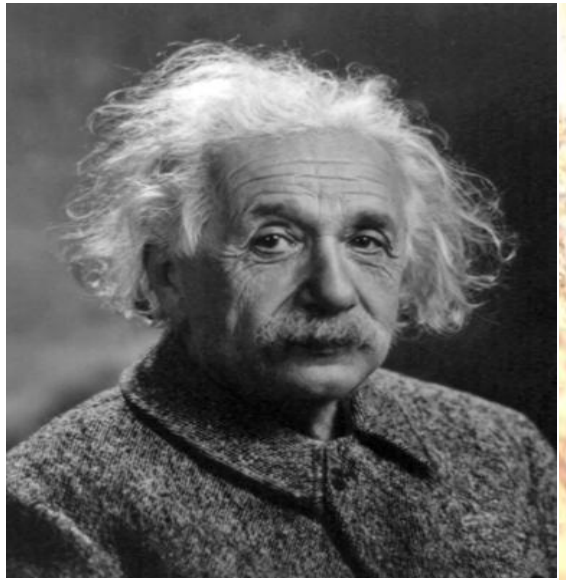
Climate Change

What is it? Why is it important for the road sector? What adaptation measures?



Structure of Presentation

- Climate Change: An Overview
- Climate Change: Evidence and Impacts
- Climate Change: Climate Threats &Vulnerability Adaptatio..
- Case Studies – Mozambique
- Conclusion and Recommendations

Climate Change- Introduction

- UN Climate Change Conferences (COP 1-1995, 26-2022 & COP27-2022)
- In 2015, 195 nations agreed with the United Nation that they can change the world for the better.
- This will be accomplished by bringing together their respective governments, businesses, media, institutions of higher education, and local NGOs to improve the lives of the people in their country **by the year 2030**.
- 17 SGDs were adopted that included Organize Climate Action as goal number 13.

Climate Change- Introduction

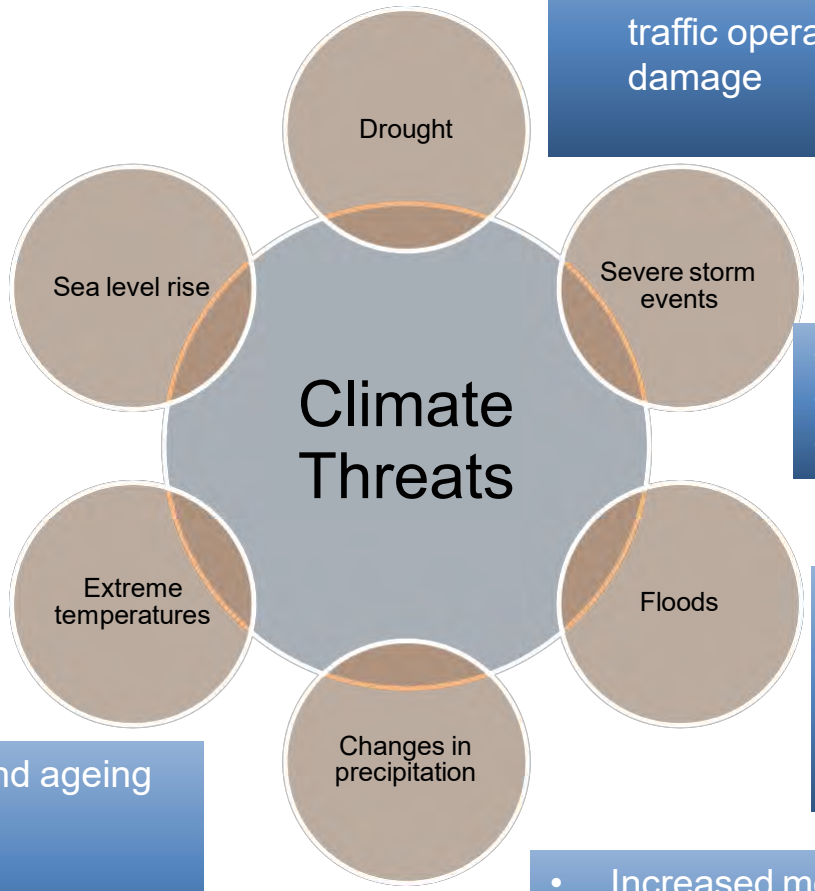
Climate Change- Introduction

- Tanzania Financial Reporting Standard (TFRS) No. 1 – January 2021 (The Governance Report):
  - Operating and Financial Review (OFR) - a narrative explanation of the main trends and factors which are likely to affect the entity's future developments, operations, performance, financial position and cash flows.
  - Environmental matters (including the impact of the operation of the entity on the environment)

Climate hazards & impacts

- Loss of structural integrity for gravel roads
- Increased wildfires potentially limiting traffic operations and infrastructure damage

- Submerged roads
- Erosion of coastal road substructure
- Increased flooding of low-lying infrastructure and tunnels



- Road infrastructure damage
- Road closures
- Reduced traffic operations

- Increased risks of landslides and slope failures
- Increased occurrences of pot holes

- Bitumen softening and ageing
- Traffic related rutting
- Surface cracking
- Restrained thermal expansion
- Warping of rigid pavements

- Increased moisture levels in pavement structures
- Pavement and embankment heave with clay material substructures

Climate Change- Introduction

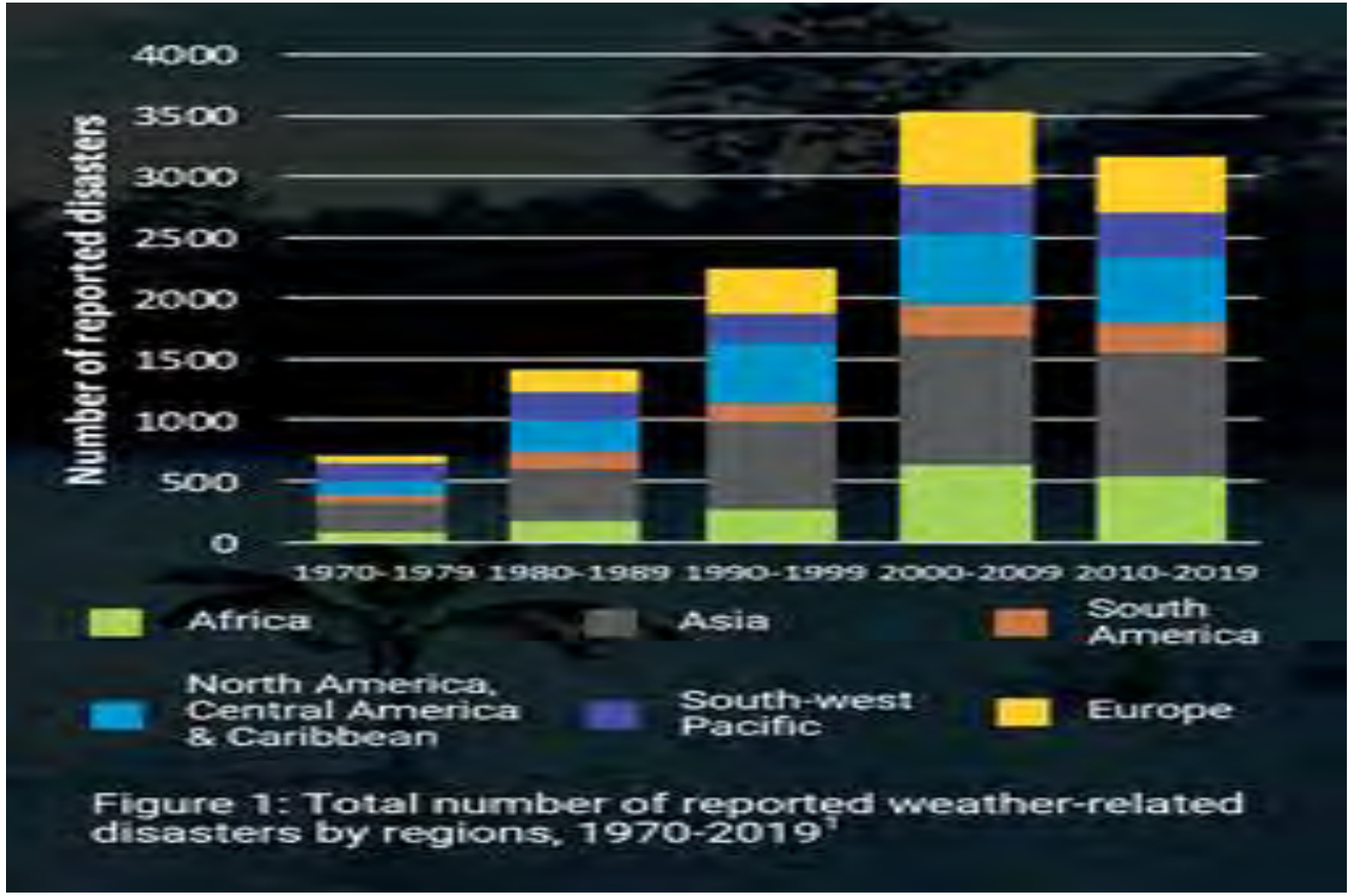


Figure 1: Total number of reported weather-related disasters by regions, 1970-2019[1]

Source: Climate resilient transport A policy Guide, 2022

Climate Change- Introduction

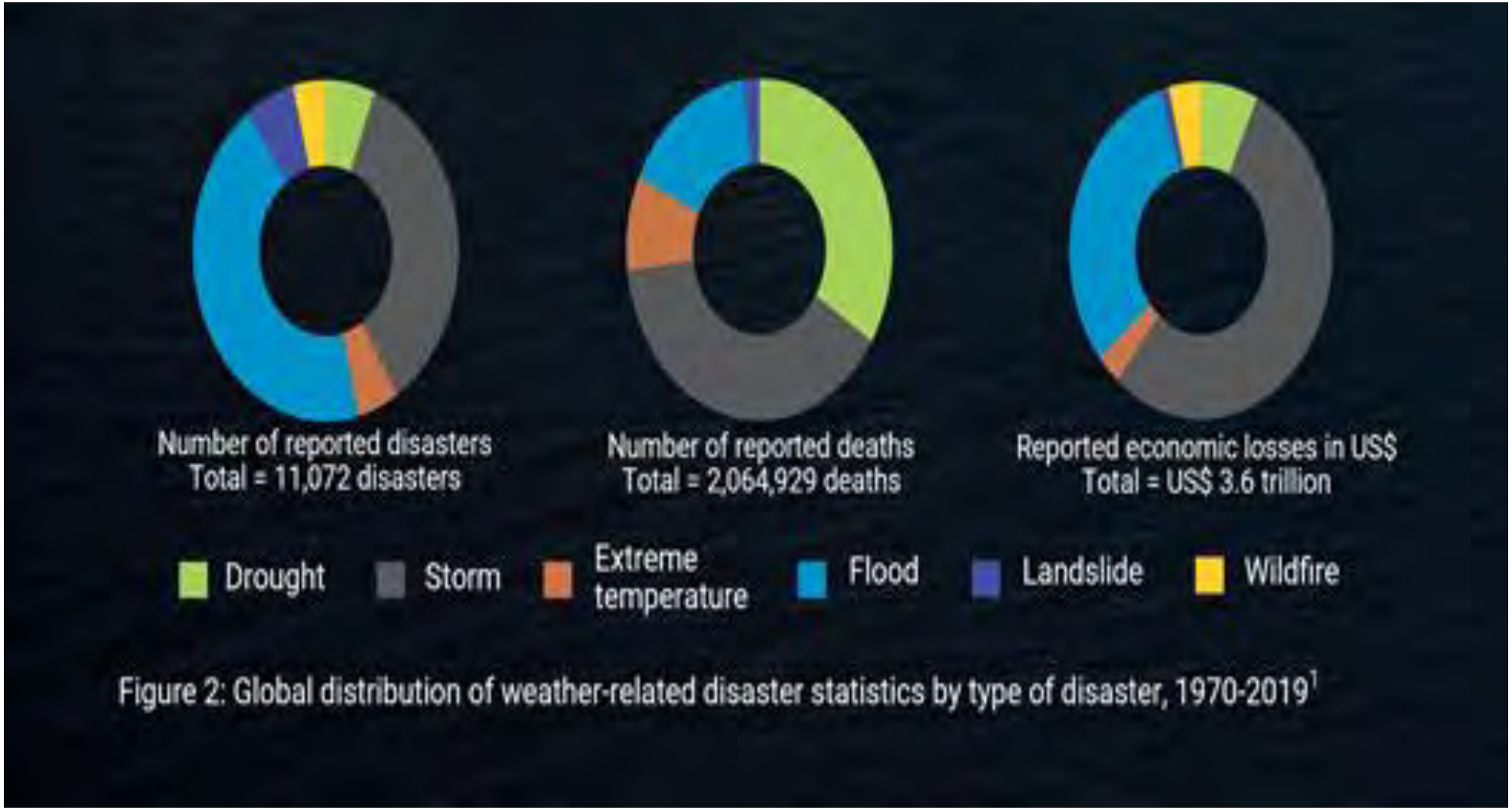
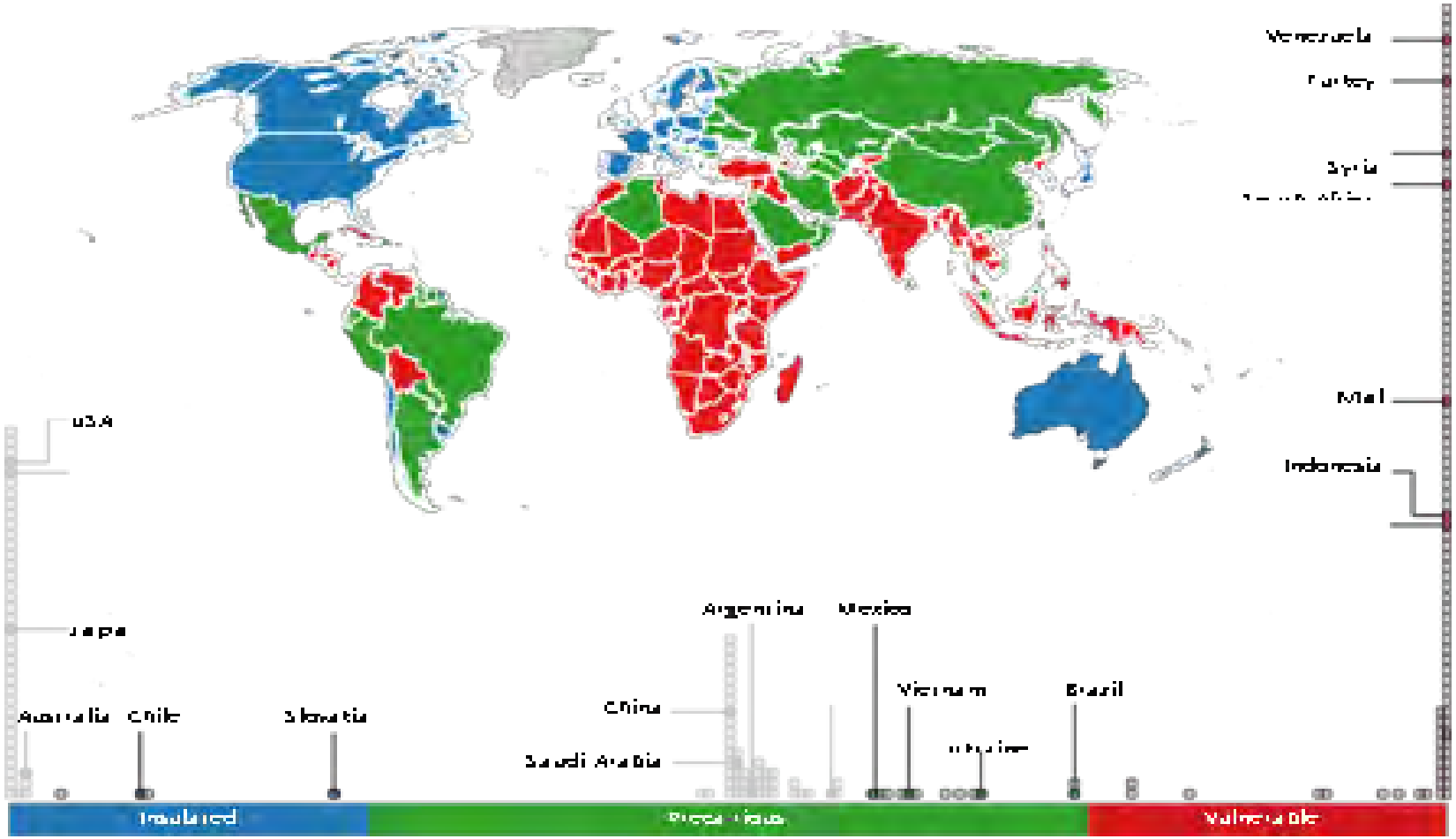


Figure 2: Global distribution of weather-related disaster statistics by type of disaster, 1970-2019[1]

Source: Climate resilient transport A policy Guide, 2022

A world divided between ‘insulated’, ‘precarious’, and ‘vulnerable’ nations



Source: Verisk Maplecroft, 2022

Climate Change Evidence

Tuvalu Foreign Minister Simon Kofe delivers a virtual speech at COP26 standing knee-deep in sea water to demonstrate the realities of climate change and rising sea levels

Climate hazards & impacts

- Situation in Africa:

PROJECTED CLIMATE CHANGE, THROUGH TO THE YEAR 2100, IS CURRENTLY ESTIMATED TO COST THE AFRICAN ROADS SECTOR US $184 BILLION TO REPAIR AND MAINTAIN IF CLIMATE ADAPTATION ACTION IS NOT TAKEN – P. CHINOWSKY (2012)

  - Enormous economic cost does NOT include new road infrastructure
  - Compounded by existing lack of adequate road infrastructure and the long distances to markets and essential services that have been a major development hurdle
  - Rural communities are especially susceptible to the impacts of climate variability as they bear the brunt of the consequences of inaction

Climate Change Challenge in Africa

The low levels of resilience to the impacts of weather and climate change is associated with gaps in:

- knowledge- little awareness of the impacts of climate on road networks leading to capacity issues such as design standards or maintenance schedules which rarely take account of weather or change in climate.
- Road as a sector is not always prioritised for climate change adaptation compared with other sectors, it does not get the attention required to improve resilience.
- Routine collecting and analysing data on how weather affects infrastructure assets is essential in order to improve transport resilience. Without it, there is no robust evidence to support decision-making, prioritise actions or plan effectively.

Climate Change Challenge in Africa

- The types of data required include weather observations, transport asset vulnerability and exposure data, and climate projections.
- Funding is crucial in planning and delivering resilient transport networks. Without the right level of funds, it is not possible to improve the resilience of transport infrastructure.

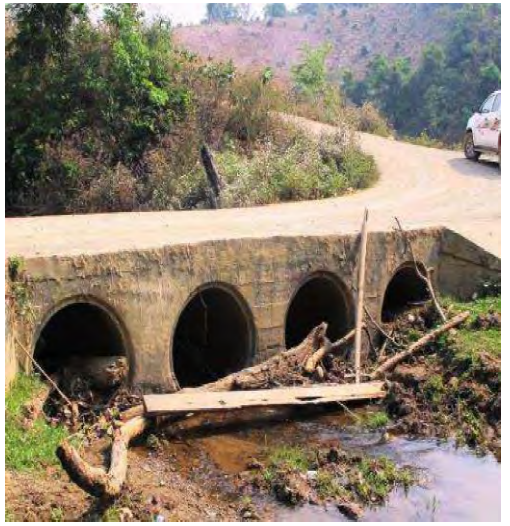
Climate Change- Introduction

- The BIG Question:
  - We have the infrastructure
  - We know climate is going to change
  - Some of it will be affected
  - What are we going to do about it?

Climate Change: Evidence and Impacts

Climate Hazards- Flooding

- Typical climate-related threats for roads include:
  - T*urbulent flow* of the overtopping water causes erosion of shoulders
  - Erosion of embankments
  - Flooding
  - Loss of structural integrity
  - Damage to water drainage structures
  - Slope stability



Climate Hazards & Impacts:

Increased temperatures

Climate Hazards & Impacts:

Increased temperatures

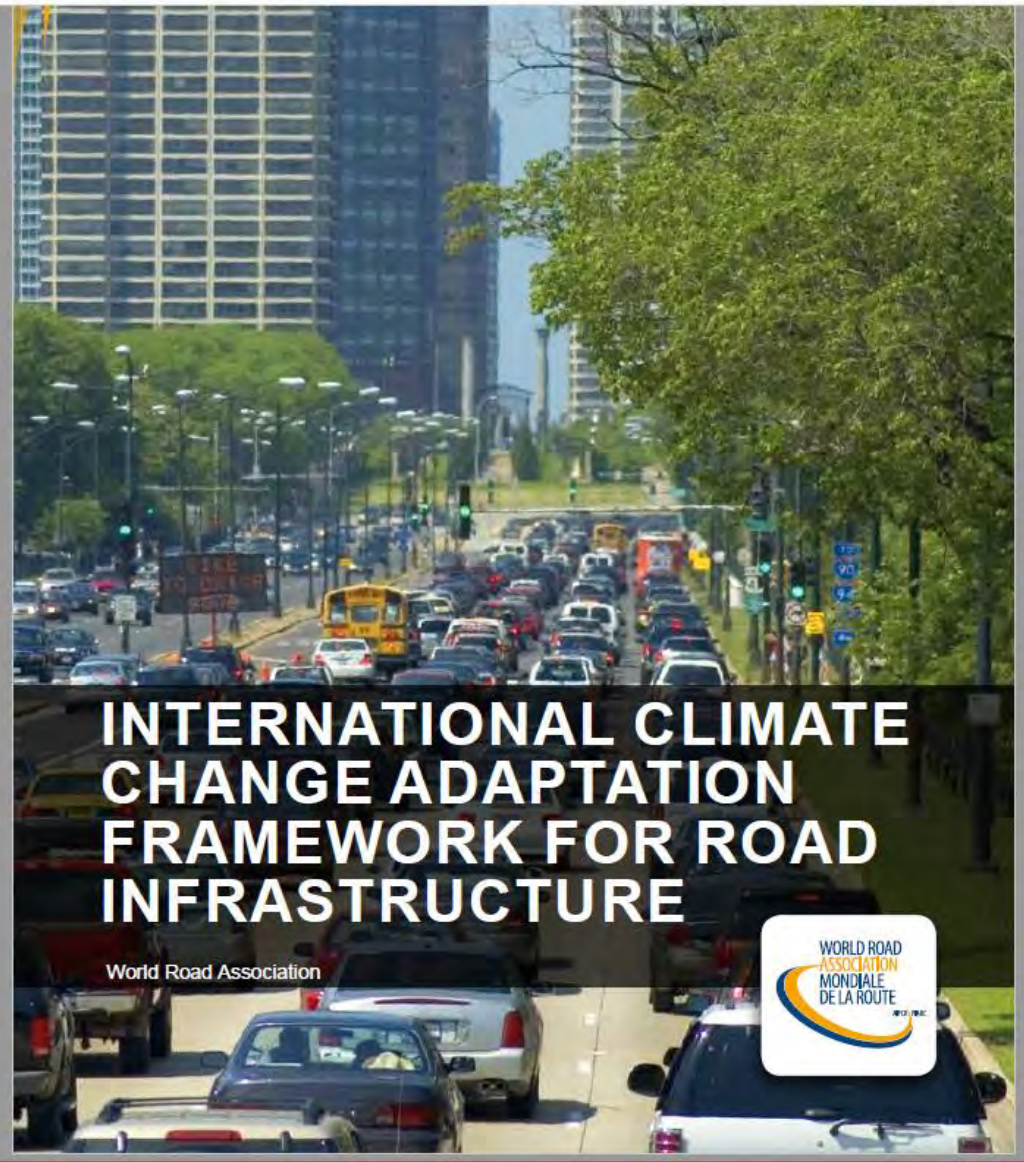
- Drier – less ground cover – more erosion – more roots in road structure.
- Erosion and siltation increased by loss of vegetation due to drought and fires
- Causes increased siltation/sedimentation requires increased maintenance
- Bear design consideration

Climate Change: Climate Vulnerability & Adaptation

PIARC's Climate Change Adaptation Framework for Road Infrastructure

The framework proposes a four-stage approach to guide road authorities through the process of increasing the resilience of their road networks and assets:

- ***Stage 1*** guides road authorities through a series of steps to *establish scope and define which assets, risks and climate change scenarios* should be included in an assessment.
- ***Stage 2*** takes findings from Stage 1 and provides *guidance for assessing the probability and severity of climate change risks, enabling road authorities to quantify risks posed to their network.*
- ***Stage 3*** outlines the process for the *identification, assessment, selection and prioritization of adaptation responses to the climate risks and opportunities* identified in Stages 1 and 2.
- ***Stage 4*** provides guidance on *effectively incorporating findings into road infrastructure programs, processes, investments, strategies and systems such as Transport Asset Management (TAM).*



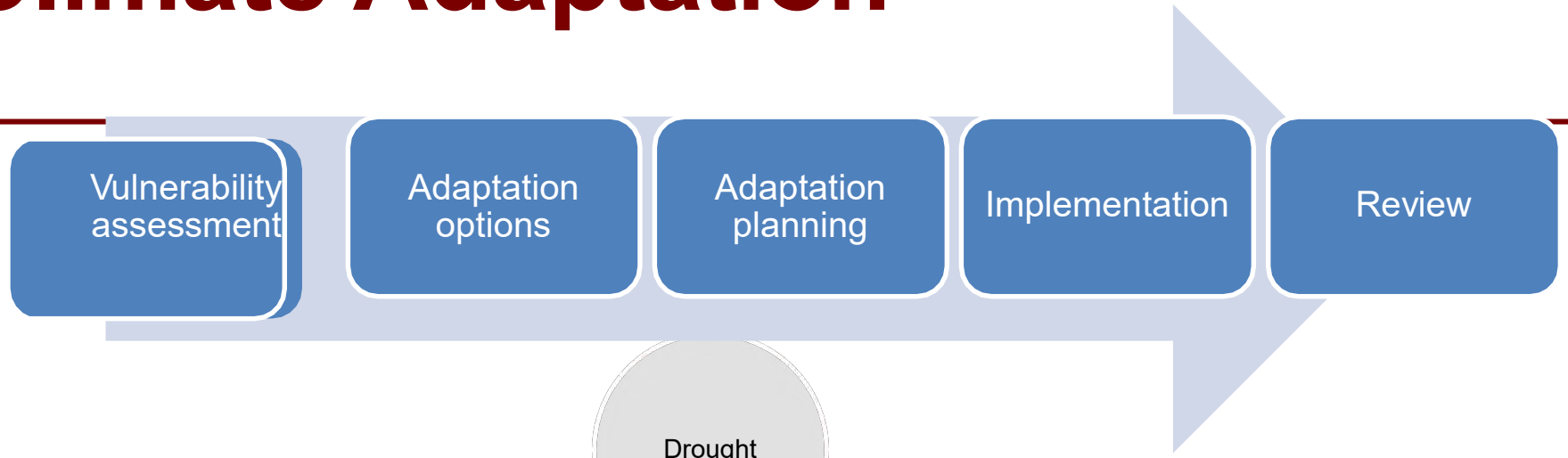
ReCAP's Climate Change Adaptation Framework for Road Infrastructure

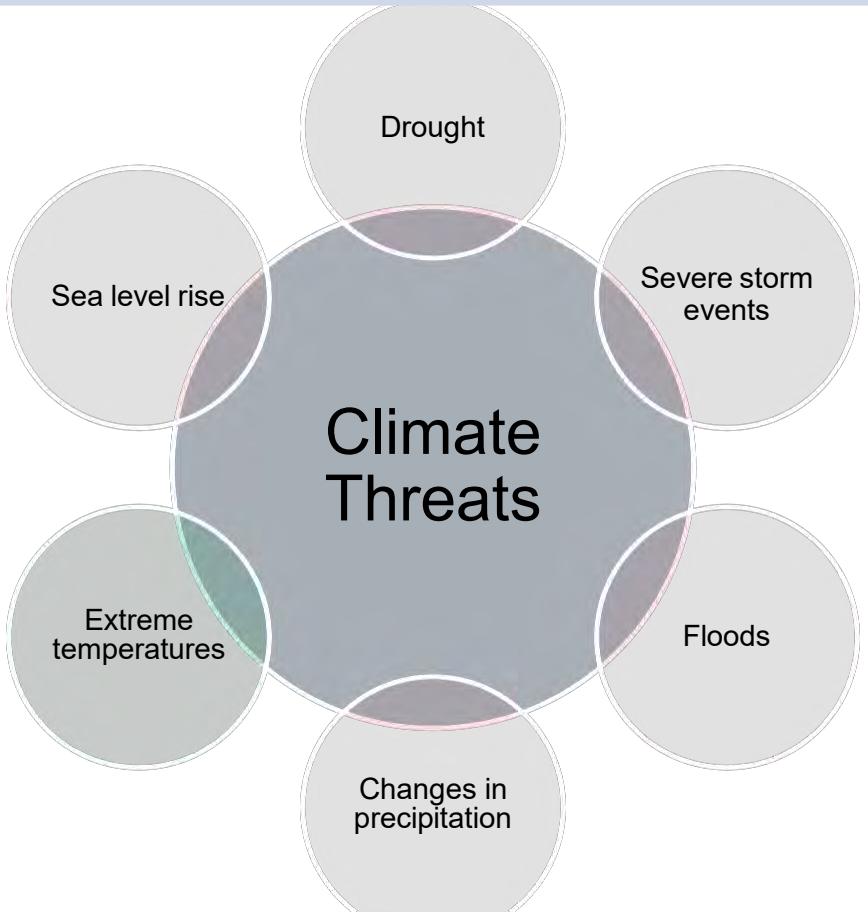
- developed a Climate Adaptation Handbook that provides a methodology to support resilience and adaptation building in the roads sector through: *Screening climate risks, carrying out impact assessments, prioritisation and evaluation of investments, design & implementation and the monitoring & evaluation* thereof.
- recognition that there is a critical need for *embedding and mainstreaming CCA not just into the road engineering practices but also into national policies, information systems , thinking and local capacities.*

Climate Adaptation- ReCAP Handbook

The Climate Adaptation Handbook illustrates the fundamental *principles, processes and steps required for climate resilience. Adaptation approaches and measures* are included in the accompanying guidelines covering *Change Management, Climate Threats and Vulnerability Assessment, Engineering Adaptation and Visual Assessment manual.*

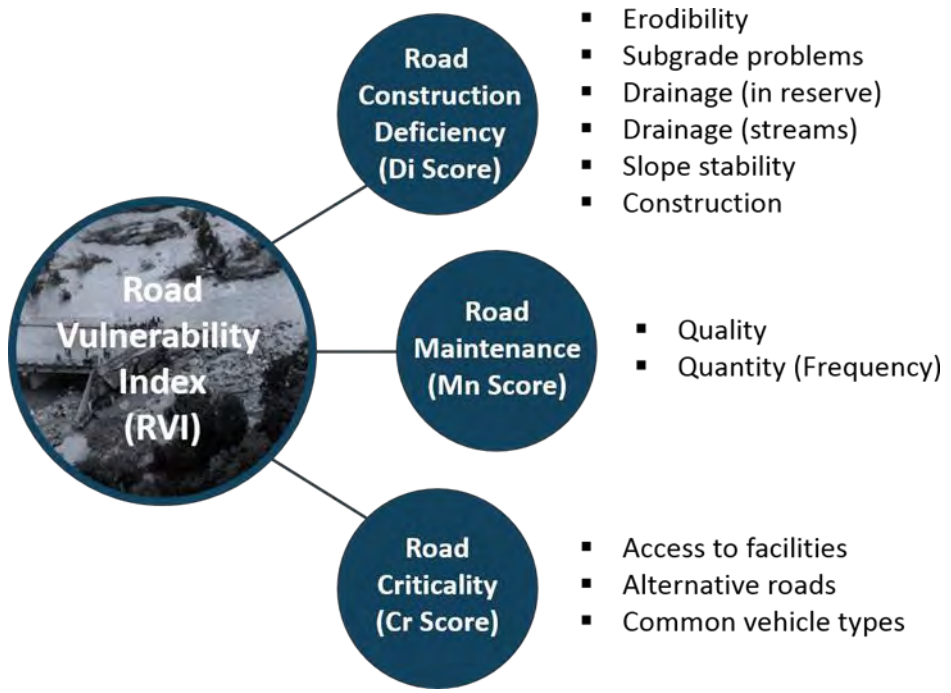
Climate Adaptation





Road Vulnerability Assessment

road vulnerability index integrates three dimensions: road condition deficiency, maintenance and criticality

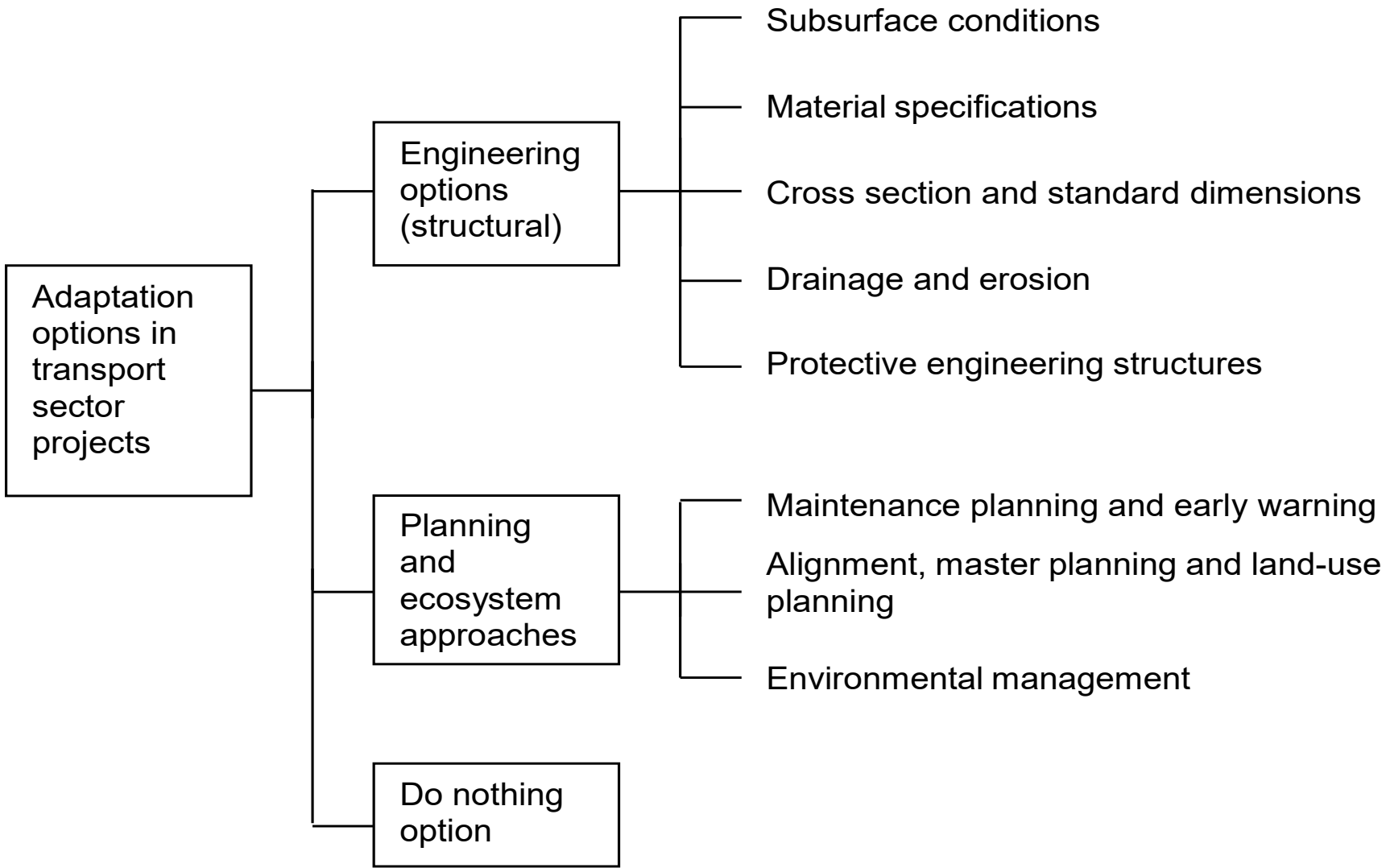


Road Condition Deficiency is a composite indicator of climate-specific deficiencies in road condition and is an aggregation of specific vulnerability factors that represent the physical/structural insufficiency of the infrastructure to withstand negative climate impacts.

Road Maintenance factor is an indicator of maintenance efficacy in terms of frequency (quantity) and quality of maintenance activities.

Road criticality pertains to the importance of that particular road for access to markets and public facilities. On a local scale, a narrative about the community's use of a particular road is important to put into perspective the losses incurred by the community when access is interrupted due to climate events.

Climate Adaptation



Case Study- Mozambique

Climate Adaption- Mozambique

Making Rural Roads More Resilient

Introduction

- Mozambique is one of the more vulnerable countries in Africa
- Climate change associated roads damages have direct socio-economic effect
- 50 km unpaved road identified for construction of demonstration section (N/C Mohambe/Maqueze)
- Climate adaption programme funded by world Bank

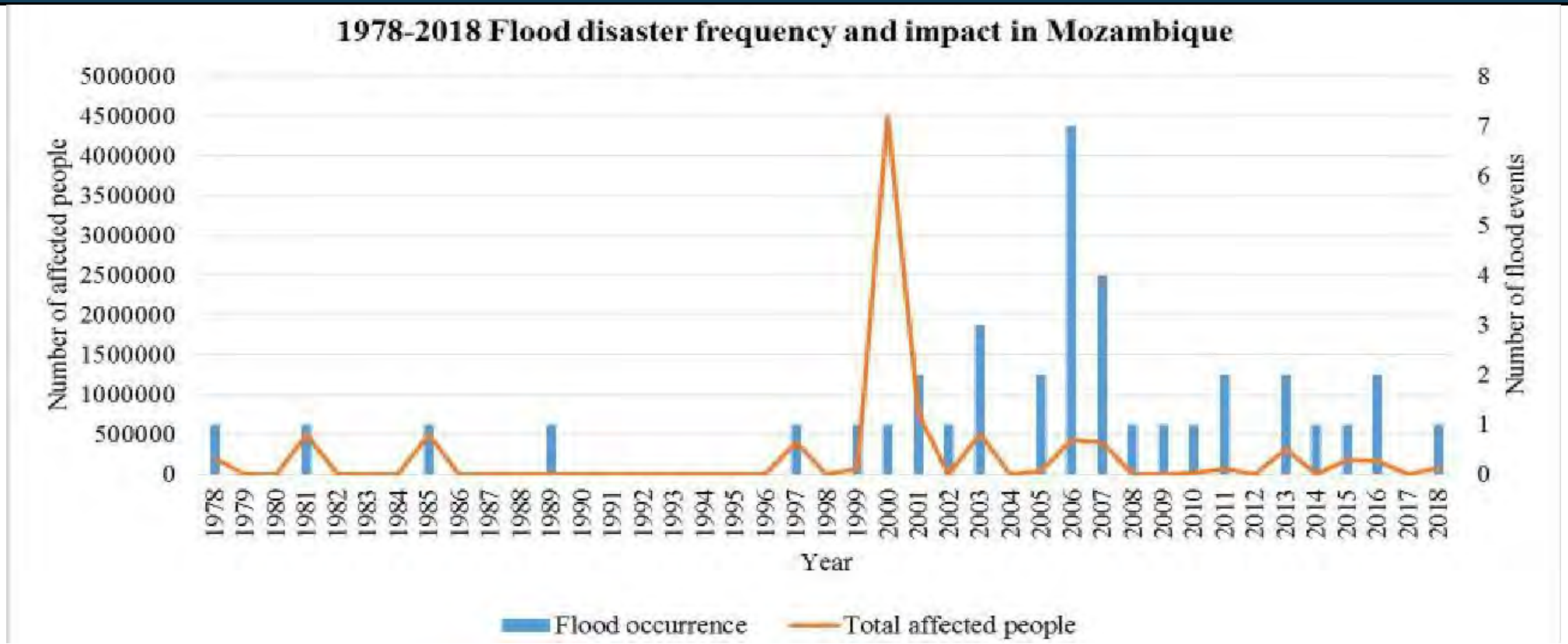
Hazards in Mozambique

Hazard frequency and impact in Mozambique (1978–2018)			
Hazard	Number of events (1978–2018)	Total deaths	Total affected
Drought	13	100,068	20,057,500
Coastal flood	2	83	649,329
Flash flood	1	5	300
Riverine flood	20	1,287	6,806,839
Other flood	8	136	1,262,285
Landslide	2	104	2,800
Convective storm	2	24	1,700
Other storms	4	17	5,117
Tropical cyclone	16	552	4,434,260
Wildfire	1	49	3,023
Total	69	102,325	33,223,153

Data source: Calculated using EM-DAT data (CRED, 2019)

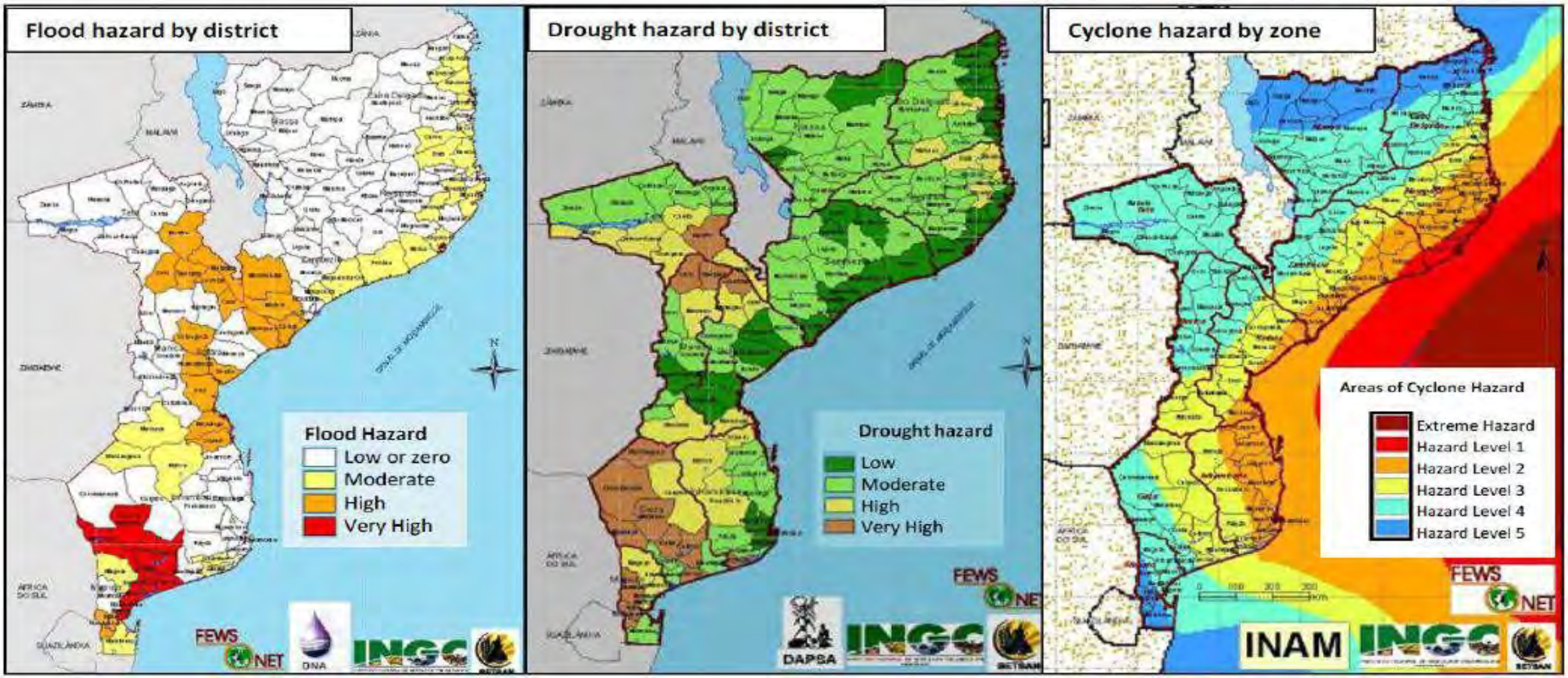
Flood Disasters

Flood disaster frequency and impact in Mozambique between 1978 and 2018



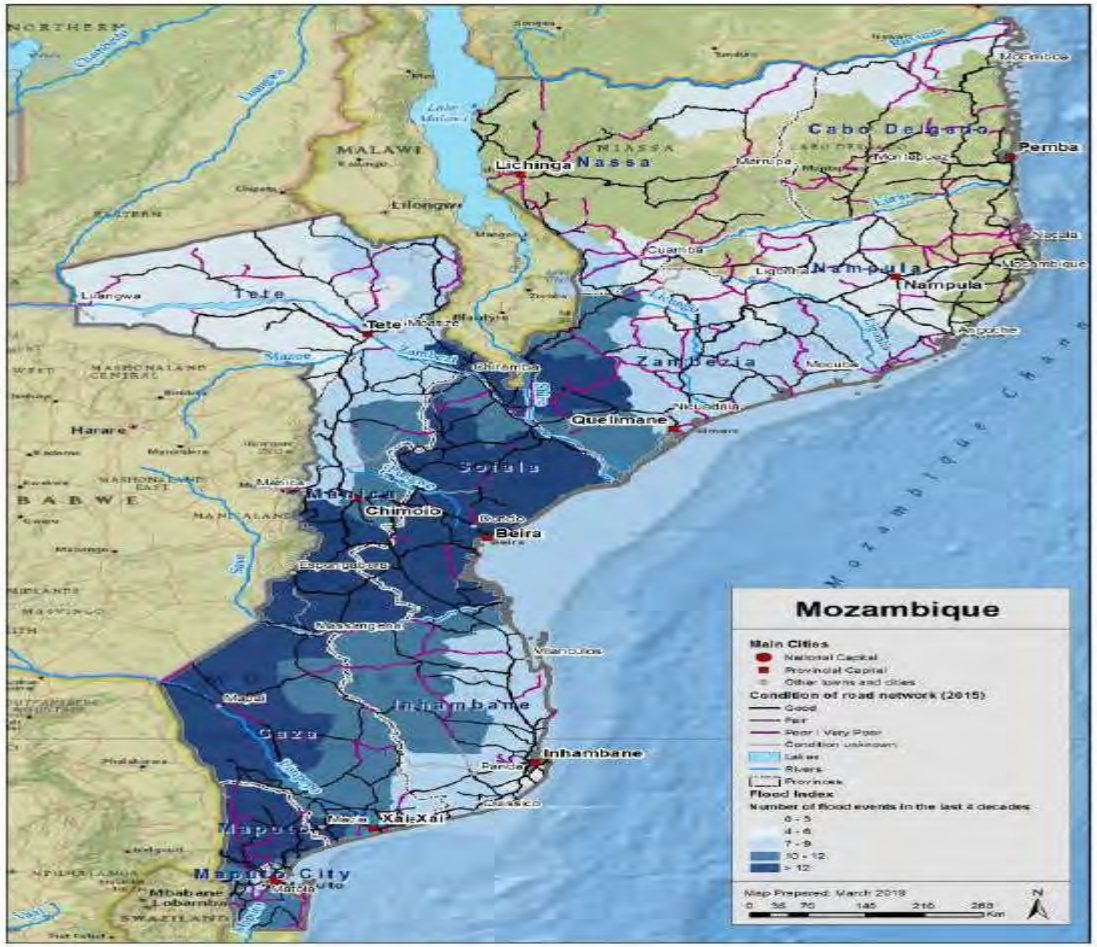
Data source: Calculated using EM-DAT data (CRED, 2019)

Mozambique: Climate Risk Profile (Vulnerability Assessments)



Road Exposure to Flood Risk

Mozambique: road exposure to flooding risk

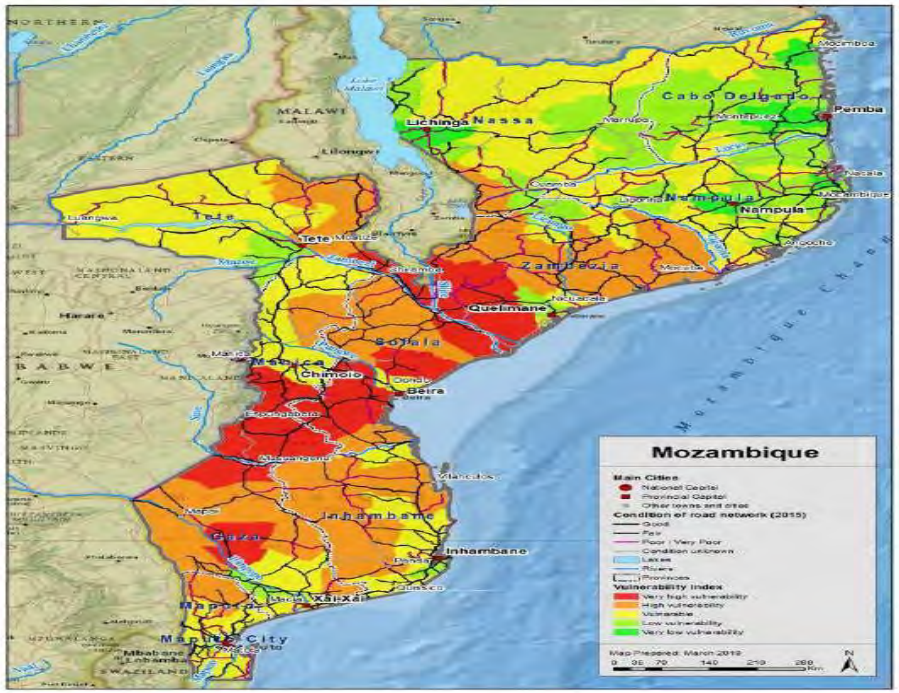


Flood events in the past 4 decades		Flood Exposure Index
	0 – 3	5
	4 – 6	4
	7 – 9	3
	10 – 12	2
	> 12	1

Data source: CSIR custom analysis using data from the National Roads Administration (ANE) Mozambique, Dartmouth Flood Observatory (2019) and DIVA-GIS (2019)

Districts at Risk

Mozambique: Climate Risk Index
(districts most at risk to climate impacts under current climate and socio-economic conditions)

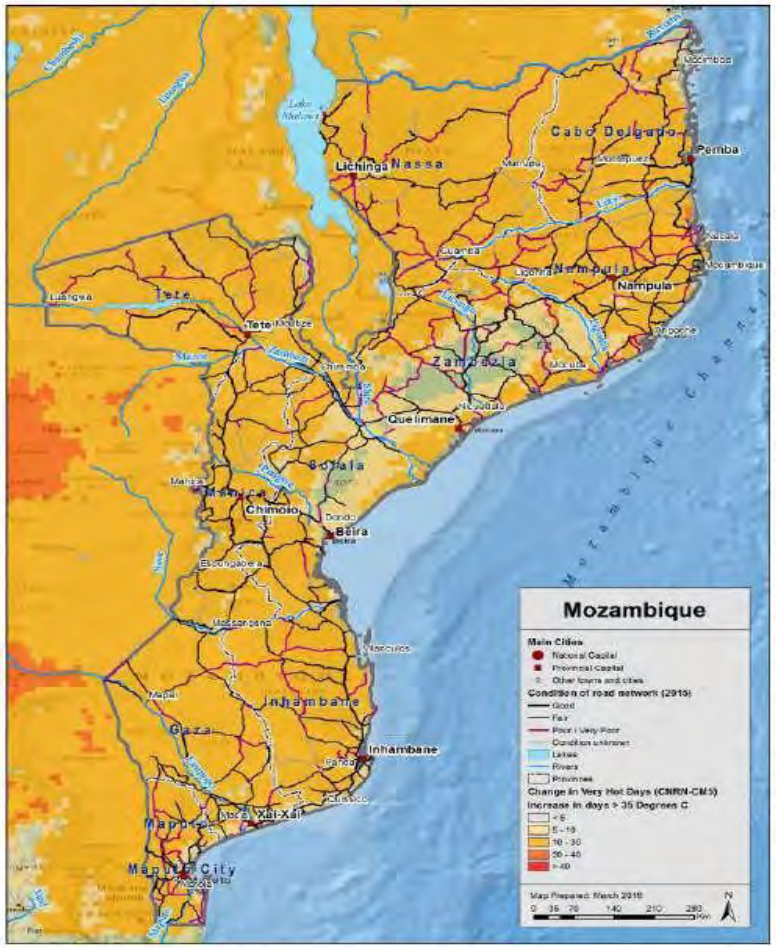


Flood Exposure Index		Criticality Index: Rural Access Index		Criticality Index: Isolation Factor		Current Climate Risk Classification	Climate Risk Index
5	+	5	−	1	=	Very Low Risk	8 – 10
4		4				Low Risk	7 – 8
3		3				Moderate Risk	5 – 6
2		2		0		High Risk	3 – 4
1		1				Very High Risk	1 – 2

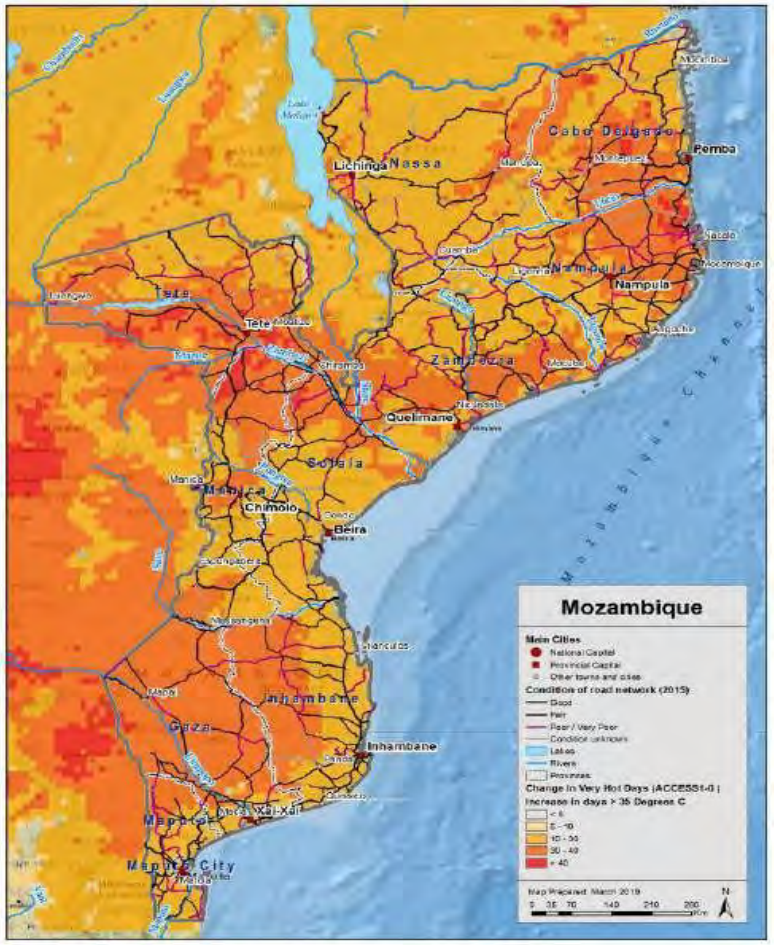
Data source: CSIR custom calculation, National Roads Administration (ANE)

Temperature maps

Mozambique: exposure of road network to increases in very hot days



Source: CNRM-CM5 downscalings (CSIR)



Source: ACCESS1-0 downscaling (CSIR)

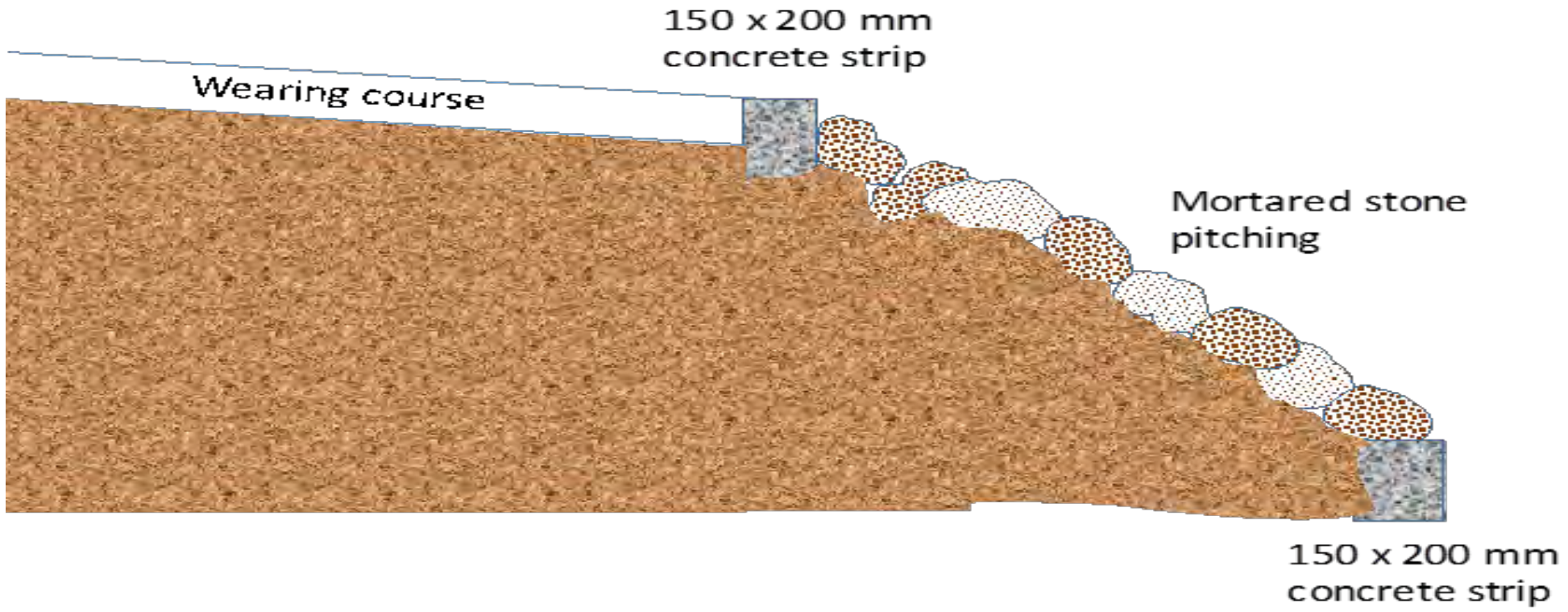
Road Vulnerability

- **Road assessment results**
  - Un-engineered earth road with minimal side drainage Some ineffective mitre drains
  - Made by local silty-sand material as wearing course
    - Two wheel tracks and very few corrugation
    - culverts under-designed

Problems identified

- Undercutting and collapse of fords
- Drainage problems
- Erosion on surface
- Damage to culvert due to erosion
- Ineffective mitre drains
- Culverts unable to move water

Shape the road and level off at the top of the culverts. Materials to be compacted to at least 95% Mod AASHTO density. Stone pitching for protection and concrete strips



Construction pictures

Conclusions and Recommendations

ALLOCATION FORMULA FOR RF RESOURCES

Road information/data fed to the following internationally recognized formula.

$$M_{Sj} = \left\{ W_j \left| a_{21} \left(\frac{PCU\_KM_{Sj}}{\sum_{S=1}^{5} PCU\_KM_{Sj}} \right) + a_{22} \left(\frac{ESAL\_KM_{Sj}}{\sum_{S=1}^{5} ESAL\_KM_{Sj}} \right) \right| \right\} * M_s$$

M_{sj}	=	Allocation to road network j
M_s	=	Allocation per road surface type (s = paved, gravel or earth)
PCU_KM_s	=	Total of passanger vehicles for each road type(s = paved, gravel or earth)
$ESAL\_Km_s$	=	Total of weight of trucks for each road type
a_{21}	=	Deterioration caused by number of passanger vehicles
a_{22}	=	Deterioration caused by number of trucks
W_j	=	relative weight based on perceived proportional contribution of each road hierarchy and functional class priority for promoting economic efficiency for road network j

Current allocation 70:30

DROMAS

- Data requirements
- Road inventory-pavement types, condition, formation, drainage, bridges, traffic
- Annual Maintenance-routine, periodic, upgrading
- Contract management
- Socio-economy-To do
- Prioritization- To do
- Maps

Tanzania Climate Risk Profile- USAID& GIZ

- Climate change is expected to significantly affect Tanzania's infrastructure sector through extreme weather events.
- High precipitation amounts can lead to flooding of transport infrastructure, especially in the coastal areas, while high temperatures can cause roads, bridges and protective structures to develop cracks and degrade more quickly.
- This will require earlier replacement and lead to higher maintenance and replacement costs.

Tanzania Climate Risk Profile- USAID& GIZ

- Despite the risk of infrastructure damage being likely to increase, precise predictions of the specific location and extent of exposure are difficult to make (GIZ_Climate-Risk-Profile-Tanzania_EN_final.pdf.)
- PIARC CCA Guide and RECAPs CCA Handbooks fill the gap identified by the two studies.

Conclusions & Recommendations

- Ensure Science-based research to identify climate hazards, vulnerability and impacts on roads
- There is a need to identify the potential problems and implement adaptations properly for construction and maintenance. Try and avoid future problems before we are too late

- Vulnerability assessments help identify regions where to direct resources for adaptation, including more detailed field research, specific engineering studies, needed for the design, programming and implementation of adaptation actions and how to develop the resilience of the road infrastructure.

Conclusion & Recommendations

- Climate change adaptation in the roads sector needs to be embedded in a range of levels spanning national policies, planning instruments, monitoring and asset management systems, information systems, down to an engineering project level
- Policies relating to Climate Change adaptation should be embedded in the entire life-cycle of roads
- Funds allocations MUST include climate change and adaptation factors
- Must identify potential resilience problems during or in conjunction with Asset Management assessments. RMMS MUST include climate hazard data and vulnerability assessment