# Adaptation Benefits Mechanism Methodology

# ABM-NM002: Deployment of Mobile Flood Barriers As A Measure Against Flooding

Version 1.0

## TABLE OF CONTENTS

# 1. New ABM methodology submission information

| Methodology summary | |
|---|---|
| **Title of the ABM Methodology** | Deployment of Mobile Flood Barriers As A Measure Against Flooding |
| **Methodology version number** | Version 1.0 |
| **Date of completion/updating of this document** | 19 September 2025 |
| **Methodology proponent** | SLAMDAM B.V. |
| **Eligible project types** | Climate change adaptation activities aiming at protecting populations, infrastructure, and/or ecosystems in vulnerable areas from flood hazards (fluvial, pluvial, or urban).<br><br>Eligible activities include:<br>1. Deploying mobile flood barriers (MFBs) in urban, peri-urban and rural settings to protect people, assets and critical infrastructure..<br>2. Deploying mobile flood-barrier solutions to mitigate fluvial (river), pluvial (rain-runoff) and urban drainage flooding.<br><br>Typical activities include, among others, community measures for enhancing resilience against floods by preventing inundation and reducing the amount of flood loss through the use of a MFB that can easily be deployed when there is a threat of flooding as an alternative for sandbags in locations, where permanent dams have not been built. The MFB can be filled in with water from the flooding using solar-powered water pumps. The water stored in the flood barrier can be kept for later use for various purposes. |
| **Exclusion criteria** | 1. Areas experiencing extreme coastal flooding or storm surges that exceed the structural capabilities of mobile flood barriers.<br>2. Regions with steep slopes, rugged terrain, or poor soil stability that compromise barrier deployment and effectiveness.<br>3. Locations with insufficient hydrological or topographical data for reliable modeling and impact assessment.<br>4. Areas lacking logistical or infrastructure support for barrier deployment and maintenance. |
| **Climate risks[1] occurrence** | • **Fluvial Flooding**: Enhanced riverine flooding due to intensified precipitation and altered hydrological patterns.<br>• **Pluvial Flooding**: Surface water accumulation from heavy rainfall exceeding drainage capacity. |

[1] See Document ABM EC/2022/15/12, “Guidelines on activity types under the Adaptation Benefits Mechanism”, Annex “Typology of ABM Adaptation Activities”.

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| | • **Urban Flooding**: Inundation in urban areas resulting from overwhelmed stormwater systems. |
| **Climate change parameters**[2] | • **Increased Precipitation Intensity**: Escalating rainfall intensity leading to higher runoff and potential flooding.<br>• **Altered Hydrological Cycles**: Changes in the timing and volume of river flows due to shifting precipitation patterns.<br>• **Sea-Level Rise**: Gradual increase in sea levels contributing to higher baseline water levels in rivers and coastal areas.<br>• **Temperature Variability**: Fluctuations in temperature affecting evaporation rates and soil moisture, influencing flood dynamics. |
| **Climate change hazards**[3] | • **Extreme Weather Events**: Such as hurricanes, floods, droughts, and heatwaves.<br>• **Glacial Retreats**: The shrinking of glaciers leading to altered water supplies.<br>• **Increased Wildfires**: More frequent and intense forest fires due to drier conditions.<br>• **Ecosystem Disruptions**: Changes in habitats affecting biodiversity. |
| **Sector/sub-sector/type**[4] | **Sector**: Water<br>**Sub-sector**: Flood Protection<br>**Type**: Structural and Physical Adaptation Measures |
| **Contribution to the targets of the UAE framework for Global Climate Resilience**[5] **(multiple contributions possible)** | ☒ Significantly reducing climate-induced water scarcity and enhancing climate resilience to water-related hazards towards a climate-resilient water supply, climate-resilient sanitation and towards access to safe and affordable potable water for all.<br>☒ Attaining climate-resilient food and agricultural production and supply and distribution of food, as well as increasing sustainable and regenerative production and equitable access to adequate food and nutrition for all.<br>☐ Attaining resilience against climate change related health impacts, promoting climate-resilient health services, and significantly reducing climate-related morbidity and mortality, particularly in the most vulnerable communities.<br>☐ Reducing climate impacts on ecosystems and biodiversity, and accelerating the use of ecosystem-based adaptation and nature-based solutions, including through their management, enhancement, restoration and conservation and the protection of terrestrial, inland water, mountain, marine and coastal ecosystems;<br>☒ Increasing the resilience of infrastructure and human settlements to climate change impacts to ensure basic and continuous essential |

2 See Document ABM EC/2022/15/12, "Guidelines on activity types under the Adaptation Benefits Mechanism", Annex "Typology of ABM Adaptation Activities".

3 See Document ABM EC/2022/15/12, "Guidelines on activity types under the Adaptation Benefits Mechanism", Annex "Typology of ABM Adaptation Activities".

4 Use to the extent possible the IPCC AR5 categorisation system (see Chapter 14: Adaptation needs and options, Table 14-1, page 14): https://www.ipcc.ch/site/assets/uploads/2018/02/WGIIAR5-Chap14_FINAL.pdf

5 See Decision 8a/CMA.5, paragraph 9 (a)-(g): https://unfccc.int/sites/default/files/resource/cma5_auv_8a_gga.pdf

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| | services for all, and minimizing climate-related impacts on infrastructure and human settlements.<br>☒ Substantially reducing the adverse effects of climate change on poverty eradication and livelihoods, in particular by promoting the use of adaptive social protection measures for all.<br>☐ Protecting cultural heritage from the impacts of climate-related risks by developing adaptive strategies for preserving cultural practices and heritage sites and by designing climate-resilient infrastructure, guided by traditional knowledge, Indigenous Peoples' knowledge and local knowledge systems. |
| **Adaptation Benefits Measured (ABs)[6]** | **Certified Adaptation Benefits (CABs)**<br><br>**Primary/optional metric (choose one for the entire crediting period):**<br>• **USD avoided flood losses** — *1 CAB = USD 1,000 avoided loss (default)*<br>• **Area protected** — *1 CAB = 1 ha protected*<br>• **People protected (M/F)** — *1 CAB = 10 people protected*<br>• **Health impact avoided (DALYs)** — *1 CAB = 1 DALY avoided*<br><br>*Only one primary CAB metric may be used across the entire crediting period; it cannot change between issuances. Others may be tracked as co-benefits for MRV.* |
| **Adaptation Co-benefits measured** | • **Environmental Protection**: By preventing floodwaters from contaminating ecosystems, MFBs help maintain biodiversity and support ecosystem-based adaptation strategies.<br>• **Economic Stability**: Reducing flood-related disruptions safeguards local economies, ensuring business continuity and protecting livelihoods.<br>• **Social Cohesion**: Effective flood management fosters community resilience, enhancing social stability and cohesion.<br>• **Capacity Building**: Training local communities and stakeholders in flood risk management and barrier deployment. |
| **Other possible benefits, which are not measured but can be reasonably expected to occur if the proposed measures are taken** | • Enhanced water security if water-filled mobile flood barriers are deployed and water from the flooding is stored for later use for various purposes, such as in agriculture.<br>• Enhanced disaster risk management due to better preparedness for tackling floods. |
| **Time period over which ABs accrue** | The recommended maximum period for this methodology is 10 years. |

[6] See definition of "Adaptation Benefits" in document ABM EC/2024/21/6 "Guidelines on the development of an Adaptation Benefits Mechanism Methodology"., Paragraph 3.

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| **Contribution to the Sustainable Development Goals (SDGs)/indicators[7] measured** | Implementing MFBs under the ABM contributes to multiple Sustainable Development Goals (SDGs), notably:<br><br>**SDG 1: No Poverty**<br>**Target 1.5**: Build the resilience of the poor and those in vulnerable situations to climate-related extreme events.<br>• **Indicator 1.5.1**: Number of deaths, missing persons, and directly affected persons attributed to disasters per 100,000 population.<br>• **Indicator 1.5.2**: Direct economic loss attributed to disasters in relation to global gross domestic product (GDP).<br><br>**SDG 13: Climate Action**<br>**Target 13.1**: Strengthen resilience and adaptive capacity to climate-related hazards and natural disasters.<br>• **Indicator 13.1.1**: Number of deaths, missing persons, and directly affected persons attributed to disasters per 100,000 population.<br>• **Indicator 13.1.2**: Number of countries with national and local disaster risk reduction strategies. |
| **Implementation scale** | • **Local Scale**: MFBs can be deployed to protect individual properties or critical infrastructure.<br>• **Subnational/Regional Scale**: Communities or municipalities can implement MFBs to shield neighborhoods or urban areas.<br>• **National/Multi-Country Scale**: Large-scale MFB systems can be employed to protect extensive regions. |
| **How does the methodology address the risks of maladaptation?** | • Conducting thorough risk assessments to ensure appropriate siting and design of MFBs.<br>• Engaging local stakeholders to align solutions with community needs.<br>• Implementing adaptive management to adjust strategies as conditions change.<br>• Considering environmental impacts to prevent ecological harm.<br>• Establishing monitoring and evaluation to ensure effectiveness and make necessary adjustments.<br><br>Maladaptation risks will be continuously tracked through MRV indicators, ensuring early detection of unintended consequences (e.g., downstream inundation, ecosystem disruption) and allowing corrective actions within the crediting period. |
| **Name, designation, date and signature of the contact person (s) for this activity.** | **On behalf of:**<br>Omar Saleh<br>SLAMDAM B.V. \| Managing Director |

[7] A list with SDGs and indicators can be downloaded here: https://unstats.un.org/sdgs/indicators/indicators-list/

# 2. Introduction

This methodology provides a framework for quantifying the adaptation benefits of deploying Mobile Flood Barriers (MFBs) as an adaptive response to climate change-induced flood risks. It is designed for use in flood-prone areas where communities, infrastructure, and ecosystems are vulnerable to fluvial and pluvial flooding. The methodology aligns with the principles of the Adaptation Benefits Mechanism (ABM), ensuring transparency, rigor, and applicability across diverse geographical and socio-economic contexts.

### Climate Change Vulnerability Context

Climate change is intensifying the frequency and severity of extreme rainfall events, leading to increased flooding in urban, peri-urban, and rural areas. Flooding results in significant social, economic, and environmental loss, including:

- **Social Impacts**: Displacement of vulnerable populations, health risks from waterborne diseases, and loss of livelihoods.
- **Economic Impacts**: Destruction of infrastructure, agricultural losses, and disruption of economic activities.
- **Environmental Impacts**: Degradation of ecosystems, soil erosion, and contamination of water sources.

In many flood-prone regions, traditional mitigation measures such as permanent levees and temporary sandbags are insufficient to address these evolving risks. The use of MFBs offers a flexible, cost-effective, and scalable solution to reduce flood impacts and enhance resilience.

### Baseline Scenario

The baseline scenario represents the "business-as-usual" condition, where no MFBs are deployed. Under this scenario:

- Flood events lead to inundation, affecting people, assets, and critical infrastructure.
- Losses and Loss are calculated using hydrodynamic models and depth-damage functions to estimate exposure and vulnerability.
- Annual Expected Loss (AEL) are quantified to reflect the recurring costs of flood impacts.

### Adaptation Activity Scenario

The adaptation activity scenario models the deployment of MFBs to mitigate flood impacts. Under this scenario:

- Flood extents and depths are reduced through the strategic placement of MFBs, as simulated using hydrodynamic models.
- The number of people, assets, and hectares of land exposed to flood risks is decreased.
- Loss reduction is quantified by comparing baseline and adaptation scenarios, with results expressed in indicators such as economic savings, protected populations and infrastructure.

**Adaptation Benefits (ABs)**

The methodology enables the quantification of adaptation benefits, which include:

1. **Reduction in Flood-Related Loss**: Tangible economic savings from avoided loss to infrastructure, homes, and agriculture.
2. **Enhanced Climate Resilience through Protection of Vulnerable Communities**: Reduced risk of displacement, injury, and health issues for communities in flood-prone areas.
3. **Safeguarding of Ecosystems**: Prevention of soil erosion, water contamination, and ecosystem degradation caused by flooding.

**Co-Benefits**

In addition to adaptation benefits, the deployment of MFBs generates significant co-benefits:

- **Environmental Protection**: By preventing floodwaters from contaminating ecosystems, MFBs help maintain biodiversity and support ecosystem-based adaptation strategies.
- **Economic Stability**: Reducing flood-related disruptions safeguards local economies, ensuring business continuity and protecting livelihoods.
- **Social Cohesion**: Effective flood management fosters community resilience, enhancing social stability and cohesion.
- **Capacity Building**: Training local communities and stakeholders in flood risk management and barrier deployment.

# 3. Scope and applicability

This methodology applies to project activities involving the deployment of mobile flood barriers (MFBs) to mitigate flood-related loss on communities, infrastructure and/or ecosystems in vulnerable areas. The system boundaries of this methodology encompass the direct operational area of the MFBs, the surrounding flood-prone regions, and the socio-economic and ecological systems influenced by flood mitigation activities.

## 3.1 Scope of the Methodology

1. **Project Activities**: The methodology covers the use of MFBs for:
    - Mitigating fluvial and pluvial flooding impacts in urban, peri-urban, and rural settings.
    - Enhancing resilience by preventing or reducing direct, indirect, tangible, and intangible loss to human life, infrastructure, and the environment.
    - Supporting emergency flood response and long-term adaptation planning.

2. **System Boundaries**:
    - **Geographical**: Includes flood-prone areas where MFBs are deployed and areas indirectly affected by flood mitigation.

- **Temporal**: Considers adaptation benefits during flood events and the advised lifespan of MFBs (10 years).
- **Physical**: Incorporates barriers, hydrological systems (e.g., rivers, drainage networks), and impacted infrastructure and communities.
- **Socio-Economic**: Considers economic activities influenced by reduced flood risks, such as business continuity and public safety.

3. **Alignment with ABM Typology and IPCC Framework**:
   - Addresses climate risk occurrences of fluvial and pluvial flooding.
   - Considers water depths, extents, and durations that MFBs can effectively mitigate.
   - Targets flooding caused by heavy rainfall and river overflow exacerbated by climate variability.
   - IPCC sector is “Water Resources Management” and subsector “Flood Risk Management”.

## 3.2 Applicability Conditions

Note: The Applicability Conditions below are hierarchical. Criterion 1 must be met before evaluating Criterion 2; only if Criterion 2 is satisfied should Criterion 3 be considered. The methodology is applicable under the following conditions:

- **Condition 1**: Floods occur in a region where loss to people, assets, or the environment can be significant and the deployment of MFBs can effectively mitigate such loss.
- **Condition 2**: Terrain characteristics are conducive to the placement and operation of MFBs (e.g., relatively flat or gently sloped land adjacent to water bodies).
- **Condition 3**: The region has the necessary logistical and infrastructure support (e.g., transport networks and storage facilities) for the deployment and removal of MFBs.

These applicability conditions are structured in line with the ABM Guidelines and linked to internationally recognized flood protection standards. They ensure that the methodology can be consistently applied across jurisdictions while respecting national policies (e.g., NAPs, NDCs) and ABM principles on comparability, conservativeness, and transparency.

## 3.3 Clarification on Non-Market Approach Criteria

This methodology is designed strictly as a Non-Market Approach (NMA) under Article 6.8 of the Paris Agreement. The following principles apply:

1. **Voluntary Multi-Party Participation**

- Activities using this methodology are implemented on a voluntary basis, involving cooperation between multiple parties, including local communities, national institutions, and international partners where relevant.

2. **Avoidance of Mitigation Outcome Transfers**
   - This methodology does not generate or transfer mitigation outcomes such as carbon credits. All quantified benefits are expressed as Credited Adaptation Benefits (CABs), which represent resilience outcomes only.
3. **Alignment with Host Country NDCs**
   - All activities must demonstrate alignment with the host country's Nationally Determined Contribution (NDC) or National Adaptation Plan (NAP), with explicit references documented in the PDD annex.
4. **Clarification on Vegetation Impacts**
   - Communities may undertake complementary activities such as planting vegetation downstream or upstream of barriers to reduce erosion and improve soil stability.
   - These actions are considered co-benefits for resilience (e.g., reducing erosion and runoff), but are not credited as mitigation outcomes under this methodology.
   - Any potential carbon sequestration effects are outside the scope of this methodology and cannot be claimed as mitigation outcomes during or after the crediting period.

### 3.4 Additional Considerations for Local Calibration and Model Justification

1. **Control Section / Recalibration for New Countries**

   When deploying MFBs in a country or region different from the pilot site, a control or recalibration exercise must be conducted:
   - Collect local flood records, topography, and socio-economic data.
   - Adjust default parameters (depth–damage curves, barrier size, material, placement) according to local hydrology and infrastructure.
   - Run a control scenario using historical or modeled floods to verify AEL and CAB calculations before operational deployment.
   - Document all assumptions, adjustments, and sources in the ADD annex.
2. **Local Adjustment of Depth–Damage Curves for Developing Countries**

   Default curves (e.g., developed for the Netherlands) may not represent local conditions. Proponents must:
   - Adjust curves based on local asset types, construction quality, and economic valuation.
   - Use historical flood data, NDCs, NAPs, or national flood surveys to contextualize the curves.
   - Apply a conservative adjustment factor if local data are incomplete to avoid overestimating avoided losses.
   - Document all adjustments and references in the ADD annex.

### 3.5 Applicability and Contextualization of Default Values

The methodology uses a set of default values (e.g., depth–damage curves, barrier size, material, and placement) derived from previous implementations in developed-country contexts. While these defaults provide a starting point, their applicability in developing countries must be contextually validated. The following procedures are introduced:

1. **Local Calibration**
   Before applying default parameters, the proponent must conduct a calibration exercise using local data, including:
   - Historical flood records (e.g., peak flows, inundation depths)
   - National flood risk curves, if available (e.g., from hydrological surveys, NDC, NAP, or national water agencies)
   - Local topography and land use
     This ensures that the MFB is appropriate for the geographical and hydrological characteristics of the new country.
2. **Contextual Adaptation of Depth–Damage Curves**
   Default depth–damage curves may underestimate or overestimate damages in developing-country contexts. Proponents should adjust curves based on:
   - Local asset types and construction quality
   - Economic valuation of affected structures
   - Community-specific vulnerability data
     In the absence of local curves, default curves may be used with a conservative adjustment to prevent overestimation of avoided losses.
3. **Applicability Criteria for Default Values**
   Default values may be applied only if the following criteria are met:
   - Geographic and hydrological characteristics of the pilot site are sufficiently similar to the original country of reference.
   - Local climate and flood patterns do not significantly deviate from the conditions assumed in the defaults.
   - Barrier dimensions, materials, and deployment procedures are adapted to local logistical and operational constraints.
     If these criteria are not met, the methodology requires custom parameterization using local field data.
4. **Justification**
   Proponents must provide a justification in the ADD for each default value used, including:
   - Why it is reasonable in the local context
   - Any adjustments applied
   - References to local hydrological or policy documents (NDC, NAP, water plans)

All adjustments of default values to developing-country contexts (e.g., GDP/capita scaling, asset replacement cost indices, or construction quality multipliers) must be explicitly documented in the Annex Data Document (ADD), with references to national policy documents (NAPs, NDCs, flood surveys) or global datasets (JRC, EM-DAT) where local data are missing.

### 3.6 Exclusion Criteria

The exclusion criteria are:

- **Exclusion Criteria 1**: The methodology is not applicable in areas where flood events exceed the height or structural capabilities of the MFBs (e.g., extreme coastal flooding).
- **Exclusion Criteria 2**: The methodology is not suitable for areas where adequate hydrological, topographical, and socio-economic assessments can't be conducted e.g. due to a lack in data.

### 3.7 Extent of Adaptation Efforts

This methodology contributes to:

1. **Enhancing Adaptive Capacity**: By improving preparedness through deployable infrastructure and capacity-building.
2. **Strengthening Resilience**: By minimizing economic disruptions and preserving infrastructure.
3. **Reducing Vulnerability**: By protecting populations and assets in the intervention zones.
4. **Addressing Loss and Damage**: By offering a cost-effective alternative to permanent infrastructure, reducing recovery costs after floods.

# 4. Normative references

**ABM Guidelines:**

- Document ABM EC/2024/21/6 "Guidelines on the development of an Adaptation Benefits Mechanism Methodology".
- Document ABM EC/2022/14/6 "Guidelines on principles, criteria, and indicators regarding the determination of adaptation benefits".
- Document ABM EC/2022/14/4 "Guidelines on the Adaptation Benefits Mechanism Activity Cycle procedure for developers of Adaptation Benefits Mechanism activities".
- Document ABM EC/15/16 "Guidelines on the procedure for approval of a new, revision of an existing, or request for clarification concerning an Adaptation Benefits Mechanism Methodology or a Methodological Tool".

- Document ABM EC/2022/15/14 “Guidelines on ABM Environmental and Social Safeguards”.
- Document ABM EC/2022/15/13 “Guidelines on demonstration that an Adaptation Benefits Mechanism activity is new and not Business as Usual”.
- Document ABM EC/2022/14/4 “Guidelines on the Adaptation Benefits Mechanism Activity Cycle procedure for developers of Adaptation Benefits Mechanism activities”.
- New ABM Methodology submission template.
- Document ABM EC/2021/12/5 “ABM Grievance and Redress Mechanism”.
- Document ABM EC/2022/15/12 “Guidelines on activity types under the Adaptation Benefits Mechanism”, including the Annex on “ABM adaptation activities typology”.
- Document ABM EC/2021/16/13 “ABM Glossary of terms”.

**Existing Methodologies and Tools:**

- **Dutch Standard Loss and Fatality Model (HIS-SSM)**: A globally recognized model for assessing flood loss, ensuring consistency and credibility in loss quantification.
- **SSM2015 – Updated Method for Flood Loss Assessment**: Builds on HIS-SSM by integrating recent advances in flood loss assessment techniques.
- **Olsen et al. (2015): Expected Annual Loss (EAD) Framework**: Establishes a probabilistic approach for flood risk assessment, crucial for quantifying adaptation benefits.
- **British Standards Institution (BSI) PAS 1188-2:2014**: Provides standardized testing procedures for flood protection products, ensuring technical reliability (BSI PAS 1188-2:2014).
- **Extreme Value Analysis (EVA) for Hydrological Events (Fisher and Tippett, 1928; Gnedenko, 1943)**: Used to determine the likelihood and return period of extreme flood events.

**Justifications for References:**

- **Scientific Rigor**: Models are internationally recognized, grounded in robust methodologies.
- **Best Practices**: British Standards provide a framework consistent with global standards.
- **Practicality and Applicability**: Tools enable implementation in diverse contexts.
- **Transparency**: Adherence ensures clarity in methodology design and implementation.

# 5. Definitions[8]

For the purpose of this methodology, the following definitions apply:

- The definitions in Document ABM EC/2021/16/13 “ABM Glossary of Terms”

### Adaptation-Mechanism Terms

- **Adaptation Benefit (AB):** The quantified output, outcome, or impact of an adaptation activity that reduces climate risks, measured against a defined baseline scenario (AfDB ABM Guidebook, Feb 2025).
- **Credited Adaptation Benefit (CAB)**: A unit of avoided loss (e.g., USD 1,000) issued when verified adaptation benefits have accrued.
- **Adaptation Benefit Period**: The time window (e.g., 5, 10 or 15 years) during which CABs may be issued for a given activity.
- **Annual Expected Loss (AEL)**: The probabilistic average yearly economic loss due to flooding, calculated as the sum or integral of loss over exceedance probabilities (Huizinga et al. 2017; ABM Guidebook Feb 2025).
- **Additionality**: The demonstration that an adaptation activity is not business-as-usual, using financial, technology, institutional or other barrier tests.

### Mobile Flood Barriers (MFBs)

- **Mobile Flood Barrier (MFB)**: A temporary structure used to mitigate flooding by blocking or redirecting water flow in flood-prone areas, providing flexible flood protection.
- **Retention Capacity**: The volume and height of water that a mobile flood barrier can effectively retain or block during a flood event.
- **Design Life**: The manufacturer-rated operational lifespan of an MFB (used to set the default crediting period).
- **Adaptation Scenario**: The conditions and outcomes observed when MFBs are deployed to mitigate flood risks, compared to the baseline scenario where no such intervention is applied.

### Flood Hazard and Vulnerability

- **Flood Hazard**: Characteristics of flooding such as depth, extent, duration, and velocity that determine its potential to cause harm.
- **Flood Vulnerability:** The susceptibility of assets, people, or ecosystems to harm from flooding, influenced by their exposure and capacity to cope or recover.

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8 Use to the extent possible, the ABM definitions as included in the most recent version of the ABM EC document “ABM Glossary of terms”, which could be found on the ABM website or requested per email from the ABM secretariat.

- **Depth-damage Function:** A mathematical relationship used to estimate flood loss as a function of water depth, often employed in loss modeling.
- **Exposure:** The presence of assets, communities, or ecosystems within areas likely to be affected by flood events.
- **Damage**: Physical harm to assets or infrastructure (e.g., structural breaks, inundation depth), expressed in physical units.
- **Loss**: Economic valuation of damage, including both direct repair/replacement costs and indirect impacts (e.g., business interruption), expressed in monetary units (USD).
- **Surface**: The total area of land or infrastructure considered in the analysis, typically expressed in hectares (ha) or square meters ($m^2$), used to calculate spatially explicit flood impacts and area-protected metrics.
- **Flood event**: A discrete occurrence of flooding at a given location and time, caused by riverine, coastal, pluvial, or flash-flood processes.
- **Flood scenario**: A modeled or projected flood event associated with a defined return period or climate scenario (e.g., 1-in-20 year flood under SSP2-4.5).
- **Cell**: A grid unit in spatial flood modeling, representing a defined area (e.g., 10m × 10m) used for hazard and impact calculations.
- **Vulnerable ecosystem**: An ecological system with low adaptive capacity and high sensitivity to flooding, where damage may cause loss of biodiversity or ecosystem services.

**Technical and Methodological Terms**

- **Hydrodynamic Model**: A computational tool that simulates water flow and interactions with terrain to predict flood depth, extent, and velocity.
- **Loss Assessment Model**: A framework that quantifies the economic, social, and environmental impacts of flood events using hazard, exposure, and vulnerability data.
- **GIS (Geographic Information System)**: A system for capturing, analyzing, and visualizing spatial data, crucial for mapping flood hazards and assessing risk.
- **Disability-Adjusted Life Year (DALY):** A composite health metric equal to **YLL + YLD**, representing the sum of years of life lost due to premature mortality and years lived with disability.
- **Years of Life Lost (YLL):** Mortality component of DALY, computed as the number of deaths multiplied by the remaining life expectancy from a standard life table at age of death.
- **Years Lived with Disability (YLD):** Morbidity component of DALY, computed as the sum across conditions of *cases × disability weight × duration*.
- **Disability Weight (DW):** A severity weight on 0,10,10,1 assigned to health states, taken from recognised sources (e.g., GBD/WHO).

**MRV and ADD Terms**

- **Activity Design Document (ADD)**: The core submission file that details methodology, data, assumptions, and annexed evidence (AfDB ABM Guidebook, Feb 2025).
- **Monitoring, Reporting and Verification (MRV)**: The process by which avoided losses are measured, documented, and checked for issuance of CABs.
- **ADD Annex**: The appendix to the ADD containing raw data, model input files, calibration spreadsheets, and policy references.

# 6. Cross-linkages with major international agreements

## 6.1 Adaptation Support and Cost-Bearing Arrangements

While the methodology demonstrates clear contributions to the UAE Framework for Global Climate Resilience targets, it is not restricted to scenarios where the host-country buyer alone bears all costs. In line with the Adaptation Benefits Mechanism (ABM) principles, the financing of mobile flood barriers and the mobilization of Credited Adaptation Benefits (CABs) may also reflect adaptation support by one UNFCCC Party to another Party.

Specifically:

- **Domestic Buyer Model**: Local municipalities, businesses, or communities in the host country may directly invest in mobile flood barriers, with CABs serving to lower their effective cost of protection.
- **Party-to-Party Support Model**: An international donor country (UNFCCC Party) may purchase CABs generated by the project, thereby providing direct adaptation support to the host country. This reflects the principle of common but differentiated responsibilities and contributes to global adaptation finance flows.
- **Blended Model**: A combination where domestic buyers contribute part of the cost, and international donors provide co-financing or purchase CABs, further reducing financial barriers for vulnerable communities.

This flexibility ensures the methodology remains consistent with ABM's goal of catalyzing additional and predictable adaptation finance, while maintaining methodological neutrality on the source of funds. The inclusion of international adaptation support options strengthens the methodology's alignment with Articles 2.1(c) and 7 of the Paris Agreement, and reinforces its relevance to the UAE GCR targets on financing resilience and supporting vulnerable populations.

The figure below illustrates the sequence of financing, implementation, and CAB issuance under the ABM. It clarifies how domestic buyers, donor Parties, and the ABM Registry interact to ensure that financing flows ex-ante while CABs are only issued ex-post, consistent with ABM program rules.

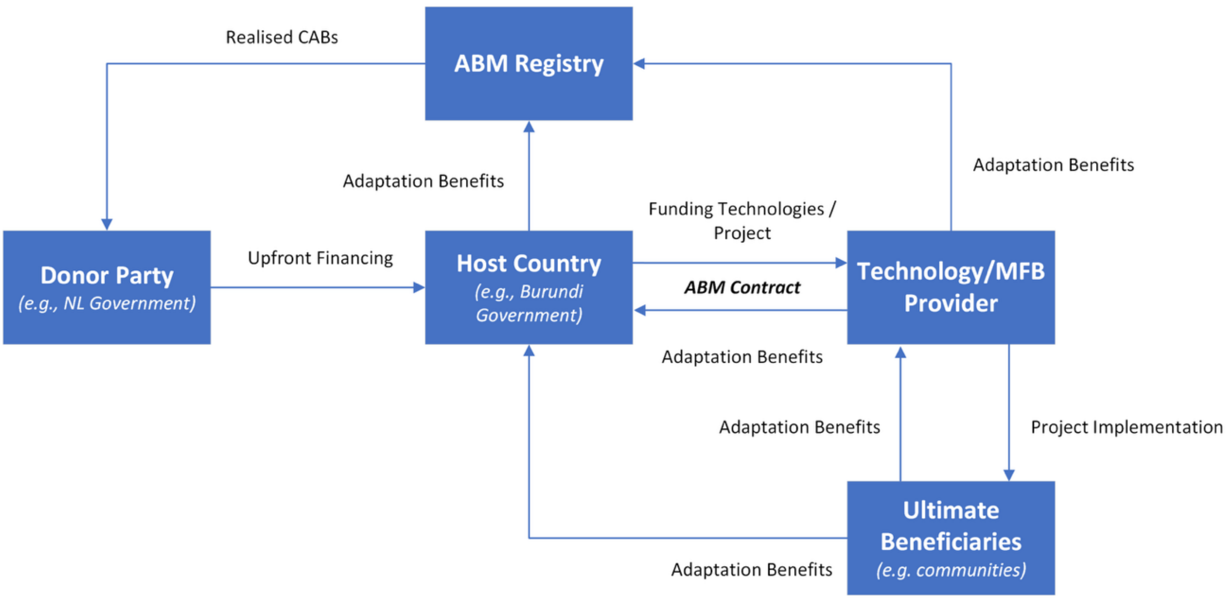



***Figure 1:*** *Financing and CAB flows under ABM for MFBs*

## 6.2 UNFCCC-specific documents and guidance

**(a) Article 6 of the Paris Agreement, paragraphs 8-9** (United Nations, 2015)

Activities using this methodology:

- **Promote adaptation and mitigation ambition:** By reducing flood risks, the methodology enhances climate resilience and contributes to sustainable development by protecting lives, livelihoods, and ecosystems.
- **Address sustainable development and poverty eradication:** The methodology develops economic stability by reducing flood-related loss to property and livelihoods. It promotes capacity building through stakeholder engagement and knowledge management.

**(b) Decision 1/CP.21, paragraph 39**

- Activities under this methodology address sustainable development by integrating flood protection measures into broader adaptation strategies.
- The deployment of MFBs directly protects vulnerable populations and contributes to poverty eradication by reducing the economic burden of flood recovery.
- Supports technology transfer by leveraging tools such as hydrodynamic modeling and GIS systems while building local capacity for their application.

**(c) Decision 4/CMA.3, paragraphs 1-3**

Activities using this methodology respect, promote, and consider:

- **Human rights and equality:** Ensuring equitable access to flood protection for marginalized and vulnerable communities. Incorporating gender-sensitive approaches by empowering women in decision-making roles and providing specific benefits to women and children.
- **Intergenerational equity**: Promoting sustainable adaptation solutions that protect resources and opportunities for future generations.
- **Indigenous and local knowledge**: Encouraging the inclusion of traditional and community-based flood management strategies in adaptation planning.

**(d) Decision 8a/CMA.5, paragraphs 6-11**

This methodology contributes to the following areas:

- **Increasing resilience of infrastructure and human settlements:** MFBs ensure continuous essential services, reducing disruptions to critical infrastructure and human settlements.
- **Reducing climate-induced poverty impacts**: By protecting assets and reducing recovery costs, the methodology minimizes flood-related poverty and supports livelihoods.
- **Enhancing water resilience and climate-resilient sanitation**: Mitigates flood-induced water contamination risks, contributing to safe and affordable potable water access.
- **Attaining climate-resilient food production:** Protects agricultural lands from flood loss, supporting food security and sustainable agricultural practices.

**6.3 Consistency with other international treaties:**

- **UN Convention to Combat Desertification (UNCCD)**: Aligns with principles to reduce land degradation by preventing flood-induced soil erosion and promoting sustainable land use.
- **Convention on Biological Diversity (CBD)**: Reduces the impact of floods on ecosystems, supporting biodiversity by safeguarding inland water systems and floodplains.
- **Sendai Framework for Disaster Risk Reduction (SFDRR)**: Directly supports the framework's priority of reducing disaster risk through early action and resilient infrastructure. Promotes data-driven risk assessments using hydrodynamic modeling and GIS. Encourages community engagement and capacity building to enhance local disaster resilience.

### 6.4 Alignment with national and sectoral policy frameworks

To ensure that each component of the baseline scenario is grounded in host-country priorities, the proponent shall map every baseline parameter (hazard, exposure, vulnerability, model configuration) to corresponding national or sub-national policies, plans or regulations. At a minimum, provide:

- **Hazard characterization (§ 9.3 a).**
  Linked to: [Country] National Adaptation Plan (NAP), Section 3.2 "Flood Risk Assessment" policy requirement; and the [Country] Water Resources Management Act (Year), Article 12 on flood-hazard mapping.
- **Exposure mapping (§ 9.3 b).**
  Linked to: [Country] Nationally Determined Contribution (NDC), Annex II on "Climate-Resilient Infrastructure"; and the [Province/State] Floodplain Zoning Regulation (Year), Article 5.3 requiring cadastral and asset-database integration.
- **Vulnerability (depth–damage functions, § 9.3 c).**
  Linked to: [Country] Building Code, Part 4 "Coastal and Riverine Flood Standards" (Year); and the [Country] Insurance Regulatory Authority's "Guidelines on Post-Event Damage Assessment" (Year).
- **Hydrodynamic model configuration (§ 9.3 d).**
  Linked to: [Country] Standard Methods for Hydraulic Modeling (Ministry of Environment, Year), Section II.4 on mesh resolution and boundary conditions; and the [Regional Economic Community] Flood Management Protocol, Annex A on design return periods.
- **Crediting period (§ 9.1).**
  Linked to: [Country] Public Finance Management Act (Year), Section 45 on asset lifetimes for capital grants; and the [Country] Disaster Management Policy (Year), Article 8 on performance monitoring cycles.

For each mapping above, include in the ADD annex a one-page table listing: the policy/plan title, publication year, exact article or section cited, and a brief explanatory note on how the baseline parameter fulfills that requirement (see example below). This mapping ensures that all baseline parameters are not only technically robust but also embedded in the host country's adaptation policy framework, reinforcing consistency with ABM Guidelines and national climate strategies.

***Table 1:*** *Baseline parameter alignment with national and sectoral policy frameworks*

| Baseline parameter | Policy basis (NDC/NAP/DRM regulation) | Citation (doc, article, year) | Effect on baseline |
|---|---|---|---|
| Design flood standard | National Adaptation Plan (NAP) – Flood Risk Mgmt | NAP 2021, § 4.2.1 | Adoption of T=50 for urban drainage design baseline |

| Baseline parameter | Policy basis (NDC/NAP/DRM regulation) | Citation (doc, article, year) | Effect on baseline |
|---|---|---|---|
| Climate scenario for baseline runs | Nationally Determined Contribution (NDC) – Adaptation Action 3 | NDC 2021, p. 15 | Use SSP2-4.5 for 2030–2050 climate projections |
| Asset valuation index | National Statistics Office – GDP deflator guidance | Statistical Bulletin 2022, Table 5 | Baseline exposure expressed in constant 2020 USD |
| Vulnerability functions | Ministry of Public Works – Building Code | Building Code 2019, Art. 12 | Masonry vs reinforced concrete typologies assigned to depth–damage classes |
| Critical infrastructure protection | National DRM Strategy | DRM Strategy 2020, § 3.1 | Hospitals and schools designated as priority assets in baseline exposure |
| Population at risk metric | Health Sector Adaptation Strategy | HSAS 2022, Annex II | Population figures disaggregated by sex/age included in exposure baseline |

# 7. Results chain for adaptation benefits (theory of change)

## 7.1 Definition of Adaptation Benefits[9,10]

This methodology recognises four quantifiable Adaptation Benefits (ABs). One of them, "USD avoided flood losses", is the primary Certified Adaptation Benefit (CAB); the other three (area protected, people protected, health impact avoided (DALYs)) may also be used as the primary CAB metric if preferred by the activity developer. Each AB links directly to the Outputs and Outcomes in the results chain and shall be monitored and verified with the procedures set out in Section 10.

**CAB unit and metric selection (mandatory)**

For any issuance period, select **one** metric and corresponding CAB unit:

- **Economic-loss metric:** 1 CAB = USD 1,000 of avoided flood loss (default).
- **People protected (M/F):** 1 CAB = 10 people protected (see counting rule in § 10.2).
- **Area protected:** 1 CAB = 1 ha protected (net flood-free footprint).
- **Health impact avoided (DALYs)**: 1 CAB = 1 DALY avoided (no age-weights; no time discounting).

[9] See definition of "Adaptation Benefits" in document ABM EC/2024/21/6, Paragraph 3.

[10] See Document ABM EC/2022/14/6 "Guidelines Principles, criteria, and indicators regarding the eligibility of Adaptation Benefits Mechanism activities and determination of adaptation benefits"

The selected unit applies unchanged throughout the crediting period (see § 10.2). State the chosen unit in the ADD and include conversion worksheets. *(Note: do not mix metrics across issuances.)*

***Table 2:*** *Overview Adaptation Benefits and CABs*

| Adaptation Benefit | Definition / How measured | CAB unit definition[1] |
|---|---|---|
| 1. Avoided flood losses (economic) | Reduction in direct economic loss to houses, businesses, infrastructure and cropland, calculated against the baseline scenario by approved depth–damage functions. | **Primary CAB:** 1 CAB = USD 1,000 verified avoided loss |
| *2. Area protected from inundation* | *Net reduction in flooded footprint (hectares) once mobile flood barriers (MFBs) are deployed.* | ***Optional/Primary CAB:*** *1 CAB = 1 ha of land or critical asset footprint kept flood-free[2]* |
| *3. People protected from flooding* | *Decrease in the number of individuals exposed to floodwater when barriers are deployed (gender-disaggregated).* | ***Optional/Primary CAB:*** *1 CAB = 10 people protected (male / female counts)* |
| *4. Health impact avoided (DALYs)* | *Reduction in DALYs by preventing flood-related mortality and morbidity, quantified as DALY = YLL + YLD with a standard life table and recognised disability weights.* | ***Optional/Primary CAB:*** *1 CAB = 1 DALY avoided* |

*[1] One primary CAB metric may be used across the entire crediting period; it cannot change between issuances.*

*[2] Area figures should be rounded to the nearest 1 ha for reporting.*

***Table 3:*** *Overview Link between Outputs, Outcomes and Impacts*

| Results-chain level | How it relates to the ABs above |
|---|---|
| **Outputs** | *Barrier available* and *Teams trained (< 3 h deployment)* create the pre-conditions for protection. |
| **Outcomes** | Deployment of MFBs during a flood event leads to:<br>• avoided economic losses,<br>• protected land/asset footprint and<br>• people shielded from inundation. |
| **Impacts / Certified Adaptation Benefits** | Verified ABs contribute to:<br>• SDG 1.5 (*resilience of the poor to disasters*)<br>• SDG 11.b (*inclusive disaster-risk reduction in settlements*)<br>• SDG 13.1 (*adaptive capacity to climate hazards*). |

### Certified Adaptation Benefits (CABs)

- **Primary metric**: 1 CAB = USD 1,000 avoided flood losses.

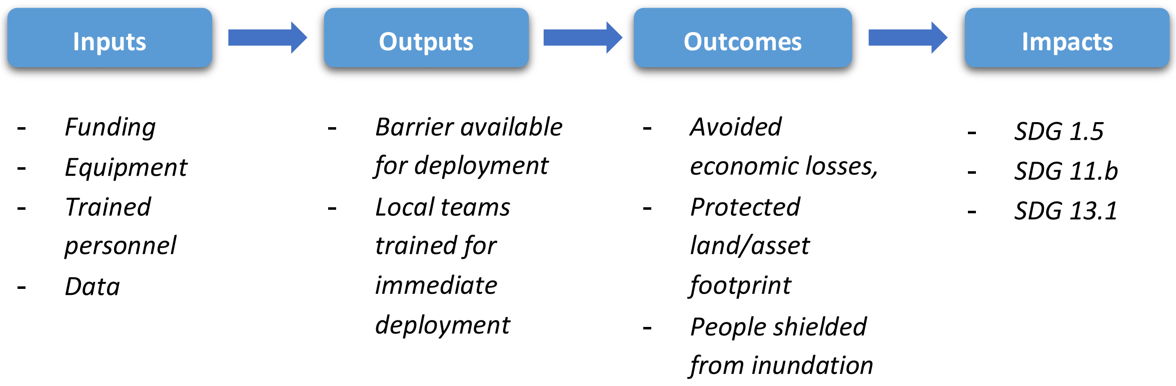
- **Optional metrics**: Developers may instead register CABs in area, people, or DALYs. The chosen primary metric remains fixed for the entire crediting period.
- **Verification**: CABs are calculated from modelled flood-depth rasters, asset maps and depth–damage curves, and certified via the MRV protocol (See section 10).
- **Finance linkage**: These benefits are recognised as Certified Adaptation Benefits (CABs) upon verification and certification and can be used to obtain results-based finance.

This alignment ensures that the same three Adaptation Benefits appear consistently in the results-chain diagram, the calculation section and the monitoring parameters table, eliminating ambiguity for verifiers and financiers.

## 7.2 Results chain

The results chain below illustrates the pathway from inputs to long-term impacts, demonstrating how activities under this methodology using mobile flood barriers (MFBs) contribute to reducing vulnerability and enhancing resilience in flood-prone areas.

***Figure 2: Result chain for the adaptation benefits***




**Inputs:**

1. **Funding**: Financial resources for procuring mobile flood barriers, conducting hydrodynamic modeling, and facilitating training programs.
2. **Equipment**: MFBs, GIS tools, hydrodynamic modeling software, and monitoring equipment.
3. **Human Resources**: Trained personnel for deployment, monitoring, and maintenance of barriers, including local stakeholders.
4. **Data and Research**: Hydrological, topographical, and vulnerability data for flood modeling and risk assessments.

**Outputs:**

1. **Barrier available for deployment**: MFB modules are procured, located, and maintained for rapid deployment.
2. **Local teams trained for immediate deployment**: Community members and stakeholders receive training to deploy SLAMDAM within three hours of flood warnings.

***Examples:***

1. *Barrier stock of* X *linear metres maintained in ready-to-deploy condition.*
2. Y *local responders certified to deploy barriers within ≤ 3 hours.*

**Outcomes:**

1. **Avoided economic losses**: monetary value of loss averted when barriers are deployed.
2. **Protected land / asset footprint**: hectares of land or critical assets that remain flood-free.
3. **People shielded from inundation**: number of individuals (gender-disaggregated) no longer exposed to floodwater.

***Example:***

1. *Avoided economic losses of approximately USD Z during a modelled 1-in-25-year flood.*
2. *Protected land/asset footprint of about X ha kept flood-free.*
3. *People shielded from inundation: roughly Y individuals (M / F disaggregated).*

**Impacts**

1. SDG 1.5: Resilience of the poor and vulnerable to climate-related disasters.
2. SDG 11.b: inclusive, climate-resilient disaster-risk reduction in human settlements.
3. SDG 13.1: strengthened adaptive capacity to climate hazards.

***Examples:***

1. *Annualised avoided losses valued at USD Z contribute to SDG 1.5, 11.b, 13.1.*
2. *Exposure of vulnerable households reduced by X %, enhancing community resilience.*
3. *Local DRM plan updated to include barrier protocol, evidencing institutional uptake.*

Local training follows a train-the-trainer approach: a core group of community personnel is certified to deploy barriers and subsequently mandated to train additional responders. This ensures sustainability across diverse socio-political contexts and supports long-term community ownership. Community benefits and technology acceptance are tracked through MRV, using deployment logs, standardized checklists, and community feedback surveys, ensuring that all adaptation benefits are both measurable and socially validated.

# 8. Additionality

## 8.1 Business Case for the Mobile Flood Barrier (MFB)

Even in case the technical lifespan of the Mobile Flood Barrier is 20–40 years, the methodology conservatively sets the maximum crediting period at 10 years in line with climate finance practices. The shorter payback horizon reflects the need to recover upfront investment costs rapidly in order to accelerate replication and scale-up, while ensuring that conservative assumptions are applied to credited benefits.

The MFB represents a financially viable alternative to conventional flood protection methods, particularly in locations where permanent flood barriers are not feasible due to high costs, technical challenges, or land-use constraints. The MFB offers a low-cost, flexible solution that can be quickly deployed in response to imminent flood threats. Key elements of the business case include:

- **Cost-effectiveness**: Compared to traditional flood barriers, MFBs can be deployed with a significantly lower upfront capital expenditure due to their portability and modular design. The initial investment is lower than constructing permanent flood defenses (e.g., levees or dams).
- **Operational efficiency**: The use of solar-powered water pumps to fill the barrier with water during flooding events allows for minimal operating costs once the barrier is deployed.
- **Revenue potential**: MFBs can be leased to local governments or private sector stakeholders for flood protection services. Alternatively, MFBs may be used to generate secondary revenue by storing water for later use in irrigation, industrial processes, or drinking water (where infrastructure permits).
- **Low maintenance**: The barrier requires minimal maintenance compared to permanent structures, reducing long-term operational costs.

## 8.2 Additionality: Overview and Mandatory Test

This subsection provides the overview. The mandatory pass/fail procedure is in § 8.5. All activities must apply that test and compile the evidence listed there.

### 8.2.1 Overview

This subsection explains why the activity is not business-as-usual and summarizes the drivers of additionality for mobile flood barriers (MFBs). It provides narrative context (policy, market maturity, financing constraints) but does not constitute the test.

#### 8.2.2 Additionality test (mandatory)

The activity is additional only if it passes all items (a)–(d) at validation ($t_0$). Evidence is annexed to the ADD.

(a) Regulatory test. Confirm no law, regulation, permit or funding program in force at $t_0$ requires deployment of MFBs at the proposed location and scale. Attach citations and copies.
(b) Financial test. Show the activity's FIRR < WACC in the BAU case (no CAB revenues) and becomes viable only with anticipated CAB cash flows (5–15 y). Provide an auditable CBA model with assumptions and ±10–20% sensitivity on CAPEX, OPEX and CAB prices/volumes.
(c) Common-practice test. Demonstrate < 20% adoption of comparable MFB solutions in similar jurisdictions/sites for the same use case. Provide market/registry evidence and sampling frame.
(d) Five-year funding check. Confirm that no entity has provided, nor will be requested to provide, the full budget to fund the activity within five years of registration. Attach letters/government budget references as applicable.

Validation decision rule (pass/fail). If any item (a)–(d) fails, the activity is not additional and is ineligible.

#### 8.2.3 Evidence package (attach in ADD)

- Regulation extracts and citations (titles, articles, dates).
- Financial model (NPV/IRR) with assumptions and sensitivity sheets.
- Common-practice assessment (method, sources, results).
- Funding confirmations/letters covering the five-year horizon.
- Summary decision table showing pass/fail for (a)–(d).

#### 8.2.4 Documentation note

All assumptions and sources must be transparent and replicable. If any evidence is confidential, provide a redacted version plus an auditor's attestation.

### 8.3 NDC Check

**Alignment with Nationally Determined Contributions (NDCs):**

- Many countries highlight water, flood risk reduction, and climate resilience as priority responses to climate change in their NDCs but lack specific, implementable solutions to address flood risks. The use of Mobile Flood Barriers (MFBs) offers an actionable adaptation solution, bridging the gap between NDC goals and on-the-ground implementation.
- **Example:** The activity supports objectives such as "improved water management systems" and "community-based adaptation" in the NDCs of flood-prone countries.

**Deviating from Business-as-Usual:**

- In the absence of this activity, flood management in many regions would remain reactive (e.g., post-flood relief) rather than proactive, leading to continued high economic and social costs.

## 8.4 Law and Regulation Check

**Not Mandated by Law**:

- No existing national or regional regulations require the deployment of MFBs for flood risk reduction. Most flood management laws focus on permanent structures like levees and dams.
- *Example: In many flood-prone countries, legislation mandates flood warning systems but not the implementation of MFBs.*

**Not a Regulatory Requirement**:

- This methodology is applicable to voluntary adaptation activities, leveraging innovative and temporary solutions not covered by statutory obligations.

## 8.5 Common Practice Check

**Deviation from Common Practice**:

- The use of MFBs is not a common practice in most flood-prone regions, where permanent structures (e.g., levees, dikes) or sandbags are the conventional response.
- Example: Sandbags remain the most commonly used short-term flood mitigation measure, even though it is less effective, less durable, and more labor-intensive compared to MFBs.
- Hydrodynamic modeling and GIS-based assessments for optimized barrier placement are not part of standard flood management practices in many (developing) countries.

**Innovative Nature of MFBs**:

- The activity introduces a flexible, scalable, and efficient solution that can be rapidly deployed and reused, filling a gap in existing flood mitigation strategies.

## 8.6 Barrier Demonstration

**Financial Barriers**:

- High initial costs for procuring and deploying MFBs prevent widespread adoption, especially the most vulnerable communities often lack the means and access to commercial finance to invest in MBF.

- Activities using this methodology use the ABM framework to mobilise funds that would otherwise be unavailable.

**Technological Barriers**:

- Limited access to modeling tools and data constraints the ability to optimize MFB deployment.
- This methodology provides an approach for data collection, modeling, and decision-making to overcome these constraints.

**Institutional Barriers**:

- Lack of capacity and expertise in MFBs deters (governmental) institutions from using these.
- The activity incorporates capacity building and training programs to address these challenges.

**Cultural/Behavioral Barriers**:

- Communities continue to use conventional flood mitigation measures due to a lack of awareness of MFBs.
- The activity includes awareness campaigns and stakeholder engagement to inform and educate communities about the benefits of MFBs.

**Substantiation of Additionality**

Above checks confirm that the activity using MFB is additional to business-as-usual practices:

- It aligns with NDC ambitions but introduces a new, implementable solution.
- It operates outside the scope of legal mandates and regulatory requirements.
- It surpasses common practices by introducing innovative and scalable solutions.
- It overcomes significant barriers that prevent widespread adoption.

## 8.7 Financial Model and Support Options

To ensure the uptake of MFBs in vulnerable, flood-prone regions, it is important to recognize that the primary barrier to deployment is cost, particularly in developing countries. While the use of loans can sometimes be part of a financing model, under the UNFCCC framework, loans are not compatible with the ABM mechanism. As ABM operates as a non-market approach, loans cannot be used as a financing tool within this methodology. Instead, the focus must be on grants, subsidies, and cooperation-based financing mechanisms.

### Holistic Cooperation under Article 6.8 of the Paris Agreement

Given that the ABM is a non-market approach under the UNFCCC, which requires at least two cooperating parties for project implementation, cooperation between nations is essential. The methodology for the Mobile Flood Barrier can serve as an example of how international collaboration can support countries in their efforts to achieve their NDCs.

**Article 6.8** emphasizes holistic cooperation, particularly in areas such as finance, capacity-building, and technology transfer. In this context, the Mobile Flood Barrier technology presents an ideal model for prioritizing support to developing countries through:

1. **Financial Support**:
    - Instead of loans, grants and financial assistance from international climate funds (e.g., the Green Climate Fund, Adaptation Fund) should be the primary sources of capital to deploy MFBs in countries where flood resilience is critical but financial resources are limited.

2. **Capacity-Building**:
    - The MFB project should include training programs, workshops, and support to enhance local technical capacity in flood risk management, barrier deployment, and maintenance.
    - Knowledge-sharing platforms should be established, where countries with successful MFB deployments can share best practices with others.

3. **Technology Transfer**:
    - As a climate resilience technology, the Mobile Flood Barrier qualifies for technology transfer to developing countries under Article 6.8, supporting the transfer of knowledge, technology, and skills necessary for its effective implementation and long-term sustainability.
    - International cooperation and partnerships can facilitate the transfer of MFB technology to countries that may not yet have the local infrastructure or capacity to deploy flood barriers independently.

# 9. Baseline methodology

The baseline methodology establishes the reference scenario required to quantify the adaptation benefits of deploying MFBs. It defines the "business-as-usual" conditions where no adaptation interventions are implemented.

This methodology incorporates hydrodynamic modeling, exposure analysis, and loss assessment to simulate flood hazards and related impacts under baseline conditions. It integrates historical data, flood hazard maps, and vulnerability functions to ensure a reliable representation of risks across various return periods. By calculating the expected annual loss (EAD) under the baseline scenario, the methodology provides a robust foundation for measuring the effectiveness of the adaptation intervention.

Conservative assumptions and globally recognized modeling tools ensure transparency and credibility in assessing flood risks and loss. This baseline serves as a key input for comparing "with" and "without" project scenarios, enabling the quantification of adaptation benefits (ABs) achieved through MFB deployment.

## 9.1. Crediting Period

1. Default period. The crediting period during which Credited Adaptation Benefits (CABs) accrue shall be 10 years, corresponding to the conservative design life of the MFB.
2. **Shortened period option.** To align with financing or operational constraints, a shorter crediting period of no less than 5 years may be chosen if all of these conditions are met:
   - The barrier's design-life warranty (e.g., manufacturer's guarantee) is < 10 years.
   - A credible repayment schedule (e.g., loan or capital lease) requires a shorter amortization.
   - Ex-post validation (see § 9.3 e) has demonstrated MFB performance over a shorter period.
3. **Extension beyond 10 years.** An extension up to 15 years is permissible only if:
   - The proponent provides third-party certification that the barrier retains ≥ 90% of its protective capacity after 10 years (e.g., accelerated-age testing).
   - A new ex-post model validation exercise (per § 9.3 e) is completed no later than year 10.
4. **Re-registration.** At the end of each crediting cycle (5, 10, or 15 years), the proponent may apply for a new crediting period by submitting:
   - Evidence of barrier inspection and any maintenance or refurbishment carried out.
   - Results of the latest ex-post validation.
   - Updated financial model (for additionality re-testing if the period extension triggers material changes in project economics).

## 9.2 ABM activity boundary

The activity boundary for this methodology defines the spatial and technological scope within which the deployment of MFBs generates measurable ABs. This boundary ensures that all relevant parameters are included and attributable to the activity. It encompasses the geographical area and technological systems directly influenced by the deployment of MFBs.

## 1. Spatial Boundary

The spatial boundary includes:

- **Flood-Prone Areas**: The regions where MFBs are deployed to prevent or reduce inundation, typically adjacent to rivers, streams, or urban drainage systems subject to flooding.
- **Protected Areas**: Geographic zones where MFB deployment mitigates flood impacts such as: Residential neighborhoods, critical infrastructure, and agricultural lands and ecosystems.
- **Downstream Areas**: Locations indirectly protected due to reduced flood propagation.

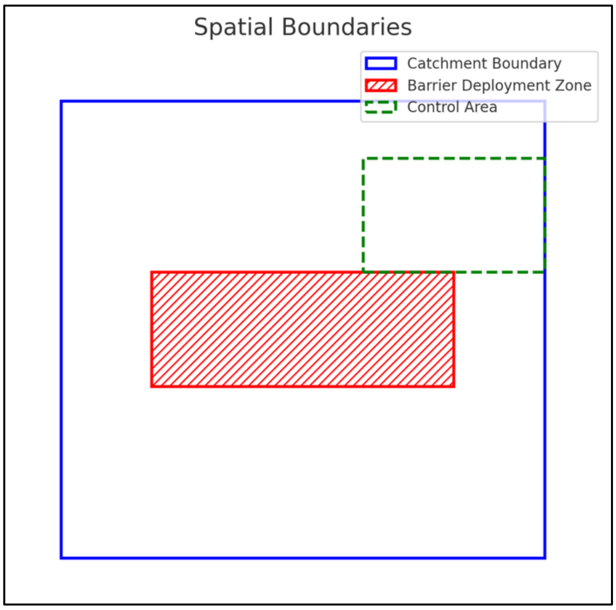



***Figure 3****: a schematic map showing the catchment boundary (blue box), barrier deployment zone (red hatch), and control area (green dashed box)*

## 2. Technological Boundary

The technological boundary encompasses:

**Mobile Flood Barriers**:

- Physical barriers deployed to block or redirect floodwaters.
- Includes all associated components, such as pumps, connectors, and other accessories.

**Supporting Systems**:

- Hydrodynamic models used to simulate flood behavior and optimize barrier placement.
- GIS-based tools for mapping flood risks and monitoring deployment effectiveness.

**Deployment and Maintenance Equipment**:

- Tools and infrastructure required for the installation, removal, and storage of MFBs.

- Vehicles and machinery used in the transport and handling of barriers.

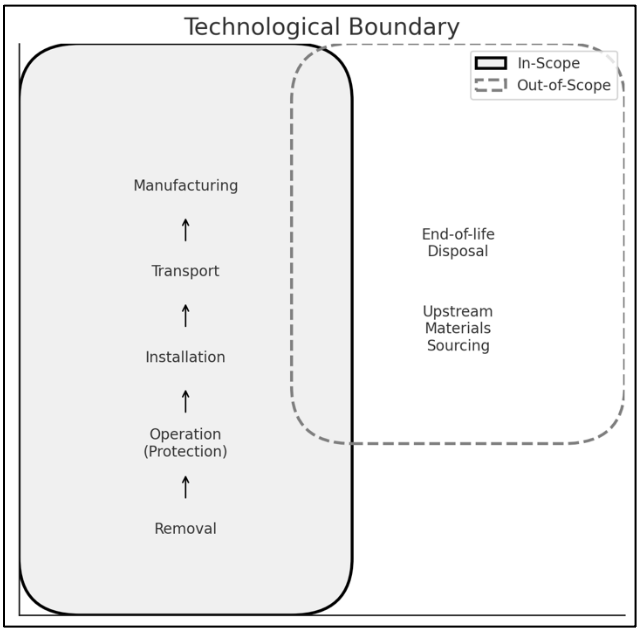



***Figure 4:*** *A system-boundary diagram highlighting in-scope stages (manufacturing through removal) versus out-of-scope stages (material sourcing, disposal)*

**3. Parameters under Participant Control**

The activity boundary includes parameters that are significant and attributable to the activity e.g.:

**Barrier Placement and Effectiveness**:

- Precise positioning of MFBs to maximize flood protection.
- Measured reductions in flood depth, extent, and duration.

**Protected Assets and Populations**:

- Quantifiable impacts on residential areas, infrastructure, land, and affected populations.

**Operation and Maintenance**:

- Regular inspections, repairs, and adherence to deployment protocols to ensure effectiveness.

The activity boundary shall therefore include all physical assets and communities directly protected by the MFB deployment and under the control of activity participants, ensuring compliance with ABM Guidelines.

**4. Attribution to the ABM Activity**

The boundary excludes external factors not under the control of activity participants, such as:

- Flood events beyond the design capacity of the MFBs.
- Broader socio-economic or environmental changes unrelated to MFB deployment.

## 9.3 Baseline Determination

In line with AMP004 recommendations, the baseline scenario represents the expected flood damages that would occur in the absence of the Mobile Flood Barrier (MFB) project. It provides the reference against which adaptation benefits (avoided damages) are quantified.

**Step 1 – Hazard characterization**

- Use hydrodynamic or statistical flood models to estimate inundation depth $h$ [m], extent [m²], and duration $d$ [hours] for relevant return periods (e.g., 2, 5, 10, 20, 50 years).
- Where possible, include flow velocity $v$ to capture kinetic energy effects (see Section 9.3(c)).

**Step 2 – Exposure mapping**

- Identify exposed assets by category (residential, commercial, public infrastructure, roads, agricultural land).
- Define asset units (e.g., m² of building floor area, km of road, ha of cropland).

**Step 3 – Vulnerability and damage factors**

- Apply locally calibrated depth–damage functions $f_s^{(host)}$ for sector s.
- Adjust with terrain/velocity multiplier $\varphi(v)$ and duration multiplier $\psi(d)$:

$$f_s^{(base)}(h, v, d) = min\left(1, f_s^{(host)}(h) \times \varphi(v) \times \psi(d)\right) \qquad \text{(Eq. 9.3.1)}$$

Where:

- $f_s^{(base)}(h, v, d)$ = baseline damage fraction
- $\varphi(v)$ = terrain/velocity multiplier (see Section 9.3(c))
- $\psi(d)$ = duration factor (e.g., 1.0 for floods <24h, 1.1 for 24–72h, 1.2 for >72h)

**Step 4 – Baseline losses**

- For each return period $T$:

$$Loss^{(baseline)}(T) = \Sigma_s \Sigma_i \in s\left[A_i \times V_s^{(host)} \times f_s^{(base)}\left(h_i(T), v_i(T), d_i(T)\right)\right] \qquad \text{(Eq. 9.3.2)}$$

Where:

- $A_i$ = exposed unit size (e.g., m², ha, km)
- $V_s^{(host)}$ = unit value of asset sss in host country currency
- $h_i(T), v_i(T), d_i(T)$ = hazard characteristics at location iii under return period T

**Step 5 – Tabulation of results**

- Populate Table 1 (affected assets per return period), Table 2 (baseline damages before MFB), and Table 3 (damages after MFB) using the above equations.

**Step 6 –Mapping Adaptation Benefits to CAB units (all metrics)**

**(a) Monetary CAB (default)**

$$CAB_{money,t} = \Delta AELt/1000 \quad \text{(Eq. 9.3.3)}$$

where $\Delta AEL_t = AEL_{base,t} - AEL_{withMFB,t}$. Use the discrete-probability AEL definition in Eq. 9.6.6 and the conservative issuance rule in Eq. 9.6.14.

**(b) People-protected CAB (optional/primary)**

$$CAB_{people,t} = \left(P_{base,t} - P_{withMFB,t}\right)/10 \quad \text{(Eq. 9.3.4)}$$

with gender-disaggregated counts as specified; this is consistent with Eq. 9.6.5 and the counting rule in §10.2. Apply the same conservative issuance logic as in Eq. 9.6.14 (i.e., use the conservative value across scenarios and apply uncertainty discounts per §10.3 if needed).

**(c) Area-protected CAB (optional/primary)**

$$CAB_{area,t} = \left(A_{floodedbase,t} - A_{floodedwithMFB,t}\right)/A_{perCAB} \quad \text{(Eq. 9.3.5)}$$

where $A_{floodedbase,t}$ and $A_{floodedwithMFB,t}$ are inundated footprints (ha) from the modeled flood-extent rasters, and $A_{perCAB}$ is the unit chosen in §7.1 (see note on consistency below). Apply the same conservative issuance logic as for (a).

**(d) DALY CAB (optional/primary)**

$$DALY(t) = YLL(t) + YLD(t) \quad \text{(Eq. 9.3.6)}$$

$$\Delta DALY_t = \Sigma_j p_j \cdot \left(DALY_{base(t,j)} - DALY_{with\,MFB(t,j)}\right) \quad \text{(Eq. 9.3.7)}$$

$$CAB_{DALY,t} = \Delta DALY_t / DALY_{perCAB} \quad \text{(Eq. 9.3.8)}$$

Where:

- $DALY(t)$: Disability-Adjusted Life Years in period *t*.
- $\Delta DALY_t$: Expected DALYs avoided in period *t* across flood events.
- $p_j$: Annual probability of flood event j (events in the exceedance/frequency set; probabilities sum appropriately over the set used).
- $CAB_{DALY,t}$: Certified Adaptation Benefits when DALY is the primary metric.
- $DALY_{perCAB}$: Unit conversion for DALYs to CABs; default = 1 (i.e., 1 CAB = 1 DALY avoided).
- $YLL(t)$ (*Years of Life Lost*): deaths(t) × L_standard(age) where L_standard(age) is remaining life expectancy from a standard life table at age of death.
- $YLD(t)$ (*Years Lived with Disability*): Sum over health conditions $k$ $of\ cases_{k(t)}$ × $DW_k$ × $duration_k$.
  - $cases_{k(t)}$: Number of incident cases of condition k in period *t*.
  - $DW_k$: Disability weight for condition k (recognised GBD/WHO weights on 0,10,10,1).
  - $duration_k$: Average duration (in years) of condition k.

with default $DALY_{perCAB}$ = 1. Use the same conservative issuance logic as in Eq. 9.6.14 (choose the conservative scenario and apply §10.3 uncertainty discounts where applicable).

*Documentation:* State the chosen metric in the ADD and include the conversion worksheet (see §7.1/§10).

**Step 7 – Conservativeness and documentation**

- If local flood duration data are not available, apply default $\psi(d) = 1.10$ to maintain conservativeness.
- Document all assumptions and data sources in the Activity Description Document (ADD).

**Policy Linkage of Baseline Parameters**

Each baseline parameter must be explicitly linked to national adaptation policy instruments and climate projections to ensure consistency with country priorities and forward-looking climate risks:

- **Hazard (h, v, d):** Use national flood hazard maps and projections where available (e.g., Ministry of Water or Disaster Risk Agency). Where only historic maps exist, these must be complemented with future climate scenarios (e.g., IPCC AR6 RCP/SSP projections or country-specific climate prognosis as referenced in the National Adaptation Plan).
- **Exposure ($A_i$):** Must be mapped using official land-use, census, or infrastructure datasets consistent with national development plans or flood risk zoning regulations.
- **Vulnerability ($f^s$, φ, ψ):** Asset classes and damage functions must reflect construction typologies and sectoral priorities identified in the NAP or NDC adaptation chapters (e.g., emphasis on agriculture resilience, coastal protection, or housing).
- **Valuation ($V^s$):** Use national statistical agency or ministry of finance replacement cost indices, consistent with economic baselines in the NDC or national disaster loss database.

**Mandatory requirement:**
For each baseline study, the proponent must provide in the Annex Data Document (ADD) a table cross-referencing each parameter (hazard, exposure, vulnerability, valuation) to the corresponding policy or national plan source (e.g., NAP, NDC, or flood management regulation).

This ensures that the methodology:
1. Does not rely solely on historic events,
2. Explicitly integrates forward-looking climate projections, and
3. Aligns baseline assumptions with nationally determined priorities.

Damage categories (residential, commercial, infrastructure, agriculture) must be reported separately in the ADD, and flood duration must always be reflected using ψ(d), with conservative defaults applied where local data are unavailable.

### 9.4 Definition of the adaptation baseline scenario

The adaptation baseline scenario represents the expected conditions and impacts of flooding in the absence of the adaptation activity. It includes the extent, depth, frequency, and duration of floods, as determined by hydrodynamic modeling and historical data, as well as the exposure of people, infrastructure, and assets to flood risks. The scenario also accounts for the vulnerability of these exposed elements, quantified using depth-damage functions and socio-economic data, and estimates economic, social, and environmental loss through tools like AEL calculations.

### 9.4.1 Adaptation baseline

The adaptation baseline scenario represents the conditions expected in the absence of the MFB deployment. It serves as the reference scenario for assessing ABs and includes the ecological, social, economic, and environmental context within the activity boundary.

**Ecological Context**

- **Flood Hazard Characteristics**: The baseline includes flood events modeled for various return periods (e.g., 10, 50, and 100 years) using hydrodynamic models. These simulations reflect the extent, depth, and duration of flooding in areas prone to floods.
- **Environmental Impacts**: Without adaptation, floods lead to soil erosion, degradation of ecosystems, and contamination of water, impacting biodiversity and agricultural productivity.

**Social Context**

- **Population Exposure**: The baseline assesses the number of people exposed to flood risks, focusing on vulnerable groups such as low-income households.
- **Health and Safety Risks**: Frequent flooding results in injuries, displacement, and increased risks of waterborne diseases, particularly affecting marginalized populations.

**Economic Context**

- **Loss to Infrastructure and Assets**: The baseline includes expected loss to critical infrastructure and land. Depth-damage functions are applied to quantify economic losses.
- **Impact on Livelihoods**: Without adaptation, floods disrupt economic activities, particularly in agriculture, leading to income loss and reduced food security.

**Environmental Context**

- **Projected Climate Trends**: The baseline incorporates future climate projections, including increased frequency and intensity of extreme rainfall events due to climate change.
- **Current Mitigation Practices**: Existing flood mitigation efforts, such as permanent structures or sandbags, are considered inadequate for addressing the anticipated risks.

**Baseline Parameters**

- **Flood Hazard**: Maps showing inundation extents and depths for specific return periods.
- **Exposure**: Geographic distribution of assets, population, and critical infrastructure at risk.

- **Vulnerability**: The susceptibility of elements are quantified through depth-damage functions.
- **Annual Expected Loss (AEL)**: A calculation combining hazard, exposure, and vulnerability to estimate the monetary impact of flooding.

It is noted that while the MFB technology may appear financially viable under certain assumptions, this does not constitute a business-as-usual baseline. The baseline explicitly excludes the project activity and assumes continuation of current inadequate practices (e.g., sandbags, no protection), consistent with national policies and NAPs. Payback periods under the activity scenario reflect financing needs and conservative ABM crediting limits, not baseline feasibility.

The baseline scenario must always combine hydrodynamic modeling with observed historical flood data (marks, gauges, community records) to avoid reliance on GIS-only representations, thereby ensuring the robustness of subsequent AB calculations.

#### 9.4.2 Incorporating future climate scenarios

To account for future climate conditions, the baseline scenario shall incorporate climate change projections from credible, downscaled sources (e.g., CORDEX projections) for the relevant region. The following steps will be applied:

1. **Climate scenario selection.**
    - The proponent will select at least one representative Representative Concentration Pathway (RCP) scenario (e.g., RCP 4.5 or RCP 8.5 (Moss et al., 2010)) based on the expected emissions pathway for the region.
    - Projections from IPCC AR6 models (IPCC AR6, 2021) will be the preferred source for future climate conditions.

2. **Flood frequency adjustment.**
    - The proponent will adjust baseline flood return periods (e.g., 10, 25, 100 years) based on projected changes in precipitation and temperature under the chosen RCP scenario.
    - For each return period T, flood depth calculations will account for the change in frequency and intensity of extreme events (e.g., by shifting probability distributions according to future climate projections).

3. **Scenario documentation.**
    - In the PDD annex, include climate model selection details, the chosen RCP scenario, and a summary of the climate impacts on flood frequency or magnitude. This should be

supported by sources such as the CORDEX dataset (WCRP/CORDEX, 2015) and national climate projections.

4. **Validation of climate impacts.**
   - The proponent will monitor climate-related changes in annual maximum discharge and flood extents, comparing projections with observed conditions in subsequent years. This will allow for adjustments to the baseline if significant deviations occur due to unforeseen climate shifts.

This baseline ensures that ABs achieved through MFB deployment are measurable, robust, and directly attributable to the activity, in accordance with ABM principles and methodology guidelines.

## 9.5 Adaptation activity scenario

The adaptation activity scenario describes the conditions and outcomes resulting from the deployment of MFBs as an adaptive measure to mitigate flood risks. This scenario contrasts with the baseline scenario by incorporating the impact of MFBs in reducing flood extents, depths, and associated loss. The scenario is modeled using hydrodynamic and loss assessment tools to quantify the effectiveness of the intervention.

**Key Components of the Adaptation Activity Scenario**

1. **Flood Hazard Reduction**:
   - The MFBs are modeled as water-retaining structures, incorporated into hydrodynamic models (e.g., Delft3D FM 1D2D). These models simulate the reduction in flood extents and depths during flood events of varying return periods (e.g., 10, 50, and 100 years).
   - The barriers are represented as fixed weirs in the model, with parameters such as crest height calibrated to reflect their retention capacity.

2. **Reduction in Exposure and Vulnerability**:
   - MFB deployment results in fewer assets, populations, and critical infrastructure being exposed to floodwaters.
   - Vulnerability is reduced by limiting the extent and depth of flooding, thereby minimizing potential loss.

3. **Quantification of Adaptation Benefits**:
   - The reduction in Annual Expected Loss (AEL) is calculated by comparing flood impacts under the adaptation and baseline scenarios.

- Other benefits, such as reduced numbers of affected people, protected hectares of agricultural land, and safeguarded critical assets (e.g., schools, hospitals), are quantified using loss assessment tools like the Delft-FIAT Accelerator.

**Indicators of Success**

- **Reduction in Affected Population**: Measured in the number of people protected from flooding.
- **Reduction in Flooded Area**: Measured in hectares of land spared from inundation.
- **Reduction in Economic Losses**: Quantified through AEL calculations.
- **Protection of Critical Infrastructure**: Number of schools, hospitals, and power stations safeguarded.

**Additional Environmental and Contextual Factors**

In addition to the primary Adaptation Benefit parameters, certain environmental and contextual factors may influence flood risks and the performance of Mobile Flood Barriers (MFBs). These factors do not generate Adaptation Benefits (ABs) themselves but should be recognized to ensure robust and context-sensitive assessments.

1. **Erosion of Vegetation Cover**
   Loss of natural vegetation can increase runoff, aggravate erosion, and amplify flood risks. Accounting for vegetation cover is essential to avoid underestimating exposure or overestimating the protective capacity of MFBs.
2. **Atmospheric Gases**
   Variations in atmospheric gases (e.g., $CO_2$, methane, water vapor) influence rainfall intensity and hydrological cycles. While this methodology does not quantify mitigation outcomes, acknowledging atmospheric drivers of precipitation helps ensure that hydrological modeling reflects realistic climate conditions.

**Implementation Notes:**

- These factors are to be treated as contextual modifiers for hazard and vulnerability assessments.
- Data should be sourced from remote sensing, national meteorological services, or global datasets.
- All assumptions, data sources, and adjustments based on these factors must be documented in the ADD annex.

**Avoiding Double Counting of Adaptation Benefits**

To prevent double counting of Adaptation Benefits (ABs), the following rules apply:

1. **Primary Indicator Selection**

- Project proponents must select one primary AB indicator (e.g., people protected, area protected, or avoided economic loss) as the basis for crediting.
- Additional indicators may be reported for co-benefit monitoring, but they will not generate additional AB credits.

**2. Optional Use of Hectares Protected**

- If hectares protected are claimed as an AB parameter, the corresponding population living in those hectares must not be simultaneously credited under the “people protected” indicator.
- The proponent must document in the ADD which indicator is used for crediting and which are reported as co-benefits.

**3. Consistency Across Parameters**

- Economic loss avoidance is inherently linked to both people protected and area protected. To avoid overlap, economic loss should only be credited when population and area indicators are excluded as crediting parameters.
- Where population and/or area data are reported, economic loss may still be shown for informational and policy purposes, but not used to claim additional AB credits.

**4. Verification**

- During MRV, verifiers will check that the same benefit (e.g., protection of a community living on a hectare of land) has not been counted under multiple AB categories.

### 9.5.1 Optional detailed formulas

The following formulas calculate optional metrics that track additional adaptation benefits beyond the primary economic losses. While these metrics contribute valuable insights, they are not required for the formal issuance of Credited Adaptation Benefits (CABs). Their inclusion is based on the project’s goals, particularly where reporting on SDG co-benefits or broader resilience impacts is prioritized.

$$CAB_{area}, t = A_t \qquad \text{(Eq. 9.5.1)}$$

Where $A_t$ is the net hectares protected in year t (1 AB = 1 ha)

$$CAB_{people}, t = P_t/10 \qquad \text{(Eq. 9.5.2)}$$

Where $P_t$ is the number of individuals protected in year t (1 AB = 10 people)

$$CAB_{DALY,t} = DALY_t/1 \qquad \text{(Eq. 9.5.3)}$$

Where $D_t$ is the number of DALYs avoided in year t (1 AB = 1 DALY)

Where either Eq. 9.5.1, Eq. 9.5.2 or Eq. 9.5.3 is applied, the resulting values (hectares or individuals protected) are converted into CABs using the standard equivalence: 1 CAB = 1 ha protected, 1 CAB = 10 people protected, or 1 CAB = 1 DALY avoided. These CABs are then verified and issued under the MRV procedure in Section 10.

## 9.6 Quantification of the Adaptation Benefits of the activity

ABs are quantified by comparing the baseline scenario (without MFBs) to the adaptation activity scenario (with MFBs). The calculations are based on reductions in flood-related loss, expressed in measurable terms such as economic losses, affected population, and protected assets. The methodology employs hydrodynamic modeling and loss assessment tools to ensure accuracy and alignment with ABM principles.

The quantification is conducted according to the following steps.
**Step 1:** Flood hazard assessment
**Step 2:** Baseline Assessment of Exposure, Flood Impact and Loss
**Step 3:** Flood Reduction through MFBs
**Step 4:** Calculation Certified Adaptation Benefits (CABs)

The quantification is done by estimating the hazard for flood events with different return periods, such as 1, 2, 5, 10, 20, 50, and 100 years. Using an Extreme Value Analysis (EVA), significant extremes can be derived from such a series of measurements to determine the type of flooding. For fluvial flooding, this would be a significant discharge, and for pluvial flooding, a significant meteorological event. The flood is simulated with a hydrodynamic model to create flood maps.

A loss estimation model converts flood maps into loss maps. The combination of return periods and the difference in loss gives the EAD. This process is illustrated in below Figure.

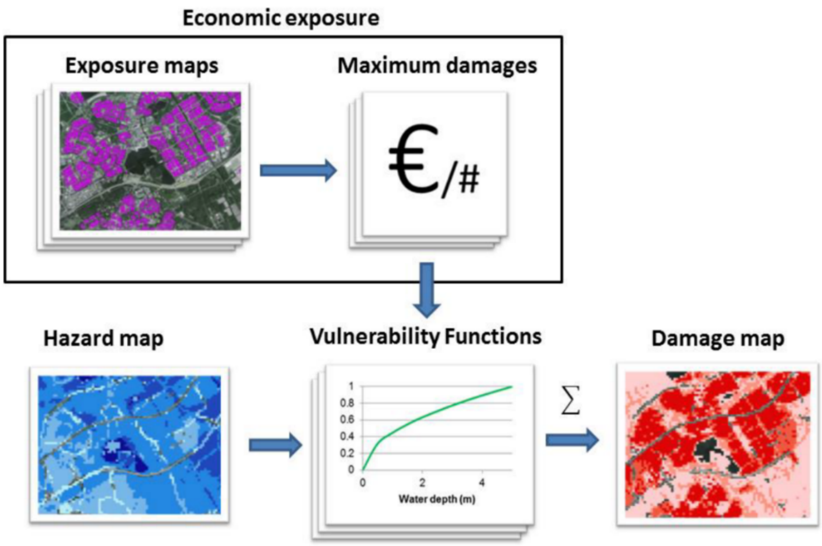



*Figure 5 Overview of data requirements for hazard, exposure and loss calculations.*

To be able to conduct a flood risk assessment several data and models are required.

- **Exposure maps**: Which assets and people are possible in danger of being flooded.
- **Maximum loss**: What is the value of the assets (and people) in danger.
- **Vulnerability function**: How and to what extent are assets (and people) affected by flood.
- **Hazard map**: What is the extend of the flood in different return periods (probability).

The combinations of these data and models are the loss maps for the different return period and the risk with the EAD. Output of this modelling could resemble results presented in below Table.

*Table 4; Affected assets from flooding per return period in years*

| Return Period (Y) | Surface (ha) | Agriculture (ha) | Houses (no.) | People (No.) |
|---|---|---|---|---|
| 10 | 20 | 18 | 10 | 40 |
| 25 | 30 | 27 | 25 | 100 |
| 50 | 35 | 30 | 100 | 400 |
| 100 | 45 | 38 | 200 | 800 |

In the following paragraphs the steps are described in more detail.

**Step 1: Flood hazard assessment**

The flood hazard assessment provides an estimate of the reduction in flood extent and depth, which serves as essential input for flood vulnerability assessments. These assessments translate the decreased flood hazard into measurable reductions in flood loss. Flood hazard reduction is evaluated by comparing the following two scenarios:

1. The baseline scenario where flooding occurs and no MFBs are placed
2. The adaptation scenario where flooding is reduced or prevented by placing the MFBs.

This approach applies to both the design and monitoring phases:

- **Design phase**: Determines the optimal location and dimensions of the MFB to minimize flood extent, depth, and loss.
- **Monitoring phase**: Quantifies loss avoided by hindcasting the flood event with the MFB in place and comparing it to a scenario without the MFB.

**Modelling requirements**

MFBs are versatile and can be applied in various flood scenarios, including fluvial, pluvial, and urban flooding. Accurate flood hazard assessments require hydrodynamic models capable of:

- Simulating flood depth and extent during flood events across diverse terrains and conditions.
- Capturing interactions between water flow and surrounding landscapes, including urban areas, floodplains, and agricultural lands.
- Incorporating the retention and diversion properties of MFBs to evaluate their effectiveness.

Models must be flexible, adaptive, and capable of integrating global and local data sources to account for varying levels of data availability.

**Data requirements for model building**

To ensure applicability in developing-country contexts, the table below provides tiered guidance on recommended datasets, tools, and adjustment measures based on the level of data availability.

***Table 5:** Guidance for Developing Country Contexts: Tool and Data Selection*

| Context Level | Recommended Datasets | Recommended Tools | Adjustment / Notes |
|---|---|---|---|
| **Low-data** | Global DEMs (SRTM, Copernicus DEM, FABDEM); global hydrography (HydroRivers, MERIT-Hydro); global land use (ESA WorldCover, USGS); global precipitation (CHIRPS, GPM) | Open-source 1D/2D models (HEC-RAS, LISFLOOD-FP, Iber) | Apply conservative assumptions; use δ discounting per §10.3; document data limitations in PDD annex |
| **Medium-data** | Mix of national datasets (gauging stations, census, land use, flood marks) and global datasets | Semi-commercial models (MIKE Hydro River, Delft3D FM, TUFLOW) or | Calibrate depth–damage curves with partial local data; |

| Context Level | Recommended Datasets | Recommended Tools | Adjustment / Notes |
|---|---|---|---|
| | (Copernicus DEM, Sentinel, Landsat) | advanced open-source where expertise exists | validate with available flood maps |
| **High-data** | High-resolution DEMs (≤ 10 m, LiDAR); long-term hydrological records (≥ 30 years); national flood databases; detailed land-use surveys | Advanced 2D/3D models (MIKE 21, Delft-FEWS, TELEMAC) | Develop localized depth–damage curves via field surveys; full calibration and validation required |

Minimum observed-data coverage: At least one observed flood event in the project area is required for calibration where possible. In low-data contexts, the methodology allows fallback to recognized global datasets (e.g., JRC flood hazard maps, Copernicus DEM) combined with conservative uncertainty discounting as specified in §10.3. All data limitations and assumptions must be documented in the ADD Annex.

The following subsections describe in more detail the specific data requirements, beginning with river geometry, digital elevation models (DEMs), land use data, and other inputs needed to construct robust flood hazard models.

**River Geometry:**
River geometry information can be obtained from river maps. These can be locally provided by water authorities or obtained from a global hydrography dataset such as HydroRivers, MERIT-Hydro or the work by Lin et al. (2019)[11]. Alternatively, high-resolution satellite imagery from sources like Google Earth, Sentinel, or Landsat can be used to extract detailed river geometry. These images provide valuable information on the shape and dimensions of the river channel.

**Digital Elevation Model (DEM):**
Elevation data can be sourced from local surveys, such as those using LIDAR, or from global datasets like SRTM, Copernicus DEM, or FABDEM when local data is unavailable. The quality of this data significantly influences the accuracy of hazard maps.

**Land Use Data:**
Land use data can be obtained from global datasets like European Space Agency's WorldCover or the United States Geological Survey (USGS) Land Cover Database, or VITO. These datasets

[11] Lin, P., Pan, M., Beck, H. E., Yang, Y., Yamazaki, D., Frasson, R., ... & Wood, E. F. (2019). Global reconstruction of naturalized river flows at 2.94 million reaches. *Water resources research*, *55*(8), 6499-6516. Link: https://agupubs.onlinelibrary.wiley.com/doi/full/10.1029/2019WR025287

provide comprehensive information on land cover types and their distribution. This type of data is used to estimate infiltration and roughness values of the land.

**Flood hazard validation data:**
Existing flood hazard maps can be used to calibrate and validate the model. To this end, flood marks or hazard maps of past events can be used. Alternatively, a global dataset containing these maps is the JRC Database.

**River Profile and Slope:**
The river profile and slope can be obtained from field surveys using GPS and leveling instruments. If local data is unavailable, estimates of river depth and width can be derived from satellite imagery and digital elevation models. Datasets like Lin et al. (2019) provide bankfull discharge information, enabling basic profile estimation.

**Upstream Discharge Data:**
Discharge data is typically collected from upstream gauging stations, which provide real-time flow rates for model calibration. In the absence of such data, discharge can be estimated using hydrological models like Wflow or HEC-HMS, driven by global precipitation datasets.

**Downstream Water Level:**
Downstream water levels can be measured using gauging stations or estimated via remote sensing techniques like satellite altimetry. Alternatively, discharge-water level relationships can be derived for use as downstream boundary conditions.

**Hydrodynamic 1D2D modelling**
Accurate fluvial flood modeling requires physics-based hydrodynamic software, which uses physical transport equations rather than empirical formulas. These equations, known as the 2D shallow water or Saint-Venant equations, simulate water flow dynamics.

$$\begin{gathered}\frac{\partial h}{\partial t}+\frac{\partial(hu)}{\partial x}+\frac{\partial(hv)}{\partial y}=0\\ \frac{\partial(hu)}{\partial t}+\frac{\partial}{\partial x}\left(hu^2+\frac{1}{2}gh^2\right)+\frac{\partial(huv)}{\partial y}=-gh\frac{\partial z_b}{\partial x}-\frac{\tau_x}{\rho h}+\frac{\tau_{wx}}{\rho h}\\ \frac{\partial(hv)}{\partial t}+\frac{\partial(huv)}{\partial x}+\frac{\partial}{\partial y}\left(hv^2+\frac{1}{2}gh^2\right)=-gh\frac{\partial z_b}{\partial y}-\frac{\tau_y}{\rho h}+\frac{\tau_{wy}}{\rho h}\end{gathered} \qquad \text{(Eq. 9.6.1)}$$

Hydrodynamic equations describe water depth ($h$), velocity components in the x- ($u$) and $y$- ($v$) directions, riverbed slope changes ($z_b$), bottom friction ($\tau_x$,$\tau_y$), and wind friction ($\tau_{wx}$,$\tau_{wy}$).

Several modeling solutions, such as HEC-RAS (USACE), MIKE11 (DHI), and Delft3D FM 1D2D (Deltares), simulate fluvial flooding using these equations. These tools solve the full shallow water equations (dynamic wave) or simplified versions (diffusive wave) for faster computations, either in a coupled 1D2D setting or fully in 2D with high resolution. They simulate river flow and its interactions with floodplains and hinterlands during flooding, providing outputs like time series (water level, flow velocity) and gridded maps (flood depth, flow velocity). They also model hydraulic structures, including MFBs.

*Example: Delft3D FM 1D2D captures processes for both fluvial and pluvial flooding and has been applied in urban and rural settings, such as Santa Cruz de la Sierra (Bolivia), Paramaribo (Suriname), Bangkok (Thailand), Surat (India), and Yangon (Myanmar)*[12]*. It has also been used in data-scarce regions like Nigeria for designing flood mitigation measures*[13]*.*

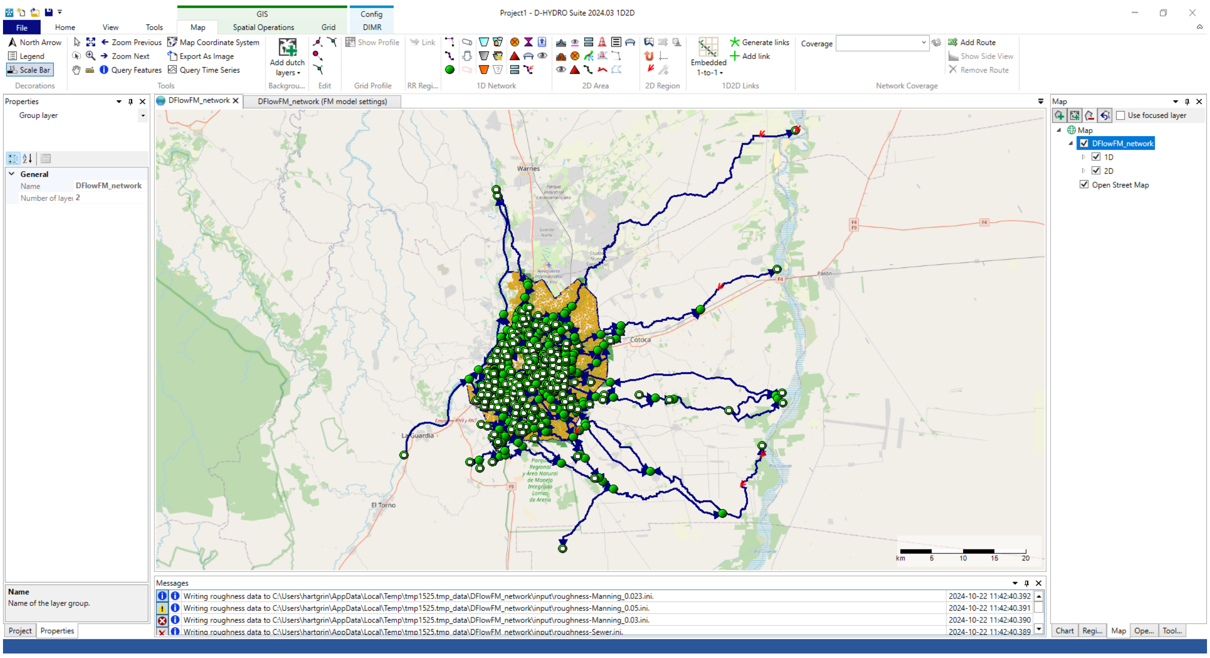


***Figure 6****: Example of hydrodynamic software with a GUI. The model is a 1D2D model for Santa Cruz de la sierra.*

Most of the example images in the following sections have been obtained from a World Bank project in Surat.[14]

[12] Read more in the Deltares Impact Report: https://specials.deltares.nl/impact_report_2023/action_to_enhance_urban_resilience

[13] A story-map describing the project in Maiduguri: https://storymaps.arcgis.com/stories/5a90f66e6fba4193b4727ad1f85de52c

[14] Reference document: Flood Risk Management Hydrologic and Hydraulic Studies for the Tapi Riverfront in Surat 11208918-005-ZWS-0001

**Technical Implementation**

A 1D2D model for flood hazard assessment consists of three main components: the river system, the surrounding land, and the design and placement of the MFB. Scenarios must also be defined to determine model forcing. These elements are detailed as follows:

***River***

The river is modeled as one or more 1D branches with multiple cross-sections. Using the graphical user interface (GUI) of the modelling tool (e.g. Delft3D), the river's layout can be manually drawn based on hydrography data or satellite imagery. Cross-section profiles are defined along the branches, using either existing data or estimates for river depth, width, and profile type (e.g., rectangular or trapezoidal). The slope is incorporated by specifying the bed level at each cross-section. These steps allow for effective modeling even with minimal prior data.

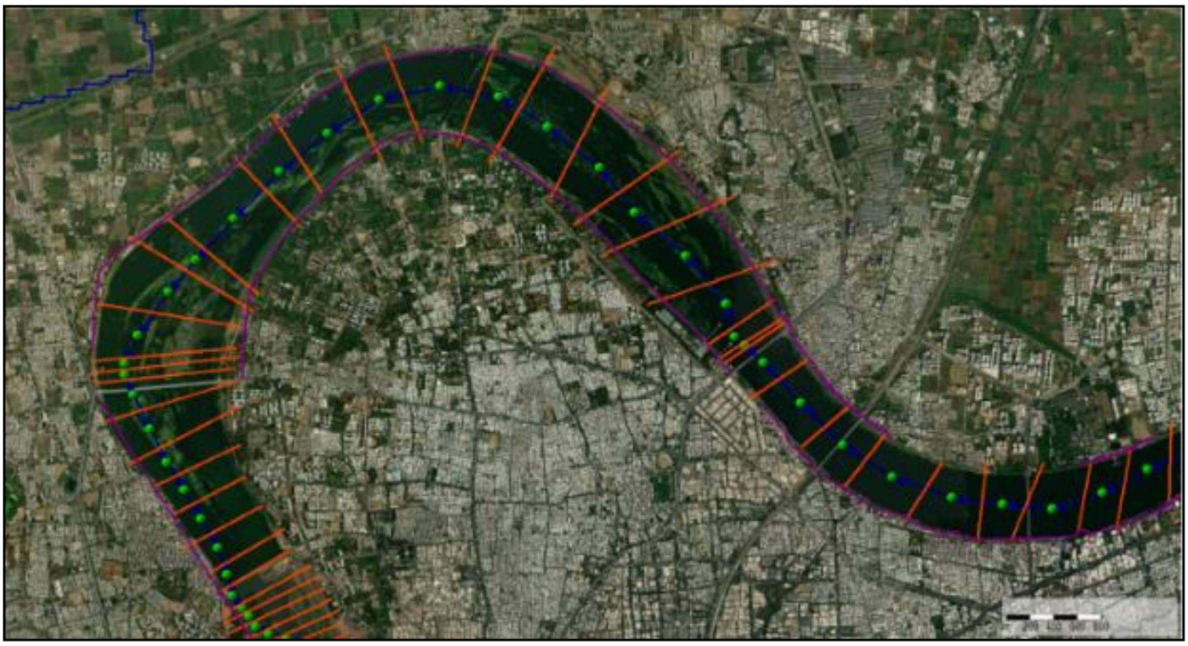


*Figure 7: Example of a 1D model with nodes (green dots), branches (blue lines) and cross-sections (red lines).*

***Gridded Data***

The surrounding land is represented as a 2D grid, incorporating elevation profiles and land use and land cover (LULC) data. Elevation data is critical for modeling flood routing, determining flood depth and extent, and quantifying flood loss. The terrain's elevation also guides the optimal placement of MFBs. While global data sources like COPDEM[15] or SRTM[16] can be used, high-resolution local elevation data provides the most accurate results.

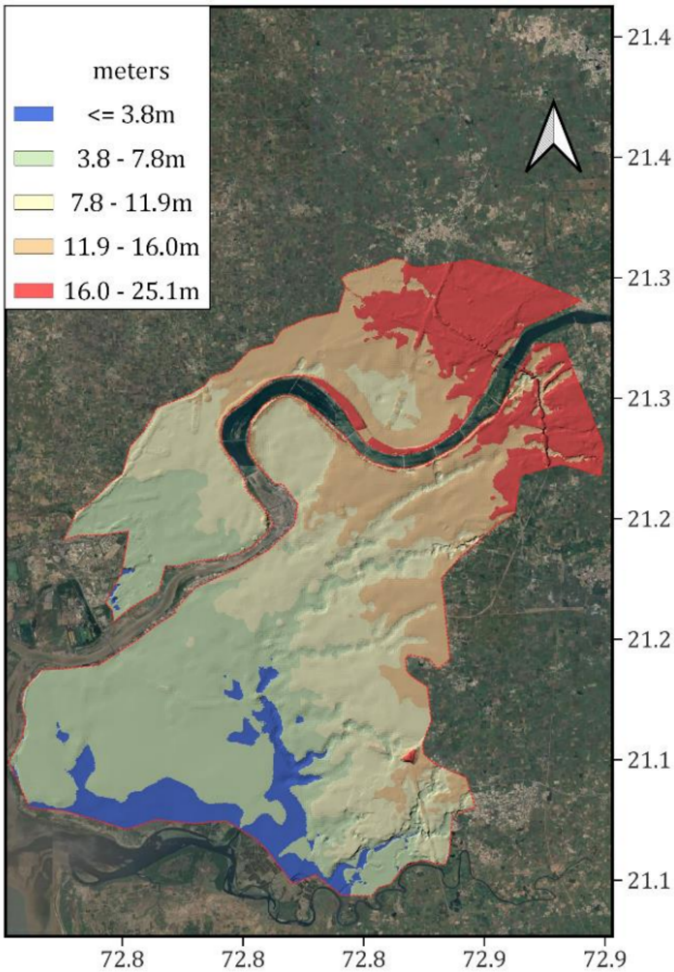



*Figure 8: Example of the use of elevation data for a Delft3D FM 1D2D model.*

LULC data is used to estimate infiltration capacity, potential evaporation, and surface roughness. Infiltration and evaporation affect surface water drainage, while surface roughness influences flood routing. LULC classes are assigned representative values for these parameters. High-resolution global LULC datasets, such as ESA WorldCover[17] and VITO[18], are available for use.

[15] Copernicus Digital Elevation Model - Copernicus Contributing Missions Online

[16] USGS EROS Archive - Digital Elevation - Shuttle Radar Topography Mission (SRTM) 1 Arc-Second Global | U.S. Geological Survey

[17] WorldCover | WORLDCOVER (esa-worldcover.org)

[18] Land Cover Viewer (vito.be)

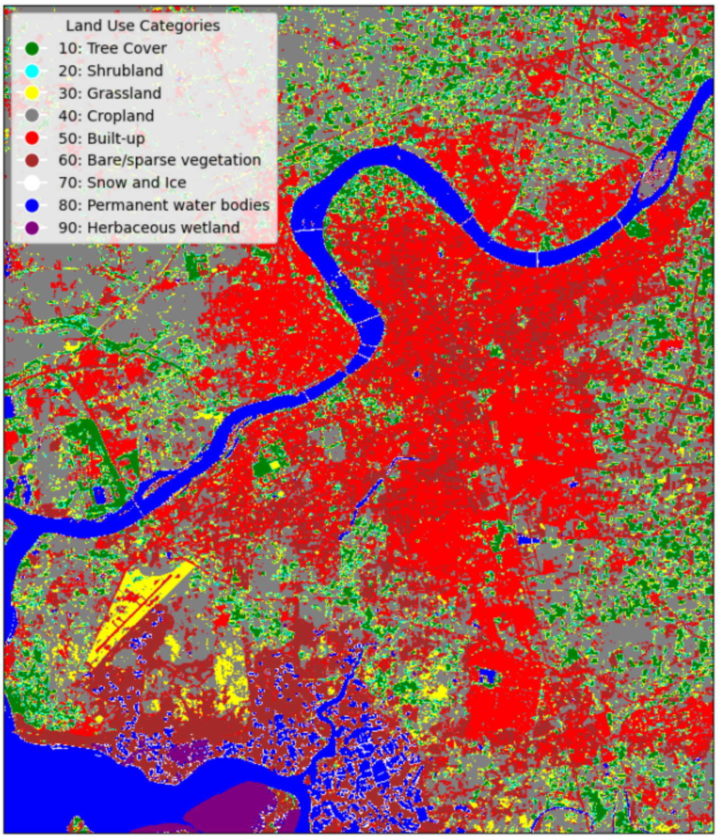



*Figure 9: Example of land-use-land-cover data from ESA Worldcover.*

### *Coupling Between the River and Land*

To simulate flood events, the river and land models must be coupled. The coupling method depends on the type of flooding and spatial scale. For this application, a 1D2D lateral coupling is used, where the 1D river model and 2D grid are connected without overlap. Flooding occurs when the river water level exceeds the elevation of the connected points in the 2D grid.

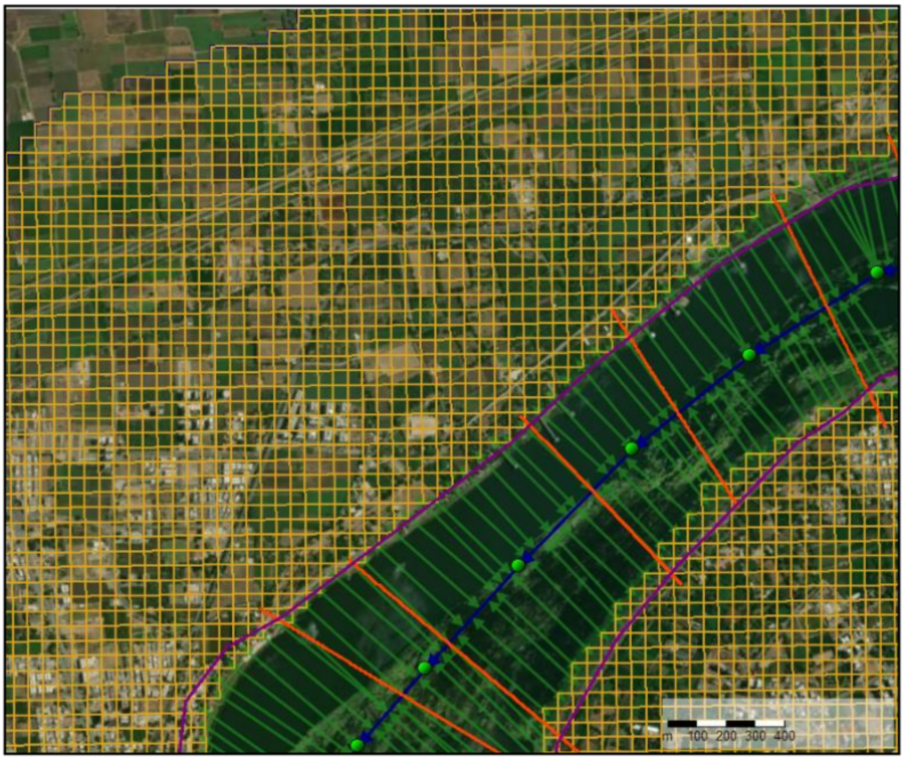



*Figure 10: Example of 1D2D coupling (green arrows) in Delft3D FM 1D2D.*

The extent of the river model can be removed from the grid, and the connection between the river and the grid can be improved by applying grid refinement along these reaches.

**Step 2: Baseline Assessment of Exposure, Flood Impact and Loss**

The impact of floods and the effectiveness of adaptation can be assessed using a flood loss model. These models calculate loss for the different hazard intensity for different probabilities (return period) following the equation:

$$D = \sum_{p=1}^{n} (H_p * E_p * V) \quad \text{(Eq. 9.6.2)}$$

In which;

$D$ = Total loss

$H_p$ = Hazard intensity at each return period with probability p

$E_p$ = Exposure (people, assets) at each return period with probability p

$V$ = Vulnerability defined by depth-damage curve of exposed assets

Flood impact assessment methodologies are essential for evaluating the potential consequences of flooding events, including economic loss and the number of people affected. These methodologies typically involve the integration of hazard, exposure, and vulnerability data to provide a comprehensive understanding of flood risks.

**Key Components of Flood Impact Assessment:**

1. **Hazard Data**: This encompasses the characteristics of the flood event, such as water depth, flow velocity, and flood extent. Accurate hazard data is crucial for understanding the severity and spatial distribution of flooding.
2. **Exposure Data**: Information regarding the people, properties, infrastructure, and economic activities that are susceptible to flooding. This includes data on population density, building types, land use, and critical facilities within the flood-prone area.
3. **Vulnerability Data**: Defines the susceptibility of the exposed elements to flood loss. This is often represented through depth-damage functions, which relate the depth of flooding to the expected degree of loss for various asset types.

**Calibration of Depth–Damage Curves in Developing Country Contexts**

Where locally derived depth–damage functions are not available, default functions may be applied with calibration or adjustment to reflect developing-country contexts. The reference depth–damage functions applied in this methodology are based on the JRC April 2017 curves. These provide standardized loss estimates for different asset categories (residential, infrastructure, agriculture) in developed-country contexts. For application in developing countries, these functions must be adjusted using the calibration procedure outlined above. Where possible, calibration should also integrate local post-disaster assessments, replacement cost data, or national disaster databases to improve accuracy. The following stepwise procedure applies:

1. **Data Collection**
   - Collect any available local flood damage data (post-disaster assessments, insurance claims, government reports).
   - Where data are absent, use global databases such as EM-DAT or DesInventar for comparable events.
2. **Socio-Economic Adjustment**
   - Adjust default European curves by applying ratios of GDP per capita, construction cost indices, or asset replacement values between the reference country (e.g., EU) and the host country (e.g., Burundi).
   - Example: If average replacement cost of residential buildings in Burundi is 25% of that in the EU, the JRC curve should be scaled accordingly.
3. **Sectoral Adjustment**

- Modify exposure categories (housing, infrastructure, agriculture) to match the local economy.
- For agriculture-dominated contexts, place greater weight on crop/land losses.

**4. Validation and Conservativeness**

- Compare adjusted curves against at least one observed flood event in the country or region.
- If validation is not possible, apply an additional uncertainty discount factor (δ = 20%) to ensure conservativeness.

**Implementation Example: Burundi**

If no national depth–damage curves exist for Burundi, the proponent may:

- Apply JRC 2017 residential building curves.
- Scale losses downward using Burundi's GDP/capita relative to the EU (approx. factor 0.1–0.2).
- Adjust agricultural losses upward to reflect the high dependence on farmland.
- Apply δ = 20% discount if no local validation data are available.

**Worked Equation Example**

In contexts where no local depth–damage curves exist, default JRC 2017 functions can be adjusted using socio-economic ratios:

$$Loss_{Burundi} = Loss_{JRC} \times \frac{GDP/capita_{Burundi}}{GDP/capita_{EU}} \quad \text{(Eq. 9.6.3)}$$

**Explanation**

- $Loss_{JRC}$ = Damage estimate from JRC 2017 depth–damage curve.
- $GDP / capita_{Burundi}$ = GDP per capita of Burundi (in USD, constant prices).
- $GDP / capita_{EU}$ = GDP per capita of reference EU country/region (same year, same currency).
- $Loss_{Burundi}$ = Adjusted damage estimate reflecting local economic conditions.

**Example application:**

If GDP/capita Burundi is ~10% of EU average, then losses estimated by the JRC curve are scaled downward by 0.1. Additional adjustments may be made for sectoral exposure (e.g., higher share of agriculture).

**Terrain and Flow-Velocity Calibration**

To ensure the methodology yields comparable results across different geographies, an additional calibration factor is introduced to account for **terrain slope and flow velocity**. This responds directly to AMP Comment 10.

- For flat terrain or slow-rising floods (e.g., ocean surge, lowland riverine flooding), depth–damage curves are applied directly without adjustment.
- For hilly or mountainous terrain with high-velocity runoff, losses are typically more severe due to kinetic energy and debris impact. In these cases, a multiplicative calibration factor $\varphi$ is applied.
- The factor $\varphi$ is derived from observed loss data where available, or otherwise from conservative default values the Table below.

$$f_s^{adj}(h,v) = min\left(1, f_s^{host}(h) \times \varphi(v)\right) \quad \text{(Eq. 9.6.4)}$$

Where:

- $f_s^{adj}$ = adjusted damage fraction for sector *s*
- $f_s^{host}(h)$ = locally calibrated depth–damage function (see previous section)
- *h* = water depth *(m)*
- *v* = flow velocity *(m/s)*
- $\varphi(v)$ = terrain/velocity multiplier

***Table 6:*** *Default terrain/velocity calibration factor (**φ**)*

| Flow velocity (m/s) | Terrain type | Default φ |
|---|---|---|
| < 1.5 | Flat / slow-rising | 1.0 |
| 1.5 – 3.0 | Moderate slope | 1.2 |
| ≥ 3.0 | Steep / mountainous | 1.3 |

**Implementation:**

- If the flood hazard model provides both depth and velocity outputs, apply the multiplier according to the Table above.
- If only depth is available, use terrain slope (from DEM) as a proxy for classifying into flat, moderate, or steep categories.
- Conservative defaults (higher multipliers) should be applied when data are uncertain.

**Clarification on the Use of Population Data**

Population data is applied in three distinct ways within this methodology:

1. **Exposure Assessment**

   Population datasets (e.g., census data, WorldPop, or national statistics) are overlaid with modeled flood extents to determine the number of people exposed to flood hazards in the baseline scenario.

2. **Adaptation Benefit Quantification**
   The indicator "People Protected (M/F)" is derived from the reduction in the exposed population due to deployment of Mobile Flood Barriers (MFBs). Calculated as follows:

$$AB_{pop,t} = \frac{P_{baseline,t} - P_{protected,t}}{10} \quad \text{(Eq. 9.6.5)}$$

Where
- $AB_{pop,t}$ = Adaptation Benefits from people protected in year $t$
- $P_{baseline,t}$ = people exposed to flooding in baseline (no MFB) in year $t$
- $P_{protected,t}$ = people exposed to flooding with MFB in year $t$
- 1 AB = 10 people protected

3. **SDG Linkages**
   Population-based metrics directly contribute to SDG 11.5.1 (reduction in deaths, missing persons, and directly affected persons per 100,000 population) and indirectly support SDG 3 (Good Health and Wellbeing) through improved protection against flood-related health risks.

**Implementation Notes:**
- Population data must be sourced from the most recent and reliable datasets available.
- Gender-disaggregated data (M/F) should be used where possible to align with ABM's gender-sensitive reporting requirements.
- All sources, assumptions, and adjustments must be documented in the PDD annex.

**Governance-Related Vulnerability Impacts**
In addition to socio-economic and physical vulnerability factors, governance-related issues can significantly influence the impacts of climate change and the effectiveness of MFBs. These include:

1. **Resource Constraints for Monitoring and Evaluation**
   - Many developing countries face financial and human resource limitations that hinder effective monitoring and evaluation (M&E) of adaptation projects, particularly in agriculture and water management.
   - Inadequate M&E can reduce the reliability of data used for calibrating loss estimates and tracking Adaptation Benefits.
2. **Operational Ineffectiveness**
   - Weak institutional coordination, limited technical capacity, and lack of clear responsibilities can delay or reduce the effectiveness of adaptation interventions.

- Operational gaps may result in late deployment of MFBs, inefficient maintenance, or limited integration into national and local disaster risk reduction (DRR) frameworks.

**Implementation Notes:**

- Governance-related vulnerabilities should be assessed alongside physical and socio-economic vulnerabilities.
- Where resource constraints or operational gaps exist, projects should include capacity-building measures, training, and institutional strengthening as part of the Adaptation Benefit framework.
- These governance vulnerabilities do not generate ABs themselves but must be documented in the PDD annex to ensure transparency and facilitate verification.

**Methodological Approach:**

The assessment process involves combining these data components to estimate potential impacts for different flood scenarios. By analyzing scenarios with varying probabilities (return periods), it is possible to calculate metrics such as Annual Expected Loss (AEL), which represent the average yearly economic loss due to flooding.

Several tools have been developed to facilitate this assessment process. For instance, the Delft-FIAT (Flood Impact Assessment Tool) by Deltares is designed to rapidly evaluate direct economic impacts of flooding on buildings, utilities, and roads using user-provided flood maps. It utilizes global data to establish flood impact models for specific areas and includes an Accelerator feature that automates the setup of these models worldwide.

The selection of appropriate tools and data sources should be tailored to the specific context and requirements of the assessment area. Integrating local hazard data with globally available exposure and vulnerability datasets can enhance the accuracy and relevance of the flood impact assessments.

Figure 9 illustrates a general overview of the loss calculation process within this framework.

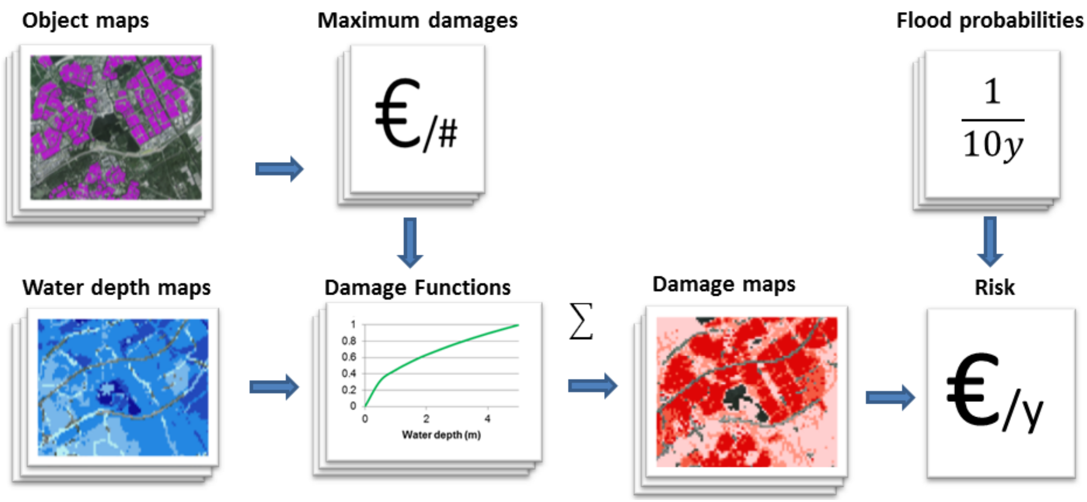



*Figure 11 Overview of loss and risk calculations in Delft-FIAT.*

A key metric in these assessments is the Annual Expected Loss (AEL), which represents the average yearly economic loss due to flooding. AEL calculations consider both frequent, low-impact events and rare, high-impact events by integrating loss estimates across various exceedance probabilities.

The Annual Expected Loss (AEL) can be calculated either using discrete return periods or as a continuous integral over all possible flood events. In the discrete approach, losses for selected return periods $T$ (e.g., 10, 25, 100 years) are multiplied by their annual exceedance probability $p(T) = 1/T$ and summed:

**1.** Select a set of return periods (e.g., 10, 25, 100 years) to represent frequent and rare events. Practitioners should select return periods to capture both frequent and rare floods. Example guidance:

***Table 7:*** *Event types and return periods*

| Event Type | Return Period (years) | Annual Exceedance Probability | Purpose |
|---|---|---|---|
| Frequent / low-impact | 10 | 0.10 | Capture small, recurring floods |
| Medium | 25 | 0.04 | Capture moderate floods impacting assets |
| Rare / high-impact | 50 | 0.02 | Capture extreme floods causing major damages |
| Extreme | 100 | 0.01 | Capture catastrophic flood events |

*Note: These return periods should be adapted to local hydrological conditions and verified during the local calibration step.*

2. For each return period (*T*), calculate flood depth and associated losses ($L(T)$) using hydrodynamic models and depth-damage functions.
3. Weight each return period by its exceedance probability ($p(T) = 1/T$), where (*T*) is the return period. This is how AEL is calculated:

$$AEL = \sum_{T} [L(T) \times p(T)] \quad \text{for all selected return periods} \qquad \text{(Eq. 9.6.6)}$$

4. Integrate the effects of climate change by updating (L(T)) based on projected shifts in flood frequency and intensity under future climate scenarios (RCPs).

The following formula represents the integration of the loss function ($D(P)$) across various exceedance probabilities:

$$AEL = \int_{0}^{\infty} D(P) * fP \, dP \qquad \text{(Eq. 9.6.7)}$$

In which;
*D(P)* = Loss at probability P
$fP$= Probability function of flood events

**Asset Valuation and Population Data Integration:**

- **Asset Valuation**: Estimating asset values often involves high-resolution population data. Global datasets, such as the Global Human Settlement (GHS)[19] framework, provide comprehensive population rasters that can be combined with local data to enhance accuracy.
- **Data Integration**: Combining population data with building footprints and infrastructure maps improves exposure assessments. A common method involves distributing the total population within a hazard extent evenly across raster cells containing buildings. This straightforward approach helps prevent discrepancies where cells might otherwise have buildings without population or vice versa.

**Enhancing Model Accuracy with Local Data:**

Incorporating locally collected data can refine flood risk assessments. Adjusting loss functions and reconstruction costs for residential structures to reflect local conditions improves the

[19] https://human-settlement.emergency.copernicus.eu/datasets.php

precision of economic analyses. This customization ensures that the model's outputs are more representative of the specific area's characteristics.

By integrating global datasets with local insights, flood risk assessment methodologies provide a comprehensive and adaptable approach, supporting informed decision-making in flood risk management.

**Contextual calibration for developing-country use**

When default depth–damage functions or unit-value proxies are sourced ex-situ, apply the following scaling before use:

$$L_{local}(d,a) = L_{ref}(d,a) * \lambda_{gdp,a} * \lambda_{mat,a} * \lambda_{service,a} \quad \text{(Eq. 9.6.8)}$$

**Where:**

- $L_{ref}(d,a)$ = reference loss at water depth d for asset class a
- $L_{local}(d,a)$ = calibrated local loss at depth d for asset class a
- $\lambda_{mat,a}$ $\lambda_{service,a}$ = dimensionless adjustment factors for materials/typology and repair/logistics
- $\beta_a$ = elasticity for asset class a (user-specified, documented)

Worked example (ADD Annex): show Burundi calibration from EU curves with chosen β and typology mapping; validate against one observed event (high-water marks / insurer reports). Requirement: document all factors and data sources; provide a before/after plot of the curve used.

**Step 3: Flood Reduction through MFBs**

To evaluate the effectiveness of the MFB, two scenarios are compared: the baseline scenario (without MFB) and the adaptation scenario (with MFB). Accurate modeling of the MFB's retention capacity is essential. In hydrodynamic modelling tools such as Delft3D, the MFB's water-retaining properties can be represented as a fixed weir, a non-movable construction typically used in numerical river simulations to model sudden depth changes.

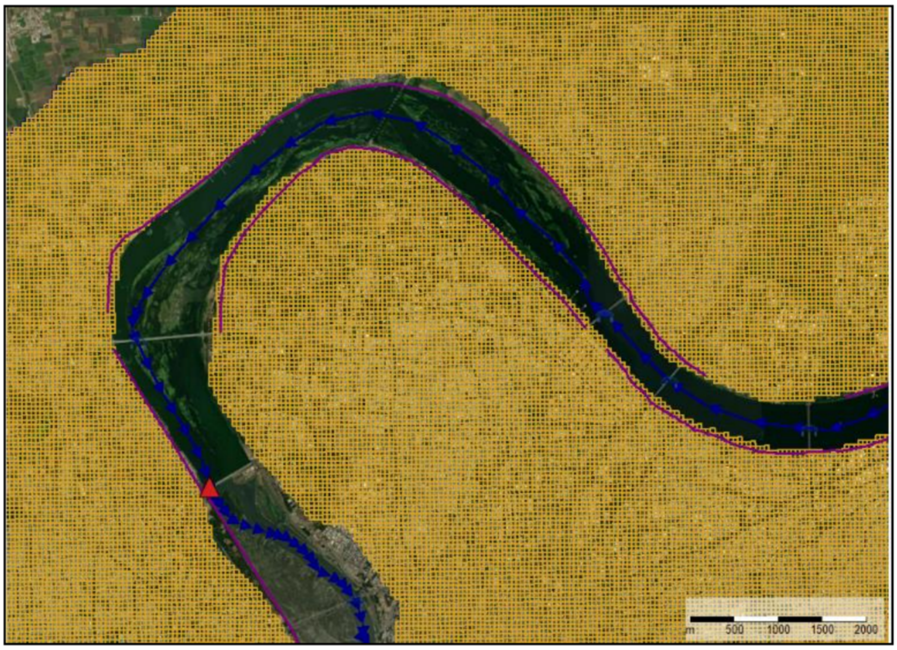



*Figure 12: Example of the fixed-weir (purple line) in a 1D2D model.*

A fixed weir can be added to the model via the GUI, with its $x$ and $y$ coordinates assigned. The crest height, a required variable, defines the overflow limit and is specified at the same points as the $x$ and $y$ coordinates. Between these points, crest height is linearly interpolated. The crest height is calculated by combining the elevation data used in the model with the height of the MFB.

Flow over the fixed weir is determined using weir equations, which depend on the water levels inside and outside the river and the height of the structure. The water level difference dictates the flow direction and determines whether to apply the free weir flow or drowned weir flow equation.

The drowned weir equation for flow from 1D to 2D:

$$q = C_e C_w (h_{2D} - z_s)\sqrt{2g(h_{1D} - h_{2D})} \quad \text{(Eq. 9.6.9)}$$

And the free-flowing weir equation for flow from 1D to 2D:

$$q = C_e C_w 2/3\sqrt{2g/3}(\mathrm{h}_{1D} - z_s)^{3/2} \quad \text{(Eq. 9.6.10)}$$

Where $C_e$ and $C_w$ and the effective discharge coefficient and weir coefficient respectively. These equations form the basis of how the MFB is implemented in the hydrodynamic model.

**Model forcing**

A hydrodynamic river model requires two primary boundary conditions: **1) discharge** at the upstream boundary and **2) water level** at the downstream boundary. In the hydrodynamic model, an additional boundary condition is set for the 2D grid, typically assigned a trivial value of 0 meters, with the grid boundary positioned far enough from the river to avoid interference.

**Model output**

The key output of the hydrodynamic model is hazard maps, showing maximum flood depth at each point in the 2D grid. Flow velocity maps can also be generated to analyze inundation dynamics, aiding in determining optimal deployment locations for the MFB.

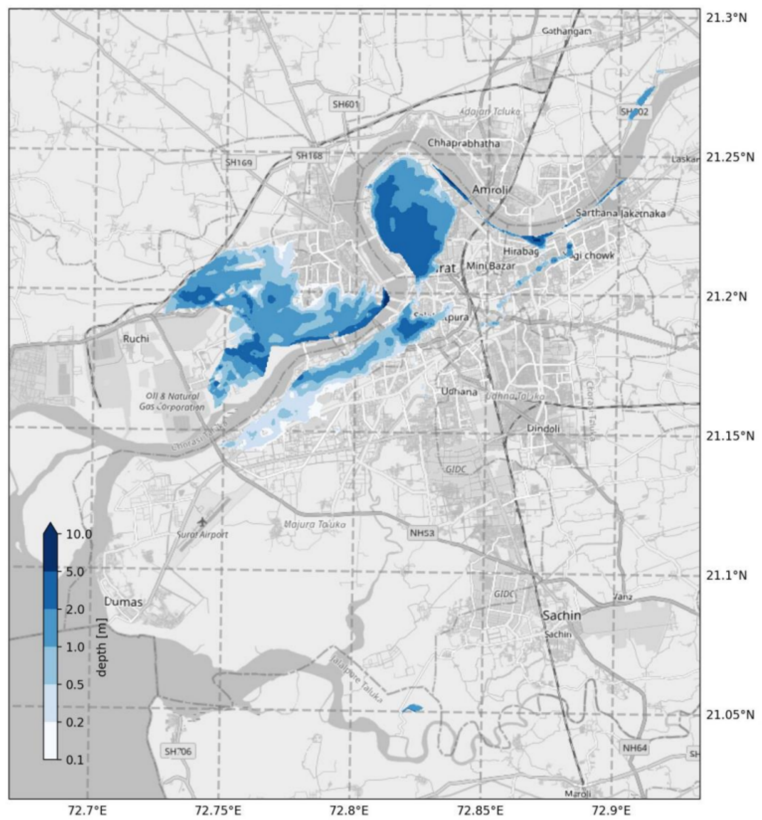



*Figure 13: Example of a hazard map showing the maximum flood depth for a specific event (T100 in this case).*

The 1D model outputs include water depth and discharge, essential for calibrating and validating the river model. These outputs also provide insights into where flooding originates and, combined with velocity maps, help identify the causes of flooding and guide effective mitigation strategies.

***Defining Flood Events***

Both baseline and adaptation scenarios are simulated for flood events with varying return periods. For fluvial flooding, peak discharge timeseries are used, while pluvial events rely on rainfall volume records. In the absence of accurate measurements, synthetic data from models can be utilized. A set of annual maxima (AM), representing the highest yearly recordings of rainfall or discharge, is compiled. Per the extreme value theorem (Fisher and Tippett, 1928; Gnedenko, 1943), these maxima follow a Generalized Extreme Value (GEV) distribution (see equation below), enabling accurate modeling of extreme events.

### 9.6.1 Choice of design return periods

To ensure the baseline captures both frequent and extreme flood events, the proponent shall select and justify at least four design return periods:

1. **Frequent event** (e.g., 10-year, 10% annual exceedance). Reflects routine flooding that tests barrier operability.
2. **Moderate event** (e.g., 25-year, 4% annual exceedance). Aligns with common “design flood” standards in many jurisdictions.
3. **Design event** (e.g., 50-year, 2% annual exceedance). Represents the upper bound of typical engineering safety factors.
4. **Extreme event** (e.g., 100-year, 1% annual exceedance or beyond). Captures tail risks critical for resilience.

The steps to determine and document these periods are:

- **Frequency analysis**. Use a continuous record of annual maximum discharges (≥ 30 years) to fit a statistical distribution (GEV or Log-Pearson III) (Fisher & Tippett 1928; Gnedenko 1943).
- **Selection rationale**. Reference national flood-design regulations, infrastructure-safety guidelines, or stakeholder risk-tolerance criteria when choosing each $T_i$.
- **Probability assignment**. Report each return period’s exceedance probability $P_i = 1/T_i$.
- **Documentation**. In the PDD annex, include: gauging-station IDs, record durations, fitted distribution parameters, goodness-of-fit statistics, and justification for any deviations from the four default periods.

In below equation, $X$ is the annual-maxima stochastic variable and $\mu$, $\sigma$, and $\xi$ are the location, scale and shape parameters of the GEV, respectively. The Gumbel distribution is the special case obtained when $\xi \to 0$, yielding

$$F_X(x) = \exp\left[-\left\{1+\xi\frac{x-\mu}{\sigma}\right\}^{-1/\xi}\right] \quad \text{(Eq. 9.6.11)}$$

Once the GEV parameters are fitted, the flood depth for any return period *T* (i.e.\ exceedance probability *p* = *1/T*) is obtained from the quantile (inverse-CDF) function:

$$x_T = \mu + (\sigma/\xi) * \left(\left(-ln(1-p)\right)^{(-\xi)} - 1\right) \quad \text{(Eq. 9.6.12)}$$

**Hydrodynamic Model 0-Value Justification**
In the hydrodynamic river model, a value of 0 is assigned to locations or cells where no inundation is expected under baseline conditions. This serves as a reference point for flood modeling and ensures that only areas susceptible to flooding contribute to the Annual Expected Loss (AEL) calculation. Assigning 0 prevents overestimation of losses in dry or unaffected areas.

**Step 4: Calculation Certified Adaptation Benefits (CABs)**
Implementing adaptation measures, such as flood barriers, reduces loss across various hazard intensities and return periods. This reduction occurs because the adaptation alters hazard intensity, exposure, and potentially the vulnerability functions. Consequently, loss can be reassessed using the following equation:

$$D = \sum_{p=1}^{n} (H_{pa} * E_{pa} * V_{a}) \quad \text{(Eq. 9.6.13)}$$

In which;
*D* = Total loss
$H_{pa}$ = Hazard intensity after adaptation at each return period with probability p
$E_{pa}$ = Exposure (people, assets) after adaptation at each return period with probability p
$V_a$ = Vulnerability defined by depth-damage curve of exposed assets after adaptation

The deployment of MFBs can significantly reduce loss across various return periods by altering hazard intensity, exposure, and vulnerability. The effectiveness of these measures is quantified by comparing baseline loss and damage during the adaptation scenario for different asset types and populations.

**Economic Feasibility Analysis:**
To assess the economic viability of such measures, a cost-benefit analysis is conducted. This involves comparing the investment costs with the discounted risk reduction benefits over the MFB's lifespan. Benefits are calculated based on the expected reduction in loss due to decreased hazard exposure and vulnerability. For instance, studies have shown that investing

in flood defenses can yield significant economic benefits, with benefit-to-cost ratios varying by region and scenario.

**Additional Performance Indicators:**
Beyond economic metrics, the success of adaptation measures can be evaluated through:

- **Reduction in Exposed Assets and Population**: Measuring the decrease in the number of assets and individuals at risk post-implementation.
- **Other Relevant Indicators**: Utilizing available data to assess improvements in safety, resilience, and social well-being within the protected area.

Comprehensive data collection and analysis are essential to accurately evaluate these indicators and inform decision-making in flood risk management.

**Certified Adaptation Benefits**
The effectiveness of adaptation measures, such as mobile flood barriers (MFB), can be quantified by analyzing reductions in:

- **Number of affected individuals**
- **Flooded areas** (measured in square meters or hectares)
- **Impacted critical assets** (e.g., schools, hospitals, power stations)
- **Overall risk levels**

These benefits are formally recognized as Certified Adaptation Benefits (CABs) to provide results-based finance.
**For this methodology:**

- **1 CAB =** USD 1,000 in avoided flood loss, calculated using flood modeling and depth–loss functions (see §5)

Equivalent reference points may include:

- ≈ 1 hectare of (crop)land protected from flooding, or
- ≈ 10 people with increased flood resilience.

**Example Scenario:**
Consider an urban area reliant on agriculture, where floods adversely affect both the community and its economic activities. Table 2 below shows flood loss to different types of assets and for different return periods during the baseline situation, i.e., no MFBs installed. Table 3 below shows flood loss for different types of assets and for different return periods during the adaptation situation, i.e., with MFBs installed.

When a hazard situation would occur with a return period of 10 years in which in the baseline situation that impact would be 22 ha of agricultural land flooded, land, 85 houses and 440 people. In the adaptation situation these would all be reduced to 2 ha of agricultural land flooded, land, 16 houses and 42 people. When CAB would be defined as:

***Table 8**: Affected assets from flooding per return period in years **before** implementation of MFB*

| Return Period (Y) | Agricultural Land (ha) | Houses (no.) | People (No.) |
|---|---|---|---|
| 2 | 4 | 30 | 120 |
| 5 | 9 | 55 | 220 |
| 10 | 22 | 85 | 440 |
| 20 | 40 | 180 | 650 |
| 50 | 76 | 250 | 880 |
| 100 | 120 | 380 | 1410 |

***Table 9**: Affected assets from flooding per return period in years **after** implementation of MFB*

| Return Period (Y) | Agricultural Land (ha) | Houses (no.) | People (No.) |
|---|---|---|---|
| 2 | 0 | 0 | 0 |
| 5 | 0 | 0 | 0 |
| 10 | 2 | 16 | 42 |
| 20 | 12 | 44 | 186 |
| 50 | 24 | 78 | 314 |
| 100 | 110 | 320 | 1120 |

The costs per CAB can be calculated once the lifespan of the MFB is known as well as the total project costs. If the lifespan of a MFB is 10 years and the total project costs are USD 200,000, the costs per CAB are:

- 1 CAB = USD 10,000
- 1 CAB = 1 hectare of agricultural land safeguarded
- 1 CAB = USD 200,000 / 20 (Ha protected land during lifespan)

Use the same return-period set in the ADD as in this methodology. Deviations must be justified (e.g., local regulation uses T=20,50,200). Provide a reconciliation table in the ADD.

### 9.6.2 Conservative scenario rule

To comply with ABM conservativeness, the conservative Adaptation Benefit for issuance in year *t* shall be:

$$\Delta AEL_{cons,t} = \min_{i \in \{T_{10}, T_{25}, T_{50}, T_{100}\}, \in S} \left( AEL_{baseline,i,s,t} - AEL_{withMFB,i,s,t} \right) \quad \text{(Eq. 9.6.14)}$$

Where:

- $t$ = year of issuance
- $i$ = selected return period (from $T$)
- $s$ = scenario (from S; e.g., baseline, 2030 SSP2-4.5)
- $AEL_{baseline,i,s,t}$ = expected annual loss under the baseline
- $AEL_{withMFB,i,s,t}$ = expected annual loss with the MFB
- $\Delta AEL_{cons,t}$ = conservative adaptation benefit used for issuance

### 9.6.3 Calibration of depth–damage functions for local contexts

To ensure the depth–damage curves (e.g. HIS-SSM, SSM2015) reflect local building and asset values, the proponent shall apply the following calibration procedure:

1. **Reference function selection.** Identify the reference depth–damage function set (D_ref(d)) used in the methodology (e.g., JRC April 2017 functions) (Huizinga et al. 2017).
2. **Local unit cost determination.** Gather local replacement-cost indices (U_local) for each asset class from national statistical offices, construction cost surveys, or insurance data.
3. **Reference unit cost retrieval.** Obtain the original unit cost basis (U_ref) underlying the reference curves (e.g., average Netherlands residential cost).
4. **Normalization coefficient.** Compute a scaling factor α for each asset class:

$$\alpha = U_{local} \div U_{ref} \qquad \text{(Eq. 9.6.15)}$$

5. **Curve adjustment.** Derive the locally adjusted damage curve:

$$D_{local(d)} = D_{ref(d)} \times \alpha^{\beta} \qquad \text{(Eq. 9.6.16)}$$

*where β = 1.0 (elasticity) by default; users may set β based on local vulnerability studies if available.*

6. **Ex-post validation.** After a flood event, compare modeled losses using D_local(d) against observed damages (from surveys, claims or post-event reports). If bias exceeds ±10%, iteratively adjust α or β and rerun the model.
7. **Reporting.** Document U_local, U_ref, α, β, validation data and any iterative adjustments in the MRV report.

## 9.7 Baseline scenario selection procedure

To ensure transparency and reproducibility in defining the counterfactual (no-project) case, the proponent shall follow these steps:

1. **Identify relevant flood drivers.**

- Compile long-term records of rainfall, river discharge, tide and surge (as applicable) from national hydro-meteorological services or highest-quality local gauges.
- Select the design return-period(s) that reflect both frequent (e.g., 10-year) and rare (e.g., 100-year) events.

2. **Define land-use and exposure conditions.**
   - Use the most recent pre-project land-cover map (satellite imagery or cadastral data) to fix exposure (buildings, infrastructure, population).
   - Do not assume any natural or engineered flood-risk reduction measures beyond those in place at the project start date.

3. **Set climate-change adjustment.**
   - For crediting periods > 5 years, shift baseline return periods using regionally downscaled climate projections (e.g., RCP4.5, RCP8.5) per IPCC AR6 methods (IPCC AR6, 2021).
   - Document the chosen scenario and source (e.g., CORDEX, local climate service) (WCRP/CORDEX 2015).

4. **Hydraulic–hydrologic model configuration.**
   - Configure your 1D/2D flood model (e.g., HEC-RAS, TUFLOW) to simulate baseline inundation depths and extents under these driver and land-use settings.
   - Keep all parameters (roughness, boundary conditions, breach criteria) identical to those in the adaptation scenario.

5. **Justify selection.**
   - Provide a one-page narrative that:
     - Explains why the chosen return-period(s) and climate scenario(s) are representative of local risk.
     - Cites data sources and metadata (gauging station IDs, satellite imagery dates).
     - References any national design standards or guidelines used.

6. **Document and archive.**
   - Include model input files, GIS layers, version-controlled scripts and raw data in the Project Design Document's annex.
   - Reference these in table 10.2 (MRV) under "Baseline scenario documentation.

## 9.8 Adaptation Benefit period

### AB (crediting) period

Select a fixed period of up to **10 years** (≤ the technical lifespan of the MFBs). A shorter crediting period (e.g., 4–5 years) may be chosen to match loan-repayment schedules, provided it still enables reliable verification of benefits.

**Mandatory monitoring frequency**

Monitor at least once per year during the season(s) in which flooding occurs and the MFBs are deployed.

- In addition, record event-specific data whenever barriers are installed for a flood-event.
- Independent verification is required mid-term (Year 2–3) and at the end of the AB period.

**Optional post-credit monitoring**

After the AB period ends, developers may continue monitoring on a voluntary basis to document long-term impacts; such data, though not creditable, can inform future methodology improvements.

**Data-retention requirement**

All raw monitoring data and supporting documents shall be retained for at least two years after the final CABs have been claimed to enable ex-post audit if requested by the ABM Executive Board.

All ex-post adjustments (AF, ΔEAD(updated)) must be transparently reported in the ADD with parameter values, data sources, and justification for each adjustment, ensuring replicability across developing-country contexts.

### 9.9 Model validation using a control area (ex-post calibration)

To ensure the credibility of loss estimates, the proponent shall implement an ex-post validation procedure using a control area that has not been protected by MFBs but is hydrologically and morphologically comparable to the project area. The steps are as follows:

1. **Control area selection.** Identify one or more control areas on the same watershed, exhibiting similar terrain slope, land-use/land-cover, and flood frequency characteristics, but without MFB deployment.
2. **Data collection.** Following a flood event, record observed water depths, inundation extents, and damages in both the project and control areas using gauging-station records, flood marks, or community reports.
3. **Model execution.** Run the baseline loss model (per §§ 9.3 b–d) for both areas using identical input data and parameters.
4. **Adjustment factor calculation.** Compute an adjustment factor (AF) for the control area as:

$$AF = \frac{Observed\ Loss_{\{control\}}}{Modeled\ Loss_{\{control\}}} \quad \text{(Eq. 9.9.1)}$$

5. **Application to project area.** Adjust the project-area model output:

$$Adjusted\ Loss_{\{project\}} = Modeled\ Loss_{\{project\}}\ X\ AF \quad \text{(Eq. 9.9.2)}$$

6. **Reporting.** Document the control-area selection criteria, data sources, AF calculation, and resulting adjusted damage estimates in the MRV report.

This validation exercise shall be conducted at least once during the crediting period immediately following the first MFB deployment for a flood event.

### 9.10 Quantification of Adaptation Benefits

Below decision tree applies across all key steps of the methodology, including baseline definition, hazard and vulnerability modelling, loss calculation, AB quantification, and MRV, ensuring transparency and internal consistency in line with ABM Guidelines (D1, D4).

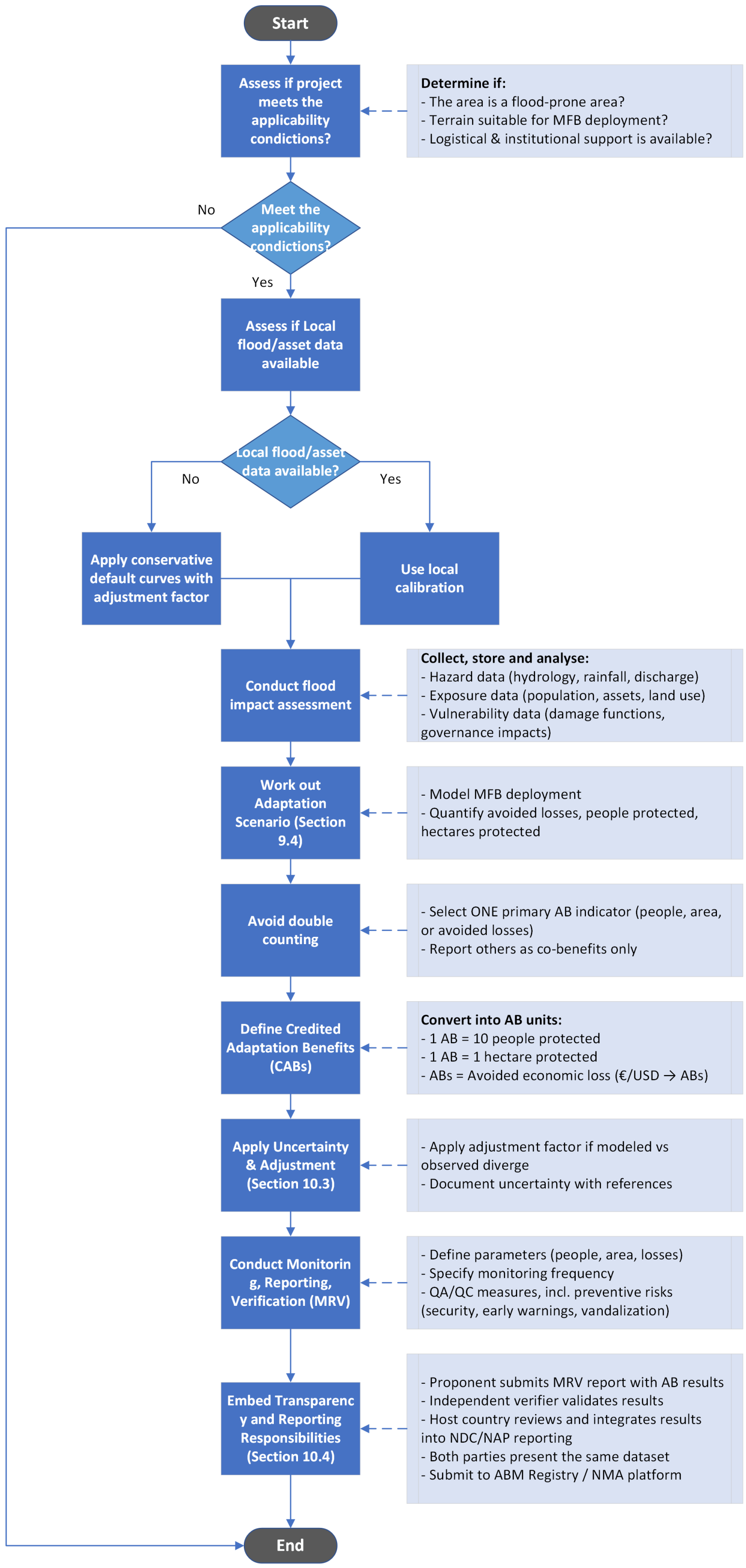



*Figure 14: Methodology Workflow Decision Tree*

### 9.10.1 Integration of flood frequencies and exceedance probabilities

To ensure that Annual Expected Loss (AEL) and Credited Adaptation Benefits (CABs) fully reflect both frequent, low-impact and rare, high-impact events, apply the following:

1. **Discrete summation form.**

$$AEL = sum_{(i=1)}^{n} P_i * L(d_i) \quad \text{(Eq. 9.10.1)}$$

where:
$d_i$ = flood depth (or hazard intensity) at return period $T_i$
$P_i = 1/T_i$ = exceedance probability of that event
$L(d_i)$ = modeled loss at depth $d_i$ (economic only)

**Note:** When DALYs are the primary metric, the same summation structure applies with $L(di)$ replaced by $D(di)$, the DALYs attributable to event $i$ at depth $di$; see §9.3(d).

2. **Continuous GEV form.**
   The Extreme Value Theorem (EVT) underpins the use of Generalized Extreme Value (GEV) distributions to model annual maximum flood discharges. EVT guarantees that maxima of independent, identically distributed variables converge to a GEV distribution, allowing accurate estimation of extreme flood magnitudes. This is essential for capturing rare, high-impact events in AEL calculations.

   Fit a Generalized Extreme Value (GEV) distribution to the annual maxima series (per § 9.3 b, using Fisher & Tippett, 1928; Gnedenko, 1943). Then:

$$AEL = int_0^1 L\big(Q(p)\big)dp \quad \text{(Eq. 9.10.2)}$$

   where $Q(p)$ is the flood quantile at exceedance probability $p$.

3. **Zero-loss threshold.**
   Depth–damage functions assign $L(d) = 0$ for $d < d_{min}$ (e.g., no inundation), which explains the “trivial value of 0” boundary in the hydrodynamic model’s grid setup (see p 37, step 3 in the hydrodynamic model).

4. **Disability-Adjusted Life Years (DALYs).**
   DALYs may be used either (a) as co-benefits for MRV/SDG reporting when another CAB metric is primary, or (b) as the primary CAB metric when selected in §7.1. Use recognised disability weights (GBD/WHO), a standard life table for YLL, with no age-weighting and no time discounting.

$$DALY(t) = YLL(t) + YLD(t) \quad \text{(Eq. 9.10.3)}$$

$$YLL(t) = deaths(t) \cdot L_{standard(age)} \quad \text{(Eq. 9.10.4)}$$

$$\mathrm{YLD(t)} = \Sigma_{\mathrm{k}}\left(\mathrm{cases}_{\mathrm{k(t)}} \cdot \mathrm{DW}_{\mathrm{k}} \cdot \mathrm{duration}_{\mathrm{k}}\right) \quad \text{(Eq. 9.10.5)}$$

To obtain expected DALYs saved across flood events, integrate over exceedance probabilities:

$$\Delta\mathrm{DALY}_{\mathrm{t}} = \Sigma_{\mathrm{j}}\mathrm{p}_{\mathrm{j}} \cdot \left(\mathrm{DALY}_{\mathrm{base(t,j)}} - \mathrm{DALY}_{\mathrm{with\ MFB(t,j)}}\right) \quad \text{(Eq. 9.10.6)}$$

If DALY is primary, convert to CABs per §9.3(d). (Optionally include the conversion explicitly:

$CAB_{DALY(t)} = \Delta DALY_t / DALY_{perCAB}\ with\ DALY_{perCAB}$ = 1. Apply the same conservative issuance logic and §10.3 uncertainty discounts as for other metrics.

where *D(di)* is the DALYs lost per event at depth *di*. DALYs can be integrated over the exceedance probability distribution in the same way as economic losses, producing an expected annual DALY impact.

When DALY is selected as the primary CAB metric (see §7.1 and §9.3(d)), the expected DALYs avoided are converted to CABs. When another CAB metric is primary, DALYs are still reported in the MRV tables as a complementary health indicator for SDG reporting.

By making this integration explicit, the methodology clarifies how different return-period scenarios feed into both economic and health-based CAB calculations and ensures transparent statistical foundations for all four CAB types.

# 10. Monitoring Methodology

## 10.1 Description of the Monitoring, Reporting and Verification Procedure

Parameters subject to modification include hazard (depth, extent, duration), exposure (asset footprints, population data), and vulnerability (locally validated depth–damage functions). These adjustments ensure that ex-post CAB calculations reflect observed realities while maintaining consistency across projects.

To ensure the effectiveness and accountability of MFBs under the ABM, a comprehensive Monitoring, Reporting, and Verification (MRV) procedure is essential (AfDB ABM Guidebook, Feb 2025). This methodology outlines the processes for monitoring outputs and outcomes, leading to the determination of ABs.

**1. Monitoring Indicators**

Key indicators to assess the performance and impact of MFBs include:

- **Flood Events Prevented**: Number of flood incidents successfully mitigated by MFB deployment.
- **Area Protected**: Total land area shielded from flooding due to MFB implementation.
- **Population Safeguarded**: Number of individuals benefiting from reduced flood risk.
- **Economic Losses Averted**: Estimated value of assets and infrastructure preserved from flood loss.

**2. Data Collection Methods**

Accurate data collection is vital for effective monitoring:

- **Field Surveys**: Conduct assessments before and after flood events to evaluate MFB performance and document any flood occurrences.
- **Remote Sensing**: Utilize satellite imagery and aerial photography to monitor changes in flood extents and validate the effectiveness of MFBs.
- **Community Reporting**: Engage local communities to report flood incidents and the perceived effectiveness of MFBs, ensuring ground-level insights.

**3. Reporting Protocols**

Structured reporting ensures transparency and facilitates verification:

- **Regular Updates**: Prepare and submit detailed reports on MFB performance, including data on the aforementioned indicators, at specified intervals (e.g., quarterly or biannually).
- **Incident Documentation**: In the event of a flood, document the circumstances, MFB deployment details, and outcomes to assess effectiveness.

**4. Verification Procedures**

Independent verification upholds the integrity of reported data:

- **Third-Party Audits**: Engage accredited independent entities to review monitoring data and validate reported ABs, ensuring objectivity.
- **Community Feedback**: Incorporate testimonials and feedback from local populations to corroborate quantitative data, providing a holistic view of MFB impact.

**5. Adaptive Management**

Continuous improvement is facilitated through adaptive management:

- **Data Analysis**: Regularly analyze collected data to identify trends, successes, and areas needing improvement in MFB deployment and performance.
- **Methodology Refinement**: Update monitoring methods and indicators based on lessons learned and evolving best practices to enhance accuracy and relevance.

Parameters subject to modification include hazard (depth, extent, duration), exposure (asset footprints, population data), and vulnerability (locally validated depth–damage functions). These adjustments ensure that ex-post CAB calculations reflect observed realities while maintaining consistency across projects.

By implementing this MRV procedure, stakeholders can ensure that MFBs deliver measurable ABs, with transparent reporting and verification ensuring trust continuous improvement.

## 10.2 Data and parameters monitored

For each monitored parameter, the methodology specifies data sources, measurement procedures, frequency, and QA/QC requirements. These are mandatory and must be documented in the Annex Data Document (ADD) for each project.

**Mapping of monitored and non-monitored parameters**

To clarify MRV scope, parameters are classified as follows:

***Table 10:*** *Mapping of monitored and non-monitored parameters*

| Parameter Category | Parameter Name | Monitored? | Rationale for inclusion/exclusion |
|---|---|---|---|
| **Core AB metrics** | Avoided economic losses | Yes | Direct CAB driver; quantified via ΔAEL model. |
| | Area protected | Yes | Optional/primary CAB; derived from GIS-based inundation extents. |
| | People protected (M/F) | Yes | Optional/primary CAB; intersect flood footprint with population maps/surveys. |
| | DALYs avoided | Yes | Optional/primary CAB; computed from monitored mortality/morbidity and durations (see §9.10). |
| **Qualitative co-benefits** | Environmental protection | No | Qualitative; tracked via case studies and stakeholder reports. |
| | Economic stability | No | Indirect; reflected in cash-flow improvements but not directly quantified. |
| | Social cohesion | No | Qualitative; captured through community engagement and survey metrics. |
| | Capacity building | No | Qualitative; documented via training logs and workshop attendance records. |

*Note: Non-monitored parameters are still recognized for high-level reporting but do not feed into CAB issuance calculations.*

***Data / Parameter tables.***

| | |
|---|---|
| *Data / Parameter:* | **Avoided economic losses** |
| *Data unit:* | USD |
| *Description:* | Monetary value of loss averted when MFBs are deployed **(primary CAB)**. |
| *Source of data:* | Post-event field reports, insurance or government loss data, hydrodynamic depth–damage model outputs. |
| *Measurement procedures (if any):* | Calculate ΔEAD using approved depth–damage curves; verify with post-event field loss survey. |
| *Monitoring frequency:* | Annual summary and after each flood event in which barriers are deployed. |
| *QA/QC procedures:* | Third-party verifier cross-checks model inputs, sampling of loss reports. |
| *SDG linkage* | SDG 11.5.2 (Direct economic loss as % of regional GDP) |
| *Any comment:* | ≥ 2 years after final CAB issuance. |

| | |
|---|---|
| *Data / Parameter:* | **Area protected** |
| *Data unit:* | ha |
| *Description:* | Net footprint of land / assets remaining flood-free. (Optional CAB if chosen by developer.). |
| *Source of data:* | Flood-extent rasters overlaid on GIS land-use & asset layers. |
| *Measurement procedures (if any):* | GIS analysis following ISO 19 115 workflow; independent replication by verifier. |
| *Monitoring frequency:* | Annual and per event. |
| *QA/QC procedures:* | Independent GIS audit; checksum of raster grid statistics. |
| *SDG linkage* | SDG 2.4.1 (Hectares of agri land protected (%)) |
| *Any comment:* | ≥ 2 years after final CAB issuance. |

| | |
|---|---|
| *Data / Parameter:* | **People protected[1] (M / F)** |
| *Data unit:* | Number of individuals |
| *Description:* | Individuals shielded from inundation; recorded male / female. (**Optional CAB**.). |
| *Source of data:* | Household census, local DRM lists, flood-extent overlay. |
| *Measurement procedures (if any):* | Intersect protected footprint with household points; gender from census or survey. |
| *Monitoring frequency:* | Annual and per event. |
| *QA/QC procedures:* | 5% random survey to confirm household location & gender data. |

| | |
|---|---|
| *SDG linkage* | SDG 1.5.3 (Disaster-affected persons per 100,000 pop.), and SDG 13.1.1 (Municipalities with DRR plans including MFBs) |
| *Any comment:* | ≥ 2 years after final CAB issuance. |

*1. Counting rule: A person or asset is deemed "protected" when (i) a flood alert is issued, (ii) the barrier is fully deployed at the location before overtopping, and (iii) no inundation is recorded on the protected side*

| | |
|---|---|
| *Data / Parameter:* | **DALYs avoided** |
| *Data unit:* | DALY |
| *Description:* | Health impact avoided due to MFB deployment, computed as DALY = YLL + YLD with standard life table and recognised disability weights. (Primary CAB if chosen; otherwise co-benefit.) |
| *Source of data:* | Death registers; hospital admissions/injury surveillance; post-event health surveys; disaster reports; literature-based casualty/injury functions when local data are lacking. |
| *Measurement procedures (if any):* | Calculate YLL = deaths · $L_{standard(age)}$; calculate YLD = $\Sigma_k$ ($cases_k$ · $DW_k$ · $duration_k$); integrate over event probabilities to obtain $\Delta DALY_t$. If DALY is primary, convert to CABs per §9.3(d). |
| *Monitoring frequency:* | After each flood event with barrier deployment; annual summary. |
| *QA/QC procedures:* | Cross-check with Ministry of Health statistics and facility registers; consistency check with control-area ex-post validation (§9.9); independent verifier replication of calculations. |
| *SDG linkage* | SDG 1.5.1 / 11.5.1 (disaster-related deaths & affected persons). |
| *Any comment:* | If only literature rates are available, apply higher uncertainty discount per §10.3. |

**Ex-post recalculation rule (after any flood within the crediting period):**
Compute **AF** in the control area per Eq. 9.9.1; 2) Adjust project-area model outputs per Eq. 9.9.2; 3) Recompute

$$\Delta AEL_{updated,t} = AEL^{adj}_{baseline,t} - AEL^{adj}_{withMFB,t} \qquad \text{(Eq. 10.2.1)}$$

For issuance related to year *t*, the credited value is min ($\Delta AEL_{cons,t}, \Delta AEL_{updated,t}$).
Timeline: Publish the updated calculation and backing data within 30 calendar days of data availability; include GIS rasters, observed stage/discharge, and loss audit trail.

**Expected levels of uncertainty**
This section quantifies the expected levels of uncertainty for each Adaptation Benefit (AB) parameter. Uncertainty arises from measurement errors, variability in hydrological conditions, modeling assumptions, and data quality. To comply with the ABM Guidebook, each uncertainty estimate is supported by references to relevant data sources, literature, or previous applications.

**Key points:**

1. **Sources of uncertainty**
    - Measurement errors (e.g., hydrological stations, population counts)
    - Model assumptions (e.g., hydrodynamic model parameters, GEV fit for extreme floods)
    - Data completeness and quality (e.g., local flood records vs global datasets)
2. **Supporting evidence**
   Each uncertainty estimate is linked to credible sources, including:
    - Depth-damage curves or empirical data (e.g., JRC 2017)
    - Local calibration and pilot studies (e.g., SlamDam pilot in Burundi 2022)
    - National or regional datasets (e.g., censuses, GIS flood mapping, WorldPop 2020)
    - Health metrics (e.g., WHO Global Burden of Disease 2019 for DALYs)
3. **Parameter-wise table**

***Table 11:*** *Parameter-wise table*

| AB Parameter | Expected Level of Uncertainty | Evidence / Reference |
|---|---|---|
| Avoided Economic Loss | ±15% | Depth-damage curves [JRC, 2017]; local calibration 3.2a; SlamDam pilot Nigeria 2022 |
| Area Protected (ha) | ±5% | GIS flood mapping [Burundi National Flood Survey, 2021]; hydrodynamic model validation 9.3 |
| People Protected (M/F) | ±10% | Population data [WorldPop 2020]; exposure analysis [Local census, 2019] |
| Disability-Adjusted Life Years (DALYs) | ±20% | WHO Global Burden of Disease, 2019; local health data if available |
| CAB Calculations | ±15% | Combined uncertainties from AEL, depth-damage functions, and calibration studies |

**4. Implementation Notes**

- The uncertainty levels should be applied consistently across all AB calculations.
- Each AB parameter's source of uncertainty must be documented in the ADD annex, including data references and justification for the estimated uncertainty.
- If local data are incomplete, the methodology requires conservative assumptions to avoid overestimation of ABs.

While co-benefits do not generate CABs, they are systematically tracked using measurable indicators. Environmental protection is assessed through documented cases of contamination avoided and biodiversity safeguarded (via ESIA or water quality reports). Economic stability is reflected in quantified downtime avoided and continuity of local business operations (via enterprise surveys and municipal reports). Social cohesion is measured through the number and quality of stakeholder engagement events and community surveys. Capacity building is measured by the number of local responders trained and certified in MFB deployment. All co-benefit data must be documented in the Annex Data Document (ADD) and aligned with relevant SDG indicators and national adaptation reporting requirements.

## 10.3 Discounting for residual uncertainty

When confidence intervals are provided, use the lower 90% CI bound of *ΔAEL* for issuance; where CIs are unavailable, apply the default uncertainty discounts in this section.

Confidence intervals are the preferred method of expressing uncertainty. Where confidence intervals cannot be derived, conservative uncertainty discount factors (δ) are applied as specified below, ensuring all CAB estimates remain conservative and consistent with ABM guidelines.

**Procedure for Considering Uncertainty**

The following steps must be applied consistently when quantifying Adaptation Benefits:

1. **Identify** each parameter contributing to CABs (avoided losses, area protected, people protected, DALYs).
2. **Quantify** parameter-level uncertainty using either confidence intervals (preferred) or discount factors (δ).
3. **Classify** uncertainty level (low, moderate, high) according to the criteria in Table 10.3.
4. **Apply** the corresponding δ to annual CAB estimates.
5. **Report** chosen δ, justification, and pre-/post-discount values in the MRV tables.

**DALY examples**: When DALYs are used as the primary CAB metric, apply a conservative discount if confidence intervals cannot be established. Use 5% if event-specific mortality/morbidity data and control-area validation are available; 10% if national statistics and recognised disability weights (DW) are used with partial validation; 20% if only literature-based casualty/injury rates are available without local validation.

To ensure conservativeness when confidence intervals are not specified, the proponent shall apply an uncertainty discount factor (δ) to annual CAB estimates according to the following classification of model/parameter uncertainty:

1. **Low uncertainty (δ = 5%)**: When historical data are plentiful (≥ 30 years), depth–damage functions have been locally calibrated (per § 9.3 c ii), and ex-post validation (per § 9.3 e) shows AF within ±5 %.
2. **Moderate uncertainty (δ = 10%)**: When one or more of the above conditions are only partially met (e.g., 15–29 years of hydrological records or AF within ±10 %).
3. **High uncertainty (δ = 20%)**. When data are sparse (< 15 years), calibration β was applied without ex-post validation, or AF exceeds ±10 % but is corrected via iterative adjustment.

The discounted CAB for year t is then:

$$CAB_t^{disc} = CAB_t \times (1 - \delta) \qquad \text{(Eq. 10.3.1)}$$

**Reporting:** In the MRV report (Table 10.2), state the chosen δ, justification (data/validation quality), and show pre- and post-discount CAB tallies.

**Metric Consistency Requirement**
The selected primary AB metric (avoided losses, area protected, or people protected) must remain consistent throughout the crediting period. While additional indicators may be reported as co-benefits, only one metric may be used for crediting to ensure comparability and prevent double counting.

## 10.4 Minimum Technical Requirements for Models

Hydrodynamic and flood impact models used in this methodology must meet the following minimum requirements:

- **Spatial Resolution:** ≤ 30 m for local-scale applications; ≤ 100 m for regional applications.
- **Calibration:** Must be calibrated with at least one observed flood event in the project area.
- **Validation:** Report goodness-of-fit statistics (e.g., Nash-Sutcliffe Efficiency > 0.6 or equivalent).
- **Data Quality:** Input data must be sourced from official national datasets or recognized global datasets (e.g., JRC, Copernicus, WorldPop).
- **Uncertainty Representation:** If confidence intervals are not reported, δ discount factors (per § 10.3) must be applied.

## 10.5 Mitigation measures (QA / QC)

1. Cross-check model inputs and outputs with independent data sources (e.g., satellite-derived flood extents).
2. Apply field validation or spot surveys after each significant flood event to verify protected footprints and household counts.
3. Document all depth–damage assumptions and keep version-controlled model files for audit.
4. Use peer review or third-party GIS audit to confirm area calculations.
5. Maintain a data-retention archive (≥ 2 years post-final CAB issuance) so uncertainty analyses can be repeated or refined as new information emerges.

**Caution on Terminology: Quality Assurance and Control Measures**
In the context of this methodology, the term "Mitigation measures" refers exclusively to proactive steps taken to prevent, reduce, or control potential problems that could affect the quality of data, measurements, or modeling outputs during project implementation. This usage is strictly related to Quality Assurance (QA) and Quality Control (QC) procedures and does not imply the generation of mitigation outcomes (e.g., GHG reductions) or any transfer of credits.

QA/QC measures may include, for example:

- Verification of hydrological and flood model inputs
- Cross-checking observed vs. modeled flood depths
- Ensuring completeness and accuracy of monitoring data for AB parameters
- Documentation of adjustments or corrections applied during data collection

## 10.6 Linkage to Sustainable Development Goals (SDGs)

In addition to the SDGs already covered, the following additional SDGs and indicators are relevant to the deployment of Mobile Flood Barriers (MFBs). Each indicator is linked to one or more Adaptation Benefits (ABs). Contributions are classified as direct (D), indirect (I), or induced (In) effects.

***Table 12:*** *Overview Linked Sustainable Development Goals (SDGs)*

| SDG | Indicator | Link to AB | Contribution Type |
|---|---|---|---|
| **SDG 1: No Poverty** | 1.5.3: Number of countries adopting national DRR strategies aligned with Sendai | Institutional strengthening via ABM participation | I |
| | 1.5.4: Proportion of local governments adopting local DRR strategies | Integration of MFBs into local DRR plans | D/I |
| **SDG 2: Zero Hunger** | 2.1.2: Prevalence of moderate or severe food insecurity (FIES) | Protection of agricultural land from flooding | I/In |
| | 2.4.1: Proportion of agricultural area under productive and sustainable agriculture | Sustained agricultural productivity due to reduced flood losses | D/I |
| **SDG 3: Good Health and Wellbeing** | 3.3.3: Malaria incidence per 1,000 population | Reduced standing water after floods lowers mosquito breeding | I |
| **SDG 11: Sustainable Cities and Communities** | 11.5.1: Number of deaths, missing persons, directly affected persons per 100,000 | Reduction in directly affected population (AB indicator) | D |
| | 11.5.2: Direct economic loss attributed to disasters in relation to GDP | Avoided economic losses (AB indicator) | D |
| | 11.5.3: (a) Damage to critical infrastructure, (b) disruptions to services | Preservation of critical infrastructure (AB indicator) | D |
| | 11.b.1: Number of countries adopting national DRR strategies | Alignment of MFB projects with Sendai Framework | I |
| | 11.b.2: Proportion of local governments adopting DRR strategies | Uptake of MFBs into local DRR strategies | D/I |
| **SDG 12: Responsible Consumption and Production** | 12.3.1: (a) Food loss index, (b) food waste index | Reduced post-harvest losses from flood protection | I/In |

## 10.7 Risk Assessment and Preventive Measures

To ensure the robustness of the methodology, potential risks to the effectiveness of Mobile Flood Barriers (MFBs) are identified and addressed through preventive measures.

***Table 13:*** *Overview key risks*

| Risk | Likelihood | Potential Impact | Preventive / Management Measures |
|---|---|---|---|
| **Vandalization, theft, or damage to barriers** | Medium | Reduced effectiveness, loss of assets | Secure storage facilities, restricted access, insurance, community-based monitoring |
| **Delayed deployment due to lack of awareness** | Medium | Increased flood damages if barriers are not deployed in time | Awareness campaigns, community training, clear deployment protocols |
| **Insufficient early warning of floods** | High | Barriers may not be deployed in time to prevent losses | Integration with national/local early warning systems, river gauges, rainfall monitoring, mobile alerts |
| **Inadequate maintenance of barriers** | Low-Medium | Reduced barrier lifespan, decreased effectiveness | Scheduled maintenance, regular inspections, training of local operators |
| **Data gaps for calibration (developing-country contexts)** | Medium | Reduced accuracy of AB calculations | Use of conservative assumptions, local calibration protocols (Section 3.2a) |

**Implementation Notes:**

- Preventive measures must be budgeted and integrated into project planning.
- Risks and responses should be reviewed regularly and updated in the Monitoring, Reporting, and Verification (MRV) framework.
- Security and early warning are especially critical in ensuring timely and effective deployment of MFBs.

## 10.8 Transparency and Reporting Responsibilities

Monitoring and reporting under this methodology are conducted jointly by the project proponent and host country, in accordance with national policies (NAPs, NDCs, DRR regulations) and international obligations under the UNFCCC (Article 6.8, GGA), BTRs, SDG indicators, the Sendai Framework, UNCCD, and CBD.

To ensure consistency and transparency, this methodology requires **both the project proponent and the host country** to maintain and present the same set of information.

1. **Project Proponent Responsibilities**
   - Prepare and submit monitoring reports, including all Adaptation Benefit (AB) parameters, data sources, and QA/QC procedures.
   - Provide evidence of calibration, adjustment factors, and uncertainty references.
2. **Host Country Responsibilities**
   - Review and validate information submitted by the proponent.
   - Ensure alignment of reported ABs with the country's NDC and/or National Adaptation Plan (NAP).
   - Submit consolidated information to the ABM registry or relevant platform.
3. **Independent Verification**

- An accredited third-party verifier will confirm that information reported by the proponent and host country is consistent.

**4. Transparency Principle**

- To avoid disputes and ensure comparability, the same datasets and monitoring results must be shared by both the project proponent and the host country.
- This ensures that Adaptation Benefits are not overstated and that reporting supports both project-level crediting and national-level adaptation planning.

## Annex: Mitigation co-benefits

Not Applicable