Climate Change Adaptation for Transportation Infrastructure

Susan Asam
March 2, 2010

North Carolina Workshop on Climate Change Adaptation
Presentation Overview

- Impacts of climate change on transportation and infrastructure
- Barriers to adaptation in transportation infrastructure
- Framework to streamline adaptation
- Efforts underway on adaptation and infrastructure
- Summary
Impacts on U.S. Transportation

- Warmer / less snowy winters:
  - improve ground and air transportation reliability
  - decrease the need for winter road maintenance

- More intense winter storms could increase risks for traveler safety and require increased localized snow removal

- Summer heat waves:
  - railroad track buckling/kinking
  - road softening and traffic-related rutting

- Increased frequency of extreme precipitation, river, and coastal flooding events may contribute to:
  - increased accident rates
  - more road closures due to flooding and landslides (single point failures)
  - more frequent short-term flooding and bridge scour
  - more culvert washouts
  - exceedence of storm drain capacity

- Permafrost thaw in Alaska will damage infrastructure

- Reduced sea ice could lengthen the ocean transport season
Gulf Coast Study
Highways Vulnerable to Relative Sea Level Rise

Baseline (Present Day)

4 Feet of Sea Level Rise

Sea Level Rise in NC – DOT Study

The Potential Impacts of Global Sea Level Rise on Transportation Infrastructure, U.S. DOT Center for Climate Change and Environmental Forecasting, 2008

6.5 cm
2.6 in
Sea Level Rise in NC – DOT Study

The Potential Impacts of Global Sea Level Rise on Transportation Infrastructure, U.S. DOT Center for Climate Change and Environmental Forecasting, 2008

N

Regularly Inundated Area
At-Risk Area
Airport Runway
Ports Property Area
Interstate Highway
Non-Interstate Principal Arterial
Minor Arterial
NHS (indicated by background)
Railroad

21 cm
8.3 in
Sea Level Rise in NC – DOT Study

31 cm
12.2 in

The Potential Impacts of Global Sea Level Rise on Transportation Infrastructure, U.S. DOT Center for Climate Change and Environmental Forecasting, 2008
Sea Level Rise in NC – DOT Study

The Potential Impacts of Global Sea Level Rise on Transportation Infrastructure, U.S. DOT Center for Climate Change and Environmental Forecasting, 2008

59 cm
23.2 in
Barriers to Adaptation

- Diverse decision makers with diverse capacity and information needs
- Perception of uncertainty is a hurdle
- Screening, assessing, and managing climate risks is complicated and resource-intensive
  - Developing planning-relevant climate change scenarios is a significant hurdle
  - Emphasis on long time-frames requires projecting not only climate, but also other long-term drivers difficult to foresee
  - Few damage functions or guidelines are available
  - Engineered structures often specify design standards in terms of intensity-duration-frequency targets (e.g., 100-year flood), and climate “stationarity is dead” (Milly et al. 2008)
  - Many climate risks have “low probability/ high consequence” characteristics
  - Little info is available on cost-effectiveness of adaptation options
  - Little info is available on costs of inaction
  - The benefits of adaptation are largely unproven
Barriers to Adaptation

- In a world of limited resources, adaptation looks scary, time-consuming, and of questionable value

How can we streamline adaptation in transportation infrastructure design, planning, asset management, and operation/maintenance?
Framework for Streamlining Adaptation

1 - Risk Screening
2 - Risk Assessment
3 - Risk Management

Prioritize where to focus efforts to adapt to climate change in the near term
Risk Screening: Where Does Climate Have a Role?

- How sensitive is the asset/system to climate change?
  - Is climate a factor now?
  - Will changes in average climate—or in the “tails”—be a factor?

- What is at stake if a wrong decision is made?
  - Impacts/damages of climate potentially high?
  - Damages irreversible or difficult to reverse?
  - Is the asset/system critical?
  - Is capital investment large?
  - Can negative effects of climate be ameliorated by possible adaptive action?

- Timing and time horizon: is there a need to take immediate action?
  - Is there an immediate threat based on current conditions?
  - Are decisions being made now that will govern actions for sometime to come, or do decisions take time to be implemented?
Adaptation Planning: Many Timeframes

Timeline source: Linda Mearns, NRC, Oct 25, 2007
Risk Screen: Output

Group 1: climate change is not a key stressor

Group 2: climate change could become important, but options remain open to adapt in the future – monitor and revisit periodically

Group 3: assess risks and start managing them now
  - Climate change risks are significant relative to other stressors
  - Planning and implementation life-cycles are long, or plans are difficult to adjust once in place
  - Resource value or project costs are high
  - Institutional resources are available to manage risk

Even without detailed climate projections, asset/ system managers can use the screen to determine whether detailed climate change risk assessment and management (e.g., engineering analysis) is warranted
Examples of Potential Candidates for Adaptation Planning in the Short-term

- **High-cost, long-lived infrastructure programs**
  - Energy generation and transmission infrastructure
  - Transportation system design
  - Wastewater treatment and drinking water treatment design and siting
  - Flood control programs

- **Long-term programs with high cost of failure/ difficult to reverse decision**
  - Land use planning/ zoning
  - Transportation plans

- **High-value programs with high cost of failure**
  - Emergency management and communication plans
  - Insurance programs
Framework for Streamlining Adaptation

1 - Risk Screening

Prioritize where to focus efforts to adapt to climate change in the near term

2 - Risk Assessment

Assess the impacts of stressors to inform management decisions

3 - Risk Management
Risk Assessment Tools

- Climate effect scenarios (e.g., FHWA climate effects typology)
  - Sea level rise (inundation, storm surge)
  - Temperature (mean and extremes)
  - Precipitation (mean and extremes)
  - Flows (mean and extremes)

- Damage functions (translating effects to impacts)
  - Endpoints
  - Functional form
  - Effect/damage relationship – probability and consequence
  - Use existing frameworks to extent possible (e.g., NIPP)
Assess the impacts of stressors to inform management decisions.

Take action to reduce impacts or exploit beneficial opportunities.

Prioritize where to focus efforts to adapt to climate change in the near term.

1 - Risk Screening

2 - Risk Assessment

3 - Risk Management
Risk Management Tools

- Lists of options
  - By type of damage
  - Conditions for suitability

- Cost models
  - First order cost estimates

- Effectiveness models
  - How much do the options reduce climate risk?
  - To what extent are there co-benefits?
  - What is the cost of inaction?

- Methods to characterize uncertainty
  - Key sources
  - Comparison to “familiar” sources of uncertainty
## Current Efforts on Adaptation and Infrastructure

<table>
<thead>
<tr>
<th>Initiative</th>
<th>Improving Risk Assessment Methods</th>
<th>Risk Management Assistance to Decision Makers</th>
<th>Communication/Outreach</th>
<th>Resources for Adaptation</th>
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FHWA Adaptation Activities

- FHWA Strategy
- Regional estimates of climate effects
- Framework for conducting vulnerability assessments (& pilots)
- Peer Exchanges (Dec 2008, Dec 2009, upcoming)
- Technical assistance on adaptation issues
- Long-term Adaptation Research
  - Gulf Coast study, Phase 2 (DOT)
  - Climate Change and Highway Infrastructure: Impacts and Adaptation Approaches (NCHRP)

Federal Highway Administration Climate Change Website: [www.fhwa.dot.gov/hep/climate](http://www.fhwa.dot.gov/hep/climate)
Regional Climate Change Effects: Useful Information for Transportation Agencies (draft)

• Forthcoming FHWA report
• Synthesizes information from other studies
• Projections of seasonal temperature and precipitation, sea level rise
• Feeds into vulnerability assessments
## Climate Change in Regional Transportation Plans

<table>
<thead>
<tr>
<th>MPO Region</th>
<th>Status of LRTP</th>
<th>Trends &amp; Challenges</th>
<th>Vision &amp; Goals</th>
<th>Policies &amp; Strategies</th>
<th>Performance Measures</th>
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Climate Change Mitigation

Climate Change Mitigation & Adaptation
Summary

- Climate change adaptation is relevant to some – but not all – transportation infrastructure planning and design
  - A risk screening process can help identify high priorities for detailed risk assessment and management

- For infrastructure, detailed assessment and management of climate-related risks is complex and involves considerable uncertainty …
  - … which makes it just like analyzing risks from many other, more familiar stressors
  - … which benefit from the availability of frameworks and info and familiarity with them

- Efforts are underway to provide frameworks and info

- If a climate bill is enacted, state and local governments could have significant resources to address adaptation which would provide an impetus for improving climate risk assessment and management

- As the US embarks on the biggest wave of investment in 70 years, we need to ensure that 21st century infrastructure is not designed for 20th century climate
Contact Info

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Providing climate change strategy services to governments, businesses, and international development institutions world-wide
Sea Level Rise – Potential Implications for Airports in Coastal Zones

- **Impact:** Flooding of runways
  - **Potential response:** Strengthen dikes, retaining walls
  - **Potential response:** Consider risk when planning new runways

- **Impact:** Flooding of out-buildings and access roads

- **Impact:** Disruption to fuel supply and storage
Temperature Change Threatens Local Airports in Alaska

- Alaska has 84 commercial airports and more than 3,000 airstrips, many of which are the only practical year-round means of transport for rural communities.
- Many airports built on permafrost.
## State-level Adaptation Planning Areas

<table>
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<tr>
<th>State</th>
<th>Agriculture</th>
<th>Biodiversity / Ecosystem</th>
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1. MD and NY are limited to addressing statewide issues associated with the impacts from sea level rise.
2. VA’s plan also addresses the Insurance sector.

Source: T. Cruce for the Georgetown Climate Center