Implication of climatic Change on the Management of Roads in Tanzania

Inauguration of e-monitoring APP for Monitoring of Road Condition, and Workshop on adaptation to effects of climate Change on Road Infrastructure (BOT College – Mwanza)

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MoWT(W)

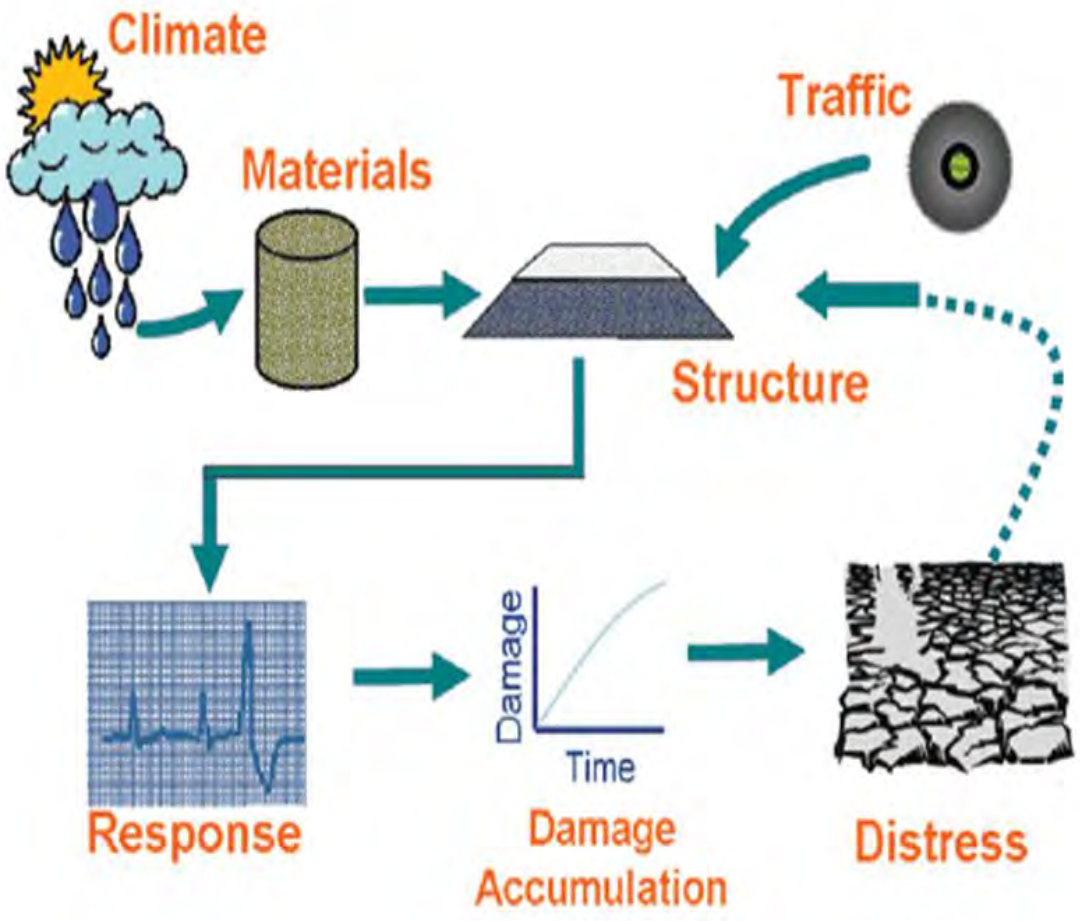
Presentation

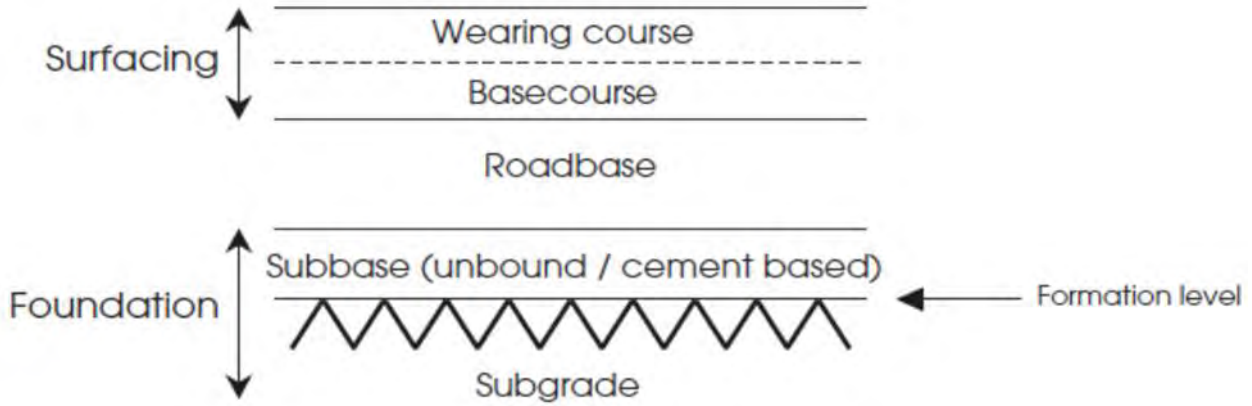
- Introduction
- The Climate, and Climate Profile In Tanzania
- Case History
- Environmental Management in Tanzania
- Pavement and Material Design Manual (PMDM) - Chapter 2 - The "Environment" (Mow, 1999)
- Discussions
- Recommendations

Introduction

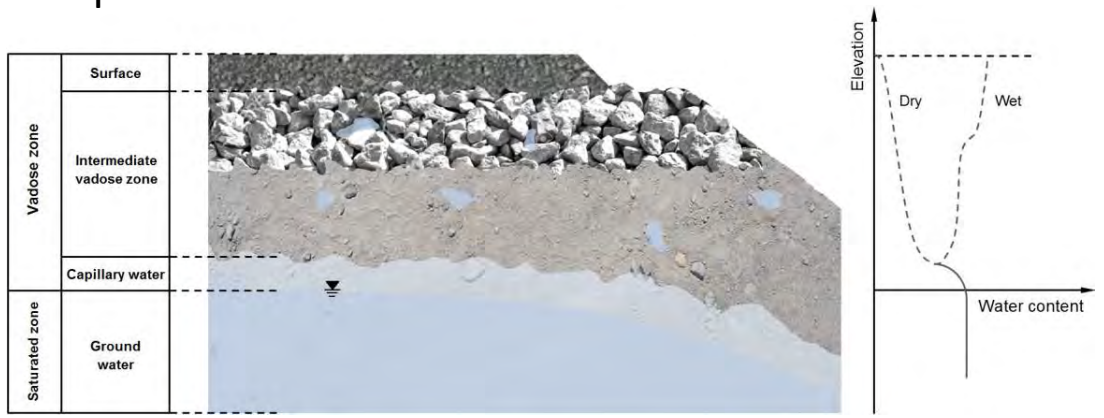
- Road networks in Tanzania provide a wide range of economic development to local, regional and national.
- Pavements and Bridge design (are long term investments, (20years for roads, 100years for bridges), their design aim at maximizing the functionality, safety and durability.

Introduction…





Conceptual schematic of the regions of surface water in pavement structures



The Climate

- Primary climate change factors:
  - Increase or decrease in temperature (average and maximum);
  - Increase or decrease in average rainfall and extreme rainfall events;
  - Increase or decrease in wind velocity.
- Secondary climate change effects:
  - Increase or decrease in road surface temperatures;
  - Rise of Sea level (RSL)
  - Flooding/drought;
  - Raising or lowering of groundwater level and soil moisture content;
- Secondary climate change impacts:
  - Damage of land cover - increased risk for erosion;
  - Changes in ecological equilibrium, growing season (shorter/longer) and agricultural produce (impact on traffic patterns);
  - Changes in the construction season and impacts on construction (e.g. compaction water in prolonged periods of drought) - raise construction cost

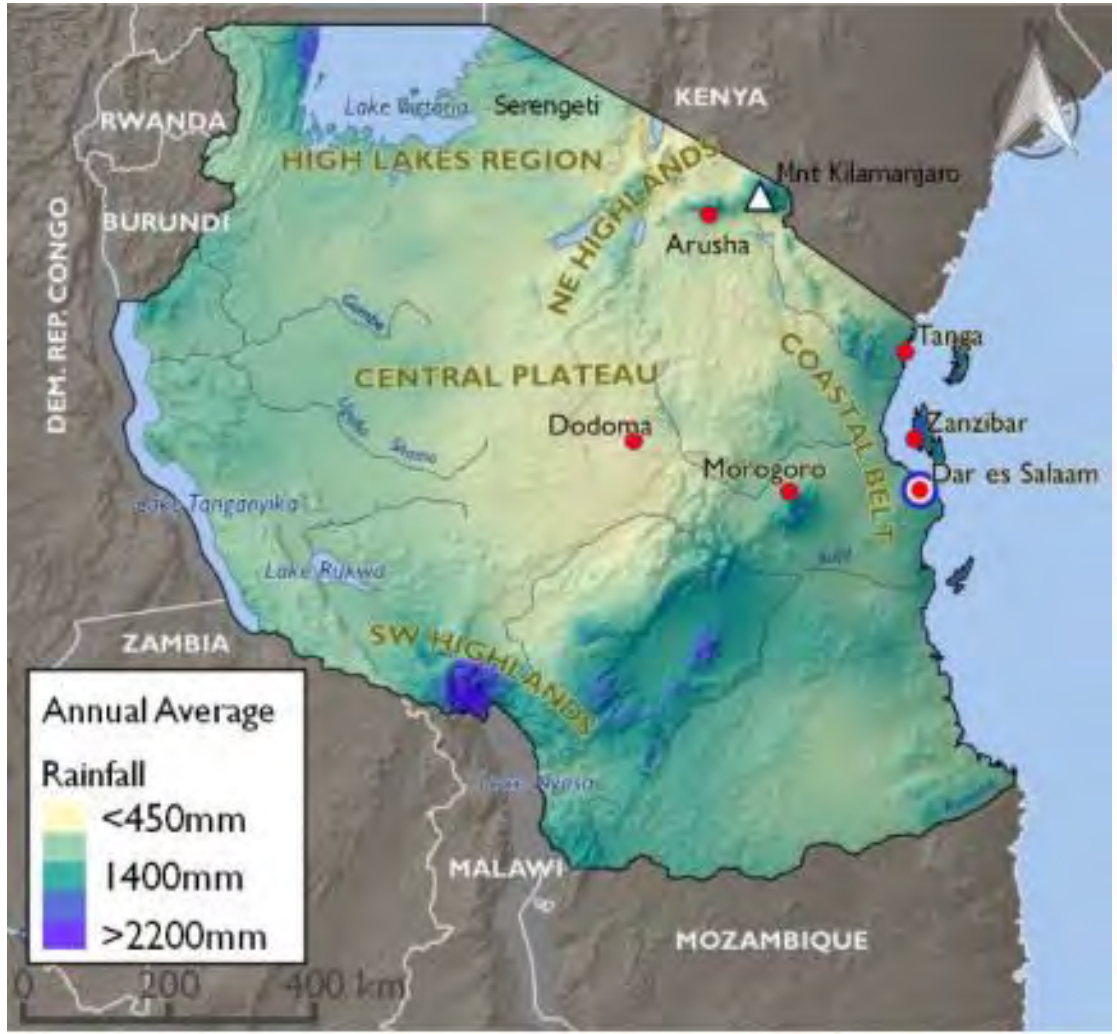
Climate ……

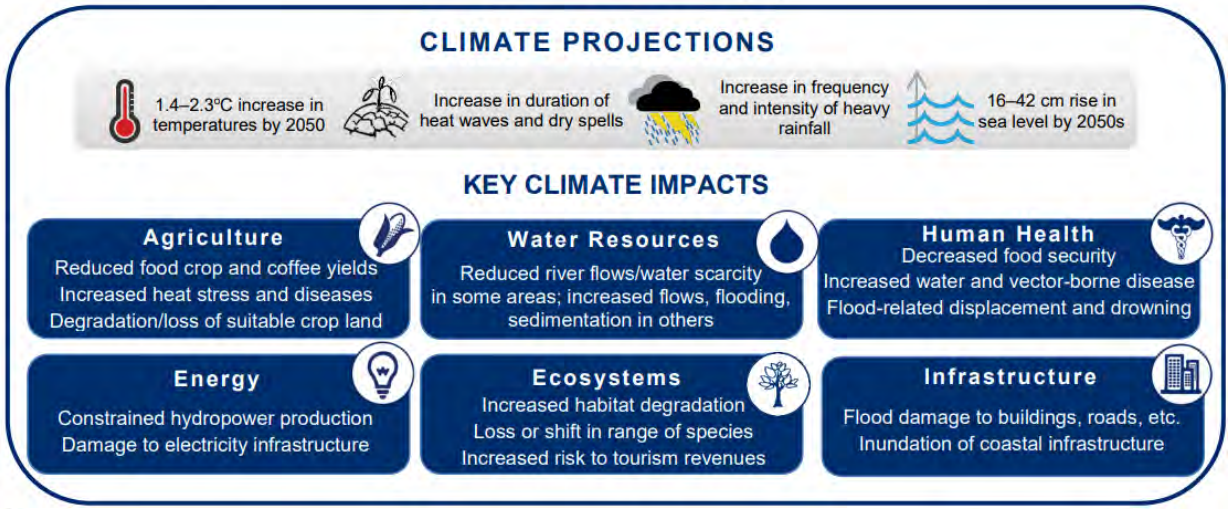
- Rainfall influences the moisture balance in the pavement structure – pavement deterioration
  - Higher water table affects the structural strength of the pavement
- The effect on the location of the population and human activities – influences the demands for roads
- Temperature influences the aging of the bitumen – increase embrittlement (cracking) of the surface treatments – loss of waterproofing
  - surface water can enter in the pavement causing potholing and fairly rapid loss of surface condition
  - more frequent reseal treatments - cost to road agencies
- The interaction of change of temperature and rainfall increase cracking, compounding the effect of increased rainfall

Climate……

- Aspects of road provision that are likely to be impacted by climate.
  - **Unpaved roads**: prone to shearing, rutting, and erosion in wet conditions
  - **Flexible paved roads**: susceptibility to moisture, susceptible to high temperatures
  - **Rigid pavements**: less susceptible to moisture, some challenges with excessive expansion in high temperatures
  - **Earthworks**: potential slope instability (cuts/fills), and erosion of cuts and embankments
  - **Subgrade**: variable moisture conditions can influence subgrades in the presence of expansive clays, dispersive soils, saline materials, collapsible sands, among others

Climatic Risk Profile of Tanzania (USAID, 2018)





Climate Stressors and Climate Risks INFRASTRUCTURE

Stressors	Risks
Increased frequency and intensity of heavy rainfall	Increased heavy rainfall and flooding damage buildings, bridges, roads, etc.
Sea level rise	Sea level rise inundates low-lying areas of Dar es Salaam and other coastal infrastructure and population centers

Tanzania Disaster Profile (CIMA, 2018)

HISTORICAL CLIMATE

Historical climate trends include:

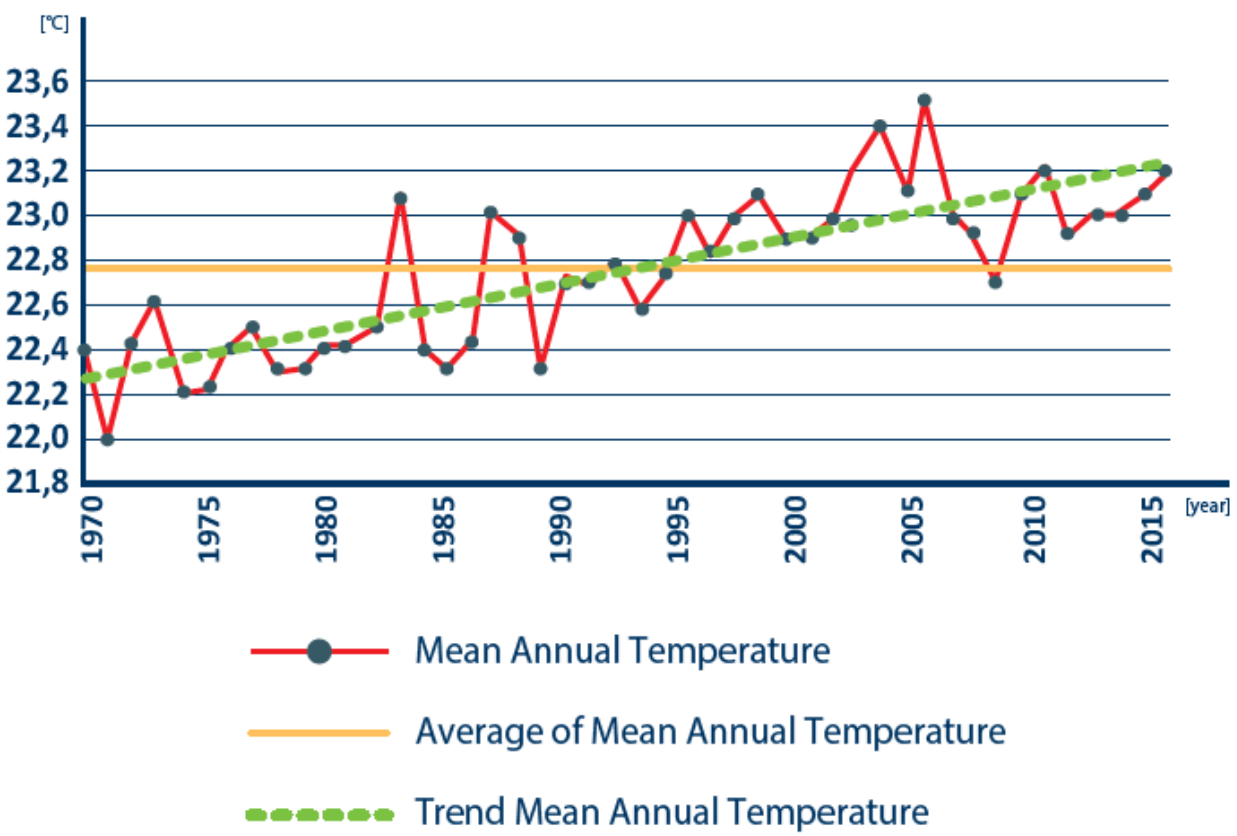
- Increased average temperature of 1°C (1960–2006).
- Little change in overall precipitation; slight decrease from 1961 to 2013, mainly from March to June (corresponding to main rainy season).
- Accelerated loss of glacial volume on Mount Kilimanjaro; with an 85-percent reduction of the Kibo Summit Glacier from 1912 to 2009.
- Rise in sea levels of 4–20 cm per decade (1955 – 2003) everywhere except Zanzibar, which recorded a decrease in sea levels (1984–2004).

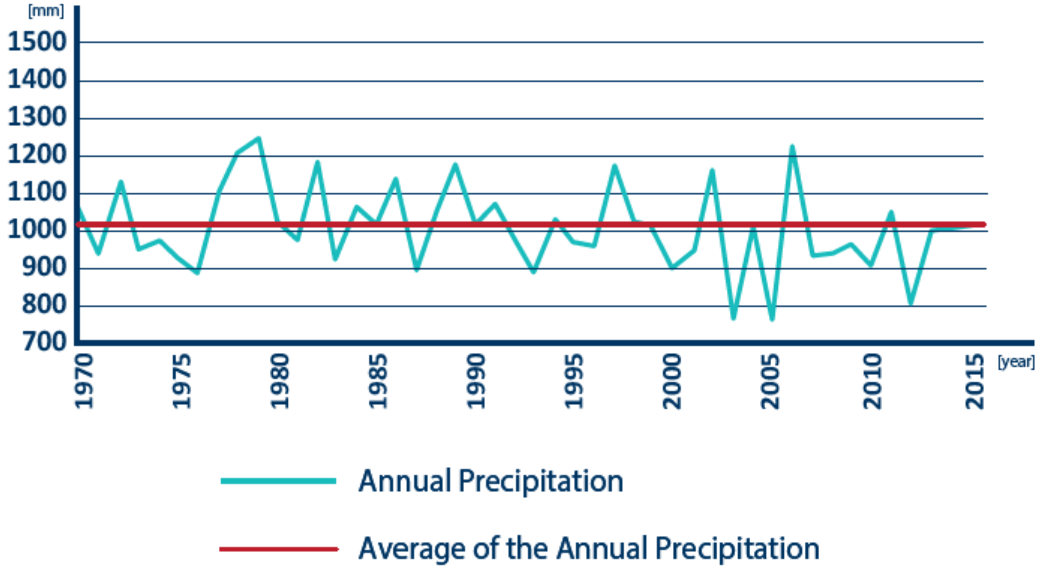
FUTURE CLIMATE

Projected changes by the 2050s include:

- Increased average annual temperature of 1.4 to 2.3°C; greatest warming in the west/southwest.
- Increased duration of heat waves (by 7–22 days) and dry spells (by up to 7 days).
- Likely increase in average annual rainfall (range of -3 to +9 percent), with greatest increase in the northeast; likely rainfall decline July–September.
- Increased heavy rainfall event frequency (7–40 percent) and intensity (2–11 percent).
- Rise in sea levels of 16 to 42 cm.
- Disappearance of glaciers from Kilimanjaro

TEMPERATURE AND PRECIPITATION TRENDS (1970 - 2015)





Source: CIMA, United Nations Office for Disaster Risk Reduction - UNDRR (2019): UR Tanzania Disaster Risk Profile

Case 1 -DOMA BRIDGE

Case 2- Mjonga Bridge

Case 3- Mkundi Bridge

Case 4 Landslides





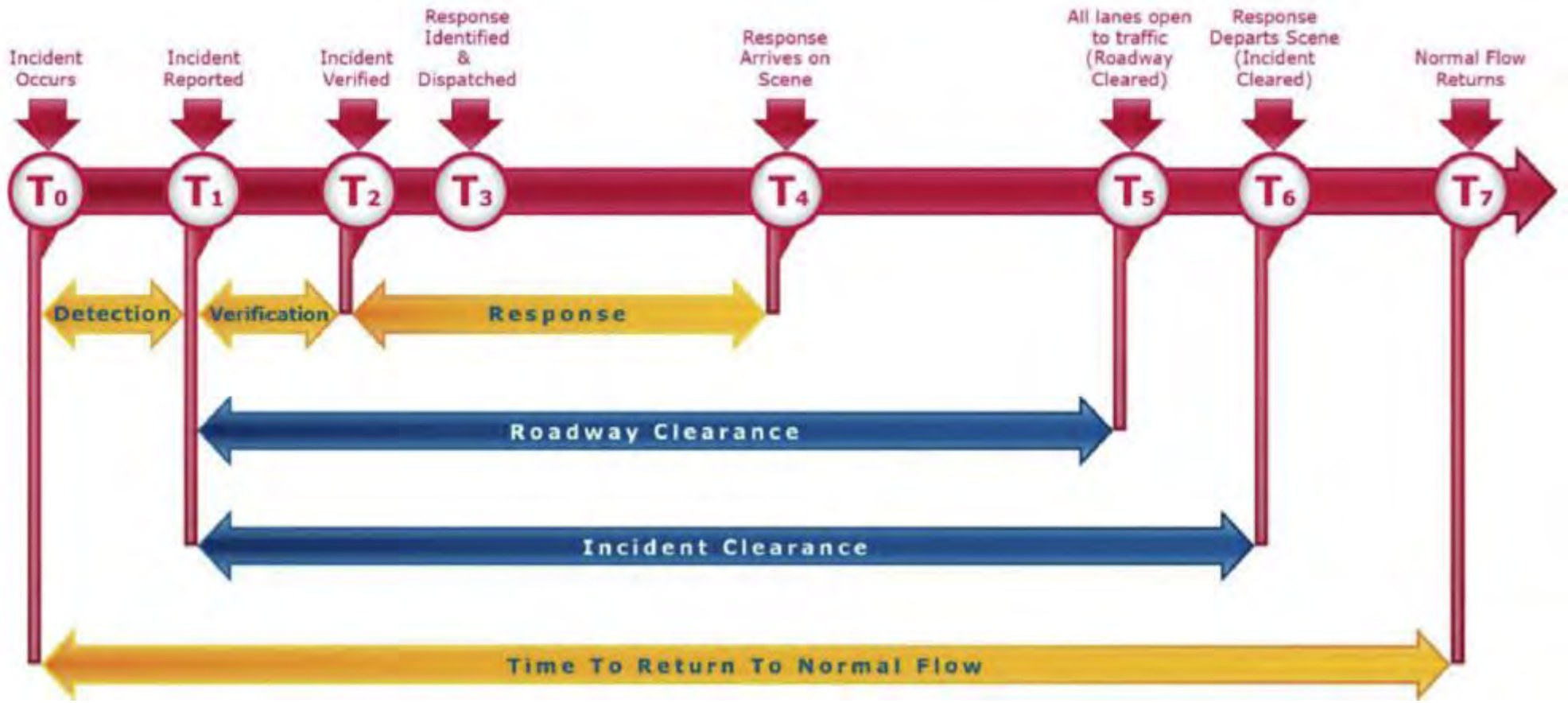



Case 5: Jangwani

Challenges

Challenge

Timeline to normal operation after incident (Amer et al., 2015).



Amer, A., Roberts, E., Mangar, U., Kraft, W. H., Wanat, J. T., Cusolito, P. C., Zhao, X., 2015. Traffic Incident Management Gap Analysis Primer (No. FHWA-HOP-15-007). United States. Federal Highway Administration. Office of Operations.

Environment Management in Tanzania

- Managed under Environmental Management Act No. 20 of 2004 (EMA)
  - Environmental Impact Assessment (EIA)
    - Purpose of EIA is to ensure that a project does not achieve its own goals at the expense of loss or inconvenience to non-beneficiaries or future generations.
- Ministry of Works
  - The Environmental code of practice for road works (sector-specific requirements for environmental assessment and management) (Ministry of Infrastructure Development, 2009).
  - The road sector environmental Assessment and management guidelines, - ease of mainstreaming the environmental assessment and management into road project cycle activities (2011).

The Environmental code of practice for road works

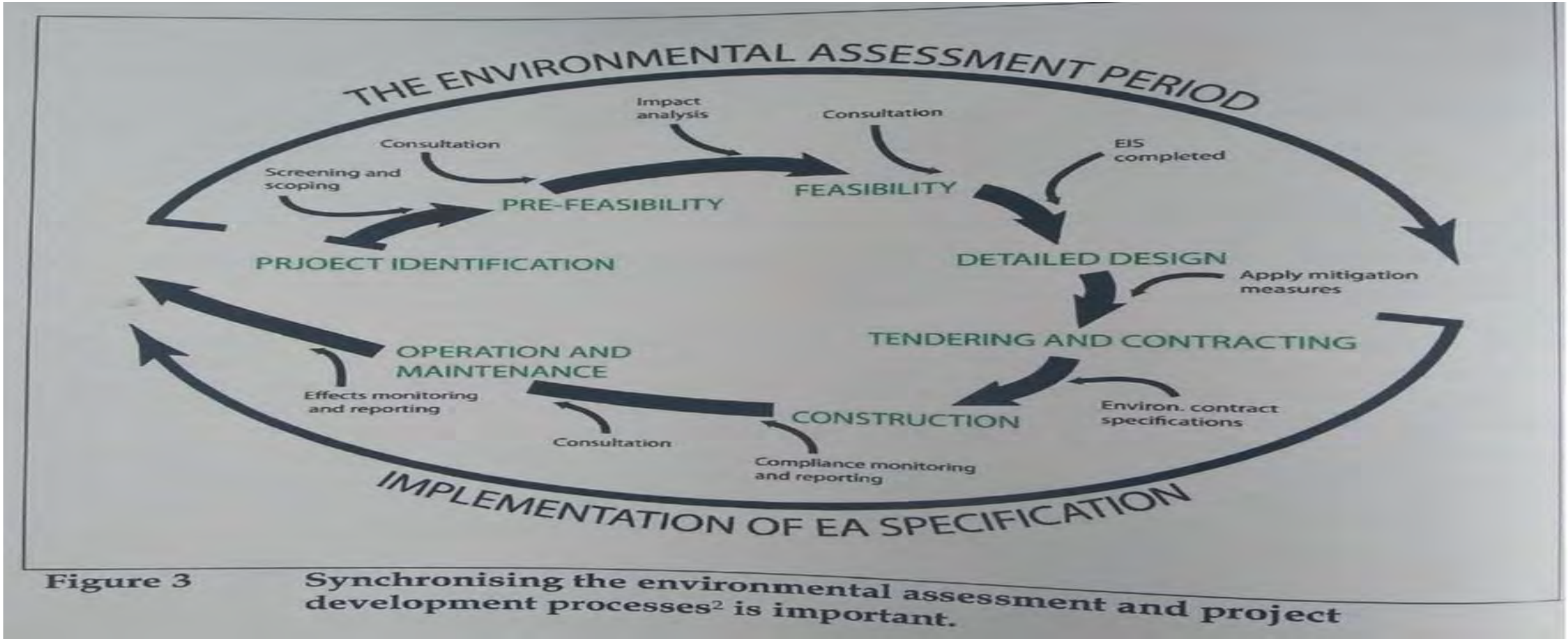


Figure 3 **Synchronising the environmental assessment and project development processes[2] is important.**

Critical Questions in Road Subsector

- Is the design perfect?
  - Are structures resilient enough?
- What are the problems/Challenges related with the current design (practice)??
  - What are the current design parameters???
  - How are they related with climate change???
- What are the mitigations/adaptation strategy???
  - how can these be achieved???
- How do the design and practice reflects in maintenance needs?

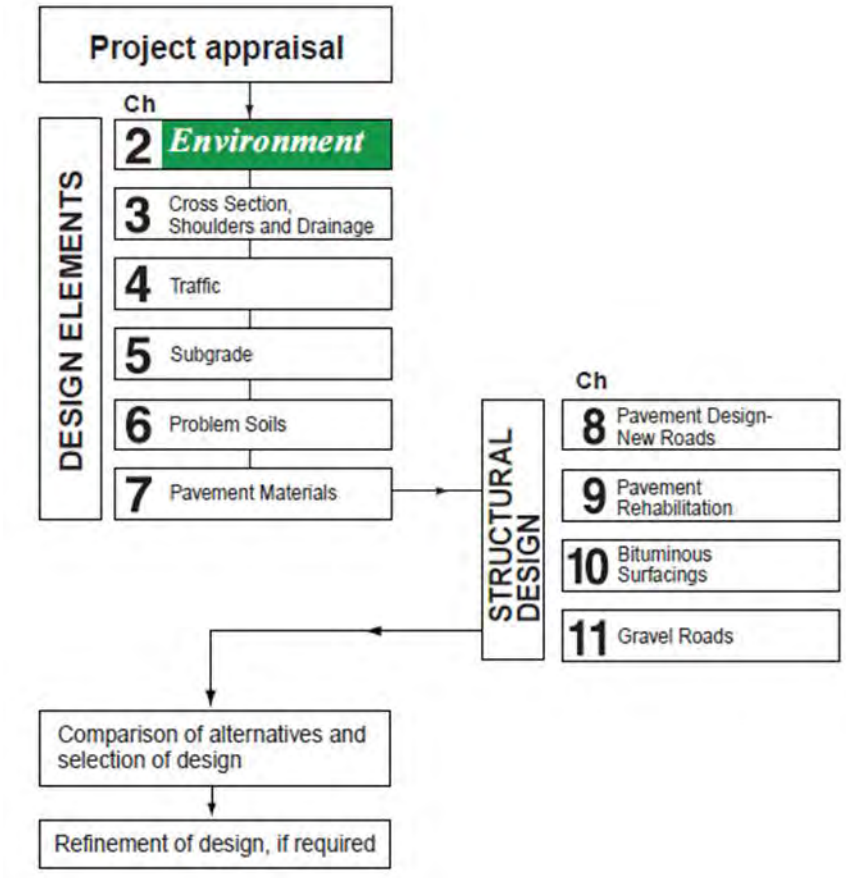
Pavement and Material Design Manual
Chapter 2: Environments

Figure 2.1 Map showing climatic zones

Table 2.1 Climatic zones

Climatic zone	Number of months per year with higher rainfall than evaporation
Dry	Less than 1 month
Moderate	1 to 3 months
Wet	More than 3 months

The Problem (extract from Chapter 2 of the PMDM_1999)



- Circumstances in which environmentally induced distress is the major distress mode

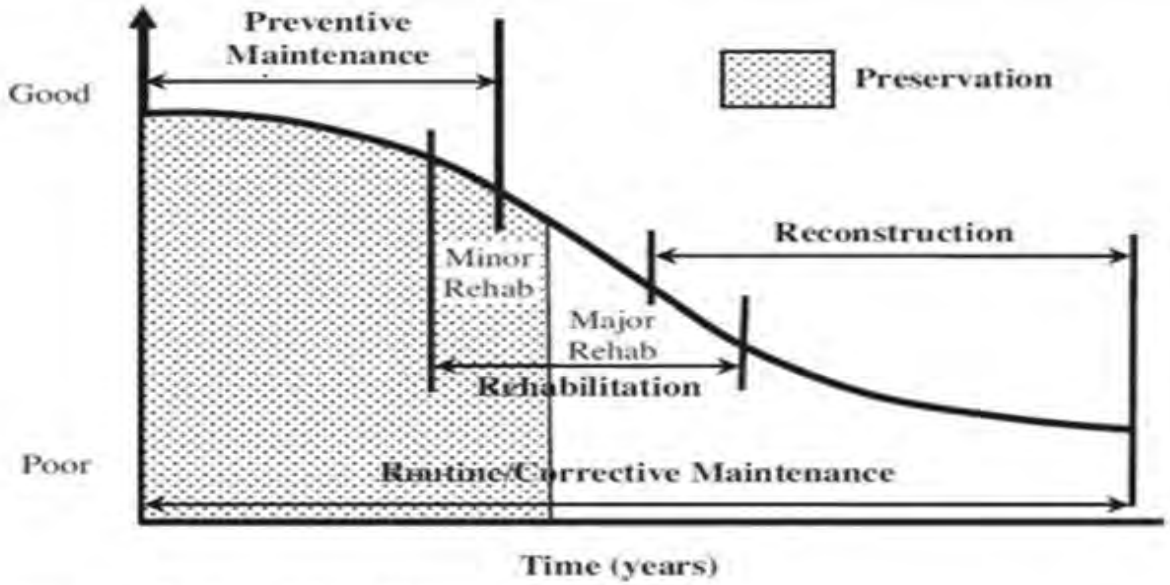
summary

- The current Practice does not cater adequately to climatic changes,
  - a balance between cost of planning, design, construction and security is anticipated **IFF** there is adequate consideration of the effects of climatic change.
- However,
  - There is lack of tools to simulating pavement behavior in different conditions.
  - Changes affecting road infrastructure will occur regardless of climate change.
    - Climate change is just another factor in the mix, and usually not the most important.
  - Impacts of climate change vary greatly among locations
- Normally, the changes in pavement and engineering policy and practice are slow
  - in absence of adaptations, more frequent rehabilitation and maintenance will be required (Underwood, 2017), for instance pavement intended for 20years will be rehabilitated earlier than planned, or bridges replaced earlier than as designed.

summary

- Frequent damage of roads infrastructure related to climate change effects
- Increased financial needs for restoration Works (emergency and long term)
- Reduce the capacity of the Road Funds to meat the maintenance demands on the network
- Disruption to economic activities and inconveniences to road users

Climate Change vs Infrastructure Life



Source: Adapted from Peshkin et al. 2007.

Strategies under the Ministry of Works

- Monitoring of the Pavement Performance (Ground Penetration Radar (GPR), Falling Weight Deflectometers (L/F/HWD), DCP, ROMDAS, a Geo-Database, and RMMS)
- Review of Standards, Specifications, and Manuals
  - Synthesize the experience gained since 1999 (23+ years of implementation)
    - Moving from Empirical Based Design to Mechanistic-Empirical Design
  - Improve design of Bridge, storm water drainage, slope protections,
  - Monitoring and Assessment of road network - based on the best scientific approach
- Innovative approaches
  - Performance based contracting,
  - EPC+F model of Project delivery

Recommendations

- Move from environmental assessment and implementation of mitigation strategies (Known, Known, Known approach, to Known, unknown, unknown approach - with accurate predictive tools)
- Complete the Calibration and validation of HDM 4 – and develop accurate local specific models
  - detailed pavement deterioration algorithm covering roughness, rutting, cracking, potholing, raveling, strength etc. based on accurate data

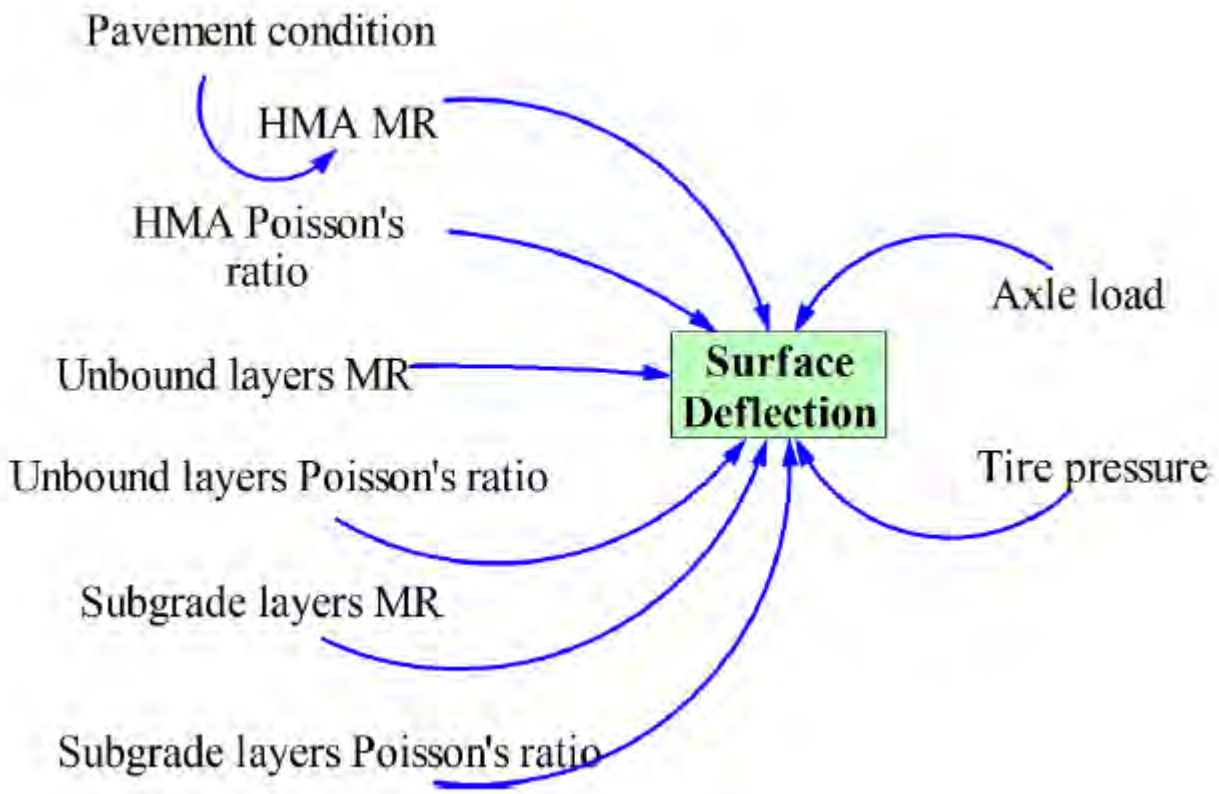
Recommendation

- Improved hydraulic and Hydrology models
  - Local flooding implications
  - catchment hydrological model to predict flooding heights, durations and water velocities, and
  - an area topology model to relate flood heights to local road infrastructure.
- The application of GIS in Planning, and management of Road network
  - (GIS is another language/tool that cannot be avoided in the near future)
- Reforms
  - **Mainstream climate change into all applicable policies and operations**
  - Enhance cooperation between ministries to address climate change across sectors
  - Review current legislation and policies –ranging from climate change, adaptation, maintenance regimes and practices

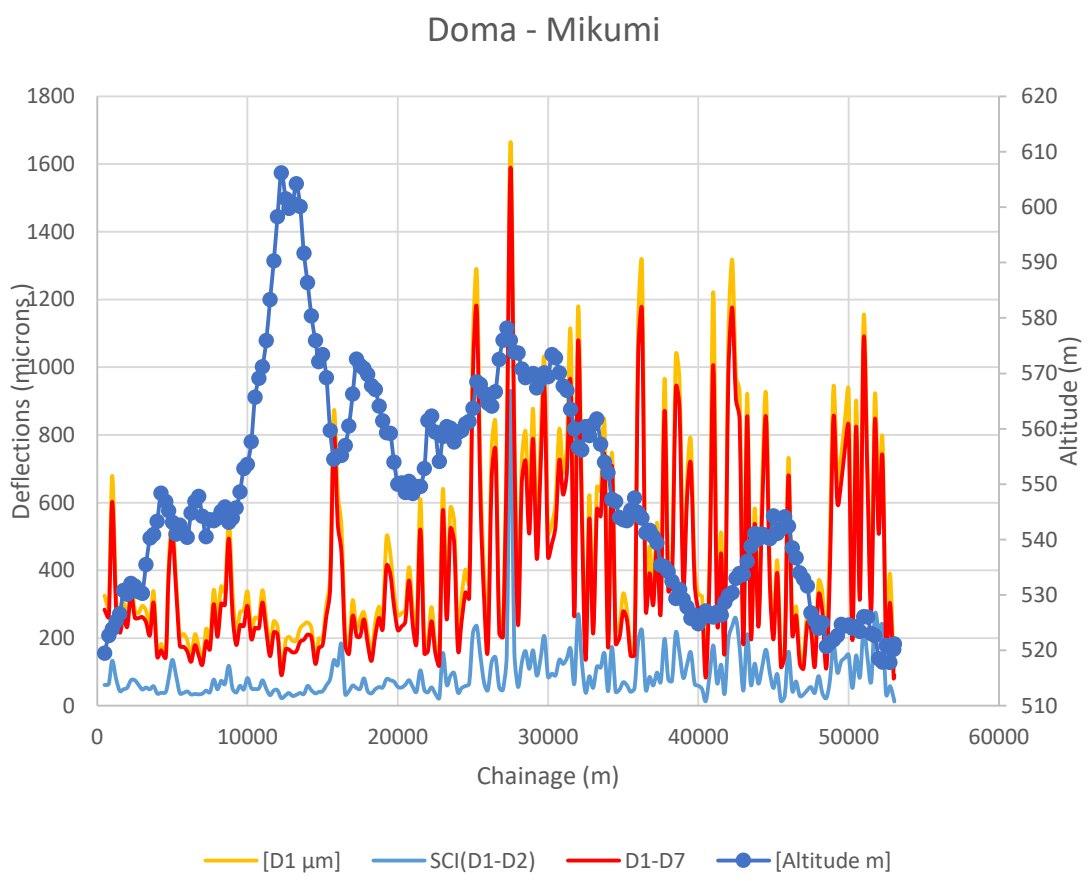
Recommendation….

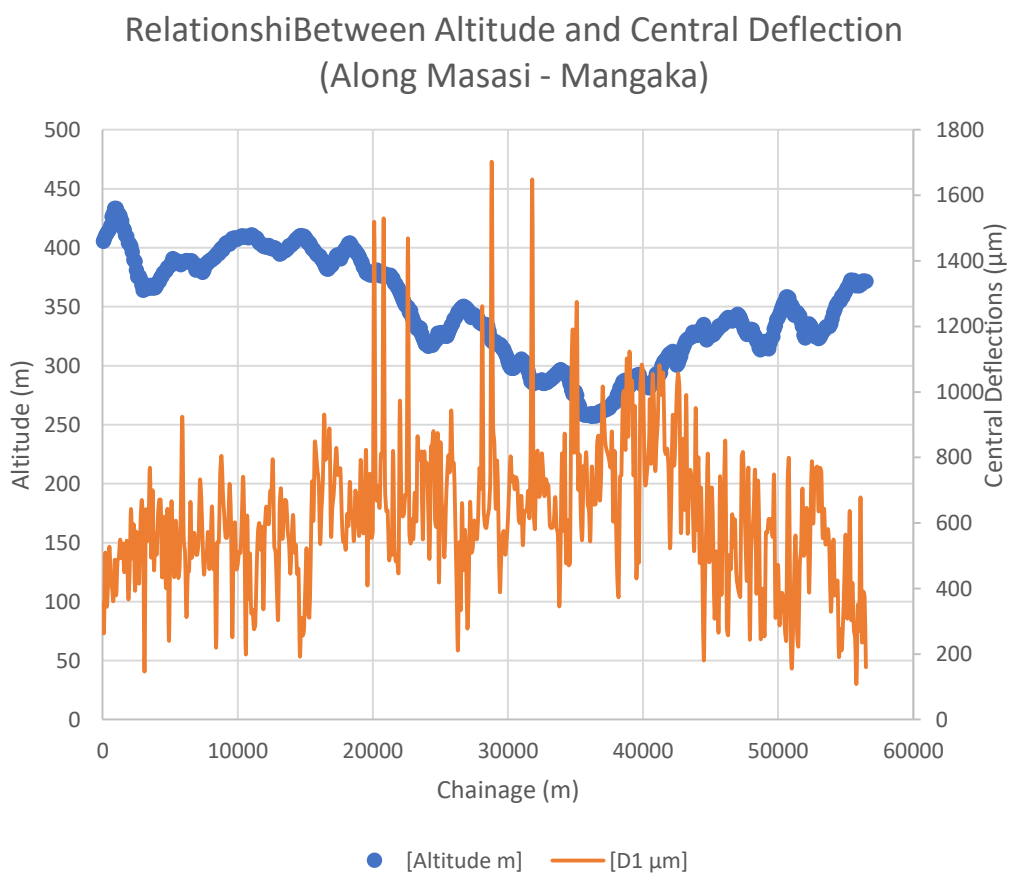
- Enhance Monitoring and Evaluation road construction and maintenance to Identify potential at risks to critical road infrastructure, establish adaptation measures, and policy implications.

Recommendation..

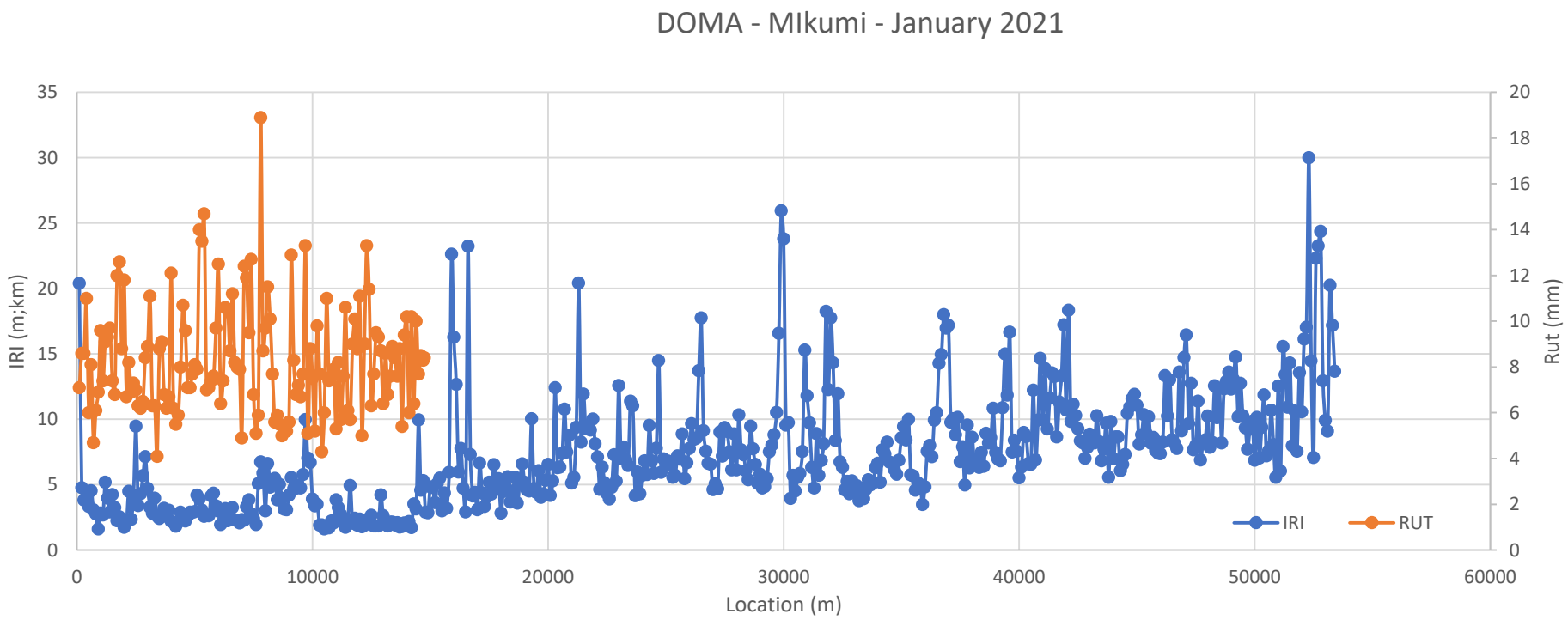


Characterization of Sections





Characterization of Sections.....



THANK YOU