12th Disaster Risk Management Seminar
Organized by the World Bank Tokyo Office and
the World Bank Disaster Risk Management Hub, Tokyo

Road to Resilience: Managing Geohazards for Less Risky Roads in Developing Countries

Geohazard Management Approach to Roads

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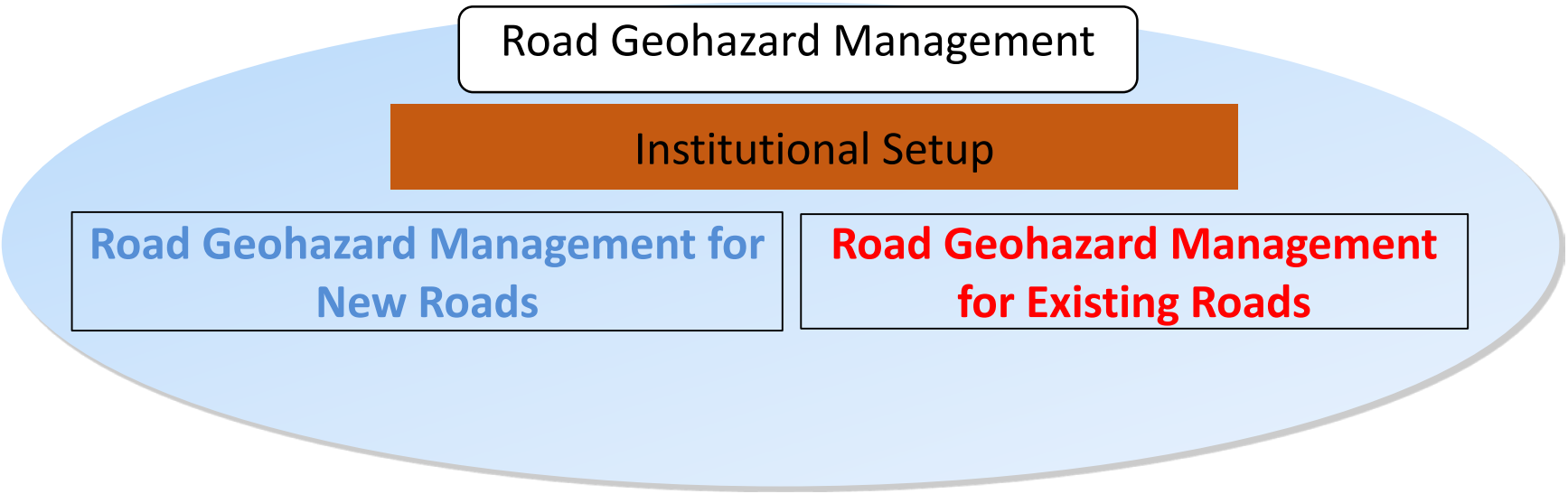
1. Framework of Road Geohazard Management (1/2)

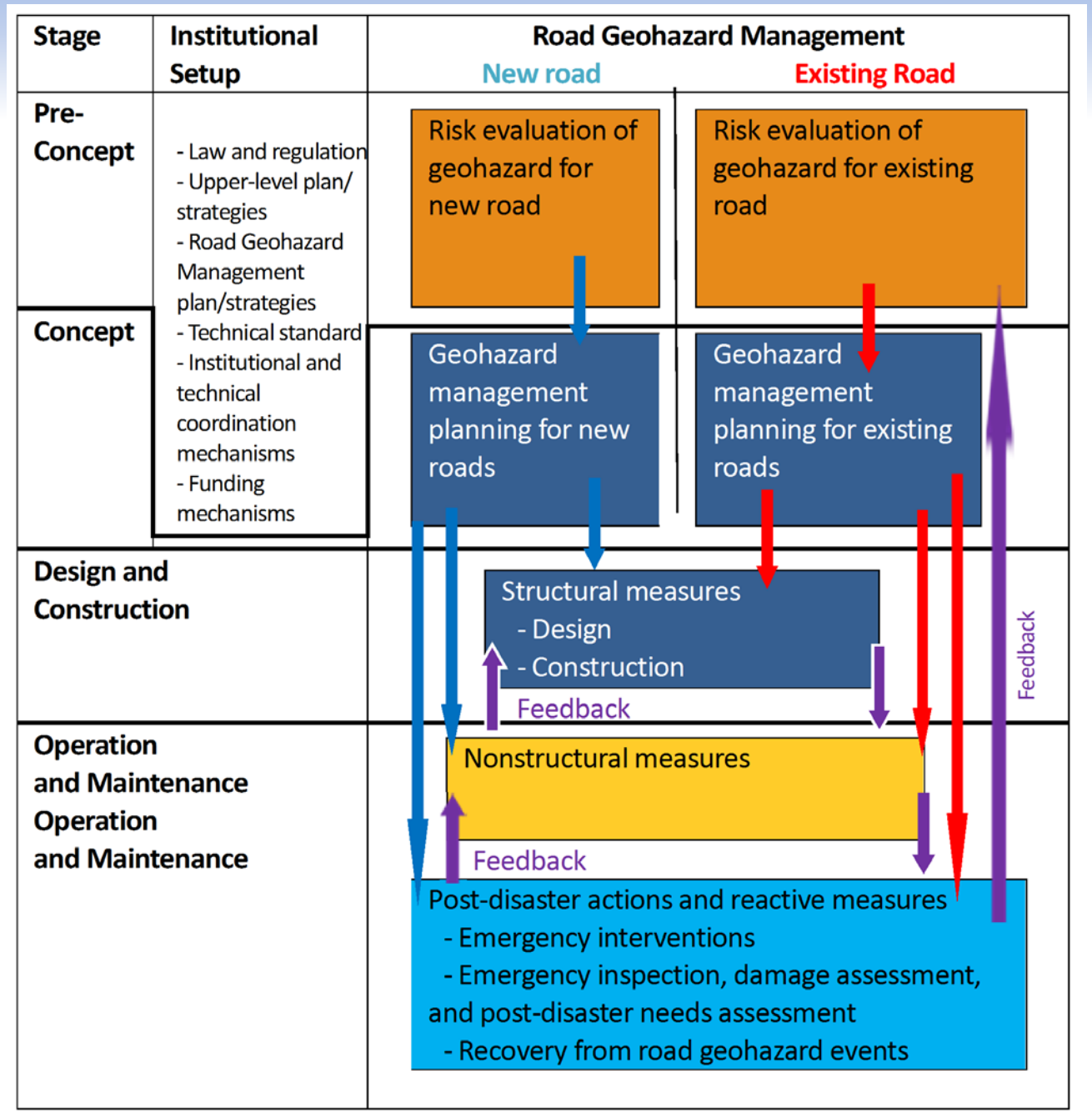
Road Geohazard Management covers three related main elements :



An adequate institutional framework is a necessary condition to guarantee proper road geohazard management.
The road geohazard management process for new and existing roads differs only in the risk assessment and geohazard management planning stages.
Proactive structural and nonstructural measures, postdisaster actions, and reactive measures are common to both new and existing roads.

1. Framework of Road Geohazard Management (2/2)

The color of each box corresponds with the color of action of the Global Facility for Disasters Reduction and Recovery (GFDRR)

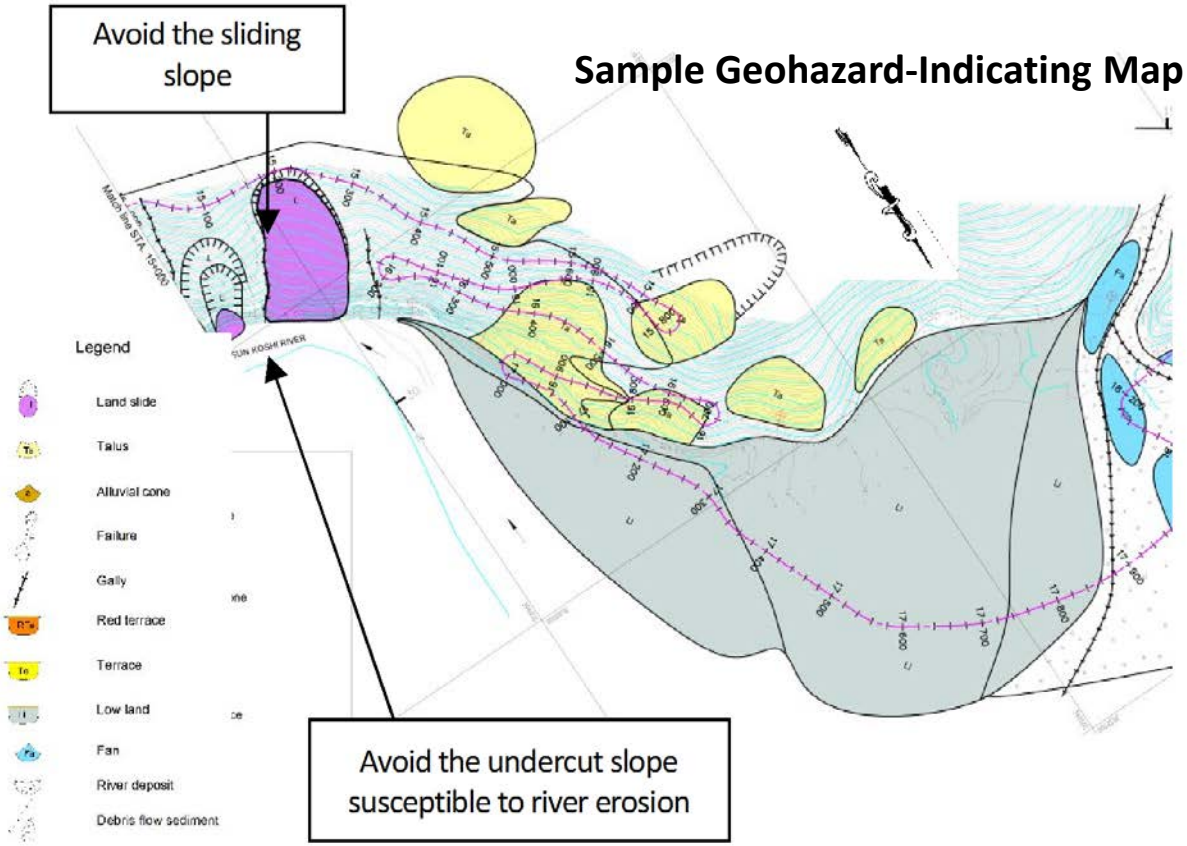


2. Pre-concept (Risk Identification)

a. The Primary Purpose and An Example of Risk Evaluation (Geohazard Indicating Map) for New Road

- The primary purpose of geohazard risk evaluation for new roads is to guarantee that road management authorities make proper decisions on new road alignments to avoid hazardous locations as much as possible.

Sample Geohazard-Indicating Map for a New Road



Source: ©Hiroaki Tauchi / World Bank.
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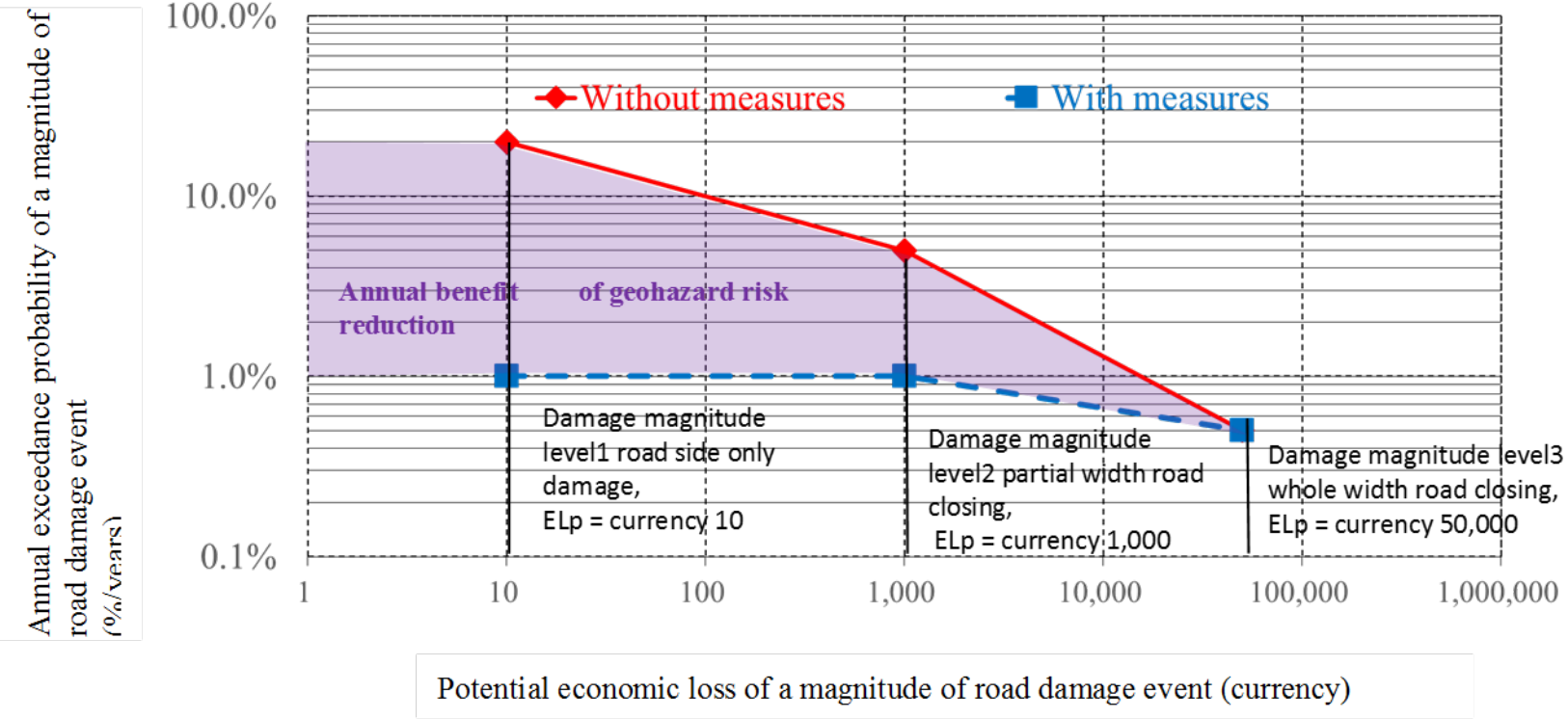
Note: Map is a fictitious example.

2. Pre-concept (Risk Identification)

b. Essential Concept Risk Evaluation for Existing Road (an Endangered Road Location)

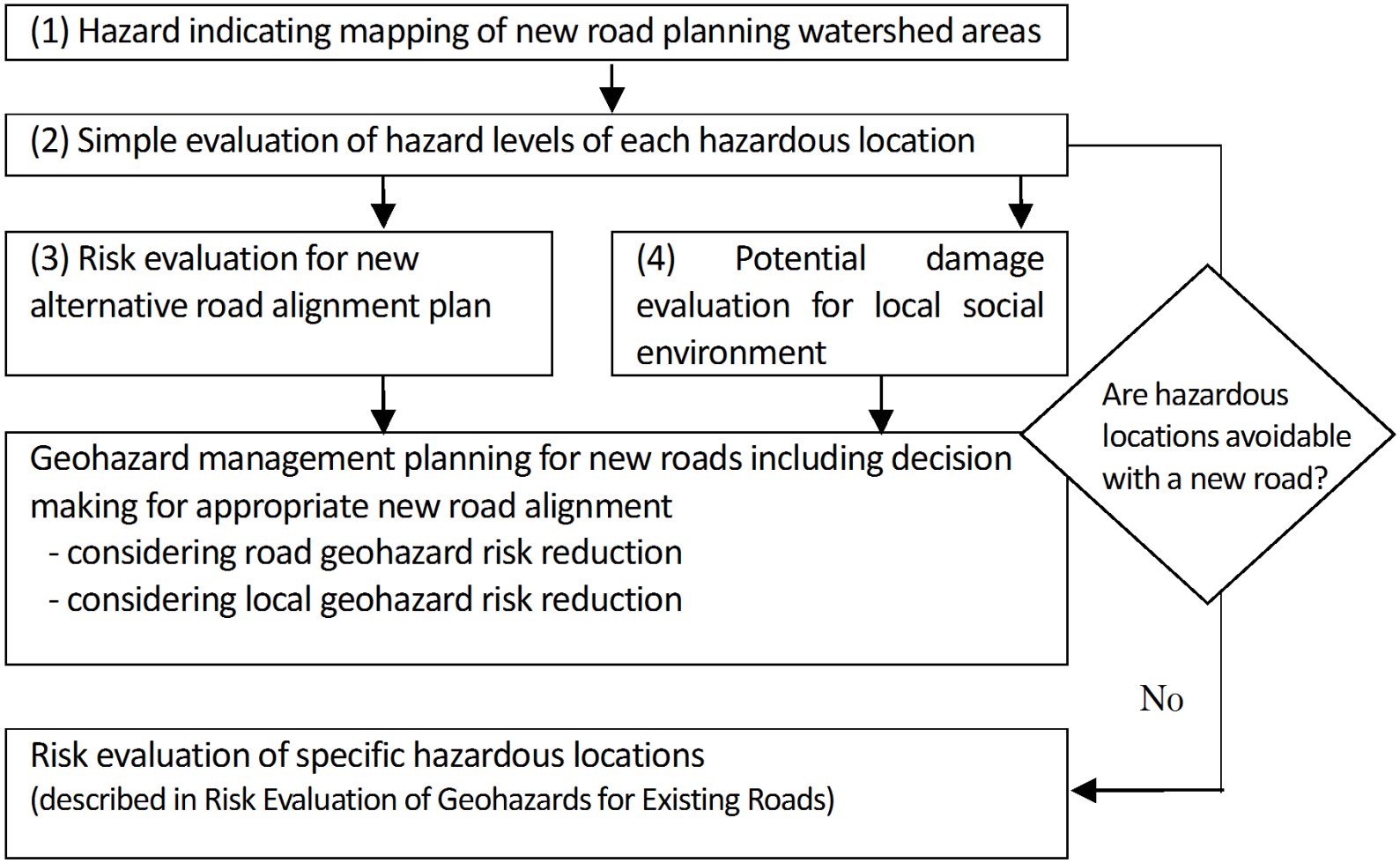
- The primary purpose of geohazard risk evaluation for existing roads is to identify and prioritize endangered road locations to plan the road geohazard management for those specific geohazard-prone road subsections or endangered road locations



Example of Risk Estimation as potential Annual Loss

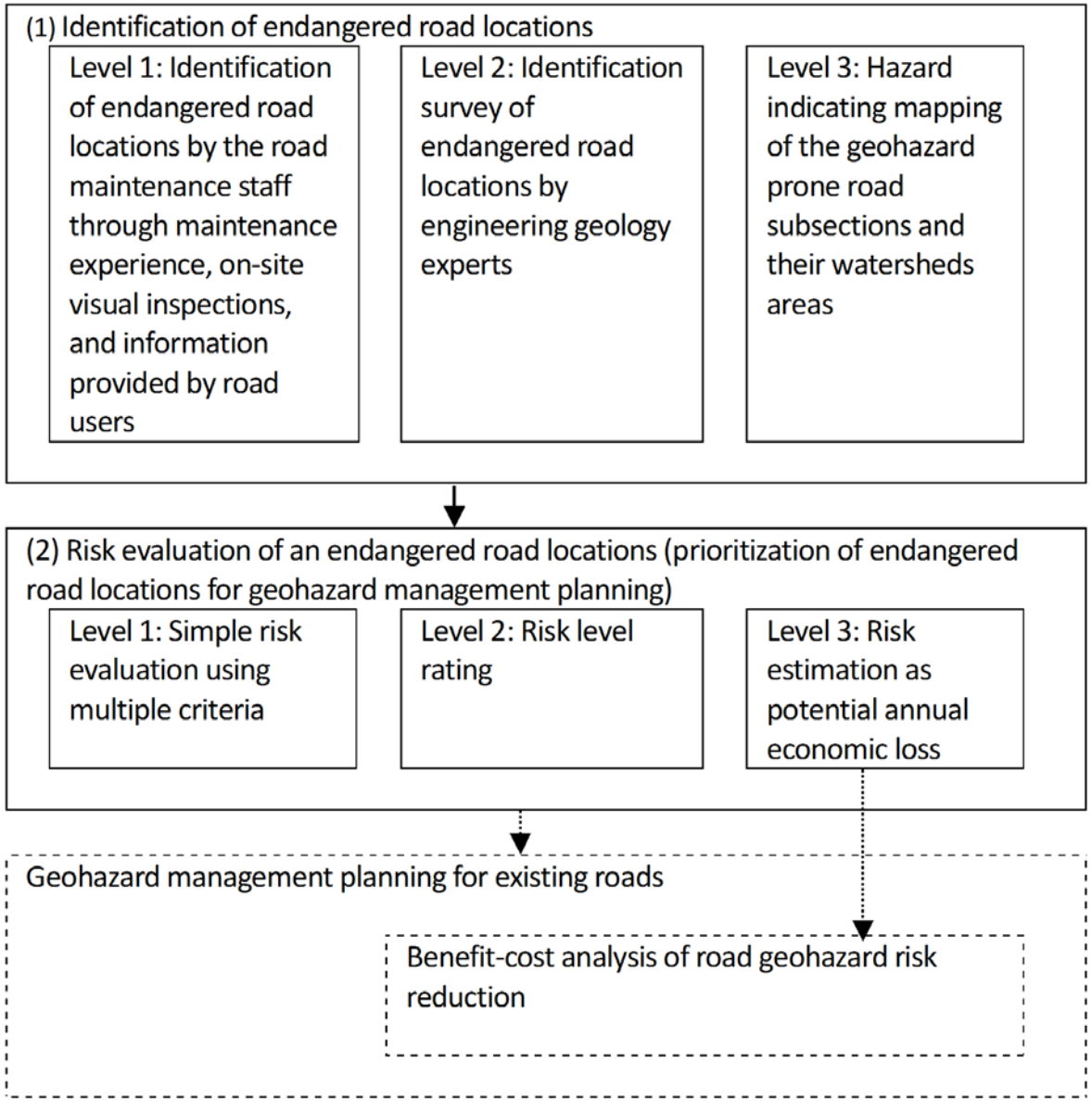
2. Pre-concept (Risk Identification)

c. Diagram for Risk Evaluation for New Road



2. Pre-concept (Risk Identification)

d. Diagram for Risk Evaluation for Existing Road



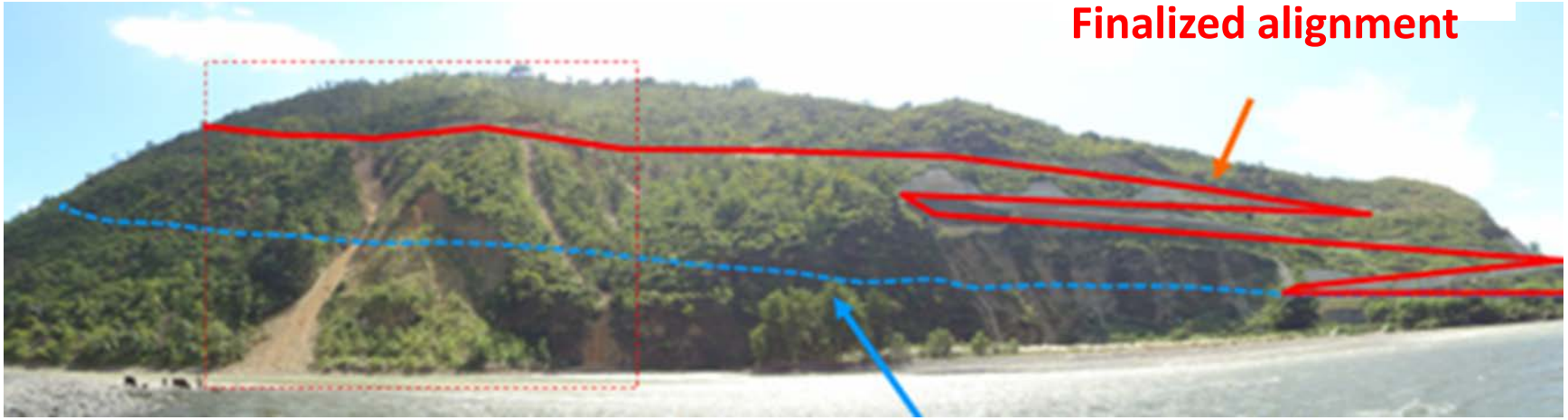
3. Concept (Risk Reduction)

a. Recommended Road Geohazard Management Strategy by Road Type

Road type	Recommended Road Geohazard Management Strategy
Urban, Inter-urban, Paved, High volume	All-weather road. Functionally operational even during extreme weather conditions such as storms. (In case of heavy rain, strong winds and any other dangerous situation for high-speed driving, road management authorities may regulate the traffic)
Rural, Unpaved, Low volume	Non-all weather road. Temporary road closing is a precondition for Road Geohazard Management efficiency. An efficient recovery maintenance system (staffing, machinery, etc.) should be set up.

3. Concept (Risk Reduction)

b. Avoidance of Geohazards for New Road Alignments at the Conceptual Stage



An Example of a Road Alignment Plan to Avoid Geohazards

The road alignment was shifted up the mountain to avoid an area of unstable collapse-type geohazard, and the undercut slope susceptible to river erosion. Although the total length of the road became longer, significant life cycle costs can be saved.

(Source: JICA/Government of Nepal, Japanese Grant, Banepa - Sindhuli –Bardibas Road Project)

3. Concept (Risk Reduction)

c. Concept of Risk Retention at the Conceptual Stage

Ford River Crossing (Armor the Driving Surface)

Ford River Crossing - without Culvert
This type is for a river whose water level presents a problem only during floods. This type of bridge allows the flow of flood waters to cross over the carriageway. It is used on rivers with gentle gradient riverbeds.

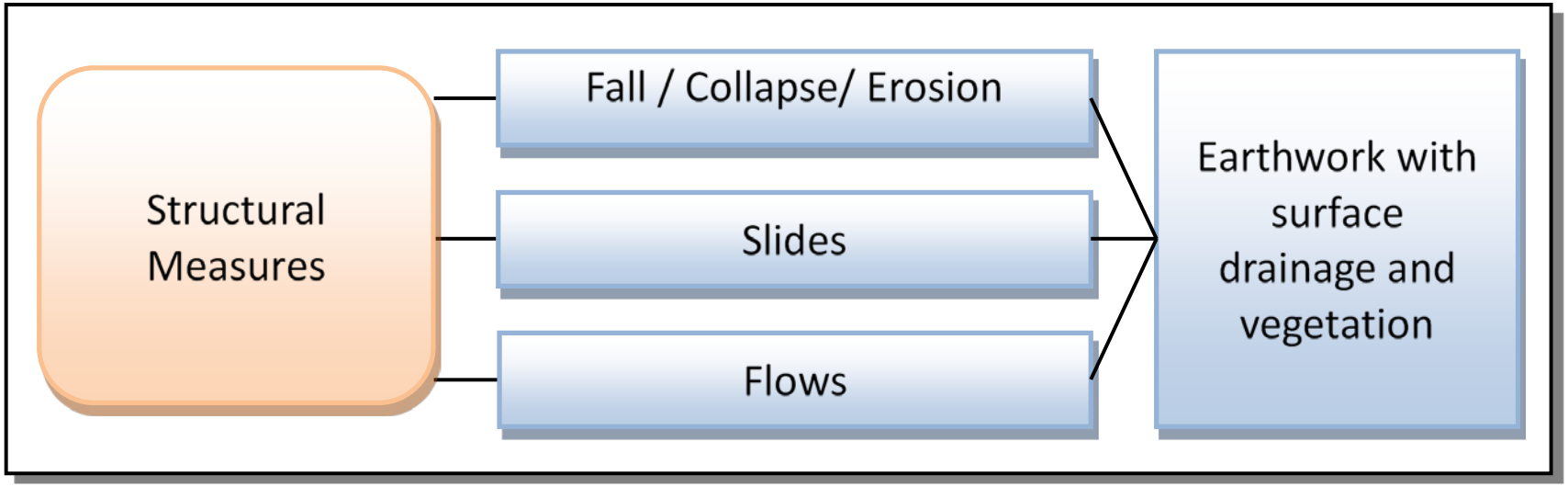
River crossing - with Culvert
This type is for a river where water also flows during normal times, not just during floods.

Ford River crossing - Continuous Box Type
This type is applied to large flow rate rivers. The design concept allows flood waters over the carriageway.

4. Design + Construction
(Risk Reduction by Structural Measures)

a. Explanation of Structural Measures

Structural measure include (a) emergency protection works in highly susceptible areas or during geohazard events, and (b) reactive measures conducted as secondary damage protection or recovery works in a postdisaster stage.



Structural measures include structures made of concrete or mortar, steel, wood, asphalt, geosynthetics, earth, and vegetation or bioengineering as well as their composites.

4. Design + Construction (Risk Reduction by Structural Measures)

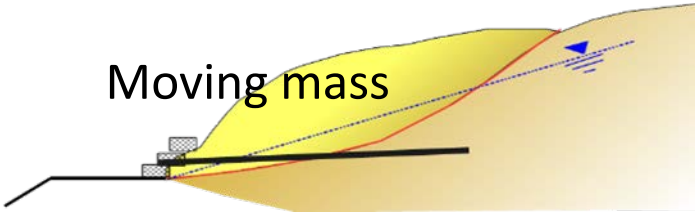
b. Slope Framework (Grid Beam) with Anchoring

Slope Protection Works at Sindhuli Road, National Road No.6 Nepal in 2014 through a Japanese Grant (JICA)

Photo taken by Tauchi Hiroaki, Nippon Koei. Co. Ltd.

4. Design + Construction (Risk Reduction)

c. Drilled Subsurface Grand Water Drainage



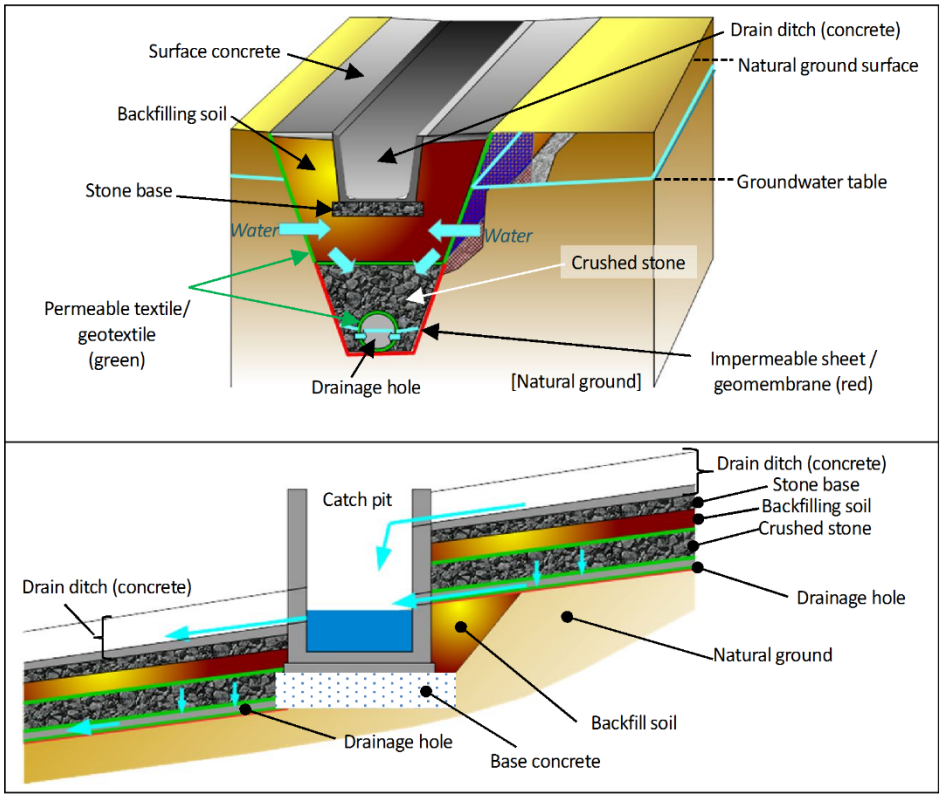
Source: Ministry of Public Works, Transport, Housing and Urban Development, Government of El Salvador, road closing January 2009.

This drilling operation, in El Salvador, was managed by the JICA Technical Cooperation Project team, April 2013.

Source: Edenilson Quintanilla / Japan International Cooperation Agency (JICA). ©JICA. Reproduced, with permission, from JICA; further permission required for reuse.

4. Design + Construction (Risk Reduction)

d. Surface-Groundwater Collecting Conduit with Ground Surface Drainage at Catch Pit



Source: Kenichi Tanaka, Nippon Koei Co.

The site is a section of the Sindhuli-Bardiabas Road in Nepal, August 2014.

Source: Mikihiro Mori / Japan International Cooperation Agency (JICA). ©JICA. Reproduced, with permission, from JICA; further permission required for reuse.

5. Operation & Maintenance (Preparedness and Resilient Recovery)

a. Explanation of Nonstructural Measures, Postdisaster Activities and Reactive Measures for Road Geohazards

- Nonstructural measures for road geohazards are any measures not involving physical construction. They are less expensive than structural measures and easier to set up. Nonstructural measures include risk avoidance methods to prevent vehicle damage and loss of human life and also seek to eansure efficient maintenance of the structural measures for geohzard risk management.
- The emergency inspection and postdisaster assessment are conducted together with nonstructural measures by the same staff responsible for the routine road maintenance while maintaining good communication with local public and private organizations. Reactive measures for recovery are subdivided into emergency recovery, repair, rehabilitation, and reconstruction.

5. Operation & Maintenance (Preparedness and Resilient Recovery)

b. Examples

i. Emergency Road Abnormality Report Number and Roadside Parking Pit for a Geohazard Prone Road Sub-section

A signboard showing the Emergency Road Abnormality Report Number (#9910) and the Road Needs Consultation Number (0185-58-5446) at a roadside parking pit

A Roadside Parking Pit in a Geohazard Prone Road Sub-section for Emergency Safety Parking and Reporting of Road Abnormalities to the Road Administration Office by Road Users

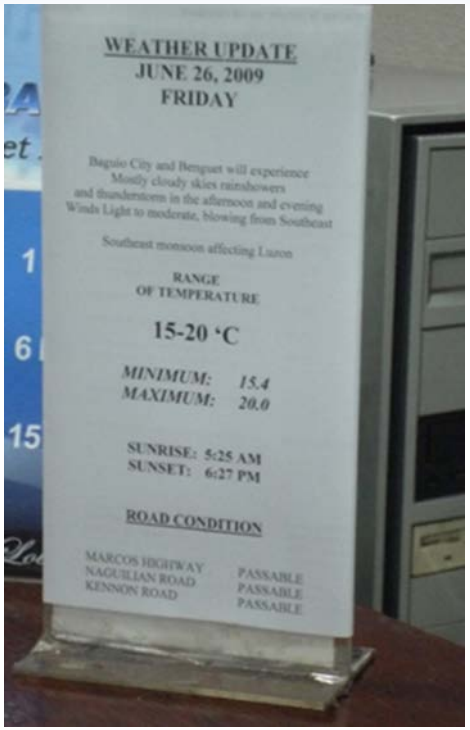
ii. Roadside Station (Michi-no-eki in Japanese) and their disaster management function including evacuation center and, road and disaster information (http://www.mlit.go.jp/road/Michi-no-Eki/)

Source: Road Public Relations Center Japan/Road Bureau, Ministry of Land, Infrastructure, Transport and Tourism (2005), Road in Japan 2005 version

Electronic Display Showing Road Information on Road Condition and the Corresponding Traffic Including Information on the Geohazard Situation

iii. Road Condition Emergency Information System including Early Warning or Precautionary Road Closure at the O&M Stage

Road condition information using electronic board in Nepal (installed through a JICA technical assistance project).
The information given includes road situation (passable or not) and early warning on geohazard event



Simple road condition information at the front desk of a hotel in Baguio City, Philippines.
The information given includes weather condition and whether the national highway is passable or not.

6. Conclusion

6.1 Expected Contribution of Japanese Road Geohazard Management Technology

- Technical Transfer on Advanced Structural Measures (including cost saving technology)
- Appropriate Nonstructural Measures (Accurate Criteria for Road Geohazard Warning or Precautionary Road Closure)
- Information and Communication Technology for Disaster Communication by Regional Disaster Management Partnerships

6.2 Key Elements on Road Geohazard Management

- Understanding the Road Geohazard Mechanism (Classification of Movement, Material, and Hazard Source Location along the Road)
- Appropriate Strategy including Risk Retention
- Accountability for Investments for Road Geohazard Risk Reduction (Cost-Benefit Analysis)