

BBB CASE STUDY

Dr Ian Greenwood

ian@gaic.nz

igreenwood.consultant@adb.org

1



NAFANUA WHARE 'EUA ISLAND KINGDOM OF TONGA

My involvement since 2013:

- World Bank Tonga Transport Sector Consolidation Project (TCSP/AF) – 2008-18
- World Bank Tonga Climate Resilient Transport Project (TCRTP/II) – 2019-24



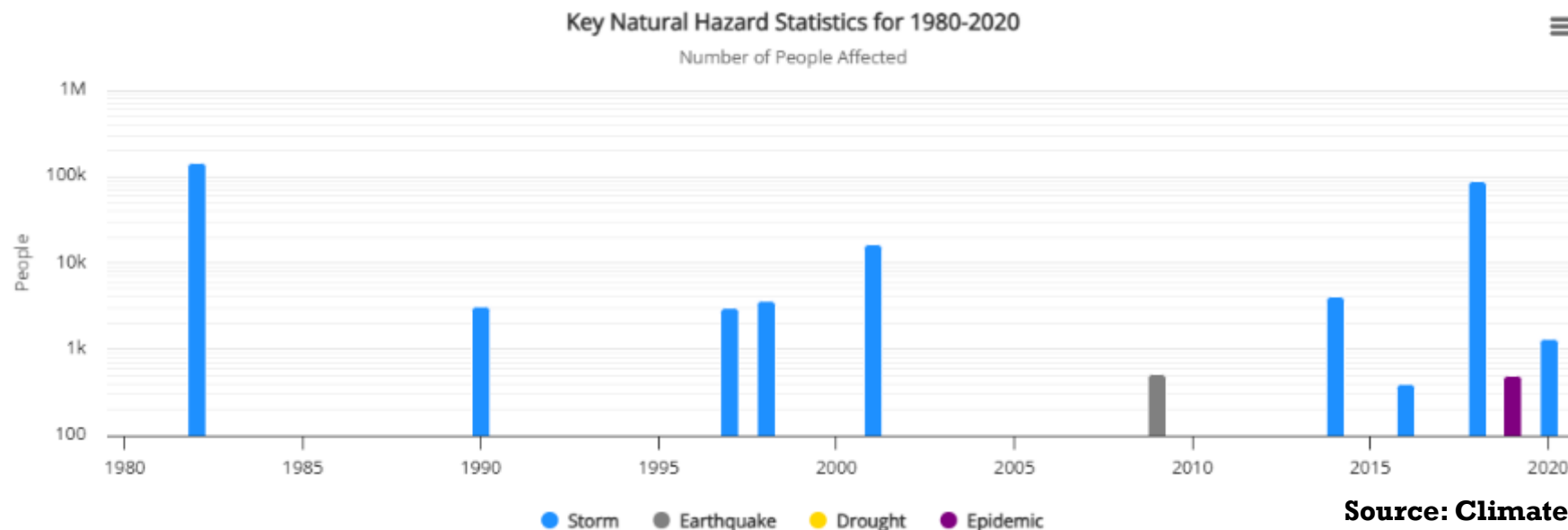
WORLD BANK GROUP

Tonga Ministry of Infrastructure (MOI)

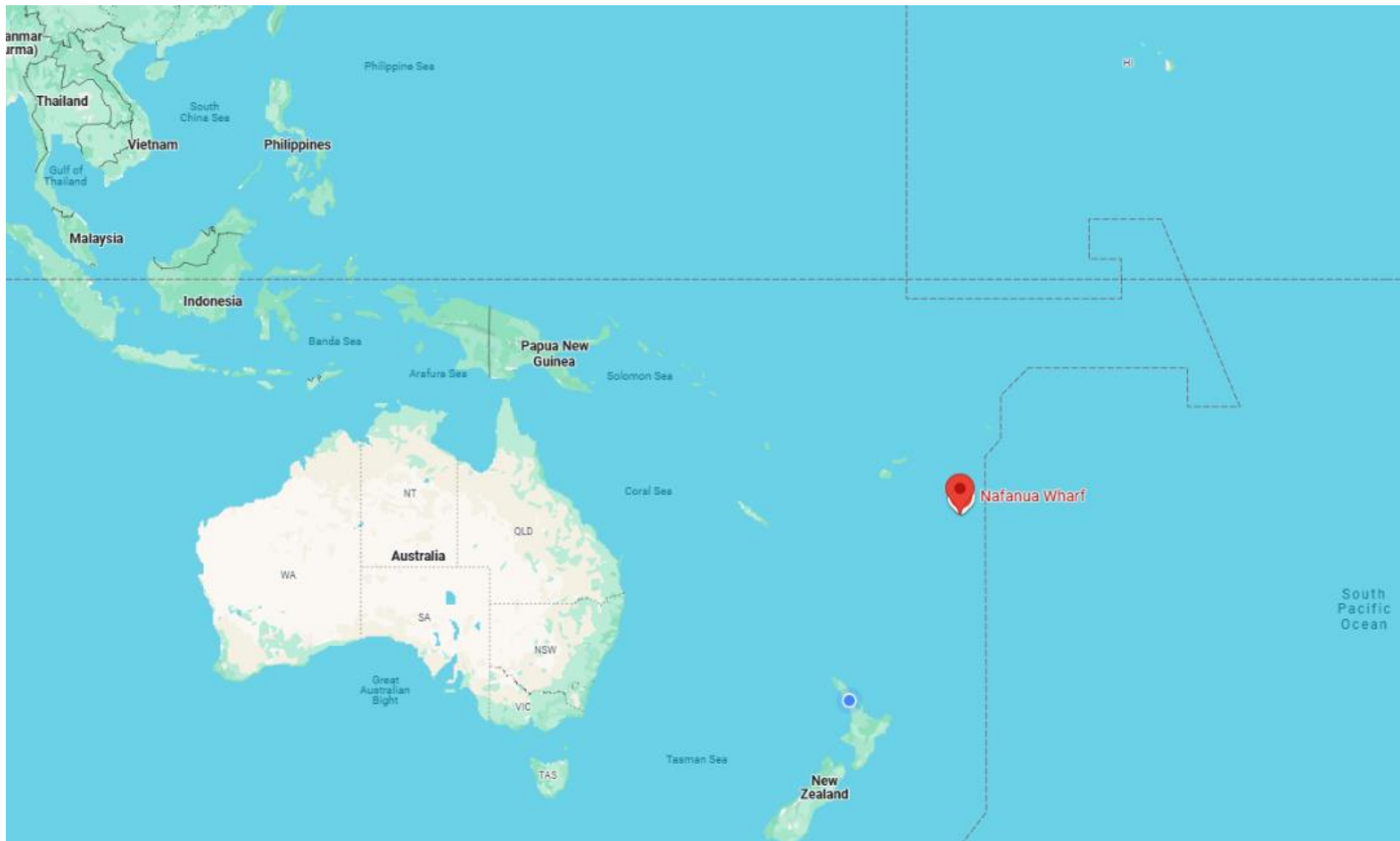
“Tonga experiences a high degree of economic and social shock during disaster years: over 40 percent of the population of Tonga is affected during a typical disaster year and Tonga’s economic losses are equivalent to 14 percent of gross domestic product (GDP).

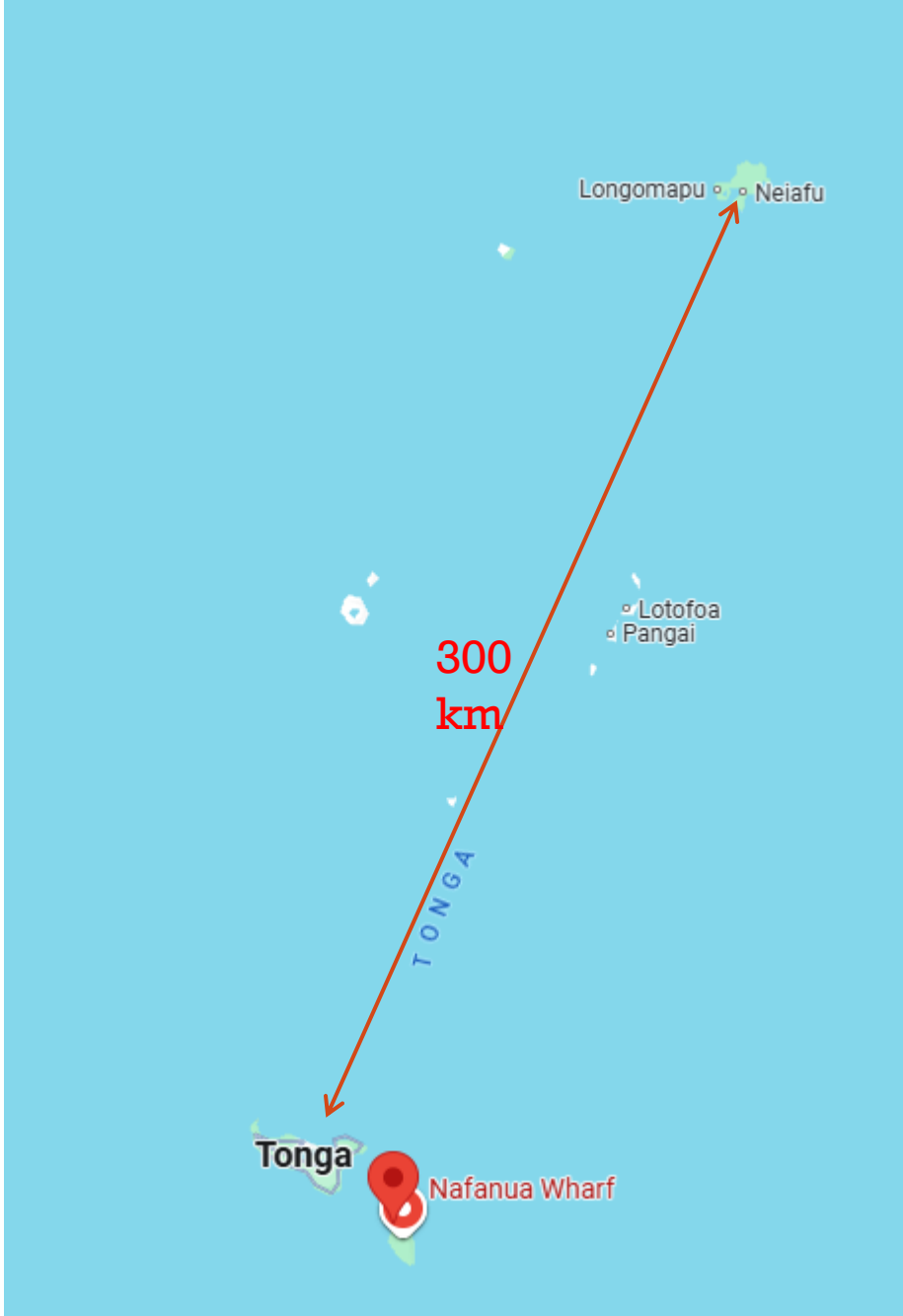
The probability and likelihood of disasters increasing under future climate events would bring more serious and greater economic losses.

In the capital city of Tonga, a cyclone with a 100-year return period, or with a 50% chance of occurring within the current generation, could likely inflict damage equivalent to 60 percent of GDP. **Tonga is at risk to tropical cyclones and storms, tsunamis, volcanic activity, and drought.”**



Source: Climate Change Knowledge Portal



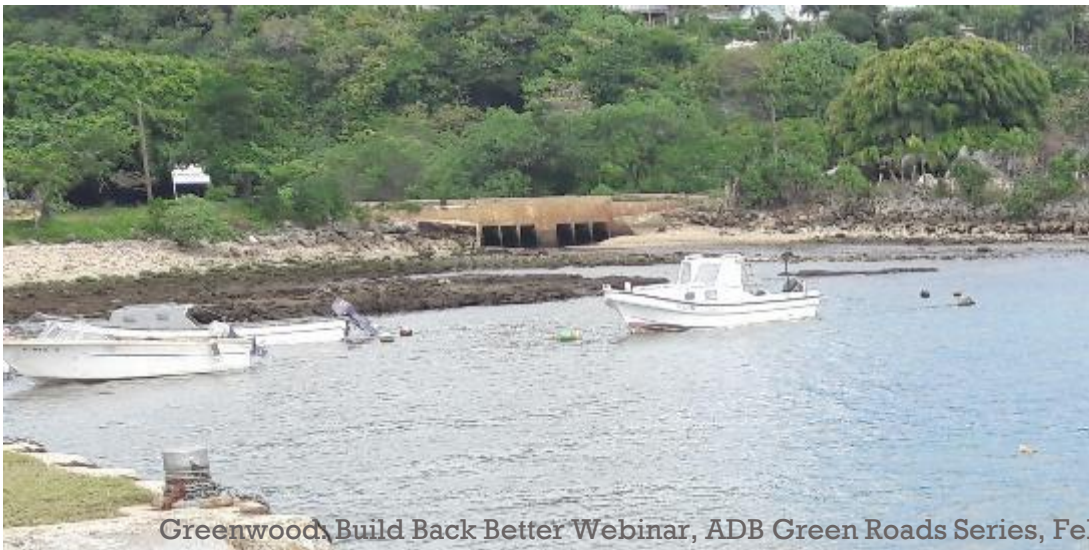


13th Feb 2025





GENERAL DETERIORATION OVER TIME (2017)



TROPICAL CYCLONES

TC GITA – FEB 2018

TC HAROLD – APRIL 2020

TC Gita

- Tonga was the hardest-hit, with severe damage occurring on the islands of Tongatapu and 'Eua; two fatalities and forty-one injuries occurred in the kingdom. US\$164m of damage.
- ... the storm knocked out power to all residents and caused extensive damage. ... older structures suffered severe damage while newer buildings fared well. **Crops were largely destroyed**. Fifty-two homes were completely destroyed on the island; eight people suffered injury, including one severe.

TC Harold

- ...Harold had become a category 5 severe tropical cyclone ...
- Storm surge, reaching 0.86 m (2 ft 10 in) above king tide, inundated coastal extents ... with their greatest impacts on the island's central and western shores. ...
- Of the islands, **'Eua was most badly affected, with serious damage wrought to its wharf**. Some houses were unroofed and electricity was lost throughout the island. Farther inland, vegetation and **crops were damaged** by the storm.
- On April 23, Tonga's Minister of Finance revealed that the total Damages from Cyclone Harold in Tonga is estimated to in excess of US\$111 million.

Source: Wikipedia.org



Road at bottom of town damaged



Coastal road badly damaged



Bridge damaged



APRIL 2020 (POST TC HAROLD)



POST TC REPAIRS



A WORD FROM THE LOCALS

- <https://youtu.be/TkI9T3m3sVE>



2022 TSUNAMI (HUNGA TONGA UNDERWATER ERUPTION)

- The Hunga Tonga–Hunga Ha‘apai volcano in the South Pacific ocean erupted on 15 January 2022,
- **...three key blasts from the volcano.**
- .. As much energy as 15 megatonnes of TNT, making it hundreds of times more powerful than the atomic bomb dropped on Hiroshima during World War II.
- **... waves surged 85 metres high within one minute of the eruption.**
- **Some 20 minutes after the explosion, 45-metre-high waves inundated the coastline of Tofua Island, located 90 kilometres north of the volcano.**
- To the south, Tongapatu — the most populated island in Tonga — experienced waves 17 metres high. “This was very much in the league of a ‘megatsunami’,” says study co-author Sam Purkis, a marine geoscientist at the University of Miami in Florida.
- **Waves hitting the east coast of ‘Eua island — roughly 25 kilometres away from Tongatapu — were a relatively modest five metres high on average.**
- <https://www.preventionweb.net/news/tonga-volcano-eruption-triggered-mega-tsunami>

BREAKWATER DESTROYED – NO LONGER A REPAIR JOB!



LARGE PART OF PORT UNUSABLE



BUILDINGS GONE SMALL BOAT RAMP UNUSABLE





THE RESPONSE

BRIDGE WASHED AWAY

- TEMPORARY 'NON-ENGINEERED'
SOLUTION IMPLEMENTED TO
RESTORE CONNECTIVITY



ADDING RESILIENCE TO THE ROAD NETWORK



Potential to add resilience to road network through constructing new 100m bridge crossing further from ocean.

But what is an appropriate investment for an island of 5,000 people?

Japan (JICA) leading this workstream

THE WHARF - IMMEDIATE



Low cost protection of wharf implemented to enable functioning.

Filled in erosion under the concrete hard stand area.

Damage to bollards etc also repaired

WHARF INFRASTRUCTURE

– THE PLAN SO FAR (STILL A WORK IN PROGRESS)

- Wallbridge Gilbert Aztec (WGA) engaged to lead design
- The passenger terminal building is proposed to be built on the existing concrete slab **where the original terminal building was constructed.**
- Primarily ‘open structures’ – columns and roof for shelter from sun and rain
- The new facility ... **finished surface level of 500mm above the wharf hardstand** which will enhance the structures resilience against inundation events.
- **In significant events, the structure may still be subject to inundation**, however, as an open structure built from reinforced concrete and tiled floor surfaces, **damage from these events is expected to be minor.**
- The structure shall be designed for site specific cyclonic and seismic conditions.
- **Concept of smaller buildings (ticket kiosks) being on trailers, so can be towed away ahead of storm events.**



Figure 6: Nafanua Port Passenger Terminal Building Facing Towards the Quay Line



Figure 7: Nafanua Port Passenger Terminal Building Facing Away from Quay Line

BUT THERE ARE CHALLENGES

- Design Standards:
 - What level of event is appropriate to design for?
 - Tropical cyclones – seems reasonable to design for these such that minimum disruption and damage occurs
 - Tsunami – sufficiently rare to not be warranted
 - What damage is acceptable after a major event?
 - Non-available during the event (ferries unlikely to be operating in any case)
 - Is inundation acceptable (potential loss of some goods)
 - At what level of event is damage to the structure acceptable?
 - What level of durability is required?
 - Imported vs domestic (coral) aggregates
- Do you address functional / operational aspects at the same time as increasing resilience?
 - Separating heavy vehicle and passenger access routes
 - Paving the carpark
 - Adding goods storage and MOI facilities
- Having an existing master plan for key infrastructure is a good initiative to speed up recovery.

MONEY CHALLENGES

- Funding

- TCRTPII projects set up to fund the rehabilitation of several ports (plus roads & airports)
- Damage at 'Eua and Taufa'ahau (on Ha'apai) far exceeds available funds:
 - US\$18-20m estimated costs from WGA work
 - Of which US\$14m identified as 'urgent short term works' on breakwaters and buildings
 - US\$7.2m budget
- How to best make use of the available funds:
 1. Do all of the things, but at a lower design standard?
 - What does that mean for breakwaters
 - Some scope with buildings to go for lighter designed structures
 2. Do the breakwater at each port, and then use whatever is left for remaining work?
 3. Do one port fully, then move on to the next when funding permits?

DISCUSSION TIME

ADB BBB Guide: Vol 2	Included	Comment
Network Planning, Integration and Redundancy	✓	<ul style="list-style-type: none"> • Potential to add redundancy in to the road network • Ensuring airport runway is in good state of repair. • Network level resilience studies
Green Transport Networks		
Intelligent Transport Systems		
Resilient Structures	✓	<ul style="list-style-type: none"> • Raising floor level • Designing to be temporarily submerged and/or moved out of the way
Resilient Material Selection	✓	<ul style="list-style-type: none"> • Cost of importing high quality rock for breakwaters
Enhanced Drainage	✓	<ul style="list-style-type: none"> • As part of bridge replacement
Slope Stabilisation and Erosion Control	✓	<ul style="list-style-type: none"> • As part of bridge replacement, need to address debris blocking bridge
Transport Sector Capacity Development	✓	<ul style="list-style-type: none"> • Core part of the overall TCRTPII project

