World Bank Study: Making Transport Climate Resilient

Findings and guidelines for roads in Ethiopia, Ghana, Mozambique
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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?
Making Transport Climate Resilient
Climate Trends and Climate Scenarios

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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Climate Trends and Climate Scenarios

**Observed climate trends the last 30-40 years:**
- increased average temperatures, 0.1-0.3°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°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
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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
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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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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
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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
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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
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Change in Temperature

An increase of 2-3°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
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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)

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

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

**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
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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?
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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
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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
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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
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