# Multi-Hazard Risk Assessment of Roads in Mindanao

## Key findings

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# Presenter

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**World Bank**


**ASSESSING THE RISK EXPOSURE OF ROAD NETWORK TO CLIMATE AND NATURAL HAZARDS IN MINDANAO**

**Budget: US$252k**
**Trust Fund: GFDRR**
**Timeline: May 2023 – Dec 2024 (18 months)**

ARUP

- **Objective:**
  - Conduct a Multi-hazard Vulnerability Assessment of the national road network and critical road links in Mindanao and identify priority asset management interventions.
  - **The study informed the technical design of the World Bank IPF "Mindanao Transport Connectivity Improvement Project" (MTCIP, P177017)**

- **Scope of Services:**
  - **Component 1:** Desk Study, assessing, benchmarking and undertaking gap analysis of existing climate and disaster information for the Mindanao region, prepare policy note on improving the existing data collection.
  - **Component 2**: Mapping (GIS-based inventory) of critical road sections, multi-hazard hazard exposure assessment, risk scoring, list of recommendations for potential interventions at high-risk locations (feeding into the MTCIP roads) and cost estimates (cost of failure).
  - **Component 3:** Capacity building, 3 training workshops and knowledge dissemination.

# Capacity Building Workshops
held in Manila, October 8-10, 2024

- ✓ Better knowledge of **risk concepts**
- ✓ Gain knowledge on **role of MHRA** in road sector
- ✓ Gain awareness of **datasets and tools**

- ✓ Deepen technical understanding of **methodologies for MHRA**
- ✓ Gain exposure to the **use of GIS for MHRA**

- ✓ Gain awareness of **high-risk road segments in Mindanao**
- ✓ Identify **types of structural interventions** to mitigate risk

- ✓ Identify **types of non-structural interventions**
- ✓ Better knowledge of **best practices** in developing a climate resilient road network

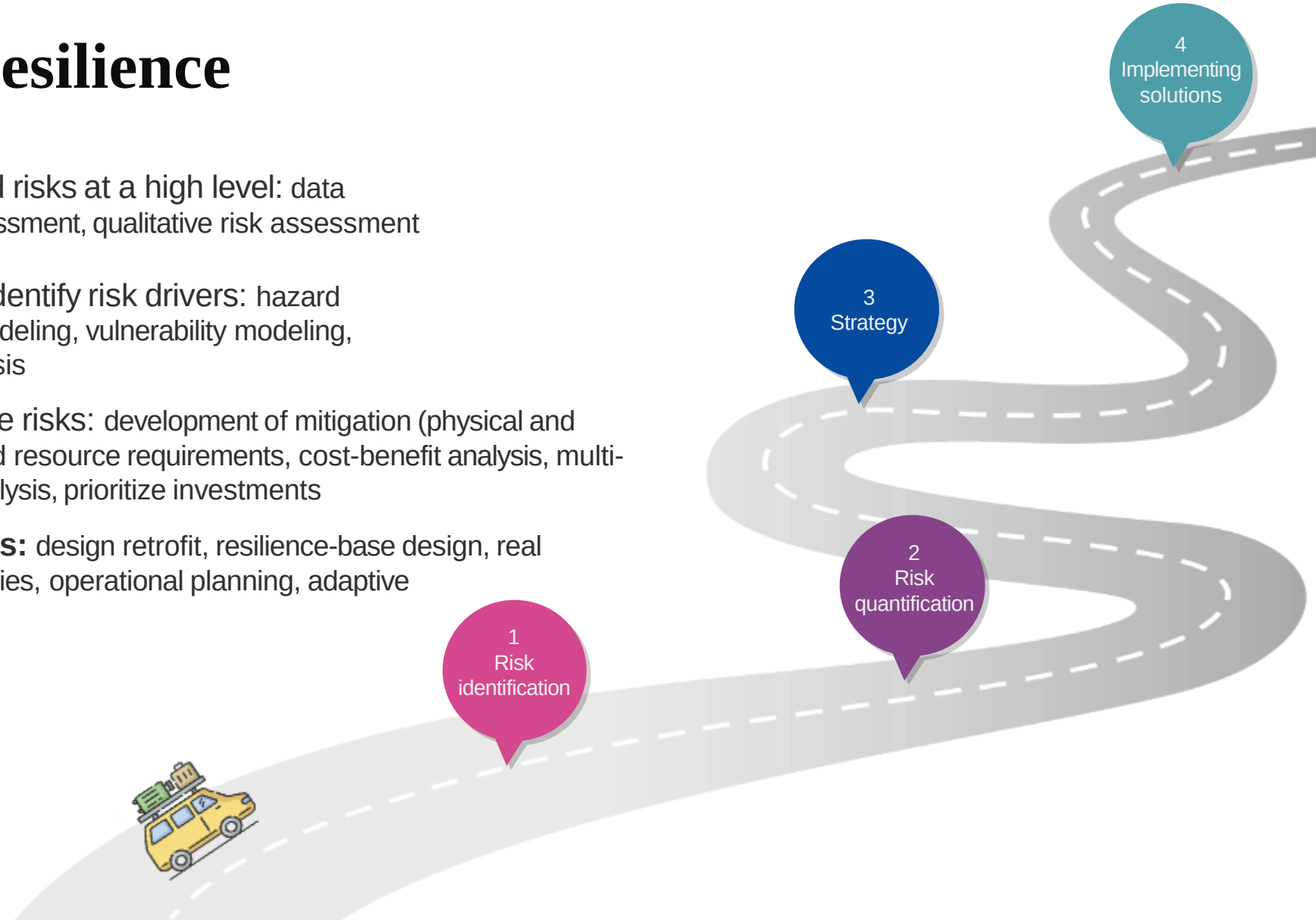
# The Road to resilience

01 **Identify** multi-hazard risks at a high level: data collection, hazard assessment, qualitative risk assessment

02 **Quantify** risks and identify risk drivers: hazard modeling, exposure modeling, vulnerability modeling, quantitative risks analysis

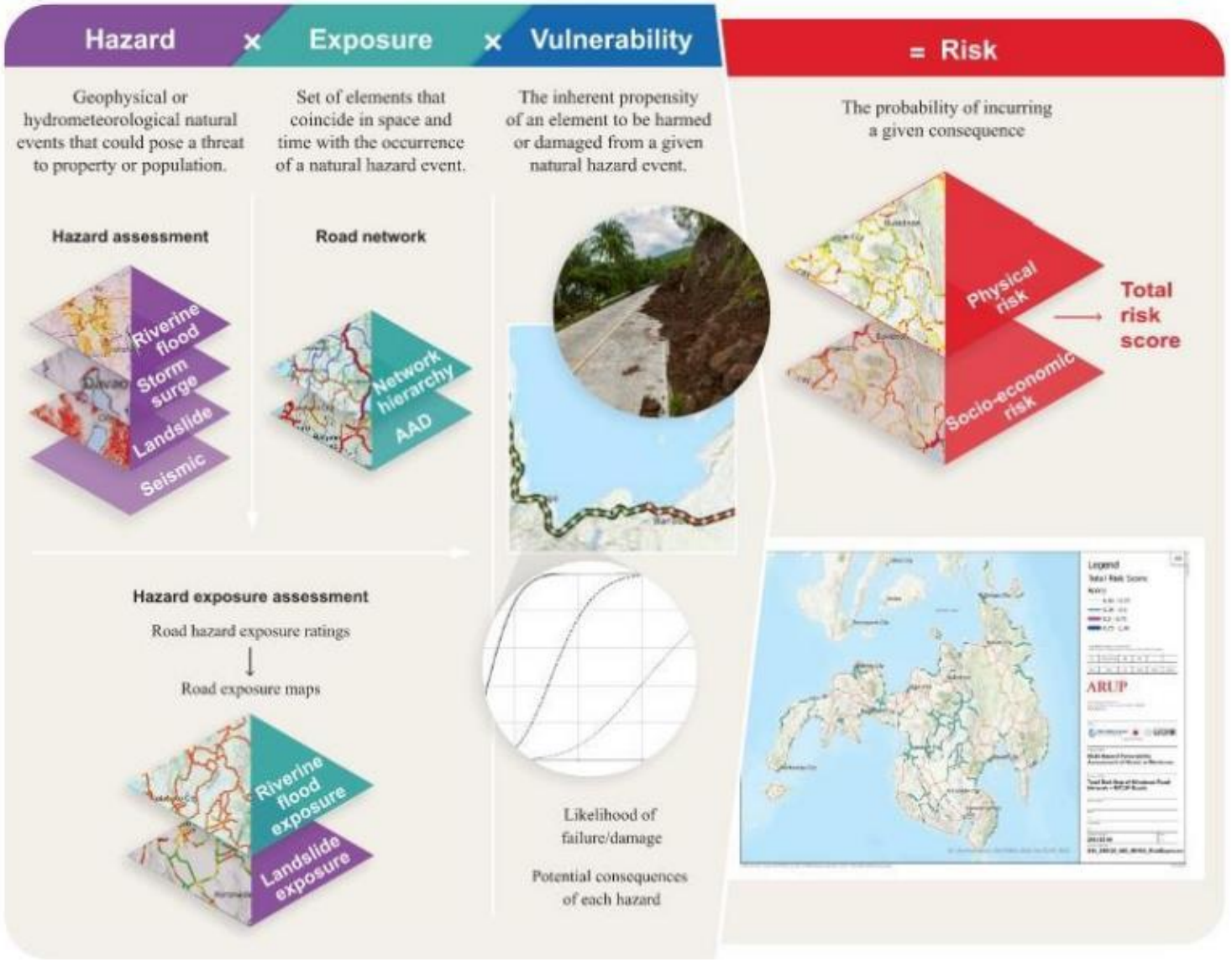
03 **Strategize** to mitigate risks: development of mitigation (physical and operational) options and resource requirements, cost-benefit analysis, multi-decision framework analysis, prioritize investments

04 **Implement solutions:** design retrofit, resilience-base design, real estate frameworks/policies, operational planning, adaptive capacity/organizational



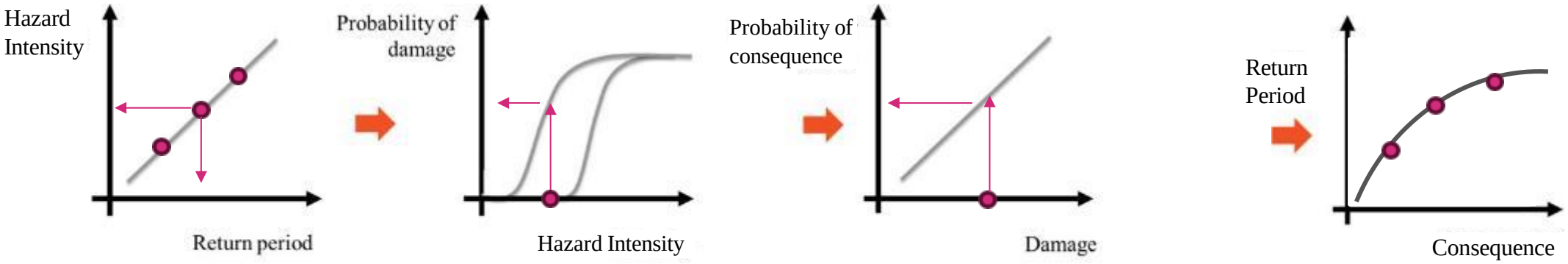
# Methodology



# 1 | Multi Hazard Risk Assessment

# Hazard x Exposure x Consequence = Risk




**Hazard**

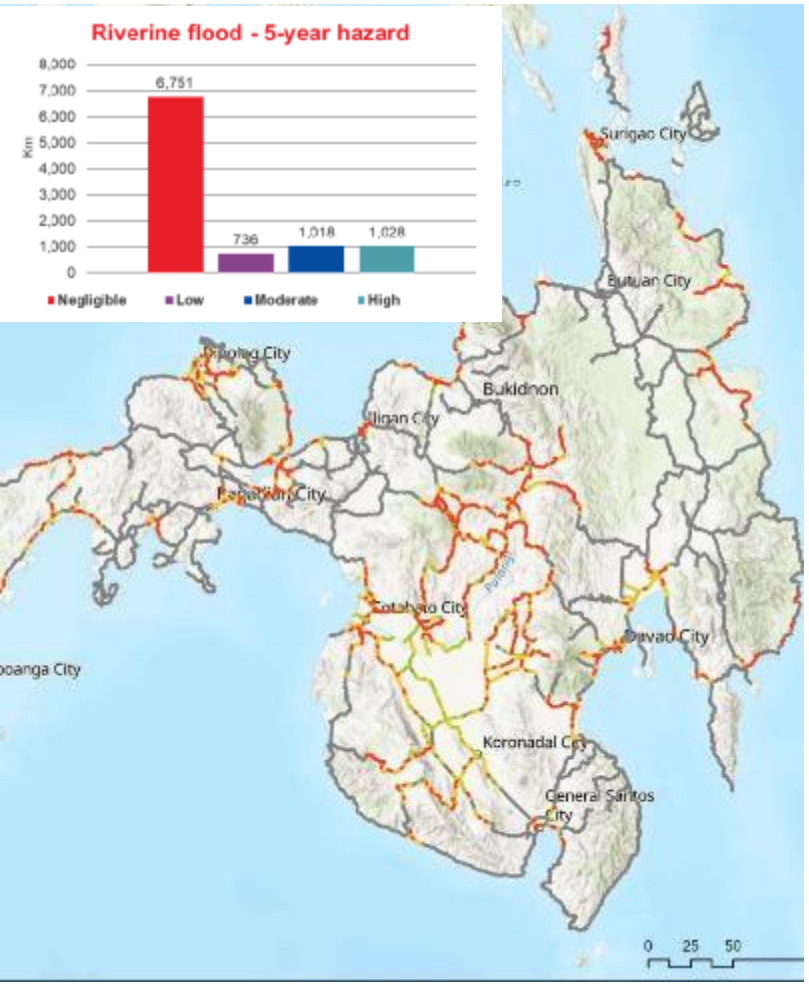
**Exposure + Vulnerability**

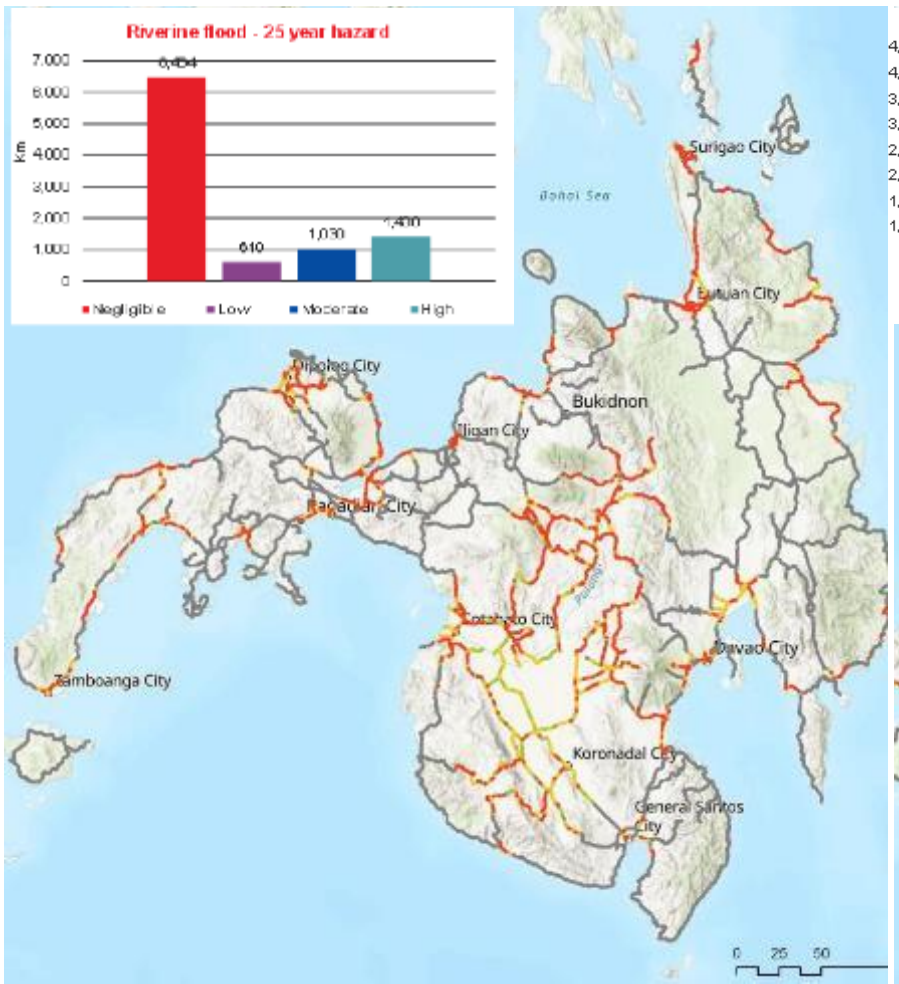
**Consequence**

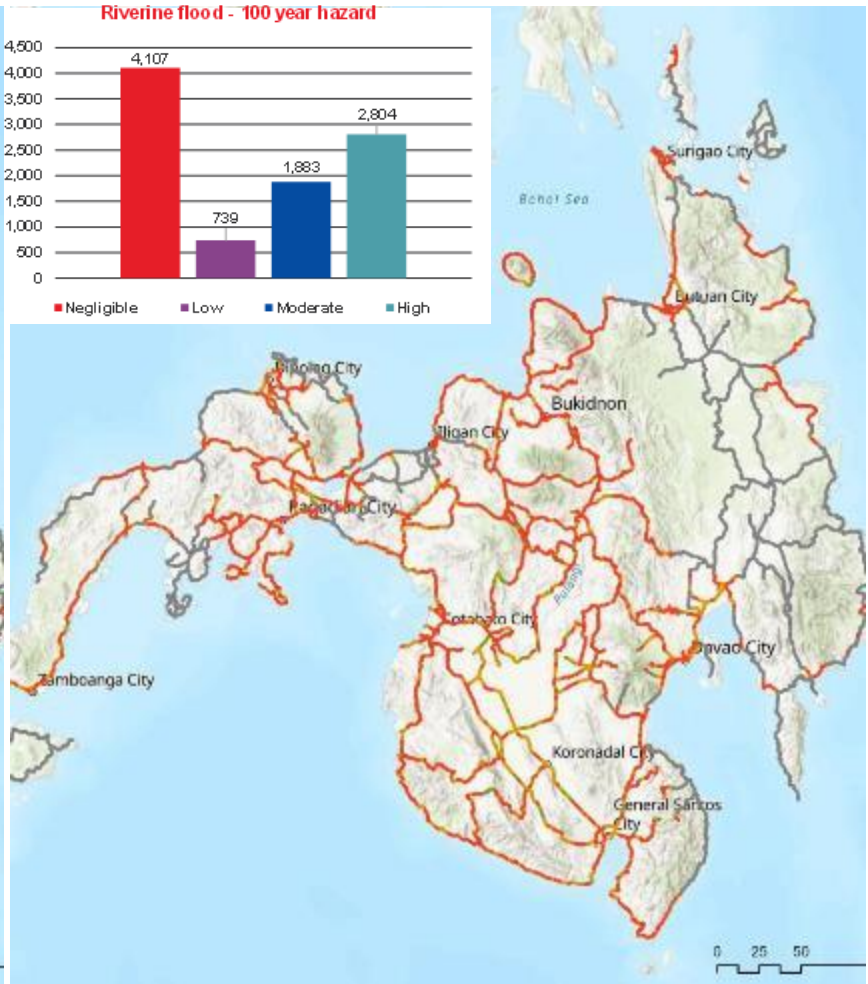
**Risk**

| Risk rating | Average annual downtime |
|---|---|
| Very High | > 300 days / year |
| High – Very High | 30 – 300 days / year |
| High | 3 – 30 days / year |
| Medium – High | 0.3 – 3 days / year |
| Medium | 0.03 – 0.3 days / year |
| Low – Medium | 0.003 – 0.03 days / year |
| Low | 0.0003 – 0.003 days / year |
| Very Low | < 0.0003 days / year |

# Exposure - Analysis Results



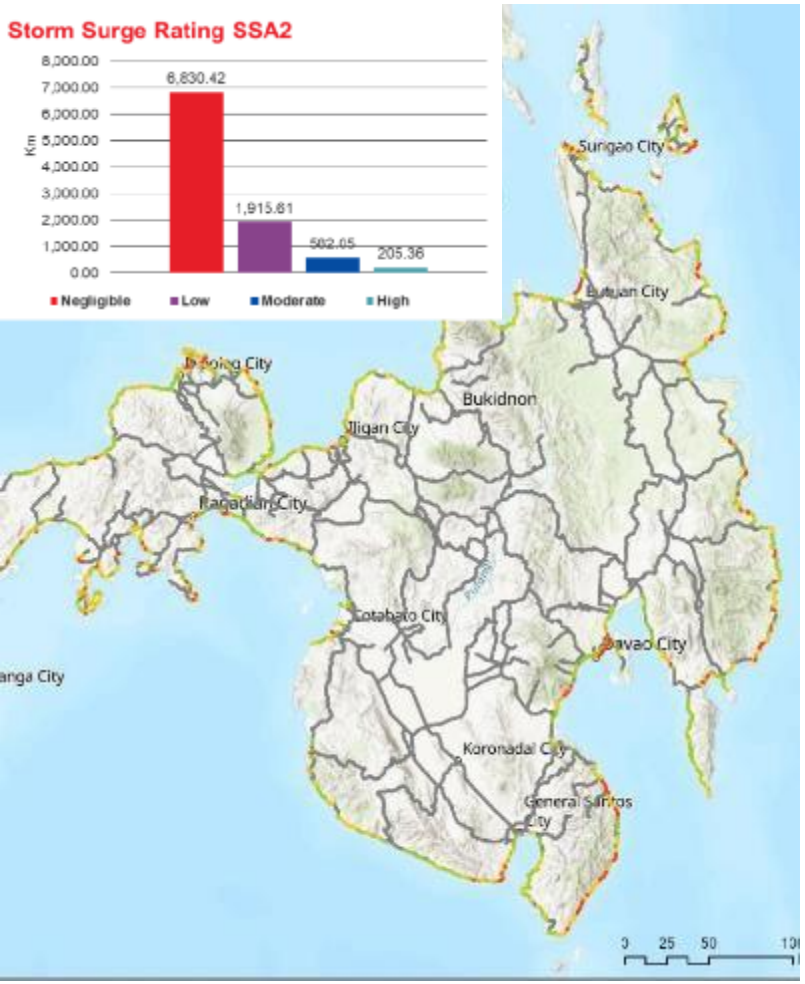



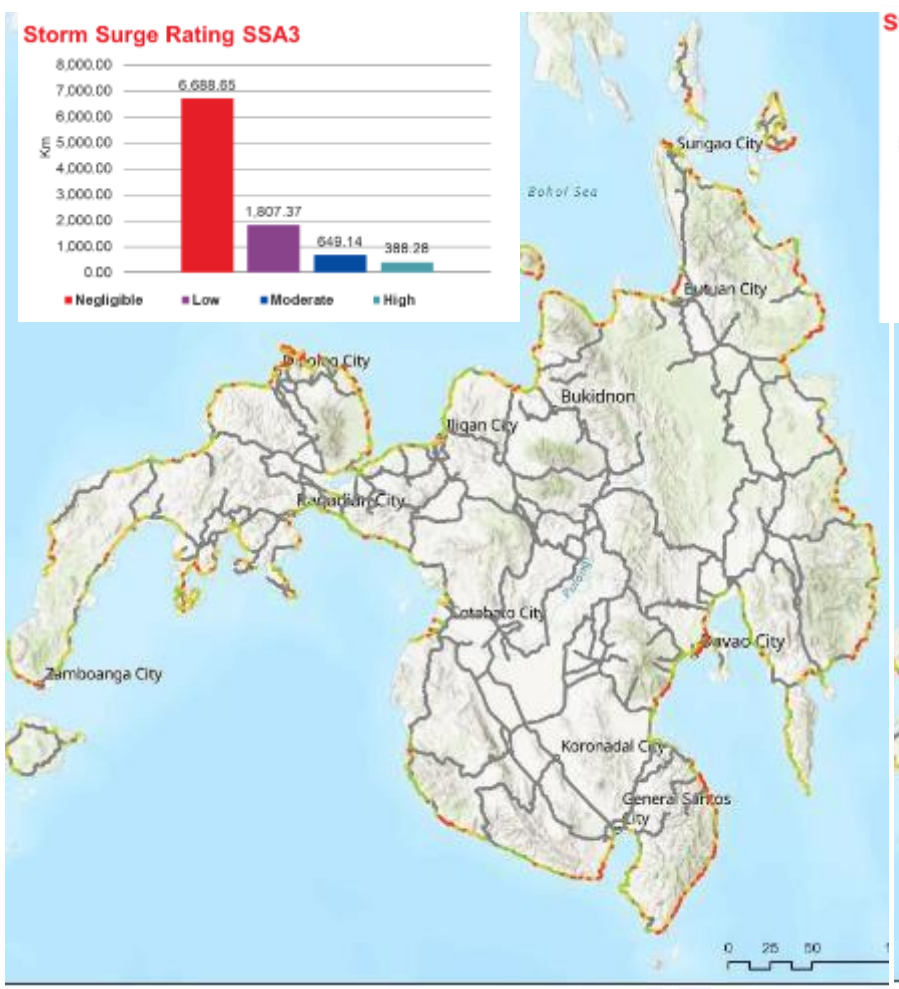
# Key Findings for Mindanao

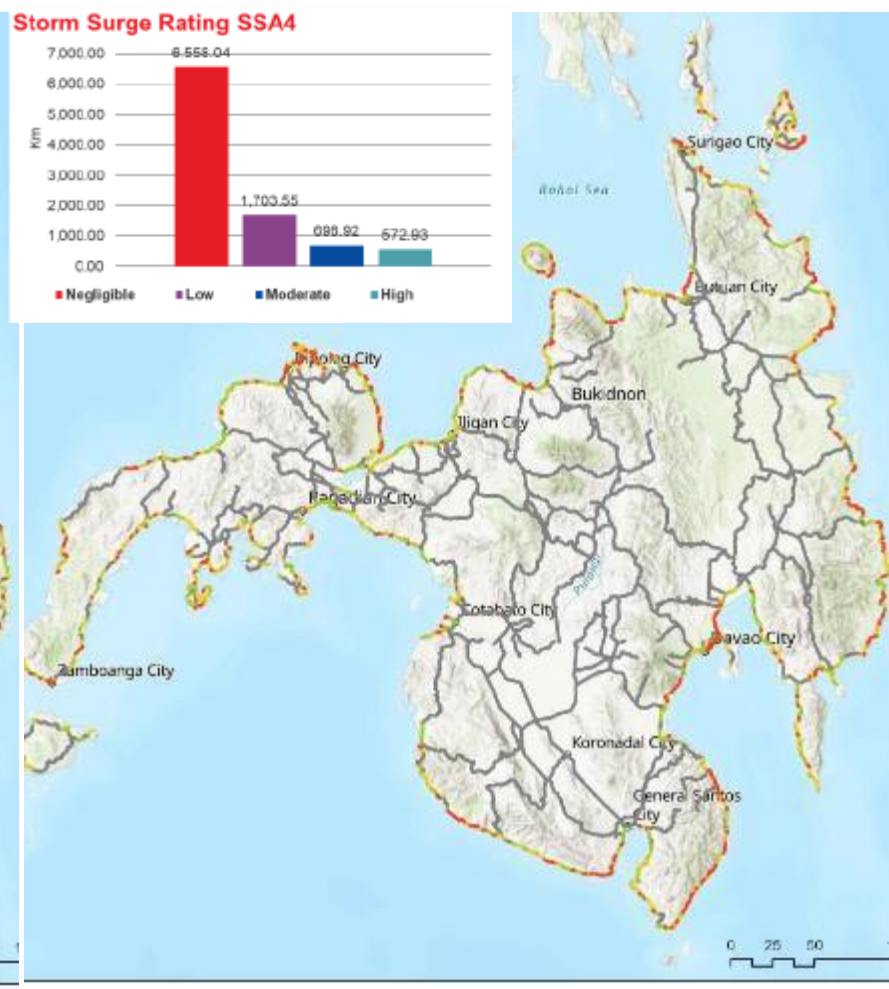


Storm surge

## Exposure - Analysis Results



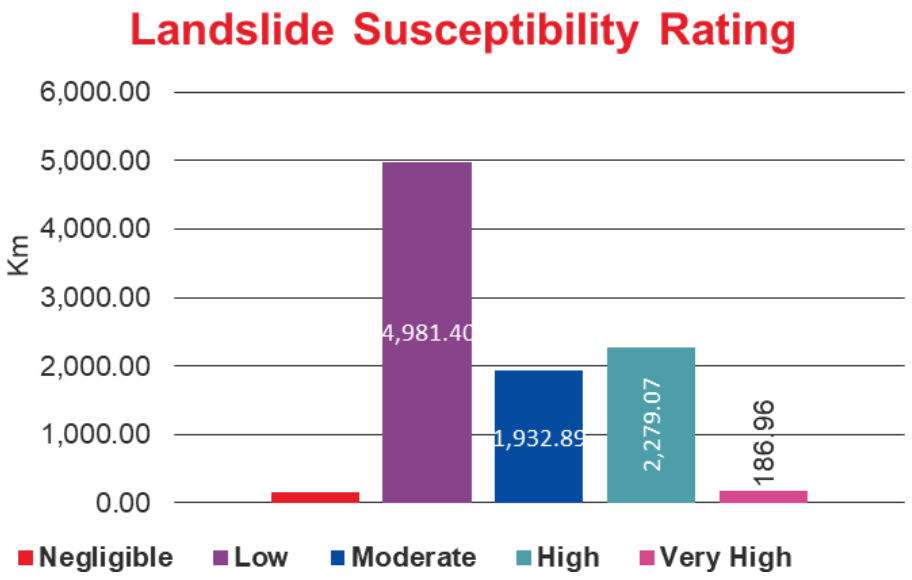



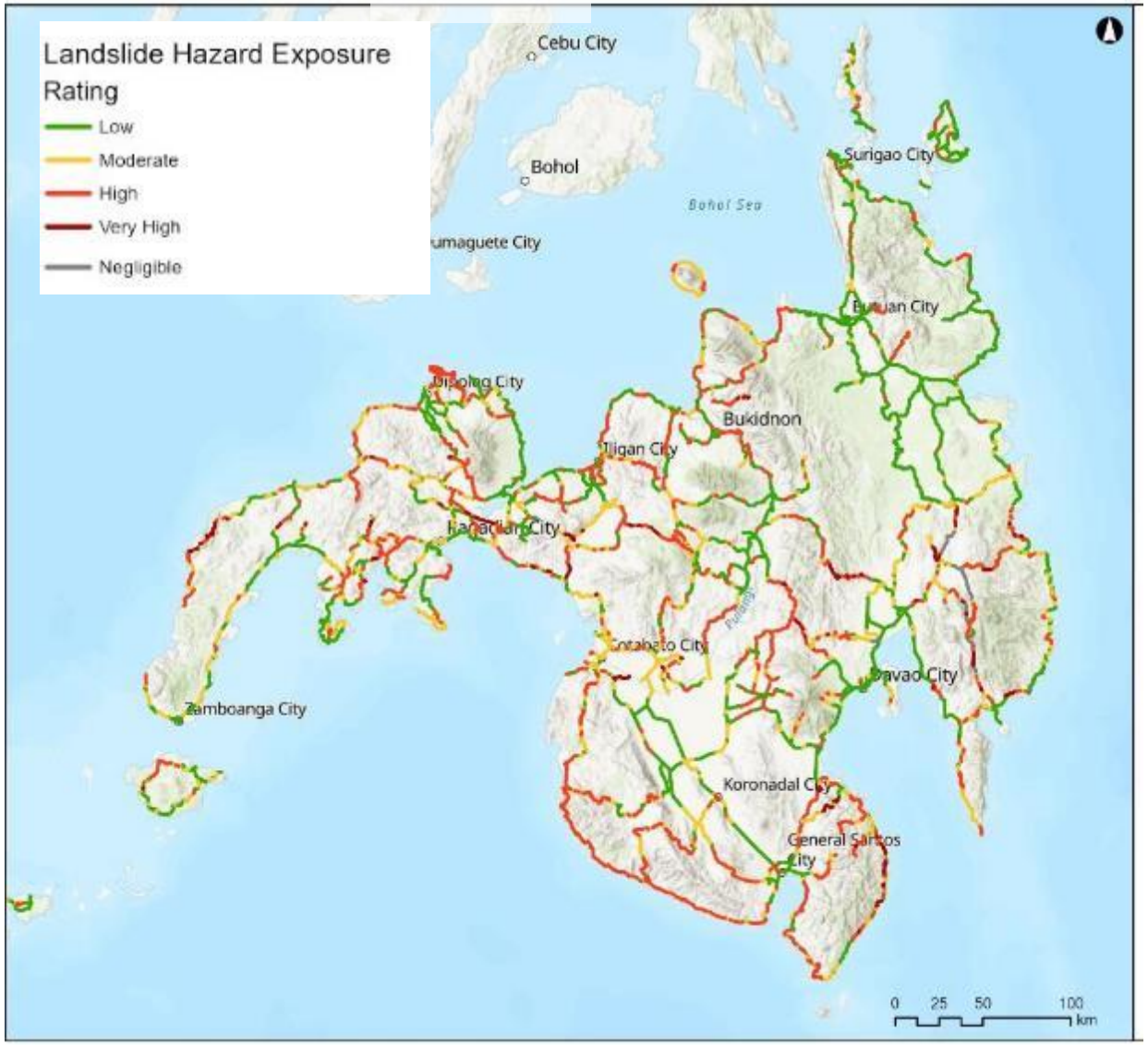



# Key Findings for Mindanao



## Exposure - Analysis Results



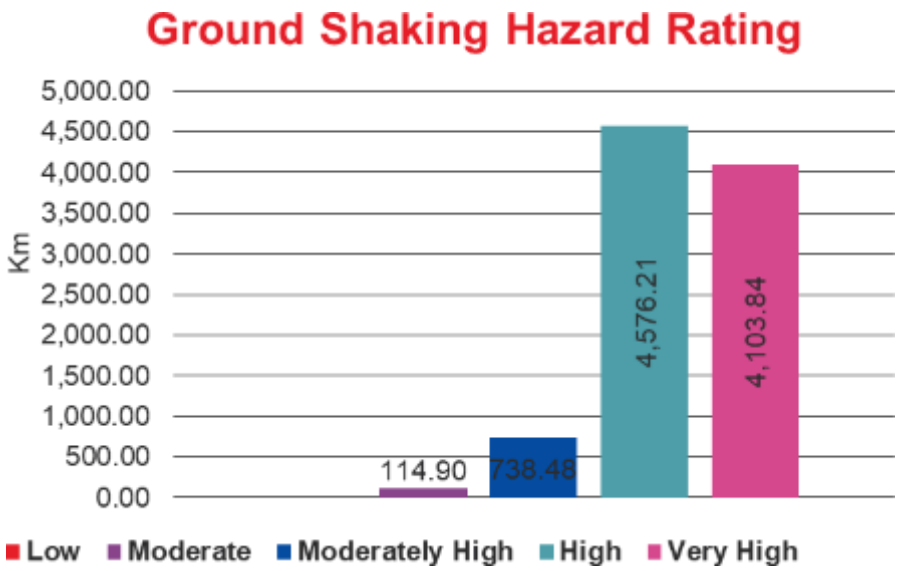



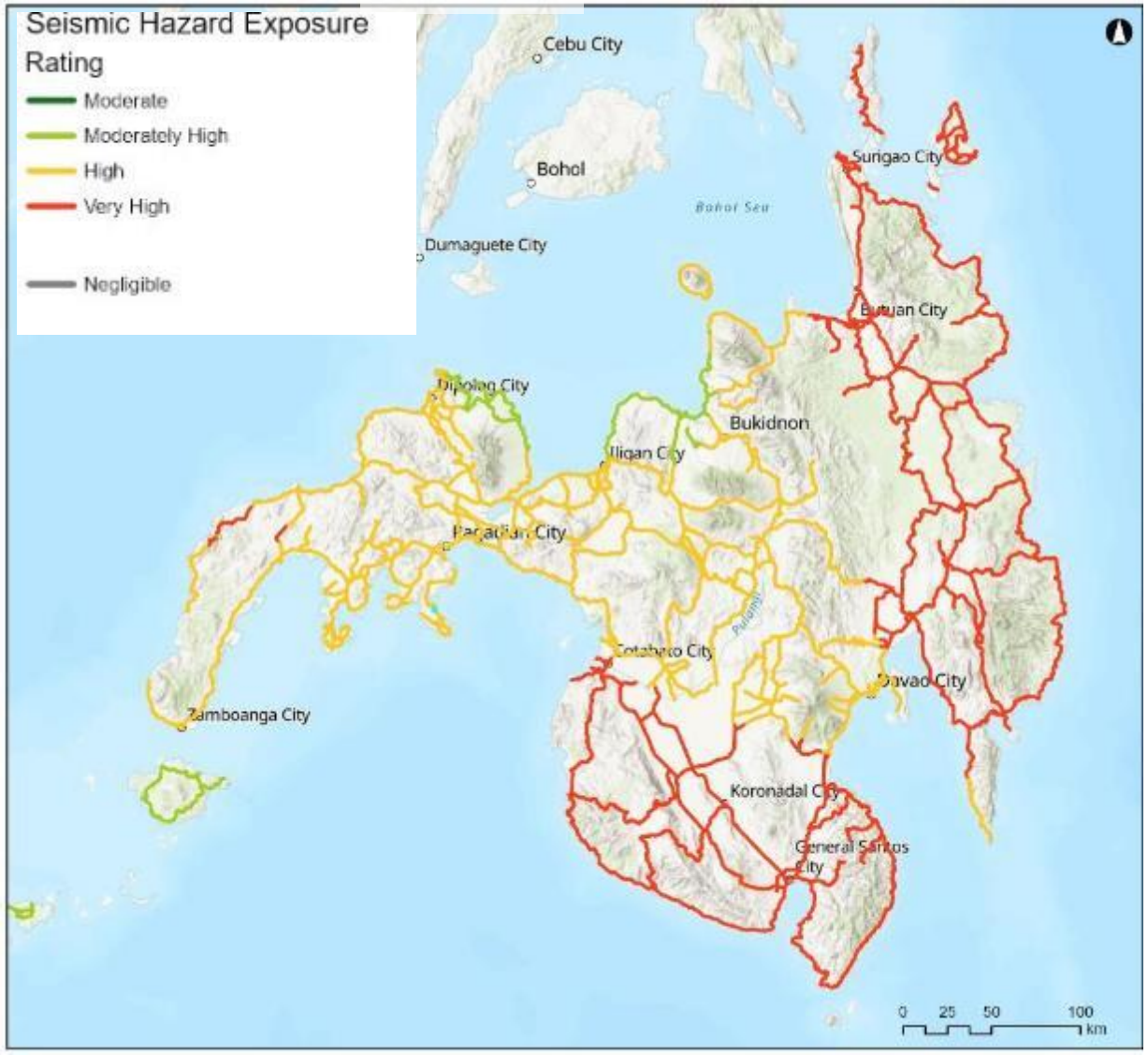
# Key Findings for Mindanao



Seismic shaking

## Exposure - Analysis Results



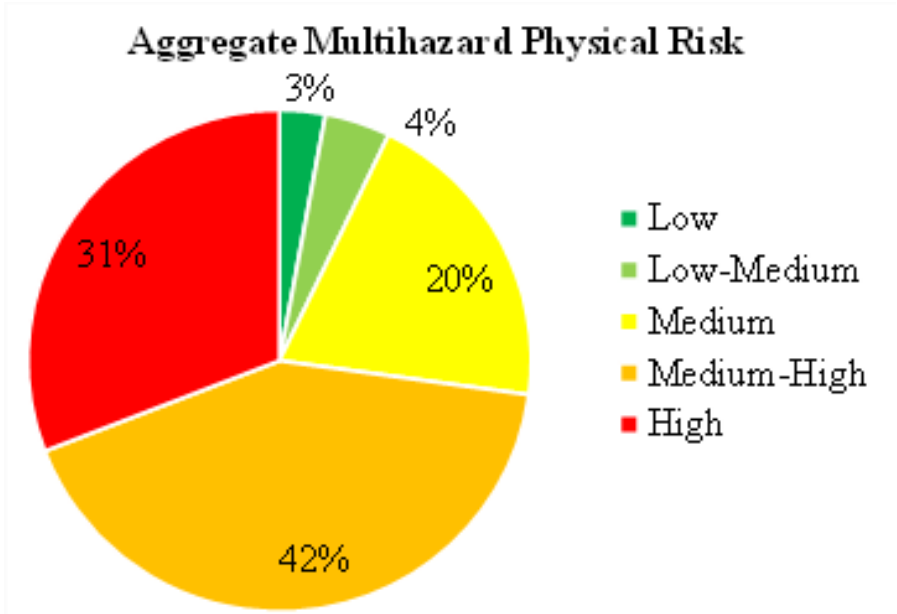
# Key Findings for Mindanao



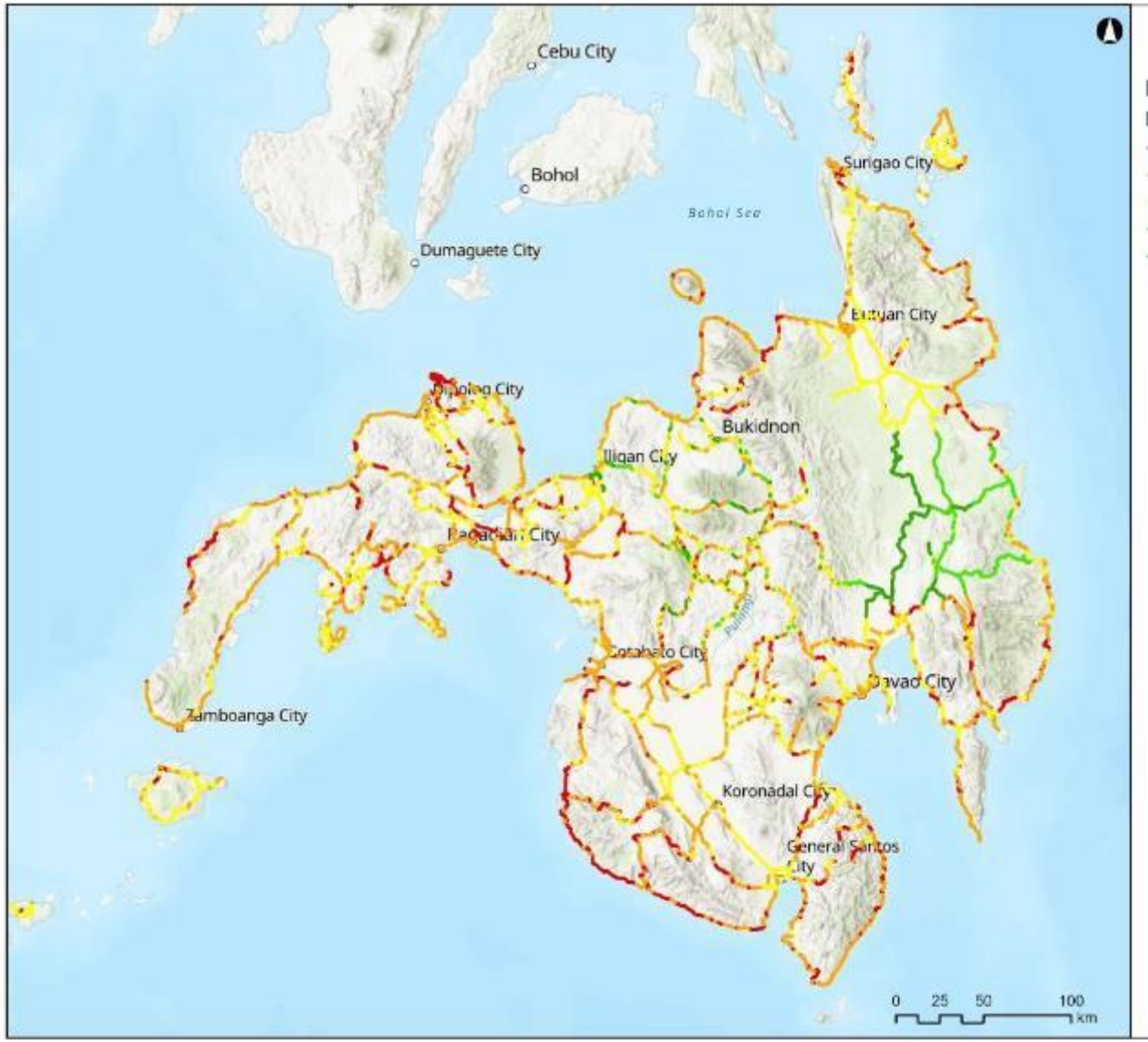
## Analysis Results

**Risk**

Results







# 2 | Road Network Criticality Assessment

## Methodology

# Criticality Scorecard

Apply Weightages to determine the final score per road link

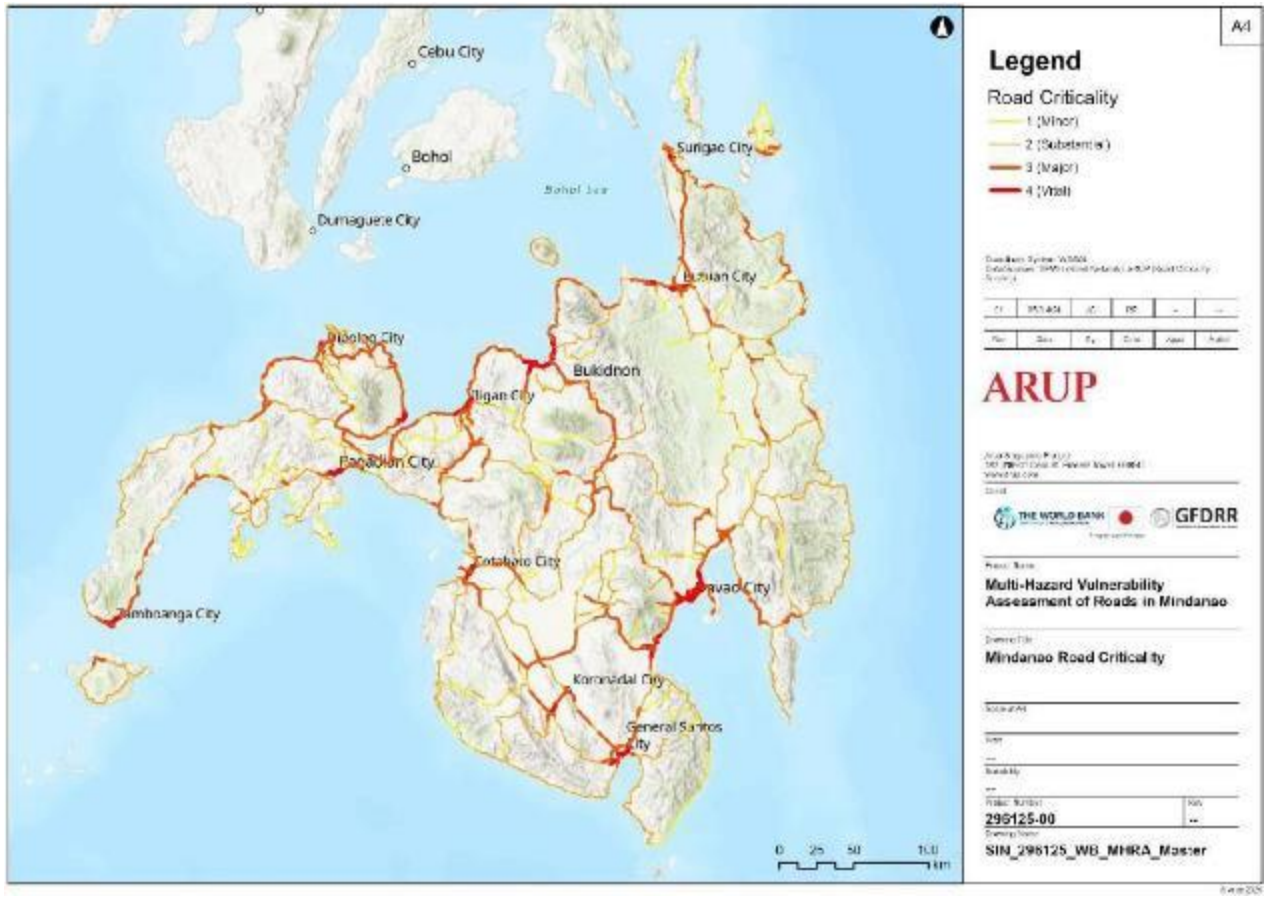
| Category and Criteria Name | | Weight | Criticality Score / Scoring Band Definition | | | |
|---|---|---|---|---|---|---|
| **A.** | **Network and Demand** | **40%** | **4** (Vital) | **3** (Major) | **2** (Substantial) | **1** (Minor) |
| A.1 | Road Hierarchy | 25.0% | National Primary | National Secondary | National Tertiary | Local Road |
| A.2 | Traffic Volume | 15.0% | >11,200 AADT | 7,000-11,200 AADT | 3,500-7,000 AADT | <3,500 AADT |
| **B.** | **Access for Economic Activities** | **30%** | **4** (Vital) | **3** (Major) | **2** (Substantial) | **1** (Minor) |
| B.1 | Access to Strategic Transport Nodes (STN) | 15.0% | **>5** STNs within 5km catchment | **3-5** STNs within 5km catchment | **1-2** STNs within 5km catchment | **0** STNs within 5km catchment |
| B.2 | Access to Economic Centres | 15.0% | **>9** Ecozones within 5km catchment | **2-9** Ecozones within 5km catchment | **1** Ecozone within 5km catchment | **0** Ecozones within 5km catchment |
| **C.** | **Access for Disaster Response** | **30%** | **4** (Vital) | **3** (Major) | **2** (Substantial) | **1** (Minor) |
| C.1 | Access to Hospitals and Major Healthcare Facilities | 10.0% | **>4** Hospitals within 1km catchment | **2-4** Hospitals within 1km catchment | **1** Hospital within 1km catchment | **0** Hospitals within 1km catchment |
| C.2 | Access to Evacuation Centres | 10.0% | **>4** Evacuation Centres within 1km catchment | **2-4** Evacuation Centres within 1km catchment | **1** Evacuation Centres within 1km catchment | **0** Evacuation Centres within 1km catchment |
| C.3 | Access to Power Stations and Substations | 10.0% | **3** Major utility assets within 5km catchment | **2** Major utility assets within 5km catchment | **1** Major utility asset within 5km catchment | **0** Major utility assets within 5km catchment |
| | **Total** | **100%** | **Total Weighted Average Score (per road segment)** | | | |

# Criticality Results

The final results of the criticality analysis help DPWH and stakeholders in Mindanao to identify priority road sections for socio-economic importance and input data to the total risk score.

Criticality Scoring Results

- 4 (Vital) = 3.3% of roads (313 km)
- 3 (Major) = 23.5% of roads (2,265 km)
- 2 (Substantial) = 54.6% of roads (5,265 km)
- 1 (Minor) = 18.6% of roads (1,800 km)



# Key Findings for Mindanao

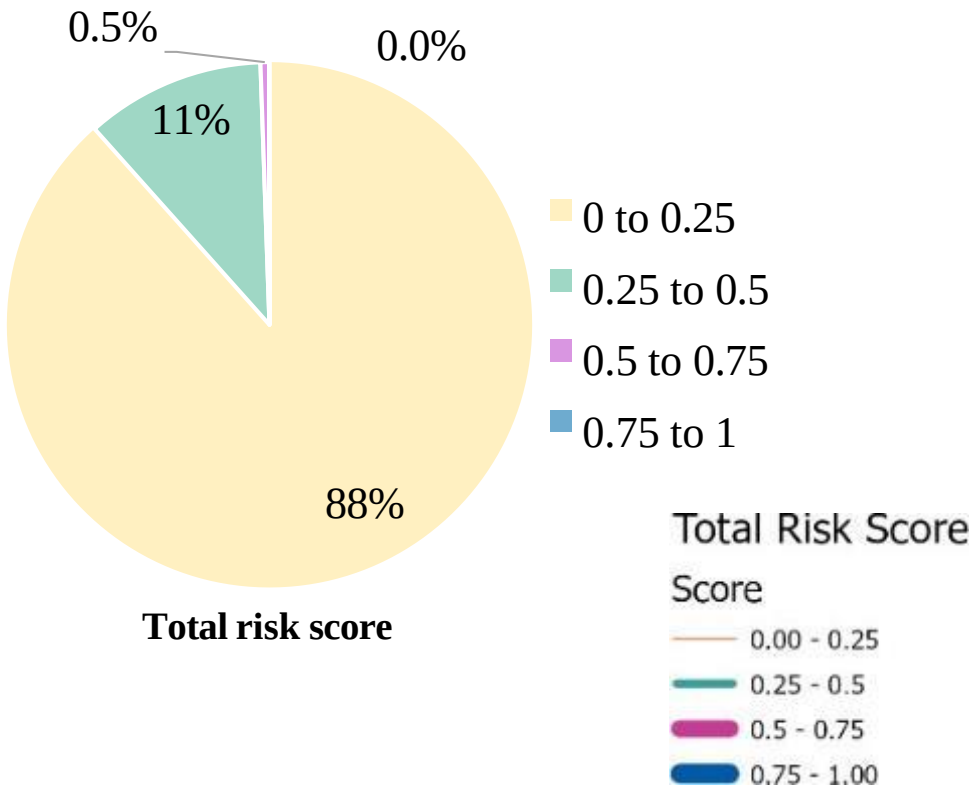


## Total Risk

$$Total\ Risk\ Score = PRS * (1 + CS)$$

*Criticality Score*

*Physical Risk Score*



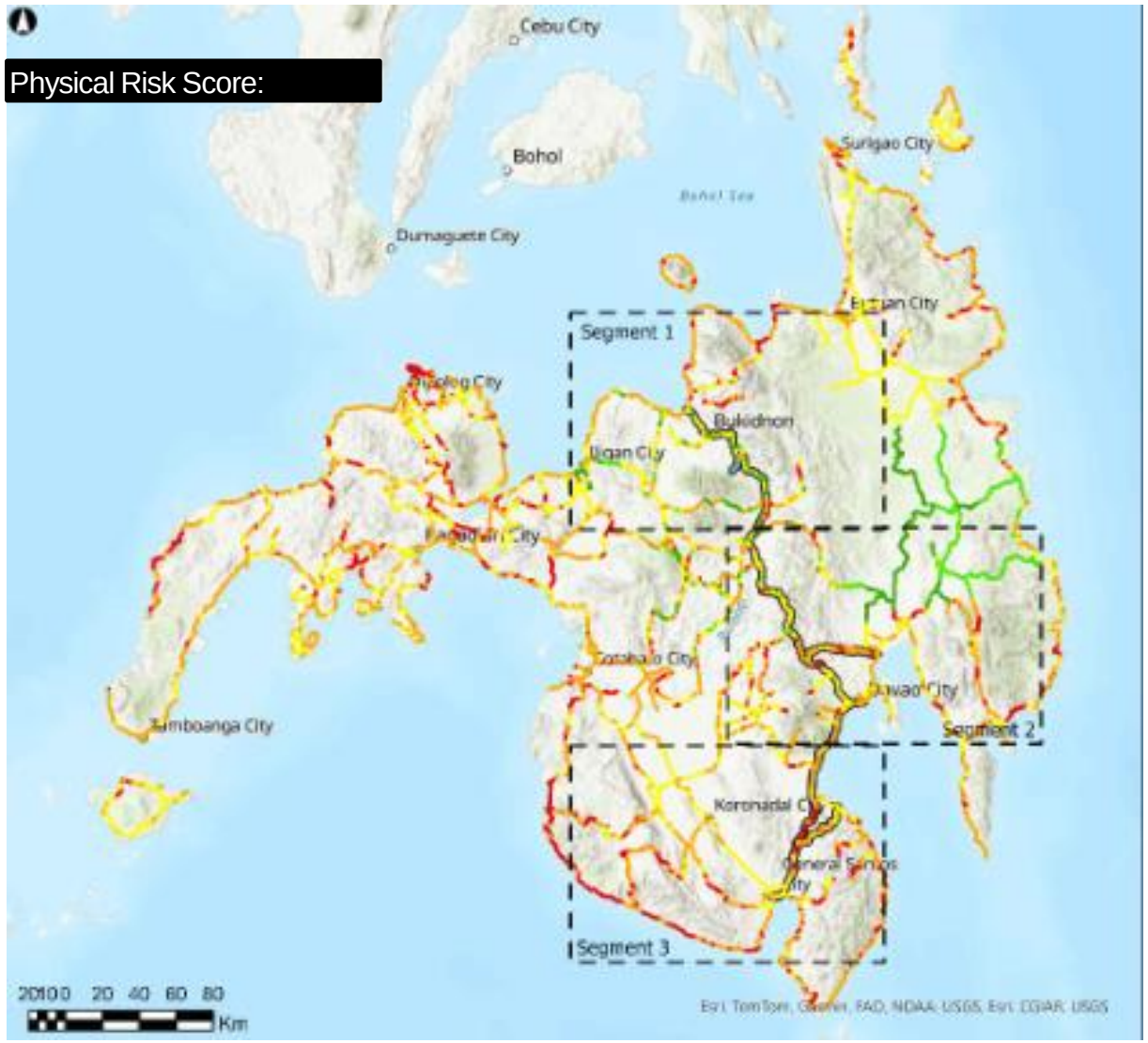

**Total risk score**




# Application for the roads of the Mindanao Transport Connectivity Improvement Project (MTCIP)



Physical Risk Score:




Total Risk Score:

# 3 | Risk Mitigation Interventions

# A risk mitigation intervention framework for roads

## A Pavements

- A1 Materials and coatings for resistance
- A2 Structural design changes
- A3 Sealants and expansion joints
- A4 Soil embankment
- A5 Rockfall and debris protection

## B Geotechnics

- B1 Hard reinforcements
- B2 Alternative reinforcements
- B3 Resistance
- B4 Road realignment and raising
- B5 Coastal and riverside erosion protection

## C Drainage and flow control

- C1 Design drainage with additional capacity
- C2 Design waterways with additional capacity
- C3 Flow control and retention facilities
- C4 Slope and subsurface drainage
- C5 Drainage protection

## D Bridges

- D1 Design for hazard resistance
- D2 Hard reinforcements
- D3 Alternative reinforcements
- D4 Modular bridges
- D5 Scour reduction and resistance

## E Nature-based solutions

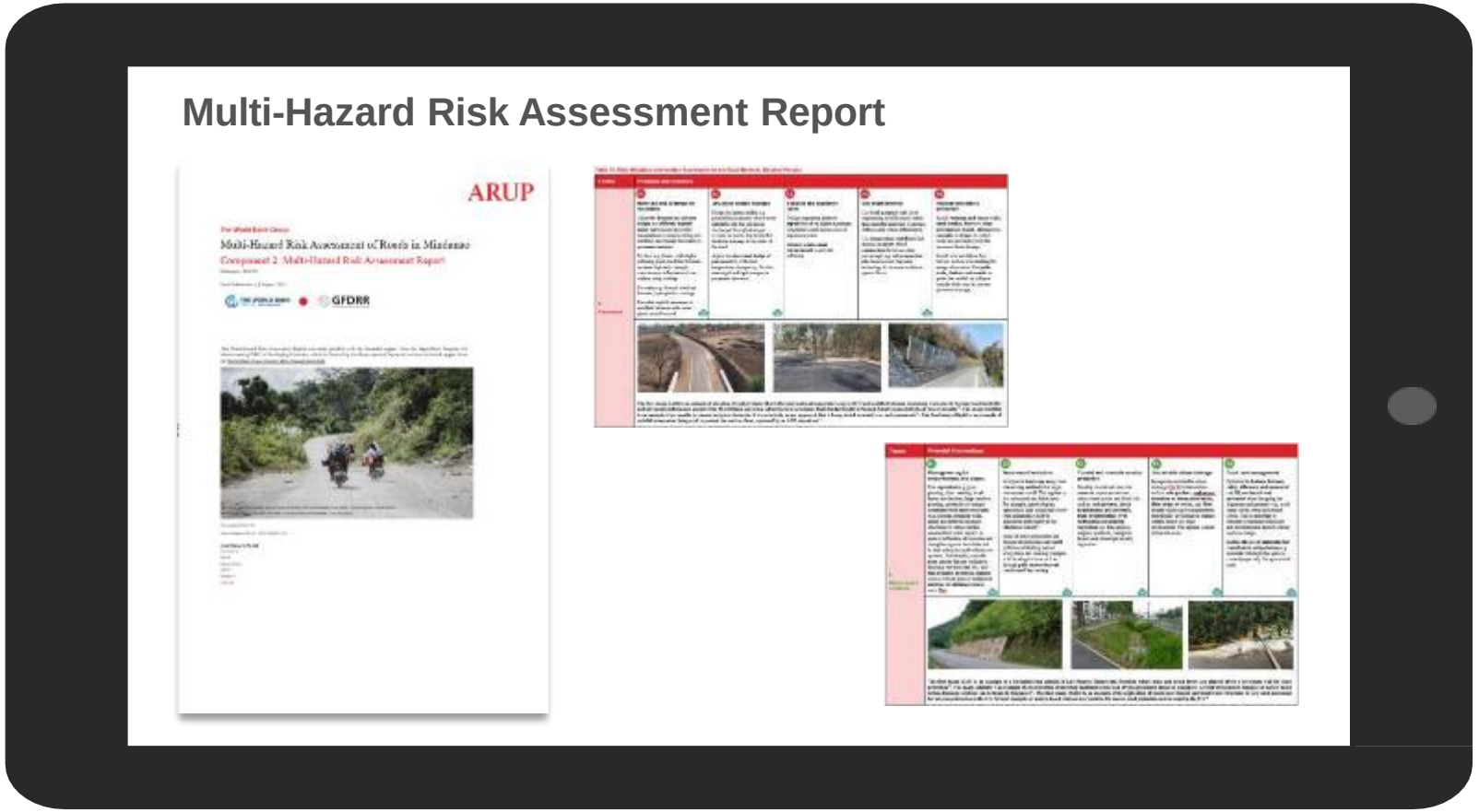
- E1 Bioengineering for embankment and slopes
- E2 Water runoff reduction
- E3 Coastal and riverside erosion protection
- E4 Sustainable urban damage
- E5 Good land management

## F Enabling environment

- F1 Planning and policy
- F2 Operations and maintenance
- F3 Emergency preparedness and response
- F4 Human and financial capacity
- F5 Research and innovation

# Detailed description and implementation examples of interventions are available

## Road Risk Mitigation Interventions Framework: **Detailed** Version




The full Component 2 report of this TA contains detailed descriptions under each intervention type

# Highlights of the Study

- In Mindanao, the highest contributor to overall risk of the road network is riverine flood risk and the lowest contributor is seismic risk.

- The spatial extent of the risks in the road network for each hazard are very different and have only particular areas where more than one risk plays a role.
  - Storm surge risk is concentrated at the outer edges of Mindanao in the flat coastal areas,
  - Landslide risk is more prevalent in the mountainous central part of the province.
  - Seismic risk is more homogenous throughout the province, but it still follows some areas of higher seismicity
  - riverine flooding is concentrated in specific valleys or around rivers.
- Despite the differences in spatial impact, most of the roads are at risk from more than one hazard.

- A menu of suggested interventions should be embraced as part of detailed design of projects.

# Thank You !

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