Transport Asset Management: Geohazard Perspective

Akiko Toya
Major Road Geohazards

- Glacial Lake Outburst Floods
- Avalanche
- Volcano
- Earthquakes, Liquefaction
- Tsunami
- Landslides, Rock Slides, Debris Flows
- Mud Slide
<table>
<thead>
<tr>
<th><strong>Infrastructure is built in highly hazard prone areas</strong></th>
<th><strong>Risk assessments are not properly used in planning</strong></th>
<th><strong>Policy and planning don’t address disaster and climate risks</strong></th>
<th><strong>Options needed for connectivity (redundancy)</strong></th>
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</thead>
<tbody>
<tr>
<td>Proper geotechnical studies are not carried out</td>
<td>Design codes and standards are not updated</td>
<td>Infrastructure is not designed for safe failure</td>
<td>Tools needed to address these vulnerabilities</td>
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<tr>
<td>Poor industry capacity</td>
<td>High upfront costs</td>
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<thead>
<tr>
<th><strong>Lack of updated and easily accessible asset management system</strong></th>
<th><strong>Lack of funding and political will for resilience and maintenance</strong></th>
<th><strong>Infrastructure is poorly maintained</strong></th>
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<tr>
<td>Disaster recovery process and protocols are needed</td>
<td>Poor financial planning</td>
<td>Poor understanding of systems functioning in the aftermath of a disaster</td>
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Multi-dimensional Approach to Geohazard Risk Management: Landscape Perspective

Building a resilient transport network by incorporating:
- people
- environment
- hydrology
- geology
- transportation infrastructure

Traditional approach:
- reactive and remediates hazards as they occur

Proactive approach:
- evaluates hazards,
- monitors the network
- manages the infrastructure

*can result in 60-80% life-cycle cost savings*
Geohazard Risk Management Objectives

One

Improve understanding of geohazard risk through:
✓ Better institutional coordination
✓ Disaster-Resilient Infrastructure Life Cycle Approach
✓ Risk-based Transport Asset Management

Two

Minimize risk on:
✓ New roads alignment
✓ Realignment of existing roads
✓ People, infrastructure asset, and environment

Three

Protect people through:
✓ Early warning systems
✓ Precautionary road closures
✓ Emergency preparedness and response services

Four

Planning for:
✓ Risk financing and insurance
✓ Efficient recovery and reconstruction
✓ Build Back Better
Transport Asset Management includes:

- Geohazard risk assessment from landscape perspective
- Hazard monitoring
- Early warning system
- Structural measures
- Emergency preparedness and response plan
- Institutional coordination and management
# Framework and Workflow for Road Geohazard Risk Management

## Main Handbook

### Part II: Institutional Capacity and Coordination
- Institutional setup
  - Laws, regulations, and technical standards
  - National or subnational plans or strategies
  - Mechanisms for implementation

### Part III: Systems Planning
- Risk identification, assessment, and evaluation of geohazard
- Disaster awareness

### Part IV: Engineering and Design
- Geohazard risk management planning
  - For new roads
  - For existing roads

### Part V: Operations and Maintenance
- Operations and maintenance of engineered solutions
- Nonengineered solutions
- Asset management as a response

### Part VI: Contingency Programming
- Postdisaster response and recovery

## Appendix A (Model ToRs)

<table>
<thead>
<tr>
<th>PART OF HANDBOOK</th>
<th>KEY CONCEPTS</th>
<th>TERMS OF REFERENCE (TOR) (REFER TO APPENDIX A)</th>
</tr>
</thead>
</table>
| **Part II: Institutional Capacity and Coordination** | Institutional setup  
  - Laws, regulations, and technical standards  
  - National or subnational plans or strategies  
  - Mechanisms for implementation | ToR 1: Institutional Capacity Review and Target Setting |
| **Part III: Systems Planning** | Risk identification, assessment, and evaluation of geohazard  
  - Disaster awareness | ToR 2: Systems Planning: Risk Identification, Assessment, and Evaluation  
ToR 3: Development of Manual for Promotion of Road Disaster Awareness and Partnership |
| **Part IV: Engineering and Design** | Geohazard risk management planning  
  - For new roads  
  - For existing roads | ToR 4: Design of Structural Measures |
| **Part V: Operations and Maintenance** | Operations and maintenance of engineered solutions  
  - Nonengineered solutions  
  - Asset management as a response | ToR 5: Development of Manual for Operation and Maintenance for Road Geotechnical Assets, and Implementation of a Road Geotechnical Asset Management Information System (AMIS)  
ToR 6: Development of Emergency Information System |
| **Part VI: Contingency Programming** | Postdisaster response and recovery | ToR 7: Development of Manual for Postdisaster Response and Recovery |
# 1. Institutional Capacity and Coordination

## Structure of Institutions and Stakeholders in Coordination Mechanisms for Road Geohazard Risk Management

<table>
<thead>
<tr>
<th>RELATED AUTHORITIES</th>
</tr>
</thead>
<tbody>
<tr>
<td>• River or landscape ecosystem management authorities (including water-induced geohazard risk management)</td>
</tr>
<tr>
<td>• Environmental authorities (environmental management including roads)</td>
</tr>
<tr>
<td>• Disaster risk management authorities (overall disaster risk management including road geohazards)</td>
</tr>
</tbody>
</table>

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<tr>
<th>EXECUTIVES OF NATIONAL AND SUBNATIONAL GOVERNMENTS</th>
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<td>(usually lead the road management authorities)</td>
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<tr>
<th>TECHNICAL SUPPORTERS</th>
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<tr>
<td>• Technical institutions for roads or geohazard risk management (research and technical development for road geohazard risk management)</td>
</tr>
<tr>
<td>• Meteorological agencies (meteorological data collection and weather forecasting, early warning for geohazard risk under abnormal weather forecasts)</td>
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<tr>
<th>NATIONAL AND SUBNATIONAL DEVELOPMENT AUTHORITIES</th>
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<td>(lead agency over road management)</td>
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<table>
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<tr>
<th>ROAD MANAGEMENT AUTHORITIES</th>
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<td>(road administration including road geohazard risk management)</td>
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<th>ROAD USERS AND ROADSIDE STAKEHOLDERS</th>
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<td>• Road users: all modes of travel; public, private, and commercial users</td>
</tr>
<tr>
<td>• Residents, business establishments, and other persons along the roads</td>
</tr>
<tr>
<td>• Public transport companies and associations</td>
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<th>SERVICE AGENCIES OR BUSINESSES USING ROAD SPACE</th>
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<td>(water supply, drainage, electricity, communication, fuel, and other companies that install facilities on the roadside or road subsurface)</td>
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<th>SUPPORTERS OF ROAD USERS AND ROADSIDE STAKEHOLDERS</th>
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<td>• Police departments (traffic regulation, traffic accident inspection)</td>
</tr>
<tr>
<td>• Rescue agencies (rescue of geohazard victims)</td>
</tr>
<tr>
<td>• Health organizations (medical care of geohazard victims)</td>
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</table>
2. Systems Planning

Understanding the fundamental equation of risk

Poverty, Inadequate designs, Aging infrastructure...

Climate change

Natural Hazards

Unplanned land use, Urbanization

Vulnerability

Exposure

Climate/Disaster Risks
2. Systems Planning

The traditional way of making decisions

Predict → Act

- Future climate from projections
- Planning infrastructure for the future
- Emissions scenarios
- Hydrological models
- Global models
- GCM initial conditions
- Downscaling methods
2. Systems Planning

Decision Making under Deep Uncertainty (DMDU)

1. Determine the criticality of a road link
2. Determine the exposure of the road link to geohazard events
3. Determine the vulnerability of the road link to geohazard events
4. Determine the risk to the infrastructure (expected annual damage to the infrastructure)
5. Calculate the resultant priority of the road link.
WB developed a model for Mozambique to:

- Quantify network criticality
- Estimate flood damage to infrastructure
- Estimate network disruption from floods
- Quantify costs and benefits from interventions
- Identify uncertainties
3. Engineering and Design

• Innovative materials, design standards and specifications that enhance robustness and flexibility of infrastructure.

• Conducting hazard assessment of project site to identify and reduce risks of and around infrastructure.

• Conducting infrastructure level vulnerability assessments to identify points of weakness and identify what preventative measures and response mechanisms could be put in place to reduce the likelihood of failure or for ensuring safe failure.
Landscape Ecosystem Management Facilities to Mitigate Road Riverside Erosion and Flow-Type Geohazards

3. Engineering and Design
4. Operations and Maintenance

Asset Management Process

- Understand and Define Requirements
  - Develop the AM Policy
  - Define Levels of Service and Performance
  - Forecast Future Demand
  - Understand the Asset Base (the asset register)
  - Assess Asset Condition
  - Identify Asset and Business Risk

- Develop Asset Life-Cycle Strategies
  - 2. How will it be paid for?
    - Financial and Funding Strategies
  - Capital Works Strategies and Plans
  - Maintenance Strategies and Plans
  - Operational Strategies and Plans

- Asset Management Enablers
  - Asset Management Teams
  - Asset Management Plans
  - Information Systems & Tools
  - Asset Management Service Delivery
  - Quality Management
  - Continuous Improvement
5. Emergency Preparedness, Response, and Recovery

Organize and facilitate inter-sectoral, inter-institutional, multi-stakeholders framed recovery in five key areas:

1. Policy Development for Recovery;
2. Institutional Framework for Recovery;
3. Prioritization and Sequencing of Recovery;
4. Recovery Financing Strategy; and
5. Implementation Arrangements, Monitoring and Evaluation.
Comprehensive Risk Management: “Buying Down the Risk”

Risk Reduction Tools:
- Initial Risk
- Zoning
- Building Regulations
- Early Warning System
- Engagement Awareness Campaigns
- Improved Drainage
- Structural Defenses

Residual Risk

Source: World Bank (2017 A)
Geohazard Risk Management in Transport Sector Community of Practice

https://collaboration.worldbank.org/groups/geohazard-risk-management-for-transport
Geohazard Perspective: Transport Asset Management

Orange: People

Brown: Soil properties and Geology

Blue: Hydrology

Green: Ecology

Grey: Infrastructure
Some Examples of Geohazards & their Definitions

**Fall (rockfall)**
a rapid gravity free fall movement of a mass of rock or soil

**Collapse (Rocks)**
a gravity movement of soil or rock, often as a result of artificial factors

**Collapse (Soil)**
a gravity movement of soil or rock, often as a result of artificial factors

**Slide**
a mass movement of earth, snow, or rock under shear mode along one or several sliding surfaces

**Flow**
a movement that exhibits a continuity of motion and a plastic or semifluid behavior with water

**Erosion (River Erosion)**
a movement of rock fragments or soil particles from one place to another usually by water
Typical Structural Measures for Mountainside Fall or Collapse

- Removed (soil) portion
- Cutting line
- Berm
- Ditch
- Slope cutting

- Slope Cutting or Removal
- Unstable area
- Rock bolt
- Road
- Rock bolting
- Stable Rock Mass
- Rock bolt
- Unstable Rock
- Fissured Rock
- Shotcrete
- Shotcrete or Vegetation
- Road
- Shotcrete (spraying)
- Armoured concrete beam

- Rock Bolting and Shotcrete for Slope Reinforcement for Mountainside Fall or Collapse
- Framework (Grid Beam) for Slope Reinforcement for Mountainside Fall or Collapse

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