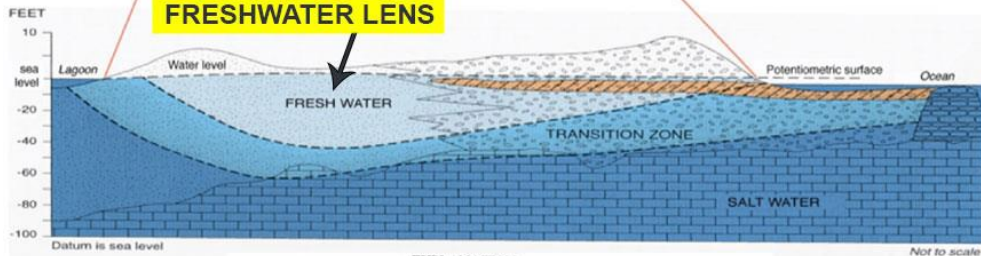
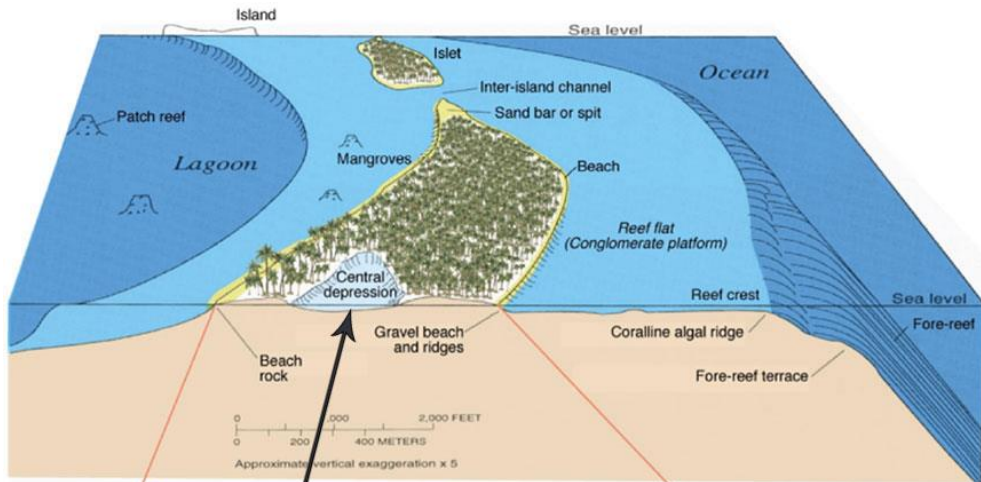


# *Climate Change Adaptation through Asset Management*



# When a 100% textbook design- fails

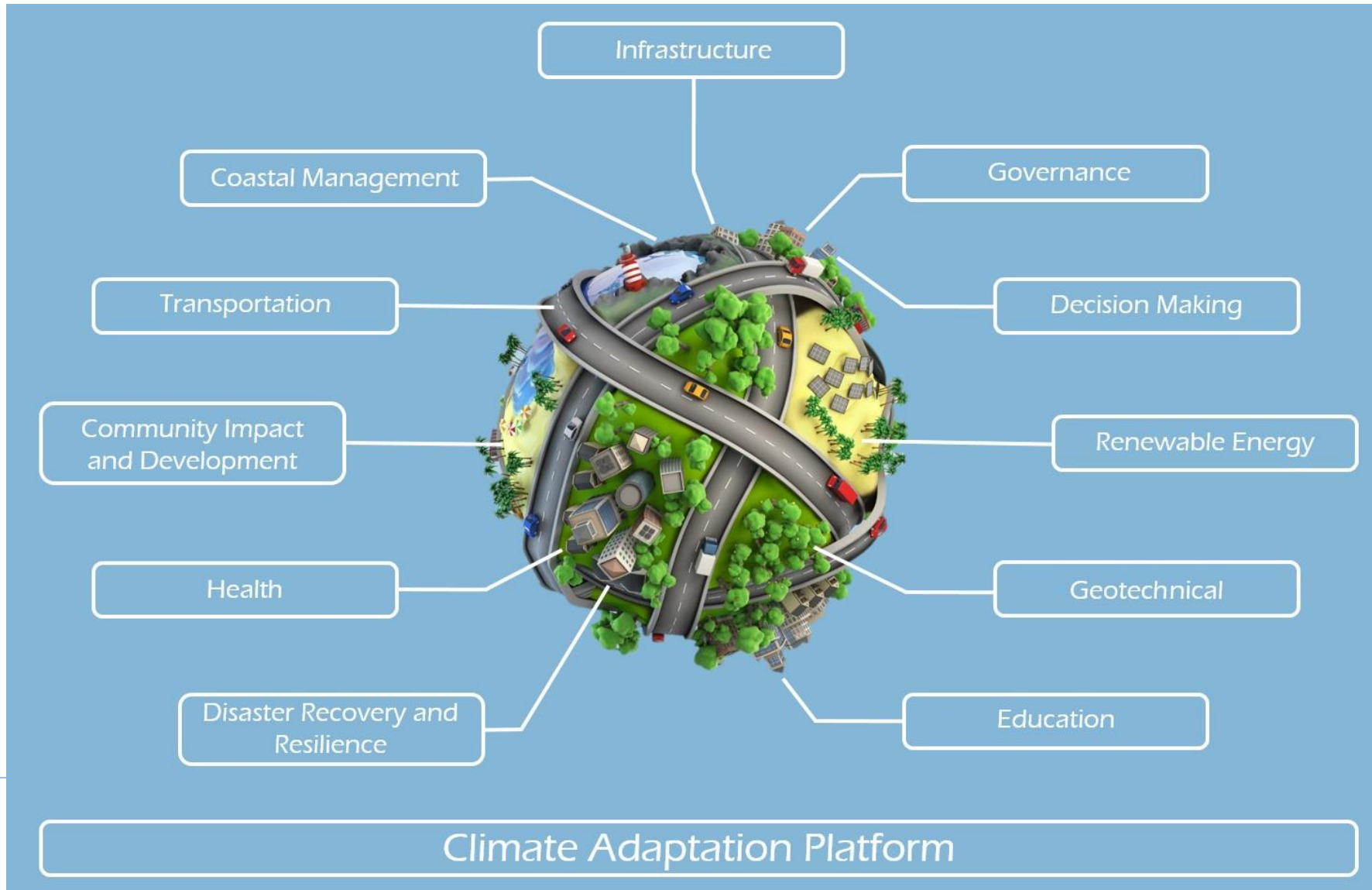


EXPLANATION

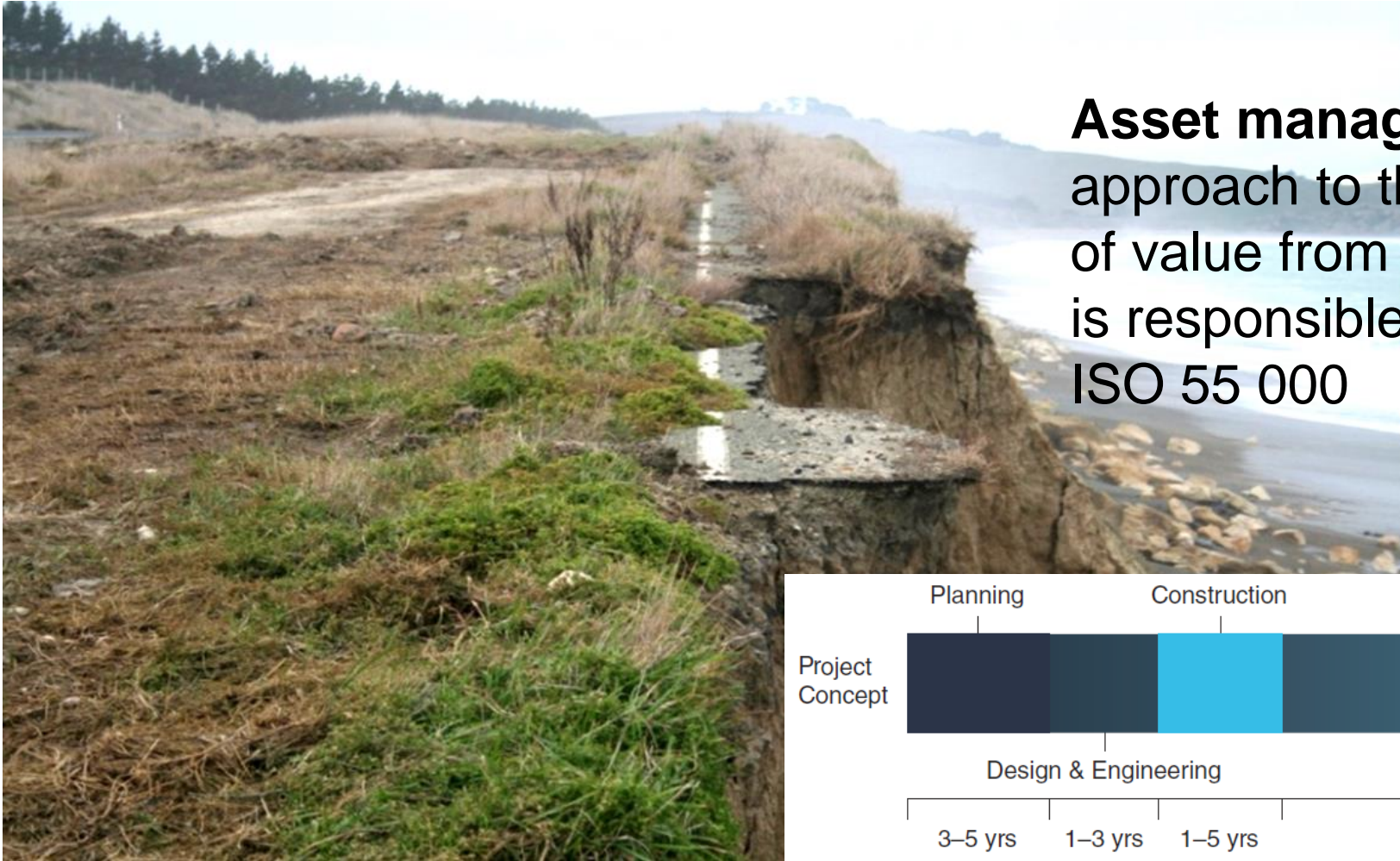
FINE	REEF
COARSE	PLEISTOCENE DEPOSITS
REEF-FLAT PLATE	



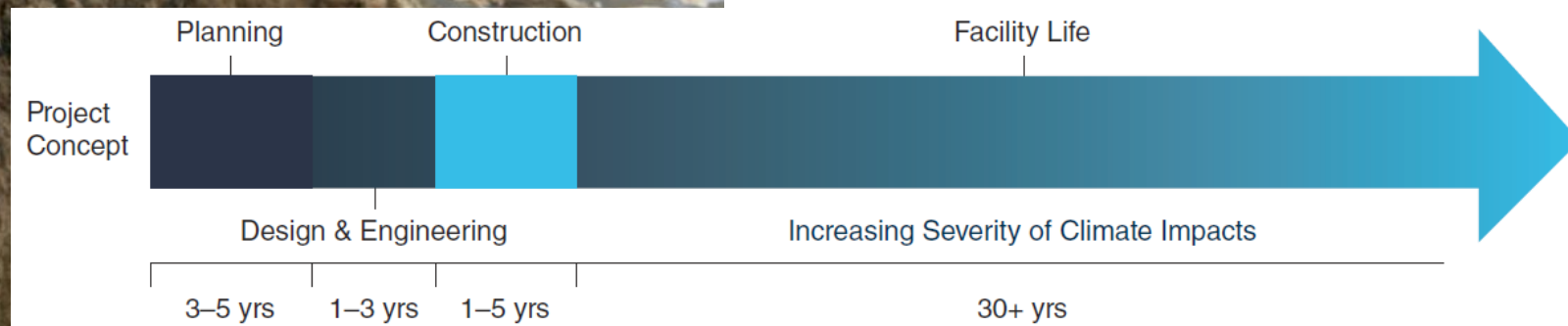
# Adaptation is a Multi-Dessiplinary Topic



# What we are trying to do is not new



**Asset management** refers to systematic approach to the governance and realization of value from the things that a group or entity is responsible for, over their whole life cycles  
ISO 55 000

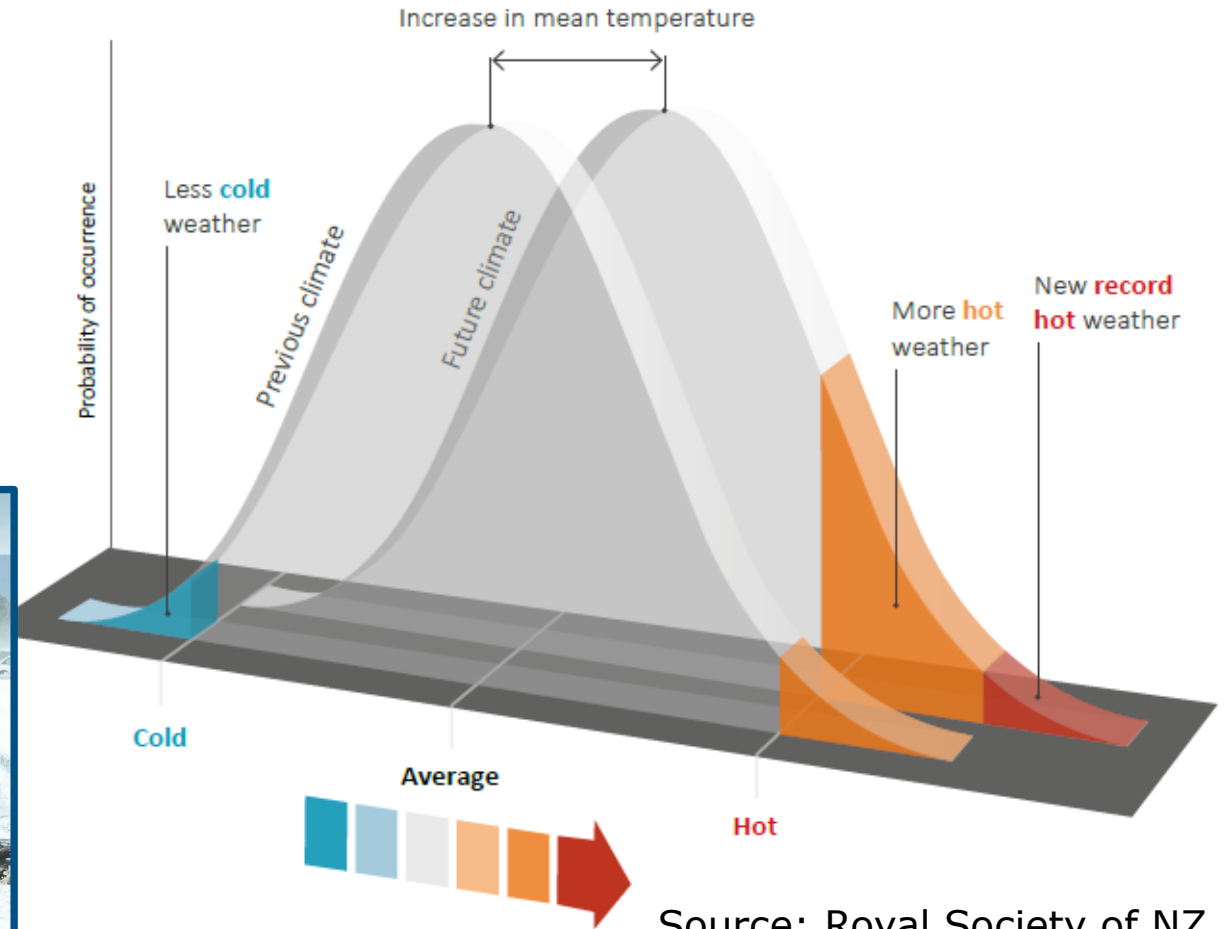


# Core Messages

- Robust Asset Management (AM) in itself, already significant enhances resilience of infrastructure
- Slight adjustments to AM process, significantly contribute to adapting for climate change
- Development Priorities:
  - Collection of relevant data
  - Vulnerability assessments need consider multi hazards
  - Interdependencies with other assets types
  - Decision making perhaps the most needed research area (incorporating uncertainty)



# The Expected Changes on networks



Source: Royal Society of NZ



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# Climate Change Affects Roads in Different Ways

Climate Change Events	Risks to the Road Infrastructure
Extreme rainfall events	<ul style="list-style-type: none"> <li>• Overtopping and wash away</li> <li>• Increase of seepage and infiltration into pavement and subgrade</li> <li>• Increase of hydrodynamic pressure of roads</li> <li>• Decreased cohesion of soil compaction</li> <li>• Traffic hindrance and safety</li> </ul>
Seasonal and annual average rainfall	<ul style="list-style-type: none"> <li>• Impact on soil moisture levels, affecting the structural integrity of roads, bridges and tunnels</li> <li>• Adverse impact of standing water on the road base</li> <li>• Risk of floods from runoff, landslides, slope failures and damage to roads if changes occur in the precipitation pattern</li> </ul>
Higher maximum temperature and higher number of consecutive hot days (heat waves)	<ul style="list-style-type: none"> <li>• Concerns regarding pavement integrity, e.g. softening of asphalt layers, traffic-related rutting, embrittlement (cracking), migration of liquid asphalt</li> <li>• Thawing of permafrost solid resulting in subsiding structures and roads</li> <li>• Thermal expansion in bridge expansion joints and paved surfaces</li> <li>• Impact on landscaping</li> <li>• Temperature break soil cohesion and increase dust volume which cause adverse health impacts and traffic accidents</li> </ul>
Drought (Consecutive dry days)	<ul style="list-style-type: none"> <li>• Susceptibility to wildfires that threaten the transportation infrastructure directly</li> <li>• Susceptibility to mudslides in areas deforested by wildfires</li> <li>• Consolidation of the substructure with (unequal) settlement as a consequence</li> <li>• More smog</li> <li>• Unavailability of water for compaction work</li> <li>• Drought decreases mortality of plants along road alignments</li> </ul>
Extreme wind speed	<ul style="list-style-type: none"> <li>• Threat to stability of bridges</li> <li>• Impact of wind borne debris on network/safety</li> <li>• Damage to signs, lighting fixtures and supports</li> <li>• Increase of wind speed causes the dynamic force of water generated by waves on road embankments</li> </ul>
Foggy days	<ul style="list-style-type: none"> <li>• Traffic hindrance and safety</li> <li>• More smog</li> </ul>



# Collecting the right data

Data Items	Application	Normally Collected
<b>Network definition – Geospatial Data</b>	Knowing “where things are”	✓
<b>Network criticality data</b>	Identified critical asset (life-lines) that would be maintained to a different standard compared to the rest of the network	✓
<b>Physical environmental information such as soil types, waterways and streams</b>	Overlay climatic information in order to undertake vulnerability assessments	✓
<b>Historical and current weather patterns</b>	Understanding storm patterns and return periods – use for designs and vulnerability assessments	✓
<b>Water damage risks (e.g. flooding, scouring)</b>	Parts or road links that could be prone to failure or at risk due to insufficient drainage provision	✗
<b>Geohazard risks (e.g. land-slides and rock falls)</b>	Parts or road links that could be prone to failure or at risk due to geohazards	✗
<b>Road function/community socio-economic or cultural activities</b>	Used for prioritising/ optimising maintenance and capital investment pre-and-post shock event	✗
<b>Historical rainfall/Storm and/or other weather impact data on infrastructure</b>	What specific impact on infrastructure resulted from any weather activity, for example, roadways that have been flooded, areas prone to water related failures etc.	✗





# What is the return on the investment?

Summary of Waitaki Storm Events		
	Storm Event	
	Flood May 2010	Waitaki Flood July 2017
Rainfall (24hr)	124mm	174mm
Return Period	1/100	1/100
Number of Road Closures	120	35
Bridges Destroyed or Closed	0	2
State Highway Closures	2	1
Duration of Disruption to Road Network	7 hours	0 hours
Road Infrastructure Cost	\$1,500,000	\$350,000 (\$250k was for bridge)

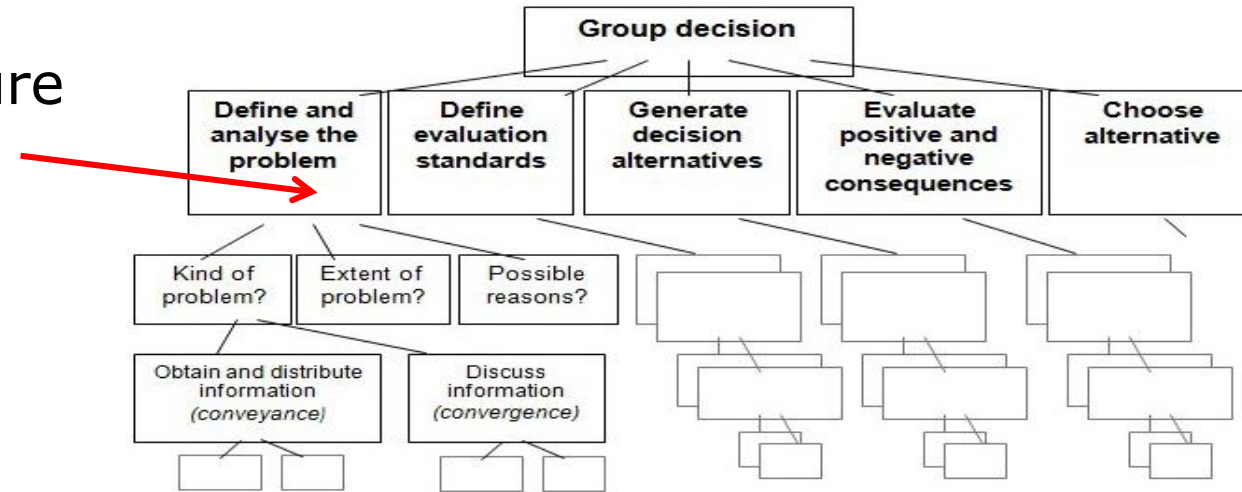


Determinants	Event	
	Pre Adaptation (2010 Flood)	Post Adaptation (2017 Flood)
Adaptation Cost	5	4
Road Closures	2	4
Bridge Closure	5	4
Closure of Arterial Routes	1	3
Disruption to Transport Network	2	3
Recovery Time of Transport Network	2	3
Cost to Transport Network	2	4
Determinant Factor	2.71	3.57
Efficacy Factor	1	0.9
<b>Adaptation Index</b>	<b>2.7</b>	<b>3.2</b>



# Decision Making Techniques

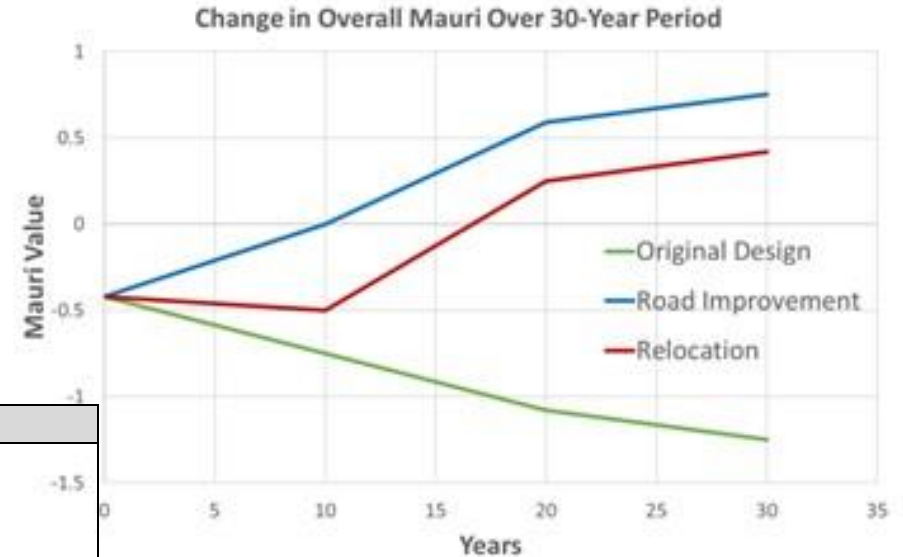
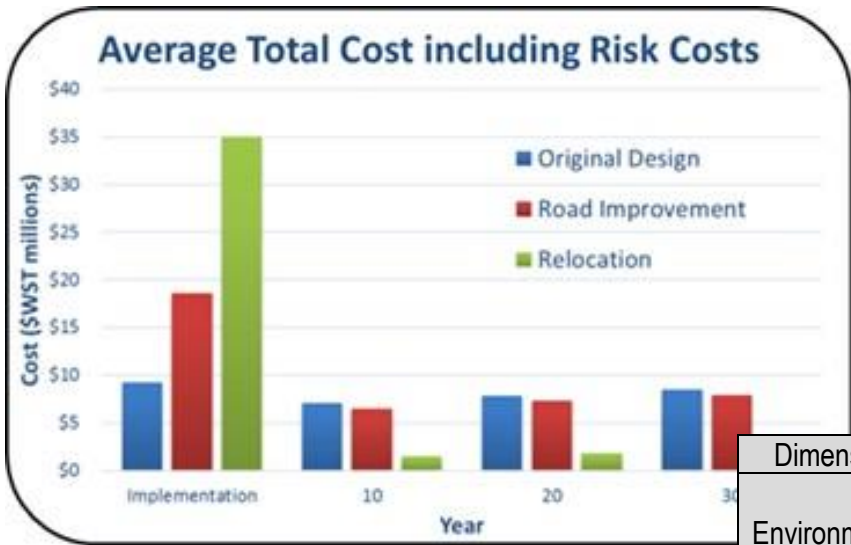
- There are already a number of techniques available
  - Risk-based methods
  - Delphi decision making
  - Hierarchical and Sequential Structure of Group Decision-Making
  - Traditional Road Management Systems
  - Multi-criteria analysis
  - Multi-objective Optimisation
- All need to be contextualised for climate adaption



(Kolbe and Boos, 2009)



# Samoa: Multi-Criteria Analysis Using 'Mauri' Model



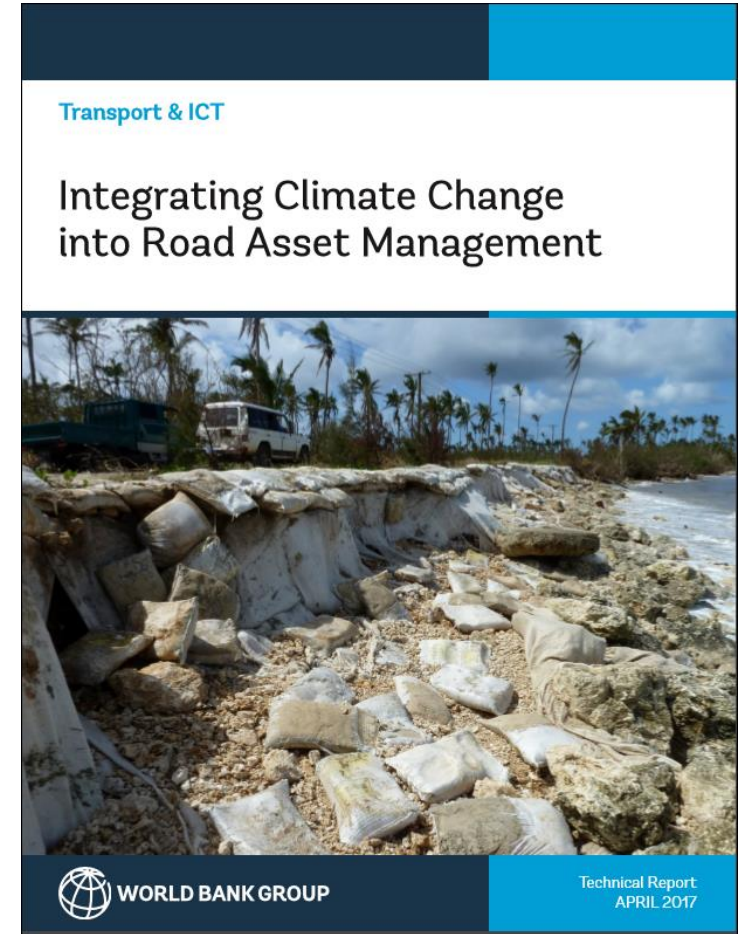
Dimension	Indicator
Environmental	<ul style="list-style-type: none"> <li>Water Quality</li> <li>Resources used</li> <li>Amount of land used</li> </ul>
Cultural	<ul style="list-style-type: none"> <li>Kaitiakitanga (Practice of spiritual and physical guardianship of the environment)</li> <li>Heritage protection measures</li> <li>Traditional Customs</li> </ul>
Social	<ul style="list-style-type: none"> <li>Public Health and Safety</li> <li>Amount of land used</li> <li>Inconvenience to affected community</li> </ul>
Economic	<ul style="list-style-type: none"> <li>Implementation Cost</li> <li>Maintenance cost</li> <li>Profit</li> </ul>



# For More Information ...

<https://climateadaptationplatform.com/>

<https://tinyurl.com/am-and-climate>



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