

**Kingdom of Cambodia
Nation Religion King**

**Ministry of Rural Development
Project Name: Cambodia Southeast Asia Disaster Risk Management Project 2
(Project ID: P177185)**

**Terms of Reference
(Ref: MRD-CDRM2-QCBS-S03)**

Flood Risk Assessment for Rural Roads in Cambodia

A. Background

Cambodia is highly vulnerable to various natural hazards, particularly floods and droughts. The 2022 INFORM Risk Index ranks Cambodia 57th out of 191 countries, largely due to its high exposure to flooding. Additionally, the 2020 World Risk Index identifies Cambodia as the 16th most disaster-prone country, citing its vulnerability and limited capacity to adapt to climate change effects. Notably, about 80 percent of the nation lies within the Mekong River and Tonle Sap basins, areas especially prone to flooding, which are responsible for 55% of the country's total annual economic losses.

Since 2009, Cambodia has faced at least three significant natural disasters related to floods and storms, with damages and losses ranging from \$132 million (Typhoon Ketsana in 2009) to \$624.7 million (2011 floods). With the ongoing impacts of climate change, such disasters are expected to increase in frequency, intensity, and severity.

In response, the Royal Government of Cambodia (RGC) has secured financing from the World Bank's International Development Association (IDA) to implement the Second Cambodia Southeast Asia Disaster Risk Management Project (KH-SEADRM-2). This project focuses on the rehabilitation and upgrade of rural roads and enhancing disaster risk management practices related to rural development. This consultancy is part of this project, aiming to support these critical objectives.

B. Objective

The objective of this consultancy is to enhance the Ministry of Rural Development (MRD)'s capabilities in incorporating flood risk information into its assessment, prioritization, and planning processes for public rural infrastructure. The focus will be on developing a systematic approach that progresses from flood risk assessment to investment prioritization, and ultimately the preparation of targeted investments to support resilience.

This consultancy will conduct a *strategic assessment* of the risks associated with flooding to the rural road network in seven provinces. This assessment specifically targets public rural infrastructure managed by MRD. The primary goal is to identify and prioritize the infrastructure most vulnerable to flooding to prepare effective intervention strategies. Key activities in this phase include: identifying and prioritizing potential investments for high-risk road sections based on risks associated with economic impact and social importance. For the rural roads, the assessment will need to be applied at link or sub-link level.

In parallel to this consultancy, MRD is in the process of improving its Rural Road Asset Management System (RRAMS). This consultancy is expected to *directly* contribute to this effort by updating the rural road inventory data within the RRAMS.

C. Scope

Geographic Scope

This consultancy will concentrate on seven provinces. Six of these provinces— Kampong Chhnang, Pursat, Battambang, Banteay Meanchey, Siem Reap, and Kampong Thom, —are located around the Tonle Sap Lake. The seventh province to be covered is Kampong Speu.

Hazard

The assessment will focus on two hazards: (i) fluvial flooding – i.e., the impacts associated with flooding from rivers and other water bodies and (ii) flash flooding – i.e., the impacts associated with excessive rainfall and surface water runoff. Additionally, the assessment will incorporate the impact of climate change, which affects the frequency, severity, and consequences of both flooding types. This approach ensures a comprehensive understanding of the dynamic flood risks in the context of a changing climate.

Infrastructure

The assessment will focus on infrastructure components categorized under rural road network. Each of these assets plays a pivotal role in ensuring the resilience and functionality of rural communities, especially in the face of frequent and intense flooding events. Understanding the vulnerability and risks associated with these assets is crucial for developing effective mitigation strategies.

The assessment will cover two types of rural roads: (i) T1: total 237 roads of approximately 3,697.69 kilometers, and (ii) T2: total 475 roads of approximately 3,810.58 kilometers, located in the seven provinces, to identify flood vulnerability and prioritize repairs or enhancements. Rural road assets include pavements, earthworks, bridges, causeways, and culverts. All of these can be adversely affected by extreme flood events.

D. Description of Activities

Module 1: Inception

Module 2: Assessment Preparation

Module 3: Data Collection and Flood Risk Assessment (Phase 1) and Cost-Estimates and Design (Phase 2)

Module 4: RRAM Inventory Update

Module 1

The first module aims to set the groundwork for all subsequent activities and ensures alignment with MRD's expectations and requirements. Activities include:

Kick-off Meeting: The Consultant will organize a formal kick-off meeting with MRD to confirm project objectives, expectations, and roles. This meeting will facilitate initial discussions on logistical and technical aspects of the project.

Inception Report: The Consultant in consultation with MRD will develop an inception report that serves as a detailed roadmap for executing the consultancy, including:

- Review of relevant reports and projects.
- Detailed descriptions of the project scope, objectives, and expected outputs.
- A comprehensive work plan with clearly defined activities, timelines, and responsibilities.
- An initial risk assessment and mitigation strategies.
- A stakeholder engagement plan.

Preliminary Data Review and Analyses: The Consultant will conduct a preliminary review of existing data and reports related to flood risk assessment to identify data gaps for the consultancy.

Face-to-Face Inception Workshop: The Consultant will organize a one-day workshop with MRD and other key stakeholders at MRD's premises in Phnom Penh. This workshop aims to present the draft Inception Report, obtain feedback, make necessary adjustments, and ensure a shared understanding of the project's framework and objectives.

Output 1

Inception Report: This report will provide all parties with a clear and comprehensive framework for moving forward, emphasizing a shared understanding and strategic alignment with the goals of the consultancy.

Module 2: Assessment Preparation

Task 2.1: Data Collection Strategy

The Consultant will develop a data collection strategy. To this end, the Consultant will conduct the following activities:

Preparation of an Overview of Data Landscape: The Consultant will assess the existing data and identify missing elements. A report will distinctly categorize data into what is currently available and what is lacking, offering a comprehensive view of the data landscape. This report will be organized in the following two parts:

Assessment of the Availability of Hazard Data: This includes:

- **Altitude Data and Hydraulic Structures:** The Consultant will conduct a thorough evaluation of essential data for the hazard assessment, focusing on altitude data identification for hydraulic calculations and analysis of the capacity of existing hydraulic structures such as dams, bridges, box culverts, pipe culverts, spillways, canals, and flood control channels.
- **Hydro-Met and Historical and Future Flood Data with Climate Change:** The Consultant will assess historical flood event data to establish baseline flood risk levels and utilize advanced climate change models and projections to assess future flood risks. The Consultant will cover, for example, maximum one-day rainfall events and changes in storm return periods.

Assessment of the Availability of Exposure and Vulnerability Data: This includes:

- **Engineering Structures:** The Consultant will evaluate the availability and adequacy of geo-referenced data concerning rural roads within identified hazard zones.
- **Minor Hydraulics and Drainage:** The Consultant is expected to assess the existing data sets relevant to minor hydraulic structures and their impact on flood exposure and vulnerability.
- **Economic Impact:** The Consultant must evaluate the sources of data for developing economic impact models.

Development of Plan for Data Acquisition: The Consultant is responsible for developing a strategic plan to acquire the missing data. This includes prioritizing data based on its significance and devising cost-effective collection methods that adhere to budgetary constraints. The Consultant will articulate the rationale behind the prioritization of data collection efforts. In cases where certain data cannot be collected feasibly, the Consultant will suggest alternative approaches or sources to approximate or replace the missing data. Based on what is currently known about the availability of data, the Consultant is expected to outline key initial considerations for the procurement of the Digital Terrain Model (DTM) and the execution of ground surveys, taking the following into account:

- DTM: The Consultant can use DTM data based on the FabDEM with 10 m Resolution (available for free). Upon conclusion of the assessment, the Consultant will ensure that the DTM is readily available to MRD, facilitating its use for future reference or related projects.
- Infrastructure Ground Survey Requirements: The Consultant will need to conduct a rapid ground survey to verify the presence and assess the condition of all rural road infrastructure under MRD management in seven provinces. Requirements include:
 - Data Collection: There is currently no reliable georeferenced inventory, and only limited data on the condition of the infrastructure is available. The consultant must use GPS and other georeferencing tools to create an accurate base inventory.
 - Methodology: The Consultant must present a detailed methodology outlining how the survey will be conducted. This should include techniques for rapid data collection, tools to be used, and the approach for assessing infrastructure condition.
 - Granularity: The level of granularity needs to be aligned with the needs of the flood risk assessment and prioritization.

Output 2

Data Collection Strategy Report: The Consultant will deliver a report that covers (i) a detailed assessment and categorization of the current data landscape, identifying available and missing data elements, (ii) a strategic plan for data acquisition that prioritizes missing data elements and outlines cost-effective collection methods, (iii) specifications for acquiring a DTM that meets the study's requirements, and (iv) a plan for ground survey needs (approach and timing).

Face-to-Face Workshop: The Consultant will conduct a one-day, face-to-face workshop with MRD at their premises in Phnom Penh. The purpose of this session is to present the data collection strategy, facilitating direct engagement and feedback from key stakeholders.

Task 2.2: Development of Database

The Consultant is required to develop and populate a database with all data required for the study, integrating all hazard, exposure, and vulnerability data in a coherent and systematic manner. The database needs to be structured to facilitate direct integration of the data into MRD's RRAMS. MRD will specify the format for data collection to ensure compatibility with the RRAM. It should be noted that the RRAM does not cover all aspects required for the flood risk assessment. Therefore, this separate database will serve as the foundational resource for the assessment.

Output 2

Database Development Documentation: The Consultant will deliver detailed documentation of the database structure and schema, outlining how hazard, exposure, and vulnerability data will be organized and integrated. This includes descriptions of data tables, relationships, and data types, ensuring clarity on how the database will be constructed and how it can be queried, and how it connects with the RRAM.

Module 3: Data Collection and Flood Risk Assessment

Following the development of a comprehensive data collection strategy in Module 2, Module 3 focuses on the practical execution of this strategy. This stage is dedicated to collecting both primary and secondary data.

Task 3.1: Data Collection

The Consultant will conduct the following activities:

- **Primary Data Collection:** The Consultant will gather firsthand accounts of flood events through surveys and interviews to enrich the database with current and historical perspectives on floods; employ GPS and drone technology to assess road networks in areas with identified vulnerabilities; utilize satellite imagery and field observations to analyze land-use changes that affect flood dynamics; and conduct detailed surveys of critical infrastructure like bridges and culverts to evaluate their impact on flood risk. The Consultant will ensure all activities are aligned with Module 2's strategy.
- **Secondary Data Acquisition:** The Consultant will obtain key hydro-meteorological data. High-resolution maps and DTM will be acquired to aid flood modeling. Additionally, the Consultant will compile data on historical and projected flood risks and gather detailed information on engineering structures and climate factors for an accurate flood risk assessment, adhering to Module 2's strategy.

Output 3

Data Collection Summary Report: The Consultant will provide a report that synthesizes the outcomes of the data collection phase and outlines the methodologies used for data collection. Additionally, the report will identify and highlight any significant issues that could affect the subsequent activities.

Task 3.2: Flood Risk Assessment (Phase 1)

- **Hazard Analysis:** The Consultant will carry out a detailed hazard analysis focusing on the factors contributing to flood risk. This includes: (i) rainfall analysis: investigating rainfall patterns based on probability of exceedance and return periods to anticipate flood occurrence, and (ii) flooding analysis: utilizing two-dimensional (2-D) hydraulic modeling for flood extent mapping to identify flood-prone areas and characterize the sources and dynamics of potential inundation. Flood hazard assessment estimates the probability of different magnitudes of damaging flood conditions, such as the depth of inundation, duration of inundation, etc.
- **Exposure Analysis:** The Consultant will assess where flood hazard is the greatest. This will be done by overlaying the roads with the hazard map to identify the most exposed infrastructure. In addition, the Consultant will assess the criticality of the exposed infrastructure, including both rural roads to their respective networks. This criticality assessment will help determine the importance of each infrastructure component in maintaining the overall functionality of the network. This also can help to protect the lives, livelihoods, and assets of their communities and plan for long-term changes such as water level rise or increased storm frequency. The Flood Risk mapping will provide intensive for scaled-up action and transformational change in integrating consideration of climate risks and resilience in national development planning, consistent with poverty reduction and sustainable development goals. consistent with poverty reduction and sustainable development goals.

Vulnerability Analysis: The Consultant will conduct an in-depth examination of rural roads and bridges. The resilience evaluation entails assessing the ability of infrastructure to withstand and recover from flooding, while the criticality analysis will focus on identifying "hot spots" within the rural road system where disruptions would have severe consequences. This involves both an analysis of the structural integrity of rural road as well as the socio-economic implications of flooding. It also includes examining the impact on communities, economic activities, and access to essential services. Flood risk maps are an important tool for raising awareness about areas at risk of flooding and for helping National and sub-National Line agencies develop strategies for reducing these risks through structural and non-structural measures.

- **Fragility Functions:** The Consultant is tasked with reviewing existing fragility functions applicable to rural roads within Southeast Asia, adjusting these to the local context as necessary. Where gaps exist, the Consultant will develop new fragility functions, with a focus on capturing and managing uncertainty in the harmonization process. Special attention will be given to those hot spots identified during the criticality analysis.
 - **Damage-to-Loss Models:** The Consultant will formulate damage-to-loss models tailored to various infrastructure types found in Cambodia or adapt suitable existing models. These models will quantify direct and indirect losses from infrastructure damage, particularly focusing on identified hot spots where the impact of disruptions could be most severe.
 - **Recovery Times:** The Consultant will estimate recovery times, focusing especially on hot spots, providing critical data for the comprehensive risk analysis that follows.
- **Risk Analysis:** The Consultant will synthesize hazard, exposure, and vulnerability assessments within the defined time-horizons (25 and 50 years) to determine the overall flood risk. Risk will be communicated in terms of:
 - Safety levels for rural road infrastructure construction (Design High Water Level).
 - Direct damage to rural roads (i.e., cost of reconstruction) in terms of annual average loss (AAL) and probable maximum loss (PML).
 - Economic losses due to interruption of economic activities and essential services.
 - Number of people affected by the flood events

Output 4

Flood Risk Assessment Report: The Consultant deliver a comprehensive report that summarizes the findings from the hazard, exposure, vulnerability, and risk analyses. This report will consist of three sub-reports:

- **Hazard Model Report:** This sub-report will detail the methodology and outcomes of the hazard modeling, including maps and descriptions of flood scenarios under different conditions. It will cover data sources, model selection, calibration, and validation processes. The report will also discuss the frequency and intensity of potential flood events, providing a foundation for understanding the areas at highest risk.
- **Vulnerability Mapping Report:** This sub-report will outline the findings from the vulnerability analysis, showcasing maps that highlight the areas and infrastructure most susceptible to flood damages. It will identify and detail "hot spots" — specific locations where the convergence of high vulnerability and significant potential impact create critical areas of concern. The report will detail the resilience and criticality of infrastructure within these hot spots.
- **Risk Analysis Report:** The final sub-report will synthesize the insights from the hazard and vulnerability assessments to present an integrated risk analysis. It will include probabilistic assessments of potential losses and the expected damages to infrastructure and economic activities. This report will also discuss potential recovery scenarios and timelines

Consultation Workshops: The Consultant will convene consultation workshops to share the findings with MRD stakeholders. This interactive session will promote in-depth dialogue on the assessed flood risks and their implications. Additionally, it will gather stakeholder input to inform subsequent phases, including the development of the prioritization framework and preliminary designs.

Task 3.3: Investment Prioritization Based on Flood Risk Assessment (Phase 1)

- **Development of a Comprehensive Investment Prioritization Framework:** The Consultant will synthesize the flood risk assessment findings into a robust investment prioritization framework. This framework will incorporate: (i) the probability and potential severity of flood events to identify areas and assets at highest risk and (ii) an estimation of the potential economic losses from flood events, including direct damages to infrastructure and indirect impacts on economic activities.
- **Proposal of Priority Investments:** Based on this framework, the Consultant will propose a list of priority investments, clearly articulating the rationale for each selection and expected outcomes. This proposal will also identify quick wins that can provide immediate benefits with minimal expenditure.

Output 5

Investment Prioritization Framework: The Consultant will synthesize the flood risk assessment findings into a robust investment prioritization framework and propose a list of priority investments.

Consultation Workshop: The Consultant will host a consultation workshop with MRD stakeholders to review and refine the investment prioritization framework, ensuring alignment of proposed investments with stakeholder expectations through collaborative discussion and feedback.

Dissemination Workshop and Training: The Consultant will conduct a dissemination workshop back-to-back with a training for MRD to present the flood risk assessment findings and training on the approach and data interpretation for investment prioritization.

Module 4

Task 4.1: Integration of Hazard and Vulnerability Data and RRAMS:

- The Consultant will ensure some of the hazard, exposure, and vulnerability data obtained as part of this assessment are compatible for integration into the RRAMS. The focus must only be on data that is useful for general application in the RRAMS. The more detailed data will need to be handed over as part of the assessment database (see module 2, output 3). [this requires further discussion as the RRAM as it is currently set up would not allow this data to be uploaded]

Output 6

RRAM Integration Report: The Consultant will deliver a report that describes and provides evidence of the work that has been conducted to format and integrate the flood risk assessment data, including the updated infrastructure inventory data, into the RRAM. The textual part of the report can be short but should clearly indicate where this data can be found in the RRAMS, the steps needed to upload it and how it can be used.

E. Data Handover

The Consultant is required to hand over all collected or generated data, both in raw and processed forms. The data should be delivered in a manner that is both accessible and systematically organized, ensuring ease of use for MRD.

Documentation and Metadata:

- **Comprehensive Documentation:** The handover must include detailed documentation outlining data sources, methodologies, assumptions, and limitations to ensure full transparency and usability of the data.
- **Metadata Standards:** Metadata accompanying the data must adhere to a standard that will be specified and approved by the MRD. This standard will be chosen to ensure compatibility with international best practices for geospatial and environmental data management.

Data Format and System Compatibility:

- **System Compatibility:** All data should be compatible with PC systems operating on MS Windows 11®.
- **Format Compatibility:** Data formats must be readily usable with common software such as Microsoft Office. Proprietary data formats are to be avoided, unless they offer significant advantages and are specifically approved by the MRD.

Spatial Data Requirements:

- **Open Formats:** Spatial data, encompassing both raster and vector formats, should be provided in universally accessible formats like GeoTIFF, GeoJSON, or GeoPackage.
- **Dataset Documentation:** Each spatial dataset must include a comprehensive description, detailing the format, variable fields, and any other relevant information for its use.

F. Timing and Payment Schedule

The study is expected to be completed within **15 months** of contract signing. The Consultant will prepare a work plan in the technical proposal and agree on deliverable deadlines for the tasks in the scope of work during the inception meeting. The Project's main deliverables are listed in the table below, with an indicative delivery date after the start of the Project. The Consultant must present a more detailed schedule of activities and milestones.

Milestone Description	Delivery Date: Weeks after Contract Signing	Payment Schedule
Output 1: Inception Report	Month 2	10% of contract value
Output 2: Data Collection Strategy, Database Development Documentation, and Workshop	Month 4	10% of contract value
Output 3: Data Collection Summary Report	Month 9	15% of contract value
Output 4: Flood Risk Assessment and Workshop	Month 11	15% of contract value
Output 5:	Month 12	15% of contract value

Investment Prioritization Framework and Workshop		
Output 6: RRAM Integration Report	Month 14	15% of contract value
Output 7: Final report with executive summary summarizing all activities	Month 14	20% of contract value

G. Required Minimum Qualifications and Experience

This study requires execution by a firm with a team of consultants that combine a wealth of experience in flood risk assessment with robust expertise in road infrastructure, alongside a specialized focus on climate change adaptation and resilience.

The firm/consultants should exhibit the following competencies:

1. At least ten (10) years of experience in flood risk assessment and mitigation issues, particularly those emphasizing resilience to current and future climate threats;
2. Having appropriate and sufficient staffing arrangements and capacity (available permanent staff and pool), portfolio of ongoing projects with evidence of satisfactory performance by Clients;
3. Having a proven record in completing at least two (2) projects that include similar implementation support of value of at least USD 0.5 million for last 10 years;
4. Experience in South East Asia or in Cambodia is an asset; and
5. Experience managing similar services under multilateral funded projects.

The consultancy firm is expected to put together a diverse team of highly qualified international and local professionals, which should include the key experts listed below. The consultant's proposals shall be evaluated on the qualifications and experience of the Key Experts identified below. The consultant may propose additional experts in the Technical Proposal as may be deemed necessary to fulfill this TOR and as necessary to execute the scope of services. Key experts to be included in the team:

No	Internationally-experienced staff	Input in Person-Month
I-1	Team Leader	14
	Total International:	14
No	Nationally-experienced staff	Input in Person-Month
N-1	Senior Transport Economist	8
N-2	Senior Hydrological and Hydraulic Engineer (Flood Risk Modeling Expert)	12
N-3	Road Engineer	12
N-4	GIS/Remote Sensing Specialist	12
N-5	Database Specialist	12
	Total National:	56

1. **Team Leader:** A minimum of 12 years of leadership experience in flood risk assessment, with substantial experience in its application to road infrastructure and strong emphasis on climate adaptation, is required. The Team Leader must also have at least a master degree or equivalent in

hydro-meteorology and demonstrated substantial project management skills. Having the technical oversight in the Mekong River Strategic Floodplain Management Study would be an advantage.

2. **Senior Transport Economist:** At least 8 years of road planning experience, with a strong analytical ability to prioritize projects under conditions of uncertainty, and a demonstrated understanding of climate resilience principles. He/she must have at least a Master degree or equivalent, in transport economics with at least ten years' experience in CGE modelling (Computable General Equilibrium), pricing strategies, market survey designs, econometric modelling, transport cost and benefit analyses and travel demand management planning and implementation.
3. **Senior Hydrological and Hydraulic Engineer (Flood Risk Modeling Expert):** Deep understanding of road engineering, with over 8 years in flood modeling, risk assessment, and the design of climate resilient infrastructure solutions for roads, and familiarity with adaptation strategies for both current and future climate impacts. He/she must have at least a bachelor degree or equivalent, in an Engineering related subject such as Civil or Environmental Engineering, hydrology, having experienced with advanced skills in catchment hydrology, floodplain hydraulics. He/she shall have a good working knowledge of modeling and practices and guidance in Mekong River Basin, and strong hydraulic design experience and having extensive experience in flood mapping, flood protection, mitigation engineering, hydrology engineering or related areas. Having the technical oversight in the Mekong River Strategic Floodplain Management Study would be an advantage.
4. **Road Engineer:** More than 8 years of hands-on experience in designing, evaluating, and maintaining road projects, emphasizing flood impact analysis and incorporation of climate resilience in infrastructure planning. He/she must have at least a bachelor degree in transportation engineering He/she need to have strong technical skills in road engineering software, such as AutoCAD, Civil 3D, etc.
5. **GIS/Remote Sensing Specialist:** A solid 5-year background in using GIS and remote sensing for detailed mapping tasks, crucial for flood risk assessment and the planning of road sector projects. He/she must have at least a bachelor degree in geographical information systems, cartography, computer science/software engineering and other numerical and analytical disciplines.
6. **Database Specialist:** At least 5 years' experience in database management on road networks, including familiarity with adaptation strategies for both current and future climate impacts. He/she must have at least a bachelor degree in database management, computer science, information technology or information systems.