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

CONSOLIDATION PHASE - FINAL ROADMAP

APRIL 2023

ASEAN AUSTRALIA SMART CITIES TRUST FUND
Asian Development Bank

Australian Government
Department of Foreign Affairs and Trade

ADB

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Prepared by	Alvaro Fonseca, Stine Dybkjær, Agata Sliwa, Amit Garg, David Rojas, Hillarie Cania, Prajnya Nayak, Vilakshna Parmar, Lars Østergaard Jørgensen
Checked by	Alvaro Fonseca
Approved by	Hillarie Cania
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ABBREVIATIONS

AASCTF	ASEAN Australia Smart Cities Trust Fund
ADB	Asian Development Bank
API	Application Programming Interface
ASEAN	Association of Southeast Asian Nations
BDRRMC	Barangay Disaster Risk Reduction and Management Committee
CDRRMC	City Disaster Risk Reduction and Management Council
CDRRMO	City Disaster Risk Reduction and Management Office
DFAT	Department of Foreign Affairs and Trade (Australia)
DOST	Department of Science and Technology (Philippines)
DOST-ASTI	DOST Advanced Science and Technology Institute
DOST-CAR	DOST Cordillera Administrative Region
FEWS	Flood Early Warning System
GESI	Gender Equality and Social Inclusion
GEDSI	Gender Equality, Disability, and Social Inclusion
LGU	Local Government Unit
MITD	Management Information Technology Division
MOA	Memorandum of Agreement
O&M	Operations and Maintenance
OTJ	On-the-job (Training)
PAGASA	Philippine Atmospheric Geophysical and Astronomical Services Administration
SLU	Saint Louis University
SOP	Standard Operating Procedures
WRF	Weather Research Forecast

1. INTRODUCTION

Source: Adobe Stock

1.1 ASEAN AUSTRALIA SMART CITIES TRUST FUND 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 ACTIVITIES AND 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:

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

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 FEWS is also set to become an integral element within the overall vision of Baguio City to become a truly resilient, dynamic, and smart city.

The activities and achievements of the project have been documented in the ten (10) 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 2022 but was extended to April 2023 with additional scope including the preparation of a Final Roadmap (this report) for the consolidation phase.

1.3 REPORT STRUCTURE

The purpose of this report is to provide a roadmap of activities in the proposed Consolidation Phase in 2023 and beyond. First, the purpose and goals of the Consolidation Phase are introduced. Second, the roadmap for the Consolidation Phase is presented including the timeline of activities in 2023 and descriptions of activities and deliverables. Finally, recommendations for 2024 and beyond are presented to truly solidify the long-term sustainability of the FEWS.

1.4 RATIONALE THE CONSOLIDATION PHASE

The FEWS has been fully installed at the LGU servers, but it was not possible to complete online testing and operational acceptance during the 2022 monsoon. The finalized system with the calibrated models and Weather Research Forecast (WRF) inputs was not running during the monsoon of 2022 and therefore a full-scale test of the system during real-time operation has not yet been completed.

The inability to test the system in 2022 was caused by delays in permissions for obtaining data, data quality issues, and delays in construction, installation, and commissioning of new monitoring stations. Furthermore, given the starting point of the Operation and Maintenance (O&M) team established at the LGU, it has not been possible to bring the O&M team to the necessary professional level to enable them to be fully responsible for the operation and maintenance of the FEWS. More training and technical support is required to the LGU, as the team needs to be able to perform a full-scale testing of the system, for which more dedicated on-the-job (OTJ) training in completion of standard operation procedures (SOPs) is needed. The team needs to gain experience in collaborating on operating and maintaining the FEWS and refining internal communication lines and work procedures as well as establishing confidence in working as a team before they can be expected to successfully operate the system independently. Thus, to validate and test the FEWS the LGU will continue to require technical assistance in preparing for a full-scale monsoon testing, running troubleshooting and feedback loops during the monsoon, and fine-tuning the system during a post-monsoon period. If this is not provided, it is very likely that the project effort will slowly start falling apart, and the competencies that have been built through the Capacity Building Program and OTJ training sessions will become stagnant. 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.

Thus, following the completion of the pilot project, it is recommended to initiate a project Consolidation Phase to enhance the long-term sustainability of the FEWS. The overall purpose of the consolidation phase is for the LGU to be fully ready to launch the system publicly and operate it independently utilizing the FEWS as an active risk mitigation instrument for Baguio City.

2. THE BAGUIO FEWS CONSOLIDATION PHASE

Source: Ramboll

As described in the previous section, the Baguio FEWS Consolidation Phase aims at enhancing the long-term sustainability of the system through support in improving the technical and institutional system structure.

The following key activities are recommended to finetune, validate, and test the FEWS and to further enhance the project outcomes ensuring that proposed plans, actions, and lessons learned are implemented in Baguio City:

FEWS Design

The FEWS will be tested, validated, and refined based on a system performance assessment. A pre-requisite to initiating the full-scale test of the system is an upgrade of five existing real-time monitoring water-level and rainfall stations[1]. This task is fundamental, as the existing stations have not been working consistently throughout 2022. The historical data from these stations, prior to 2022, also contains significant inconsistencies and gaps. Additionally, improvements to the system are recommended, with some updates to be implemented pre-monsoon and tested during the monsoon period, and additional updates to be implemented post-monsoon following monsoon data capture and assessment of system performance.

1 In addition to the five new stations procured, contructed and installed in 2022 under the project. See: Section 4.2 in Flood Early Warning System Report Phi: Baguio City Smart Flood Warning, Information And Mitigation System, AASCTF, April 2022.

FEWS Capacity Building and Governance

The focus on building capacities at local level has been a fundamental driver throughout the pilot project. Through the *Targeted Capacity Building Program to Enhance the sustainable delivery of FEWS* and OTJ training, the local technical capacity was increased. However, more training and technical support is required for the FEWS O&M group to be able to operate the system independently. Capacity building efforts should be continued through facilitation of OTJ training and technical guidance in the implementation of SOPs. Furthermore, efforts to enhance the FEWS governance are needed to ensure the foundation for effective operation and maintenance of the system. In addition to the two MOAs achieved in the pilot project, it is recommended to formalize partnerships with DOST-ASTI, Saint Louis University, and other relevant partners, to delineate expectations across organizations and set the foundation for long-term sustainability of the system. Additionally, efforts to ensure financial sustainability and institutionalization of the FEWS O&M team are of key priority. A Sustainment Plan outlining the recommended measures to enhance technical, institutional, and financial sustainability will be prepared as part of the Consolidation Phase.

Dissemination and outreach

During the process of developing the *Data Dissemination and Outreach Plan*[2], a series of actions to move forward were identified with the primary action being the testing and validation of the FEWS. It is proposed that the testing and validation includes three distinct phases gradually involving more stakeholder groups, followed by the development of SOPs for the different stakeholders involved in getting messages across to the recipients/end-users. In the third testing phase, Awareness and Education activities should be developed, as well as media partnerships to ensure the effective delivery of messages. The testing and validation phase is expected to cover multiple monsoon seasons, depending on the frequency of events and resources available to develop the necessary communication tools and channels. An explicit vulnerability program and specific gender and social inclusion actions will also need to be included. The recommendations for Data Dissemination and Outreach are further described in the Data Dissemination and Outreach Plan, and these should be considered through the various test phases of the FEWS.

2 Data Dissemination and Outreach Plan, Phi: Baguio City Smart Flood Warning, Information And Mitigation System, AASCTF, December 2022.

Gender and Social Inclusion

The findings of the *Gender and Social Inclusion (GESI) Study*[3] highlight a number of ways in which stakeholders involved in the design and implementation of the flood early warning system in Baguio City can take action to ensure that the FEWS is effective for everyone who needs it, leaves no one behind, and supports equitable and inclusive risk reduction and resilience. Recommendations may be found in the Mixed Methods Gender and Inclusion Study report, and associated publications including the Policy Brief and the tailored Implementation Plan which details the actions and responsibilities for a gender transformative FEWS in Baguio City. In the consolidation phase beyond 2023, further support to the LGU in the implementation of the gender transformative action plan is recommended. This includes mentoring and coaching of key actors responsible for implementing actions, as well as selection (with CDRRMO input) and implementation of a limited number of priority actions to be supported by consolidation phase funding.

Flood Mitigation Action Plan

The *Flood Mitigation Action Plan*[4] included the development of high-level conceptual designs for three pilot sites identified for potential NbS implementation in Baguio. The perspectives of formulating an investment project as part of the city's overall urban sustainability projects (Green Walks and Blue Walks) are big and it is recommended to further assess the opportunity for advancing the pilot projects to a schematic design phase and eventually initiating construction. As outlined in the *Flood Mitigation Action Plan*, the adaptive capacity of the population, institutions and governmental bodies will play a key role in the continuous shift towards a resilient city in future climate conditions. Thus, in addition to implementation of physical flood mitigation measures, efforts to prepare individual households and build technical and institutional capacities across stakeholders in Baguio should be prioritized to enhance the adaptive capacity of the city and thereby improve resilience. The recommendations for flood mitigation actions are further outlined in the *Flood Mitigation Action Plan*. To the extend possible, support to the LGU in formulating potential investment projects will be explored as part of the city graduation journey under the AASCTF.

3 Mixed Methods Gender and Inclusion Study Report. PHI: Gender Transformative Approach for Strengthened Development, Application, and Replication of the Baguio City Smart Flood Early Warning. AASCTF. August 2021.

4 Flood Mitigation Action Plan Report Phi: Baguio City Smart Flood Warning, Information And Mitigation System, AASCTF, December 2021.

3. FINAL ROADMAP FOR THE CONSOLIDATION PHASE

Source: Ramboll

Figure 3.1 provides an overview of the activities planned for the Consolidation Phase in 2023 and beyond. The activities for 2023 have been divided into four main tasks, designed around the monsoon phases:

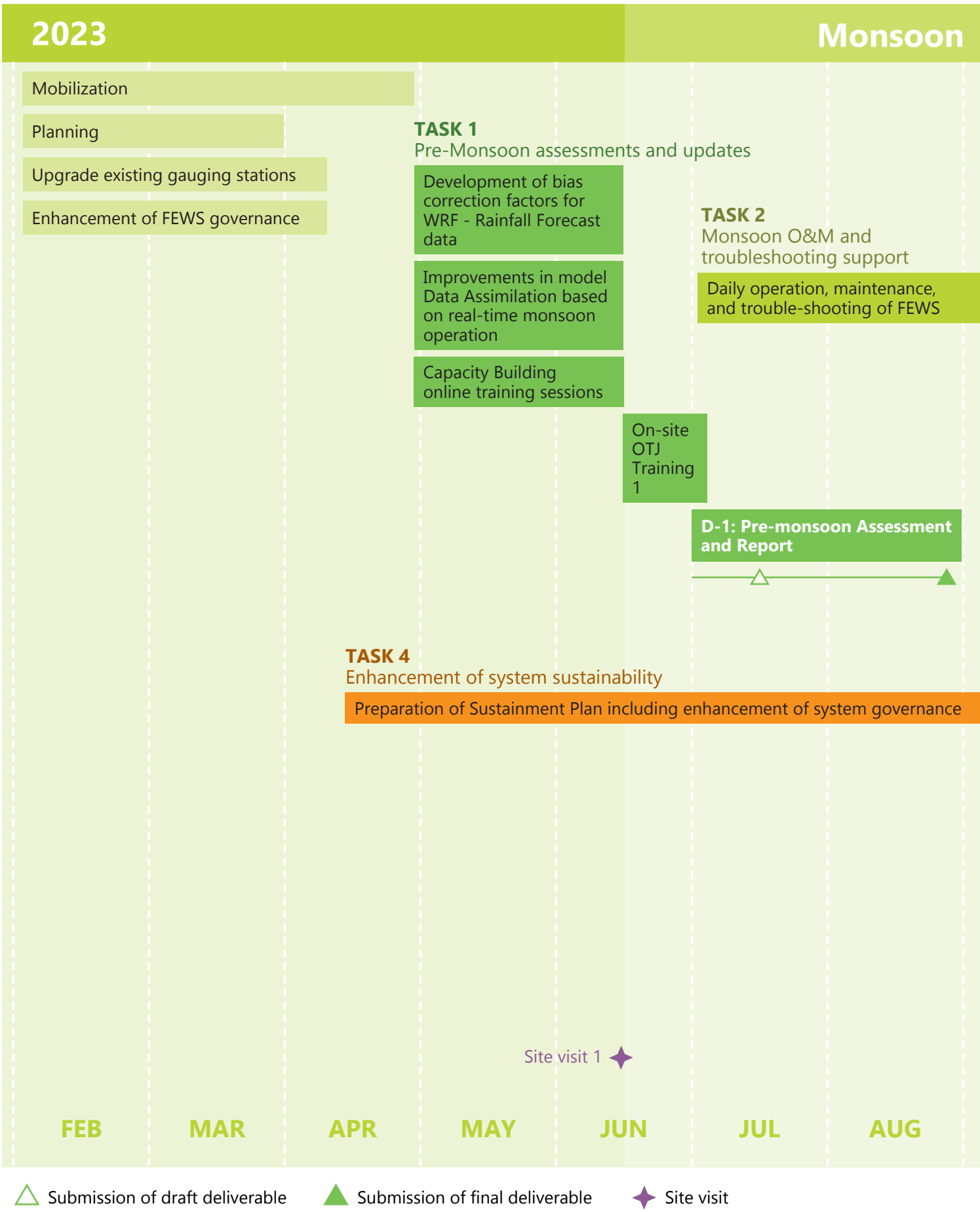
Task 1: Pre-Monsoon assessments and updates
Task 2: Monsoon O&M and troubleshooting support
Task 3: Post-monsoon system performance assessment and system updates
Task 4: Enhancement of system sustainability.

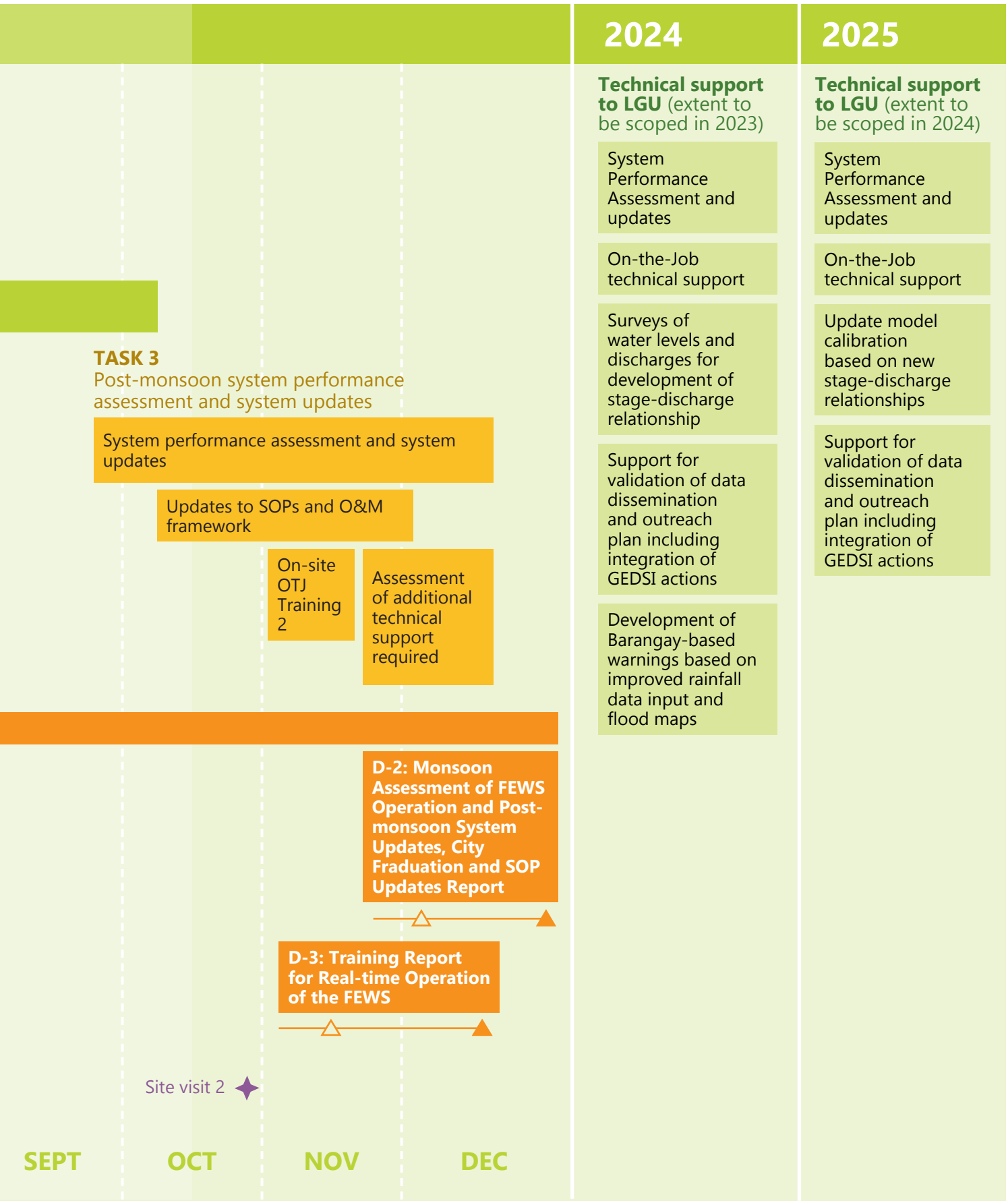
There are three deliverables planned, with the first deliverable (*Pre-monsoon Assessment and Report*) marking the end of Task 1 and two deliverables (*Monsoon Assessment of FEWS Operation and Post-monsoon System Updates, City Graduation and SOP Updates Report* and *Training Report for Real-time Operation of the FEWS*) concluding Task 4.

The activities will be completed in close collaboration with the LGU. As the system is anchored in the LGU it is crucial that the LGU are involved in key decisions and system design and sustainment plans to ensure well-established ownership structures, responsibilities, and commitments.

The activities beyond 2023 will be further detailed based on an assessment of additional support needed towards the end of 2023 as the impact of the planned activities are assessed and the readiness for the LGU to operate the system is understood.

Figure 3.1 Final Roadmap for Baguio FEWS Consolidation Phase




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

3.1 2023 ACTIVITIES

3.1.1 EARLY 2023

Towards the end of the pilot project in 2022, the urgency of initiating key activities in the Consolidation Phase was evident. Thus, additional scope was added to the pilot project through an extension of the project until April 2023 to finalize planning for the consolidation phase and initiate key activities to be completed ahead of the monsoon. These activities are briefly described below.

Planning
Preparation of a consolidation plan and roadmap for the sustainable operationalization of the FEWS. The Final Roadmap is presented in this report and includes the development of a detailed scope of work for technical support and capacity development over the 2023 period, before, during and after the monsoon season.

Upgrade the existing gauging stations
This task entails improvement of the consistency of real-time data from existing stations. The task covers both the rainfall data captured by the rainfall gauges owned by PAGASA, and the real-time water level data captured through the water-level sensors, with both data types being published at the PhilSensor website, to which access has been provided by DOST-ASTI via the APIs. This is a fundamental task to complete, as the existing stations have not been working consistently throughout 2022. The historical data from these stations, prior to 2022, also contains significant inconsistencies and gaps, with a few exceptions covering limited periods of time. These issues have been discussed with the Mayor of Baguio City and the LGU, ADB, DOST-CAR, PAGASA and DOST-ASTI. FFollowing meetings in December 2022, DOST-CAR recommended replacement of five existing stations 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. Finalizing establishment of real-time API access by DOST-ASTI to the stations is on-going. The new stations ensure greater spatial real-time data coverage of the river basins in Baguio. The ownership of the existing stations at these locations was with PAGASA, but through a collective coordination effort between Baguio LGU, La Trinidad LGU and Tuba LGU, a request of formal ownership of the station was sent to PAGASA. PAGASA has acknowledged the request and has accepted to transfer the ownership. PAGASA is currently sharing the signed ownership documents with the respective LGUs.

Enhancement of FEWS governance
In close collaboration with the LGU, efforts in enhancing FEWS governance has been continued in early 2023. These efforts will be continued in the preparation of a Sustainment Plan to be delivered by end 2023.

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. The technician has become an active part of the FEWS O&M and will attend upcoming training activities related to the FEWS. The addition of a technician to the team is expected to enhance the effectiveness of troubleshooting and maintenance and ensure effective communication with partner organizations including DOST-CAR, DOST-ASTI, and PAGASA.

In addition, efforts to strengthen partnerships with collaborating institutions have been continued. In addition to the two Memorandum of Agreements (MOAs) achieved in the pilot project with PAGASA and DOST-CAR respectively, it is recommended to formalize partnerships with DOST-ASTI, SLU, Tuba LGU, and La Trinidad LGU to delineate expectations across organizations and set the foundation for long-term sustainability of the system, anchored at the Baguio LGU. Communication with these partners has been continued and drafts of MOAs with SLU, Tuba LGU, and La Trinidad have been prepared. While acknowledging that formalization and official endorsement of these agreements may take time, it is expected that these MOAs will be finalized and signed in 2023.

3.1.2 TASK 1: PRE-MONSOON ASSESSMENTS AND UPDATES

The activities in the pre-monsoon phase focus on preparation of the FEWS and the FEWS O&M team for operation, testing and validation of the system in the monsoon.

Ahead of the monsoon season, the following activities will be undertaken:

Development of bias correction factors for WRF Rainfall Forecast data
The development of bias correction factors for WRF Rainfall Forecast data will be done using the historical station rainfall data and using the historical WRF data which has already been collected. The aim of this activity is to improve the forecasts from the FEWS, for which the developed models are calibrated using station rainfall data. This activity will take place before the 2023 monsoon so the real-time performance testing can be carried out during the monsoon.

Improvements in Model Data Assimilation based on real-time monsoon operation
Assessment of the appropriate period to be considered for error calculation in real-time operation with respect to each station location will be completed ahead of the monsoon, and the updated system will be migrated to the MITD server. The improved data assimilation during the full-scale test of the system, so this activity is closely linked to the OTJ training and operation and maintenance activities. This activity will be followed up with additional iterative offline model test runs post-monsoon as part of the system performance assessment and system updates.

Capacity Building – Online training sessions

As outlined in Section 2 of this report, more training and technical support is required for the FEWS O&M team to be fully ready to operate the system independently. Both online training sessions and OTJ training are planned, with a focus on refreshing the learnings from the 2022 training activities, familiarizing the FEWS O&M team with the SOPs, and the team for testing the FEWS. The online training sessions will serve to prepare the team for the OTJ training, as feedback from the 2022 training activities highlighted the enhancement of learnings from the OTJ training due to online sessions.

The eleven members (three women and eight men) of the 2023 FEWS O&M team are expected to attend the training program. The trainees are signing letters of commitment, confirming their availability/ commitment to attend the planned program activities and their appreciation that their engagement entails a longer-term commitment as a central part of the FEWS O&M team.

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

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

To monitor the Training Program Effectiveness, a Pre-Training Knowledge Assessment is carried out prior to the start of the training program to garner a proper understanding of the participants current confidence level and knowledge related to the planned topics of the training modules.

On-site in-person OTJ Training

A tailored in-person OTJ training program is planned for 2023: a pre-monsoon/monsoon session and a post-monsoon session. The pre-monsoon OTJ training is scheduled for June 2023 and is to take place at Baguio City Hall. The training will provide in-depth hands-on experience in FEWS monsoon standard operating procedures, which is expected to build confidence in the team in a more efficient manner than traditional classroom trainings or online e-learning modules. Gathering the trainees in-person at the same location will allow for enhanced interaction and collaboration between trainees. The training will consist of presentations, Q&A discussions, testing of standard operating procedures, live demonstration, and operation of the FEWS, and hands-on team exercises. The feedback on the 2022 OTJ training sessions was very positive, and the trainees expressed that the hands-on in-person exercises are crucial in their learning process.

The aim of the pre-monsoon OTJ training is to prepare the FEWS O&M team for operating the FEWS through the full-scale of the system with expert guidance and support from the technical project team.

3.1.3 TASK 2: MONSOON O&M AND TROUBLESHOOTING SUPPORT

Throughout the monsoon, the key priority is real-time operation, maintenance and troubleshooting of the FEWS to test and validate the setup ensuring that as much data as possible is gathered for the subsequent system performance assessment.

Daily operation, maintenance, and troubleshooting of FEWS
During the monsoon period, the O&M Team will perform daily operation, logging, and troubleshooting of the FEWS with guidance from the technical project team. This will be the first test of the FEWS and the first opportunity for the FEWS O&M team to work together as a team in the operation and maintenance of the system. Thus, it is expected that the test will provide valuable insight into the aspects of the technical, institutional, and operational aspects of the system that are working well and the aspects that can be further improved. The activities throughout the monsoon are closely interlinked to the OTJ training as the O&M team will receive online guidance and mentoring in the real-time operation and application of standard operating procedures during the monsoon season.

3.1.4 TASK 3: POST-MONSOON SYSTEM PERFORMANCE ASSESSMENT AND SYSTEM UP-DATES

The post-monsoon activities focus on assessment and updating of the FEWS. In this phase, the system will be assessed to evaluate its performance in the 2023 monsoon. Based on the system performance assessment, system updates will be recommended and completed, and recommendations for further support will be detailed.

System performance assessment and system updates
System performance will be assessed based on data from the real-time operation in the 2023 monsoon period. As outlined in the SOPs for the FEWS, the task is two-fold:

- Assessment of real-time performance including an assessment of which monitoring stations work well, which experience down-time, which are consistent, which are overpredicting/underpredicting, recommendations for addition of any new stations in the network, script and job failures, etc.
- Updating the FEWS by inclusion/removal of input data based upon above performance assessment and readjustment of the models (including NAM parameters and other required updates) to accommodate any changes.

The FEWS O&M team will be closely involved in the system performance assessment and model updates as this will allow the team members to gain experience and understanding of the extent of the post-monsoon activities.

Updates to SOPs and O&M framework
The O&M framework and SOPs will be updated based on the findings from real-time operations of the FEWS during the 2023 monsoon period. Following the post-monsoon assessment, the SOPs may need to be updated as new information becomes available and data, tasks and responsibilities for the operation and maintenance of the Baguio FEWS are validated. All procedures should be reviewed and, if necessary, adjusted or expanded to ensure lessons learned from the monsoon season are incorporated.

On-site in-person OTJ training
The planned post-monsoon in-person OTJ training will take place at Baguio City Hall in end-October and focus on building capacities in post-monsoon standard operating procedures. The format is expected to be similar to the pre-monsoon OTJ training but will be adapted based on feedback from the pre-monsoon training.
The aim of the post-monsoon OTJ training is for the FEWS O&M team to gain experience in assessment of FEWS performance and to reach an understanding of the resulting required system updates. To the extend possible, depending on the technical level and readiness of the team, the team will assist in completing system updates and documentation of system performance and updates.

Assessment of additional technical support required
The real-time operations of the FEWS during the 2023 monsoon period will serve as a basis to determine the O&M Team's needs for further technical support. The need for testing of the Baguio FEWS is not limited to one single monsoon season, as any FEWS requires proper validation (several monsoons) before it's publicly launched. 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, however, it is very likely, given the starting point of the FEWS O&M team, that it will not be possible to bring them to a professional level to enable them 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.

3.1.5 TASK 4: ENHANCEMENT OF SYSTEM SUSTAINABILITY

A key focus of the consolidation phase is enhancement of system sustainability to secure effective long-term operation of the FEWS. Several steps for enhancement of long-term sustainability have already been taken including the establishment of the FEWS O&M team, implementation of the targeted capacity building and training program, preparation of SOPs, and establishment of MOAs with partner organizations. Building on these efforts, actions to further enhance the foundation for effective operation and maintenance were identified at the end of the pilot project, and support to the LGU towards achieving these actions will be prioritized in 2023. The activities center on the preparation of a sustainment plan including plans for technical, institutional, and financial sustainability and will focus on the components outlined below.

Preparation of Sustainment Plan including enhancement of system governance
This task is an overarching activity spanning all of 2023. The sustainment plan will focus on enhancing four aspects:

- **Technical sustainment**
  The technical sustainment will build on the validation of SOPs and assessment of system performance to outline actions for continual system improvement and long-term operation and maintenance. The FEWS is a dynamic system that should be adapted as additional data and knowledge is gained and lessons learned are incorporated in the system to enhance its value for the citizens of the City of Baguio. The FEWS SOPs contribute to enhancing long-term technical sustainability by outlining specific activities and tasks to be undertaken by the O&M team and serving as a guide for the team throughout the different operation and maintenance phases. At the same time the SOPs contribute to achieving efficiency, quality output, and uniformity of performance, while reducing miscommunication and failure to comply with standards. The plan for technical sustainment will focus on physical/IT infrastructure operation (including schedules for regular software updates, inspections, repairs, and replacements) and include the development of a roadmap for future technical system enhancement including incorporation of new features and functionalities.

- **Human resources sustainment**
  A plan for sustainment of available and well-trained human resources is crucial. A significant effort in training, motivating, and guiding the nominated local resources for the FEWS project was made, and these efforts will be continued in 2023. The established FEWS O&M team will have the responsibility of operating and maintaining the FEWS and the LGU should continuously ensure that the O&M team members are available and have the mandate to prioritize and perform the required tasks[5]. Roles and responsibilities of the team members have been defined, but implementation of the SOPs is a responsibility shared by all members of the O&M team. Support and guidance for the LGU in establishing the required human resources structures and availability will be prioritized. The sustainment plan will outline actions and a roadmap to further enhance the capacity and resiliency of the O&M team.

- **Institutional/Governmental sustainment**
  Throughout the project, it has become increasingly apparent that the institutional setup in Baguio is highly complex and not well defined, with local organizations not being able to clearly explain their roles and mandates, which many times are concurrent across different organizations. It has therefore been a challenge to identify which organizations to engage on specific matters and clarify the existing distribution of responsibilities and roles. The foundation of the operation and maintenance of the FEWS is established through preparation of standard operating procedures (SOPs), but the implementation of these is highly dependent on well-established partnerships between the City of Baguio and stakeholder institutions. Thus, the need for clearly defined roles, responsibilities and well-established communication lines with partner organizations will be a key activity in 2023. Support to the LGU in establishment of MOAs to formalize partnerships as outlined below will be prioritized.

5 The LGU plans to institutionalize FEWS O&M through an Executive Order by the City Mayor to ensure that the Offices have mandate to provide the Human Resources required.

MOA with DOST-ASTI: DOST-ASTI is a crucial stakeholder in the FEWS project, as they oversee processing, storing, and publishing the real-time data from the gauging stations. Thus, there is a need to formalize an agreement that specifies that formalizes the collaboration and data-sharing between the agency and Baguio LGU.

MOA with La Trinidad LGU and Tuba LGU: As the network of monitoring stations covers La Trinidad and Tuba, and these LGU's have requested transfer of formal ownership of the stations from PAGASA, there is a need to formalize a strong collaboration between the LGU's. The MOA will strengthen partnerships between the LGU's and outline roles and responsibilities in relation to the continuous station operation and maintenance.

Signing of MOA with Saint Louis University (SLU): The MOA with SLU will enable knowledge exchange, support through student projects to further develop the FEWS, and formalize the role of Janice Aquino in the FEWS organization. Janice, in her position as Assistant Professor at the University, will also be acting as the Deputy Team Lead in the FEWS O&M team. She will also be leading the Modelling Team and it will, therefore, be essential for her to have the time and mandate to properly fulfill her tasks in the FEWS, which will be enabled by MOA

- **Financial sustainment**
  A maintenance budget and an overview of potential funding sources will be prepared as part of the sustainment plan. This requires preparation of an overview for all costs associated with operation and maintenance and an overview of which departments/institutions are to cover these costs. Some of the key costs related the operation and maintenance of the Baguio FEWS include:
  - Salary to staff involved in running the system
  - Costs related to operation and maintenance of the gauging stations
  - IT-related costs
  - Software-related costs
  - Expert support
  - Costs related to additional training, workshops, meetings

3.1.6 DELIVERABLES

D-1 Pre-monsoon Assessment and Report
The report will document the pre-monsoon assessment and system updates and the training activities implemented to prepare the FEWS O&M team for the real-time operation and maintenance. The report will be max. 20 pages.

Deliverable D-2 Monsoon Assessment of FEWS Operation and Post-monsoon System Updates, City Graduation and SOP Updates Report
The report will document real-time monsoon operation and maintenance of the FEWS, the subsequent assessment of system performance and post-monsoon updates. The report will present the Sustainment Plan for the FEWS including updated SOPs and outline recommendations for additional technical support beyond 2023. The report will be max. 30 pages.

Deliverable D-3 Training Report for Real-time Operation of the FEWS
The report will document the training activities implemented in the 2023 Baguio FEWS Training Program. The report will include an assessment of program effectiveness, team performance throughout the real-time operation of the FEWS, and the ability of the team to operate the system independently beyond 2023 as well as a needs assessment for continuous training activities. The report will be max. 20 pages.

3.1.7 KEY RISKS AND IDENTIFIED MITIGATION ACTIONS

The following key risks and mitigation actions have been identified:

Delays in finalizing the contract for the 2023 Consolidation Phase leading to delays in upgrading the system ahead of the 2023 monsoon
Contract finalization for the 2023 Consolidation Phase is still pending. This is a key risk that has a high cascade potential to affect all following tasks. Task 1, related to system updates, must be finalized ahead of the 2023 monsoon. Delays in contract signing will therefore have an impact on the ability of the technical team in finishing all needed system updates, which in return will affect the project timeline and increase the risk of not meeting the milestones ahead of the monsoon. The squeezed project timeline is particularly affecting the development of bias correction factors and update of data assimilation, which will need to be completed within a shorter timespan leaving a minimal buffer for resolution of technical issues. To mitigate this risk, the team is currently adapting the technical upgrades to the reality of having less time, but at this moment it is not possible to assess in full scale the impacts of this delay. The month of May will be crucial to assess progress in this regard.

Continuous high workload of key LGU project staff / Lack of sufficient resources to operate and maintain the FEWS
During the site visits in June and September 2022, it was observed that the trainees have many work commitments, long workdays, and high workloads. Although LGU staff have a strong will to learn and push the development forward, it became evident that they cannot cope with the complexities of the FEWS if their workload remains the same. This is a big risk to the long-term program sustainability, as the LGU staff may not have the time required to maintain and operate the FEWS.

The project team highlighted this matter during a meeting with the Mayor in June 2022, where Chief of Staff at the Mayor's Office, Mr. Philip Puzon was also present. A similar conversation was also taken during the second visit in September 2022. There is indeed a high awareness on this matter, which is specifically critical for the CDRRMO. It was identified that there are some institutional barriers regarding the composition of the CDRRMO, which hinder the LGU from hiring more staff. The project team will continue looking into this matter to understand better the situation and outline recommendations to improve it.

To mitigate this risk, the project team is working to institutionalize the FEWS O&M framework developed as part of the Sustainment Plan in close collaboration with the LGU to enhance long-term sustainability.

Lack of cooperation and communication across institutions
Throughout the project, it has become increasingly apparent that the institutional setup in Baguio is highly complex and not well defined, with local organizations not being able to clearly explain their roles and mandates, which many times are concurrent across different organizations. It has therefore been a big challenge for the team to identify which organizations to engage on specific matters and clarify the existing distribution of responsibilities and roles. Meeting key stakeholders in-person in Baguio enhanced the understanding of the institutional setup, but it also highlighted the institutional complexity and the need for clearly defined roles, responsibilities, and communication lines in the O&M of the FEWS. The project team is

providing the foundation of the O&M of the FEWS through preparation of standard operating procedures (SOPs), but the implementation of these is highly dependent on well-established partnerships between the City of Baguio and external institutions. The MOAs outline roles and responsibilities (hence, mitigate the risk of lack of clearly defined roles), and enable collaboration, but it is ultimately outside the reach of the project team to ensure that all stakeholders take the responsibility required.

DOST-ASTI is a crucial stakeholder in the project, as they oversee processing, storing, and publishing the real-time data from the gauging stations. Despite having met with DOST-ASTI several times, it remains challenging to fully understand the very complex system of data acquisition, decoding, storage, publication, and online access. At the core of the functionality of the FEWS in Baguio lies the need to operate in real-time. Hence, for the proper design of the system, it is crucial to cover all potential vulnerabilities in the entire real-time data assimilation chain. This covers, among other things, both the vulnerabilities at the stations, but also the vulnerabilities in data transmission and (virtual) data access. In this regard DOST-ASTI is the key organization to establish a partnership with. DOST-ASTI has expressed their concern that any form of documentation they would provide, should not end up supporting any commercial activity. Documentation and insight knowledge provided by DOST-ASTI should only be used for research purposes or to support public authorities. Thus, there is a need to formalize an agreement that specifies that the sole beneficiary of all FEWS activities is the City of Baguio and formalizes the collaboration and data-sharing.

It remains a high risk for project sustainability that roles and responsibilities of the various organizations are not clearly understood by the organizations themselves. As outlined in Section 3.1.5, the activities of the consolidation phase will continue to build on the established FEWS governance, and enhance the foundation for efficient operation by facilitating agreements and ownership structures.

Inconsistency in data collection at real-time monitoring stations
In the last year there have been several problems with the real-time monitoring stations forming part of the FEWS. This relates to issues dealing with real-time connectivity, failure with specific physical components of the stations, lack of API-connectivity and gaps in the data. Overall, data-related problems with the stations persist and continue posing an important risk to the project.

The team is continuously trying to overcome these issues through close communication with the FEWS O&M and Instrument teams. But the problems persist for several different reasons, sometimes not directly linked to technical reasons but rather institutional. In this regard, this risk is closely connected to the risk outlined above related to lack of cooperation and communication across different organizations in Baguio. Specifically, this relates to DOST-CAR and DOST-ASTI. To mitigate this risk, the team is therefore preparing a tailored program to address these issues during the upcoming visit in June 2023 (incl. high-level meetings with DOST-CAR and DOST-ASTI, together with the Mayor of Baguio, to discuss institutional cooperation), and it is also including specific contents as part of the capacity building online training sessions, to raise awareness among the Baguio FEWS O&M team and address specific data-related challenges.

3.2 BEYOND 2023: RECOMMENDATIONS FOR TECHNICAL SUPPORT TO THE LGU IN 2024 AND 2025

To further solidify the long-term sustainability of the Baguio City FEWS, the following activities are recommended for the LGU to be fully ready to launch the system publicly and operate it independently. The exact scope of these activities taking place in 2024 and 2025 will be assessed as part of the 2023 post-monsoon activities, when the performance of the FEWS, as well as local capacities to operate and maintain the system are better understood.

System Performance Assessment and updates
As the purpose in the FEWS is to continuously get better coverage of rainfall data and more water-level calibration points, the additional data collected for the new stations installed in 2022 will also be used for improvements in model calibration post-monsoon, i.e., they cannot be used for the model being run in 2023 and can first be used in the model calibrated for monsoon of 2024. It should be noted that these new stations are indeed used for water-level data assimilation and this process will indeed be tested during the upcoming monsoon seasons.

On-the-Job technical support
As stated in Section 3.1.4, 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. However, it is expected that further technical support for finetuning, testing, and operating the system will be needed beyond 2023. The extent of this technical support will be based on the evaluation of the two 2023 OTJ traning sessions.

Surveys of water levels and discharges for development of stage-discharge relationship
The stage-discharge relationships currently applied to derive the calculated discharge are generated using the inbuilt tool in MIKE Hydro. These should be revised based on simultaneous measurements of water levels and flow data, but this requires further development. Measurements should be taken in the next few monsoons and non-monsoon seasons to have sufficient data to apply this system improvement.

Support for validation of data dissemination and outreach plan including integration of GEDSI actions
The *Data Dissemination and Outreach Report* outlined three testing and validation phases, starting from an initial trial only including the FEWS Operation and Maintenance team, and gradually expanding groups of recipients and using more varied dissemination channels, eventually reaching the end users. A thorough testing of the warning dissemination component over multiple monsoon seasons is crucial to ensuring an equitability and credibility of the FEWS.
As stated in the final recommendation of the *Gender and Social Inclusion (GESI) Study*[2], the implementation of GESI actions must be an ongoing process spanning multiple years which will be continued beyond the 2023 Consolidation Phase. This will include testing the warning messages with focus groups including people with language, education, literacy and disability-related barriers, surveys and further research into

vulnerable groups and the role of community leaders in dissemination, awareness raising activities, and more. In the Consolidation Phase and beyond, GEDSI (Gender Equality, Disability and Social Inclusion) will be used in place of GESI to highlight and further integrate the needs of people with disabilities in the FEWS.

Update model calibration based on new stage-discharge relationships

Due to the inconsistencies and gaps in the station data, a limited period of 2-3 years has been identified for calibration based on historical station data. This period should be longer to ensure models are reliable and truly representing the catchment hydrology. Models need to be continuously improved every year, with addition of more and better monsoon data and with a more consolidated data assimilation.

Development of barangay-level warnings based on improved rainfall data input and flood maps

This task can take place after the full-scale testing of the system has been completed and lessons have been drawn regarding how the system is emitting warnings on the Dashboard. WRF data, which have been bias-corrected against station rainfall data, will be compared to rain intensities for various return periods (as per existing IDF curves developed by PAGASA) and based on this comparison, flood warnings will be triggered by the FEWS for the various at-risk barangays. This will allow the FEWS to benefit areas in the city which experience flooding not just due to the riverine flooding but also due to other issues such as insufficient or blocked urban drainage infrastructure. For identifying the at-risk barangays with greater reliability, flood maps will need to be prepared for more return periods as required and the ones prepared already will need to be prepared again based upon new rain data analysis using only most appropriate station data. The same stations would be used for the bias correction of the WRF data to ensure proper correlation.

ABOUT THE ASEAN AUSTRALIA SMART CITIES TRUST FUND

The ASEAN Australia Smart Cities Trust Fund (AASCTF) assists ASEAN cities in enhancing their planning systems, service delivery, and financial management by developing and testing appropriate digital urban solutions and systems. By working with cities, AASCTF facilitates their transformation to become more livable, resilient, and inclusive, while in the process identifying scalable best and next practices to be replicated across cities in Asia and the Pacific.

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