# World Bank Study:
# Making Transport Climate Resilient

## Findings and guidelines for roads in Ethiopia, Ghana, Mozambique

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# Making Transport Climate Resilient
# Study Objectives and Outputs

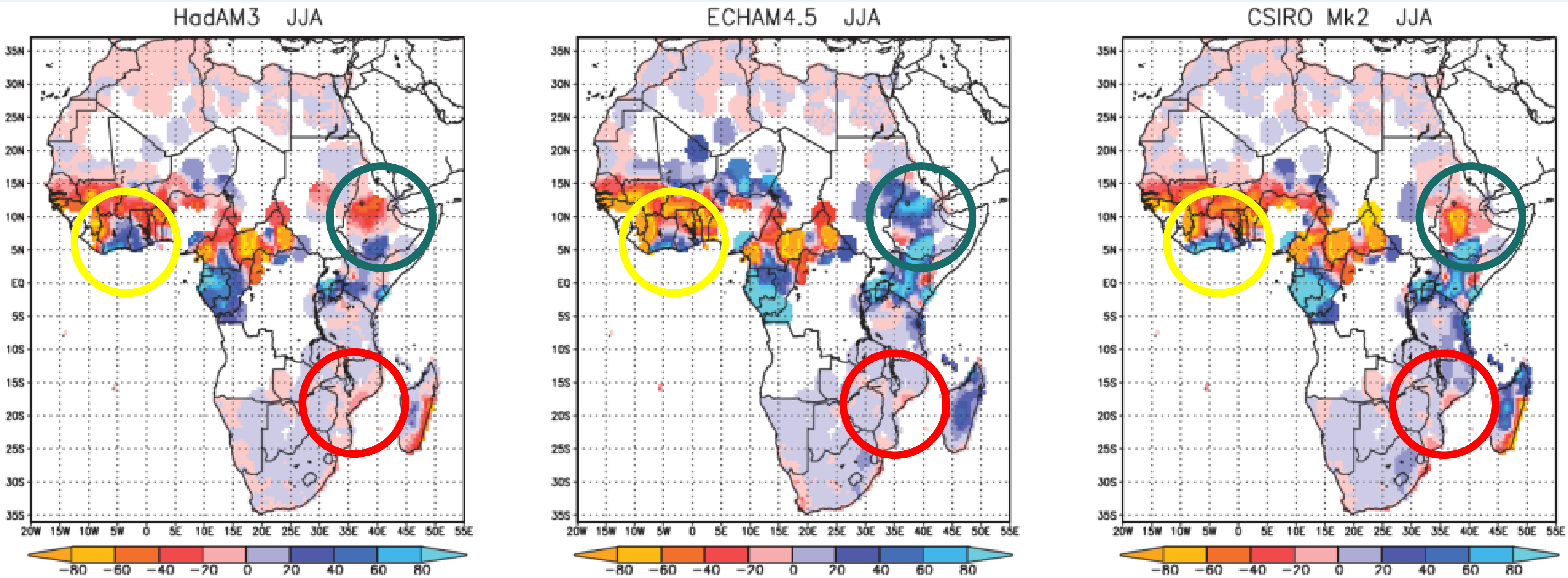
**Study objectives:**

- establish knowledge base
- deliver guidelines for road transport planning and policy decisions
- contribute to creation of awareness

**Outputs to contribute to answering – given existing climate predictions:**

- what are the types and magnitude of climate change relevant for roads sector?
- what are the most important challenges for roads assets?
- what are the additional costs for making roads climate resilient?
- what are the costs to road users if adaption is not applied?
- what are the policy implications?
- what are the recommended measures in the short and the long term?

## Predicted anomaly of mean monthly precipitation (mm) for the summer rainy season, JJA, 1990-2089




**Source: UNDP (using subset of IPPC climate models**



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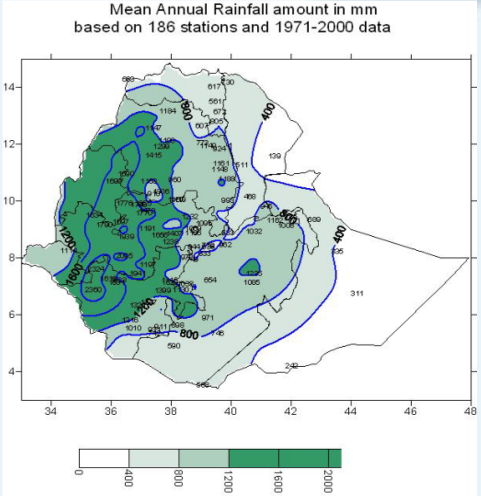
# Making Transport Climate Resilient
# Climate Trends and Climate Scenarios

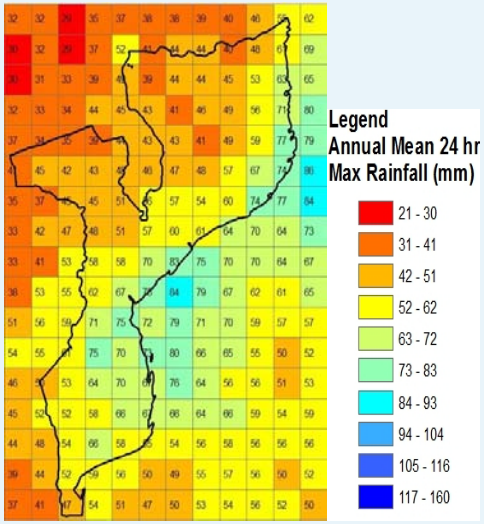
**Observed climate trends the last 30-40 years:**

- increased average temperatures, 0.1-0.3$^{O}$C per decade
- increased number of hot days and nights
- larger variation from year to year in extreme events
- no significant trend in annual rainfall




**Climate scenarios / model results:**

- mean temperatures increase with around 2$^{O}$C till 2050
- rainfall patterns are uncertain to predict, but probably increased annual and max 24 hour rainfall in most areas
- *IPPC sea level scenarios vary greatly – e.g. increases between 20 cm and 100 cm in 2060 in Mozambique*
- *the number and/or intensity of extreme events will increase – for cyclones: less frequent & more intensive*

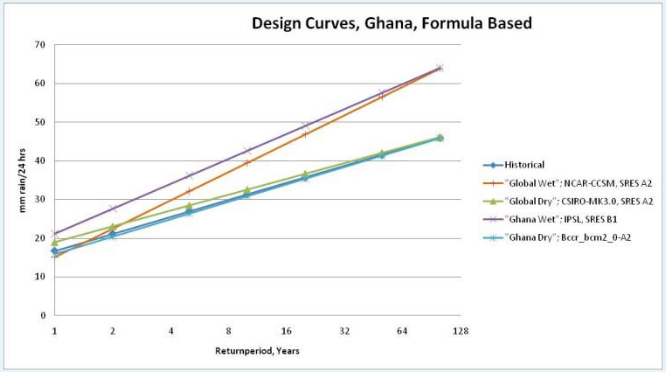


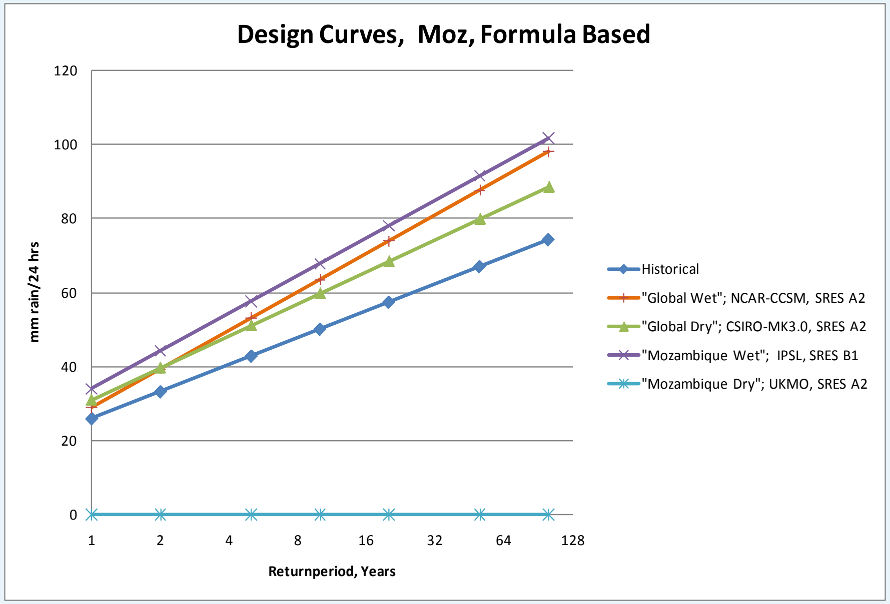
# Making Transport Climate Resilient
# Climate Scenarios' Impact on Road Designs

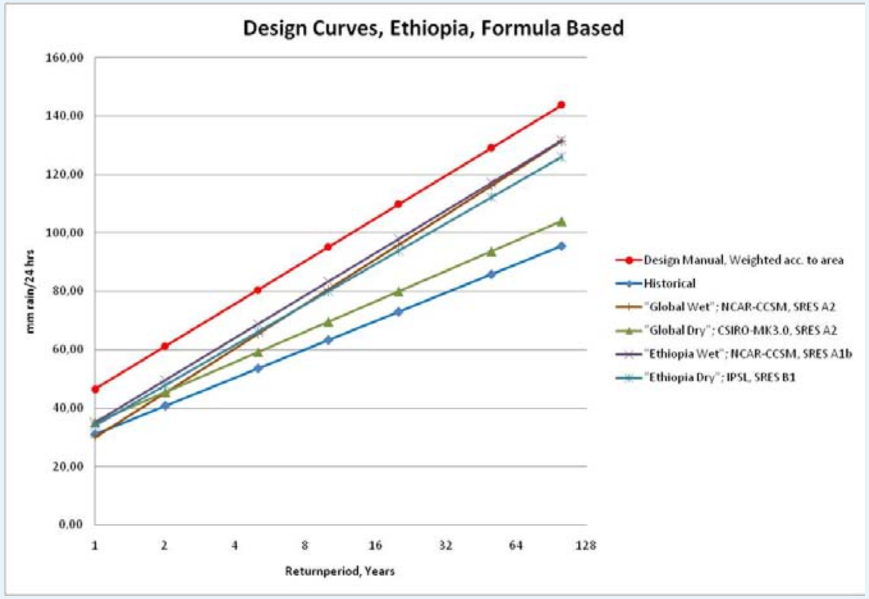
## Future return periods of design storms in 2050:

today's design storms for roads:

- for 10 year storms will be 2-3 times more frequent
- for 20 year storms will be 2-3 times more frequent
- for 100 year storms will be 3-6 times more frequent



# Making Transport Climate Resilient
# Road Asset Elements Affected

**Road network elements**

- pavements & road base
- bridges
- culverts
- slopes (stability)/landslides
- surface drainage

# Making Transport Climate Resilient
# Challenge for Road Assets

**Success of roads relies on:**

- choice of alignment, design and construction
- climate and topography of location
- traffic loading (axle loads)
- maintenance

**Largest problem for current road assets:**

- overloading of roads
- poor maintenance
- lack of repair

*These problems are amplified by climate/climate change*



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# Making Transport Climate Resilient
# Change in Precipitation Intensity – Structures

Increased peak flows and floods

➔

scour and bank erosion for bridges

hydraulic capacity reduced

floods/wash away of bridges and culverts

Measures:

Long term:

- revise future design criteria as more information on climate becomes available
- upstream river training to stabilize channels

Short term:

- more maintenance will reduce risks generally
- spot upgrades in a few critical areas based on cost/benefit assessments

# Making Transport Climate Resilient
# Change in Precipitation Intensity – Roads

Increased rain intensity

➔

flooding and wash away of roads

more land slides

Measures:

Long term:

- improved future design of surface drainage – in cities co-ordinated with urban planning
- better slope protection for new constructions, e.g. increased plantation
- more critical hydrological analyses before constructing in river beds
- increased research in suitability of local materials for community roads

Short term:

- more maintenance
- spot upgrades in critical areas

# Making Transport Climate Resilient
# Sea Level Rise, Cyclones, Ocean Tides

Raising sea levels and cyclones
(but ocean tides are the big challenge!)

➔

flooding and wash-away of roads

Measures:

Long term:

- construct coastal defences e.g. sea walls
- relocate infrastructure (and population)
- no future construction in high risk areas

Short term:

- more maintenance
- spot upgrades in critical areas e.g. elevate low-lying critical road links
- ensure sufficient monitoring stations to collect reliable data
- improve hydrological data and models

# Making Transport Climate Resilient
# Change in Temperature

An increase of 2-3$^{O}$C will mainly have an effect for bridges and bituminous pavements

**Bridges:**

- no change in design methodology needed
- design temperature can be increased
- no significant additional costs expected

**Bituminous pavements:**

- stiffness of asphalt will be affected
- use more adequate asphalt mix when resurfacing
- no additional costs may occur

# Making Transport Climate Resilient
# Additional Construction Costs for a Paved 2L Road

*Summary of construction cost distribution today and assessment of cost increase (full adaptation) due to climate change in 2050 for upgrading gravel to paved road (cost per km/road)*

| Description | Percentage of total costs today | Likelihood of cost increase |
|---|---|---|
| General & Site Clearance | 10%-25% | No increase |
| Earthworks | 10%-15% | Can be significant |
| Sub Base, Road Base and Gravel Wearing Course<br>Bituminous Surfacings and Road Bases | 35%-60% | Can be significant |
| Drainage | 5%-15% | Can be significant |
| Structures | 5%-10% | Can be significant |
| Day works | 1%-3% | Can be marginal |
| Road Furniture & Miscellaneous | 1%-5% | No increase |
| **Total** | **100%** | **2% - 10% (Low climate effect )**<br>**9% - 19% (High climate effect )** |



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# Making Transport Climate Resilient
# Cost of Climate Change – Approach

**Base scenario – no climate change:**

"in 2050, the climate is as today"

**Climate scenario – based on different strategies:**

A. all adaptation measures are implemented

B. no adaptation measures are implemented

C. optimal adaptation strategy is implemented

**Cost of climate change =**

cost of climate scenario – cost of base scenario

# Making Transport Climate Resilient
# Economic Costs – Total Costs & Stakeholders

| | Road Agencies | Road users | Third parties |
|---|---|---|---|
| Existing network | • increased annual reconstruction costs<br>• higher unit reconstruction costs<br>• reduced value of infrastructure in 2050<br>• increased maintenance costs | • reduced service level | • more detours<br>• impacts from adaptation measures |
| New network | • higher unit construction costs<br>• increased maintenance costs | • none – if current service levels are maintained | • none – if adaptation does not impact on transport users |
| Total | carry almost all costs | carry few costs | carry almost no costs |

**With very simplistic assumptions: NPV of adaptation costs 2010–2050 amounts to around 2 years of current total road budgets**

**Annual additional costs increase over time as climate change develops because of stronger measures required and growing networks**

# Making Transport Climate Resilient Mitigation – the CO2 Emission Cycle

**$CO_2$ emissions in the transport sector are a combination of:**

- the overall demand for transport and mobility
  - depends on economic development and taxation schemes
- the supply of transport options available
  - road transport is the overall dominating motorised mode of transport in most African countries
- the efficiency of transport means
  - utilisation and specific energy use

# Making Transport Climate Resilient
# Mitigation – Measures for the Future

**Current mitigation initiatives:**

- strategic climate and environmental plans are prepared or under preparation
- trials with improved public transport services
- taxation regime in the transport sector

**Specific initiatives**

- revitalisation of urban rail – where it has existed
- provision of improved bus service – e.g. in form of rapid bus systems on dedicated lanes
- taxation of vehicles based on energy use and emission levels

**More focus on physical planning, bicycles?**

# Making Transport Climate Resilient
# Policy Implications (I)

**Yearly reconstruction costs for existing roads will increase (shorter lifetime and higher unit costs)**

adaptation strategy: infrastructure is reconstructed when destroyed or lifetime exceeded using newest climate data

**New climate resilient roads are more costly (higher unit costs)**

for areas exposed to adaptation measures: frequent revision of design storm parameters

adapting fully to climate changes is not necessarily the optimal strategy for all road elements – but probably for most (this needs further research and location specific CBA analysis!)

**Protect infrastructure by using more and better maintenance**

# Making Transport Climate Resilient
# Policy Implications (II)

**Raising sea levels and variations in ocean tides - decisions have to be made**

- protect the infrastructure by coastal defences or over time relocate infrastructure (and population)

**Research to strengthen knowledge about current climate – as a starting point**

- consistent data collection
- hydrology data and models

# Making Transport Climate Resilient
# Strategic Recommendations – Long Run

**Long run recommendations:**

- review climate related parts of design guidelines at 5–10 year intervals to take account of observed climate trends
- establish more focused maintenance strategies
- develop more reliable hydrology models to improve decisions on future road alignments
- develop and test methods to improve maintenance practices (e.g. scour protection of bridges)

# Making Transport Climate Resilient Recommendations – Short Run

**Short run (next 5 years) initiatives:**

spend more on maintenance – it is cost-efficient today

– maintenance is to cope with existing climate, changed designs with the future climate

more critical analysis of alignments before constructing to avoid high climate risk locations

do not reconstruct existing network because of climate change before the network is worn out – maybe with a few carefully selected exceptions

existing good and comprehensive design manuals may be adjusted – after due consideration to future service levels

do more research in predicting sedimentation and run off in the landscape

# Making Transport Climate Resilient
# Strategic Recommendations – Decision making

A strategy needs to be flexible, adaptive and robust

and acknowledge that climate models show large variability in future rainfall patterns – which is the most important design parameter

***A climate resilient road in the future (till 2050) will not be that different from a climate resilient road now***

***The current state-of-the-art technical and economic approaches and methods to assess projects/initiatives in the decision processes will also be valid in the coming years***

***-***

***but need to be based on robustness to various climate conditions***