Developing a strategy for adapting to climate change

Dr. Adnan Rahman

World Road Conference – Lisbon
May, 2010
Outline

• Introduction
• A framework for adaptive decision/policy making
• Conclusions
Adaptation

Reduce impacts

Greenhouse gas emission and concentration → Climate changes → Environmental Effects → Impacts on transportation infrastructure → Policies/ actions

Mitigation

Reduce greenhouse gas emissions

Adaptation
## Impacts on operations and infrastructure

<table>
<thead>
<tr>
<th>Event</th>
<th>Impact on Operations</th>
<th>Impact on Infrastructure</th>
</tr>
</thead>
<tbody>
<tr>
<td>Increase in the number of extremely hot days (heat waves)</td>
<td>Fewer working days</td>
<td>Thermal expansion on bridge expansion joints and road surfaces</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Pavement integrity, traffic related rutting, migration of fluid asphalt</td>
</tr>
<tr>
<td>Increase/decreases in arctic temperatures</td>
<td></td>
<td>Subsistence of road beds and bridge supports</td>
</tr>
<tr>
<td>Rising sea levels and storm surges</td>
<td>Interruptions to road services</td>
<td>Inundation of roads</td>
</tr>
<tr>
<td></td>
<td>Emergency evacuations</td>
<td>Flooding of tunnels and low lying infrastructure</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Erosion of road base and bridge supports</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Reduced clearances under bridges</td>
</tr>
<tr>
<td>Extreme precipitation (flooding)</td>
<td>Weather related travel delays</td>
<td>Flooding of roads, road washouts</td>
</tr>
<tr>
<td></td>
<td>Flooding of evacuation routes</td>
<td>Landslides and mudslides damaging roads and structures</td>
</tr>
<tr>
<td>Hurricanes</td>
<td>More frequent and intensive evacuations Debris on roads</td>
<td>Increased probability of infrastructure failure</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Larger threat to bridge decks</td>
</tr>
</tbody>
</table>
Predict-and-act is insufficient for dealing with climate change challenges

- Long planning horizons (decades/centuries versus 5-50 years)
- Massive uncertainty (predict and act optimally, versus unexpected, unplanned events and system redundancy)
- Considerable resource requirements for dealing with long-term and lasting impacts
- Lack of relevant information for decision making
Questions to ask in developing an adaptation strategy

- Which changes are most relevant?
- What are the hazards (e.g., flooding, storm surge coupled with sea level rise)?
- Which assets may be affected?
- How severe must a hazard be before action is required? Can thresholds be identified?
- How likely is it that a hazard will exceed the threshold, when, and where?
- What level of much risk is acceptable, or in other words, what infrastructure performance level is tolerable?
- What level of investment (capital and operating) is needed to maintain different levels of service?
- Are there critical levels of service needed to protect health and safety?
- Who is empowered to make these judgments and decisions?
- What are the risks of adverse impacts or consequences if no action is taken?
- If action is necessary, how will investment priorities be determined?
- Who will make the necessary investments, and how will they be funded?
A framework for adaptive decision-making

I. Stage Setting
   - Objectives
   - Constraints
   - Definition of success
   - Options set

II. Assembling a basic policy
   - Necessary conditions for success
   - Policy Actions

III. Specifying rest of policy and monitoring
   - Vulnerabilities
     - Monitoring
     - Signposts
   - Mitigating actions
   - Hedging actions
   - Triggers
   - Uncertain
   - Certain

IV. Adapting the policy
   - Others' actions
   - Unforeseen events
   - Changing preferences
   - Reassessment
   - Corrective actions
   - Defensive actions
I. Stage Setting

Objectives

Definition of success

Constraints

Options set

Definition of success

Objectives:
- Safeguard infrastructure assets
- Maintain usability of assets
- Prevent loss of life

Constraints:
- Available resources
- Technical performance characteristics of materials and designs

Definition of success:
- No failure
- No failure but damage

Option set:
- Do-nothing
- Retrofit
- Redesign and relocate
II. Assembling a basic policy

### Necessary conditions for success

<table>
<thead>
<tr>
<th>Policy actions</th>
<th>Conditions for success</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Policy actions:</strong></td>
<td><strong>Availability of up to date information for the risk assessment and cost-benefit analysis</strong></td>
</tr>
<tr>
<td><strong>Develop inventory of assets</strong></td>
<td><strong>Establishment of and agreement upon the definitions for:</strong></td>
</tr>
<tr>
<td><strong>Estimate:</strong></td>
<td>- Exposure</td>
</tr>
<tr>
<td>- Exposure: Identify potential threats and risks</td>
<td>- Vulnerability</td>
</tr>
<tr>
<td>- Vulnerability: exposure, design, condition and age of asset</td>
<td>- Criticality</td>
</tr>
<tr>
<td>- Criticality: network importance and redundancy requirements (evacuation routes)</td>
<td>- No-failure and damage but no-failure</td>
</tr>
<tr>
<td>- Impacts based on average daily traffic and detour length</td>
<td></td>
</tr>
</tbody>
</table>
III. Specifying rest of policy and monitoring

**Vulnerabilities:**
- Changing weather patterns
- Changes in use of infrastructure assets

**Mitigating actions:**
- Stricter enforcement of land use and zoning regulations

**Hedging actions:**
- Creation of a special contingency fund for emergency retrofitting/repairs to assets

**Signposts:**
- Precipitation above a certain level in some given time period
- Population density

**Triggers**
- Threshold values for the signposts
IV. Adapting the policy

Other actions, unforeseen events and changing preferences:

Implement a tolls on using specific assets

Reassessment:

Redefine no failure and damage but no-failure criteria

Redefine hazard, threat and vulnerability algorithms

Corrective actions:

Changing the category in which in an asset is placed

Defensive actions:

Divert traffic along specific routes
Conclusions

• Climate change poses some special challenges for transport planners decision and policymakers
• These challenges cannot adequately be met using a predict and act approach
• New approaches are needed to meet these challenges, including:
  – Risk assessment
  – Options analysis
  – Monitoring
• In short, adaptation requires adaptive decision/policy making