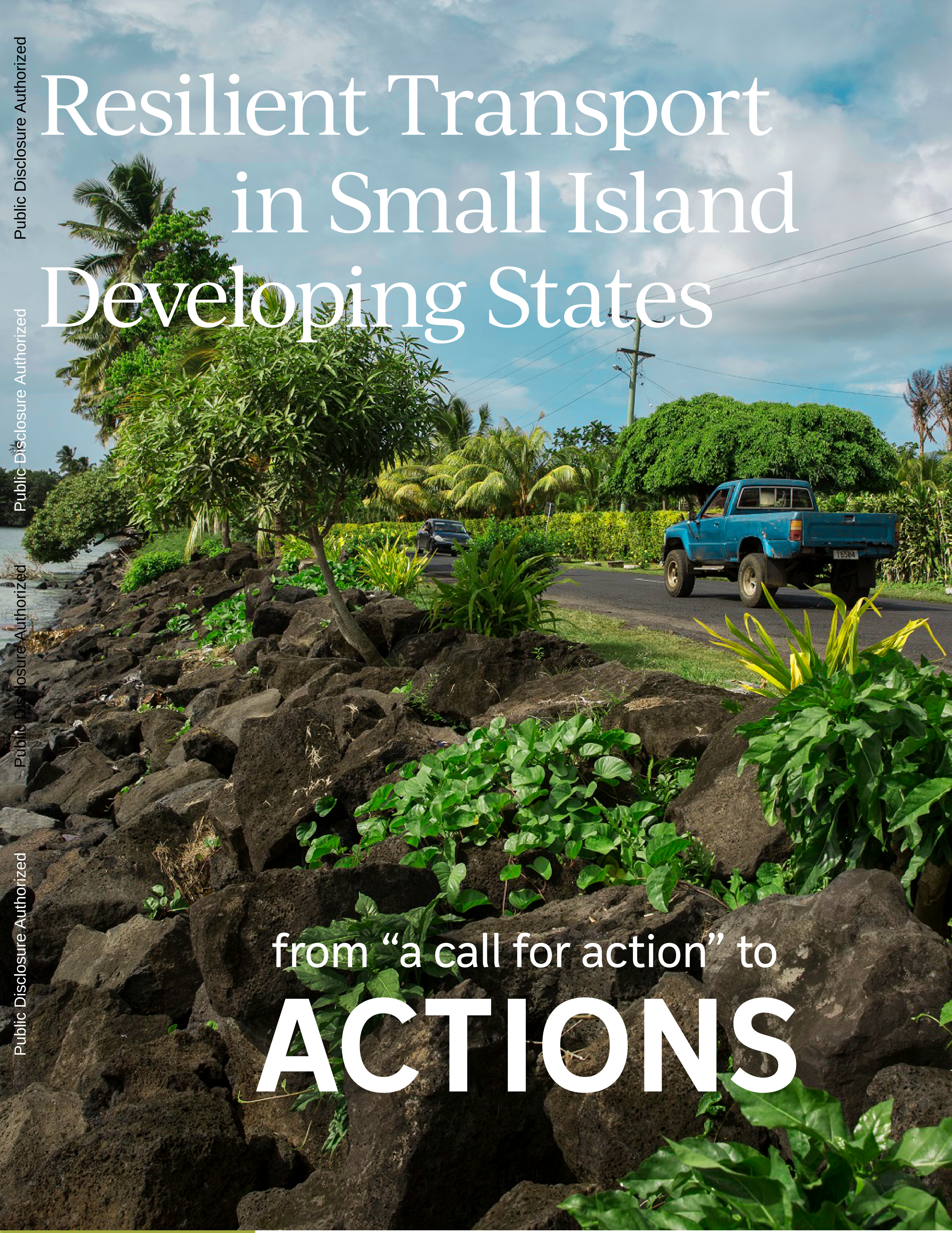
Resilient Transport in Small Island Developing States



from "a call for action" to ACTIONS

March 2022

GFDRR
Global Facility for Disaster Reduction and Recovery

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Abbreviations

AMS	Asset Management Systems
BRAGSA	Buildings, Roads, and General Services Authority
GDP	Gross Domestic Product
GFDRR	Global Facility for Disaster Reduction and Recovery
GIS	Geographic Information System
MoTW	Ministry of Transport, Works, Lands and Physical Planning
NDMO	Department of National Disaster Management Office
ProMIS	Project Management and Information System
PWD	Public Works Department
RAMS	Road Asset Management System
RIMS	Road Inventory Management System
SCM	Supply Chain Model
SIDS	Small Island Developing States
SITAMS	Solomon Islands Transport Asset Management System
S.O.F.T.	Simplicity – Operationality – Flexibility – Transferability
TAMS	Transport Asset Management System

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Aims and Objectives

Small island developing states (SIDS) are among the most exposed, vulnerable countries in the world to natural hazards and the impacts of climate change. SIDS are already experiencing significant economic and social losses from climate change impacts. Extreme weather events such as flooding and hurricanes significantly affect the transport sector, with damage from such events accounting for a large percentage of total infrastructure damage costs. The need for climate adaptation is recognized in SIDS' nationally determined contributions to the Paris Agreement under the United Nations Framework Convention on Climate Change. The World Bank supports its clients in implementing nationally determined contribution objectives and actions. The World Bank Group Climate Change Action Plan sets a climate finance target of 35 percent of World Bank Group commitments by 2025. This is expected to translate to US$25 billion average annual climate financing between 2021 and 2025, with 50 percent to be dedicated to climate adaptation. Furthermore, at the 2021 United Nations Climate Change Conference of the Parties the World Bank announced the alignment of its financial commitments with the Paris Agreement objectives by 2030 and inclusion of country climate development reports, which are a new diagnostic assessment for client country engagement, to identify and prioritize opportunities for high-impact climate action.

The World Bank's programmatic technical assistance, Resilient Transport in Small Island Developing States, implemented with the aim of enhancing the resilience of the transport sector in SIDS, was delivered in three phases. Phase 1, completed in 2017, addressed the urgent need to enhance the climate resilience of the transport sector in SIDS and proposed a holistic framework to integrate climate resilience considerations systematically into transport asset infrastructure lifecycles. Phase 1 included production of the report *Climate and Disaster Resilient Transport in Small Island States: A Call for Action* (World Bank 2017a). Phase 2 implemented the resilient transport framework across four selected countries in the Pacific, Africa, and the Caribbean. Phase 3 promoted knowledge sharing through an online training course and a knowledge platform (i-Knowledge) to disseminate materials online for easy access of client countries and partners.

The objective of this report, *Resilient Transport in Small Island Developing States—From "A Call for Action" to Actions*, is to help practitioners integrate climate resilience considerations into transport asset management and thus enhance climate resilience in the transport sector of SIDS (Phases 2 and 3 of the technical assistance). The report starts by introducing the topic of natural hazards and climate change in SIDS and how they affect the transport sector. The report describes how governments can develop resilient transport asset management systems (TAMS) and then summarizes the activities implemented in four SIDS— Cape Verde in Africa, Saint Vincent and the Grenadines in the Caribbean, and Solomon Islands and Vanuatu in the Pacific —and shares lessons learned to improve the approach and framework. Finally, the report introduces an online training course on resilient TAMS and the *i*-Knowledge platform.

1 Introduction

This chapter introduces the topic of natural hazards and climate change in small island developing states (SIDS) and impacts on the transport sector and proposes ways to integrate resilience considerations into transport asset management systems (TAMSs).

1.1 Climate Change and Natural Hazards in SIDS

SIDS, located in Africa, the Caribbean, the Indian Ocean, and the Pacific (Map 1), are particularly vulnerable to natural hazards and climate change impacts because of high exposure, isolated geography, small economies, and strong reliance on sectors such as tourism and fisheries that in turn depend on vulnerable ecosystems.

Map: Small Island Developing States According to Region

Source: UNCTAD.

Most SIDS are located in the tropics and are therefore seasonally affected by extreme weather events such as tropical storms, cyclones, and hurricanes. SIDS also experience climate variability and resulting droughts, floods, and landslides. Many SIDS are in tectonically active hotspots, exposing them to geohazards such as volcanoes, earthquakes, and tsunamis (e.g., Cape Verde, Samoa, Saint Vincent and the Grenadines, Solomon Islands, Tonga, Vanuatu).[1] Many SIDS have a maximum elevation of less than 5 m (e.g., Kiribati, Maldives, Marshall Islands, Tonga, Tuvalu)

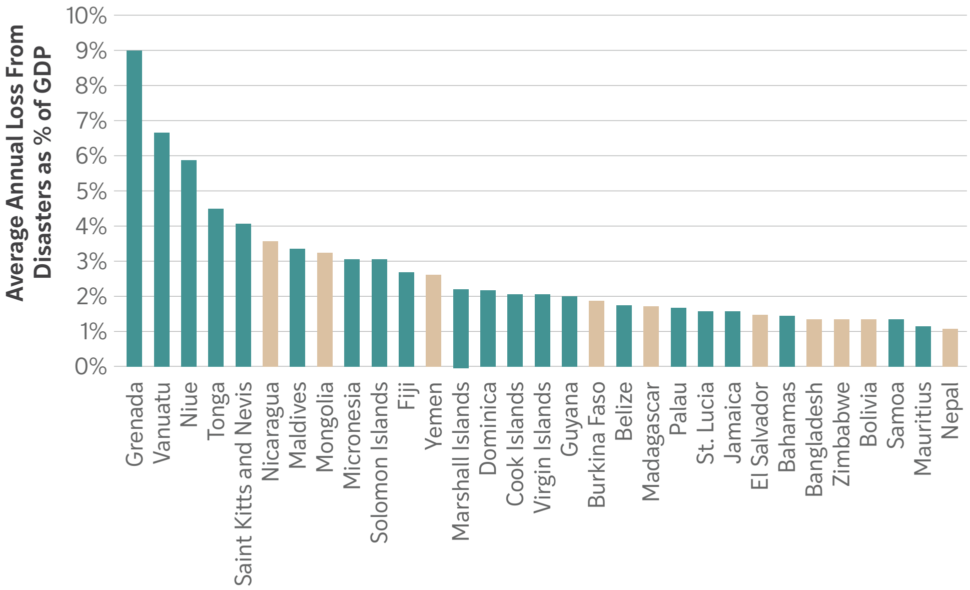
[1] See ThinkHazard database (accessed September 21, 2021), https://thinkhazard.org/en/.

above mean sea level. Climate change is projected to alter parameters such as temperature and precipitation, cause sea-level rise, and increase the intensity and frequency of extreme weather.

The Caribbean has already been experiencing the impacts of climate change, with increased temperature of the Caribbean Sea, decreased rainfall levels, and prolonged dry spells. Countries in the Caribbean have also experienced flooding and landslides. In the Pacific, there has been an increase in surface air temperature, coastal erosion, and seawater intrusion and changes in rainfall, wind, and ocean currents. In Africa, countries such as Cape Verde are experiencing greater climatic aridity and frequency of droughts and storms.

Natural hazards and climate change lead to significant economic losses. SIDS are among a small number of countries with average annual disaster losses of greater than 1 percent of gross domestic product (GDP) (Figure 1). Average annual loss from tropical cyclones is estimated at US$835 million in the Caribbean and US$178 million in the Pacific. A single event can have devastating impacts on SIDS' small economies. In 2015, Cyclone Pam caused US$450 million in damage and losses in Vanuatu—64 percent of the country's GDP (World Bank 2016).

Figure 1: Average Annual Loss from Natural Disaster as a Percentage of Gross Domestic Product



Source: World Bank Group 2014.

In addition to economic losses, SIDS experience high social impacts from natural hazards. Social and psychological impacts of disaster events can persist for a long time. The small size of the population limits institutional capacity, and limited economic activity constrains revenues, limiting ability to respond to disasters. Because of lack of socioeconomic resilience, asset losses can translate into significant income and well-being losses.

1.2 Effects of Natural Hazards on the Transport Sector

The transport sector is a foundation for social and economic development, playing a crucial role in providing access to basic services such as health, education, jobs, and markets. In the UN 2030 Agenda for Sustainable Development, transport is incorporated into several Sustainable Development Goals, especially those concerned with food security, health, economic growth, resilient infrastructure, cities, and human settlements.

Transport also plays a key role in facilitating response to natural hazards, although disasters such as flooding and hurricanes affect transport more than any other infrastructure sector, with damages from natural hazards accounting for a large percentage of total infrastructure damage costs. For example, 90 percent of infrastructure damage costs from Solomon Islands' flooding in 2014 were in the transport sector, and in Belize, transport accounted for 51 percent of infrastructure damage costs from Hurricane Keith in 2006 (GFDRR 2014). Transport assets account for a large share of public assets and government budgets, so when floods or storms damage them, governments must pay for reconstruction.

Climate variability, extreme weather events, and seismic and geophysical hazards present risks to the transport sector in SIDS (Figure 2). Transport assets are often underinvested in, and poorly maintained, and institutional capacity is often limited, compounding the climate vulnerability of the sector. Transport networks in SIDS typically have low redundancy, with often only one major airport and port on an island offering limited to no redundancy to the road network. Damage to transport infrastructure can affect accessibility of essential services such as schools and hospitals and create business interruptions for the tourism, fishery, and agricultural sectors, exacerbating economic losses.

Figure 2: Examples of How Climate, Seismic, and Geophysical Hazards Can Affect Transport Infrastructure and Operations

AIR TRANSPORT

- **Sea-level rise, storm surges, and strong waves** can cause transient or permanent flooding of low-lying airports and access infrastructure.
- **Changes in intensity and frequency of rainfall** can lead to floods and damage equipment.
- **Strong winds and storms** can damage infrastructure and equipment and interrupt service.
- **Seismic and geophysical hazards** can damage airport infrastructure and disrupt operations.

ROAD TRANSPORT

- **Extreme rainfall** events can overtop and wash away road infrastructure, increase seepage and infiltration into pavement and subgrade, and decrease cohesion of soil compaction.
- **Seasonal rainfall** affects soil moisture levels, affecting the structural integrity of roads, bridges, and tunnels, and increases risk of floods from runoff, **landslides**, and slope failure, damaging road assets.
- **High maximum temperature and number of consecutive hot days (heat waves)** affect pavement integrity (e.g., softening of asphalt layers, traffic-related rutting, embrittlement (cracking), thermal expansion of bridge expansion joints and paved surfaces).
- **Extreme wind** can threaten bridge stability, damage signs, and increase storm surge near the coast.
- **Seismic and geophysical hazards** can damage road infrastructure and disrupt traffic.

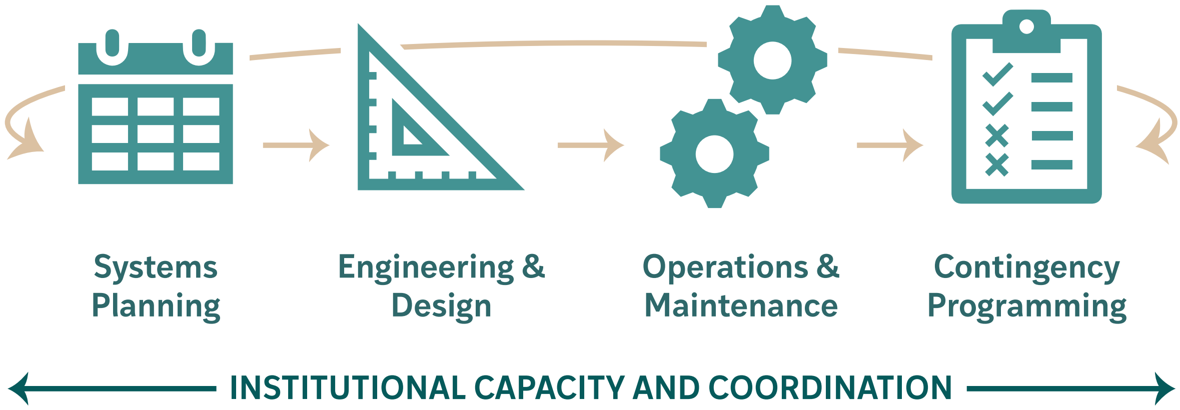
MARITIME AND RIVERINE TRANSPORT

- **Sea-level rise, storm surges, and strong waves** can cause transient or permanent flooding of seaports and connecting roads and rail lines; damage infrastructure, equipment, and cargo; and increase maintenance and rehabilitation costs.
- **Extreme rainfall and landslides** affect connection and access to ports.
- **Strong winds** can cause infrastructure failure, damage to navigation equipment, problems in vessel navigation, and berthing and service interruptions.
- **Heat waves** limit operations, damage pavement, and increase operational costs by increasing cooling and ventilation demand.
- **Changes in sea currents and increased erosion and sedimentation patterns** affect port operations and navigation channels.
- **Seismic and geophysical hazards** can damage port infrastructure and disrupt operations.

1.3 Resilient TAMS

Although SIDS are highly exposed to natural hazards and climate change impacts, it is possible to reduce the transport sector's vulnerability, damages, and losses. A range of polices and measures can enhance resilience in SIDS—in particular in the transport sector. Measures could include physical protection against hazards, implementation of early warning systems, better infrastructure maintenance to reduce asset vulnerability, and provisions for rebuilding faster after an event. Resilient transport policies can reduce well-being losses by some 25 percent (World Bank 2017a).[2] To facilitate systematic identification and deployment of climate resilience measures in the transport sector, government authorities can use the transport infrastructure lifecycle management framework to establish resilient TAMS (Figure 3).

Figure 3: Transport Infrastructure Lifecycle Management Framework



Source: World Bank 2017a.

The transport infrastructure lifecycle management framework comprises five pillars:

- **Systems planning** enables resilience to be increased at the transport network level and exposure of critical infrastructure to climate and natural hazard impacts to be reduced. Climate and natural hazard vulnerability assessments and asset criticality and asset failure risk assessments can inform systems planning at the network level.
- **Engineering and design** consist of setting climate- and natural hazard–informed design standards and construction and material specifications, offering consistency in integration of climate and natural hazard considerations at the asset level.
- **Operations and maintenance**, although often overlooked and underinvested in, enable asset lifespans to be extended and performance and service levels to be maintained (low disruptions). Activities include incorporating resilience considerations into operations and maintenance strategies, developing asset inventories, assessing asset condition, defining asset performance and service levels, and defining inspection and maintenance plans.
- **Contingency programming**, which is essential to prepare for and respond to extreme weather events and disasters in an efficient, effective manner, requires multi-agency, cross-sectoral collaboration. Activities include developing early warning systems and emergency management plans and establishing financial mechanisms.
- **Institutional capacity and coordination** support the other four pillars and involves

[2] Analysis and report produced during Phase 1 of the resilient transport SIDS programmatic advisory services and analytics.

establishing required capacity in terms of processes, people, technology, and finance. Investments in asset management systems (AMS) that do not address gaps in any of these four factors ultimately struggle to sustain the AMS in the medium to long-terms (World Bank 2007b). Institutional capacity and coordination also include establishing mechanisms for multi-agency collaboration for sharing data, information, and knowledge to integrate climate and disaster resilience considerations into the transport asset lifecycle management framework.

A proactive approach to integrating climate change and natural hazard considerations into transport asset management includes reducing sector vulnerabilities by identifying no-regret measures,[3] such as strengthening maintenance practices, stress testing the transport network, and monitoring climate impacts and cross-sector effects to inform adaptive transport planning and operations. Countries will adopt TAMS with different levels of complexity and resource requirements depending on country needs and conditions. SIDS typically have simple systems because their transport networks are small, and availability of financial and technical resources is limited.

Current TAMS in SIDS often do not consider climate and natural hazard risks when making decisions on transport planning, maintenance programming, and resource allocation. Transitioning to a resilient TAMS requires understanding the country context, the existing institutional setting and governance systems, risks and risk tolerance, and capacity to adapt. Local stakeholders will define the level of investment that can be deployed for proactive climate resilience measures, possibly integrating these into a monitoring system to inform decision making as conditions change and define a financial strategy that is responsive to the level of climate and natural hazard risks as these evolve.

To be able to deliver a sustained transition, it is important to work closely with transport authorities, as well as other government agencies and partners, to define clear objectives and design and deploy practical solutions that have local buy-in and ownership. A practical approach to engage client countries in supporting development and implementation of resilient TAMS includes:

- **diagnosing** the existing transport asset management process throughout the infrastructure lifecycle
- working with transport authorities to understand needs and **define a desired TAMS**
- **developing a transition plan** that considers any limiting factors, including cost implications, and recommends actions to be performed in the short, medium, and long term
- **mobilizing funds** for implementation of the elements recommended in the transition plan
- **coordinating with development partners** to avoid overlapping and missing areas for improvement
- supporting the client to **implement the critical elements** defined in the transition plan

Resilient TAMS provide a strategic and systematic process of effective planning, operating, maintaining, upgrading, and expanding transport assets throughout their lifecycle. Resilient TAMS should improve service levels and reduce maintenance costs and transport asset and economic losses from disasters.

Transport asset management diagnostic and transition plans were developed for Saint Vincent and the Grenadines, Solomon Islands, and Vanuatu to identify measures to enhance resilience
Transport asset management diagnostic and transition plans were developed for Saint Vincent

[3] Measures worth implementing regardless of which event actually happens when consequences are uncertain and that yield benefits independent of climate change.

2 Building Resilient TAMS in Four SIDS

and the Grenadines, Solomon Islands, and Vanuatu to identify measures to enhance resilience of the transport sector to natural hazards and climate change impacts. Support focused on the road sector, based on the interests of the client countries. Support to Cape Verde focused on understanding the impact of climate and natural hazards in the maritime and aviation transport supply chains, so the study was conducted at a systems planning level. Working closely with local stakeholders, measures identified should be tailored to local context and needs, which will make it more sustainable. This chapter provides an overview of climate and natural hazards in the four SIDS and summarizes diagnostic assessments, transition plans, and activities implemented.

2.1 Climate and Natural Hazards in the Four SIDS

2.1.1 Cape Verde

Cape Verde is an archipelago located 500 km off the west coast of Africa with a population of 520,500 scattered across 10 islands and nine islets. It has scarce water resources, and only 10 percent of the territory is considered arable. It depends on imports to satisfy 80 percent to 90 percent of food needs. Cape Verde's economy is supported by tourism.

Cape Verde is exposed to natural hazards and climate change impacts and has low capacity to adapt. It is highly exposed to landslides and moderately exposed to coastal flooding.[4] Temperatures are projected to increase by up to 2.5°C by 2060 and 3.7°C by 2090, and rainfall is projected to decrease by up to 20 percent by 2100. Climate variability is also projected to increase, with more storms, floods, and droughts.[5]

Cape Verde depends on imports and exports, mostly from Europe and Africa. Because of its strategic location, the government has endorsed a national strategy to become an international trading hub. To accomplish this, its transport sector must operate reliably and efficiently. A comprehensive approach is required to understand the likely impacts of natural hazards on Cape Verde's ports, airports, and supply chains.

[4] See ThinkHazard database (accessed September 21, 2021), https://thinkhazard.org/en/.

[5] Climate Change Knowledge Portal—Cape Verde (database), World Bank Group, Washington, DC (accessed January 22, 2022), https://climateknowledgeportal.worldbank.org/country/cape-verde/climate-data-projections.

2.1.2 Saint Vincent and the Grenadines

Saint Vincent and the Grenadines, located in the Caribbean, is highly mountainous, with limited flat land. More than 90 percent of the infrastructure lies on the narrow coastal belt less than 8 m above sea level. The main natural hazards are riverine flash flooding and landslides because of the rugged, steep topography, followed by seasonal hurricanes, coastal flooding from storm surges, and sea-level rise. Saint Vincent and the Grenadines is at medium risk of seismic hazards such as volcanic eruption, earthquake, and tsunami, although La Soufriere volcano erupted in April 2021, displacing almost 20 percent of the population.[6]

Climate risks are likely to become more intense because of climate change. Sea-level rise projections and flood risk analysis indicate that coastal flooding reaching at least 0.5 m above high tide will become common throughout most of the Caribbean within half a century and probably sooner. Floods above 1 m may become common by the end of the century, and permanent sea-level rise exceeding this threshold is possible, although mean annual rainfall projections indicate a decrease in wet months, and the proportion of total rain falling during heavy rainfall events is projected to decline by 2090. Air temperatures and numbers of hot days and nights are projected to increase, and numbers of cold days and nights are projected to decrease significantly.[7]

The transport sector is one the most adversely affected sectors in the aftermath of disasters, resulting in significant social and economic losses. The sector also plays a key role in disaster preparedness, response, and recovery by providing evacuation routes and access to affected communities and enables distribution of relief and construction materials.

2.1.3 Solomon Islands

Solomon Islands, located in the Pacific, is among the 20 countries with the highest economic risk exposure to geological, hydrological, and climatic hazards, including tropical cyclones, volcanic eruptions, earthquakes, tsunamis, landslides, floods, droughts, and sea level rise. Natural hazards and extreme climate events have historically led to significant economic losses in Solomon Islands, and projections show that natural hazards and climate change could lead to an annual average direct loss of US$20.5 million (3 percent of GDP) for the next 50 years (GFDRR 2018).

The location of Solomon Islands in the western Pacific places it in the tracks of tropical cyclones and under the influence of El Niño and La Niña cycles, which bring high risks of droughts and floods. Solomon Islands experienced an undersea earthquake of magnitude 8.0 in 2013; tropical Cyclone Ita, which caused severe flooding in 2014; and an earthquake of magnitude 8.0 in 2016. Climate change threatens to exacerbate the risk of damage from tropical cyclones, floods, and droughts (GFDRR 2011).

Solomon Islands has high poverty rates and excessive dependence on foreign aid and is remote (GFDRR 2011). Most of the population lives within 1.5 km of the coastline, which is where livelihood activities and services are located. Infrastructure assets are limited. The road network is sparse and has limited redundancy, and most of it is coastal or mountainous, making it vulnerable

[6] Climate Change Knowledge Portal—Saint Vincent and the Grenadines (database), World Bank Group, Washington, DC (accessed January 22, 2022), https://climateknowledgeportal.worldbank.org/country/st-vincent-and-grenadines/climate-data-projections.

[7] Climate Change Knowledge Portal—Saint Vincent and the Grenadines (database), World Bank Group, Washington, DC (accessed January 22, 2022), https://climateknowledgeportal.worldbank.org/country/st-vincent-and-grenadines/climate-data-projections.

to flooding, coastal storms, sea level rise, and landslides. In Gizo Province, for example, floods washed away the roads in Malakarava village, and water runoff has increased landslide hazard in steep areas. Most roads are categorized as deteriorated, and approximately 30 percent of bridges require major repair (World Bank 2022a).

2.1.4 Vanuatu

Vanuatu, located in the Pacific, includes more than 80 islands distributed over an exclusive economic zone of 680,000 km². Distances between islands vary significantly, with some neighboring islands separated by more than 100 km of open ocean, whereas others are near each other in relatively sheltered waters.

Vanuatu is one of the most vulnerable countries in the world to climate change and natural hazards—exposed to cyclones, volcanic eruptions, drought, extreme precipitation and flooding, and subsequent landslides. In May 2018, the government was forced to consider permanently evacuating the entire island of Ambae because of volcanic eruptions. Vanuatu ranks second among countries that suffer high economic losses when extreme events strike, with average annual losses ranging from 1 percent to 10 percent of GDP. Climate- and natural hazard–related risks are likely to increase with climate change. Around Vanuatu, sea levels have been rising on average 6 mm annually over the last two decades based on satellite observations, making storm surges, cyclones, strong winds, and tsunamis more damaging (PCCSP 2013).

The road infrastructure in Vanuatu is inadequately maintained and in need of rehabilitation and routine maintenance. Poor road conditions are driving up transport costs, hindering access to services and markets, and restricting economic growth in rural areas. Because it is an island, most roads are located along the coast or in the mountains, exposing them to risks such as sea level rise, coastal storms, flooding, and landslides. The overall road network is simple, with almost no redundancies. Any disruption to a major road is likely to result in connectivity loss at the network level (World Bank 2021a).

2.2 Diagnostic Assessments of Transport Asset Management

2.2.1 Overview

Diagnostic assessments were conducted along the transport asset lifecycle by interviewing transport authorities and other government agencies. Asset management practices and systems were assessed to clarify needs and identify opportunities to increase the resilience of TAMS. Examples of questions included in the diagnostic assessment are provided in Figure 4.

Figure 4: Questions Illustrative of the Scope of the Transport Asset Management System Diagnostic Assessment

SYSTEMS PLANNING	ENGINEERING DESIGN AND MATERIALS	OPERATIONS AND MAINTENANCE	CONTINGENCY PROGRAMMING
• Are transport systems analyzed at the network level to identify the most critical and vulnerable assets? • Are natural hazards and climate risks mapped along with transport network? • Are a transport asset inventory and an investment programming system in place? • Does the investment prioritization system and process consider climate vulnerability? • Where is long-lived infrastructure located, and are there plans to locate it away from disaster-prone areas to avoid development lock-in? • If location change is not possible, are nature-based and engineering protection solutions being considered?	• Are hazard vulnerability assessments conducted at the infrastructure level? • Is there a national engineering design standard for transport asset? • Do design and construction standards, specifications, and guidelines reflect the likelihood of hazards and current and projected climate change impacts?[a] • Are material specifications and testing facilities available to explore resilient local materials?	• Is there a regular asset condition monitoring practice in place? • Does prioritization of maintenance take into account climate vulnerability levels of candidate roads? • What are the institutional, financial, and contractual arrangements for infrastructure maintenance? • Are climate considerations mainstreamed in transport systems' operational procedures?	• Does the country have a financial protection strategy, including disaster reserve funds, contingency budgets, and insurance programs to repair and replace transport infrastructure components damaged by a climate-related disaster? • Are there emergency preparedness plans to meet local and regional evacuation, response, and recovery needs and to prepare for relief distribution? • Are goods and service providers prequalified for rapid procurement after a disaster?

INSTITUTIONAL CAPACITY AND COORDINATION
• Are there policies or legislation referring to the need for asset management? • Are institutional mandates clearly set, and is there a need for coordination mechanisms? • Does the country have government-wide objective setting and results monitoring for climate resilience? • Do key agencies have clear processes and required human resources, technology, and finance?

[a] Many countries have construction design standards that were established based on past climate conditions. Climate-resilient design standards, specifications, and guidelines consider more-recent climate conditions that reflect current climate impacts and projected climate change parameters to assess hazards, exposure, and risk.

The diagnostic assessment showed that Saint Vincent and the Grenadines, Solomon Islands, and Vanuatu shared similar strengths and gaps in TAMS along the transport asset lifecycle framework, with minimal divergences. They have clear mandates related to transport management and have transport asset management practices in place. Saint Vincent and the Grenadines reported having provisions for contingency programming in terms of disaster preparedness, response, and recovery for the transport sector. The diagnostic reports identified several areas with opportunities for further strengthening such as road network mapping, asset criticality and network vulnerability assessment, development of climate-resilient road design standards, and strengthening of the RAMS (Table 1).

Table 1: Overview of Transport Asset Management System Diagnosis for Solomon Islands, Vanuatu, and Saint Vincent and the Grenadines.

TRANSPORT ASSET LIFECYCLE	SOLOMON ISLANDS	VANUATU	SAINT VINCENT AND THE GRENADINES
Systems planning			
• Road and bridge network mapping	No	No	No
• Road network vulnerability assessment	No	No	No
• Road asset criticality assessment	No	No	No
Engineering design and materials			
• Road design standards	Room for improvement	No	Room for improvement
• Climate-resilient road design standards	No	No	No
• Material specifications	No	No	No
Operations and maintenance			
• Investment in maintenance	Room for improvement	Room for improvement	Room for improvement
• Road inventory	Room for improvement	Room for improvement	Room for improvement
• Regular surveys and inspections including asset conditions	Room for improvement	No	No
• Asset management system in place	Room for improvement	Room for improvement	Room for improvement
• Resilient asset management system in place	No	No	No
Contingency programming			
• Disaster preparedness	Room for improvement	Room for improvement	Yes
• Disaster response	Room for improvement	Room for improvement	Yes
• Disaster recovery	Room for improvement	Room for improvement	Yes
Institutional capacity and coordination			
• Clear mandates related to transport management	Yes	Yes	Yes
• Natural hazard data shared between ministries	No	No	No
• Climate-informed transport strategies	No	No	No
• Climate-informed transport master plans	No	No	No

2.2.2 Systems Planning

Solomon Islands, Saint Vincent and the Grenadines, and Vanuatu have not conducted road network criticality and vulnerability assessments, which are essential to define strategies to move critical infrastructure away from disaster-prone areas or to identify and prioritize the most critical and most vulnerable assets to target with resilient interventions.

2.2.3 Engineering Design and Materials

SAINT VINCENT AND THE GRENADINES AND SOLOMON ISLANDS

Saint Vincent and the Grenadines and Solomon Islands have road design standards, but they are not tailored to the islands' contexts, and design specifications do not include climate resilience considerations for all road types. International construction companies typically provide road design and construction standards, which reflect the standards of their home country.

VANUATU

Rural roads in Vanuatu have been designed based on local expertise and, because of lack of standards, are inconsistently designed. For example, in some cases, the roads are too wide for users' requirements, whereas in other cases, the roads are too narrow. This lack of a match between road design and users' needs has fiscal implications and can affect user and pedestrian safety. Most rural roads do not accommodate climate change risk considerations, increasing the vulnerability of roads and communities.

The Public Road Act of 2013 established a mandate for development and implementation of road design standards and specifications that consider environmental factors (including natural hazards and climate change impacts), with the objective of providing reliable access to communities at minimum cost. In response, in 2016, the Public Works Department (PWD) of the Ministry of Infrastructure and Public Utilities published the Vanuatu Rural Roads Design Guide: Incorporating Climate Resilient Design to guide integration of climate change risk considerations into the design of rural roads across Vanuatu. The guide is the only national-level road design guide. There is no similar guide for urban roads. It outlines the engineering design parameters for new and rehabilitated rural roads in Vanuatu based on the Australian Road Research Board's Manual for Unsealed Roads—Guidelines to Good Practices, the Austroad Guide to Road Design,[8] and Vanuatu's local context. In addition to guidance on road design standards, the guide provides a vulnerability screening for coastal roads, which are generally more exposed to erosion and wave overtopping, and suggests measures to enhance the resilience of these roads, including realigning road routes, building sea walls, raising road embankments, and adding cross drainage.

Local sources of construction materials are limited. Materials can be sourced from a borrow pit (unconsolidated deposit) on the island where the construction work will be undertaken or from a quarry (hard rock to be blasted, crushed, and sieved) on the island, or it can import processed materials from other islands or overseas. Importing materials or blasting the bedrock would provide materials of higher quality, but they would be easily 4 to 20 times as costly as material found loose on the island. Identifying and using suitable local materials for construction is critical for sustainable, affordable road sector development.

Construction materials suitable for low-volume roads are available in Vanuatu at affordable prices. Materials commonly used in roadworks include coronous material (uplifted, decomposed, or weathered coral found on land away from the beach), beach coral, volcanic rock, beach sand, and basalt cobble. These materials may not be ideal, but they are affordable and acceptable for low-volume roads. For higher-volume roads, local materials may not be suitable because they must meet construction standards. Many locally available road materials are classified as sub-standard because they do not meet Australian, European, or North American specifications.

Use of local materials requires good knowledge of their properties and behavior and understanding of application conditions such as traffic volume, loading, and physical environment. Vanuatu has a comprehensive understanding of the materials available in-country, their potential use for construction, their advantages and disadvantages, recommended specifications, and proposed actions for study. The government has a material testing laboratory, but it is not accredited, and it is presently not operating. Communities do not widely welcome local materials because they perceive them to be inferior and prefer concrete roads like they see in the capital.

[8] Austroads is a collective of the Australian and New Zealand transport agencies.

2.2.4 Operations and Maintenance

SAINT VINCENT AND THE GRENADINES, SOLOMON ISLANDS, VANUATU

Saint Vincent and the Grenadines, Solomon Islands, and Vanuatu have RAMS, but they are used for reporting purposes only and have limited planning capabilities. The three countries report underinvestment in road maintenance, with most maintenance work being performed reactively, with limited proactive, planned, or preventative maintenance. Data collection on road, bridge, and drainage assets is conducted manually in all three countries.

Vanuatu has a road inventory, but other asset types such as bridges, culverts, and slope protection infrastructure have not been surveyed. In Saint Vincent and the Grenadines, road inventory data are available but are not managed and maintained using a standardized data scheme or software system. Saint Vincent and the Grenadines does not conduct systematic asset condition surveys.

SOLOMON ISLANDS

Solomon Islands has two core systems supporting road management that are disconnected and function separately:

- **The Solomon Islands Transport Asset Management System (SITAMS)** is used to update condition and inventory information on the road network. It comprises a Microsoft Access database and a user-friendly interface covering data on roads, structures along roads, and wharves. The system can operate without an annual license and produces annual reports containing an overview of asset information. The current reports are not used for transport investment planning, and staff are not trained to use SITAMS to support transport planning.
- **MapInfo geographic information system (GIS)** holds geographic layer[9] information on all roads, bridges, and culverts. The GIS map system also has geographic-socioeconomic data (e.g., coastal lifelines, rivers, education and health facilities). Government authorities procured three MapInfo licenses and use them to update the map layer information and to provide maps of the network for use in routine maintenance contracts and to provide engineers with maps of any development areas.

Full inventory and condition surveys were conducted in 2014, 2015, and 2016, funded by the National Transport Fund. These surveys were time consuming and labor intensive. The condition assessment relied on surveyors' subjective judgement and scoring of surveyors is inconsistent. There is no business process for on-going updating of the database when rehabilitation or maintenance takes place. Without regularly monitored condition data, it is impossible to prioritize investments based on up-to-date asset conditions.

The National Disaster Management Officer (NDMO), under the Ministry of Environment, Climate Change, Disaster Management, and Meteorology, monitored and tracked disaster incidents from the 1950s to 2014 in incident logs, so the ministry has good baseline data on all major disasters that have occurred in Solomon Islands, including the outer island provinces. A wide range of climate and natural disasters are tracked through incident logging, including cyclones, tsunamis, heavy rainfall, and droughts, but the NDMO does not have the in-house capacity for climate and natural disaster projection or production of hazard maps.

The NDMO also has historical disaster data from 1968 to 1992, aerial photographs (from flyovers), flood and landslide impact descriptions (1986), and descriptive data in the form of situation and

[9] Layers are logical collections of geographic data used to create maps and scenes.

initial damage assessment reports. NDMO has been using some open-source data and tools such as Pacific Catastrophe Risk Assessment and Financing Initiative data, the Pacific Disaster Net web portal, the Pacific Damage and Loss information system, and the KoBoToolbox (an open-source suite of tools for field data collection for use in challenging environments). In 2017, the Ministry of Health and Medical Services conducted a light detection and ranging aerial survey of Honiara and surrounding areas, including townships sites in the provinces, mapping an area of 229.6 km^2 to delineate the topography and the surrounding environment for 11 urban and rural health facility sites.

2.2.5 Contingency Programming

Solomon Islands and Vanuatu reported lack of disaster preparedness, response, and recovery mechanisms for the road sector, whereas Saint Vincent and the Grenadines reported having a well-structured contingency programming system in place, with active participation of transport authorities.

SAINT VINCENT AND THE GRENADINES

Saint Vincent and the Grenadines highlighted in the diagnostic report that opportunities to enhance information on the transport network and to increase organizational readiness to respond to disasters should be explored as part of establishing a resilient TAMS. For example, having a strong network inventory system before an event significantly enhances ability to assess and plan for recovery after a disaster. Because this information is of use only if it is accessible during and after events, it is important to have a holistic resilience approach to the system and data security. Whether the data are properly backed up and located where they cannot be damaged or lost during an extreme weather event should be considered.

VANUATU

The Vanuatu National Disaster Committee develops policies and strategies related to preparation for and response to national disasters, and the NDMO implements these strategies. There is a government-led cluster system to coordinate humanitarian responses. In each cluster, a government agency holds the leading role, and a humanitarian partner holds the co-lead role, with cluster members including representatives from community groups and the private sector. This cluster system has established solid relationships and partnerships, enhancing communication and response during disasters. The Ministry of Infrastructure and Public Utilities leads the logistics cluster, which focuses on supply and transportation of disaster-response resources. There is no infrastructure cluster under the existing mechanism.

After a disaster, the president has the authority to declare a state of emergency, with advice from the Council of Ministers, if the disaster constitutes a significant and widespread danger to life or property and exceeds the affected community's ability to respond. Upon declaration of a state of emergency with respect to a disaster, the National Disaster Operations Centre becomes operational under the management of the director of the NDMO.

The NDMO coordinates disaster response actions and aid requests, controls and directs disaster aid allocation, and ensures dissemination of information to the public through situation reports. The National Disaster Plan and the relevant National Disaster Support Plan guide disaster response actions at the national level, and the Provincial Disaster Plan does so at the provincial level. The Provincial Disaster Plan must be consistent with the National Disaster Plan and the National Disaster Support Plans for approval of the director of the NDMO.

2.2.6 Institutional Capacity and Coordination

SAINT VINCENT AND THE GRENADINES, SOLOMON ISLANDS, VANUATU

Saint Vincent and the Grenadines, Solomon Islands, and Vanuatu have clearly established institutional mandates related to transport management. Climate and disaster resilience priorities are reflected in national legislation and policies, but there is limited reference to transport management in national legislation, policies, and strategies. Given the size of the countries and relatively close working relationships between ministries, interministerial collaboration is strong. No specific hurdles have been identified, except that information exchange could be improved. Because official information management systems are lacking, gathering and exchanging information is often done manually and can take some time. There is room for improvement in interagency coordination mechanisms to share information on natural hazards and climate change and to integrate this information into transport strategies, master plans, transport planning, and asset management.

The diagnostic reports also assessed the institutional capacity of Saint Vincent and the Grenadines, Solomon Islands, and Vanuatu in terms of processes, people, technology, and supporting finance. The diagnostic reports revealed that each country has its own institutional context and capacity that must be considered when proposing improvements to build on available resources and ensure full integration in broader governance processes.

SAINT VINCENT AND THE GRENADINES

The Saint Vincent and the Grenadines Ministry of Transport, Works, Lands and Physical Planning (MoTW) has the legal mandate to develop roads, and the Buildings, Roads, and General Services Authority (BRAGSA) has responsibility for maintaining the transportation network. There is good coordination between the agencies, with a clear definition of roles. To develop its annual work program, MoTW (with input from BRAGSA) collects information on needs from various sources, including the public, who inform the MoTW of road repair needs. MoTW also visits road sites to assess needs. Neither BRAGSA nor MoTW collects condition data annually; instead, a round of road inspections is undertaken before budget preparation to identify needed maintenance. For road rehabilitation needed because of landslides, transport engineers conduct the assessments and make cost estimations.

Maintenance projects are identified and prioritized at monthly meetings in each district, at which a road maintenance officer reports to engineers and needs and priority areas are reviewed, and the work program list is updated accordingly. During the last quarter of the year, planning activities increase in preparation for the coming budgeting period, including a review of the rolling program, taking into account new and emerging priorities. Individual projects are packaged for budgeting.

The criteria used to prioritize projects are road type and hierarchy (e.g., major road), material type (asphalt or concrete (easier with concrete)), cost of projects, and additional work and studies required. Some roads need additional work such as retaining walls and drainage, which require surveying to align the road.

On completion of the planning process, BRAGSA submits road rehabilitation and maintenance needs for road sections that were identified as priority to MoTW for investment analysis and budget application.

BRAGSA manages road network inventory data and maintenance records using Excel spreadsheets, and the tools for capturing inspection records are paper based. The assessment found that maintenance records and costs are accurately reported. Road asset condition data are collected using standard paper forms, and this information is not kept and managed in a system. Although this may be adequate for planning, scoping, and costing for individual projects, it does not allow for network-level analysis. AutoCAD drawings are used for design and as-built information, and no GIS system is available.

Without an official road management system, it is difficult to establish what data exist and their characteristics (e.g., date). A qualitative assessment indicates that 80 percent of information on roads is loaded into an Excel-based system and that there are major data gaps for bridges, drainage, and other structures. Significant amounts of data in reports and documents are not easily accessible internally. There have been some discussions about adopting a road management system, but ideas and plans have not come to fruition.

Climate and natural hazard risk assessment data exist only for tsunami- and volcano-prone areas. Data for flooding zones and unstable slopes could also be of benefit. Eighty percent of the information concerning population settlements, vulnerable communities, and critical buildings and about 50 percent on climate risk, socioeconomics, the environment (e.g., land cover, habitats), and roads are loaded into an information system. There are major data gaps concerning the definition of agricultural land and future zoning changes.

MoTW is responsible for collecting road (and building) damage information after a disaster. The National Emergency Management Office has standardized the information requirements from the damage assessments across asset groups. The form requires substantial damage information on the entire road corridor, including the road itself and drainage.

The Ministry of Finance finances all activities of the MoTW. The budget is allocated annually, comprising approved projects and maintenance funds to address government priorities. All ministries must justify new infrastructure projects, for instance by indicating alignment with government strategic priorities. If this evidence or justification is not provided, the funding application is likely to be denied. The routine maintenance program is considered a recurrent budget that has a different application format. A 3-year rolling budget is updated annually during July and August, and the annual budget allocation runs from January to December, with Cabinet approval normally taking place in December. A focused project-level approach is used for renewal planning, which, as a result, does not consider overall network needs.

Post-disaster repair and rehabilitation is financed on a case-by-case basis. After a disaster with severe impact, the government may decide to fund projects through a supplementary budget. MoTW will estimate the damage and specify what repairs were not included in the original budget allocation. The Ministry of Finance will clarify whether additional funds will be made available. Depending on the nature of the damage and foreign aid committed, the government will prioritize recovery and rebuilding using an approach similar to the annual budgeting process. MoTW will revisit the original program of activities to rationalize it based on budget constraints. MoTW has the authority to adjust existing project priorities according to levels of additional damage funding.

VANUATU

Vanuatu's PWD has been experiencing staffing constraints. PWD operation relies on international engineers and consultants funded by Australia. There are few local engineers working in PWD, and they are responsible for managing a disproportionally large work program across the country. There is one staff member in charge of management of road information management system. Recruiting additional staff requires approval from the Ministry of Internal Affairs and usually takes 1 to 2 years to complete. Vacancies in PWD have been difficult to fill.

With staffing constraints, PWD must deploy existing staff effectively and align their roles and responsibilities with the core business needs of the department. Where possible, PWD should seek to automate processes as much as possible to free up limited staff time for other productive roles. Roles and responsibilities of staff must be reviewed in conjunction with analysis of the functional requirements of information systems.

It is critical to develop a training and capacity-building framework for existing PWD staff based on a robust training needs assessment, which not only helps PWD understand where its staff must increase their competence to perform their mandates, but also increases staff job satisfaction because they feel that the department values them and will invest in their professional growth.

2.3 Defining Resilient TAMS

Government authorities in the four SIDS shared their visions for resilient TAMS in terms of goals and objectives and key principles that should be observed. As mentioned above, SIDS typically have simple systems because their transport networks are small and financial and technical resources are limited. This must be reflected in the design of their resilient TAMS. **S.O.F.T**. principles (**S**implicity – **O**perationality – **F**lexibility – **T**ransferability) should be used to determine what such systems include.

- **Simplicity.** Resilient TAMS must be as simple as possible to match the capacity of the relevant government authorities. The system must be easy to use and manage with available resources and skills. Saint Vincent and the Grenadines and Vanuatu use Excel-based road inventories with limited capacities. Vanuatu's road network consists of just a few hundred kilometers of roads, and a simple system suffices for local needs.
- **Operationality.** The system must be simple so that it can be operated in a SIDS context. A resilient TAMS must be tailored to the local context and risk type and levels and be well aligned with governance processes of the transport authority so as to inform transport planning and budgeting. The governments of Saint Vincent and the Grenadines, Solomon Islands, and Vanuatu acknowledged this need. In addition, transport authorities must manage the transport network, prioritizing maintenance and capturing and recording information from routine inspections. The TAMS must be resilient and secure so that it is accessible and operational on a continued basis and can be regularly updated even after an extreme weather event or disaster.
- **Flexibility.** The structure of the resilient TAMS must consider potential for expansion to cover other islands or additional functionalities as country needs and capacity evolve over

time. The technical assistance supported development of a resilient RAMS for Saint Vincent Island. Once tested and operational, the plan is to be expanded to cover the Grenadine Islands. The existing system was developed in a modular format, facilitating expansion and replication. Similarly, in Solomon Islands, a resilient TAMS was developed for the island of Malaita, with the objective of expanding to other islands of the archipelago once it is tested and operational. The system being developed in Vanuatu will also follow this principle.

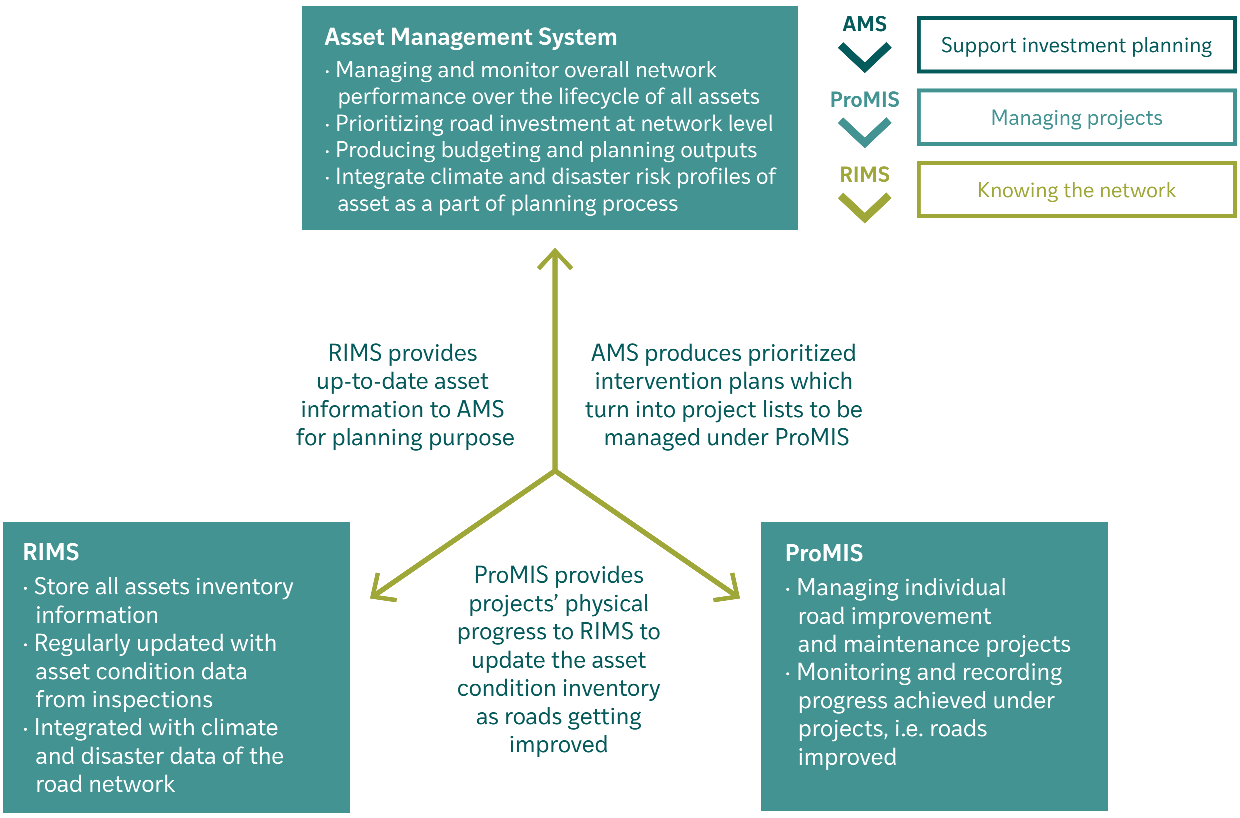
- **Transferability.** The resilient TAMS must adhere to standards that enable access by other government agencies and permit different users and applications to use the information. Such information can also be transferred in reports as relevant government agencies require. In Vanuatu, the road inventory system that the Ministry of Infrastructure and Public Utilities uses does not link up with the Ministry of Finance reporting software, making the annual reporting process difficult. The new resilient TAMS will be accessible by the Ministry of Finance and will incorporate climate and disaster risks and road network vulnerability information, allowing for a comprehensive analysis of priorities and investment results.

The objectives for the resilient TAMS were defined based on the needs identified during the diagnostic assessment conducted for each SIDS and in conversation with government authorities.

- **In Saint Vincent and the Grenadines**, the objective for the resilient TAMS is to integrate climate and disaster risk considerations into annual transport investment planning and prioritization. To do so, the resilient TAMS will enhance the efficiency and completeness of data collection on road assets, compilation of data on natural hazards and climate risks, and report preparation. The goal is to facilitate timely preparation and submission of the annual resilient transport plan and budget to the Ministry of Finance as part of the government annual planning and budgeting process.
- **In Solomon Islands**, the objective for the desired resilient TAMS is to facilitate integration of climate and natural hazard risks into all aspects of transport asset management. This will require upgrading SITAMS to integrate climate and disaster risk profiles of roads into the road asset inventory and decision-making process. Furthermore, the resilient TAMS must have better reporting functions to be fit for purpose and in line with government business demands. To deliver on these objectives, cooperative agreements must be signed with other ministries to facilitate access to climate and disaster information, staff must be reassigned and trained to enhance institutional capacity, and the road network's vulnerability to climate change impacts must be assessed.
- **In Vanuatu**, the objective for resilient TAMS is to enhance transport investment planning and prioritization, develop projects, and integrate asset condition and resilience into projects. To deliver on this, tools and institutional capacity for data collection, compilation, and analysis must be enhanced, understanding of road vulnerability to natural hazards and climate impacts must be increased, and management of climate risks must be improved. One aspect of a resilient TAMS is integration of an AMS into the current road inventory management system (RIMS) and the corporate and project management information system (ProMIS). The AMS would focus on supporting investment planning and prioritization and project development, taking into consideration resilience. The AMS will facilitate integration of asset profiles (information on physical conditions, climate and disaster risk exposure, and asset vulnerability level from the vulnerability assessment) into the Ministry of Infrastructure Development's planning process. The AMS assists the ministry in prioritizing interventions at the network level and recommends budget allocations and work programs for rehabilitation and maintenance based on a recommended prioritization of interventions. ProMIS provides modules to process, store, and manage processes such as procurement, contract management, and supervision for each project, and the RIMS would store asset inventory and asset condition information, combined with climate and disaster data (Figure 5).

- **In Cape Verde**, the objective for the resilient TAMS is to facilitate dialogue between transport agencies across islands in the archipelago on climate risk management in aviation and maritime logistics and supply chains. The dialogue is to be supported by information on inventory storage capacity and simulations of potential impacts of natural hazards and climate change.

Figure 5: Conceptual Relationship Between Vanuatu's Resilient Road Asset Management System (AMS), Project Management Information System (ProMIS), and Road Inventory Management System (RIMS)



Source: World Bank 2021a.

2.4 Transition Plans and Actions for Resilient Transport

Based on the diagnostic assessments, transition plans were developed to guide integration of climate resilience considerations into the transport asset lifecycle in Saint Vincent and the Grenadines, Solomon Islands, and Vanuatu. Transition plans enhance the four pillars of the lifecycle framework by increasing institutional capacity and coordination in terms of the key elements of people, processes, technology, and finance. The transition requires interventions to enhance processes, usually by defining new strategies that realign the institutional structure and operating procedures; enhance human resources, usually by defining the skillset and competence needed to perform the roles that the business model requires, with associated staffing and training; enhance the tools available by re-evaluating the data and information needed and investing in system upgrades for information management and tools for data collection; and ensure availability of finances to ensure sustainability of transport asset management in the short, medium, and long terms.

The transition plans suggest short- (0-12 months), medium- (12-24 months), and long-term (beyond 24 months) timelines and suggest sources of support. Some measures identified for implementation in the short term were delivered in the resilient transport SIDS technical assistance. Examples of activities prioritized for implementation during the technical assistance include a vulnerability assessment of the road network in Solomon Islands and a resilient RAMS in Saint Vincent and the Grenadines with capacity-building activities on cost-effective data collection practices.

Some measures identified for the medium- to long-term timelines were included in World Bank operations, or it was recommended that support be sought from other development partners. Examples of activities prioritized for inclusion in World Bank operations in Vanuatu are upgrading the current RIMS to a resilient RAMS; introducing and providing training on new tools for data management, including collection, storage, updating, and use for effective decision making; updating road project technical specifications based on Vanuatu's Resilient Road Manual; and improving and accrediting Vanuatu's construction materials testing laboratory. The operation in Vanuatu has been approved and is being implemented.

2.4.1 Cape Verde

The Strategic Plan for Sustainable Development 2017–2021 and Ambition 2030—The Strategic Agenda for Cape Verde Sustainable Development outline the government's priorities, and the goal of both strategic documents is to position the country as a trading hub and include as one of its main objectives the country's transformation into a maritime and air transport hub. It is therefore expected that Cape Verde will provide services to freighters, cruise ships, and other ships and connect the islands and neighboring countries based on a blue economy approach to allow for sustainable development, with environmental protection and coastal-area management to address climate change risks (Ministério das Finanças, Direção Nacional do Planeamento 2018; World Bank 2019).

Tourism and employment in tourism-related activities are critical for Cape Verde, as is moving people and cargo through the islands to supply domestic markets, but inter-island mobility is difficult. Because of its geography, Cape Verde faces major infrastructure challenges. Despite its low population density, the country needs many functioning airports and ports to ensure domestic and international connectivity. Cape Verde has four international airports, three aerodromes, and nine domestic and international ports.

Inter-island maritime and air transport costs are high due to the lack of economies of scale and the current monopoly market situation since TACV Cabo Verde Airlines withdrew from the domestic aviation market. Despite the high tariffs, there are still insufficient, infrequent, and unreliable transport services for both freight and passengers. Inter-island maritime transportation is mostly not convenient for passenger transport as open sea waters are rough for most part of the year and the maritime fleet is not adapted to navigating in such conditions, leading to long and uncomfortable maritime travel. As such, high tariffs and poor air and maritime transport services leads to a need to review domestic inter-island transportation policies (e.g., tariff estimation, service quality standards and frequencies, etc.), which should allow the country to better perform to achieve its socioeconomic development goals.

Cape Verde has made significant investments in maritime and aviation infrastructure (ports and airports), but the quality and reliability of transport services remain unsatisfactory. Logistical facilities for transferring cargo from maritime to road or air transport are limited, adding to storage costs and delays that undermine competitiveness. Bottlenecks in integrating air, sea, and road transport must be addressed to support trade, tourism, and inter-island connectivity more broadly (World Bank 2013). Cape Verde is highly dependent on its supply chain. Exposure to natural hazards and disaster events threaten precarious balances in the supply chain, posing risks to retailers and limiting market offerings. Stores often lack specific products, limiting market offerings and increasing prices. Disruptions due to adverse natural events and climate change could aggravate these challenges.

In Cape Verde, the resilient transport SIDS technical assistance supported development of a supply chain model (SCM) to estimate stock levels of major commodities at key warehouses near transport terminals and population centers and to predict stock-out periods for commodities for a range of adverse natural event scenarios. The SCM was applied to estimate the benefits (shorter stock-out periods) of various infrastructure-strengthening options to make the infrastructure more resilient and provide higher buffer stock levels in warehouses for a range of adverse natural event scenarios.

Cape Verde's SCM simulates weekly ordering of products from overseas suppliers by warehouse managers. Demand levels are estimated based on available information on the size of the population within the catchment area of the warehouses on each island, which the size of the population of the port city, regional townships, and any tourist resorts that depend on that warehouse will influence in turn. Cabo Verde ports and airports generate orders once a week.

Economic order quantity models are used to estimate the frequency and size of orders that importers place based on the availability and capacity of warehouses. Overseas shippers receive orders, which are sent on ships or aircraft depending on type of product and destination. Warehouses are assumed to be located near transport terminals, have buffer or reserve stock levels, and receive new stock at regular intervals.

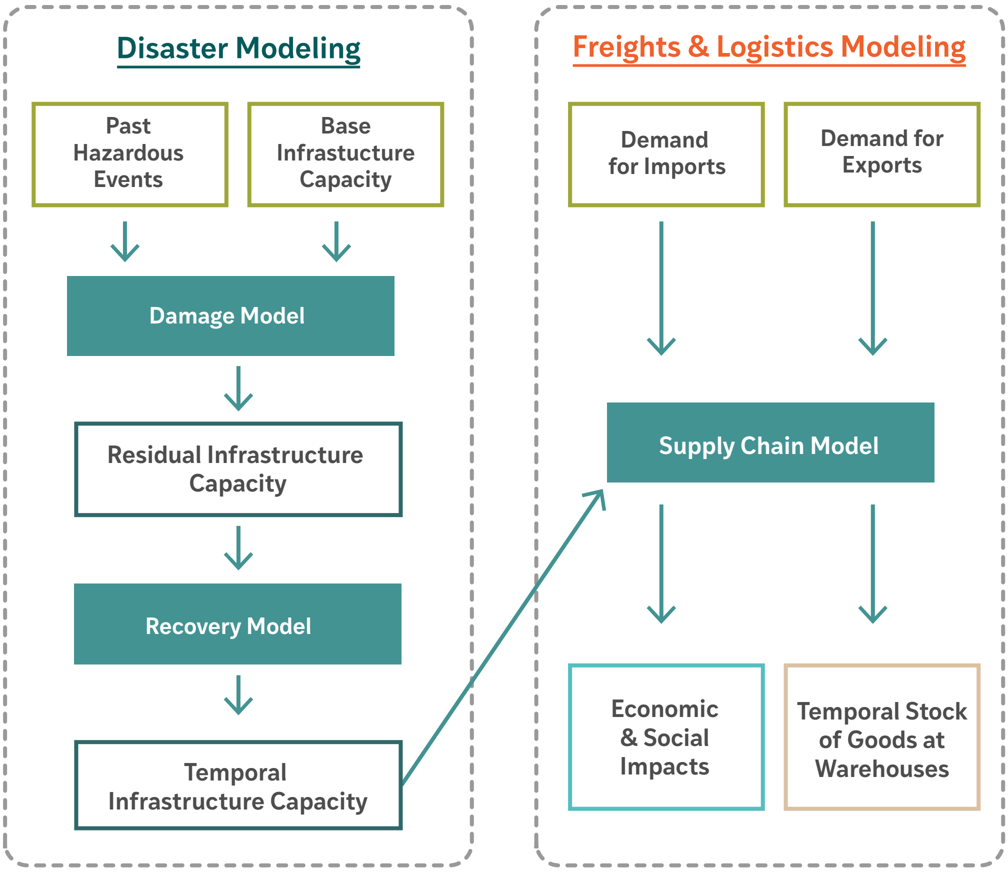
Each port and airport is linked to a nearby warehouse that stores goods received daily from ports and airports. These goods are delivered daily to local retailers in trucks. The capacity of the warehouse is limited to the maximum shipment size. The minimum amount of goods stored in each warehouse is set to cover the need for 2 days on each island in case an incident takes place. Daily shipments are scheduled for airline and ferry services.

The SCM can predict the effects of adverse natural events by accounting for the reduction in capacity of transport terminals to receive imports. Aircraft and ships are not able to unload goods at the same rate when disruptions occur because terminals will have less capacity and be less efficient. It is assumed that demand levels remain constant but that orders cannot be fulfilled at the same rate. Figure 6 provides an overview of the inventory management process and where a disaster would affect the inventory management process. Figure 7 provides a high-level overview of the links between models developed to evaluate investment options to strengthen facilities against adverse natural events. The SCM can predict stock levels in warehouses over the recovery period, incorporating the diminished capacity of transport terminals and expected recovery. Impacts on cities and islands that depend on other international terminals can also be estimated.

Figure 6: Inventory Management Process and Effects of a Disaster on Orders and Inventory Levels

Note: CV – Cape Verde.
Source: World Bank 2022b.

Figure 7: Models and Data Developed to Evaluate Investment Options to Strengthen Facilities Against Adverse Natural Events



Source: World Bank 2022b.

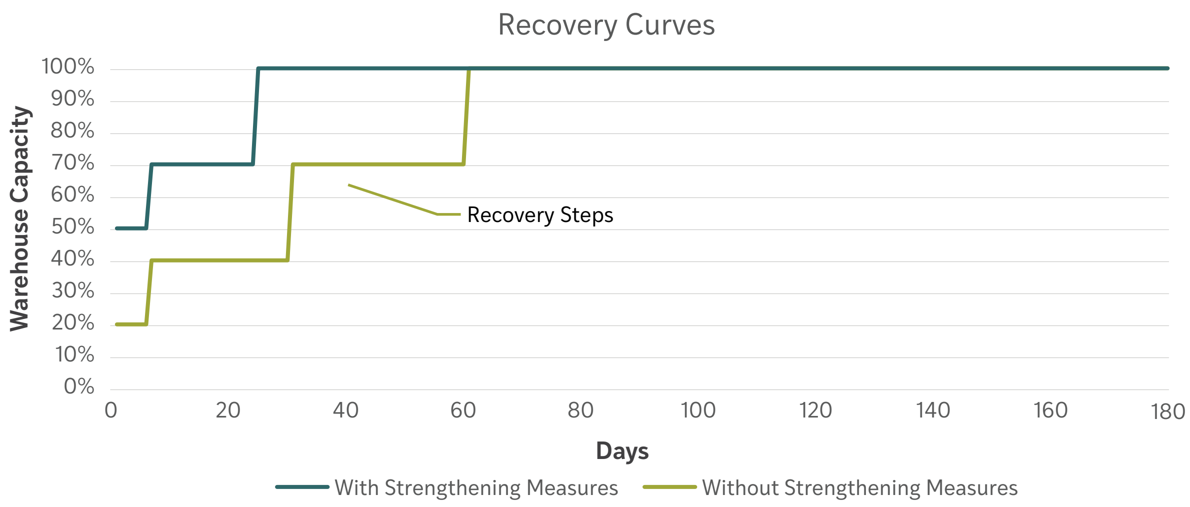
Supply chain shortages are constant in Cape Verde because of the fragile transport system and the small size of the market. Disasters can greatly affect the ordering tendencies of customers for goods from warehouses. Depending on the type of disaster and the type of goods, demand can increase because of panic buying or decrease because activity patterns change. Disasters can also change arrival patterns of goods at warehouses because of delays in transport or a reduction in capacity in transport terminals such as ports and airports.

The SCM can be used to predict inventory levels of goods in ports, airports, and warehouses over an extended period after a disaster. The effects of various types of disasters on availability of goods in cities and the ability of strengthening measures and projects to reduce shortages of goods can be predicted to inform development of investment plans for mitigating the impacts of disasters. Inventory levels usually fluctuate based on domestic demand and ordering cycles. As such, the SCM model assumes that, under optimum conditions, there will be no "stock out" periods.

When adverse natural events such as earthquakes and volcanoes occur, or landslides close roads, delays in imports can increase the length of stock-out periods and cause hardship for communities. The SCM can be used to predict stock-out times for several different disaster scenarios, to assess the benefits of undertaking strengthening options at transport terminals, and to determine how higher buffer stock levels affect length of stock-out times.

The effect on the capacity of transport terminals of various types of adverse natural events was estimated using hazard models. Investment in strengthening infrastructure and operations as a preventative measure can reduce initial decline in capacity of a terminal and the required recovery time. In Figure 8, the recovery curve under the "with strengthening" scenario is hypothetical and shows the capability of the SCM model.

Figure 8: Recovery Curves from Earthquake with and without Strengthening Measures for Warehouses



The reduction in operational capacity resulting from damage and disruption caused by a disaster is calculated considering indirect intensity parameters for storms and hurricanes (wind speed, rain intensity, wave and surge height) and direct intensity parameters for earthquakes and volcanic eruptions (magnitude information for each island and a qualitative measure of eruption force).

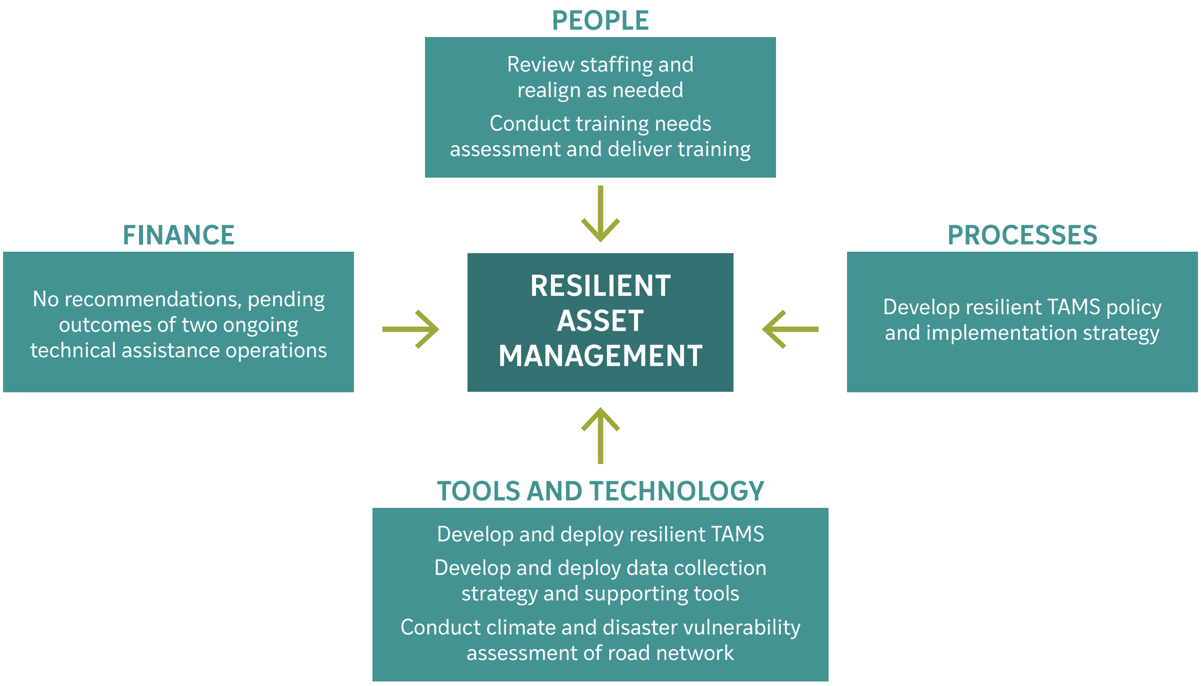
The SCM was used to estimate the effects of an earthquake on inventory levels in a warehouse on Sao Vicente. It was estimated that the earthquake would cause a period of stock-out longer than

3 weeks because of reduced capacity of the airport. The analysis also considered the impacts from a combination of multiple extreme natural events. One crucial step toward improvement of this kind of tool is systematic data collection regarding characteristics of hazard events and the impact on the operation of infrastructure and supply chain components.

2.4.2 Saint Vincent and the Grenadines

The transition plan of Saint Vincent and the Grenadines recommends a series of actions and corresponding implementation schedule to transition from the current transport asset management practices and system to a climate- and disaster-resilient AMS. The transition plan was developed with deep consultation and engagement with government authorities and stakeholders and serves as a practical, succinct roadmap that the government can use to realign, enhance, and upgrade its existing AMS. Figure 9 provides an overview of the actions recommended in the transition plan. (World Bank 2021b)

Figure 9: Overview of Key Actions Recommended in Saint Vincent and the Grenadines Plan to Transition to a Resilient Transport Asset Management System (TAMS)



The high-level recommendations from the Saint Vincent and the Grenadines transition plan include development of a resilient TAMS policy and a corresponding implementation strategy that should observe International Standards Organization 55000 requirements. The resilient TAMS policy and implementations strategy should include an overall approach to resilient TAMS, functional requirements for the core planning tools, a data acquisition and management strategy, a climate- and disaster-risk framework, a mechanism for work program development, a review of the institutional framework (structures, rules, and informal norms for service provision) to ensure it is supportive of the resilient TAMS, a staff competence framework, and a financing strategy.

The resilient TAMS policy and implementation strategy will define the organizational roles and responsibilities of the entities involved in road asset management (MoTW and BRAGSA), the competency framework for the asset management unit, and the entire asset management process. The next step would be to establish the team that will undertake the asset management functions:

- investigating MoTW and BRAGSA to gain understanding of staff functions and responsibility
- establishing a resilient TAMS unit
- mapping functional roles and resource requirements based on new business processes
- enhancing resilient TAMS unit resources (more staff and skills)
- developing a skill-set framework

The transition plan also recommends strengthening technical information systems and tools to integrate climate and disaster risk considerations into road and bridge asset management. This initiative is foundational to full procurement and adoption of a resilient TAMS. The scope for the next stages includes:

- developing detailed software functional requirements
- defining base data standards for inventory, conditions, and construction records
- developing detailed training and support strategy
- providing and implementing a software application that fulfills functional requirements

The transition plan also recommends development of a technical roadmap to increase the resilience of the road and bridge network, which would include:

- techniques to enhance understanding of the vulnerability of roads to specific hazards, such as conducting a climate and disaster vulnerability assessment of the road network and of specific critical assets
- exploration of resilient materials and retrofitting techniques that will increase the resilience of roads to natural hazards
- enhancement of resilience in design and rehabilitation of roads and bridges
- development of design and strategies for adopting Build Back Better concepts for post-disaster construction

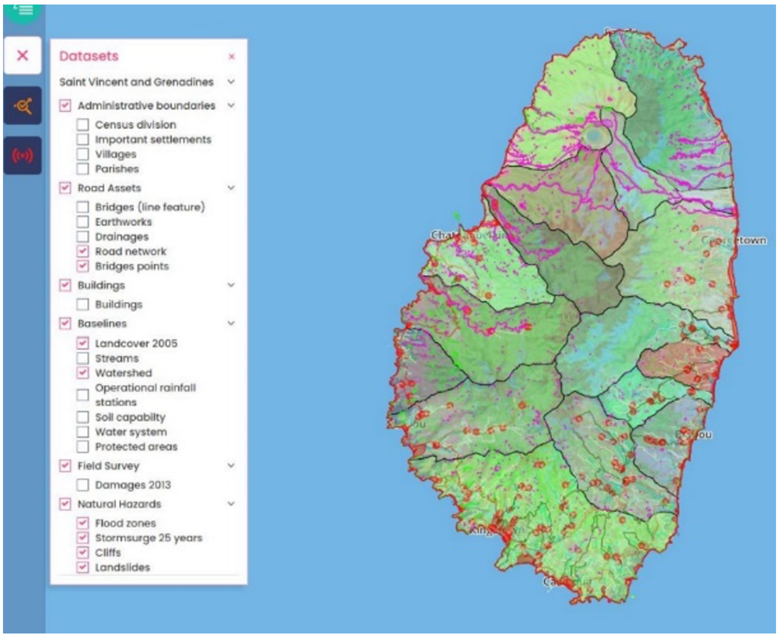
An analysis of the plans and investment needs for road asset renewal should be conducted according to asset management principles to allow for:

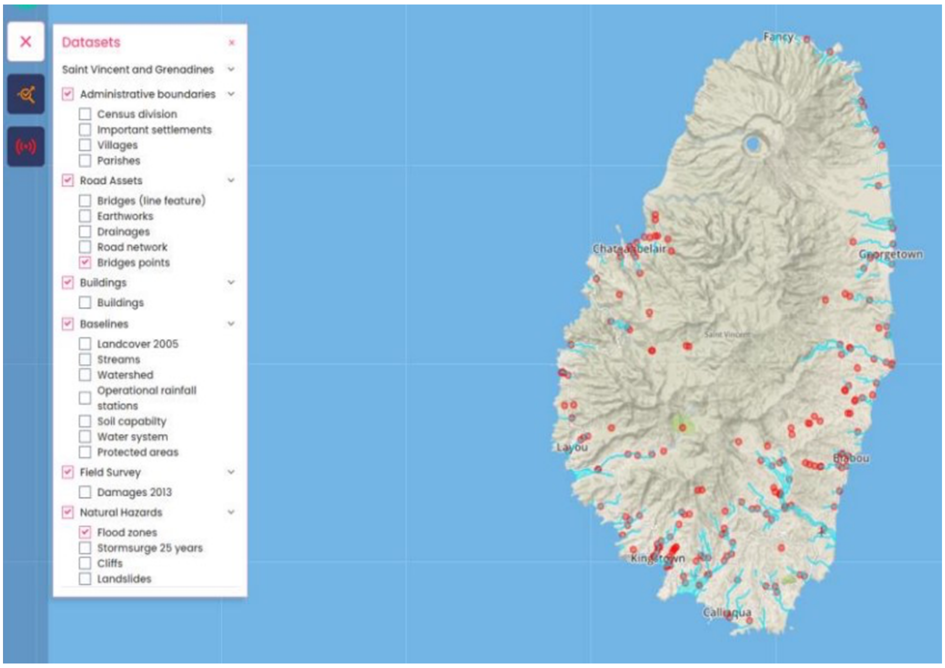
- performance-based asset management, with maintenance prioritized according to asset conditions
- greater network-level resilience and lifecycle-based project planning, choosing options with low lifecycle costs or costs aligned with the government's financial strategy

In Saint Vincent and the Grenadines, the resilient transport SIDS technical assistance supported development of a GIS-based transport asset data model that combines data on road assets and their condition, natural hazards, and climate risks. The new resilient RAMS provides a centralized location for data and information compilation, facilitating transport planning activities, budgeting, and reporting. The new resilient RAMS is cloud based, which enhances the climate resilience of the system itself.

The road asset data model was developed to serve as the starting point for a road asset data management system for the island of St. Vincent that can be extended to include road assets in the Grenadines. It considers the need for a comprehensive asset inventory, an overview and management of asset conditions, and records of asset repair and maintenance history and schedules. Ultimately, the goal is to provide a foundation that can be used to support efforts to increase the resilience of the road network (including bridges and other road assets) on St. Vincent Island (Map 2). This will allow MoTW to explore actions and tools that could facilitate collection and analysis of data on the road network and its users. It should also support decision making about management, rehabilitation, and maintenance of the road network, bearing in mind the resilience requirements given the current and future potential impacts of climate change and climate variability.

Map 2: Saint Vincent Island Maps Showing Land Cover, Road Assets, Multi-Hazard Exposure Levels, Bridge Assets, and Potential Flood Zones





The data model captures and hosts data in a streamlined manner, optimizing data collection using smart technology and tools and facilitating analysis to support decision making about use of and investment in the road network. The data model complements road asset policy making and policy implementation by translating the business process into systematic data rules and structures. It also allows implementation of data assessment actions to process information on physical assets. The collected data provide a uniform overview of asset classes and their status.

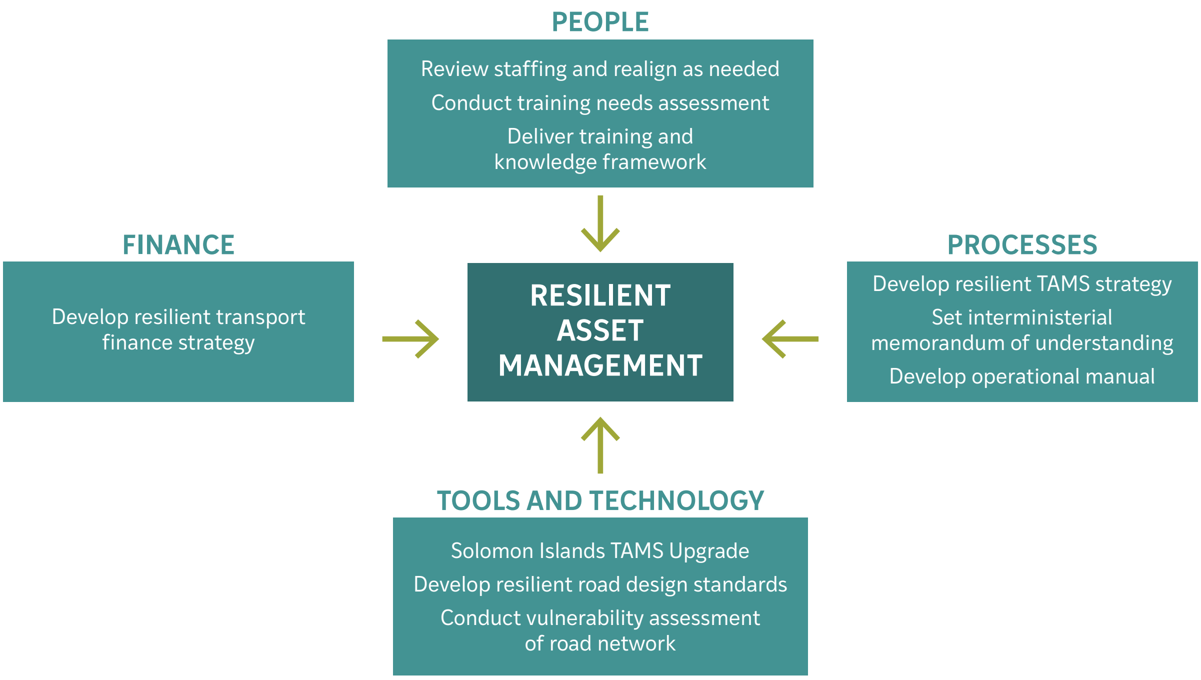
The geographic data used to demonstrate the potential of the data model were captured in a road network and asset survey in 2013; the government physical planning unit provided additional data. The model is based on review of the aforementioned data and discussions with Saint Vincent and the Grenadines counterparts on current and future workflow for road asset maintenance and rehabilitation. The technical support team has combined GIS technology with traditional database system design and advances in the use of location-based technology. Given local familiarity with Esri GIS software in Saint Vincent and the Grenadines, the consultant opted to use a geodatabase design. Geodatabases provide powerful tools and technology to create validation rules and relationship classes and ensure that data collection remains error free at the point of collection through multiple sets of data rules and validation.

Ultimately, the data model provides a basis for a RAMS that could enable government authorities to integrate climate risk management into transport planning activities, including the ability to prioritize investments for road maintenance, rehabilitation, and expansion. It has the potential to facilitate access from a centralized location to data to support and enable compilation and reporting of information on road assets, their condition, and associated risks and to facilitate reporting, financial planning, and budgeting activities and general decision making about the road network, including resilience-related decisions.

2.4.3 Solomon Islands

The Solomon Islands transition plan recommends a series of actions and a corresponding implementation schedule to transition from the current transport asset management practices and system to a climate- and disaster-resilient AMS over time. The transition plan was developed with deep consultation and engagement with government authorities and stakeholders in Solomon Islands and serves as a practical, succinct roadmap that the government can use to realign, enhance, and upgrade its existing AMS. Figure 10 provides an overview of the actions recommended in the Solomon Islands transition plan. (World Bank 2021c)

Figure 10: Overview of Key Actions Recommended in Solomon Islands Plan for Transition to a Resilient Transport Asset Management System (TAMS)

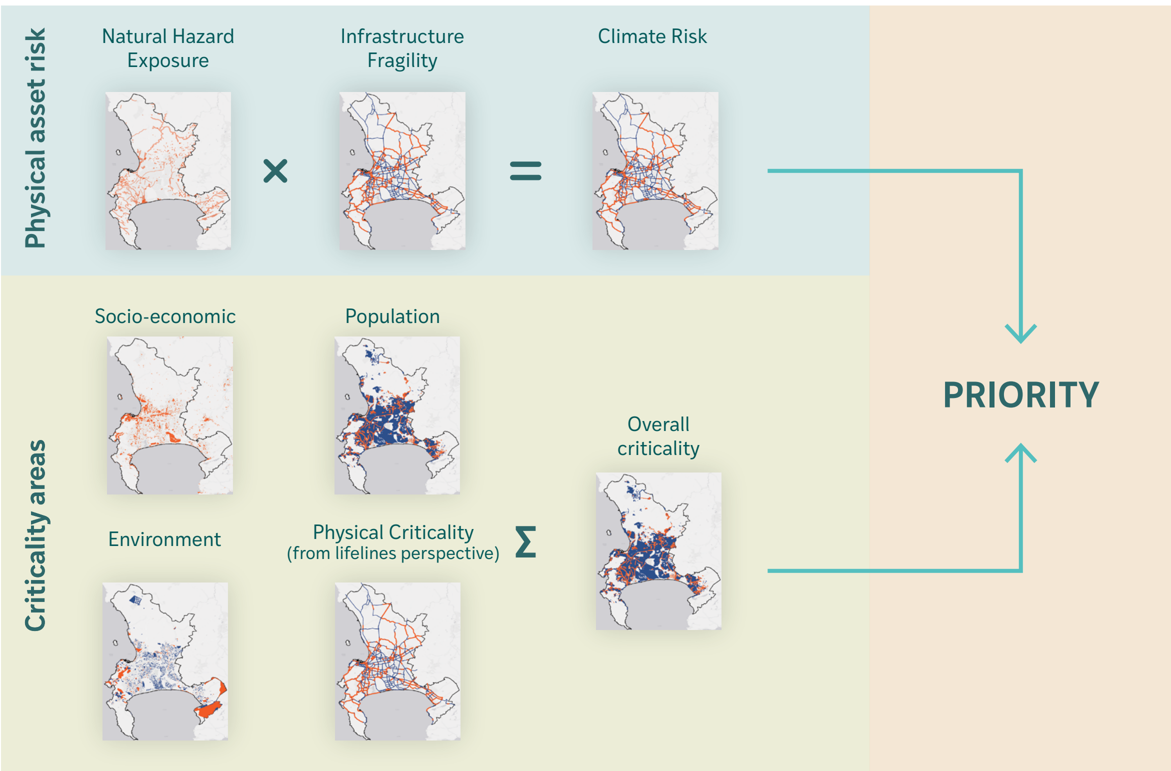


The high-level recommendations are to integrate climate and disaster risks into all aspects of transport asset management and reflect such in the resilient TAMS strategy; collaborate with other ministries to access and use climate and disaster information services for transport asset management; reassign staff as needed and build capacity to perform resilient asset management practices; upgrade systems for information management and tools for data collection to support evidence-based planning and investment decision making; conduct a vulnerability assessment of road network; develop national road design standards and specifications that consider climate and disaster resilience; and develop and implement a resilient transport finance strategy to guide use of resources from the National Transport Fund, donor financing, and other finance sources.

The resilient transport SIDS technical assistance supported development of a resilient road asset management framework strategy by providing recommendations on several working areas for development:

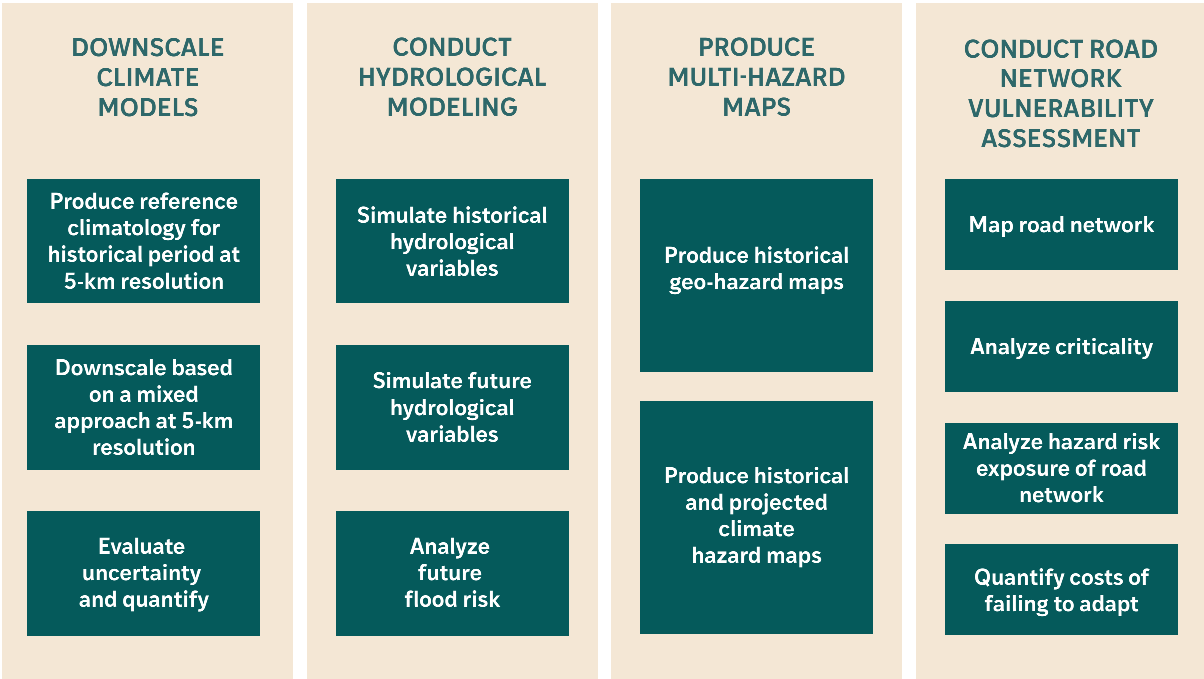
- road asset management policy to define key principles, responsibilities, and an approach to asset management for the Ministry of Infrastructure Development
- functional business requirements for road asset management planning tools such as the technical specifications for SITAMS
- core requirements for the data collection strategy to place SITAMS at the center of the maintenance and budgetary planning processes
- climate and disaster risk assessment and adaptation framework (Figure 11)
- resilient road asset management competency framework based on an institutional and organizational study of the Ministry of Infrastructure Development
- sustainable financing strategy to secure road management financing for 3 to 5 years.

Figure 11: Proposed Natural Hazard Risk Framework



The resilient transport SIDS technical assistance also supported development of a vulnerability assessment of the road network. The Solomon Islands Road Network Criticality and Vulnerability Assessment included four workstreams: use global or regional climate projections to make local projections, conduct hydrological modeling, produce multi-hazard maps, and conduct the road network criticality and vulnerability assessment (Figure 12).

Figure 12: Workstreams of Climate Vulnerability Assessment of Solomon Islands Road Network



Source: World Bank 2022a.

The vulnerability assessment required a comprehensive set of climate data for historic and future periods. Such data sets include a climatological baseline for the entire country for the key parameters studied. These data are used to understand historical climate, calibrate the impact models, and serve as a reference for downscaling and correction of simulated scenarios. The climate change scenarios simulated using regional climate models cover historical periods and future projects up to 2100. The climate scenarios that the international community produced had to be adapted to the needs of the study.

In Workstream 1, downscaling allowed for disaggregation of the AUSTRALASIA-CORDEX climate scenarios available at 0.44° (or about 50 km) at a resolution of 5 km. The variables applied were precipitation and minimum, mean, and maximum temperature. Changes from 1981 to 2100 show an increasing trend for temperatures and a decreasing trend for precipitation (Table 2).

Table 2: Summary of Climate Variable Evolution

CLIMATE VARIABLE	PAST EVOLUTION (1981-2019)	COMMENTS	FORECAST EVOLUTION (1981-2100)	COMMENTS
Precipitation	Slight increase	Non-significant trend	Strong decrease	-3.5mm (RCP4.5) and -234.2mm (RCP8.5) in 2030 -190.9mm (RCP4.5) and -394.7 mm (RCP8.5) in 2050 -297.9mm (RCP4.5) and -400.2mm (RCP8.5) in 2085
Minimum temperature	Strong increase	+0.2°C/decade	Strong increase	+0.89°C (RCP4.5) and +0.93°C (RCP8.5) in 2030 +1.29°C (RCP4.5) and +1.63°C (RCP8.5) in 2050 +1.69°C (RCP4.5) and +3,00°C (RCP8.5) in 2085
Mean temperature	Strong increase	+0.2°C/decade	Strong increase	+0.88°C (RCP4.5) and +0.93°C (RCP8.5) in 2030 +1.29°C (RCP4.5) and +1.63°C (RCP8.5) in 2050 +1.69°C (RCP4.5) and +3,03°C (RCP8.5) in 2085
Maximum temperature	Strong increase	+0.2°C/decade	Strong increase	+0.88°C (RCP4.5) and +0.96°C (RCP8.5) in 2030 +1.29°C (RCP4.5) and +1.66°C (RCP8.5) in 2050 +1.71°C (RCP4.5) and +3,09°C (RCP8.5) in 2085

Note: RCP, representative concentration pathway.

According to representative concentration pathway (RCP)4.5 (a greenhouse gas concentration trajectory), models forecast a decrease in annual precipitation from the reference climatological scenario of 3.5 mm in 2030 (-0.1 percent), 190.9 mm in 2050 (-6 percent), and 297.9 mm in 2085 (-9.4 percent). According to RCP8.5, models forecast a decrease in annual precipitation of 234.2 mm in 2030 (-7.4 perc1ent), 394.7 mm in 2050 (-12.5 percent), and 400.2 mm in 2085 (-12.6 percent), from the reference climatological scenario. Evolution of annual precipitation is geographically variable, with a greater decrease in the north of Malaita. These results must be interpreted with caution wherever the changes are not significant (grid mesh with dots in the maps) (everywhere in 2030 and 2050 and on some parts of the islands in 2085).

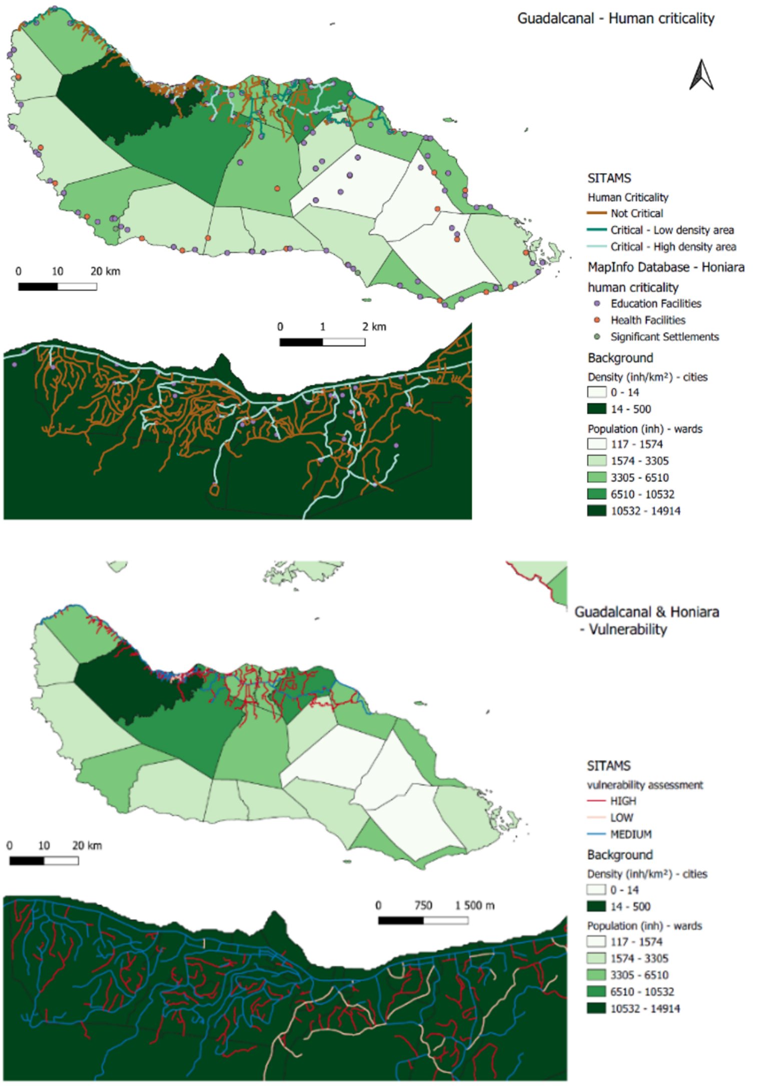
Under Workstream 4, the vulnerability assessment mapped the road network and scored road sections in terms of criticality and exposure to climate and natural hazard risks. The assessment also evaluated costs of reconstruction of the most damaged and critical sections. This work will inform prioritization of road sections for investments in climate resilience and rehabilitation based on criticality, exposure, and vulnerability (World Bank 2022a).

A road is defined as critical if it serves one or more points of interest (human, strategic, or economic), is a main or coastal road linking communities, or links a road serving a point of interest to a main road or coastal road by the shortest route (Map 3). The assessment showed that, in Honiara, most roads are moderately vulnerable and that smaller unpaved roads are highly vulnerable. In Malaita, most roads, including main roads, are highly vulnerable.

Criticality and vulnerability analyses showed which road sections are the most critical based on human, strategic, and economic criticalities and which road sections are highly vulnerable to natural hazards such as flooding and landslides. The study showed that vulnerability depends on the condition of the roads and the data required for this type of assessment and that would be beneficial to include in the country's TAMS for regular updates.

This analysis was delivered along with GIS shapefiles and databases to allow local governments to use them, update the information in real time when and where required, and take action. Information and data generated through the vulnerability assessment will be integrated into the Solomon Islands resilient RAMS, together with climate data from the Ministry of Environment and Climate Change. This will strengthen transport planning and budgeting.

Map 3: Road Criticality and Vulnerability Assessment on Guadalcanal, Including a Focus on Honiara

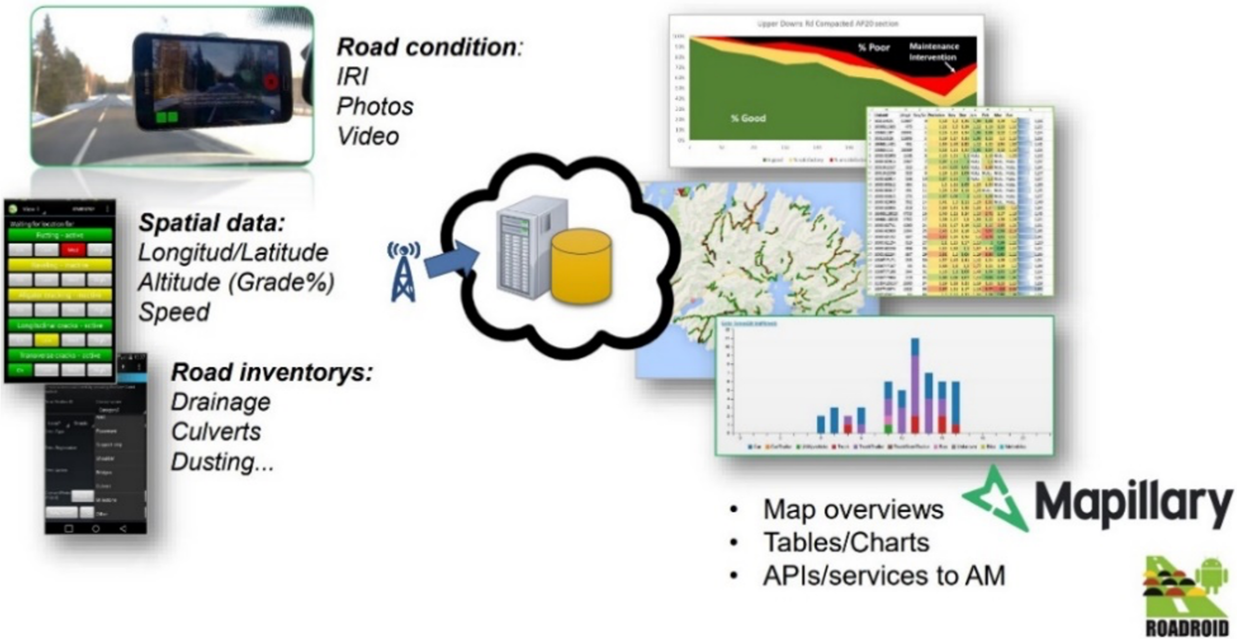


Source: World Bank 2022a.

In Solomon Islands, the resilient transport SIDS technical assistance contributed to development of a resilient RAMS and introduction of cost-effective data collection practices using smartphones. Use of new technologies is a cost-effective approach to data collection, which is of particular importance on islands with limited access to human and financial resources. Using user-friendly technologies, it is possible to update data more frequently. This can be critical for keeping the system working after an extreme weather event and supporting disaster-response activities and post-event rehabilitation.

Smartphone apps are used to collect information on road asset location (longitude, latitude, altitude), road characteristics (grade, speed permitted), and conditions (international roughness index), with additional visual information in the format of photos and videos. Resilient RAMS will enable information and data to be presented in overview maps, tables, charts, and reports (Figure 13). The resilient RAMS has been integrated into government planning and budgeting processes and will be able to inform annual reporting and budget in the upcoming year.

Figure 13: Data Collection on Roads, Bridges, Drainage, and Culverts Using Smartphones and Data Processing to Produce Reports, Maps, Tables, and Charts



Note: IRI – international roughness index; API – Application Programming Interface; AM – Access Management
Source: RoadRoid Presentation.

In Solomon Islands, investment operations informed by the resilient transport SIDS technical assistance were designed to support upgrade of infrastructure of two airports to incorporate climate resilience considerations into asset deployment and maintenance. Investment operations include provisions to support road improvements and a maintenance program focused on climate resilience. The project will help establish the National Transport Fund 2.0, to increase availability of funds for road maintenance and resilience.

The first and second Solomon Islands Roads and Aviation Projects, under the Pacific Aviation Investment Program, invested US$134.5 million in Honiara and Munda airports and Malaita roads to increase operational safety and overall infrastructure resilience to climate change, road improvement and maintenance focused on climate resiliency, institutional strengthening, project implementation support, and a contingency emergency response component. These projects also include investment in transport asset management and planning by enhancing SITAMS, which was designed and deployed with development partner support. The projects enhance SITAMS by implementing the following climate resilience changes.

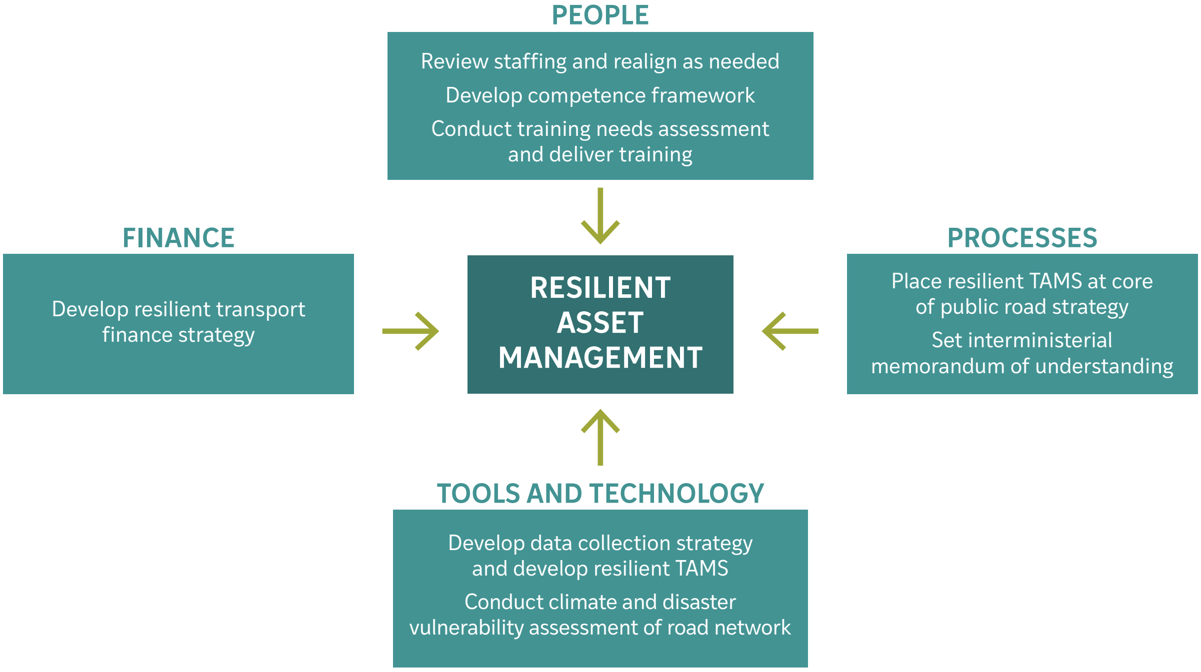
- Update road inventory and condition survey methodology.
- Procure appropriate road survey equipment for road condition surveys.
- Update GIS platform with all relevant datasets and develop data processing and treatment selection algorithms.
- Update approach to bridge inspections and align with an appropriate guideline to ensure more systematic inspection and better link inspections to a corrective maintenance program.
- Develop a systematic methodology for development of a 3-year maintenance program (sealed roads), which entails annual field verification and updates to the program, budget estimates, and contract inputs, including consideration of disaster risk and climate change criteria.
- Provide asset management staff with on-the-job and online certified training in use of GIS and road and bridge survey methodologies.

The project will train staff in use of the AMS as a planning tool and how to incorporate the results into annual and multi-year plans. Using the updated AMS, the project will also support the Ministry of Infrastructure Development in developing a road strategy; defining prioritization and selection procedures; and setting targets for road improvement and maintenance in terms of funding, conditions, and standards.

2.4.4 Vanuatu

Vanuatu's transition plan recommends a series of actions and a corresponding implementation schedule to transition from current transport asset management practices and system to a climate- and disaster-resilient AMS. The transition plan was developed with deep consultation and engagement with government authorities and stakeholders and serves as a practical, succinct roadmap that the government can use to realign, enhance, and upgrade its existing AMS. Figure 14 provides an overview of the actions recommended in Vanuatu's Transition Plan. (World Bank 2021a)

Figure 14: Overview of Key Actions Recommended in Vanuatu Plan for Transition to a Resilient Transport Asset Management System (TAMS)



The government endorsed a draft public road policy in early 2020 that is ready to be introduced. It will be Vanuatu's first road policy to guide planning of, investment in, and management of road infrastructure. The government is also developing a public road strategy that will mirror the policy direction specified in the policy and serve as a basis for implementation and operationalization of the policy.

The public road strategy is expected to redefine how road systems are managed in Vanuatu and chart the course for future government business operations. The strategic focuses specified in the public road policy emphasize supporting road resilience by improving core road networks and prioritizing maintenance. Development of the strategy is an important opportunity to concretize specific measures to integrate climate and disaster risk management practices into road asset management lifecycle.

In light of this, the Vanuatu transition plan recommends the following key actions.

- Develop a data requirement analysis based on the asset management decision-making and reporting needs specified in the public road strategy.
- Develop a data collection strategy and data standard to specify tools, methodologies, processes, and formats to use to collect all necessary data.
- Establish a memorandum of understanding with the Ministry of Climate Change Adaptation on data sharing (climate and disaster-related data) and collaboration on information analysis.
- Conduct a network-level climate and disaster vulnerability assessment for the road network.
- Based on a system business function analysis, develop technical software specifications for the AMS, including integration of climate and disaster risk profiles (from the network-level vulnerability assessment) of road assets.
- Conduct staffing review, develop competence framework, and conduct training needs assessment.
- Develop training and knowledge management framework and provide necessary training.
- Identify staff shortfalls and develop business justifications and job descriptions for additional staff.
- Recruit additional staff or local consultant to fulfill expanded PWD functions.

The recommendations provided in the Vanuatu transition plan were used to inform World Bank operations under preparation. The Vanuatu Climate Resilient Transport Project, under the Pacific Climate Resilient Transport Program, is investing US$112.8 million in sectoral and geographic planning tools, climate-resilient road infrastructure, and strengthening of the enabling environment to integrate climate resilience into the transport asset lifecycle. A contingency emergency response component was also included in the project.

Vanuatu's RIMS[10] will be upgraded to a resilient RAMS, and new tools for data collection will be introduced to improve capture, storage, updating, and use of road asset data for effective decision making. Resilient RAMS introduces a system module to systematically integrate climate and disaster risk profiles of the road network into asset inventory and criticality analyses to inform prioritization of road maintenance.

The project also included updating of road work technical specifications based on the Vanuatu Resilient Road Manual, and accreditation of and improvements in the construction material testing laboratory in Port Vila to provide quality assurance and facilitate use of local materials. The project will build capacity within the transport authorities, in collaboration with the Ministry of Climate Change Adaptation, by hiring a climate change specialist to be part of the Ministry of Infrastructure and Public Utilities PWD.

More broadly, climate resilience has increasingly been emphasized in World Bank operations, primarily by considering climate and disaster risks in project design and using engineering standards to offset potential climate and disaster risks to which the targeted infrastructure may be exposed.

[10] RIMS deployed with support from Roads for Development of the Australian Department of Foreign Affairs and Trade. It contains information on road network data (e.g., road length according to province), population served by road sections, road asset conditions, and climate and disaster risk profiles.

3 Lessons Learned

Cape Verde, Saint Vincent and the Grenadines, Solomon Islands, and Vanuatu welcomed the technical assistance provided under the resilient transport SIDS technical assistance, with authorities demonstrating a high level of awareness of the climate and natural hazard risks that their transport sectors face. Transport authorities recognized the need to integrate climate and natural hazard resilience considerations into transport asset lifecycle management and appreciated the structured approach used to diagnose the sector, identify needs and opportunities, define objectives, and develop a transition plan that is closely aligned with the country context and institutional needs. This chapter highlights key lessons learned to enhance the engagement approach and framework for integrating climate resilience into transport asset management practices in SIDS.

Engagement and activities undertaken in each SIDS generated the following lessons.

1. **Long-term engagement and strong commitment in terms of capacity building, knowledge creation, and finance are crucial for sustained transition to resilient transport asset management.** Using a holistic, systems-based approach helps define a long-term vision and a pathway for integrating climate and natural hazard resilience considerations into transport asset management. It promotes understanding of interconnections between separate areas of work, facilitating sequencing of activities and investments and identifying the need for coordination across sectors and among development partners. Easy-win opportunities were implemented in the short term using technical assistance resources, whereas interventions that require medium- and long-term implementation required coordination with other finance instruments such as World Bank investment project financing.

   This lesson became evident, for example, when conducting the diagnostic assessments and developing the transition plans for Solomon Islands. The structured interviews that covered the various areas within the asset lifecycle management framework identified the need for a climate and natural hazard vulnerability assessment of the road network and a coordination mechanism between the Ministry of Environment, Climate Change, Disaster Management and Meteorology and the Ministry of Infrastructure Development to facilitate exchange of information and data on climate change and natural hazards. The front-end analytical support was deployed under the technical assistance, and the institutional coordination mechanism will be deployed under World Bank–funded investment project finance operations, together with enhancements of the existing RAMS to integrate climate and natural hazard considerations.
2. **Adjusting the level of complexity of resilient TAMS to the local context, building on existing capacity and skills, and addressing practical needs facilitate local ownership and long-term sustainability of solutions.** Structured stakeholder consultations from early engagement help increase understanding of local context, risk levels, existing capacity, and limitations. This understanding is crucial to define solutions that follow the **S.O.F.T.** principles (**S**implicity – **O**perationality – **F**lexibility – **T**ransferability) when developing resilient TAMS in SIDS.

During the diagnostic assessments and development of transition plans, SIDS expressed preference for solutions that offer compatible, incremental changes to existing systems and build on existing skills. There is agreement that new technologies can be used to overcome limitations of budget, time, and human resources but that deployment of new technologies requires building capacity and developing simple management processes for updating and use. For example, during the diagnostic assessment structured interviews in Saint Vincent and the Grenadines, the department with mandate over government information systems expressed the need for capacity building on any new information technology system deployed for use at the Ministry of Transport, Works, Lands, Surveys and Physical Planning because it would support regular maintenance, troubleshooting, expansion, and general use by other government agencies.

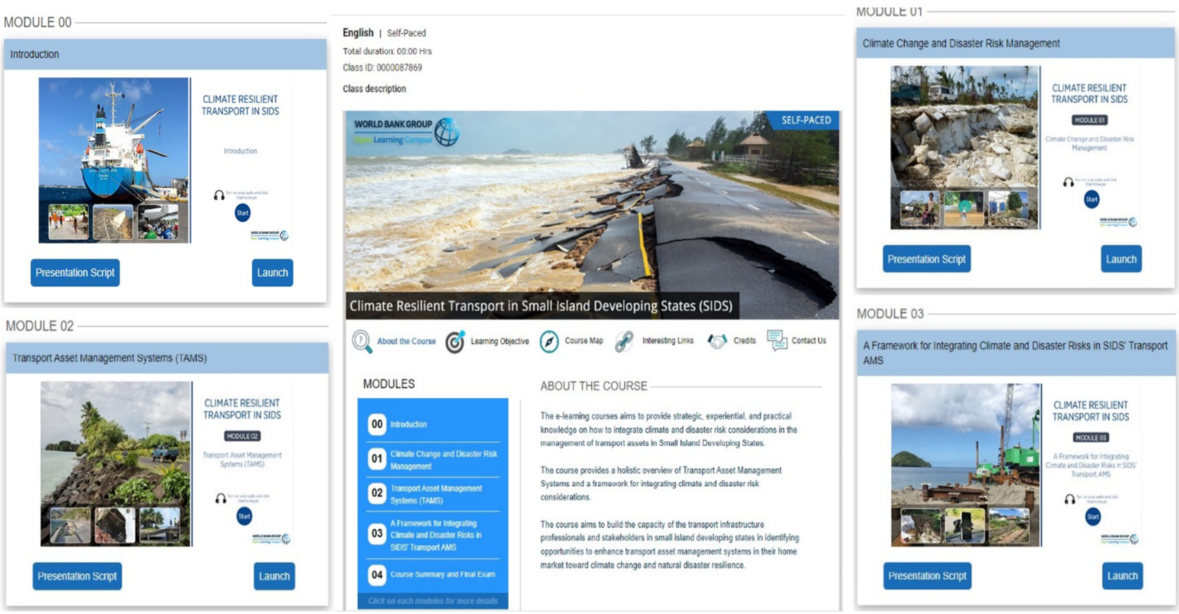
3. **Leveraging modern tools to fill critical data and information gaps is critical for resilient transport asset management.** SIDS must prioritize investment and maintenance intervention given the limited fiscal capacity of their governments. To optimize network-level resilience to climate and disaster risks, SIDS must channel limited resources to the most critical and vulnerable assets. To do so, up-to-date data and information on transport assets, their conditions, and their exposure to current and future climate risks must be collected and incorporated into planning processes. The studies conducted in SIDS under this technical assistance struggled with data availability. Current processes to collect these data are ineffective and costly. Introducing new tools such as cellphone-based data collection makes regular asset condition monitoring possible. For climate and disaster data, interministerial collaboration is critical to ensure that transport authorities have access to relevant data and necessary support from relevant line ministries.
4. **Coordinating with other development partners is essential to build on each other's efforts and to offer continued support in terms of capacity building and incremental improvements in resilient TAMS.** In Vanuatu, the World Bank consulted local transport authorities and the Australian Department of Foreign Affairs and Trade, identifying in the diagnostic assessment and transition plan the need to improve institutional arrangements, increase capacity, and strengthen the existing RAMS. As a result, Vanuatu is setting up a road asset management unit within the PWD of the Ministry of Infrastructure and Public Utilities. The Australian Department of Foreign Affairs and Trade plans to finance a road asset management advisor for the road asset management unit, and the World Bank will finance integration of a climate and natural hazard module into the existing RAMS using investment project financing. A local team will be trained, and a new resilient RAMS will be implemented and managed in close coordination with the World Bank and the Australian Department of Foreign Affairs and Trade, ensuring complementarity of efforts and investments.

4 Capacity Building and Knowledge Sharing

SIDS have limited institutional and technical capacity. Local context and capacity must be considered when developing resilient TAMS. The transition plans highlighted the importance of developing a strategy to define capacity needs and acquire sufficient capacity on resilient transport asset management.

The experience needed in SIDS to implement good practices is increasing, and value can be created through knowledge sharing. To facilitate knowledge sharing and replication of best practices, the online course Climate-Resilient Transport in Small Island Developing States was developed and made available as a World Bank Online Learning Course[11] (Figure 15), which provides continued access to practical information on how SIDS can strengthen TAMS. It was designed taking into consideration that government officials have limited time because they have heavy workloads. The online course provides flexibility in terms of when to access the course, facilitating participation in locations with intermittent Internet access. The course is free, which is important for budget-constrained departments with high staff turnover. Individuals who complete the course satisfactorily will receive a World Bank certificate of completion.

Figure 15: Online Training Course on Climate-Resilient Transport in Small Island Developing States



[11] Link to course page: https://olc.worldbank.org/content/climate-resilient-transport-small-island-developing-states-self-paced.

The course is designed to provide strategic, experiential, and practical knowledge on how to integrate climate and disaster risk considerations into transport asset management in SIDS. It provides an overview of climate vulnerability and TAMS and illustrates how countries can integrate climate resilience into the transport asset lifecycle management framework, which will enable task teams and country counterparts to identify opportunities to enhance investment operations.

A website built exclusively for resilient transport in SIDS (*i*-Knowledge) is being disseminated at the Global Facility for Disaster Reduction and Recovery–managed website,[12] where publications, reports, videos, and links to useful sources of knowledge will be posted. Client and World Bank staff can access the website free of charge.

The online course and the *i*-Knowledge platform on resilient transport in SIDS are designed to provide resources to build capacity in client countries and can be accessed any time and as often as required. This should be of interest to teams with limited time and financial resources to attend formal training domestically or internationally. The *i*-Knowledge platform and online course will be coupled with capacity-building activities deployed through World Bank operations.

[12] URL for i-Knowledge Platform landing page in the GFDRR Website: https://www.gfdrr.org/ResilientTransportinSIDS.

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