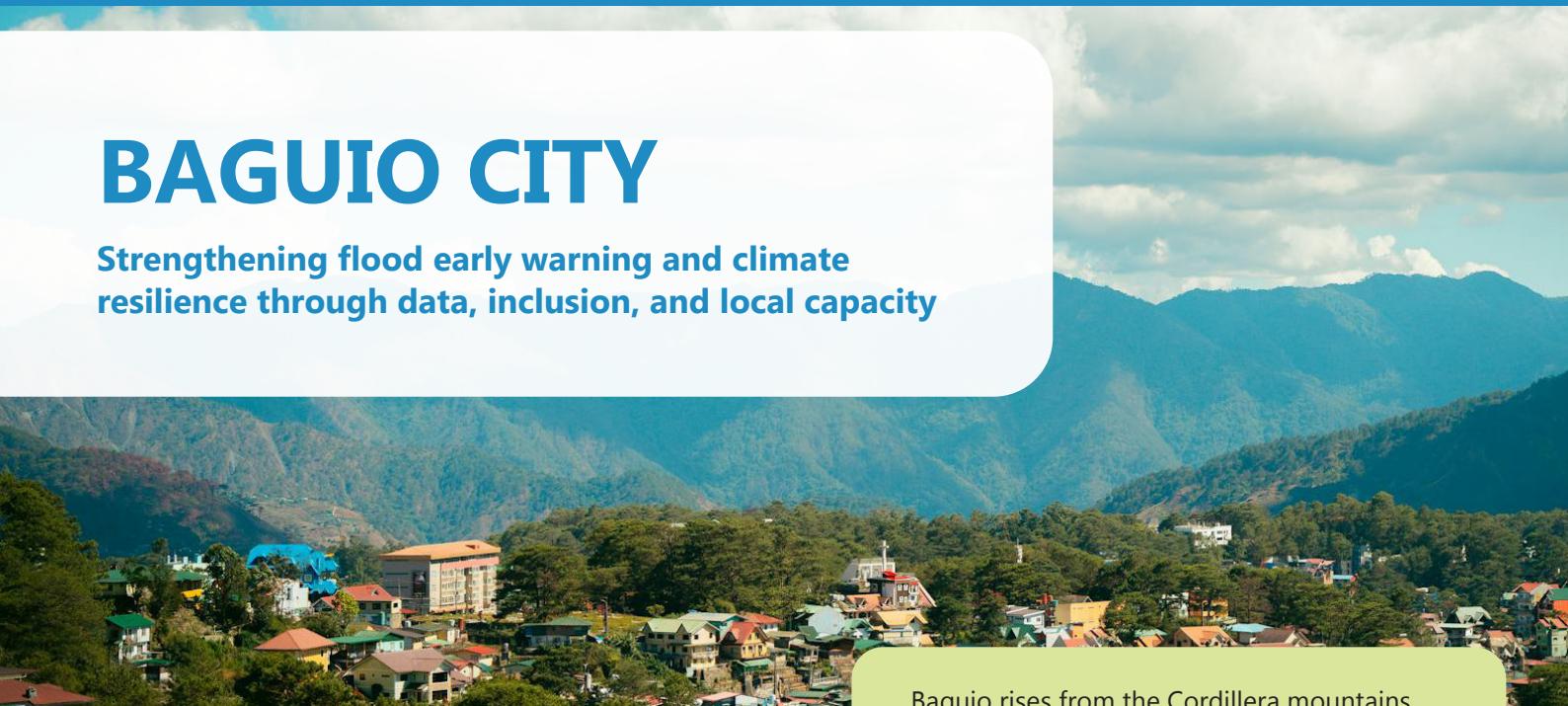




BAGUIO CITY

Strengthening flood early warning and climate resilience through data, inclusion, and local capacity



PROJECT SNAPSHOT

PROJECT NAME	Baguio City Smart Flood Early Warning, Information, and Mitigation System
COUNTRY	Philippines
SECTOR	Water and urban development
MAIN GOVERNMENT BODY SUPPORTED	City Government of Baguio
SMART SOLUTION	Smart Flood Early Warning System, Real-time Data Capture System across four river basins, Flood Mitigation Action Plan with toolbox of nature-based solutions, GEDSI-integrated capacity building and communication improvements
PROJECT PERIOD	August 2020 – April 2023; April 2021 – March 2022; May 2023 – late 2023; August-December 2025
ADB PROJECT OFFICER	Allison Woodruff, Principal Water Security Specialist
MAIN PROJECT OBJECTIVE	To assist Baguio City with planning for flood mitigation and delivering smart, inclusive flood early warning and response services through a hydrological model, real-time monitoring, a mitigation plan, and strengthened communication and capacity development systems.

Baguio rises from the Cordillera mountains in a landscape of pine forests, steep ridges, and winding roads that sit above fast-moving drainage channels and river systems. The 'summer capital of the Philippines' draws millions of visitors each year— this steady movement of people shapes how the city prepares for hazards. But Baguio's geography also makes it one of the most flood-prone mountain cities in the Philippines. Climate change is intensifying these pressures. The city faces more frequent and unpredictable extreme rainfall events, reducing the time communities have to react.

Faced with these realities, Baguio needed a way to see risks more clearly and act sooner. The Smart and Inclusive Flood Early Warning System (FEWS) was designed to meet this need. By combining modelling, real-time monitoring, understanding of the needs of gender minorities, communication, dissemination and outreach guidance, and capacity building, it helps the city anticipate rising water levels, coordinate more quickly across departments, and protect those most exposed and vulnerable to flooding.

THE CHALLENGE

Understanding Baguio's Flood Realities

Baguio's geography shapes its risks. Homes line creeks and hillsides, drainage channels fill quickly during heavy rains, and rivers rise without warning. Localized storms—expected to intensify due to climate change—can cause flash floods within minutes. These events disrupt mobility, damage homes, and put vulnerable communities at risk.

Before the project, flood information in the city came from scattered sources. Agencies operated sensors independently, and data was not integrated into a single system. Forecasts relied on general

weather bulletins rather than localized assessments and modelling. Warning messages varied across barangays, and there was no unified mechanism to combine technical inputs with community realities.

These gaps made it difficult for the city to issue early alerts, coordinate across departments, and plan future investments based on evidence. Baguio needed a system that could unify data, improve forecasting, and strengthen data dissemination and outreach: one that reflects and responds to the lived experiences of its diverse communities and frontline responders.



THE SOLUTION

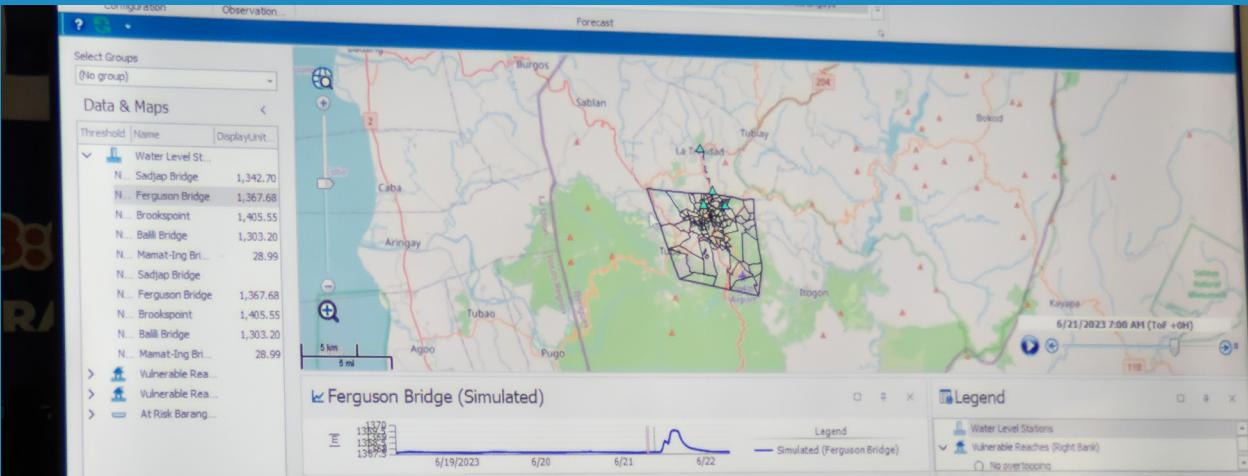
Building a Smarter, More Inclusive Flood Warning System



Through the ASEAN Australia Smart Cities Trust Fund (AASCTF), the City Government of Baguio is developing a Smart and Gender-Transformative Flood Early Warning System, an initiative shaped by detailed modelling and the lived realities of the people who depend on alerts during storms.

The FEWS brings together hydrological modelling, real-time data, and clear warning protocols into a single system. The technical team studied historical flood events, available drainage data, mapped the functionality of existing sensors, visited barangays where water rises quickly, and verified which areas flood during heavy rainfall. These findings guided the development of the city's hydrological and hydraulic models, which showed how rainfall in one district can trigger rapid surges downstream, insights that helped validate local government officials' on-the-ground experience.

As the modelling matured, a unified dashboard was created to integrate real-time data from water-level and rainfall gauges, purchased and installed as part of the FEWS. City staff worked closely with the developers to understand system components, data processing, and required workflows to support early decisions ahead of anticipated heavy rainfall.





The team also recognized that technology would only work if warnings were accessible to everyone. The Gender and Inclusion Study, conducted in 2021, documented how women, including older persons, caregivers, persons with disability, and residents with limited mobility receive, and often struggle to act on, messages. These insights informed policy recommendations and practical actions that FEWS stakeholders could take, in the short and long term, towards the realization of a gender-transformative FEWS in Baguio.

This people-centered approach guided the development of the Data Dissemination and Outreach Plan, which outlines how early warnings should move from the Emergency Operations Center to barangays and ultimately to households with different communication needs. The Plan provides practical guidance on phrasing, timing, roles, and the mix of channels: radio, short messaging systems (SMS), public address (PA) systems, and community networks, that help ensure no one is left behind during storms.

Finally, the project translated technical insights into long-term action through the Flood Mitigation Action Plan (FMAP), which outlined priority areas where nature-based solutions, open space improvements, and drainage upgrades could help slow runoff and reduce flood risk across barangays. It demonstrated how multi-functional climate adaptation can support safer, greener, and more livable spaces.



THE PROCESS

How the System Came Together

The FEWS was developed through close engagement with staff from the Local Government Unit (LGU) of Baguio City, beginning with a detailed understanding of how floods behave in the city's mountain landscape. The project team reviewed hydrometeorological data in the current and future climate, analyzed available drainage system data, assessed the technology of existing local and national sensor networks, studied past flood events, and conducted field visits to areas that repeatedly experience flooding. These steps ensured that the modelling reflected both technical evidence and lived experiences.

With this foundation, the hydrological and hydraulic models were built: tools that simulate how rainfall moves across steep river basins and how river water levels respond during storms. As the models and supporting information technology (IT) infrastructure became more refined, the FEWS dashboard was developed to consolidate real-time sensor data and modelling outputs into a single map-based interface. For the first time, the city has a locally operated, data-driven decision-support tool to facilitate early flood preparedness and response.





As the technical tools took shape, operational workflows were co-developed with city departments. Together, teams clarified roles and responsibilities, implemented and revised standard operating procedures, and initiated discussions on public dissemination to define how messages should flow between agencies and barangays during weather events. These discussions helped align the system with daily operational realities.

To strengthen the system's technical backbone, the city formalized key partnerships through a series of Memoranda of Agreements (MOAs). In 2022, Baguio City, the Philippine Atmospheric, Geophysical, and Astronomical Services Administration (PAGASA), and the Department of Science and Technology Cordillera Administrative Region (DOST-CAR) signed two MOAs outlining cooperation on real-time weather data gathering, sensor operation and maintenance, system migration, and continued technical support. In 2023, the mayors of Baguio, La Trinidad, and Tuba signed additional MOAs establishing shared responsibilities for operating and maintaining hydrometeorological stations across their jurisdictions. These agreements strengthened inter-agency and inter-jurisdictional coordination, ensuring that the real-time rainfall and water-level data feeding into the FEWS would be reliable, jointly managed, and supported by clear institutional commitments.

In parallel, the gender-transformative workstream advanced. Insights from the Gender and Inclusion Study were used to shape policy recommendations and draft practical actions that FEWS stakeholders (departments, representatives) can adopt to realize a gender-transformative FEWS. Central to this work was the participatory process used to co-develop actions—an approach that supports Baguio's longer-term commitment to a gender-transformative FEWS. The process enabled stakeholders to think about the bigger picture of what the system could become with sufficient resources and capacity. It also provided a roadmap outlining immediate actions as well as long-term directions, collaborations, and investments required to achieve them.

Together, these technical and social components form the backbone of the FEWS, ensuring that the system is grounded in science, shaped by community realities, and designed to evolve with the city.

Building Local Capacity

Strengthening Baguio's ability to operate and sustain the FEWS was central to the project's long-term vision. The system's effectiveness depends not only on modelling and sensors, but on the people interpreting data and making decisions during fast-moving storms.



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"The FEWS is not an isolated tool, it's a living tool that needs continuous improvement. The key enabler of this project is the capacity of the people."

***Alvaro Fonseca, Project Team Lead,
Ramboll***

Capacity-building began with extensive consultations to understand how staff monitored river basins, managed geospatial and hydrometeorological data, and prepared for flooding events, what information they relied on, and where gaps existed. The project then designed a targeted training program for eleven staff from the city government, PAGASA, DOST-CAR, Saint Louis University, and the University of the Cordilleras to form the FEWS Operations and Maintenance (O&M) team—an inter-agency group responsible for operating the system, reviewing data, and supporting preparedness and response. Between 2022 and 2023, they completed targeted classroom and on-the-job training to build a shared understanding of hydrology, catchment behavior, modelling, and early warning operations.

Early training modules covered how rainfall moves through Baguio's steep river basins, how catchments respond, and why certain neighborhoods flood quickly. These concepts became clearer to the O&M team through hands-on hydraulic and hydrological modelling exercises using the FEWS models.





Additional virtual and in-person sessions helped the team understand catchment dynamics, interpret modelling outputs, troubleshoot data anomalies, adhere to standard operating procedures (SOPs) for system operation and maintenance, and apply early warning workflows during heavy rains.

In-person mentoring reinforced the team's confidence to apply these tools in practice. Sessions focused on enabling the O&M team to work together as a multi-disciplinary inter-agency team to sustain the system, exchange ideas, and share experiences.

For many participants, the topics covered were new ground. Trainees described learning hydrology, water movement, and data management as challenging but motivating, with some noting how the experience renewed their sense of purpose. Their training demonstrated that technical tools become effective only when paired with the skills and confidence of the people who use them.

Mentoring by the AASCTF project team also supported the O&M team's long-term routines: regularly reviewing data and system readiness ahead of the monsoon season, refreshing workflows and SOPs, and refining the system together as new information became available. These practices helped embed FEWS operations into institutional processes and helped to encourage coordinated work across departments.

By the end of the project, Baguio had an O&M team with stronger technical and operational skills. Since then, some trainees have moved to new roles, and new staff have joined the O&M team, highlighting a recurring challenge: sustaining the FEWS requires continuous training, periodic retraining, and dedicated support to ensure new personnel can operate, maintain, and improve the system over time.



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“This training increased my technical capacity... I am more confident of the responsibilities given to me as part of the core team in the operationalization of the FEWS.”

Stephanie Trinidad, formerly of the Baguio City CDRRMO

Why It Matters

Baguio City Smart Flood Early Warning, Information, and Mitigation System

- Detects potential flooding events earlier
- Strengthens coordination using shared data
- Reaches more residents through clearer alerts
- Links early warnings with mitigation planning
- Supports decisions with real-time monitoring
- Builds capacity across local teams
- Makes early action more accessible for people with different needs

Early Results and Emerging Benefits

While full operational use is still ahead following comprehensive system testing and validation through multiple monsoon seasons, the FEWS is already influencing how the city prepares for rainfall events. Staff can now monitor real-time river water levels, interpret how forecasted rainfall may affect basins using the modelling tools, and anticipate which areas may experience localized flooding.

The FEWS is not a static tool: it will continue to evolve and improve as more data is gathered and lessons learned from previous monsoons are embedded, further strengthening the tool's ability to support sound decision-making and inform advisories.

The Flood Mitigation Action Plan is informing conversations on how open spaces, natural systems, and drainage improvements can reduce flood risks while supporting broader urban development goals. It provides the city with a roadmap for investments that address both immediate risks and upstream drivers of flooding. The toolbox of nature-based solutions has been adopted by city departments, informing the redevelopment of Emilio Aguinaldo Park (now Happy Glen Park) led by the City Planning, Development, and Sustainability Office (CPDSO), and the development of new



planning typologies including the 'Complete Streets' concept by the City Engineering Office (CEO) which promotes inclusive, pedestrian-friendly, green streets.

The Data Dissemination and Outreach Plan provides a starting point for improving communication. As the city adapts and tests its recommendations, residents—whether they rely on radios, mobile alerts, or barangay announcements—may receive clearer messages.

The gender transformative process strengthened awareness of the needs of the people most vulnerable to flooding, and set core stakeholders on a pathway towards a gender transformative FEWS.

Mayor Benjamin Magalang emphasized the value of systems that *"help us protect lives, especially in areas where floods can happen with very little warning."* FEWS supports this aim by helping responders anticipate rather than react.



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"It gives us some sort of a level of confidence that every time we come up with decisions, especially when there is a forthcoming typhoon... we will be able, based on data, to come up with the right decisions."

Mayor Benjamin Magalang,
City Government of Baguio



Lessons and Pivots

As the FEWS took shape, several lessons emerged that helped refine both the system and the workflows supporting it.

- Shared data improves coordination. Different departments benefit from working with the same real-time information, strengthening situational awareness and joint decision-making.
- Residents use multiple communication channels. Radio, SMS, PA systems, and community networks must be strengthened together to increase reach.
- Understanding diverse needs improves warning effectiveness. The Gender and Inclusion Study showed that not all groups receive, interpret, or act on warnings the same way.

- Barangay involvement is critical. Barangays remain the first point of contact during weather events and are trusted first responders and messengers for households.
- Clearer thresholds, communication lines, and workflows help standardize action. Defined roles and standardized procedures help agencies coordinate more effectively.
- Systems need to evolve. FEWS performance will improve as more data becomes available, as climate risks intensify, and as new staff take on operational roles.

These insights helped strengthen both the FEWS and the institutional practices that support its use.

Sustaining the Gains

Sustaining the FEWS requires continued use, upkeep, and coordination across agencies. Sensors must be regularly maintained and calibrated, and the system will need updates as more data is collected. Model calibration and feature enhancements should be guided by lessons learned during actual monsoon operations. New staff assigned to FEWS operations will require orientation and training, while seasoned members of the O&M team trained under the project are equipped to guide these activities with ongoing mentoring support.

The Data Dissemination and Outreach Plan provides a foundation for improving communication and tailoring warning messages to the needs of the most vulnerable, helping the city strengthen its “last mile” outreach. As its recommendations are tested and refined, updated practices can be integrated into standard operating procedures.



The actions developed under the gender transformative workstream provide a flexible roadmap for advancing an inclusive FEWS. These actions should continue to be referenced and adapted as the system evolves, recognizing that stakeholders, capacities, and community needs will also change over time.

Memoranda of Agreement signed with PAGASA, DOST-CAR, and the municipalities of La Trinidad and Tuba also strengthen the system's long-term sustainability. By clearly defining responsibilities for data sharing, maintaining hydrometeorological stations, and supporting technical coordination, these agreements help ensure that the FEWS continues to function as an inter-jurisdictional system beyond the project period. This inter-agency cooperation is essential given that Baguio's flood risks are shaped by watersheds that extend across municipal boundaries.

Early Dialogue with the UNDRR RICH-MHEWS Project

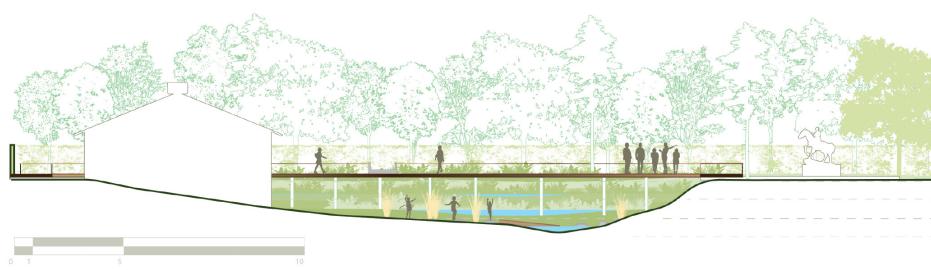
As Baguio deepens its commitment to early warning, the project team reached out to the UNDRR Resilient and Inclusive City Hub – Multi-Hazard Early Warning System (RICH-MHEWS) project team to discuss potential complementarity. UNDRR is reviewing FEWS materials as they shape Phase II of RICH-MHEWS and may explore how the gender transformative work under the project could inform disability-inclusive early warning initiatives. While no formal linkage exists, the early dialogue indicates shared priorities, particularly around inclusive communication and engagement.



Happy Glen Park: Inspiring New Public Space Design

A significant early project impact is the use of insights from the Flood Mitigation Action Plan in shaping the city's proposal for the redevelopment of Happy Glen Park. The park is one of the priority sites identified in the FMAP for implementation of nature-based solutions to reduce flood risk. The park redevelopment, further advanced by the city, was later selected for the Philippine Department of Health's Green Open Spaces initiative. Community workshops related to the redevelopment project echoed the participatory principles recommended by the AASCTF team, demonstrating how risk-informed planning can support safer, more inclusive public spaces.

As the city continues to refine and operationalize the FEWS, these pathways demonstrate how the system can evolve into an integral part of Baguio's long-term resilience strategy.



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The [flood mitigation action] plan pointed us to the right direction, because of course we didn't have that kind of plan before... We put everything together, we had the pieces of the puzzle, and we formed that big plan now to develop the master development plan of (Happy Glen) Park.

Donna Tabangin, City Planning and Development Office, City Government of Baguio

Ripple Effect Across ASEAN Cities

Baguio's FEWS shows how focused pilots can shape broader resilience efforts. During early exchanges on the RICH-MHEWS initiative, UNDRR staff shared that FEWS often appears in their discussions on the city's capacity within early warnings and disaster preparedness, underscoring its contribution to broader early warning discussions. This reflects how practical, inclusive approaches can influence wider planning. The FEWS experience, community-informed message development, modelling-supported decision-making, and inclusive planning offer insights that may be relevant to other cities.

The Flood Mitigation Action Plan offers a replicable approach to the development of a context-specific toolbox of nature-based solutions and city-wide prioritization solutions for implementation, demonstrating how modelling-based insights can inform mitigation planning. Its ridge-to-river

approach and integration of nature-based options resonate with many cities facing similar terrain and rainfall challenges.

The Happy Glen Park redevelopment demonstrates how FMAP-inspired thinking can shape broader resilience and urban design efforts. The city plans to replicate this approach in other barangays, helping translate flood mitigation into community spaces, mobility networks, and cultural value.

Across the region, cities with similar flood challenges can draw lessons from Baguio's experience as they strengthen their early warning systems and inclusive resilience strategies. These developments position Baguio as an example of how local initiatives under AASCTF can support long-term resilience pathways and contribute to broader regional efforts to strengthen inclusive, multi-hazard early warning systems.





Baguio's experience offers valuable lessons for other cities navigating topographic constraints, growing urban pressures, and climate-driven extremes. It shows how modelling, communication, and governance can be linked through an inclusive, evidence-based framework owned and operated at city-government level.

Perhaps most importantly, Baguio demonstrates that resilience is not built by tools alone. It grows through local insight and curiosity, continuous training, and a willingness to combine scientific evidence with human-centered planning. This balance is what gives FEWS the potential to inspire other ASEAN cities facing similar challenges.



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Being resilient is no longer a choice for a city—it is a must, so the end goal will be that the city will be able to prepare for and respond more quickly and better to floods.

Thuy Trang Dang, Asian Development Bank

LEARN MORE



For more information on this project, check the Baguio resources in the AASCTF Data Room:



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. AASCTF is supported by the Australian Government through the Department of Foreign Affairs and Trade, managed by the Asian Development Bank, and implemented by Ramboll.



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