Road Asset Management (RAM)

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Session: Climate Resilient Road Management

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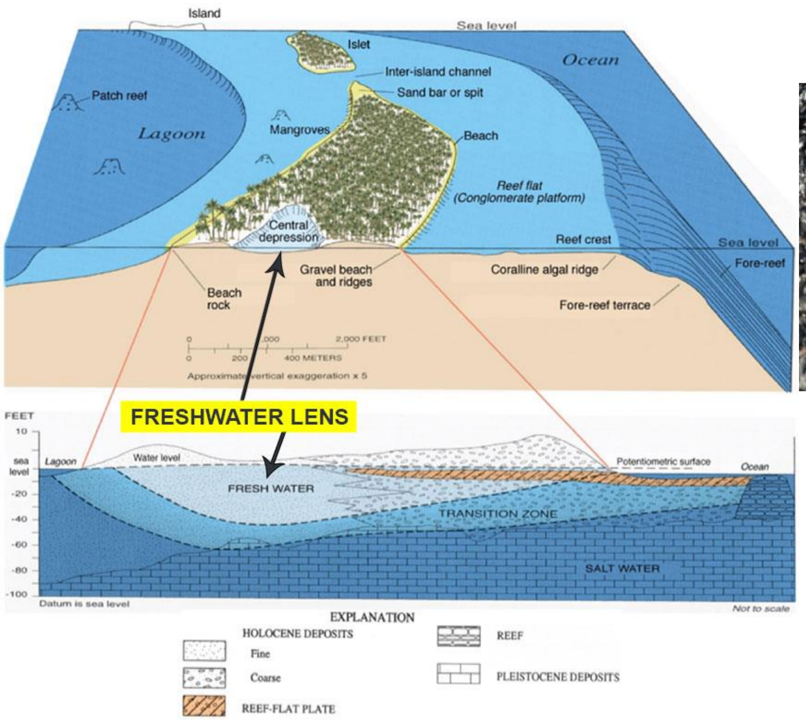
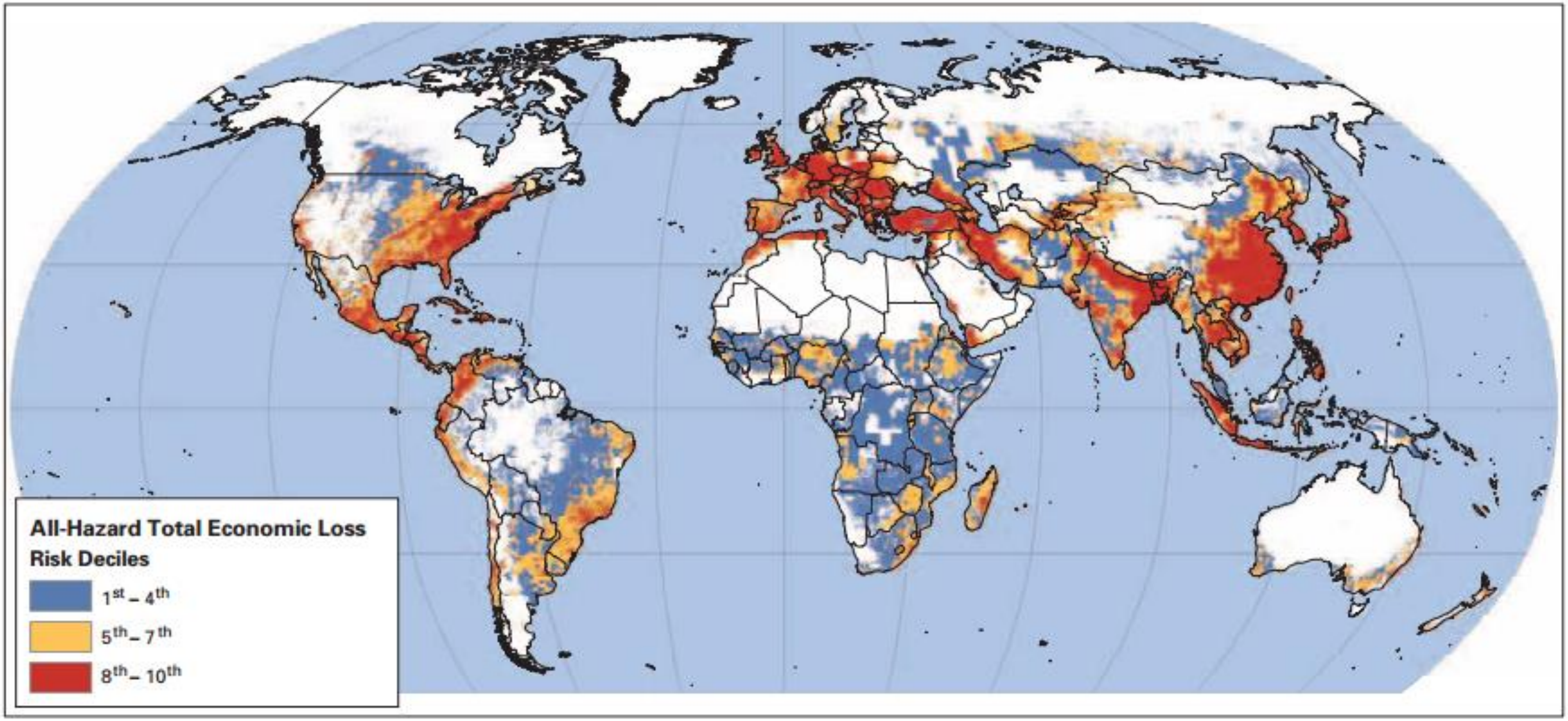
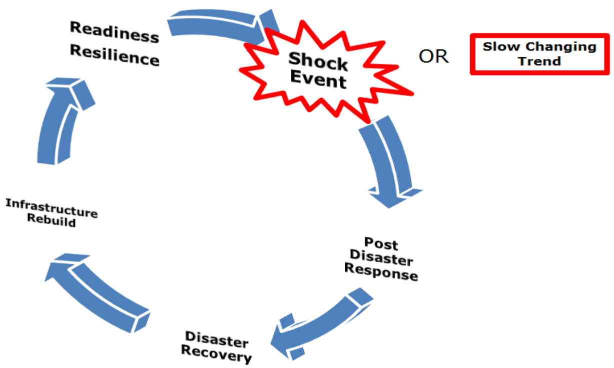
When a 100% textbook design- fails

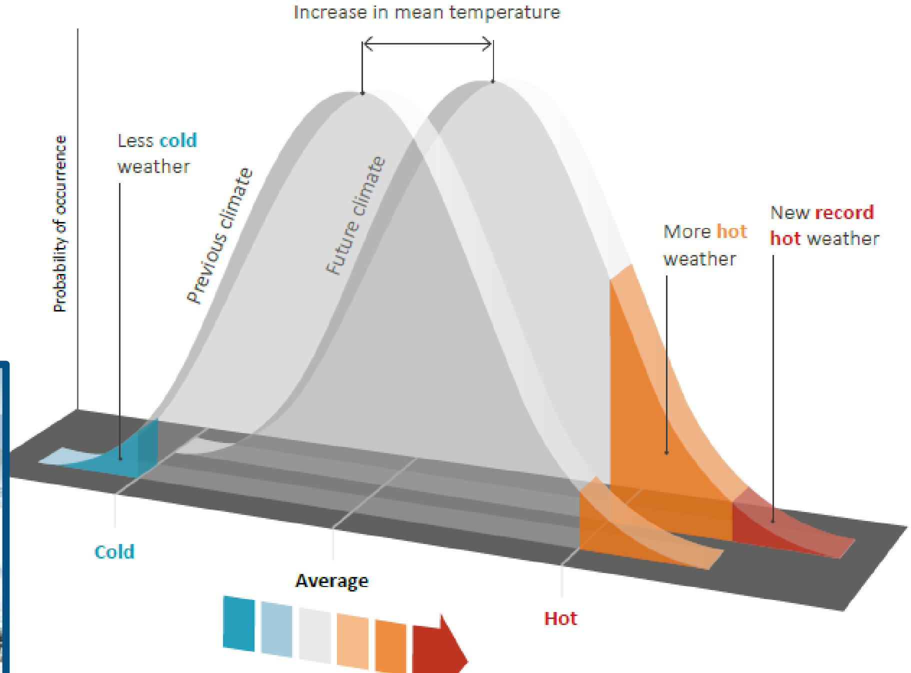


Not all Countries have the same vulnerability but it will be a global problem



The Expected Changes on networks

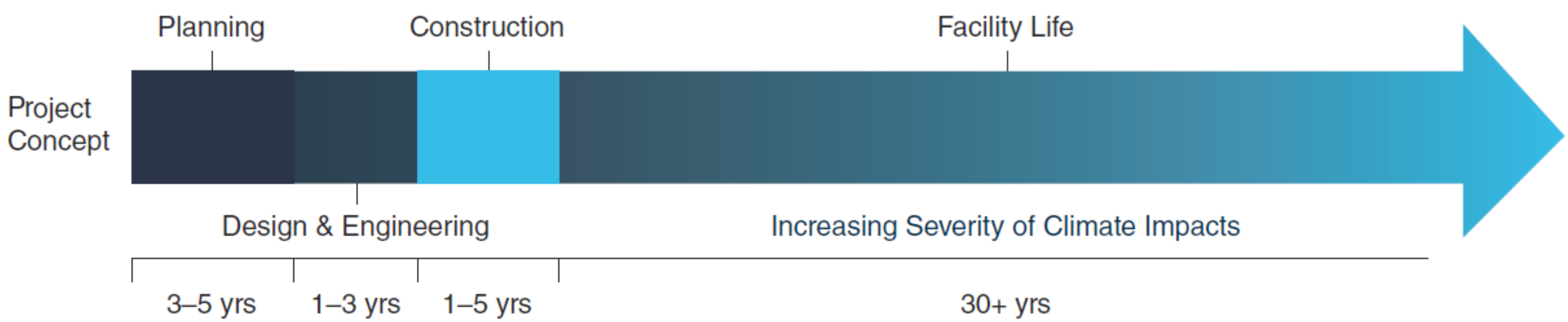




Source: Royal Society of NZ

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



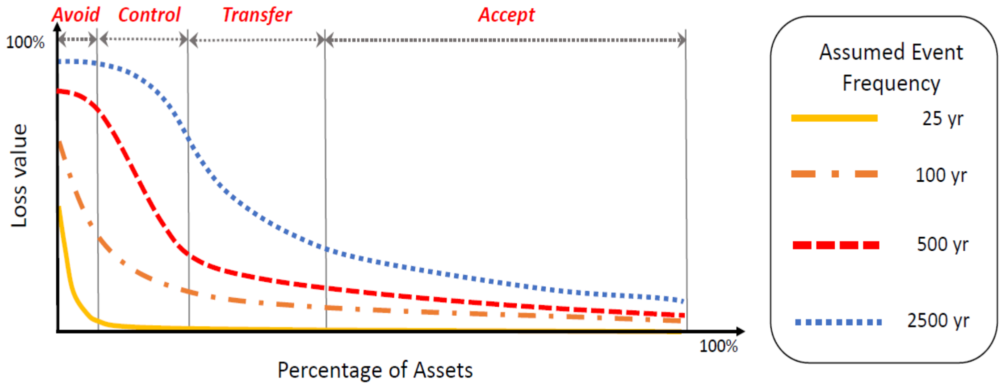
Context –The Problem we are Trying to Solve

AVOID - Reduce exposure

CONTROL - Mitigate physical impact

TRANSFER – Limit financial loss and aid recovery

ACCEPT - Adaptive response arrangements



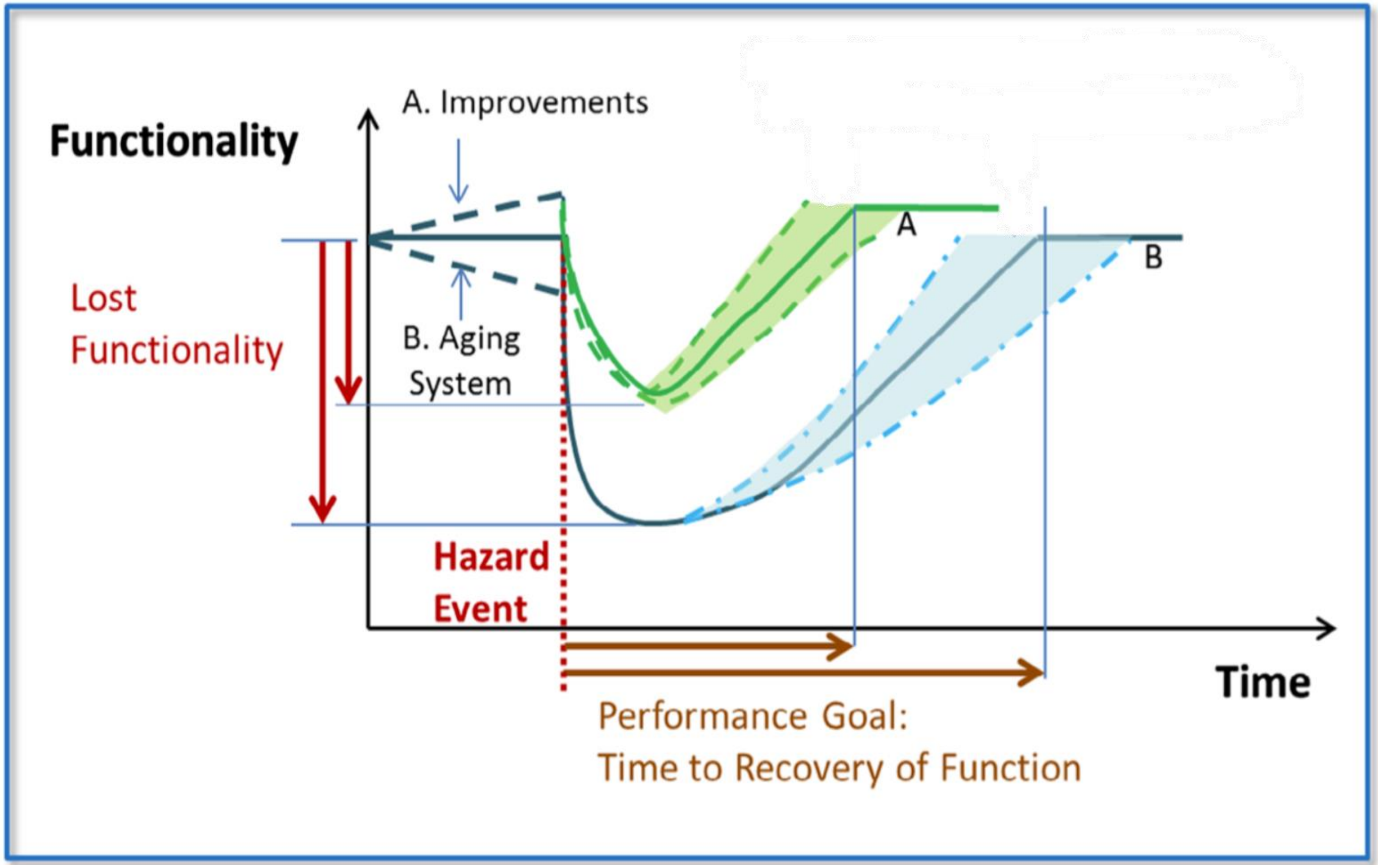
Consider multiple possible futures, where risk(s) change with time

Source: Hugh Cowen

A Criticality framework is key for this analysis

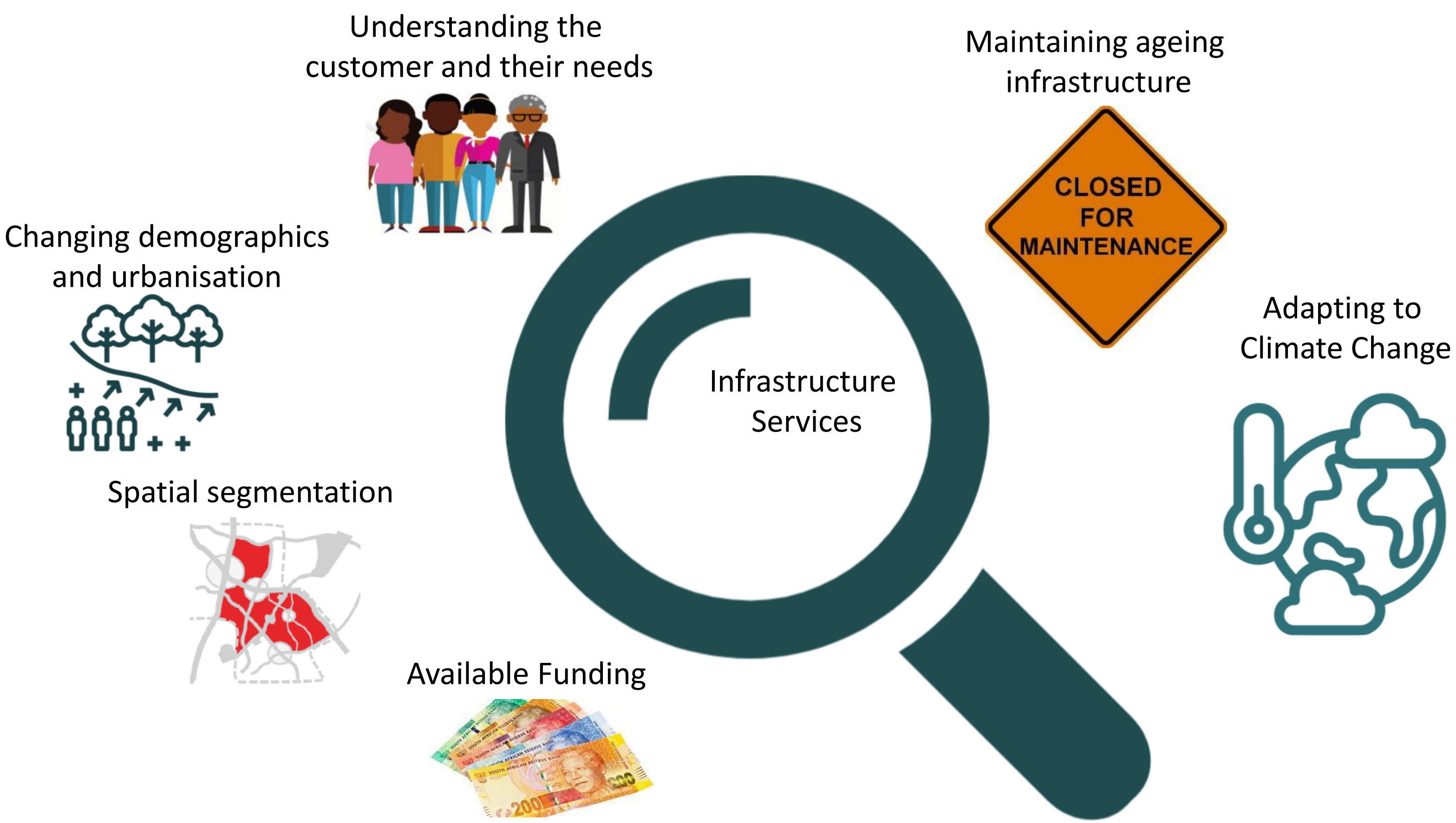
- Avoid ->Very small portion of the infrastructure where avoiding the risks may be appropriate – e.g. coastal infrastructure that gets damaged with every storm or high tidal event.
- Accept ->large portion of most infrastructure networks where the likely loss would be minimal and investing in adaptation for these parts would be uneconomical or even unnecessary.
- Control vs Transfer -> AM system helps us answer
  - Control->portion of the infrastructure where adaptation projects will control the potential losses from events. (Good return on investment)
  - Transfer - different financing instruments such as insurance or bonds may be more practical

Fundamentals of Resilience



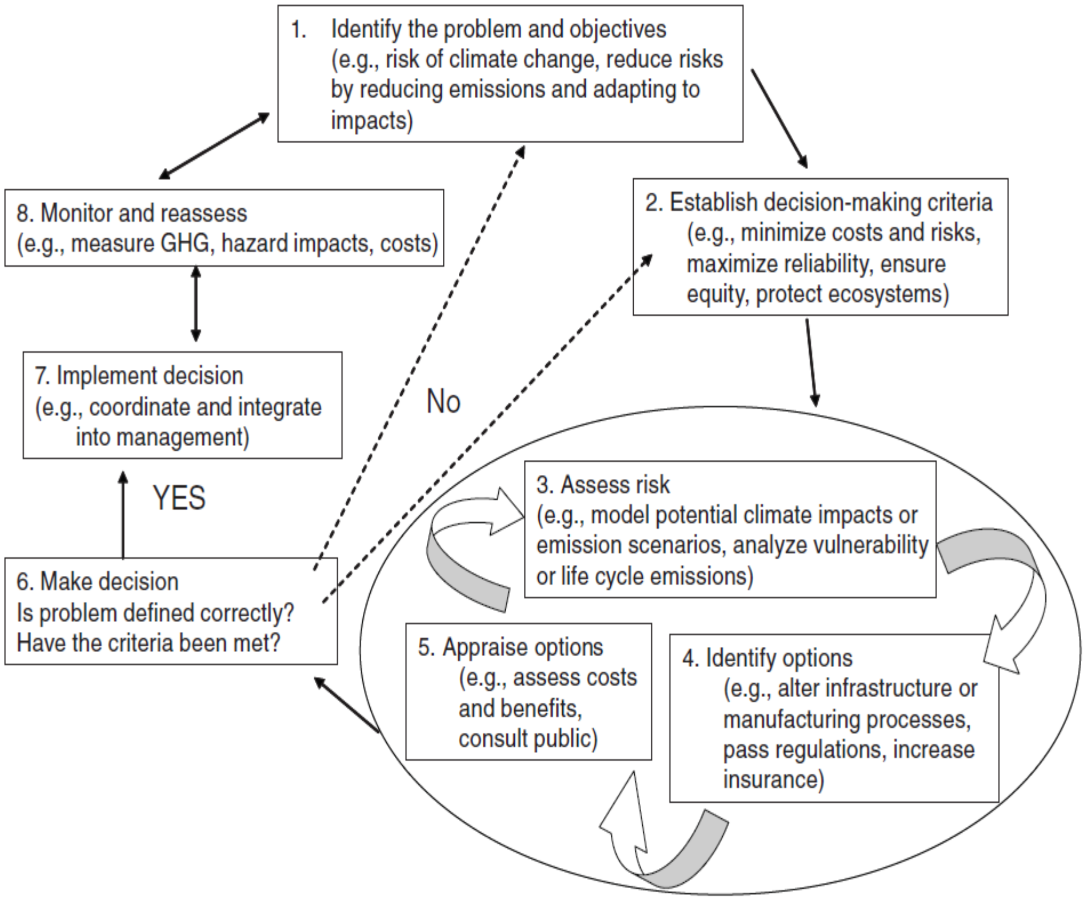
Source: https://imgur.com/gallery/3F82Ot1

A Key Message – Climate Adaptation is an AM Driver and is Managed According to the Same Processes



Asset Management Input to Resilience Cycle

Resilience Analysis Planning Approach



Source: National Research Council (2010)

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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	$350000 ($250k was for bridge)

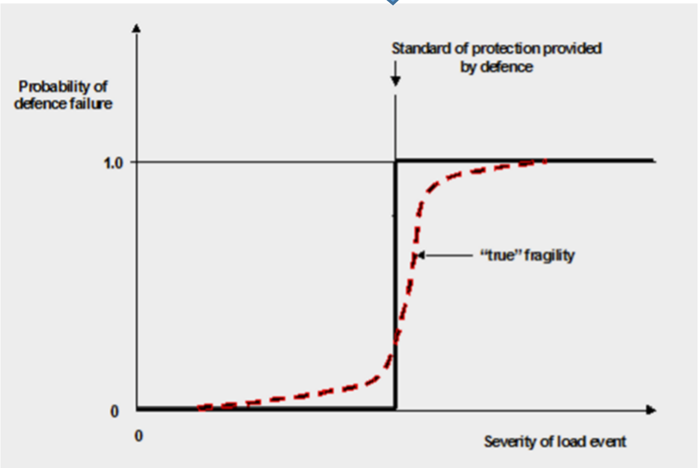
Determinants	Event	
	Pre Adaptation (2010 Flood)	Post Adaptation (2017 Flood)
Adaptation Cost	5	4
Road Closures	2	4
Bridge Closure	5	4
Closure of Arterial Routes	1	3
Disruption to Transport Network	2	3
Recovery Time of Transport Network	2	3
Cost to Transport Network	2	4
Determinant Factor	2.71	3.57
Efficacy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

Climate And Asset Management Data

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

IDS Infrastructure Decision Support

We also have to convert asset characteristic and performance to a fragility



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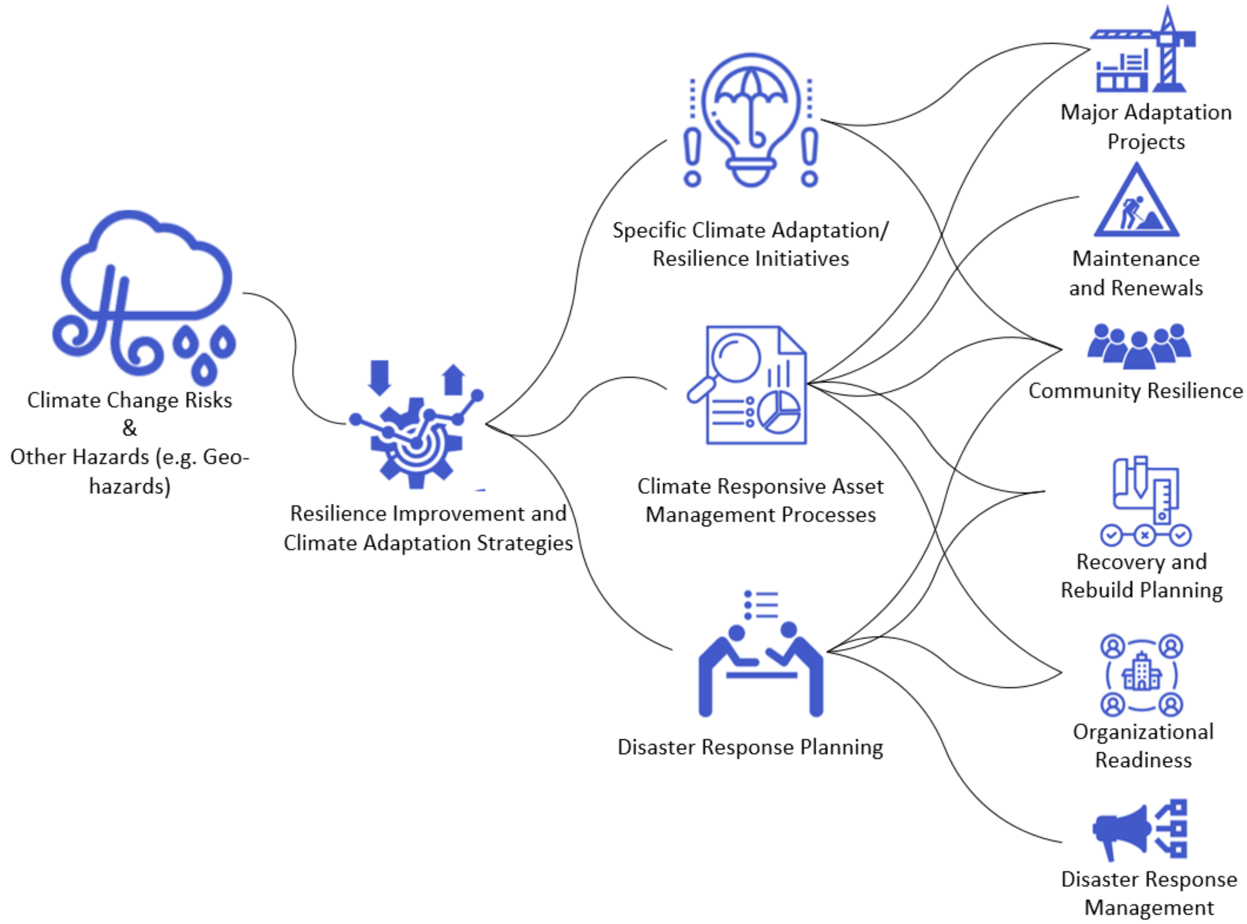
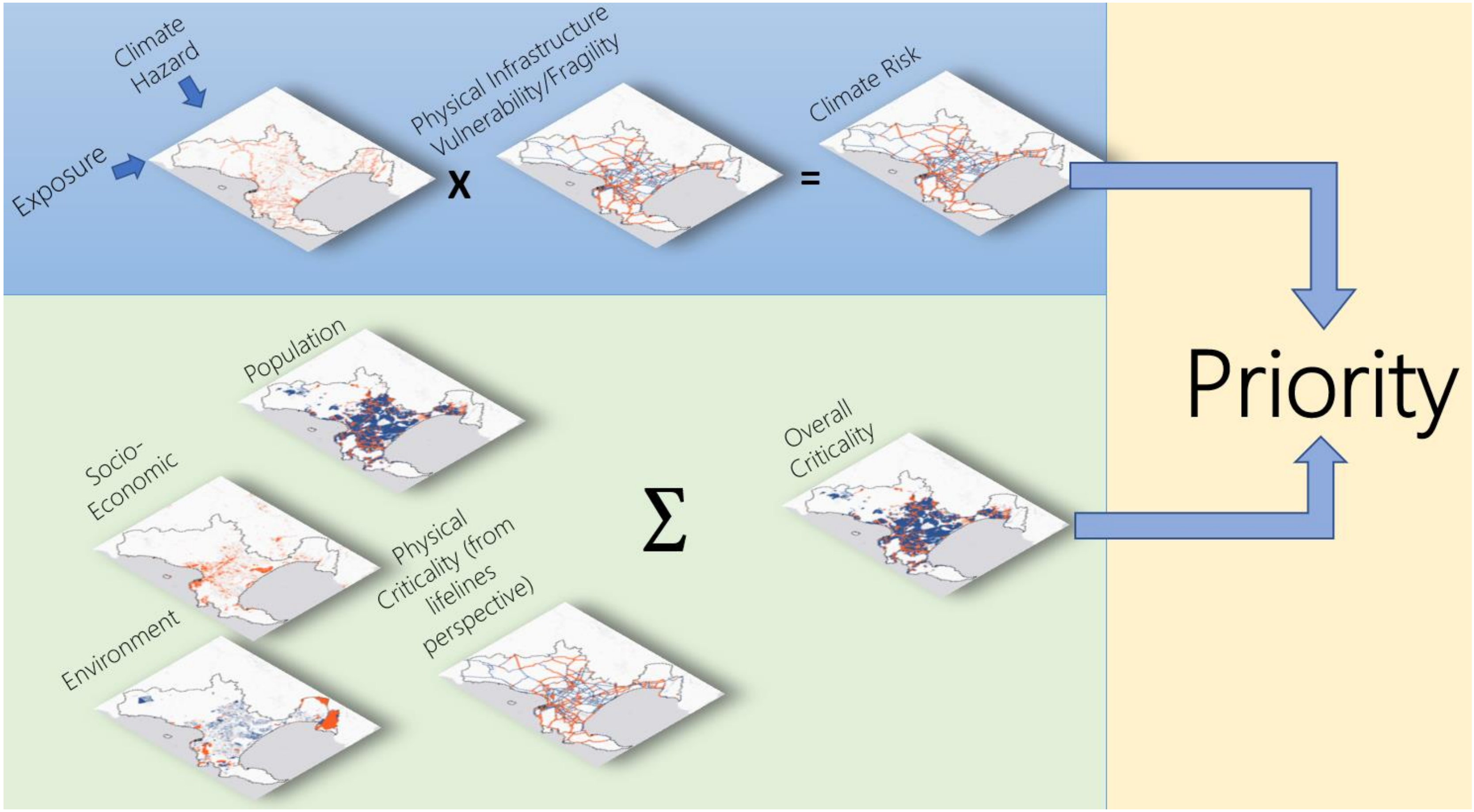
Asset Management In Climate Adaptation

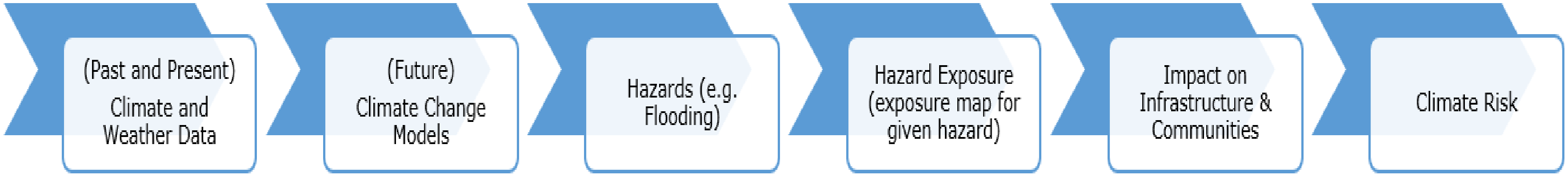


- Asset Management is a strong vehicle for a more holistic approach to adaptation
- Asset Management data and outputs could benefit capital projects and disaster management
- Our analysis needs more of a socio-economic focus than ever before

Overall Analysis Process



Implementation of Climate Risk Assessment

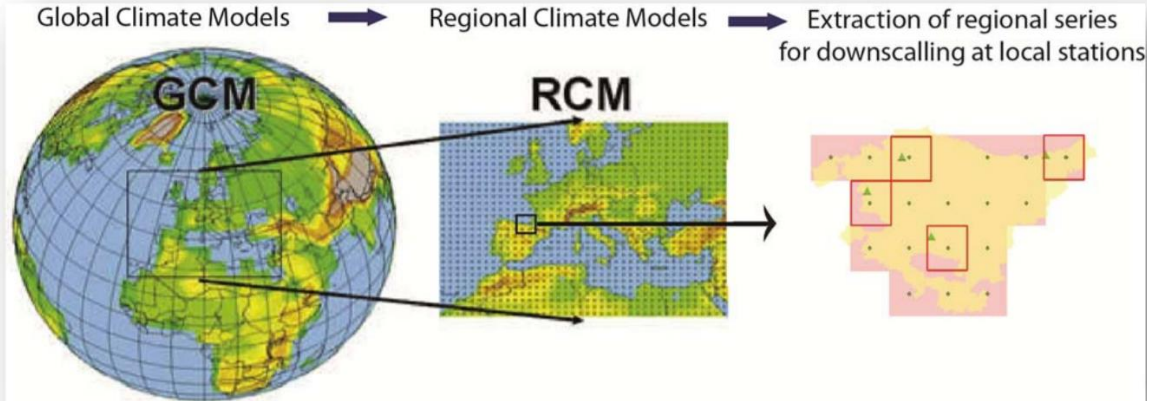


For Consideration:

- Up to hazard exposure analysis, the information would be common for all asset groups
- Specific impacts analysis would be different for different asset groupings
- Implementation Options
  - Risk assessment for smaller geographic areas (e.g. high risk areas)
  - Do full risk assessment for specific asset groups first
  - Do full risk assessment for a council clusters (see Resilient South case study)

Options For Analysing Possible Climate Outcomes

- Down Scaling Climate Models



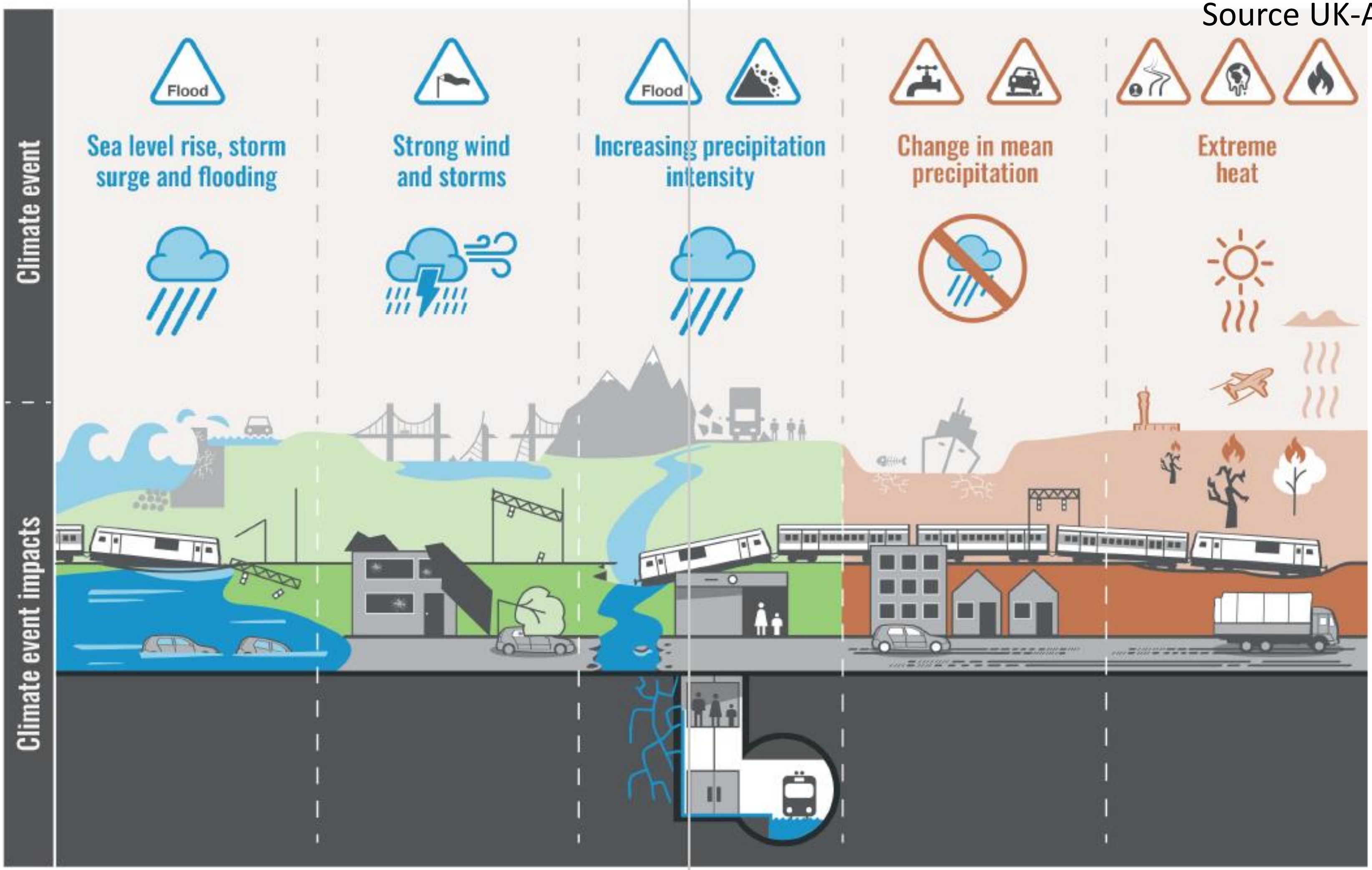
Iratxe González-Aparicio

- Sensitivity analysis
- Trend extrapolation
- Pattern-scaling
- Weather generators
- Empirical/Dynamic downscaling

Source: National Academy of Sciences

Impacts of Weather & Climate Change on Transport Infrastructure

Source UK-Aid



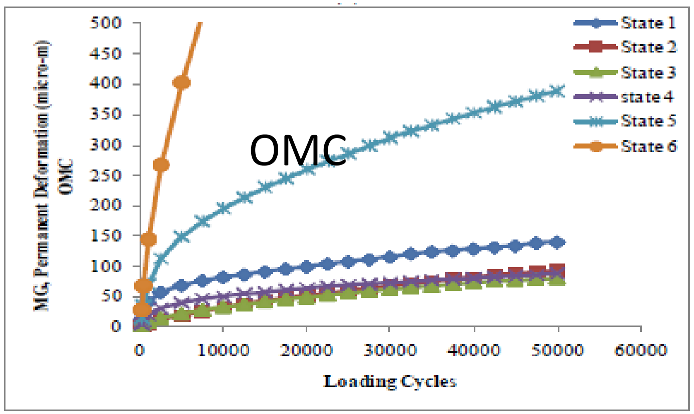
Climate Change Impacts on Roads

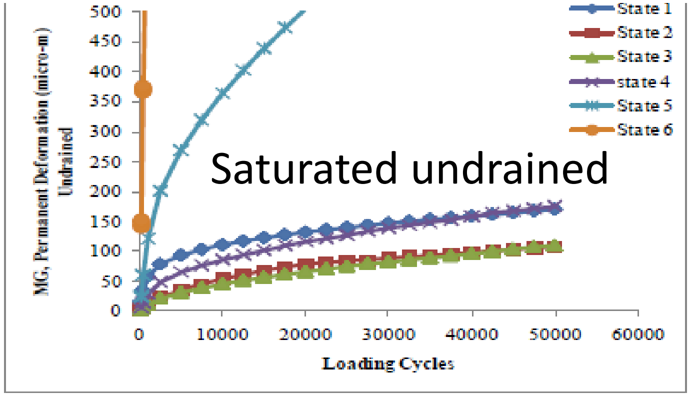
Climate Change Events	Risks to the Road Infrastructure
Extreme rainfall events	• Overtopping and wash away • Increase of seepage and infiltration pass • Increase of hydrodynamic pressure of roads • Decreased cohesion of soil compaction • Traffic hindrance and safety
Seasonal and annual average rainfall	• Impact on soil moisture levels, affecting the structural integrity of roads, bridges and tunnels • Adverse impact of standing water on the road base • Risk of floods from runoff, landslides, slope failures and damage to roads if changes occur in the precipitation pattern
Higher maximum temperature and higher number of consecutive hot days (heat waves)	• Concerns regarding pavement integrity, e.g. softening, traffic-related rutting, embrittlement (cracking), migration of liquid asphalt • Thermal expansion in bridge expansion joints and paved surfaces • Impact on landscaping • Temperature break soil cohesion and increase dust volume which caused health and traffic accidents
Drought (Consecutive dry days)	• Susceptibility to wildfires that threaten the transportation infrastructure directly • Susceptibility to mudslides in areas deforested by wildfires • Consolidation of the substructure with (unequal) settlement as a consequence • More smog • Unavailability of water for compaction work • Drought decreases mortality of plants along road alignments
Extreme wind speed	• Threat to stability of bridge decks • Damage to signs, lighting fixtures and supports • Increase of wind speed causes the dynamic force of water generated by waves on road embankments
Foggy days	• Traffic hindrance and safety • More smog

CEDR (Grendstad, 2012)

Climate Impact on Road Surfaces

Climate Impact	How it Impacts the Road Surface
Extreme wind	• **Mechanical damage to the surface as wind-borne debris on the road (e.g. truck overturning)**
Flooding	• **Delamination of the surface** • **Scour of wearing course for unsealed roads**
Increased rainfall	• **Increasing rainfall results in higher moisture conditions within the pavement layers. One way to prevent moisture build-up is through providing surfaces with better waterproofness.** • **Increased risk for aqua/hydroplaning**
Sea level rise (tidal movement)	• **Blistering of surface as a result of pressure build-up below the surface.**
Increase variations between cold and hot temperatures	• **Temperature cracks**
Extreme high temperatures	• **Decrease in viscosity of the bitumen binder leading to flushing** • **Increased hardening of the bitumen (oxidation)**
Increased droughts	• **Increased cracking**





Hussain, J., Henning, T., Wilson, D. J., & Alabaster, D. (2011b). What happens when it rains? Performa
nce of unbound flexible pavements in accelerated pavement testing. Road and Transport Research 2
0(4), 3-15.

Slips and Landslides

- In may countries, this is the #1 issue
- Normally very costly to restore
- Creating the perfect storm -> moisture + seismic activities

Flooding

- Overtopping, erosion and washouts
- Increased moisture conditions in pavements and subgrade
- Traffic interruption
- Loosing bridges

Freeze Thaw

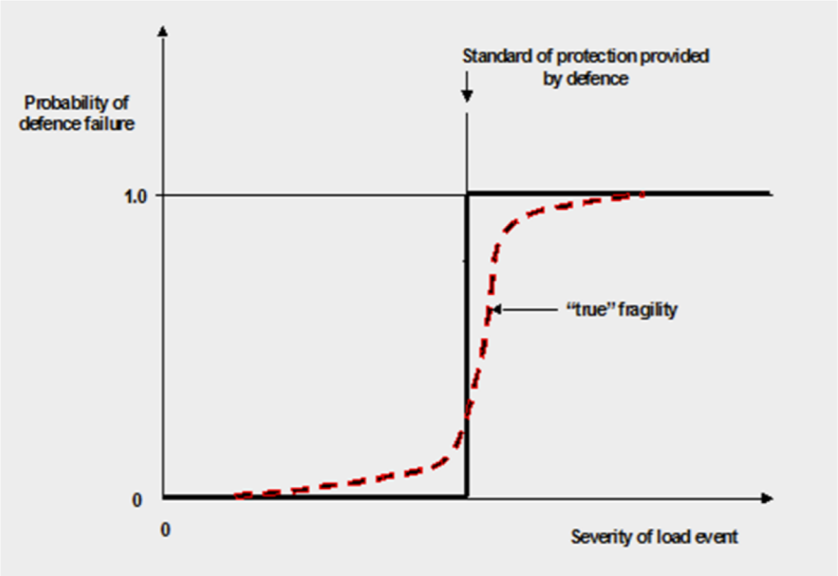
- Varying patterns on freeze-thaw
- Some countries have issues with losing permafrost

Infrastructure Fragility / Physical Vulnerability for Shock Events

Grade	Description	Condition x (Capacity or Utilisation)
Grade 1	withstand substantially more significant climate events compared to design standard	**< 4**
Grade 2	withstand more significant climate events compared to design standard	**4 to 7**
Grade 3	withstand the design standard climate event	**8 to 11**
Grade 4	not able to withstand the design standard climate event	**12 to 18**
Grade 5	not able to withstand minor climate events	**> 19**

Basic Level

Advanced Level



Treatment Categories

Adaptation Approach	Description	Examples
Avoid damage	In cases of extreme hazard exposure, or places where there is a certainty of infrastructure loss, the damage could be avoided by relocating infrastructure to less exposed areas.	Coastal roads that are low-lying thus prone to overtop, and moving inland is a more practical option.
Protecting road assets or construction new features	Various protection strategies exist to avoid hazards impacting road assets.	Flood protection structures Slope stabilisation techniques
Retrofitting existing infrastructure	Retrofitting involves strengthening or changing infrastructure to be less vulnerable to most likely hazard impacts.	Bridges could be retrofitted to withstand floods and seismic activities better. E.g. clippings to strengthen bridge deck's lateral stability on beams.
Catchment area improvements	Taking a more holistic approach to reducing the hazard exposure for a geographic area.	Improving overall catchment/stormwater drainage or improving run-off characteristics
Do minimum or nothing	Don't take any resilient specific actions other than increased maintenance and renewals.	Situations where higher priorities elsewhere or funding constraints prohibited investment into resilient options.
Delay adaptation to post-event	In some more costly adaptation options, it may be more economical to delay an adaptation strategy until after an event.	Bridge structures that will require costly relocation could still be functional until the next significant events. A new bridge is constructed elsewhere or at an increased height or strength on destruction.

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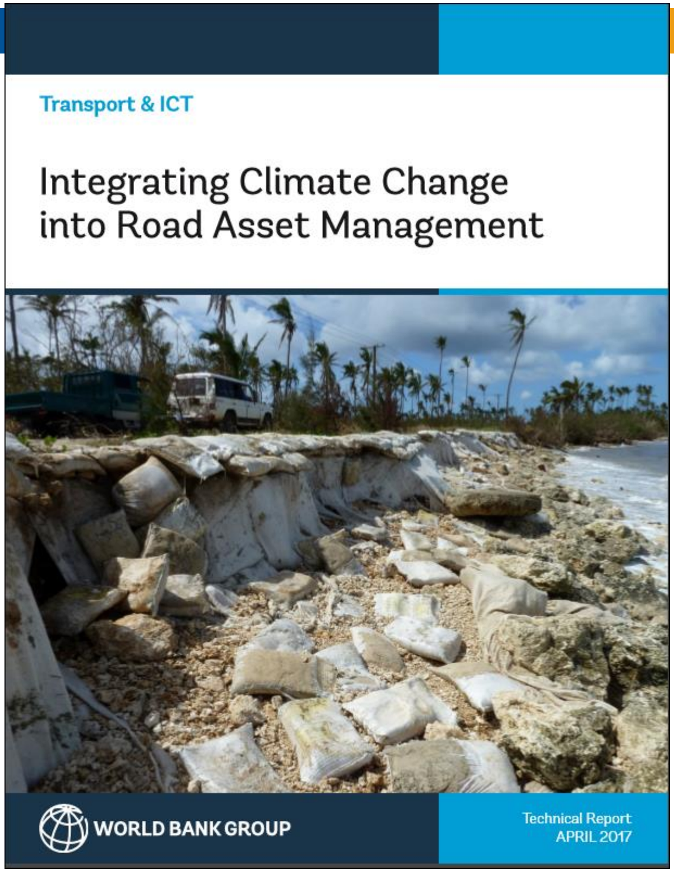

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