OUTPUTS FROM THE THIRD SOUTH-TO-SOUTH LEARNING WORKSHOP

STRENGTHENING GEOHAZARD RISK MANAGEMENT IN DRM AND TRANSPORT IN THE SOUTH ASIA REGION

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THE WORLD BANK
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Geohazard Risk Management in Transport Sector

GFDRR
Global Facility for Disaster Reduction and Recove

Cover photo was taken by Sam William Johnson

Geohazard
Risk Management
in Transport Sector

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Abbreviations

ANDMA	Afghanistan National Disaster Management Agency
BRO	Border Roads Organization (India)
CDEM	Civil Defence Emergency Management
CERA	Canterbury Earthquake Recovery Authority
DMC	Disaster Management Center (Sri Lanka)
DoC	Department of Conservation
DoLI	Department of Local Infrastructure
DoR	Department of Roads
DRM	Disaster Risk Management
DRR	Disaster Risk Reduction
ECI	Early Contractor Involvemen
EO4SD	Earth Observation for Sustainable Development
EQC	Earthquake Commission
ESA	European Space Agency
GDP	Gross Domestic Product
GFDRR	Global Facility for Disaster Reduction and Recovery
GNS	Institute of Geological and Nuclear Sciences Limited
GPDRR	Global Platform for Disaster Risk Reduction
GHRM	Geohazard Risk Management
HFA	Hyogo Framework for Action
IDNDR	International Decade for Natural Disaster Reduction
IFI	International Financial Institution
ISDR	International Strategy for Disaster Reduction
JICA	Japan International Cooperation Agency
KPI	Key Performance Indicator
LGA	Local Government Act
LIDAR	Light Detection and Ranging
LINZ	Land Information New Zealand
LS	Lump Sum
LTA	Land Transport Authority (Samoa)
M&V	Measurement And Verification
MAFFF	Ministry of Agriculture and Food, Forests and Fisheries (Tonga)
MBIE	Ministry of Business, Innovation and Employment
MCDEM	Ministry of Civil Defence and Emergency Management
MIA	Ministry of Internal Affairs (MIA) (Tonga)

MLSNR	Ministry of Lands, Survey & Natural Resources (Tonga)
MOI	Ministry of infrastructure (Tonga)
MoPIT	Ministry of Physical Infrastructure and Transport (Nepal)
MORTH	Ministry of Road Transport and Highways (India)
MoT	Ministry of Transport
MWTI	Ministry of Works, Transport and Infrastructure (Samoa)
NBRO	National Building Research Organization (Sri Lanka)
NCTIR	North Canterbury Transport Infrastructure Recovery
NDF	Natural Disaster Fund
NHAI	National Highways Authority of India
NHIDCL	National Highways & Infrastructure Development Corporation Limited (India)
NIWA	National Institute of Water and Atmospheric Research
NMRE	Ministry of Natural Resources and Environment (Samoa)
NZ	New Zealand
NZLC	New Zealand Lifelines Council
NZTA	New Zealand Transport Agency
O&M	Operations and Maintenance
PBC	Performance-based Contract
PGA	Peak Ground Acceleration
PGV	Peak Ground Velocity
PPP	Public-private Partnership
PRD	Provisional Road Development Authority (Sri Lanka)
PWD	Public Works Department (India)
RAMS	Road Asset Management System (Bhutan)
RDA	Road Development Authority (Sri Lanka)
RMA	Resource Management Act
ROMDAS	Road Measurement Data Acquisition System (Bhutan)
SAMS	Samoa Asset Management System
SDGs	Sustainable Development Goals
SFDRR	Sendai Framework for Disaster Risk Reduction
SH	State Highway
SSLW	South-to-South Learning Workshop
UNDRR	United Nations Office for Disaster Risk Reduction
UNFCCC	United Nations Framework Convention on Climate Change
UNISDR	United Nations Strategy for Disaster Reduction

Photo was taken by Masatsugu Takamatsu

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1 Workshop Overview

The Third South Asia Regional South-to-South Learning Workshop (SSLW) was organized by the Disaster Risk Management (DRM) and Climate Change Unit of the South Asia Region of the World Bank and held from April 29 to May 2, 2019. This is part of the Building Resilience to Landslide and Geohazard Risk in the South Asia Region program, which was launched in August 2016 with funding assistance from the European Commission and the Global Facility for Disaster Reduction and Recovery (GFDRR).

Because New Zealand is exposed to a range of geological hazards, being located in between two tectonic plates, and because it has adapted to geohazards, Wellington, New Zealand, was selected as the venue for the third SSLW. Furthermore, the country has a firm adherence to the disaster risk reduction global agendas, which is manifested in its excellent governance structure, policy framework, and institutional arrangement. The primary purpose of the SSLW is to help bolster the capability of the policymakers, practitioners, and specialists from counterpart agencies in the governments of Afghanistan, Bangladesh, Bhutan, India, Nepal, Pakistan, and Sri Lanka in their geohazard risk management (GHRM) function, with the vision of helping implement a sustainable and resilient transport sector in those countries. Thirty-six people, including resource persons and the World Bank team, participated in the workshop.[1] Taking advantage of the proximity and expected learning, Samoa and Tonga joined the workshop.

South Asian countries are mostly located in seismically active zones. As such, they are affected by numerous geohazards such as earthquakes, landslides, rockslides, rock falls, debris flows, mudflows, avalanches, and flash floods—all exacerbated by rough mountainous terrains. Earthquakes, rainfall, and snowfall can be a trigger for some of these hazards. Climate change, resulting in more frequent short, high-intensity rain downpours or prolonged rainfalls, could render the region more vulnerable. These countries must develop proactive strategies that will make their communities safe and stable in all aspects of life. South Asian countries, though they each have different hazard profiles, have many commonalities. This is the main reason that South-to-South learning is essential to gaining knowledge for practical application in their own countries.

Overall, the workshop aimed to achieve two outcomes: (i) to strengthen GHRM capacity in policy makers and practitioners; and (ii) to apply the workshop lessons to projects in each country to better implement GHRM practices in road assets to reduce social and economic damage from geohazards, as illustrated in the SSLW theory of change on GHRM (see Figure 1.1).

The SSLW facilitated an active exchange of knowledge and experience among participants, practitioners, experts, and organizers, who all were learners in GHRM.[2] This third SSLW program was built on two past geohazard workshops held in the South Asia Region—the first one in Kandy, Sri Lanka, and the second one in Kathmandu, Nepal—focusing on sharing project experience, challenges, and good practices in the South Asia Region (Appendix D summarizes the three SSLWs). Participants actively discussed the progress made on their action plans from 2017 to 2018, the challenges they faced, and how those challenges were addressed. New action plans for 2019, which they formulated during the workshop, were presented with enthusiasm, but with the caveat that the plans would undergo careful discussion and consideration once the participants get back to their posts.

In addition, this workshop touched on understanding the global policy framework and its relation to the national policy and institutional arrangement in GHRM, as exemplified by the New Zealand country practice (see details in Appendix F). Likewise, the workshop looked closely at how the policy and institutional

1 For the full list of participants, affiliations, and countries see Appendix B, "Participants List."
2 For details of the workshop agenda, see Appendix A, "Agenda."

Figure 1.1: Theory of Change

Theory of change south to south learning workshops on Geohazard Risk Management in DRM and Transport

Note: O&M = operations and maintenance; PPP = public-private partnerships.

arrangement can be applied to the four themes of the Resilient Infrastructure Life Cycle Framework: Systems Planning, Engineering and Designing, Operations and Maintenance (O&M), and Contingency Programming (see Appendix E for details) through field investigations in two sites, the Transmission Gully and the Manawatu Gorge projects. Both sites are faced with challenging terrain and complex construction issues. The Earth Observation for Sustainable Development (EO4SD) Program presented by the European Space Agency (ESA) provided an additional way to support decision making. A launch and distribution of the *Road Geohazard Risk Management Handbook* was held on the third day of the workshop with a handbook overview presentation. The main handbook and a separate appendix booklet of Terms of Reference were distributed to the participants at the workshop.

Participants' informal evaluation rated the workshop's content, delivery, and overall quality of the training as very satisfactory. Site visits, as well as expert presentations from GNS Science, were regarded as very useful because of the high level of commitment and qualification of the implementors, as observed during the discussion at the sites. Participants articulated positive learning outcomes—such as understanding the need for their countries to incorporate GHRM in sectoral policies, priorities, and budget allocation. The exchanges between the participants and experts were greatly appreciated as their questions related to each theme of the Resilient Infrastructure Life Cycle Framework were clarified. More than ever, the participants in the third SSLW recognized the need for peer-to-peer learning.

This workshop report provides a summary of lessons learned from the third SSLW workshop. Chapter 2 covers lessons from New Zealand about how the country tackles its very high geohazard risk in transport. Chapter 3 provides lessons from the two field site visits and from the classrooms at GNS Science and the National Geohazards Monitoring Centre that monitors major geological hazards to help keep New Zealanders safe 24/7. Chapter 4 discusses the applicability of lessons from New Zealand to South Asian countries and tabulates the country action plans developed during the workshop in Appendix C.

Participants in this workshop learned about geohazard risk management practices in New Zealand. This section summarizes the major lessons learned from New Zealand based on the feedback from participants.

2 Lessons Learned in New Zealand

2.1 OVERVIEW OF THE GEOHAZARD RISKS IN NEW ZEALAND

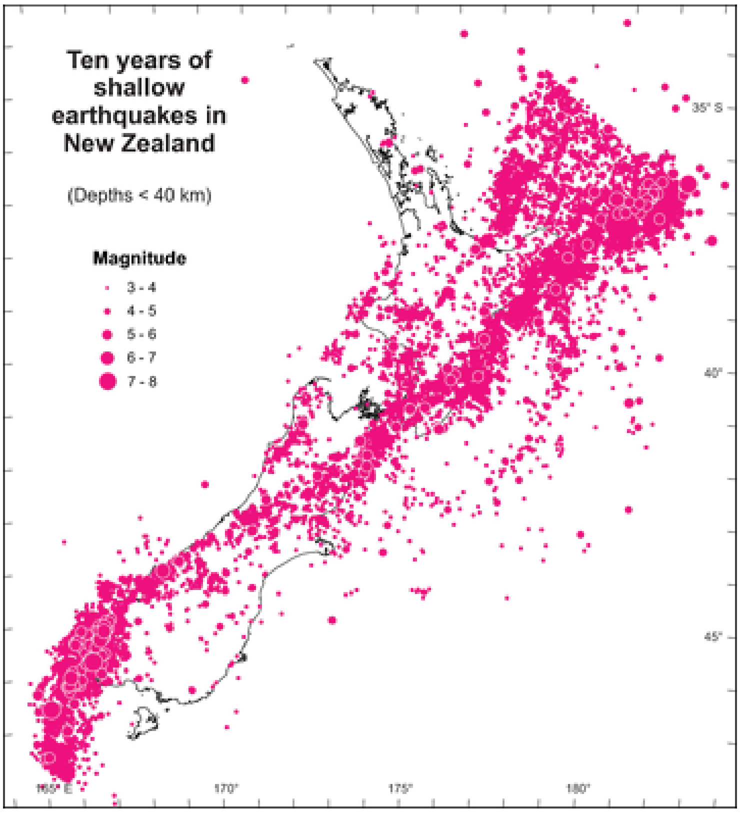
New Zealand is a geologically young country that experiences several geohazards—the intensity of these hazards vary across the country from areas that are highly seismic to areas that are heavily impacted by extreme rainfall events and coastal erosion (see Figure 2.1). New Zealand sits on the boundary between the Pacific and Australasian tectonic plates; this plays a dominant role in both the form of the landscape and the geohazard exposure:

- **Earthquakes.** Across the South Island, and crossing from Wellington out to the East Cape of the North Island, are many active fault lines. These have caused significant earthquakes at relatively regular intervals. New Zealand has around 15,000 earthquakes per year; 100–150 of them are large enough to be felt. Since the 1840s, on average, the country experiences several magnitude 6 earthquakes every year, one magnitude 7 every 10 years, and a magnitude 8 every century.

- **Volcanoes.** New Zealand has two main volcanic areas: the relatively sparsely populated central North Island plateau and Auckland. Auckland is built on top of a volcanic field of some 50 volcanoes; the most recent eruption occurred around 700 years ago.

- **Landslides.** Given the country's geological form, it is not surprising that landslides occur both after significant rainfall events (in the steep hill country with soils that lose significant

Figure 2.1: Ten-Year (2000–2010) Earthquake Plot for New Zealand



Source: GNS Science.

strength when soaked) and as a result of earthquakes. For example, after a major storm in June 2015 in the Tarakani-Manawatu region, over 1,000 landslides were reported (most on adjacent farming land), closing over 30 roads.

- **Tsunamis.** With its long coastline in relation to the land area and the predominance of people living by the ocean, the consequences of tsunamis are severe. The country is exposed to both locally generated tsunamis and those from across the Pacific.

- **Floods.** No part of the country is immune from flood events; New Zealand often experiences the tail end of tropical cyclones and other similar major storms.

Several significant geohazard events have occurred that resulted in substantial damage to infrastructure (and, in some cases, loss of life) in New Zealand. These include:

- **The 1931 Hawke's Bay/Napier earthquake of magnitude 7.8:** This destroyed the city of Napier and killed 256, injured many thousands more, and caused widespread devastation to the region. This remains New Zealand's deadliest natural disaster.

- **The 2011 Christchurch earthquake (often referred to as the Canterbury Earthquake) of magnitude 6.3:** This followed a magnitude 7.1 earthquake in the same location six months earlier. This earthquake resulted in the loss of 185 lives, the destruction of large parts of the city of Christchurch's infrastructure, and the abandonment of significant areas of the city that were no longer considered suitable for residential use.

- **The 2016 Kaikoura earthquake of magnitude 7.8:** This resulted in the loss of two lives and the closure of the main state highway and rail line in the South Island for approximately one year. Scientists noted that the earthquake ruptured along multiple fault lines and has been described as the "most complex earthquake ever studied" (Ulrich et al. 2019). The rupture happened over at least 12 fault lines (some previously unknown) and across 200 kilometers.

The response to these events has been to study both the nature of the event itself to design infrastructure to withstand the earthquakes better and to understand the response to the earthquakes. For instance, the 2011 Christchurch earthquake identified very high vertical accelerations on newly identified fault lines, while the 2016 Kaikoura earthquake resulted in the establishment of a different working arrangement between infrastructure (road and rail) owners and industry to repair the damage.

2.2 LIFELINES

Within New Zealand, a key aspect of creating a resilient society is that of seeing resilience as not being tied to a single piece of the infrastructure puzzle (for example, transport in isolation)—but rather the integration of all the critical infrastructure and services that support communities.

This integrated thinking enables better consideration of scenarios that illustrate what impact geohazard risks would have on society as a whole—for instance, how an earthquake may affect not only the road but also the supply of fuel that would be necessary to reopen the road. Similarly, this thinking improves the ability to determine priorities for what roads should be reopened first after a disaster—for example, a relatively minor road may be critical if it is providing access to a water treatment plant.

Within the New Zealand context, lifelines are the essential infrastructure and services that support the community—including utility services such as water supply, wastewater treatment and stormwater management; electricity, gas, and telecommunications networks; and transportation networks including road, rail, airports, and ports. The New Zealand Lifelines Council (NZLC) supports regional group activity and provides a link to government agencies. The NZLC's mission is connecting lifeline utility organizations across agency and sector boundaries to improve infrastructure resilience.

2.3 ASSET MANAGEMENT

An important aspect of geohazard management within New Zealand is the overall importance placed on a strong infrastructure asset management approach. Although asset management or geohazard management is not specifically legislated, the requirements of the Local Government Act (LGA) do implicitly require this to be addressed as an integrated process.[3] For instance, while the term *asset management* appears only once in the entire LGA, there is a requirement for the local governments (municipalities) to have a long-term plan that covers a minimum of 10 years and describes the activities of the local authority and the community outcomes; provides integrated decision-making and coordinates the resources of the local authority; provides a long-term focus for the decisions and activities of the local authority; and provides a basis for holding the local authority accountable to the community. In delivering the legal requirements of the long-term plan, municipalities find themselves needing to implement sound asset management practices.

All local councils (municipalities) are required to have in place a long-term plan (10 years minimum) that must include the consideration of all risks and how these will be funded. It is within this context that asset management (of which geohazard management is considered a part) is critical. It is also acknowledged that undertaking robust asset management is the first step for having a more resilient infrastructure.

Box 2.1: The Benefits of Robust Asset Management

Better and well-maintained infrastructure is more robust and less vulnerable to the potential impact of geohazards. Furthermore, asset management is an effective vehicle for implementing resilient improvement programs as it results in geohazard management being integrated into all aspects of the infrastructure lifecycle.

2.4 TRANSPARENCY AND SHARING DATA

Much of the success of New Zealand's geohazard management is the result of the underlying willingness by all parties (government ministries, universities and other research organizations, consultants, and so on) to be open with sharing knowledge and data. This means that there is minimal duplication of effort and that research in one area can be readily leveraged across the entire geohazard sector.

By making data sets open to all, research can be undertaken that best leverages the investment in the data. Aligned to this is the fact that, for most information relating to road management, New Zealand has adopted national standards (as opposed to state or regional standards) for data, which enables research to take place using national data sets.

3 Information about the LGA is available at http://www.legislation.govt.nz/act/public/2002/0084/latest/versions.aspx.

2.5 THE FOUR ELEMENTS OF WELL-BEING

Within New Zealand, projects are developed and implemented, considering the impact equally across four elements of well-being—the economy, the environment, and social and cultural impacts. The result is that, when projects are being delivered, the focus is not merely on building infrastructure, but also on the wider impact of the work. For the Transmission Gully highway project, for example, one consequence of this wider focus was the collection of 10,000 fish from a stream ahead of the onset of the project; these fish—which are kept alive during the work in holding ponds/tanks/streams—are then released back into the stream once it is safe for habitation again.

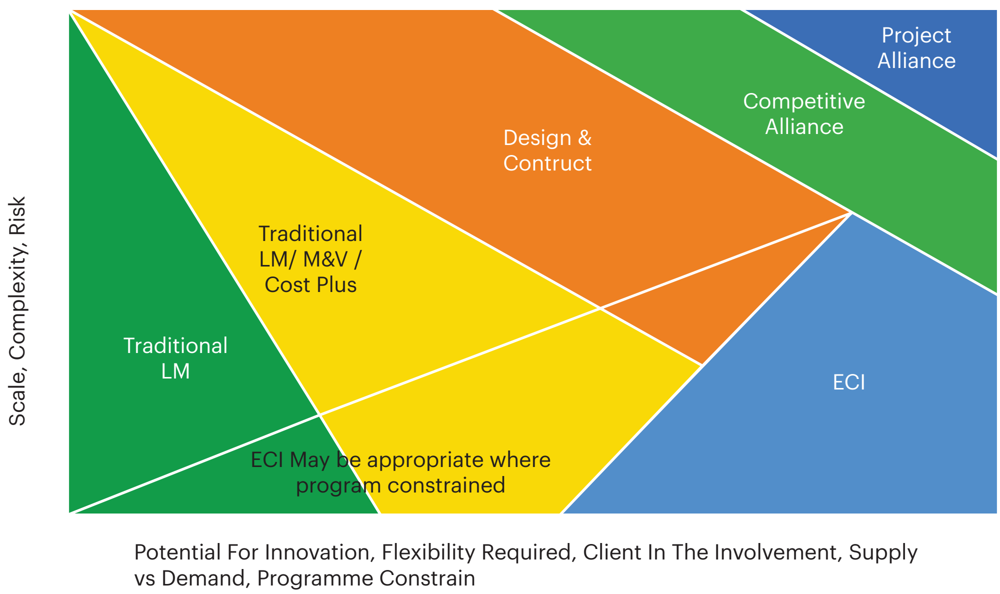
This focus is not just on protecting endangered species, but on ensuring that road projects are beneficial across all the aspects that are essential to the community's well-being. One form this takes is that seeds are collected from endemic plant species along proposed road alignments, propagated, and then planted back in as part of the geohazard risk management process. While this focus on what may be considered non-traditional aspects of road building appears a luxury that developing nations may not be able to afford, the approach drives the road design and construction to avoid erosion of soil—thereby using environmental impacts to deliver a more resilient road infrastructure. Loss of fish life as a result of rivers becoming full of sediment on a day-to-day basis can be considered a lead indicator that the road infrastructure is not sufficiently resilient against extreme weather events should they occur.

2.6 CONTRACTUAL ARRANGEMENTS

New Zealand road authorities have many decades of experience with outsourced delivery of physical and consulting work. The road authorities understand how different contract models affect risk allocation and adopt a "best-of-circumstance" approach. This means that road projects can be delivered using a multitude of contract models—from traditional measure and value through to public-private partnerships (PPPs). Table 2.1 lists common contract types for road projects, along with the circumstances in which each type is most beneficial.

Figure 2.2 illustrates the broad spectrum of contract models in use in New Zealand. Early contractor involvement (ECI) is noted as being of use in areas where there are significant construction constraints on the project—in these cases, the "how to build" is as a much a challenge as the "what to build." Under ECI, the contractor is selected early in the process and is directly involved in the design process.

Figure 2.2: New Zealand Transport Agency Contract Models



Source: www.nzta.govt.nz
Note: ECI = early contractor involvement, LS = lump sum, M&V = measurement and verification.

Table 2.1: Common Contract Types of Road Project and Ideal Circumstances for Implementation

Contract Type	Description	Ideal Circumstances for Implementation
Lump Sum	Contractor gives a lump sum fixed price to deliver the agreed work. Payment is made upon the completion of the work to the agreed standard. The contractor takes all risks associated with the quantity of inputs needed to deliver the outputs.	Ideal for standard type work, such as gabion walls, where industry is well acquainted with what is required, or where the design of the work is comprehensive and the risks are appropriately allocated such that the contractor is able to give a lump sum price for the work.
Measurement and Verification (M&V)	Contractor tenders rates for each item, and then during the work the engineer and contractor agree on the quantity of inputs used and payment is made. Inputs such as $/m3 of concrete typically include all costs associated with the production, delivery, and placement of the concrete, such that risks associated with labor efficiency remain with the contractor.	Ideal for simple jobs where time is of the essence and, while the nature of work is understood, there is not sufficient information to fully quantify the volume of work at the time of tender. Can be combined with the Lump Sum contract—for instance using the M&V model for foundation work, then the Lump Sum model for the above-ground work.
Design and Construct	The client defines the outcome required (e.g., a retaining wall with a 50-year design life, that will resist an XXX magnitude earthquake). The contractor and their engineer are then free to design and construct any form of solution that meets the requirements.	For projects where it is possible to define the outcome wanted, and decisions around value-engineering will need to occur throughout the project. Ideal where there are different ways to achieve the same outcome, such that contractors are able to use their individual strengths to deliver the works.
Alliance	The client, consultant, and contractor agree on the high level objectives to be achieved, and then payment is made on the basis of inputs plus an acceptable profit margin. If the works come in under budget, the profit is typically shared; and similarly if they go over budget this is also shared.	Suitable for a response to a major geotechnical event, such as post earthquake or a similar circumstance where the flexibility of the Alliance model is a significant benefit.
Early Contractor Involvement	Upon development of the concept of the work to be completed, the contractor selection process occurs. The contractor then works with the design team to help develop the design ensuring that constructability is taken into account.	Ideal for projects where the key challenge is the “constructability” of the design. For work in tightly constrained sites or precarious locations (e.g., the side of unstable hillsides) the engagement of the contractor in determining the method of construction to be used can be of real benefit.

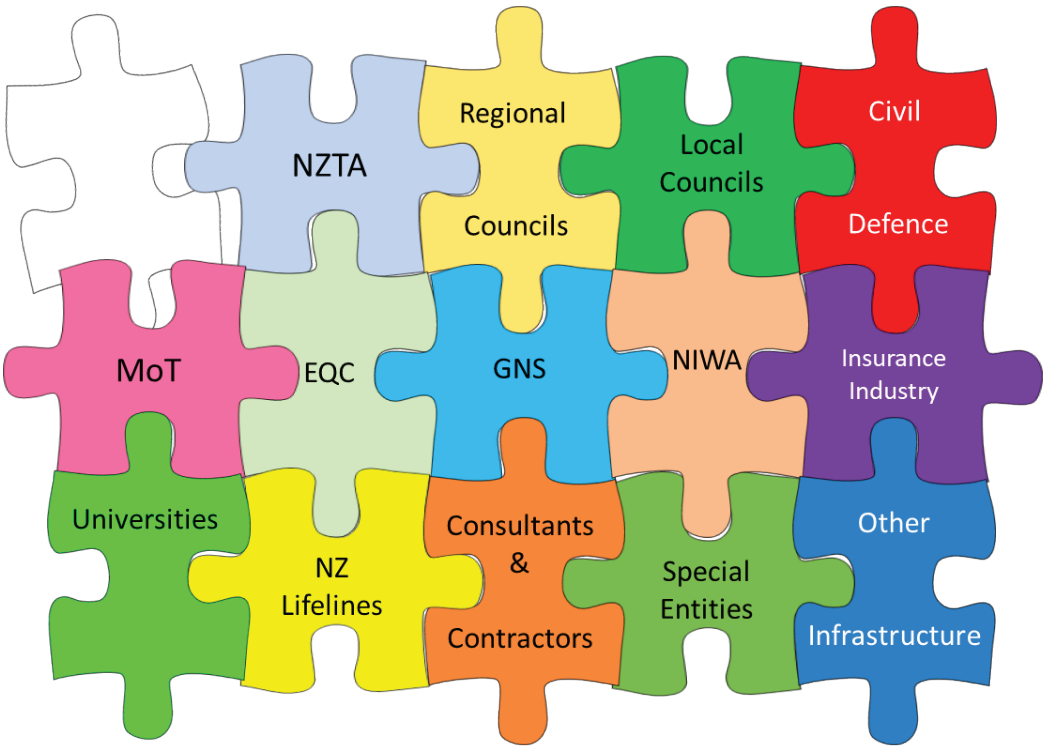
Within its routine maintenance contracts (both the physical works and the consulting support services), New Zealand has included provisions for emergency response that enables a quick response to geohazard disasters when they do occur. The response mechanism typically splits between relatively minor geohazard impacts—where the contractor takes the risk and just gets the road reopened—through to full involvement and payment by the road authority for the response to major geohazard events. For the vast majority of geohazard events, this approach means that no new tendering is required, enabling a rapid response to occur.

Another consideration worth noting is that New Zealand's road maintenance contracts allow for their transformation following significant disaster events. For example, the Kaikoura earthquake during 2016 basically destroyed the network that was under a long-term performance-based contract (PBC). Following negotiations after the earthquake, the maintenance contractor's contract was quickly restructured to allow the same provider to start in a rebuild capacity immediately. The ability to convert the existing PBC into a rebuild-alliance style of contract assisted in the rapid deployment of resources to start the rebuilding process.

2.7 INSTITUTIONAL ARRANGEMENT IN GEOHAZARD RISK MANAGEMENT IN THE TRANSPORT SECTOR

The key institutions involved in geohazard risk management in New Zealand are illustrated in Figure 2.3 and further explained in Table 2.2.

Figure 2.3: Key Institutions in New Zealand Transport Geohazard Management



Source: Greenwood, Institutional Arrangements in NZ Transport for Geohazard Risk Management, 2019 SSLW workshop presentation.
Note: EQC = Earthquake Commission, GNS = Geological and Nuclear Science, MoT = Ministry of Transport, NIWA = National Institute of Water and Atmospheric Research, NZTA = New Zealand Transport Agency.

Table 2.2: Key Institutions in New Zealand Road Transport Geohazard Management

Institution	Key Roles	Areas of Major Involvement				
		Systems Planning	Engineering & Design	Operations & Maintenance	Contingency Programming	Institutional Capacity & Coordination
Ministry of Transport (MoT) **www.transport.govt.nz**	• **The Ministry of Transport is the government's principal transport adviser.** • **MoT aims to:** › improve the overall performance of the transport system, › improve the performance of government transport entities, and › achieve better value for money for the government from its investment in the transport system. • **MoT helps the government implement its policy by supporting the development of legislation, regulations, and rules.** • **MoT manages and accounts for funds invested in transport.** • **MoT represents New Zealand's interests internationally, particularly in the aviation and maritime sectors that are subject to international standards and treaties** • **MoT assists the government in its relationship with government transport entities to ensure they are effectively governed**	✓			✓	✓
New Zealand Lifelines Council (NZLC) **www.nzlifelines.org.nz**	• **The mission of the New Zealand Lifelines Council is "connecting lifeline utility organisations across agency and sector boundaries to improve infrastructure resilience."** • **The NZLC supports regional group activity and provides a link to government agencies.** • **Two major activities include:** › The National Lifeline Utility Forum held in October or November each year › The National Infrastructure Vulnerability Assessment report	✓			✓	✓
Ministry of Civil Defence and Emergency Management (MCDEM) www.civildefence.govt.nz	• **The Civil Defence Emergency Management (CDEM) Act 2002:** › provides leadership in reducing risk, being ready for, responding to and recovering from emergencies, › manages the central government's response and recovery functions for national emergencies, and › supports the management of local and regional emergencies. • **The primary function of MCDEM is to support and enable communities to manage emergencies.** • **The MCDEM's overarching strategy is to build resilience through a risk management approach and the four Rs of:** › Risk Reduction, Readiness, Response, Recovery • **The approach starts with recognizing the range of hazards NZ faces and the vulnerability of its communities, buildings, and infrastructure to those hazards.** • **The ministry aims to put the right tools, knowledge, and skills into the hands of those who will be responsible for designing and implementing solutions at the local level.** • **Manage the central government response to, and recovery from, large-scale emergencies resulting from geological (earthquakes, volcanic unrest, landslides, tsunamis), meteorological (coastal hazards, floods, severe winds, snow), and infrastructure failure. MCDEM is the lead agency for these emergencies.** • **Provide advice to government agencies on civil defence emergency management matters.** • **Identify hazards and risks.** • **Develop, maintain, and evaluate the effectiveness of the civil defence emergency management strategic framework.** • **Ensure coordination at local, regional, and national levels.** • **Promote civil defence emergency management and deliver public awareness about how to prepare for, and what to do in, an emergency.** • **Support civil defence emergency management sector capability development, planning, and operations, including developing guidelines and standards.** • **Monitor and evaluate the performance of the 16 regional Civil Defence Emergency Management Groups (Groups).** • **Maintain and operate the National Crisis Management Centre, including maintaining a duty team to staff the Centre, and issue warnings and public information.**				✓	

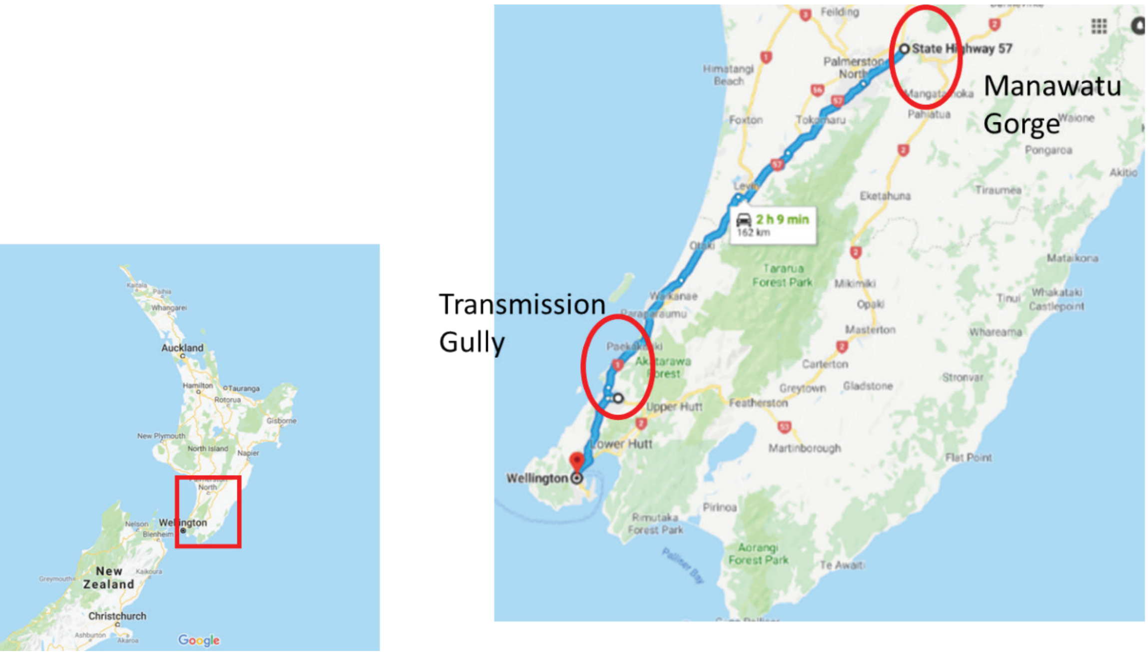
Institution	Key Roles	Areas of Major Involvement				
		Systems Planning	Engineering & Design	Operations & Maintenance	Contingency Programming	Institutional Capacity & Coordination
New Zealand Transport Agency (NZTA) **www.nzta.govt.nz**	• Construct, maintain, and operate the state highway network (11,000 kilometers). • Fully outsource physical works; mostly outsource consulting. • Fund 50 percent of local road costs (83,000 kilometers). • Stand as the primary driver of development of standards for road design in NZ. • Oversee driver's licensing, vehicle inspections and registrations, rail, road safety for pedestrians and bikers	✓	✓	✓	✓	
Regional Councils	• There are 11 regional councils across NZ, plus 6 unitary councils (combined regional + local responsibilities). • Regional councils do not have any roads. • Regional councils are charged with the integrated management of the natural and physical resources of a region. • These councils are required to develop regional land transport strategies that guide the decision-making of local councils. • Regional councils are generally responsible for making decisions about: › Regional planning and growth › Discharges of contaminants to land, air, and water › Water quality and quantity › Soil conservation › Ensuring appropriate land use to avoid natural hazards › Investigating land to identify and monitor contaminated land • Councils can also issue infringement notices, abatement notices, and excessive noise directions to people who are not complying with the Resource Management Act (RMA), national environmental standards or council plans.	✓				✓
Local Councils	• There are 61 territorial authorities—11 are city councils and 50 are district councils. • There are also 6 unitary councils. • Local councils own, construct, maintain, and operate the local road network (83,000 kilometers). • They receive 50 percent of their funding for roads from NZTA. • They are legally required to have a long-term (20 year) plan for all their assets, including how it will all be funded. • For some of the rural local authorities, roads make up around 80 percent of their annual expenditure.	✓	✓	✓	✓	✓
Earthquake Commission (EQC) **www.eqc.govt.nz**	• The Earthquake Commission (EQC) is a New Zealand government entity investing in natural disaster research and education and providing insurance to residential property owners. • The EQC is funded through a small premium on insurance policies. • The EQC was established under the Earthquake Commission Act 1993, which replaced the Earthquake and War Damage Commission that was established in 1945. • EQC core functions are to: • Provide natural disaster insurance for residential property (contents, dwellings and some coverage of land); • Administer the Natural Disaster Fund (NDF), including its investments and reinsurance; and • Fund research and education on natural disasters and ways of reducing their impact. • The purpose of the NDF is to make sure that claims for damage by people with home and content insurance can be paid out in the event of a natural disaster. • In 2010, before the Canturbury and Kaikoura earthquakes, the Fund had over NZ$6.1 billion in accumulated funds. The Canturbury and Kaikoura earthquakes may use all of this.	✓			✓	
GNS Science	• GNS Science, Te Pū Ao, is New Zealand's leading provider of earth, geoscience, and isotope research and consultancy services. • Its purpose is to understand natural earth system processes and resources, and to translate these into economic, environmental, and social benefits. • GNS Science has been doing a lot of work on the cost modeling associated with natural disasters.		✓		✓	

Institution	Key Roles	Areas of Major Involvement				
		Systems Planning	Engineering & Design	Operations & Maintenance	Contingency Programming	Institutional Capacity & Coordination
National Institute of Water and Atmospheric Research (NIWA) **www.niwa.co.nz**	• NIWA, the National Institute of Water and Atmospheric Research, is a government research institute established in 1992. It operates as a standalone company with its own board of directors and executive. • NIWA's mission is to conduct leading environmental science to enable the sustainable management of natural resources for New Zealand and the planet. • The main research of relevance to geohazard risk management is around climate change modeling and associated impacts.		✓		✓	
Insurance Industry	• There are two main kinds of insurance in New Zealand—private insurance and public infrastructure insurance. • Major changes to the New Zealand insurance industry have taken place since the Christchurch earthquakes: • New Zealand went from being considered a small irrelevant part of the global insurance market to a major player in the global market as the long-term liabilities were better understood. [[confi"player"]] • The insurance industry is no longer treating the whole country as one equal risk. • Some areas are now considered "uninsurable."	✓			✓	
Consultants and Contractors	• Consultants and contractors are key in the delivery of all aspects of the geohazard risk management spectrum, from the identification of hazards through to the emergency response after an event. • Consultants and contractors support all the other pieces of the puzzle. • Most New Zealand roads are subject to multiyear (typically 3–7 year) contracts for their maintenance and renewal, with either integrated or parallel contracts for the associated consulting services. • Actual contract arrangements vary across the road authorities.	✓	✓	✓	✓	
Universities	• Universities focus on applied research. • They provide strong links to all other institutions. • Universities are supported by NZ's underlying transparency in regard to knowledge and data sharing.	✓	✓		✓	
Special Entities	• Special entities are formed as necessary in response to major events. Two recent examples are: • CERA • The Canterbury Earthquake Recovery Authority (CERA) was established as a government department on March 29, 2011, to lead and coordinate the government's response and recovery efforts following the earthquakes of 2010 and 2011 in Canterbury. • CERA was disestablished on April 18, 2016, when the government began to transition from leading the recovery to establishing long-term, locally led recovery and regeneration arrangements. • NCTIR • The North Canterbury Transport Infrastructure Recovery (NCTIR) alliance includes the NZTA, KiwiRail, and infrastructure companies Fulton Hogan, Downer, Higgins, and HEB Construction.		✓		✓	
Other Infrastructure Providers	• Other infrastructure providers, both public and privately owned, have an impact on the geohazard arrangements for roads in New Zealand. Each has its own regulatory framework and is noted briefly below: • Rail plays a role as a provider of transport services, but also has a key role in that, throughout the country, the road and rail corridors are parallel to each other, with failure of one often impacting the other. • Water, wastewater, and stormwater assets are typically buried within the road, such that damage (and subsequent repair) to any of these assets after a major geohazard event affects the ability to reopen roads. • Telecommunications are used for communications after events, but—like the water networks—the telecommunications cables are typically buried alongside or under the road. • Fuel: following a major event there is a need to reopen roads. The supply of fuel to the equipment to open the roads is understood to be a key constraint in such an event.	✓				✓

3 Site Visits

Visits were made to two major road project sites—Transmission Gully and Manawatu Gorge—as well as to the GNS Science offices (see Figure 3.1).

Figure 3.1: Location of Road Project Site Visits



Source: Based on googlemaps.com.

3.1 SITE VISIT: TRANSMISSION GULLY

3.1.1 Background

Key facts of the project:

- A 27-kilometer four-lane motorway is under construction; it is scheduled to be open for traffic in 2020.
- The public-private partnership being delivered by the Wellington Gateway Partnership for the New Zealand Transport Agency.
- There is a 25-year O&M period.
- It will cost NZ$850 million (US$570 million).
- It will have four interchanges
- Two new link roads will provide additional connectivity to the route.

Transmission Gully is a key part of the Wellington Northern Corridor (Figure 3.2) and one of the most significant single pieces of new road construction in the lower North Island. It is being built to provide another route between Wellington and the lower and central North Island that will be safer and more reliable for motorists against earthquake and storm surge hazards.

The project is highly complex, with difficult and steep terrain following a major fault line, so it requires large-scale earthworks during the construction of the project (Figures 3.3 and 3.4). Twenty-five new structures that together cover more than a kilometer will be constructed along the route. The largest of these, the Cannons Creek Bridge, will stretch 230 meters long and sit 60 meters above the valley floor. Although the route may appear undesirable, the lack of practical alternatives meant that it was the best option available. Widening the existing coastal route would have resulted in significant reclamation of the sea in an area of significant storm events, and it would still have been exposed to many of the same geological risks on the new route.

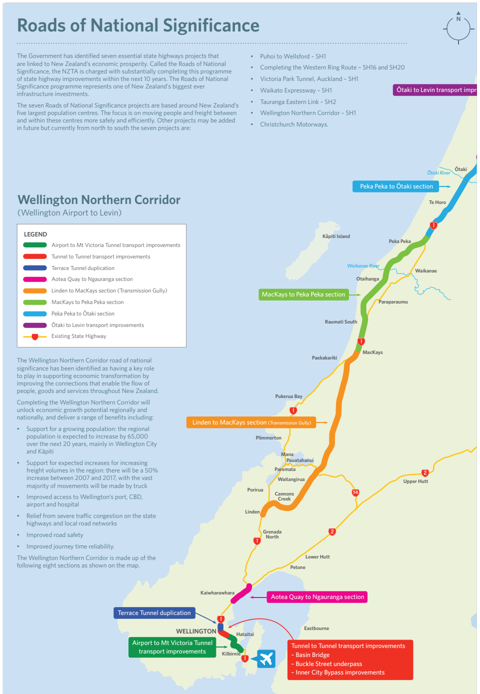
Adding to the design and construction challenges of this project is the fact that much of the rock within the area of the road is highly fractured as a result of the faults. This has resulted in a lack of high-quality materials for the upper road pavement layers, although plenty of material is available for the construction of road embankments and the lower pavement layers. The terrain has resulted in high cuts and fills to reach an acceptable alignment.

Transmission Gully is the first motorway in New Zealand to be constructed under a PPP contract. The New Zealand Transport Agency (NZTA) notes that

- PPPs allow large and complex projects to benefit from private sector innovation and funding which can increase the certainty of delivery and drive better value-for-money. There are also savings to be had on all aspects of the project – design, build, maintenance and operational management. PPPs are typically used for large-scale infrastructure projects where risks can be effectively identified and transferred to the private sector. The NZ Transport Agency aims to use successful ideas and innovations that come out of the Transmission Gully motorway PPP across other motorway projects and the wider transport network (www.nzta.govt.nz).

The project will be the first motorway constructed in New Zealand to achieve Greenroads™ silver certification—an international sustainability rating system for road design and construction. The social and environmental work covers the installation of over 100 sediment ponds, 37 kilometers of construction run-off channels, 17 kilometers of silt fences, the relocation of thousands of fish and lizards, and the propagation of hundreds of thousands of plants from locally sourced seeds.

Figure 3.2: Wellington Northern Corridor



Source: www.nzta.govt.nz.

Figure 3.3: Map of Transmission Gully Key Features

Source: www.nzta.govt.nz.
Note: the red line is the existing road; ;the black line is the Transmission Gully road being built.

3.1.2 Key Observations from the Site Visit

The following observations were made from the site visit and discussions (see also the photos in Figure 3.4):

- The design and construction approach holistically allows for the geohazard resilience of the project and the end-product.
- The project maintains a major focus on its "soft-engineering" aspects, with the collection of fish and lizards prior to the construction work commencing; they are then released back once the work is completed.
- Vegetation (500,000 plants) has been planted to reduce the risks of erosion in the broader corridor.
- Earth embankments subject to staged engineering approach include:
  - → Low embankments are made of only compacted earth with grass.
  - → Medium-height embankments include features to assist with vegetation growth.
  - → High embankments make full use of geotextiles to reinforce and provide a framework for vegetation.
- Shotcrete and rock/soil nailing are confined just to those areas of the cuttings that require it (maybe a 3- to 4-meter strip within an overall cutting of 100 meters).

Figure 3.4: Photos of Transmission Gully Works (circa 2015–2019)

Source: www.nzta.govt.nz.

3.2 SITE VISIT: MANAWATU GORGE

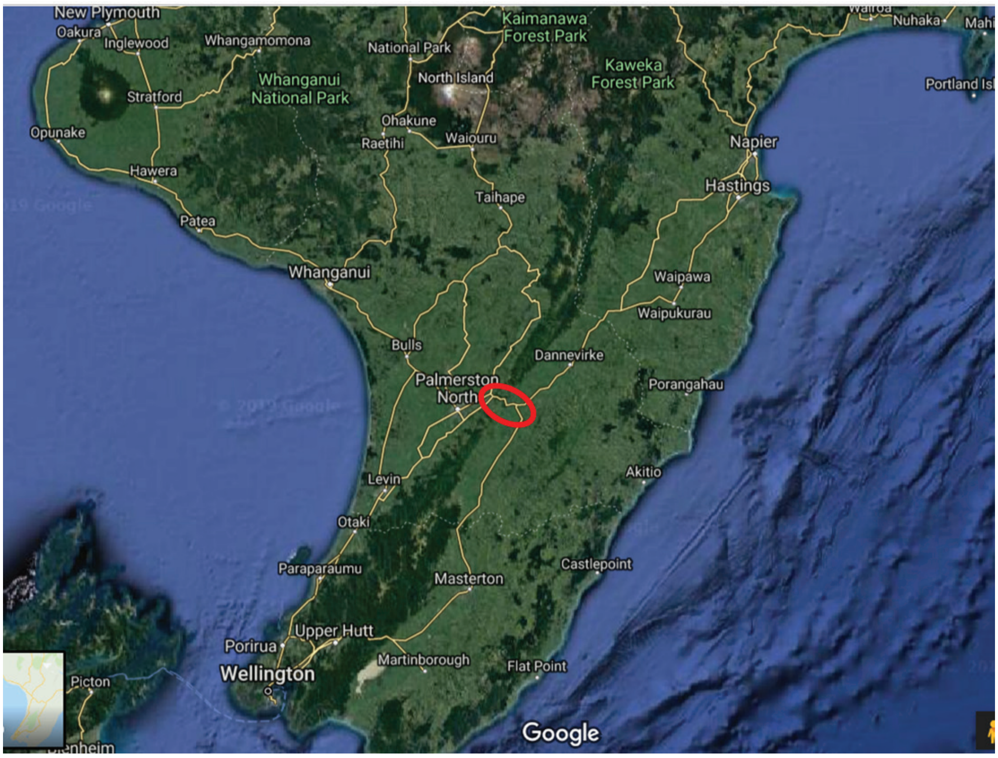
3.2.1 Background

The Manawatu Gorge (Figure 3.5) provides the key east-west movement across the Tararua Range for the lower North Island. The existing state highway through the gorge was subject to multiple slips over its history and carried around 3,600 vehicles per day prior to being closed when traffic was diverted onto two local low-design-standard roads running in the broadly parallel to the gorge road. The local roads have much lower geometric standards than state highways; they were also not designed to carry the loads that were diverted onto them. The closure of the gorge has added significant delays to travel because the local roads have high grades (10 percent) and limited passing opportunities.

The Manawatu Gorge project involves the construction of a new link following the decision to abandon the existing state highway. The existing road was subject to repeated landslides that resulted in regular road closures for periods of days to weeks.

In 2011 a slip closed the road for 14 months. Although it was reopened, there was concern that it could come down again at any time. In April 2017 the existing route was officially abandoned following multiple large-scale rock falls. Another major land movement occurred in July 2017—of approximately 10,000 cubic meters of material—that reinforced the decision to abandon the route. Figure 3.6 illustrates some of the damage done to the existing road from the slips, including the destruction of a bridge.

Figure 3.5: Location of Manawatu Gorge



Source: Based on map googlemaps.com.

Figure 3.6: Damage on Existing Route

Source: www.nzta.govt.nz.

Following the decision to abandon the existing road, a project to develop a new route has been underway. Figure 3.7 shows the indicative timeline of the project.

Figure 3.7: Timeline of the Manawatu Gorge Project

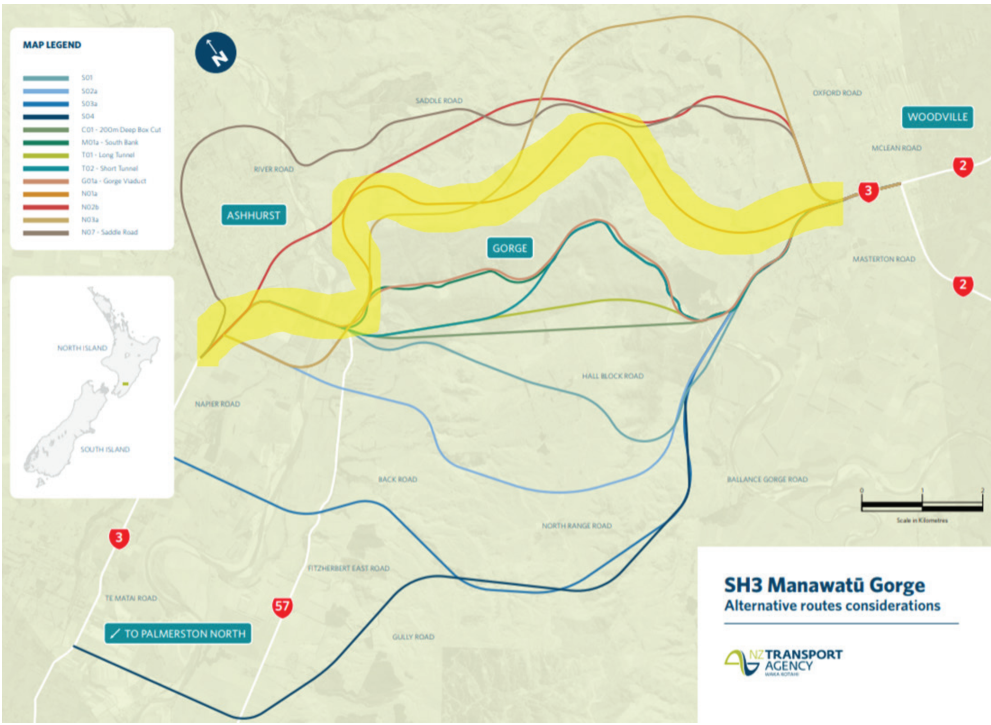
Source: www.nzta.govt.nz.

3.2.2 Key Observations from the Site Visit

This project is a prime example of situations where communities have to decide between futilely restoring and repairing existing routes or abandoning the status quo for a more sustainable option.

The decision of where to build the new route underwent a comprehensive evaluation process that considered with 13 possible alignments (Figure 3.8) before the preferred route was selected (see Figure 3.11). It is noted that none of the alignments is perfect with respect to geohazard risks as they all traverse a major fault line, and all have high grades as enforced by the terrain (Figure 3.12). The end result is a road alignment that is 12.4 kilometers in length (longer than the existing route) and with an average grade of 5.8 percent (maximum of 10 percent).

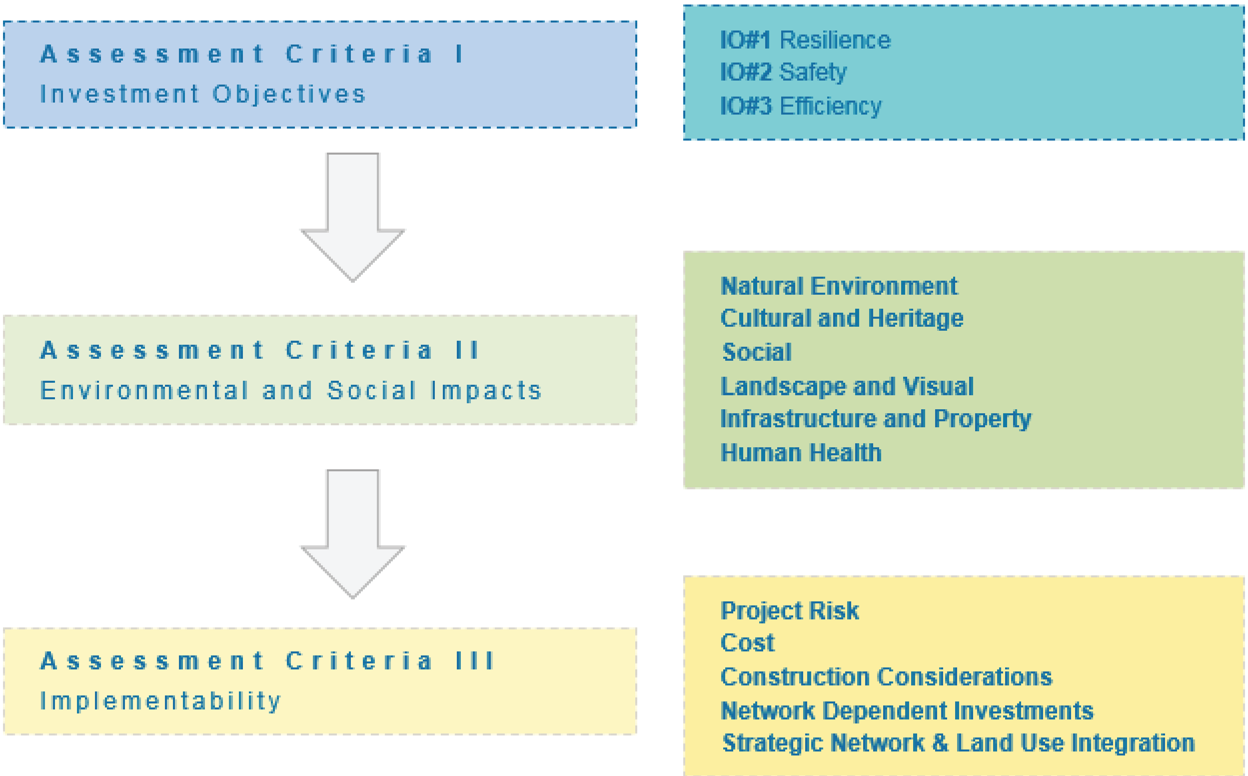
Figure 3.8: Manawatu Gorge Alternative Route Options



Source: www.nzta.govt.nz.

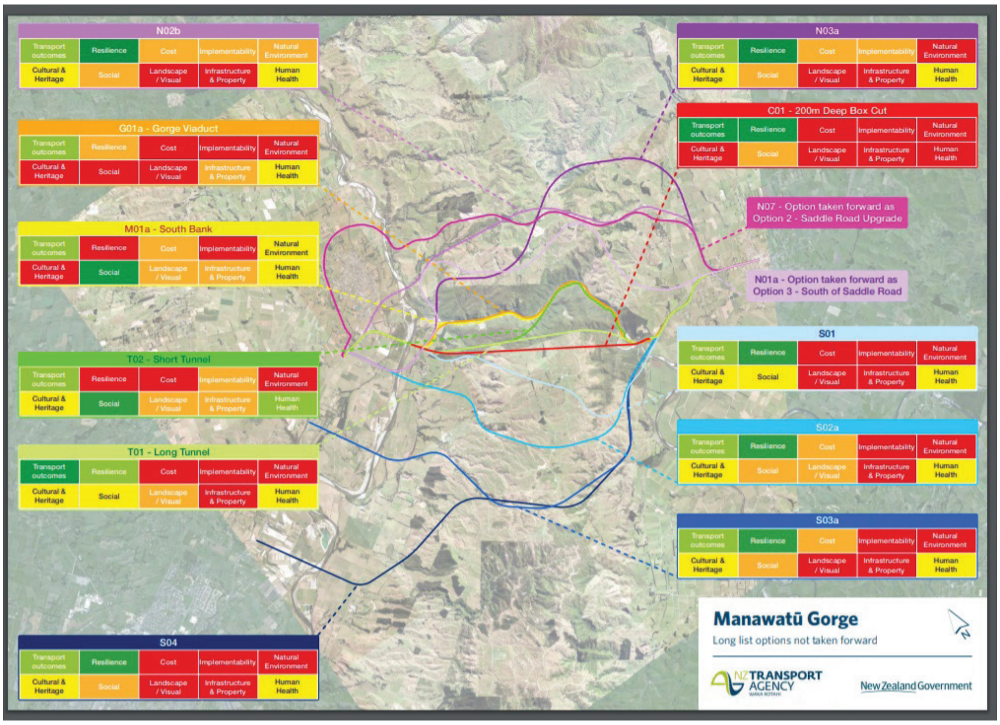
The route selection process began with the identification of a long list of potential options. These were then subject to the shortlisting criteria (see Figure 3.9), with the output summarized in Figure 3.10. The shortlisted options were then further evaluated and consulted upon before determining the preferred option.

Figure 3.9: Manawatu Gorge Option Shortlisting Criteria



Source: nzta.govt.nz/projects/sh3-manawatu/publications

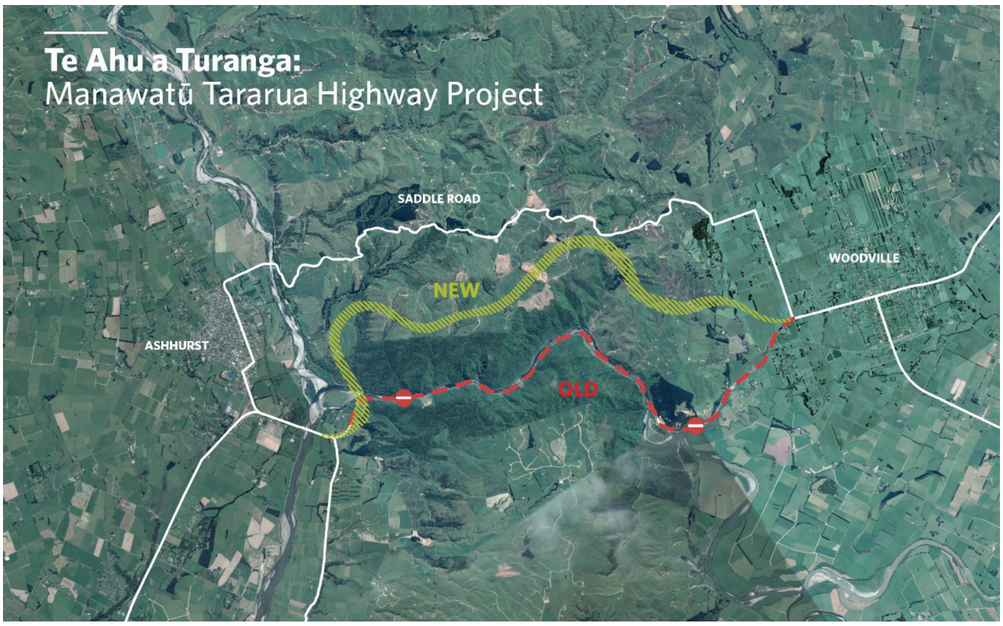
Figure 3.10: Results of Shortlisting Criteria



Source: nzta.govt.nz.

The main fault line runs northeast-southwest toward the eastern end of the gorge, in the vicinity of the southern route options, as shown in Figure 3.10. From a geohazard perspective, these options were less desirable because they would have an enlarged length of the damaged road if the fault line were to fail. The northern four alignments cross the fault at closer to a 90-degree angle, minimizing the potential length of rupture.

Figure 3.11: Manawatu Gorge Selected Alignment



Source: www.nzta.govt.nz.

Figure 3.12: Terrain that New Alignment Passes Through

Source: www.nzta.govt.nz.

The project will be delivered through an alliance model contract, with two consortiums (contractor plus consultant) currently bidding to win the right to form the alliance with NZTA. Under the alliance model, the parties agree on the expected outcome price and key performance indicators (KPIs) to be achieved, along with the expected risks. The alliance agreement then specifies how cost overruns or savings are allocated between parties should they occur.

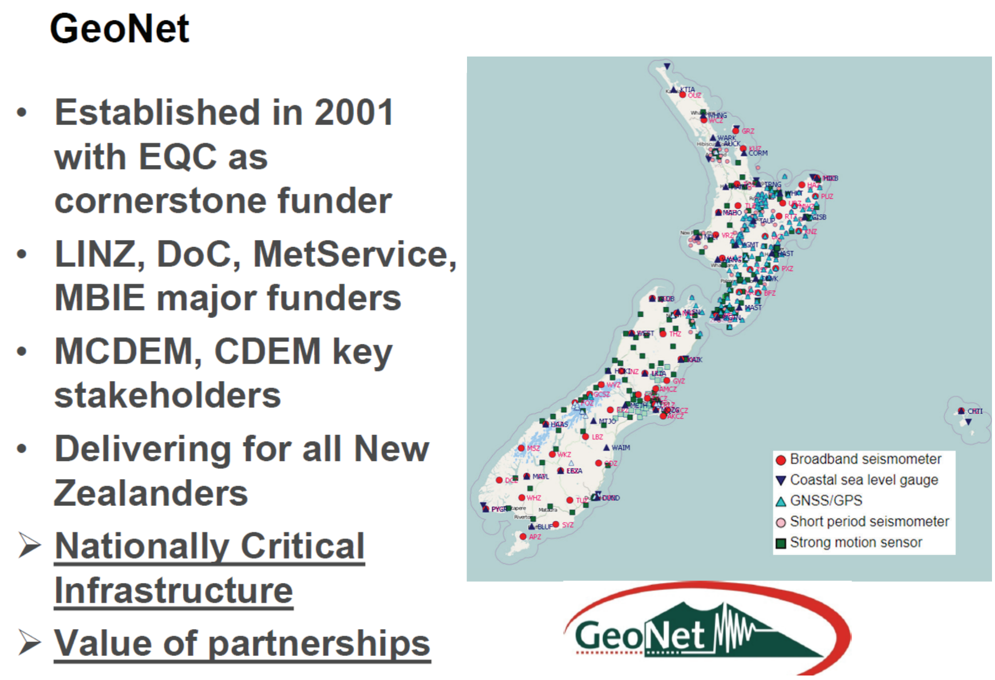
3.3 SUMMARY OF SESSIONS AT HELD AT GNS

On the third day of the workshop, a series of presentations were delivered to the participants at the GNS Science offices. GNS Science is one of the top research organizations and service providers in the world in geohazard risk modeling and its application to lifeline infrastructures. The presentations covered both GNS and non-GNS activities, along with a visit to the on-site New Zealand 24/7 Geohazards Monitoring Centre. This section highlights the session held at GNS.

3.3.1 GNS Presentation Summaries

The GNS presentations started with a "**Introduction to GNS Science and the management of geological hazard risks to the road network infrastructure in New Zealand"** by Gill Jolly, Earth Structure and Process Manager. She provided an overview of the GNS Science organization, natural disasters GNS deals with, and the support GNS provides to neighboring Pacific countries; these include monitoring southwest volcanic activities and capacity building of risk assessment and risk management capabilities through their PARTneR program. She also introduced participants to the New Zealand geological monitoring system called *GeoNet* that has more than 600 monitoring stations all over the country (Figure 3.13), serviced since 2001 and hosted by GNS. The monitoring system and observed data enable research on geological hazards and enhance risk assessments for re-insurance, national positioning of infrastructure, and timely responses to events. She stressed that collaborative science to understand natural disaster risks and partnerships could ultimately (i) lead to safer communities, (ii) reduce risks to the economy, and (iii) optimize infrastructure investment.

Figure 3.13: GeoNet Monitoring System Coverage in New Zealand

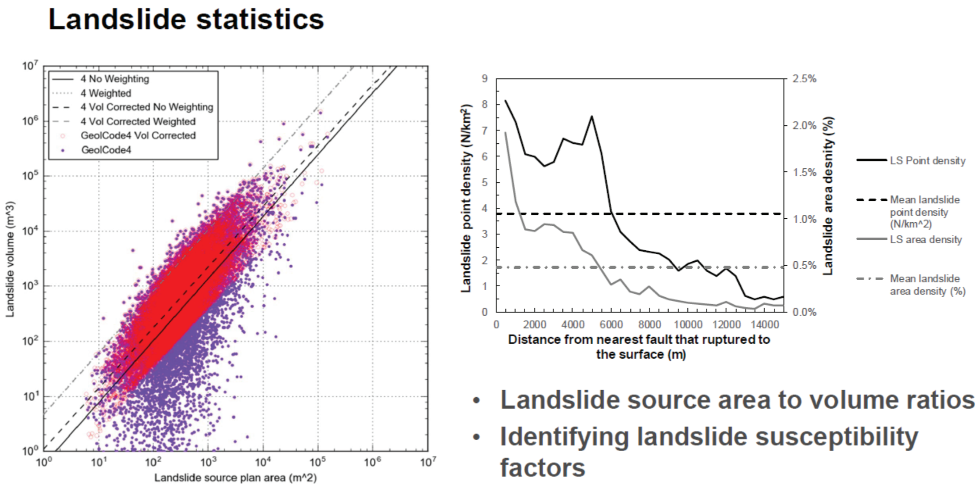


Source: Jolly, 2019 SSLW GNS Science workshop presentation.
Note: CDEM = Civil Defence Emergency Management; DoC = Department of Conservation; EQC = Earthquake Commission; GNS = Geological and Nuclear Sciences; LINZ = Land Information New Zealand; MBIE = Ministry of Business, Innovation and Employment (MBIE); MCDEM = Ministry of Civil Defence and Emergency Management; SSLW = South-to-South Learning Workshop.

Chris Massey presented **"Regional-scale tools to evaluate the impact of earthquake and post-earthquake rain-induced landslides."** He discussed the characteristics of landslides triggered by the magnitude 7.8 November 2016 Kaikoura earthquake. The analysis included landslide inventory development, lost volume estimate, and slope change characteristics. He explained the relationship between landslide volume and landslide source area that is also used for empirical landslide modeling, as well as the importance of distance from the fault line. The graph shown in Figure 3.14 shows that the density of landslides is highly related to the distance from the fault line; Massey also explained that geology is one of the variables that significantly impact landslide occurrence. In addition to distance from the fault, he explained that slope angle, local slope relief (the height of the slope), peak ground acceleration (PGA) and peak ground velocity (PGV), elevation, and geology are key control factors in landslide events, and geology controls the types of landslides and failure mechanism.

The developed landslide model based on the investigation of past landslides in New Zealand predicts not only high-risk slope locations but also landslide volume, failure mode, and debris runoff. The significance of such a model is that the model predicts the size and distance that the landslides would travel depending on the size and strength of the earthquake. The model is also used to raise the alarm to impact areas only after a few minutes of the earthquake (Figure 3.15).

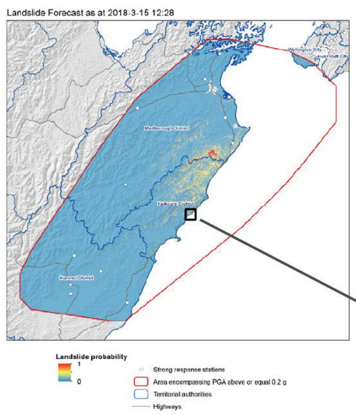
Figure 3.14: Landslide Statistics in New Zealand



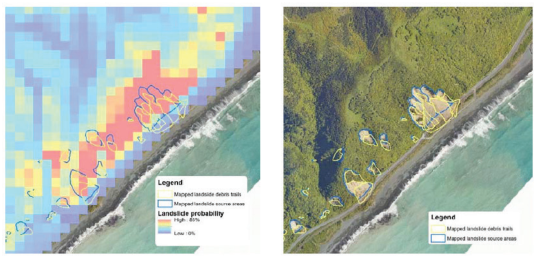
Source: Massey, 2019 SSLW GNS Science workshop presentation.
Note: GNS = Geological and Nuclear Sciences; SSLW = South-to-South Learning Workshop.

Figure 3.15: Landslide Alert and Maps Generated by the GNS Landslide Model

Advisory: Text and Maps 7 mins after tool triggered



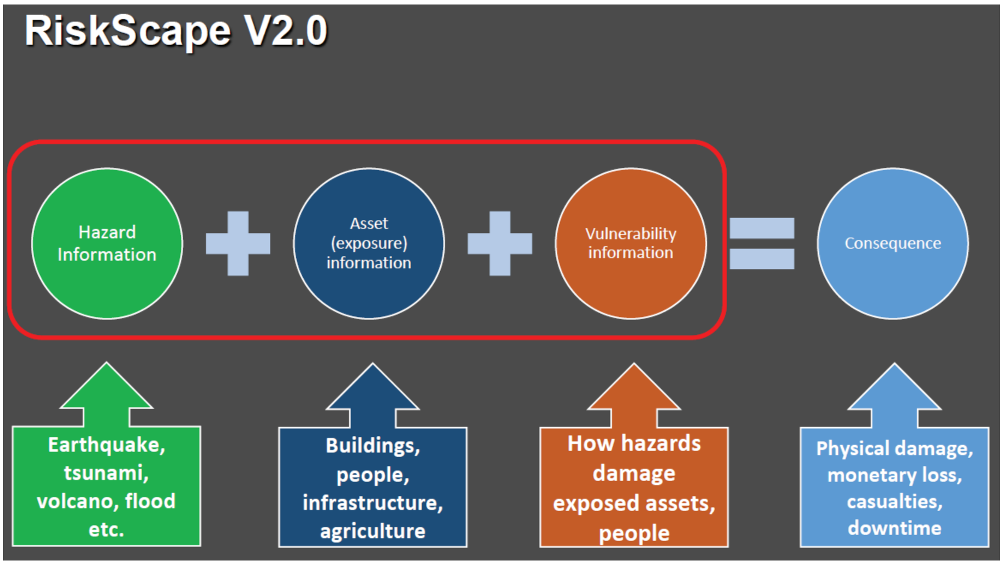
TA that might be affected by landslides	Area where PGA exceeds 0.2 g (km2)	Percent of TA's area where PGA exceeds 0.2 g	Maximum PGA within TA (g)
Hurunui District	4205.08	48.6	0.68
Kaikoura District	2046.78	100	1.27
Lower Hutt City	1.2	0.3	0.22
Marlborough District	6362.82	60.8	1.27
Wellington City	22.72	7.8	0.26



Source: Massey, 2019 SSLW GNS Science workshop presentation.
Note: GNS = Geological and Nuclear Sciences; SSLW = South-to-South Learning Workshop.

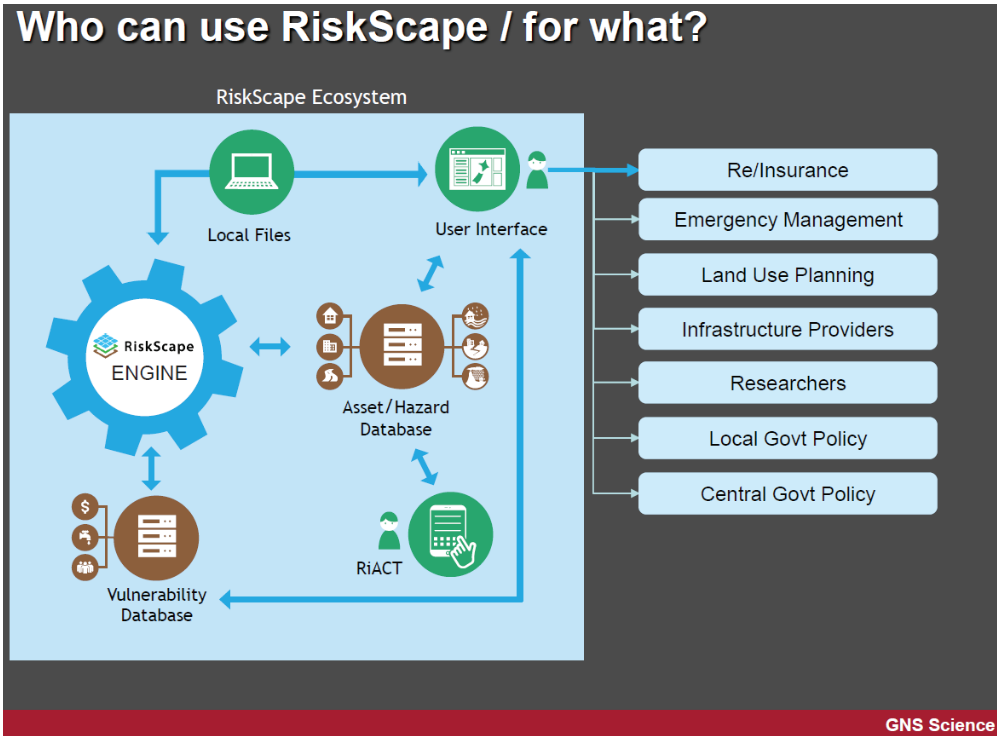
Vinod Sadashiva, the Deputy Program Leader of the RiskScape, presented **"Natural Hazard Risk Modeling in New Zealand"** and introduced the RiskScape Tool that his team has developed. The tool is a program to study the impact of natural hazards on communities and to forecast the future impacts through risk modeling. The natural hazards the tool covers are earthquakes, volcanos, floods, storm surge, tsunamis, and wind. RiskScape uses hazard, asset (exposure), and vulnerability information to predict consequences. Their onsite asset information collection conducted digitally via their RiACT tool works at the building level with data on the building attributes and users; it also collects vulnerability information that involves post-event survey insurance claim data and engineering modeling to improve fragility models of assets. This collected information is plugged into the RiskScape analysis framework and the outputs are used for many purposes, including re/insurance, emergency management, land use planning, decision making by infrastructure providers, and informing national and local government policies and academia.

Figure 3.16: GNS RiskScape Framework



Source: Sadashiva, 2019 SSLW GNS Science workshop presentation.
Note: GNS = Geological and Nuclear Sciences; SSLW = South-to-South Learning Workshop.

Figure 3.17: GNS RiskScape Ecosystem and Its Uses



Source: Sadashiva, 2019 SSLW GNS Science workshop presentation.
Note: GNS = Geological and Nuclear Sciences; SSLW = South-to-South Learning Workshop.

Sadashiva also provided an overview of two tools specifically developed by GNS Science for transportation networks: (i) the Road Risk Evaluation Tool (Sadashiva et al. 2017) evaluates the service disruption state of the highway network when subjected to geological and hydrological hazard events of varying intensities (Figure 3.18); and (ii) *rapid*Alert, a web-based earthquake alert application for KiwiRail, a state-owned enterprise and the largest rail transport operator in New Zealand. This application identifies areas of potential rail damage to help KiwiRail make post-earthquake decisions such as the prioritization of damage survey and inspections to reduce service restoration time. It is a fully automated system using data from the GeoNet monitoring network of strong motion instruments. After a magnitude 5 or greater earthquake is detected, the application sends an email alert to KiwiRail engineers and operators with strong motion data and creates and updates an online event page with maps and tables of strong-motion data.

Figure 3.18: Road Risk Evaluation Tool

Source: Sadashiva et. al. 2017

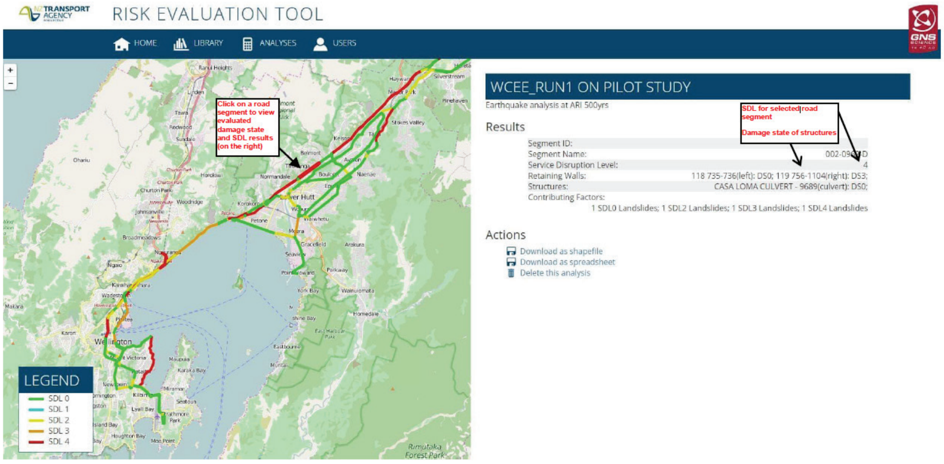
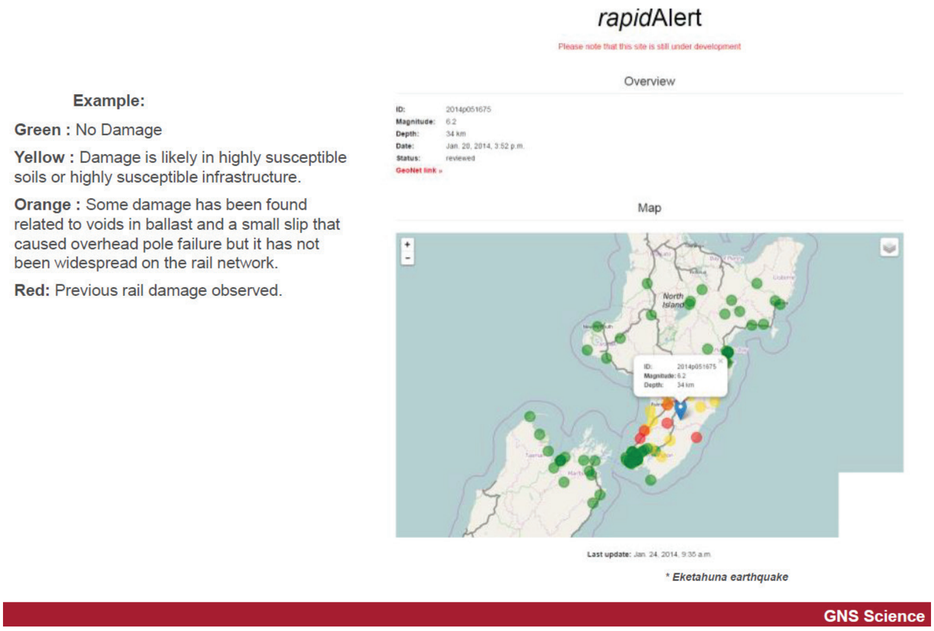


Figure 3.19: rapidAlert Demonstration

Source: Sadashiva, 2019 SSLW GNS Science workshop presentation.
Note: GNS = Geological and Nuclear Sciences; SSLW = South-to-South Learning Workshop.



SR Uma, the Team Leader of Risk & Engineering, presented the Wellington Lifelines Business Case project that demonstrates how Wellington Lifelines has undertaken a quantitative cost-benefit assessment to inform the next 10 years of infrastructure investment upgrades. Her presentation highlights the importance of integrated impact modeling through a systemic risk modeling framework as shown in Figure 3.20. The framework requires hazard scenarios and asset information to estimate asset damage and service outage of lifelines; predicts the recovery process in different lifelines and infrastructure by accounting for their functional interdependencies; and estimates economic losses and funding required for recovery. The tool was used in the Wellington Lifelines Business Case project to prioritize infrastructure projects to minimize losses from a Wellington fault earthquake scenario and related secondary hazards. The tool covers different elements of infrastructure, including roads, rails, electricity, telecommunications, water and wastewater, gas, airports, and so on. Figure 3.21 shows the preferred intervention projects identified by Wellington Electricity to improve the resilience of the electricity network from the impact of a Wellington fault event.

Figure 3.20: Earthquake Impact Model Framework

Source: Uma, 2019 SSLW GNS Science workshop presentation.
Note: GNS = Geological and Nuclear Sciences; SSLW = South-to-South Learning Workshop.

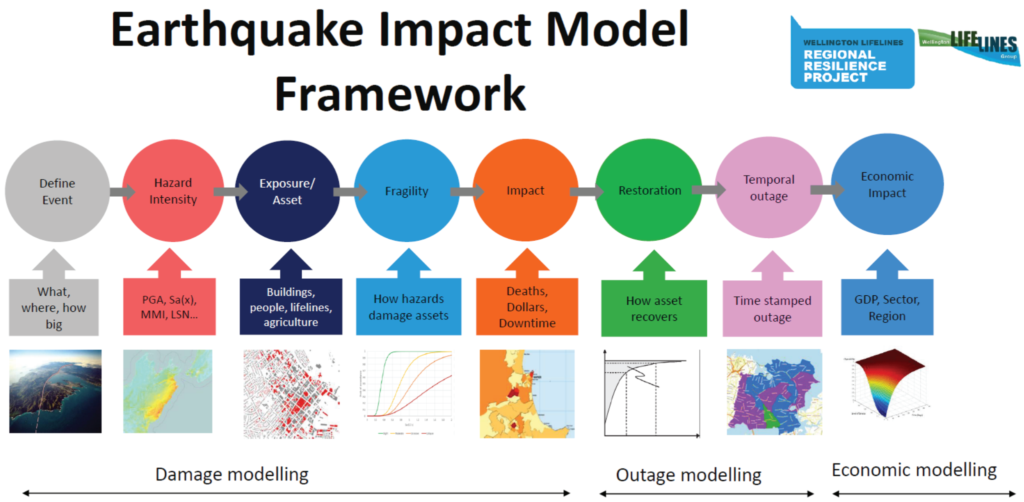
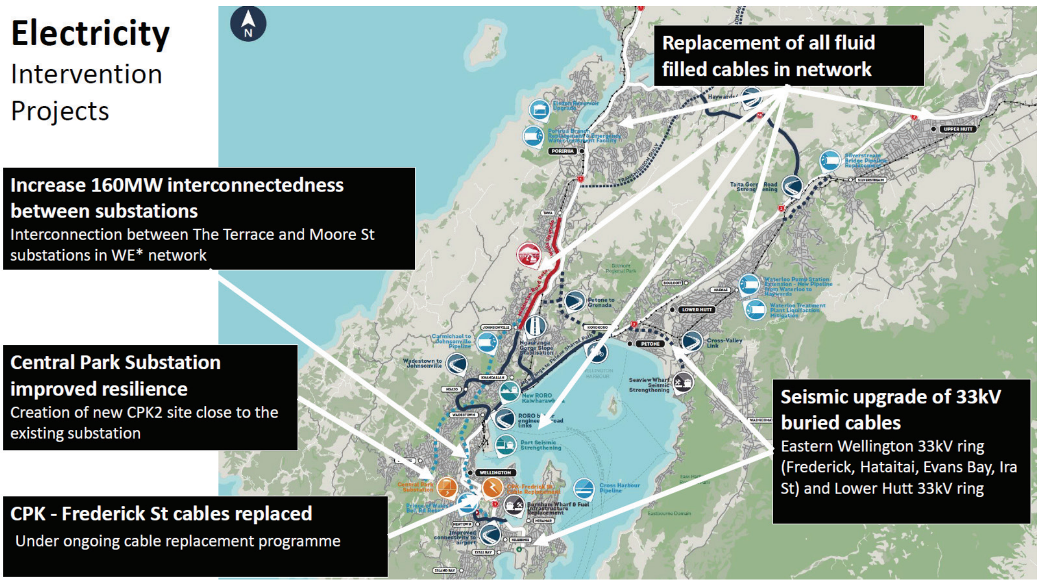


Figure 3.21: Electricity Intervention Projects

Source: Uma, 2019 SSLW GNS Science workshop presentation.
Note: GNS = Geological and Nuclear Sciences; SSLW = South-to-South Learning Workshop.



Box 3.1 presents an overview of the response to the 2016 Kaikoura earthquake and its lessons for successful recovery and resilience.

BOX 3.1: 2016 KAIKOURA EARTHQUAKE TRANSPORT NETWORK RECOVERY & RESILIENCE

Overview. A magnitude 7.8 severe earthquake hit New Zealand's upper South Island just after midnight on Monday November 14, 2016. The earthquake triggered thousands of large landslides and caused severe disruption to approximately 200 kilometers of the road and rail networks. The resilience of the transport corridor was assessed considering the increased vulnerability of hillslopes to future landslides. This enabled the asset owners to manage the future outage risks to their networks so that service levels and social and statutory responsibilities can be met.

Earthquake damage. The earthquake generated the strongest acceleration ever recorded in New Zealand and caused widespread damage through the northeast of the South Island, closing both the main costal State Highway 1 (SH1) and the Main North Line railway between Christchurch and Picton, as well as Kaikoura's harbor.

Recovery. Following the earthquake, the North Canterbury Transport Infrastructure Recovery (NCTIR) Alliance was formed, consisting of the New Zealand Transport Agency (NZTA), KiwiRail, and four of New Zealand's largest contractors. The NCTIR was tasked to quickly restore the road, rail, and harbor infrastructure that are critical lifelines to the surrounding communities. The alliance committed to support the goal of reconnecting these communities by the end of 2017.

Resilience assessment. The future resilience of the coastal transport corridor through Kaikoura was assessed considering the increased vulnerability to future landslides. This showed critical sections of the route where potential long-duration outages could occur; the assessment formed the basis for identifying initiatives to enhance resilience. These range from corridor realignments and engineered solutions to establishing response plans for future hazard events. The assessment was integrated into the recovery of the transport corridor and enabled the asset owners to manage the future outage risks to their networks. The assessment considered robustness, redundancy, and response as components of the corridor resilience.

Summary

- Large disruption from earthquake damage resulted in an increase in slope instability for many years.
- Understanding future damage and disruption posed by natural hazards is key to successful recovery and resilience.
- This event provided an opportunity to enhance future resilience through NCTIR recovery works.
- Screen and understand the resilience of the network/corridor, appreciate differences, and identify areas of concern.

→ Map sections of high vulnerability, allowing for more detailed assessment, are vital for:

→ Understanding the distribution of critical vulnerabilities for NCTIR recovery program

→ Prioritizing interventions

→ Enhancing resilience

→ Emergency response planning

Sources: Mason 2016; Mason, Justice, and McMorranet.

3.3.2 New Zealand 24/7 Geohazards Monitoring Centre and GeoNet

Refer to https://www.geonet.org.nz/.

GeoNet is a collaboration between the Earthquake Commission and GNS Science. It tracks all earthquakes, landslides, volcanic, and tsunami events within New Zealand, providing information to other entities and government departments they can use to make decisions. Given the critical nature of the work to the resilience of New Zealand society, a backup center is located in the central north island.

Benjamin Wylie-Cheer took participants to the New Zealand 24/7 Geohazards Monitoring Centre (Figure 3.22), which is installed in the GNS Science building. He explained the functions and roles of the monitoring center that receives all GeoNet monitoring system's real-time data, which allows them to react very quickly to analyze the real-time hazard information and impact to inform governments and stakeholders about events.

Figure 3.22: New Zealand 24/7 Geohazards Monitoring Centre

Source: Workshop participant.

3.3.3 Natural Hazards Research Platform

The Natural Hazards Research Platform (www.naturalhazards.org.nz) was established in 2009 by the New Zealand Government to provide long-term funding for natural hazard research and to help researchers and end-users work more closely together. The Platform is led by GNS Science, with the National Institute of Water and Atmospheric Research (NIWA) as a co-anchor organization and with Opus Research and the Universities of Canterbury, Massey, and Auckland as partners. Collaboration extends wider with subcontracts to other parties.

The Platform is obligated to provide the best scientific advice possible in the national interest, and research is aligned with the strategies of government agencies responsible for the reduction of, readiness for, response to, and recovery from natural hazard events.

The Platform structure includes a Strategic Advisory Group of end-users, a Technical Advisory Group of international scientists, a Management Group representing all Platform partners, a Theme Leaders Group providing science leadership and coordination across the Platform, and an Anchor CEO Group made up of the CEOs of GNS Science, NIWA, and the Ministry of Business, Innovation and Employment (MBIE).

The research aims to directly contribute to improved economic, infrastructural, and social resilience to natural hazards in New Zealand. The science capability supported by the Platform is also available to assist decision makers during significant hazard events.

The Platform is organized into five themes:

- Geological hazards
- Weather, flood, and coastal hazards
- Developing regional and national risk evaluation models
- Societal resilience: social, cultural, economic and planning factors
- Resilient buildings and infrastructure

Recent Platform activities include extensive responses to the Christchurch earthquakes, the Tongariro and White Island volcanic events, extreme weather events, risk modeling throughout New Zealand, and studies of social and business vulnerability to natural hazard events.

The Platform has approximately NZ$14M per annum (as of 2019) to invest in long- and short-term projects that align with end-user needs. The short-term funding round is open to all New Zealand–based natural hazards researchers.

3.3.4 The European Space Agency's Earth Observation for Sustainable Development, Disaster Risk Reduction Initiative

This section describes the overall intent of the Earth Observation for Sustainable Development (EO4SD) activities and the Disaster Risk Reduction (DRR) project (http://eo4sd.esa.int/).

Satellite Earth Observation (EO) technology has significant potential to inform and facilitate international development work in a globally consistent manner. Since 2008, the European Space Agency (ESA) has worked closely together with the international financial institutions (IFIs) and their client countries to harness the benefits of EO in their operations and resources management.

EO4SD—Earth Observation for Sustainable Development—is a new ESA initiative that aims to achieve a step increase in the uptake of satellite-based environmental information in the IFIs' regional and global programs. It will follow a systematic, user-driven approach in order to meet longer-term, strategic geospatial information needs in individual developing countries as well as international and regional development organizations.

Although a wide range of issues have been identified where EO can have an impact, the EO4SD initiative will begin by addressing three top-priority thematic areas:

- Urban development
- Agriculture and rural development
- Water resources management

The activities implemented in the 2016–2018 timeframe included Phase I (2016) dedicated to the stakeholders' engagement and requirements consolidation, and Phase II (2017–2018) focusing on EO information production, delivery, and capacity-building with the users to ensure that the information brings benefit to operational activities.

Within this broader context sits the Disaster Risk Reduction (DRR) activities that are directly related to the use of Earth observations from satellites.

The European Space Agency **(ESA) EO4SD Disaster Risk Reduction** project (http://eo4sd.esa.int/) aims to promote the adoption of Earth Observation (EO)–based products and services mainstreamed into the working processes of projects funded by international financial institutions **(IFIs)** that seek to prevent or mitigate the adverse impacts of natural disasters in developing countries. EO applied to disasters is evolving quickly and has proven to be effective in all phases of the disaster risk management cycle, including **prevention/preparedness**, **early warning**, **post-event recovery,** and **reconstruction activities**.

The project pursues the following objectives:

- Carrying out demonstrations of the benefit and utility of EO-based information in support of international development projects and activities in the thematic domain of disaster risk reduction (prevention, preparedness, recovery, and reconstruction phases)

- Providing direct support to programs/projects, monitoring, and evaluation methodologies, and policy and planning of the IFIs and their respective client states, not only in the sector of disaster management but also in transportation, habitat, energy, water, and sanitation

- Mainstreaming and transferring EO-based information into operational working processes of the individual countries and development organizations

Understanding disaster risk in all its dimensions of vulnerability, exposure of persons and assets, hazard characteristics, and the environment is the first priority action of the **Sendai Framework for Disaster Risk Reduction (2015-2030)**.

IFIs play a significant role as facilitators of funding in developing countries, in direct cooperation with national mandated disaster authorities to prevent and mitigate the adverse effects of natural disasters and foster sustainable development.

4 Applicability of New Zealand's Lessons to South Asia

Reiterating the lessons learned from New Zealand, this section discusses the applicability of these lessons to South Asia.

A summary of lessons from the third workshop in New Zealand includes the following:

- Recognizing that New Zealand straddles two tectonic plates, the country harnesses its capacities to surmount the threats from nature. Geological hazard is an ever-present threat in the country; thus, the government's disaster risk management structure is designed to manage geological risks, with the aim of attaining resilience.

- Because of its geographical location, the country experiences earthquakes daily, though most of these are imperceptible. New Zealand's structure is geared toward community preparedness for the worst-case scenario. The country is continually learning—learning from recent earthquakes and designing approaches to meet the challenges of the future possibility or likelihood of a large magnitude earthquake event. The country is mustering its earthquake technology using a variety of tested methodologies—research, system planning, construction techniques, designing, asset management, operation and maintenance expertise, and so on.

- The overall strategy for managing geohazards risk is wholistic. Consultations with a multitude of stakeholders, even if it takes time, and coordination with relevant agencies, supported by appropriate favorable policies anchored on scientific research and field investigation, are ideal—even necessary—ingredients of risk governance.

- Institutional arrangements are designed to support the governance and policy structure. Budgetary allocation shows the political will and commitment to ensure geological hazard risk management is successful.

- The utilization of PPPs and employing disaster risk-sensitive public and private investments are worth emulating.

- Complementation, instead of competition, and sharing knowledge and expertise is encouraged to become a common practice.

- New Zealand adheres to the Sendai Framework for Disaster Risk Reduction (SFDRR) by implementing its four priorities: understanding risk; strengthening disaster risk governance to manage risks; investing in disaster risk reduction for resilience; and enhancing disaster preparedness for effective response and building back better.

The participants discussed applying such lessons to South Asia as follows:

Understanding and accepting the risk. The New Zealand approach for managing geohazards starts with accepting the high likelihood of significant events: high-magnitude earthquakes will happen; the question is how we can adjust to be prepared. Scientific and technical evaluation of geohazard risks at the local level are yet to be evaluated in many places in South Asia—even in places where the geohazard risk is very high. Risk evaluation capabilities and planning processes based on evaluated risk can be strengthened in South Asian countries to better address increasing geohazard risk.

Integrated infrastructure asset management. In Wellington, the city practices integrated infrastructure asset management rather than maintaining separate different databases; road assets, water, gas, and critical infrastructure are all part of the integrated infrastructure database. This enables the government and stakeholders to evaluate and understand natural disaster risks throughout the entire lifeline of the city. In addition, asset management itself is the vehicle used to plan and deliver resilience on existing networks. While road asset management is being implemented, this type of integrated asset management approach can be slowly brought into large cities in the South Asia Region.

Data and knowledge sharing. Sharing data and knowledge is another good practice being applied in New Zealand, and this is one of the keys to the country's successful institutional arrangement. In South Asia, where the impact of climate change is increasing and seismic risk remains high in specific countries and regions, evaluating integrated geohazard risk is becoming critical. Its success requires more sharing of data and knowledge among different technical agencies, and closer coordination among different divisions, departments, and agencies. Many participants in the workshop understood the importance of information sharing and close coordination with different government agencies.

Investment in research and technology. New Zealand invests heavily in research and technology that improves resilience. Transmission Gully is a technically challenging project, but through implementing difficult projects, they are gaining new technologies and experience. GNS Science, the highly technical organization and a key player in geohazard risk modeling, is another successful outcome of investment in research and technology. South Asian countries can follow the path for capacity building by investing in research and technology.

Unique and flexible contract arrangements. Many participants from South Asian countries expressed an interest in New Zealand's flexible contract arrangement such as the PPP contract in Transmission Gully and the performance-based contract with a provision of emergency response in case of disasters. These contracts are still rare in South Asia, but they can be brought into each country.

Holistic resilience approach. All the points listed above are boiled down to this: New Zealand practices a holistic resilience approach for better governance, policy, processes, design, O&M, and a lifeline strategy to communities. In the workshop, participants were able to learn about the different elements that form New Zealand's holistic geohazard resilience approach from site visits and various presentations, and the workshop gave an opportunity to think about what practices can be brought into each country.

Based on the above learning and discussion, each of the eight participating countries compiled a proposed action plan as an outcome of the workshop. The eight country action plans are presented in Appendix B.

New Zealand: October 19, 2015: Tourists walk to the Real Journeys tour bus because the road has been washed away by torrential rain causing flooding and road collapse.

5 References

Mason, D. 2016 Kaikoura Earthquake Transport Network Recovery & Resilience

Mason, D., R. Justice, and T. McMorran. "Assessment of the Resilience of the North Canterbury Transport Network Following the 2016 Kaikoura Earthquake." https://www.ipwea.org/HigherLogic/System/DownloadDocumentFile.ashx?DocumentFileKey=e0a0f02e-09bf-0533-9f93-1ea5df8c824f

Sadashiva et al., 2017

Ulrich, T., A.-A. Gabriel, J.-P. Ampuero, and W. Xu. 2019. "Dynamic Viability of the 2016 Mw 7.8 Kaikōura Earthquake Cascade on Weak Crustal Faults." *Nature Communications* 10 (1) DOI: 10.1038/s41467-019-09125-w

UNISDR (United Nations Office for Disaster Risk Reduction). 2016. *The Sendai Framework for Disaster Risk Reduction 2015–2030*. Geneva: UNISDR.

World Bank. 2016. *First Annual South-to-South Learning Workshop on Landslide and Geohazard Risk in Transport: Outputs and Guidance Notes (English)*. Washington, DC: World Bank Group. http://documents.worldbank.org/curated/en/536711527089370922/Second-Annual-South-to-South-Learning-Workshop-on-Strengthening-Resilience-to-Geohazards-in-Transport-Outputs-and-Guidance-Notes

———. 2017. *Second Annual South-to-South Learning Workshop on Strengthening Resilience to Geohazards in Transport: Outputs and Guidance Notes (English)*. Washington, DC: World Bank Group. http://documents.worldbank.org/curated/en/536711527089370922/Second-Annual-South-to-South-Learning-Workshop-on-Strengthening-Resilience-to-Geohazards-in-Transport-Outputs-and-Guidance-Notes

———. 2019. Road Geohazard Risk Management Handbook. Unpublished. Washington, DC: World Bank.

———. "Building Resilient Transort in the South Asia Region." 1st SSLW in Sri Lanka Summary Video. https://www.youtube.com/watch?v=hMM3CWG1qA0

———. "Building Resilience: Second Workshop on Geohazard Risk Management in Transport Sector in South Asia." 2nd SSLW in Nepal Summary Video. https://youtu.be/MLs_QRt4jhk

6 Appendices

APPENDIX A: AGENDA

Itinerary

The following pages provide a day-by-day itinerary with indicative timeframes, venues, and objectives of each day.

Day 0: Sunday, April 28

Participants arrive in Wellington and check into the James Cook Hotel Grand Chancellor.

Grand Chancellor in Wellington
147 The Terrace, Wellington, New Zealand
Phone: +64 4 499 9500
https://www.grandchancellorhotels.com/james-cook-hotel-grand-chancellor/location

DAY 1: MONDAY, APRIL 29

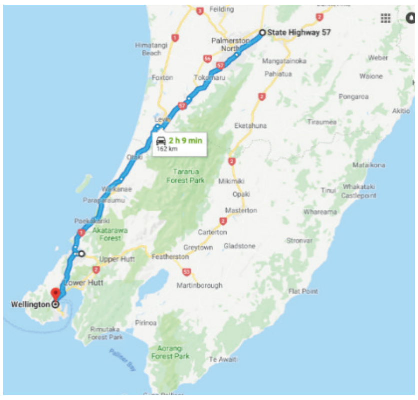
Summary: Workshop kickoff, updates on each country's action items, learning New Zealand transport sector overview and policy framework, and briefing of the site visits.

Sharing each country's updates is one of the highlights. We look forward to hearing each country's recent accomplishments, challenges, and action plan status on geohazard resilience. We also give a briefing about the New Zealand transport sector for the participants to have relevant background information before the site visits start.

Date/Time	Topic/Activity	Person Responsible
8:30-9:00	Registration	Facilitated by Marie and Bibash
9:00-9:30	Opening Ceremony: Welcome Remarks from WB Inspirational talk from NZ Lifelines Council http://www.nzlifelines.org.nz/	Chris Bennet (WB) Roger Fairclough – Chairman Lifelines (Utilities) Council
9:30—10:00	Introduction of Participants and Resource Persons	Facilitated by Zen
10:00-10:15	Objectives, Expected Outcome and Schedule	Masa
10:15–10:45	Water/Coffee Break	
10:45-11:00	Input: Disaster Risk Reduction and Management Framework	Zen
11:00-11:20	Learning outcome from the past workshops	Shruti Kulkarni video presentation
11:20-12:20	Part 1: Panel presentation on Accomplishments as per Action Plan 2017 (Panel of 5 Presenters) and Discussion Note: 5 minutes presentation; 5 minutes commentaries/questions.	To be facilitated and managed by Zen Note: using suggested template P1 for presentation
12:20-13:20	Lunch	
13:20-14:00	Part 2: Panel presentation on Accomplishments as per Action Plan 2017 (Panel of 4 Presenters) and Discussion Note: 5 minutes presentation; 5 minutes commentaries/questions	To be facilitated and managed by Zen Note: using suggested template P1 for presentation
14:00-14:20	Overview of NZ transport sector, geological history etc.	Theuns Henning
14:20-14:40	Policy Framework in Transport Sector Geohazard Risk Management in New Zealand	Theuns Henning
14:40-15:00	Input: Institutional Arrangement in Transport Sector GHRM in NZ	Ian Greenwood
15:00-15:15	Water/Coffee break	
15:15-15:45	Planning for the Field Visit - Organizing of groups: • Group 1: System planning + **Chris Bennett** • Group 2: Engineering and design + **Ian Greenwood** • Group 3: Operation and Maintenance + **Theuns Henning**	Participants to sign up for a group at registration or morning tea.
15:45-16:15	Briefing on the objectives and activities of the Study tour site visit the following day	Ian Greenwood
16:15-16:45	Synthesis for the Day and Announcements	Zen/Masa
18:30-21:00	Dinner Reception – to be held at Te Papa museum Meet in hotel reception at 6:30pm.	Ian Greenwood

DAY 2: TUESDAY APRIL 30

Today we have a full day site visit with an inspection of the under-construction Transmission Gully project in the morning and visit to the Manawatu Gorge project in the afternoon.



Transmission Gully is a 27 kilometers four-lane motorway being constructed under a public-private-partnership model. The project is described as "highly complex, with difficult and steep terrain requiring large-scale earthworks during the construction of the project. 25 new structures equating to a total length of more than a kilometer will be constructed along the route. The largest of these, the Cannons Creek Bridge, will stretch 230 meters in length and sit 60 meters above the valley floor." This visit will examine the process of designing and constructing in high-risk geohazard areas with high seismic activities. It will also help understand how the private sector considers geohazard risks when it is by contract responsible for any costs over an extended (25 year) period.

The afternoon session is based around the major decision by the New Zealand Transport Agency to abandon a state highway (the Manawatu Gorge) following multiple rock slides in April of 2017, and instead of developing a completely new route through rugged terrain. Will be covering the processes they went through to make the decision to abandon the route, and how the new alignment was selected from multiple options.

Through the two site visits, we will learn how New Zealand does 1) system planning, 2) engineering and design, 3) operations and maintenance, and 4) contingency programming, in geohazard prone areas.

Date/Time	Topic/Activity	Person Responsible
6:30-7:30	Breakfast at hotel	
7:30-8:00	Assemble at advised location ready for departure on site visit	Marie/Bibash
8:00-9:00	Wellington to Transmission Gully Project	NZ counterpart partners
9:00-12:00	Site visit to Transmission Gully PPP project (major earthworks in steep earthquake prone area) and associated discussions with design and construction teams (https://www.nzta.govt.nz/projects/wellington-northern-corridor/transmission-gully-motorway)	NZ counterpart partners
12:00-14:00	Travel on to Manawatu Gorge project & lunch	NZ counterpart partners
14:00-15:00	Briefing on the Manawatu Gorge project (https://www.nzta.govt.nz/projects/sh3-manawatu-gorge)	NZ counterpart partners
15:00-17:00	Inspect and discuss Manawatu Gorge project with NZTA (gorge is closed due to major slides and new routes are being investigated) to understand logic for abandoning current alignment and starting anew	NZ counterpart partners
17:00 -20:00	Return to Wellington & Dinner on the return trip	NZ counterpart partners

DAY 3: WEDNESDAY, MAY 1

Today we are in Wellington all day. In the morning we focus on learning New Zealand geohazard risk management including a visit to the New Zealand 24/7 Geohazards monitoring center. The morning session will be hosted by the New Zealand GNS Science, the main developer of the New Zealand geohazard monitoring system and New Zealand's leading provider of earth, geoscience and isotope research and consultancy services. GNS assists communities in resilience-building through research and consultancy in hazard monitoring, modelling, land use planning, building design, emergency management and education. https://www.gns.cri.nz/Home/Our-Science/Natural-Hazards/

In the afternoon, we have a series of exciting presentations. The first is from the European Space Agency for sustainable development (ESA4SD) Program. We learn their technologies and activities related to natural disasters focusing on geohazards, and discuss potential collaboration opportunities.

We wrap up the day with the team discussion of country specific action planning. This is to prepare the next day's presentation to the entire participants.

Date/Time	Topic/Activity	Person Responsible
6:30-7:30	Breakfast at hotel	
7:30-8:00	Travel to GNS Science by bus (get together at 7:30 am at hotel lobby)	
8:00-8:15	Overview of day and Synthesis of previous day site visit	Zen
8:15-12:00	1. Quick intro to GNS Science and the management of geological hazard risks to road network infrastructure in New Zealand (GNSScience representative) 2. Overview of the Kaikoura earthquake, complexity and impacts to transport infrastructure (GNS and a representative from NICTA the road network reinstatement agency) 3. Natural hazard risk modelling in New Zealand and how it's used to inform national and local policy (GNS – local/central government representative) 4. The Wellington Lifelines Business Case project – How Wellington lifelines have undertaken a quantitative cost benefit assessment to inform the next 10 years of infrastructure investment upgrades (GNS and Wellington Lifelines). 5. Tour of the New Zealand 24/7 Geohazards Monitoring Center and GeoNet (https://www.geonet.org.nz/)	Gill Jolly Chris Massey &Doug Mason (Opus) Vinod Sadashiva Sheng- Lin Lin &potentially Richard Mowll Benjamin Wylie-Cheer
12:00-13:00	Lunch	
13:00-15:00	Technical Presentations / Discussions 1. Presentations from ESA EOS 4D DRR Initiative (http://eo4sd.esa.int/)	ESA EO4SD
	2. Auckland University Natural Hazards Platform - progress with research and development in this area	Assistant Prof. Liam Wotherspoon
	3. Introducing new geohazard risk management handbook	Akiko Toya & Ian Greenwood
15:00-15:30	Water/Coffee break	
15:30-17:00	Group work: Country Specific Action Planning	Per country
17:00-17:15	Synthesis for the Day and Announcements	Zen /Masa/Marie
19:00 -	Dinner	

DAY 4: THURSDAY, MAY 2

Today we are in Wellington in the morning, before departure to home countries in the afternoon.

First, we will have a group discussion with an expert for each resilient transport category: 1) System planning, 2) Engineering and design, 3) Operation and Maintenance, and 4) Contingency programming; based on the learnings and findings from the entire workshop program. This will be a great opportunity to summarize their key learnings and share the thoughts as to how these learnings can be brought back home to tackle challenges along each country's geohazard resilient context.

Lastly, each country will give a presentation about new action plans, and then we close the workshop.

Date/Time	Topic/Activity	
8:30-10:30	Reflection of the workshop learnings, group discussions and advisory with experts for each category (30 minutes each session) 1. System planning 2. Engineering and design 3. Operation & Maintenance 4. Contingency programming	Groups with experts on the four areas Lead Experts: 1. Chris Bennett 2. Ian Greenwood 3. Theuns Henning 4. Zenaida Wilson
10:30-10:45	Water/Coffee break	
10:45- 12:15	Country Action Plan Presentation (8 minutes x 8) and commentaries/clarification	9 Countries representatives
12:15 - 12:45	Concluding Session: Lessons Learned	Facilitated by Zen
12:45 - 13:00	Closing Remarks and distribution of certificates	Masa and NZ Counterpart partner/s
13:00-14:00	Lunch	
14:00	Departure to home.	All

APPENDIX B: PARTICIPANTS LIST

#	Participant	Base Country
1	Mohammad Ajmal Askerzoy	Afghanistan
2	Dung Anh Hoang	Australia
3	Sam Johnson	Australia
4	Keelye Hanmer	Australia
5	Pierre Graftieaux	Australia
6	Naoki Kakuta	Australia
7	A.K.M. Manir Hossain Pathan	Bangladesh
8	Raiz Ahmad Jaber	Bangladesh
9	Md. Rabiul Islam	Bangladesh
10	Mohammad Shahja-han Ali	Bangladesh
11	Yeshey Penjor	Bhutan
12	Dhan Raj Chhetri	Bhutan
13	Susanta Kumar Jena	India
14	Khushal Chand	India
15	Shruti Kulkarni	India
16	Paolo Manunta	Manila
17	Ram Chandra Shres-tha	Nepal
18	Bibash Shrestha	Nepal
19	Deepak Man Singh Shrestha	Nepal
20	Ian Greenwood	New Zealand
21	Theuns Henning	New Zealand
22	Christopher R. Ben-nett	New Zealand
23	Zenaida Willison	Philippines
24	Maverick Wetzell	Samoa
25	Uditha Atapattu	Sri Lanka
26	Wanigavitharana Asiri Karunawardena	Sri Lanka
27	Ranaweera Mudi-yanselage Senarath Bandara	Sri Lanka
28	Priyanka Kumari Udage Arachchige Dissanayake	Sri Lanka
29	Tevita Lavemai	Tonga
30	Ringo Faoliu	Tonga
31	Masatsugu Takamatsu	United States
32	Akiko Toya	United States
33	Marie Florence Elvie	United States
34	Sean David Michaels	United States

APPENDIX C: COUNTRY ACTION PLANS

Afghanistan

Key Topic	Action Plan			Additional Comments
	What activities will you undertake to address each key topic?	Who/what agency will implement the plan and with whom?	Target completion date	Applicable lessons from New Zealand
Institutional capacity and coordination	Arrange a one-day workshop in Kabul to present the World Bank's Road Geohazard Risk Management Handbook for the Road Engineers in the Client Ministries and transfer knowledge from this workshop. Arrange a one-day workshop on the findings of the risk assessment of avalanche hazard on Salang Corridor	World Bank in collaboration with the country's Ministry of Transport World Bank in collaboration with the Ministry of Transport	2019 2019	Community engagement and awareness applied by New Zealand in project implementation The concept of a pro-active approach to hazards vs. a reactive approach
System planning	Complete and disseminate the risk assessment of avalanche for the Salang Corridor and ensure that key recommendations are considered in the design for the rehabilitation A first attempt to introduce the concept of operational resilience and criticality assessment of road network in Afghanistan	Ministry of Transport with the support from World Bank Transport and Disaster Risk Management team Ministry of Transport in collaboration with the Transport and Disaster Risk Management Team	2019 2020 and beyond	Operational resilience assessment of the rural road network Criticality assessment of road network for access to essential services
Engineering and design	Review of road engineering design for resilience	Ministry of Transport	2019–2020	
O&M	Complete the asset registration for primary and secondary roads	Ministry of Transport	2019–2020	Use satellite data for road registration
Contingency planning	Continuous coordination meetings and sharing data with the Afghanistan National Disaster Management Agency (ANDMA)	Ministry of Transport and ANDMA	Continuous	Communication and data sharing policies/ approaches

Bangladesh

Key topics	Action Plan			Additional Comments
	What activities will you undertake to address each key topic?	Who/what agency will implement and with whom?	Target completion date	Applicable lessons from New Zealand
Institutional capacity and coordination	Introduce the importance of geohazard risk management priority issue to national-level decision makers (government) as a part of global concern. Form a committee for policy directives and preparation of national action plan considering disaster risk and environmental conservation. Upgrade laws, regulations, and technical standards if required.	Prime Minister's Secretariat with Ministry of Planning and related multiple agencies; World Bank will work as facilitator Regulatory agencies	June 2020	All related agencies are working together, sharing data, optimizing resources, saving time, conducting research, and ensuring sustainable functioning. Build resilient structures by applying innovative and appropriate technology under a coordinating authority. Respect local culture and rituals. Document for next-generation learning.

System planning	Map geohazards. Identify and prioritize projects. Identify sources of funding. Share responsibility among the implementation agencies.	Ministry of Planning and related multiple agencies; development partners will work as facilitator	December 2020	Consultation with communities. The relationship among the client and contractor but be responsible and trustworthy. Be innovative in the procurement system.
Engineering and design	Identify risk/hazard issues. Perform data collection and research. Share experience and training. Keep provision in World Bank–supported Technical Assistance. Improve the design of structures.	Related existing agencies' in-house employees with the help of experts and consultants	n.a.	Employ the following: In-depth analysis and problem understanding Multiple option study Multi criteria analysis Local capacity development International standard achievement
O&M	Prepare a manual for operation and maintenance. Establish an asset management information system. Allocate budget.	Related agencies' in-house employees, with the help of experts and consultants if required	n.a.	Improve partnership and trust. Improve performance.
Contingency planning	Preparation of manual for post disaster response and recovery.	Related agencies and the Ministry of Disaster Management	n.a.	Use a flexible and secured project implementation guarantee..

Note: n.a. = not applicable.

Bhutan

Key topics	Action Plan			Additional Comments
	What activities will you undertake to address each key topic?	Who/what agency will implement and with whom?	Target completion date	Applicable lessons from New Zealand
Institutional capacity and coordination	Enhance institutional capacity Capacity development of countermeasures of slope disaster in the country Submit separate budget for the Road Asset Management System (RAMS) and the ROad Measurement Data Acquisition System (ROMDAS). Co-ordinate Apprise higher authorities in the formulation of policy for better coordination (top-down approach).	Department of Roads (DoR) with is Japan International Cooperation Agency (JICA) experts	December 2019–November 2022 December 2019 December 2019	Implement other models of financing (apart from government). Collaborate between various organizations/institutions.
System planning	Road Asset Management System: Consolidate RAMS with the bridge management system. Geo-hazard Risk Management System: Develop standard operating procedures for using the risk assessment tool by various divisions within the department.	DoR with the JICA bridge management system team DoR with the World Bank	December 2020 December 2020	Undertake detailed planning and study and of the environmental impact assessment, cultural implications, and the important corridors prior to the design and construction of any road projects.
Engineering and design	Incorporate the design for structural and non-structural countermeasure for debris and rock slope failure though JICA TCP	DoR with JICA experts	December 2020	Adopt climate-resilient design and drawings.
O&M	Prepare investment plans for O&M and submit budget proposal by using RAMS tool database for entire road network to adopt PBMS.	DoR in coordination with the nine regional offices DoR in coordination with the regional offices	December 2020	Establish a performance-based maintenance contract system.

Bhutan

Contingency planning	**Install the ex-ante traffic (early warning system) to one of the biggest slides in the country.** **Install road safety signs and crash barriers along the road.** **Improve the reach of road safety app (early warning).**	**DoR in coordination with JICA project experts and the Regional Offices** **DoR in coordination with the 9 Regional Offices** **DoR in coordination with regional offices, the Road Safety Transport Authority, and police personnel**	**December 2020** **December 2020** **December 2019**	**Establish operating procedures of Geo Hazard Monitoring system at GNS Science.** **Promote public awareness before and during construction projects.**

India

Key topics	**Action Plan**			**Additional Comments**
	What activities will you undertake to address each key topic?	**Who/what agency will implement and with whom?**	**Target completion date**	**Applicable lessons from New Zealand**
Institutional capacity and coordination	**Establish an institutional framework to manage road geohazards** **Implement laws and regulations.** **Provide technical guidelines, standards, and manuals.** **Enact a strategy plan to address road hazards.** **Tender documents for the procurement of contractors and consultancy services.** **Provide training for concerned officials and consultants.** **Establish a funding mechanism to undertake repair and to address geohazards.**	**Ministry of Road Transport and Highways, Govt. of India (MORTH)** **MORTH** **MORTH** **MORTH, National Highways Authority of India (NHAI), National Highways & Infrastructure Development Corporation Limited (NHIDCL), Border Roads Organization (BRO), Public Works Department (PWDs)** **MORTH** **MORTH, NHAI, NHIDCL, BRO, PWDs** **MORTH, NHAI, NHIDCL, BRO, PWDs**	**One year** **One year** **One year** **One year** **One year** **Two years** **Two years**	**Enhance the use of bioengineering to protect from landslides.** **Enhance coordination among all stakeholders.**
System planning	**Establish a plan to identify risks on the existing road network.** **Use GIS in managing the road network.** **Finalize the methodology to select the optimal solution for geohazards.** **Employ technical expertise for system planning.**	**MORTH, NHAI, NHIDCL, BRO, PWDs** **MORTH, NHAI, NHIDCL, BRO, PWDs** **MORTH** **MORTH, NHAI, NHIDCL, BRO, PWDs**	**One year** **One year** **One year** **One year**	**Technologies to identify potential geohazards and prioritize mitigation** **100 percent of the land acquisition shall be in place before start of the project.** **Include incentive and penalty clauses in the contract agreement for contractor and consultants.**

India

Engineering and design	**Prepare a manual to carry out soil, geological, seismic, and hydrological surveys and other investigations with the latest equipment and techniques.** **Prepare guidelines and a manual for designing various types of road geohazards including stability analysis.** **Formulate guidelines and checklist to prepare the strategy and methodology to take up the road geohazards projects, including the list of equipment, contractors, consultants, clearances to be obtained from various departments, and so on.** **Formulate guidelines for the preparation of a quality assurance plan to be implemented during execution.**	**MORTH in consultation with NHAI, NHIDCL, BRO, PWDs**	**One year** **One year** **One year**	**Put in place the criteria for the finalization of alignment, contractor, and consultant, considering the site conditions and the rules and regulations applicable in New Zealand. These criteria are to be modified as per our site and country rules and regulations.**
O&M	**Prepare guidelines and tender documents for the operation and maintenance of road hazards including a checklist of equipment, key personnel, and so on.** **Establish a mechanism to monitor the day-to-day activities of installed equipment such as CCTV cameras, rockfall detectors, extensometers, crack gauges, surface tilt meters, GPS devices, LiDAR, Piezometer, rain gauges, and so on.** **Establish a mechanism to communicate the warning/ precautionary information to the road users, concerned authorities, communities, disaster information center, and so on by telephone, email, and mobile phone.**	**MORTH in consultation with NHAI, NHIDCL, BRO, PWDs**	**One year** **One year** **One year**	**n.a.**
Contingency planning	**Contingency provision can be used for unplanned works. All planned works including emergency works shall be a part of main agreement.**			

Note: n.a. = not applicable.

Nepal

Key topics	**Action Plan**			**Additional Comments**
	What activities will you undertake to address each key topic?	**Who/what agency will implement and with whom?**	**Target completion date**	**Applicable lessons from New Zealand**
Institutional capacity and coordination	**Coordinate with the Department of Roads (DoR) on the strategic roads.** **Coordinate and support province-level Ministry of Physical Infrastructure and Transport (MoPIT) to initiate the concept in local roads.** **Assign and develop specific geohazard risk management activity in the Department of Local Infrastructure (DoLI).** **Develop in-house expertise, training materials, and trainers on this subject at DoLI.** **Conduct training for DoLI and MoPID engineers.** **Train local communities on small-scale engineering or bioengineering.** **Explore use of engineering university or similar research units to develop the expertise on this field (long term).**	**The DoR at the federal level; the DoLI and MoPIT at the province level**	**Start in 2019 and continue**	**Use university and or consulting/ research firms to develop the needed expertise.**

Nepal

Engineering and design	Identify and apply relevant international slope stabilization standards. Carry out slope stabilization works on the East Coast Road.	LTA LTA	2020 2021	Investigate mechanically stabilized earth measures that can be used on existing vulnerable slopes and in future projects.
Operation and Maintenance	Review maintenance contracts to be longer multi-year contracts, and revise performance measures for performance-based contract (PBC). Update SAMS. Update axle load limit and road design standards.	LTA LTA LTA	2019 2020 2019	Look into improving drainage maintenance to prevent rainfall-induced landslides. Investigate whether a public-private partnership contract will be feasible in Samoa.
Contingency planning	Carry out a feasibility study of Alafaalava road as an alternative route to the West Coast Road.	LTA	2020	Carry out models/scenarios of network failure due to various geohazards.

Sri Lanka

Key topics	Action Plan			Additional Comments
	What activities will you undertake to address each key topic?	Who/what agency will implement and with whom?	Target completion date	Applicable lessons from New Zealand
Institutional capacity and coordination	Prepare a framework/ guideline for managing the geohazards along main roads. Allocate separate funding for managing geohazards. Assess the capacity of the staff in relevant government institution for geohazard management.	National Building Research Organization (NBRO) Disaster Management Center (DMC) Road Development Authority (RDA) Provisional Road Development Authority (PRD) Ministry of Finance	2020 Already exists, needs to be streamlined 2020	Emulate the asset management system of NZ. Importance of developing of capacity of relevant institutes.
System planning	Prepare a manual for geohazards risk identification along major roads. Identify the location with geohazards. Prepare a methodology to prioritize sites for mitigation. Develop a flow chart for selecting an appropriate solution for minimizing geohazard risk.	NBRO DMC RDA	2020 2022 2020 2020	NZ has identified the priority and road capacity with the ideas of all related stake holders. They have assigned a critical index for all major roads. Allocating sufficient funds for geohazard mitigation is very important. Data are being shared among all related stakeholders.

Sri Lanka

System planning	**Include geohazard risk assessment in the Terms of Reference in all road design work.** **Include geotechnical engineers in the design team.** **Include bioengineering measures in all hill roads for high embankment and cut slopes.** **Encourage the use of communities in implementing bioengineering, as possible.**	**DoR at the federal level and DoLI through MoPID at province level**	**Start in 2019 and continue**	**Consider climate change and hazards: because of steep slopes, earthquakes, and rainfall the roads/bridges need to be carefully designed considering all risks.**
Engineering and design	**Prepare a geohazard map for the road corridor.** **Include geohazard risk assessment in the design report.** **Include adequate site-specific measures for identified risks.** **Include adequate costing for the measure and bioengineering projects to be included in costs.** **Bridges to be resilient to the Earthquake.**	**DoLI, DoR to implement through MoPID at the province level**	**Start in 2019 and continue**	**Geohazard risk assessment and site-specific measures.** **Planning, design, and implementation of the project, as seen in Transmission Gully project.**
O&M	**Start regular monitoring of critical locations, especially before and after monsoon rains.** **Allocate adequate budget for preventive maintenance.** **Use local communities in slope management.**	**DoLI through the MoPID and local government**	**Start in 2019 and to be continued**	**Only proper operation and maintenance reduces not only the risks of road closures and accidents, but also reduces the vehicle operating costs.**
Contingency planning	**Create a budget head for each province for emergency work.** **Support the province for creating a heavy equipment unit for emergency work.**	**DoLI with MoPID for each province**	**Start in 2019 and continue**	**n.a.**

Note: n.a. = not applicable.

SAMOA

Key topics	**Action Plan**			**Additional Comments**
	What activities will you undertake to address each key topic?	**Who/what agency will implement and with whom?**	**Target completion date**	**Applicable lessons from New Zealand**
Institutional capacity and coordination	**Share data between agencies (Light Detection and Ranging [LIDAR], rainfall data, and so on).** **Establish a database for geohazard events such as landslides.**	**Land Transport Authority (LTA), Ministry of Natural Resources and Environment (MNRE), Ministry of Works, Transport and Infrastructure (MWTI)** **LTA**	**2020** **2019**	**There is a need to record as much information/data on (geohazard) events as possible in order to carry out models and determine vulnerable sections of the road network.**
System planning	**Update the following:** **Samoa Asset Management System (SAMS)** **Crash database** **Vulnerability Assessment**	**LTA** **MWTI** **LTA**	**2020** **2020** **2020**	**Split the country into regions and define risks in each region.**

Samoa

Engineering and design	Prepare a manual for geotechnical investigation for the design of roads. Prepare a design manual for landslide mitigation. Encourage capacity development for engineers and geologists for designing countermeasures.	NBRO DMC RDA	Already exists, needs to be improved with resilience construction; target year is 2020 2021 Ongoing	Incorporate road resilience into the engineering design. Consider many alternatives and select the best for the condition. Carry out relevant research and development work.
O&M	Prepare a maintenance manual for structural countermeasures to build for geohazard mitigation. Install monitoring instruments to detect geohazards early. Establish an awareness program for road users and landowners for geohazard management. Train local contractors for maintenance work.	NBRO DMC RDA Local authority	2021 Already commenced as pilot sites Ongoing	Understand the importance of having an asset management system Allocate sufficient budget for maintenance. Understand the importance of considering nonstructural measures for road maintenance and operations. Advance site-specific instrumentation for early warning. Enhance the general public's awareness of road maintenance.
Contingency planning	Prepare an emergency preparedness and response plan (Standard Operating Procedure) for handling geohazards. Conduct evacuation drills, training, and so on. Simulate case scenarios for understanding the damage, the necessary funds for rehabilitation, and so on.	NBRO DMC RDA Local authority Police	2020 Ongoing, needs to be strengthened 2020	Many studies have been done to simulate the potential disasters with different impact level and prepare the contingencies planning accordingly.

TONGA

Key topics	Action Plan			Additional Comments
	What activities will you undertake to address each key topic?	Who/what agency will implement and with whom?	Target completion date	Applicable lessons from New Zealand
Institutional capacity and coordination	Establish an institutional framework inclusive of geohazard risk management. Improve collaboration. Improve stakeholders' participation. Road Maintenance Fund 10 Local Civil Contractors (NONE – 2012) Multiyear routine maintenance contract Annual periodic maintenance Introduced PBC – multiyear	Propose the Ministry of Infrastructure (MOI) internal collaboration policy to the Cabinet of Government of Tonga	End of 2019/2020 FY	Establish a comprehensive arrangement of institutional Framework. Share Information through collaboration. Work with each other, do not challenge each other. Ensure customers' (e.g., road users) satisfaction Preserve wildlife and historic places.

Tonga

System planning	Strengthen the climate resilience of all road projects. Ensure that wildlife will not be harmed in all projects.	MOI, Ministry of Lands, Survey & Natural Resources (MLSNR), Ministry of Internal Affairs (MIA), Ministry of Agriculture and Food, Forests and Fisheries (MAFFF)	End of FY19/20	Employ proactive planning. Collaborate within and with external stakeholders/experts. Share information for the benefit of the country as a whole (through transparency). Strengthen the climate resilience of all road projects.
Engineering and design	Factor climate resilience into all road projects in Tonga. Review current specifications. Review current projects' climate resilience: Fanga'uta Lagoon Bridge Evacuation roads	MOI, MLS, MIA, MAFF, UTILITIES	December 2019	GNS Science's contribution to New Zealand Build local experts' capacities—using development projects' expertise for knowledge transference. Use specific expertise on the corresponding field/areas of expertise
O&M	Review the current Road Maintenance Contract to allow for timely response to any disaster. The current contract allows the government to use the contractors' equipment and staff for any disaster emergency work Review current specs Train/build local civil contractors' capacities with RAM (road asset management), Excel version	MOI, MEIDECC, MOP, MOF, HDF, civil contractors	December 2019	Use PBC Use routine multiyear road contracts. Use traditional tender methods. O&M Establish a resilient management plan Establish a road asset management plan Keep good roads good
Contingency planning	Review the current Road Maintenance Contact to allow for timely response to any disaster. The current contract allows the government to use the contractors' equipment and staff for any disaster emergency work. Review current projects' climate resilience: Fanga'uta Lagoon Bridge Evacuation roads	MOI, MEIDECC, MOP, MOF, HDF, CIVIL CONTRACTORS	December 2019	Prepare a vulnerability assessment Use a Contingency Emergency Response Component (CERC) - DRR approach Use current specs to empower each relevant ministry to divert funds for emergency matters when a natural disaster happens.

APPENDIX D: SUMMARY OF THE THREE WORKSHOPS IN SRI LANKA, NEPAL, AND NEW ZEALAND

The three learning workshops were designed to cover topics identified from surveys and participant feedback. Methods used ranged from presentations of the current situation of the project areas, the challenges they encountered, and how those challenges were overcame; theoretical inputs on the relevant subjects by subject experts; questions and answers; sharing experiences through presentations and roundtable discussions; field investigations and interaction with the implementers; and, finally, a forum with experts to discuss additional points. The workshops provided a valuable opportunity for learning from other participants and from experts. Action planning toward the end of the workshop ensured that the participants would take their learning and pursue and advocate for necessary actions with relevant agencies and departments back home.

Both the first and second SSLW had the same theme: "Building Resilience to Landslide and Geohazard Risk in Transport Sector," while the theme of the third SSLW was "Strengthening Geohazard Risk Management in DRM and Transport" to expand the focus to the DRM sector.

The first SSLW was held in Kandy, Sri Lanka, on November 15–17, 2016, and covered the following topics: geohazard risk mitigation; rain-induced landslides and early warning system – the Sri Lanka experience; geotechnical asset management and tools: Global and US Federal Highway experience; and decision support systems for geohazard risk management in the transport sector in Afghanistan. Workshop participants in the first SSLW visited the Kandy – Mahiyangana – Padiyathalawa Highway (known as the "eighteen-bend road"), a critical road connection to the eastern part of Sri Lanka. The government wanted to stabilize 18 unstable slope sections on this particular road under the World Bank–funded Climate Resilience Improvement Project. The landslide and rock fall sites are located within a stretch of 10–15 kilometers along the road, where participants were able to observe a wide range of stabilization techniques being applied.

The second SSLW was held in Kathmandu, Nepal, on November 15–17, 2017, and covered the following topics: an overview of disaster risk management in transport sector; resilient road asset management: monitoring and maintenance; and preparedness in transport: key elements of disaster preparedness strategy. The participants in the second SSLW visited the Banepa (Dhulikhel)-Sindhuli-Bardibas Road, an important road in the eastern Kathmandu valley. Initially the road was intended as an agricultural access road, but it has become one of a few alignments that provides all-weather access to the Terai. During the 2015 earthquake, for example, it proved one of the most reliable means of access to Kathmandu from the south.

All three workshops had many productive interactive sessions where participants learned from each other and from the experts. The site visit to the project areas provided the participants a broad range of possibilities for managing geohazard risk in transport sector.

There are remarkable learning experiences from the three SSLWs: Sri Lanka, November 2016; Nepal, November 2017; and, the most recent one, New Zealand, April 2019. Lessons learned and experiences shared by the participants are expected to remain with them for application to their respective countries. The first two workshops held within the South Asia Region provided the participants with an opportunity to compare their own practices to and gain insights from the geohazard risk management of their neighboring countries. The last workshop, held in New Zealand, impressed the participants with an advanced application of GHRM practiced in New Zealand with risk modeling, institutional coordination, and new technologies.

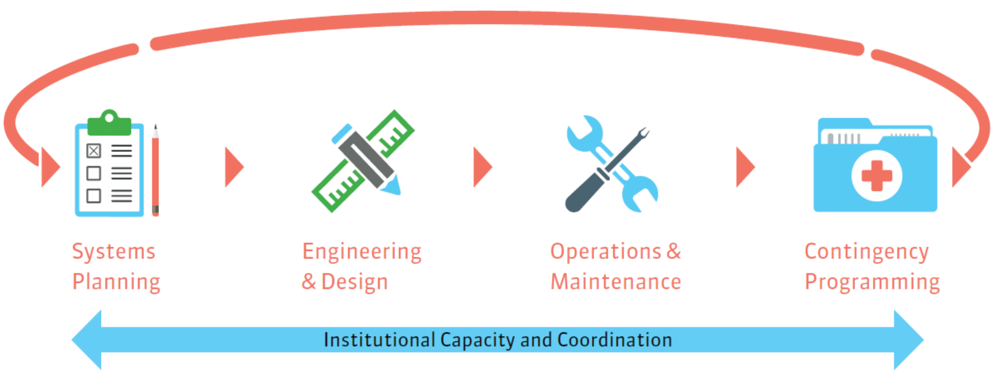
APPENDIX E: RESILIENT INFRASTRUCTURE LIFE CYCLE FRAMEWORK

The World Bank Disaster-Resilient Infrastructure Life Cycle is illustrated in Figure E1 and it is this overall approach that the workshop was based around. The GFDRR and the World Bank have released a *Road Geohazard Risk Management Handbook* in 2019 that provides more details on the application of the life cycle.

The key phases of the life cycle are:

- Systems Planning: The systems planning stage of the life cycle covers those activities that are often referred to as the institutional arrangements that are necessary to be in place to support the overall geohazard risk management process. The main aspects of systems planning are risk identification and assessment, risk evaluation, and risk management planning.
- Engineering and Design (and construction): This phase of the life cycle involves the use of engineered (or structural) measures to reduce or mitigate geohazard risks.
- Operations and Maintenance (O&M): This phase covers the day-to-day activities associated with managing transport infrastructure from a geohazard perspective, including the use of traffic management and other nonstructural measures.
- Contingency Programming: This phase covers three distinct phases of Emergency preparedness – what happens before a geohazard event; Emergency response – what happens during and in the immediate aftermath of an event; and Recovery – what happens following the emergency to restore full functionality to the road network.
- Institutional Capacity and Coordination: This phase addresses the human and institutional capacity required to deliver the overall life-cycle approach.

Figure E1: World Bank Disaster-Resilient Infrastructure Life Cycle Approach



Source: World Bank Resilient Transport Community of Practice.

The geohazard handbook outlines an approach to proactively manage the risks of geohazards on roads, road users, and the people living near roads and affected by them through:

- Improving understanding of the risks of geohazards throughout the road infrastructure cycle;
- Promoting risk avoidance on the alignment of new roads or the realignment of existing roads to manage construction costs, maintenance costs, and losses from geohazard-induced traffic disruptions;
- Protecting road users through preparedness, including measures for early warning, precautionary road closures, access to emergency services and evacuation routes; and
- Contributing to the speedy recovery and reconstruction of roads after geohazard events, and the mitigation of future geohazard events.

APPENDIX F: OVERVIEW OF GLOBAL DISASTER RISK REDUCTION FRAMEWORK

Coherence of approaches is one of the main themes of the latest Global Platform in DRR (May 2019). The SSLW tackles all the four priorities contained in the SFDRR, directly and indirectly. As participants discussed various topics related to geological hazard risks, it was clear that, in New Zealand, policies and practices are based on an understanding of disaster risk in all its dimensions of vulnerability, capacity, exposure of persons and assets, hazard characteristics, and the environment. It also became apparent that disaster risk governance at national levels is of great importance for effective and efficient management of disaster prevention, mitigation, preparedness, response, recovery, and rehabilitation. The SSLW participants witnessed the efficient and productive engagement between public and private partnerships by considering risk-sensitive investments through structural and nonstructural measures. This is essential in enhancing the economic, social, health, and cultural resilience of communities and their assets, as well as the environment. It was demonstrated in our visits to several project areas that the reconstruction of transport pathways can be a critical opportunity to build back better. Considering climate change as a factor in the design of infrastructure was also observed.

The global framework is a useful guide for the development of countries' relevant national policies, implementation mechanisms, institutional arrangements, and budgetary allocations. Several global frameworks are endorsed by the South Asian countries; these are committed to contextualize and adapt to their national and local situation. Disasters caused by natural hazards, by human activities, and by a combination of both are continuously on the rise. While the number of casualties decreases, direct physical, economic, and financial losses from disasters increases. Disasters certainly upset years of development gains. Geological hazards exacerbated by climate change cause tremendous destruction to physical infrastructure and critical facilities and incalculable harm to the populace. Damage to critical infrastructure and major lifelines and disruption to basic services are some of the main problems when hazards hit communities. Dilapidated transport routes, precarious power grids, and unsafe bridges hamper efficient emergency operations and restrain the potential for the affected people to help themselves. Thus, geohazard risk management (GHRM) is an essential component of protecting communities and preparedness is a necessary activity.

Counties are expected to protect their people from harm and danger resulting from preventable disaster risks. The goal of devising a global paradigm in disaster risk reduction is to set a global pattern for building safe and resilient communities and nations. GHRM in the transport sector is an important aspect of promoting countries' resilience. Therefore, it is necessary to incorporate GHRM into the country's overall integrated disaster risk reduction plans, priorities, and implementation. Understanding the country's program on disaster risk reduction and climate change adaptation with the global agendas is vital for monitoring progress of country's preparedness and resilience to disasters.

The disaster risk reduction landscape has evolved over the years. Global progress has been made through international protocols and agreements. This section will tackle the three most relevant frameworks for disaster risk reduction: the Sendai Framework for Disaster Risk Reduction (SFDRR) 2015–2030, the Sustainable Development Goals (SDGs) 2030, and the Paris Climate Change Agreement.

The Sendai Framework for Disaster Risk Reduction 2015–2030

Reducing disaster risks from natural sources through disaster prevention, preparedness, and mitigation has been the center of the global initiatives under the International Framework for Action for the International Decade for Natural Disaster Reduction (IDNDR) of 1989; the Yokohama Strategy for a Safer World and its Plan of Action of 1994; and the United Nations International Strategy for Disaster Reduction (UNISDR) of 1999. The Hyogo Framework for Action (HFA) 2005–2015 and the Sendai Framework for Disaster Risk Reduction (Sendai Framework) 2015–2030 were devised to give further impetus to the above-mentioned global policy frameworks.

The Sendai Framework has brought in several improvements identified during the consultations and negotiations, such as a strong emphasis on disaster risk management as opposed to disaster management. In addition, the scope of disaster risk reduction has been broadened significantly to focus on both natural and human-made hazards and related environmental, technological, and biological disaster risks. The Sendai Framework also articulates the need for resilience of health infrastructure, cultural heritage, and workplaces; strengthens international cooperation and global partnership, as well as risk-informed donor policies and programs, including financial support and loans from international financial institutions. There is also clear recognition of the global and regional disaster risk reduction platforms as mechanisms for coherence across agendas, and for monitoring and periodic reviews in support of UN governance bodies. The former UNISDR, which was transformed into the United Nations Office for Disaster Risk Reduction (UNDRR) in May 2019, has been tasked to support the implementation, follow-up, and review of the SFDRR.

The Sendai Framework's Goals and Targets

The **overarching goal** of the SFDRR is to build nations and communities' resilience against disasters. The SFDRR has the following seven targets by 2030:

1. Substantially reduce global disaster mortality.
2. Substantially reduce the number of affected people globally.
3. Reduce direct disaster economic loss in relation to global gross domestic product (GDP).
4. Substantially reduce disaster damage to critical infrastructure and disruption of basic services, among them health and educational facilities, including through developing their resilience.
5. Substantially increase the number of countries with national and local disaster risk reduction strategies.
6. Substantially enhance international cooperation to developing countries through adequate and sustainable support to complement their national actions for implementation of the present Framework.
7. Substantially increase the availability of and access to multi-hazard early warning systems and disaster risk information and assessments to people.

The Sendai Framework's Four Priorities

Priority 1: Understanding Disaster Risk
Policies and practices for disaster risk management should be based on an understanding of disaster risk in all its dimensions of vulnerability, capacity, exposure of persons and assets, hazard characteristics, and the environment.

Priority 2: Strengthening Disaster Risk Governance to Manage Disaster Risk
Disaster risk governance at the national, regional, and global levels is of great importance for effective and efficient management of disaster risk. Clear vision, plans, competence, guidance, and coordination within and across sectors, as well as the participation of relevant stakeholders, are needed. Strengthening disaster risk governance for prevention, mitigation, preparedness, response, recovery, and rehabilitation is therefore necessary and fosters collaboration and partnership across mechanisms and institutions for the implementation of instruments relevant to disaster risk reduction and sustainable development.

Priority 3: Investing in Disaster Risk Reduction for Resilience
Public and private investment in disaster risk prevention and reduction through structural and nonstructural measures are essential to enhance the economic, social, health, and cultural resilience of persons, communities, countries, and their assets, as well as the environment.

Priority 4: Enhancing Disaster Preparedness for Effective Response and to "Build Back Better"
Disasters have demonstrated that the recovery, rehabilitation, and reconstruction phase—which needs to be prepared ahead of a disaster—is a critical opportunity to "Build Back Better," including through integrating disaster risk reduction into development measures, making nations and communities resilient to disasters.

Global Platform for Disaster Risk Reduction

Every two years, the Global Platform for Disaster Risk Reduction (GPDRR), a multistakeholder forum, is held to review progress, share knowledge, and discuss the latest developments and trends in reducing disaster risk. Box F.1 is a summarized overview of the GPDRR culled from https://www.unisdr.org/conference/2019/globalplatform/.

Sustainable Development Goals 2030

Development for all is constrained by both natural and human-sourced disasters. It does not have to be this way because, though geological and metrological hazards are inevitable, high death tolls are not, if only appropriate measures are undertaken on a global scale. Amid this backdrop, leaders from 193 countries of the world came together in September 2015 and crafted the Sustainable Development Goals (SDGs). This ambitious set of 17 goals dreams of a world without poverty and hunger and safe from the worst effects of climate change and disasters. Disaster risk reduction (DRR) is an integral part of social and economic development. The 2030 Agenda for Sustainable Development recognizes and reaffirms the urgent need to reduce the risk of disasters by reducing the exposure and vulnerability of the poor to disasters or by building resilient infrastructure. Several SDGs and targets can contribute to reducing disaster risk and building resilience. Without addressing disaster and climate risks, it would be impossible to pursue the achievement of the SDGs. Reducing mortality and economic losses from disasters, and—more importantly—preventing hazards from becoming disasters are key to fulfilling the SDGs. Detailed information on the SDGs can be found at *https://sustainabledevelopment.un.org/?menu=1300*.

Paris Climate Agreement

The Paris Agreement was adopted by 196 Parties to the United Nations Framework Convention on Climate Change (UNFCCC) at the United Nations Climate Change Conference in Paris on December 12, 2015. It brings all nations into a common cause to undertake ambitious efforts to combat climate change and adapt to its effects, with enhanced support to assist developing countries

BOX F.1: AN OVERVIEW OF THE GPDRR

The GPDRR is a critical component of the monitoring and implementation process of the SFDRR (2015–2030). The outcomes of the Global Platform inform the deliberations of the High-Level Political Forum on Sustainable Development and the UN 2019 Climate Summit from a disaster risk reduction perspective. These efforts contribute toward the successful achievement of a risk-informed 2030 agenda for Sustainable Development.

Over the past decade, the Global Platform has assumed the role of assessing and reviewing progress in the implementation of the global disaster risk reduction agenda, and has served as a platform for governments and stakeholders to share good practices, identify gaps, and make recommendations to further accelerate its implementation. In total, five sessions of the Global Platform have taken place since 2007. While each of the sessions focused on specific themes, the following topics have been recurrent in most of the sessions, in different forms and reiterations: (i) national and local implementation, (ii) investments and the economics of disaster risk reduction, and (iii) linkages and coherence with climate change and sustainable development.

The sixth session of the Global Platform for Disaster Risk Reduction (GP2019) took place in Geneva, Switzerland, on May 13–17, 2019. It was convened and organized by the UN Office for Disaster Risk Reduction (UNDRR) and hosted by the Government of Switzerland. The theme of the GP2019 was "resilience dividend" and focused on how managing disaster risk and risk-informed development investments pay dividends in multiple sectors and geographies; across all scales; and throughout social, economic, financial, and environmental fields. The concept of *resilience dividend* in this context goes beyond monetary profit, which means the gains contribute to reducing disaster risk; foster development; and trigger multiple social, environmental, and economic benefits in the long

to do so. It charts a new course in the global climate effort to limit global temperature rise to 1.5 degrees Celsius by adapting to and mitigating climate change by reducing greenhouse gas emissions. Strengthening the capacities of national and subnational authorities, civil society, the private sector, indigenous peoples, and local communities can support the ambitious actions that would be required to limit global warming to 1.5 degrees Celsius. Harmonized strategies to combat climate change risks and disaster risks are one of the imperatives of today in order to contribute to attaining the Sustainable Development Goals. To face this big challenge, Asian governments have been taking steps to mainstream climate change mitigation and adaptation—including identifying and executing disaster risk reduction measures—by supporting local development to make communities more climate and disaster resilient.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OUTPUTS FROM THE THIRD SOUTH-TO-SOUTH LEARNING WORKSHOP

STRENGTHENING GEOHAZARD RISK MANAGEMENT IN DRM AND TRANSPORT IN THE SOUTH ASIA REGION

Wellington, New Zealand
April 29–May 2, 2019

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Geohazard
Risk Management
in Transport Sector

GFDRR
Global Facility for Disaster Reduction and Recove