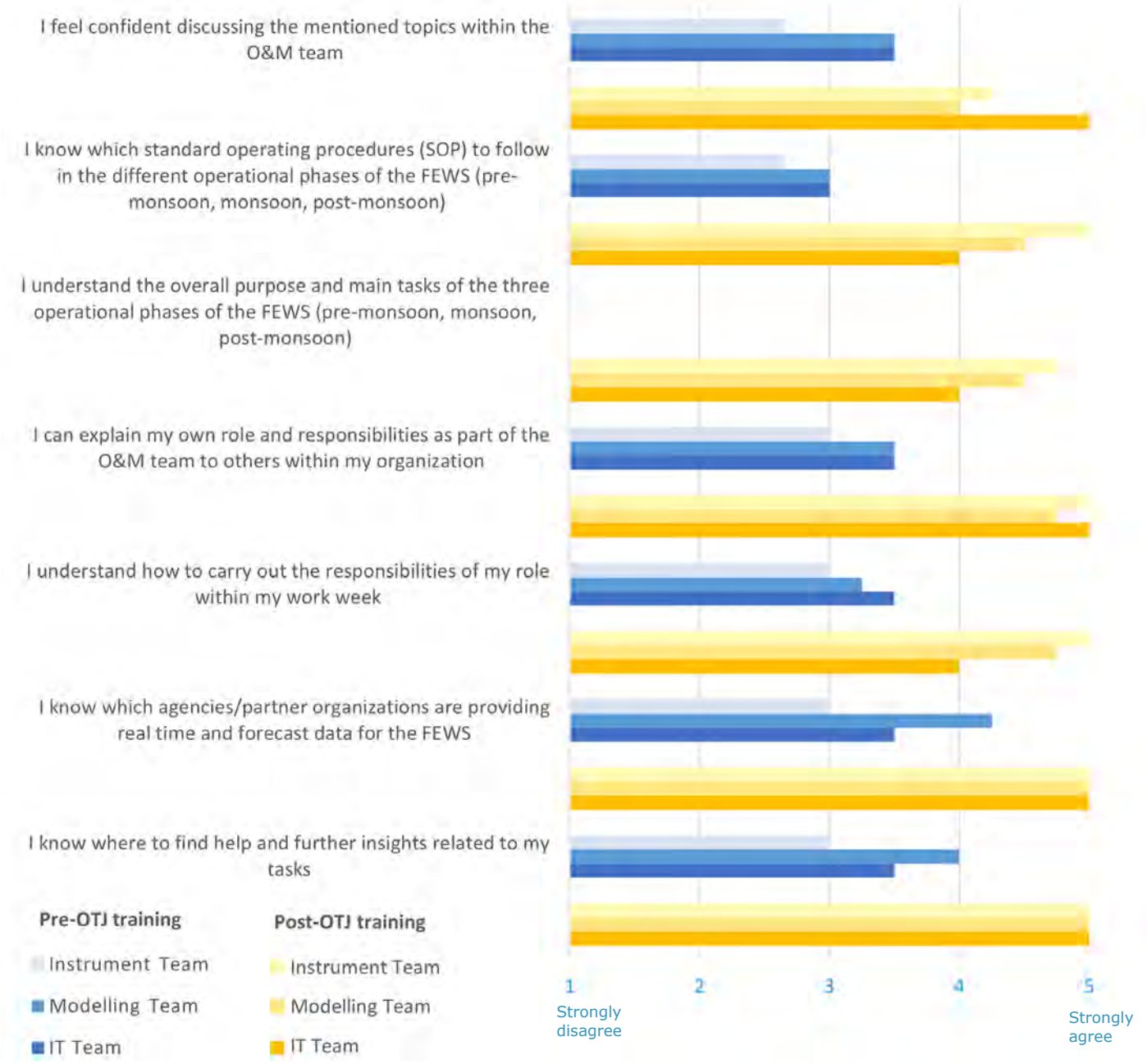


Figure 8-7 Pre- and post-OTJ training confidence levels

1= strongly disagree, 2= disagree, 3= neutral, 4= agree, 5= strongly agree

Source: Ramboll

9. ENHANCEMENT OF FEWS GOVERNANCE

Source: Ramboll

Several steps for enhancement of long-term sustainability have already been taken including the establishment of the FEWS O&M team, the implementation of the targeted capacity building and training program, preparation of SOPs, and the establishment of MOAs with partner organizations. In close collaboration with the LGU, efforts in enhancing FEWS governance has been continued in 2023.

The system governance and long-term sustainment was discussed in-person in meetings with key staff from the CDRRMO and with Mayor Benjamin Magalong in June 2023. There is a need to properly anchor and institutionalize the FEWS O&M team in the LGU to ensure that team members have the mandate to undertake the assigned tasks and responsibilities. In agreement with the CDRRMO Officer-in-charge, an executive order will be drafted establishing a new Early Warning and Monitoring Unit under the Operations and Warning Division in the CDRRMO. The FEWS O&M team will be anchored in this unit. Mayor Benjamin Magalong expressed his commitment to ensuring the establishment of proper institutional structures to support FEWS governance. The project team will follow this closely throughout 2023 and provide guidance and support as necessary.

Several additional activities related to enhancement of FEWS governance has been completed in the 2023 pre-monsoon phase:

- To further enhance the capacities of the FEWS O&M team, a technician with experience in operation and maintenance of monitoring stations has been hired in the MITD in early 2023. The technician has become an active part of the FEWS O&M team serving as technical lead of the instrument team. The addition of a technician to the team has enhanced the effectiveness of troubleshooting and maintenance as well as increased effective communication with partner organizations including DOST-CAR, DOST-ASTI, and PAGASA.
- The project team has facilitated the establishment of two Memoranda of Agreements with La Trinidad and Tuba, which were signed in a ceremonial signing event. The Mayors from the City of Baguio, La Trinidad, and Tuba, Hon. Benjamin Magalong, Hon. Romeo Salda, and Hon. Clarita P. Sal-ongan attended the ceremony and signed Memoranda of Agreement on June 23, establishing a partnership in support of the Baguio FEWS Project. The MOAs formalize the collaboration on maintenance of the network of monitoring stations and knowledge and data-sharing on the Baguio FEWS between the three municipalities. The signing event demonstrated the good partnership that has been established between the municipalities on disaster preparedness and provided an opportunity for all partners to meet in-person.
- Throughout the pre-monsoon phase, a key focus has been to strengthen the partnership with DOST-ASTI. DOST-ASTI is a crucial stakeholder in the Baguio FEWS, as they are in charge of processing, storing, and publishing the real-time data from the network of monitoring stations. The Baguio LGU had invited the Director of DOST-ASTI Mr. Franz A. de Leon to an in-person meeting on June 23 to discuss the partnership on the FEWS project following an online meeting on May 16. The online meeting initiated the discussion expectations to roles and responsibilities of DOST-ASTI in the FEWS project and the coordination mechanism going forward. The communication with DOST-ASTI has greatly improved in the past months and a direct link to the technical team at DOST-ASTI has been established. In the meeting on June 23, the Director of DOST-ASTI expressed the commitment of DOST-ASTI to support the FEWS O&M team in relation to data management. Furthermore, opportunities for future partnerships in the use and implementation of DOST-ASTI technology was discussed. DOST-ASTI and Mayor Benjamin Magalong agreed that there is great potential for replicability of the 'Baguio approach'. Following the in-person meeting, the partnership between the Baguio LGU and DOST-ASTI is strengthened and conversations on opportunities will be continued in the coming months leading up to the next planned site visit in October.

The efforts to enhance the system governance throughout the consolidation phase will be documented in the sustainment plan to be delivered by end 2023.

Source: Ramboll

10. PLAN FOR THE 2023 MONSOON TEST OF THE FEWS

Source: Adobe Stock

In anticipation of the monsoon season, enhancements to the models and scripts have been completed to prepare for the 2023 testing of the FEWS. These modifications, as detailed in earlier sections, build upon our prior efforts and insights, aiming to strengthen the system's ability to forecast and manage flood-related risks during the monsoon conditions.

While the system was not subjected to real-time testing during the monsoon of 2022, the pre-monsoon system review and upgrades have allowed the project team and FEWS O&M team to comprehensively understand the potential challenges that may arise in the monsoon of 2023. To address these challenges, a new troubleshooting segment has been added within the previously prepared Standard Operating Procedures.

In the 2023 monsoon, it is planned to test all aspects of the operational FEWS in real-time by implementing procedures defined in the SOPs. The system will be tested on three main parameters:

1. Technical – this entails assessment of station performance, WRF performance, model performance and performance of the automations in the system.

2. Procedures – this entails assessment of the procedures for maintenance and operation as defined in the SOPs and to log any gaps and improvements that are identified during the real-time operations.

3. Roles and responsibilities - While implementing the SOPs, a review of how effectively the defined roles and responsibilities for the O&M team are being fulfilled will be made. This aspect of the test will be closely linked to the preparation of the system sustainment plan and the assessment of additional support needed beyond 2023.

In addition to the application of the monsoon SOPs, historical simulations for strengthening the bias correction assessments will be run during the monsoon months and multiple parallel simulations for assessments of DA parameters will also be run in real-time.

10.1 EXECUTION OF MONSOON SOPS

The following activities, in line with the previously defined monsoon SOPs, are planned for the monsoon phase of 2023. During this monsoon, support will be given to the responsible sub-teams in the FEWS O&M team in carrying out the tasks defined in Table 10-1. To enable a thorough knowledge transfer and test the team members ability to operate and maintain the system, the O&M team members are to execute their stipulated responsibilities with support, guidance and backing form the team of experts at Ramboll. This is also a part of the OTJ training which is expected to reinforce the online training sessions and classroom trainings that have been conducted so far.

As part of the monsoon SOPs, day-to-day collaboration with the O&M team is planned for real-time troubleshooting activities. Logs of all issues encountered will be maintained which will be used in the post monsoon phase to assess overall system performance. If any bugs, new errors, or gaps are identified during the real-time operation, the system will be parallelly updated to mitigate the issues. The SOPs will also be updated to include the new/modified information and will be published in December 2023.

The FEWS O&M team initiated real-time operation of the FEWS and completion of monsoon SOPs on Friday June 30, 2023, following the completion of the 8-day in-person OTJ training program in Baguio. Since this date, the FEWS O&M team has operated and maintained the system with daily support from the technical project team.

Table 10-1 Monsoon SOPs[2]

S. No.	Standard Operating Procedure	Responsible	Frequency
1	Operate system, check IT system and connectivity and create backup	IT team	Daily
2	Daily review of system logs and Jobs	Team lead Deputy team lead Modelling team IT team Instrument Team	Daily
3	Daily review of data logs	IT team Instrument Team	Daily
4	Daily report on Job and script performance	IT team	Daily
5	Daily report on model performance	Modelling team	Daily
6	Real-time station maintenance and weekly report on station performance	Instrument team	As needed/as scheduled
7	Weekly report on quality of model input data	Modelling team	Weekly
8	Flood warning and flood occurrence	Modelling team Instrument team	As needed

Source: Ramboll

2 Flood Early Warning System Report Phi: Baguio City Smart Flood Warning, Information And Mitigation System, AASCTF, April 2022.

The SOPs for the Baguio FEWS to be completed during the Monsoon 2023 are briefly explained below:

1. Operate system, check IT system, connectivity and create backup - The aim is to ensure all the components of the FEWS are operating as per the requirements, which includes servers, internet connection, DHI license and creation of backup.

Timestamp	Email Address	Name of Job Failed	Date of Job Failed	Time of Job Failed	her Details of the identified issue/Remai	Date of Inspection
6-29-2023 20:38:07	shanry.roberts.pnp@gmail.com	database backup	W	1:01:00 AM	Maintenance was manually killed	29-06-2023
6-29-2023 20:39:51	Shanry.roberts.pnp@gmail.com	Operation Process	27-06-2023	1:00:00 AM	Run Call to Adapter Failed - Model 3	27-06-2023
7-2-2023 7:23:20	shanry.roberts.pnp@gmail.com	Operation Process	01-07-2023	11:43:00 AM	SetDateForRub	02-07-2023
7-2-2023 7:24:42	shanry.roberts.pnp@gmail.com	Operation Process	01-07-2023	2:20:00 PM	ResampleWeightedRainfall	02-07-2023
7-2-2023 7:25:59	shanry.roberts.pnp@gmail.com	Operation Process	01-07-2023	8:44:00 PM	ApplyCorrection	02-07-2023
7-4-2023 18:58:06	shanry.roberts.pnp@gmail.com	OperationProcess	05-07-2023	7:50:00 AM	rioManagerException. Run call to adapter	05-07-2023
7-5-2023 20:41:58	shanry.roberts.pnp@gmail.com	Operation Process	06-07-2023	10:50:00 AM	Exec - download and process WRF	06-07-2023
7-5-2023 20:43:28	shanry.roberts.pnp@gmail.com	Log Email	06-07-2023	12:20:00 AM	RunScript - MakeDailyDataReport	06-07-2023
7-6-2023 19:58:36	shanry.roberts.pnp@gmail.com	Operation Process	07-07-2023	7:50:00 AM	RunScenario - Model 3 (Old)	07-07-2023
7-6-2023 20:01:52	Shanry.roberts.pnp@gmail.com	Operation Process	07-07-2023	12:00:00 AM	script was made to run for the New Mod	07-07-2023
7-6-2023 20:02:54	shanry.roberts.pnp@gmail.com	Log Email	07-07-2023	12:00:00 AM	No Log Email was sent today	07-07-2023
7-7-2023 0:00:49	shanry.roberts.pnp@gmail.com	Log Email	07-07-2023	12:00:00 AM	Didn't send out e-mail	07-07-2023
7-7-2023 1:05:31	shanry.roberts.pnp@gmail.com	Log Email	07-07-2023	12:20:00 AM	idn't send log of water level station failur	07-07-2023
7-7-2023 16:56:52	shanry.roberts.pnp@gmail.com	Operation Process	08-07-2023	1:50:00 AM	RunScript - CheckWRF_Upload	08-07-2023
7-7-2023 16:58:16	shanry.roberts.pnp@gmail.com	Operation Process	08-07-2023	4:50:00 AM	RunScenario - Model 3	08-07-2023
7-8-2023 20:09:02	shanry.roberts.pnp@gmail.com	Operation Process	09-07-2023	10:50:00 AM	RunScript - CheckWRF_Upload	09-07-2023
7-8-2023 20:18:00	shanry.roberts.pnp@gmail.com	Operation Process	08-07-2023	10:50:00 PM	RunScript - CalculateForrcastError	09-07-2023
7-9-2023 17:59:16	shanry.roberts.pnp@gmail.com	Log Email	10-07-2023	12:30:00 AM	License Issue	10-07-2023
7-9-2023 18:01:22	shanry.roberts.pnp@gmail.com	Database Backup	10-07-2023	1:00:00 AM	License Issue	10-07-2023
7-9-2023 18:04:53	shanry.roberts.pnp@gmail.com	RealTimeData	10-07-2023	12:00:00 AM	License Issue	10-07-2023
7-9-2023 18:07:03	shanry.roberts.pnp@gmail.com	RealTimeStation_log	10-07-2023	12:00:00 AM	License Issue	10-07-2023
7-9-2023 18:08:15	shanry.roberts.pnp@gmail.com	WaterLevel_Alert	10-07-2023	12:00:00 AM	License Issue	10-07-2023
7-9-2023 18:12:53	shanry.roberts.pnp@gmail.com	Operation Process	10-07-2023	1:00:00 AM	License Issue	10-07-2023
7-11-2023 0:00:17	shanry.roberts.pnp@gmail.com	Operation Process	11-07-2023	1:50:00 PM	RunScenario - Model 1 and Model 3	11-07-2023
7-11-2023 1:23:04	shanry.roberts.pnp@gmail.com	Operation Process	11-07-2023	1:50:00 PM	RunScript Model_3	11-07-2023
7-11-2023 1:24:30	shanry.roberts.pnp@gmail.com	DOST Server	12-07-2023	9:40:00 AM	Server Error, no data transmission	11-07-2023
7-12-2023 18:01:32	shanry.roberts.pnp@gmail.com	Operation Process	13-07-2023	1:50:00 AM	RunScript - CheckWRF_Upload	13-07-2023
7-12-2023 18:01:32	shanry.roberts.pnp@gmail.com	Operation Process	13-07-2023	4:50:00 AM	RunScript - CheckWRF_Upload	13-07-2023
7-12-2023 20:33:29	shanry.roberts.pnp@gmail.com	Incomplete Data set	12-07-2023	12:00:00 AM	ov.ph/api/data/latest, if there are errors i	13-07-2023

Figure 10-1 Daily review of system logs and jobs

Source: Ramboll

2. Daily review of system logs and Jobs – A daily review of the operational logs and execution of jobs is planned by checking the automated alerts and FEWS to ensure seamless operation without any failures. Relevant troubleshooting in case of any failures will also be performed. Reports as indicated in Figure 10-1 will be generated to record any system failures.

Time of Inspection	Assigned to:	Trouble Shooting Process Applied	Date of Rectification of Issu	Control #	Remarks
10:00:00 AM	Shan-ry D. Roberts - IT Team, MITD	None	29-06-2023	20230630-JS-01	
10:00:00 AM	Vilakshna Parma - Modelling Team, Ramboll	Assigned to modelling team	30-06-2023	20230630-JS-02	
10:22:00 PM	Shan-ry D. Roberts - IT Team, MITD	Pending		20230702-01	
10:24:00 PM	arg - IT Team, Ramboll, Shan-ry D. Roberts - IT Tean	Pending		20230702-02	
10:25:00 PM	arg - IT Team, Ramboll, Shan-ry D. Roberts - IT Tean	Pending		20230702-03	
9:56:00 AM	Vilakshna Parma - Modelling Team, Ramboll	Referred to Modelling Team		20230705-01	
11:41:00 AM	Shan-ry D. Roberts - IT Team, MITD		6 jul 23	20230706-01	
11:43:00 AM	Shan-ry D. Roberts - IT Team, MITD			20230706-02	
10:58:00 AM	Janice "Nikka" Aquino - Modelling Team, SLU			20230707-01	
11:01:00 AM	Amit Garg - IT Team, Ramboll	Referred to sir Amit		20230707-02	
11:02:00 AM	Shan-ry D. Roberts - IT Team, MITD			20230707-03	
2:30:00 PM	Shan-ry D. Roberts - IT Team, MITD	Manually Ran the Script	07-07-2023	20230707-04	
4:00:00 PM	Shan-ry D. Roberts - IT Team, MITD			20230707-05	
7:56:00 AM	Shan-ry D. Roberts - IT Team, MITD			20230708-01	
7:57:00 AM	Janice "Nikka" Aquino - Modelling Team, SLU			20230708-02	
11:07:00 AM	Shan-ry D. Roberts - IT Team, MITD			20230709-01	
11:16:00 AM	arg - IT Team, Ramboll, Shan-ry D. Roberts - IT Team, MITD			20230709-02	
8:40:00 AM	Shan-ry D. Roberts - IT Team, MITD	Restarted Machine then manually executed the job	10-07-2023	20230710-01	
9:00:00 AM	Shan-ry D. Roberts - IT Team, MITD	Restarted Machine then manually executed the job		20230710-02	Job is still running
9:00:00 AM	Shan-ry D. Roberts - IT Team, MITD	Restarted Machine then manually executed the job	10-07-2023	20230710-03	
9:00:00 AM	Shan-ry D. Roberts - IT Team, MITD	Restarted Machine then manually executed the job	10-07-2023	20230710-04	
9:00:00 AM	Shan-ry D. Roberts - IT Team, MITD	Restarted Machine then manually executed the job	10-07-2023	20230710-05	
9:00:00 AM	Shan-ry D. Roberts - IT Team, MITD	Restarted Machine then manually executed the job		20230710-06	Job is still running
2:58:00 PM	Modelling Team, Ramboll, Janice "Nikka" Aquino - M	Referred to modelling team		20230711-01	out no data for 9:40 am
3:35:00 PM	MO, Vilakshna Parma - Modelling Team, Ramboll, J	Referred to Modelling team		20230711-02	
2:45:00 PM	Steven Guiller B. Ramirez - Instrument Team, MITD	Referred to instrument team to coordinate with DOST		20230711-03	
9:00:00 AM	Shan-ry D. Roberts - IT Team, MITD	Job ran successfully after 2 execution	13-07-2023	20230713-01	No actions required
9:00:00 AM	Shan-ry D. Roberts - IT Team, MITD	Job ran successfully after 2 execution	13-07-2023	20230713-02	No actions required
9:00:00 AM	D. Roberts - IT Team, MITD, Henry Hambon - IT Tea	ther script to get the data for the day to complete the fi	13-07-2023	20230713-03	

3. Daily review of data logs - The aim is to review of reception of input data from gauging stations and WRF data using automated emailers and the system. Troubleshooting plan will be followed in case of any issue.

Date of forecast											
Time of forecast	10:00			13:00			16:00				
	Forecasted W	Observed WL	Difference	Forecasted W	Observed WL	Difference	Forecasted W	Observed WL	Difference	Forecasted W	
tof + 0	1342,662231	1342,715	0,052768555	1342,645752	1342,695	0,049248047	1342,69446	1342,755	0,060541992	1342,752686	
tof + 1	1342,662476	1342,725	0,062524414	1342,643433	1342,725	0,081567383	1342,99365	1342,765	-0,228652344	1342,716553	
tof + 2	1342,656738	1342,725	0,068261719	1342,638184	1342,725	0,086816406	1343,18823			1342,694092	
tof + 3	1342,650879	1342,695	0,044121094	1343,448853	1342,755	-0,693852539	1343,04016	1342,825	-0,215161133	1342,676636	
tof + 4	1342,645386	1342,725	0,079614258	1343,648926	1342,765	-0,883925781	1342,88989	1342,815	-0,074892578	1342,658936	
tof + 5	1342,640137	1342,725	0,084863281	1343,745972			1342,80762	1342,805	-0,002617188	1342,643066	
tof + 6	1342,640625	1342,755	0,114375	1343,184814	1342,825	-0,359814453	1342,76416	1342,815	0,050839844	1342,630859	
tof + 7	1342,671997	1342,765	0,09300293	1342,933472	1342,815	-0,11847168	1342,73828	1342,785	0,04671875	1342,62085	
tof + 8	1342,67395			1342,81897	1342,805	-0,013969727	1342,71826	1342,775	0,056738281	1342,612427	
tof + 9	1342,666748	1342,825	0,158251953	1342,758667	1342,815	0,056333008	1342,70288	1342,775	0,072119141	1342,604858	
tof + 10	1342,655396	1342,815	0,159604492	1342,725708	1342,785	0,059291992	1342,68994	1342,775	0,085058594	1342,598145	
tof + 11	1342,644165	1342,805	0,160834961	1342,701172	1342,775	0,073828125	1342,67883	1342,765	0,086166992	1342,591553	
tof + 12	1342,633545	1342,815	0,181455078	1342,683716	1342,775	0,09128418	1342,66773	1342,775	0,107275391	1342,585693	
tof + 13	1342,624878	1342,785	0,16012207	1342,670044	1342,775	0,104956055	1342,65674	1342,755	0,098261719	1342,583984	
tof + 14	1342,61731	1342,775	0,15769043	1342,656982	1342,765	0,108017578	1342,64771	1342,755	0,107294922	1342,583252	
tof + 15	1342,610718	1342,775	0,164282227	1342,645264	1342,775	0,129736328	1342,63977	1342,765	0,125229492	1342,55542	
tof + 16	1342,604858	1342,775	0,170141602	1342,635498	1342,755	0,119501953	1342,63281	1342,725	0,0921875	1342,57666	
tof + 17	1342,599609	1342,765	0,165390625	1342,627197	1342,755	0,127802734	1342,62647	1342,685	0,058535156	1342,5448	
tof + 18	1342,594971	1342,775	0,180029297	1342,619995	1342,765	0,145004883	1342,62085	1342,705	0,084150391	1342,56311	
tof + 19	1342,590454	1342,755	0,164545898	1342,61377	1342,725	0,111230469	1342,6156	1342,685	0,069399414	1342,538452	
tof + 20	1342,586182	1342,755	0,168818359	1342,608398	1342,685	0,076601563	1342,61072	1342,705	0,094282227	1342,549438	
tof + 21	1342,582153	1342,765	0,18284668	1342,603638	1342,705	0,101362305	1342,6062	1342,725	0,118798828	1342,563477	
tof + 22	1342,588135	1342,725	0,136865234	1342,599365	1342,685	0,085634766	1342,60205	1342,735	0,132949219	1342,549194	
tof + 23	1342,559326	1342,685	0,125673828	1342,595581	1342,705	0,109418945	1342,59815	1342,695	0,096855469	1342,579102	
tof + 24	1342,590576	1342,705	0,114423828	1342,592163	1342,725	0,132836914	1342,59448	1342,745	0,150517578	1342,542725	

Figure 10-2 Daily model performance log

Source: Ramboll

4. Daily report on Job and script performance - Logs of Job and script which failed during the operation and the troubleshooting steps applied will be maintained. The goal is to identify the frequency and type of failures and update the scripts.

03-07-2023												
19:00		22:00			01:00			04:00			07:00		
Observed WL	Difference	Forecasted W	Observed WL	Difference	Forecasted W	Observed WL	Difference	Forecasted W	Observed WL	Difference	Forecasted W	Observed WL	Difference
1342,825	0,072314453	1342,74402	1342,815	0,07098145	1342,71094	1342,775	0,0640625	1342,71106	1342,775	0,06394043	1342,70288	1342,765	0,06211914
1342,815	0,098447266	1342,7323	1342,785	0,0527002	1342,70288	1342,775	0,07211914	1342,703	1342,755	0,05199707	1342,69898	1342,725	0,02602539
1342,805	0,110908203	1342,71985	1342,775	0,05515137	1342,69421	1342,765	0,07078613	1342,69495	1342,755	0,06005371	1342,69177	1342,685	-0,0067725
1342,815	0,138364258	1342,70886	1342,775	0,0661377	1342,6853	1342,775	0,08969727	1342,6875	1342,765	0,0775	1342,6853	1342,705	0,01969727
1342,785	0,126064453	1342,69934	1342,775	0,07565918	1342,67725	1342,755	0,07775391	1342,68079	1342,725	0,04421387	1342,6792	1342,685	0,00580078
1342,775	0,131933594	1342,68933	1342,765	0,07566895	1342,66992	1342,755	0,08507813	1342,67444	1342,685	0,01056152	1342,67346	1342,705	0,03153809
1342,775	0,144140625	1342,68042	1342,775	0,09458008	1342,66235	1342,765	0,10264648	1342,66821	1342,705	0,03678711	1342,66748	1342,725	0,05751953
1342,775	0,154150391	1342,67273	1342,755	0,08227051	1342,65552	1342,725	0,06948242	1342,66174	1342,685	0,02325684	1342,66138	1342,735	0,07362305
1342,765	0,152573242	1342,66455	1342,755	0,09044922	1342,64917	1342,685	0,03583008	1342,65576	1342,705	0,04923828	1342,65564	1342,695	0,03936035
1342,775	0,170141602	1342,6571	1342,765	0,10789551	1342,64319	1342,705	0,06181152	1342,65002	1342,725	0,07497559	1342,65002	1342,745	0,09497559
1342,755	0,156855469	1342,65039	1342,725	0,07460938	1342,63745	1342,685	0,04754883	1342,64465	1342,735	0,09034668	1342,64478	1342,755	0,11022461
1342,755	0,163447266	1342,64404	1342,685	0,04095703	1342,6322	1342,705	0,07279785	1342,65527	1342,695	0,03972656	1342,63953	1342,765	0,12547363
1342,765	0,179306641	1342,63818	1342,705	0,06681641	1344,53088	1342,725	-1,8058838	1343,14807	1342,745	-0,4030713	1342,63464	1342,775	0,14035645
1342,725	0,141015625	1342,63269	1342,685	0,05230957	1343,42517	1342,735	-0,6901709	1343,09924	1342,755	-0,3442432	1342,63001	1342,775	0,14499512
1342,685	0,101748047	1342,62756	1342,705	0,07743652	1343,05591	1342,695	-0,3609082	1342,91602	1342,765	-0,1510156	1342,62537	1342,775	0,14963379
1342,705	0,149580078	1342,62268	1342,725	0,10231934	1342,96619	1342,745	-0,2211865	1342,80774	1342,775	-0,0327393	1342,62073	1342,765	0,14427246
1342,685	0,108339844	1342,61829	1342,735	0,11671387	1342,90881	1342,755	-0,1538135	1342,74951	1342,775	0,02548828	1342,61658	1342,775	0,15842285
1342,705	0,160200195	1342,6145	1342,695	0,08049805	1342,82263	1342,765	-0,0576318	1342,71985	1342,775	0,05515137	1342,61231	1342,775	0,16269531
1342,725	0,161889648	1342,61279	1342,745	0,13220703	1342,75684	1342,775	0,01816406	1342,69727	1342,765	0,06773438	1342,6084		
1342,735	0,196547852	1342,62366	1342,755	0,13134277	1342,72339	1342,775	0,05161133	1342,68091	1342,775	0,0940918	1342,60461	1342,755	0,15038574
1342,695	0,145561523	1342,63733	1342,765	0,1276709	1342,70081	1342,775	0,07419434	1342,66602	1342,775	0,10898438	1342,60083		
1342,745	0,181523438	1342,6405	1342,775	0,13449707	1342,6842	1342,765	0,0807959	1342,65149			1342,59717	1342,745	0,14783203
1342,755	0,205805664	1342,63464	1342,775	0,14035645	1342,6709	1342,775	0,10410156	1342,63892	1342,755	0,11608398	1342,59351	1342,745	0,15149414
1342,765	0,185898438	1342,62549	1342,775	0,14951172	1342,6571	1342,775	0,11789551	1342,62866			1342,58984	1342,755	0,16515625
1342,775	0,232275391	1342,61621	1342,765	0,14878906	1342,64526			1342,62	1342,745	0,12500488	1342,5863	1342,755	0,16869629

5. Daily report on model performance - The model performance will be monitored using daily reports as indicated in Figure 10-2 and appropriate actions will be taken in case any prolonged issue is seen which consistently influences the model performance.

6. Real-time station maintenance and weekly report on station performance - A weekly report as indicated in Figure 10-3 will be prepared on the station's performance, highlighting station online durations, data on PhilSensor website, site visits and manual station maintenance.

7. Weekly report on quality of model input data - A weekly review of the data from real-time monitoring stations and rainfall forecast data will be carried out to identify gaps, outliers, negative values, and unrealistic values.

8. Flood warning and flood occurrence - During the monsoon season, floods can be forecasted with a warning from the FEWS, but they can also occur without any prior notification. For both cases, the additional field data will be gathered such as flood extent, depth to assess the reliability of the system.

ID	Station name	Sensor type	Date of inspection	Purpose/Action taken
460	City Camp Lagoon	Tandem	10-07-2023	Cleaning and Preventive Maintenance
892	Camp 6 Bridge	Tandem	10-07-2023	Cleaning and Preventive Maintenance
463	Nangalisan, Asin	Tandem	10-07-2023	Cleaning and Preventive Maintenance
2892	Ferguson Bridge	Water level	10-07-2023	Cleaning and Preventive Maintenance
2893	Sadjap Bridge, Km3	Water level	10-07-2023	Cleaning and Preventive Maintenance
2894	Brookspoint	Tandem	10-07-2023	Cleaning and Preventive Maintenance
2896	Woodsgate, Camp 7	Water level	10-07-2023	Cleaning and Preventive Maintenance
3028	Irisan Fire Station	Rain gauge	10-07-2023	Cleaning and Preventive Maintenance
892	Balili Bridge, Km6	Tandem	10-07-2023	Cleaning and Preventive Maintenance
892	Camp 6 Bridge	Tandem	14-08-2023	Cleaning and Preventive Maintenance

Figure 10-3 Real-time station maintenance log
Source: Ramboll

10.2 RUNNING HISTORICAL SIMULATIONS FOR FURTHER BIAS CORRECTION ASSESSMENTS

Historical simulations for generating large sample sizes required for supporting and adding to the pre-monsoon assessments of bias corrections (refer section 5.1) will be carried during the monsoon months on a parallel database, as explained in section 7.3.

The number of simulations that is planned to be run during these months are approximated around 11500. This will add significantly to the sample size for bias correction analysis which has been initiated in the pre-monsoon phase.

10.3 RUNNING PARALLEL SIMULATIONS FOR DA ASSESSMENT

Parallel simulations for MODEL 1 (Balili), to test the four DA strategies in real-time, as explained in section 5.3.2 will be run in real time in the FEWS to create sample size for data analysis for DA parameters.

The results required for post-monsoon assessment will be extracted parallelly to reduce manual work by the scripts added to the updated FEWS. This will be monitored regularly to ensure that the process gets executed as intended.

	Findings	**Remarks/Recommendations**	**Repair no.**	**Actioned by:**
	N/A	Need Padlock for the gate		CDRRMO, MITD
	N/A	Need Padlock for the gate		CDRRMO, MITD
	N/A	Need Padlock for the gate		CDRRMO, MITD
	N/A	N/A		CDRRMO, MITD
	N/A	N/A		CDRRMO, MITD
	N/A	N/A		CDRRMO, MITD
	N/A	N/A		CDRRMO, MITD
	N/A	Need Padlock for the gate		CDRRMO, MITD
	Negative Values read by the WL Sensor	Operational BUT with negative values; Waiting for ASTI to update the sensor height on their server	BB-0002	CDRRMO, MITD, DOST
	Negative Values read by the WL Sensor	Operational BUT with negative values; Waiting for ASTI to update the sensor height on their server(Need padlock for Cage and arq and battery enclosure)		CDRRMO, MITD

11. CONCLUSION

Source: Adobe Stock

This report summarizes the pre-monsoon assessment of the Baguio FEWS in preparation for the first full-scale real-time test of the Baguio FEWS during the 2023 monsoon. The main conclusions and achievements of the pre-monsoon assessment are presented below.

During the pre-monsoon phase, the project has successfully upgraded the network of real-time stations by replacing five stations which were not operational. The station equipment and construction works were procured, civil works repairs completed, platforms constructed, and the new station equipment installed by early April 2023. The five upgraded stations have been operational since May 2023 with DOST-ASTI and DOST-CAR continuously supporting in trouble-shooting of any technical issues that may arise.

During the pre-monsoon phase, efforts have been made enhance the FEWS by improving bias correction, data assimilation and implementing model upgrades. The following measures have been taken:

- The various bias correction models have been developed and are being tested using both historic data and during real-time operation. Based on sample results, bias correction model with error estimation from 12-hour time span model is performing well and is applied for the real-time testing.
- Four data assimilation techniques have been formulated for continuous automation during the real-time operation of the 2023 monsoon. These strategies are currently undergoing testing within the real-time 2023 monsoon operation. The information gathered throughout this live operation will be evaluated, and necessary adjustments to the data assimilation methods will be implemented in the period following the monsoon season.
- Considering the frequent emergence of extreme weather events, the models have been improved to function seamlessly during the occurrence of a higher magnitude rainfall event.

An extensive analysis of historical data has revealed a deficiency in the presence of overlapping data, a crucial element for refining the model, performing bias correction, implementing data assimilation, and enhancing the overall functionality of the FEWS system. The performance of the model benefits significantly from a larger dataset, resulting in increased model reliability. It is essential to emphasize that the entirety of the collected data holds potential for further model improvements and improvement of FEWS. Therefore, in this stage, the acquisition of additional data is pivotal.

Throughout the pre-monsoon phase, several scripts have been developed to ensure and strengthen the system's performance and the applicability of its results. These scripts generate daily/monthly reports and ensures timely updates on the station and system's status to the FEWS O&M team. Thus, these scripts contribute to effective operation and ensures minimal manual analysis for the O&M team members. The FEWS setup has been optimized, as presented, to minimize potential system failure and increase system resiliency.

A targeted training program building on the 2022 training activities kicked off in end-April 2023. The aim of '2023 Baguio FEWS training program' is to strengthen local capacity for independent operation and maintenance of the FEWS in parallel with implementing, testing and refining the system. The pre-monsoon training activities were built around three main areas: technical, procedures, and roles and responsibilities. The pre-mosoon activities have been two-fold: online sessions (end-April to June) and OTJ training (8-day program in June). Results from satisfaction and knowledge surveys demonstrate that the training successfully achieved its objective of building a comprehensive understanding of testing and operating FEWS, while preparing the participants for the FEWS test during the monsoon season. It is expected that the capacities within the FEWS O&M team will continue to increase through on-the-job training and implementation of standard operating procedures in 2023 throughout the consolidation phase, however, it is very likely, that it will not be possible to bring them to a professional level to enable the team to be fully responsible for the operation and maintenance of the FEWS. Thus, it is expected that further technical support for finetuning, testing, and operating the system will be needed beyond 2023.

The plan for the 2023 real-time test of the FEWS has been prepared and is currently being executed. Three main aspects of the system will be tested: technical performance, effectiveness of procedures, and team performance. The FEWS O&M team initiated real-time operation of the FEWS and completion of monsoon SOPs on Friday June 30, 2023, following the completion of the 8-day in-person OTJ training program in Baguio. Since this date, the FEWS O&M team has operated and maintained the system with daily support from the technical project team.

In close collaboration with the LGU, efforts in enhancing FEWS governance has been continued in 2023. The system governance and long-term sustainment was discussed in-person in meetings with key partner organizations and Mayor Benjamin Magalong in June 2023. As a result, the partnership with crucial stakeholders including DOST-CAR and DOST-ASTI has been strengthened. Furthermore, the project team has facilitated the establishment of two Memoranda of Agreements with La Trinidad and Tuba. The MOAs formalize the collaboration on maintenance of the network of monitoring stations and knowledge and data-sharing on the Baguio FEWS between the three municipalities.

There is a need to properly anchor and institutionalize the FEWS O&M team in the LGU to ensure that team members have the mandate to undertake the assigned tasks and responsibilities. In agreement with the CDRRMO Officer-in-charge, an executive order will be drafted establishing a new Early Warning and Monitoring Unit under the Operations and Warning Division in the CDRRMO. The FEWS O&M team will be anchored in this unit. The project team will follow this closely throughout 2023 and provide guidance and support as necessary.

The need for testing is not limited to one single monsoon season, as any FEWS requires proper validation (several monsoons) before it's publicly launched. Launching a FEWS without proper testing and troubleshooting time can have serious consequences on the credibility of the LGU and ultimately on the confidence in the system itself.

ABOUT THE ASEAN AUSTRALIA SMART CITIES TRUST FUND

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