A Review of Quantitative Methods for Evaluating Impacts of Climate Change on Urban Water Infrastructure

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Session B.2: Progressive Adaptation: Planning and Engineering for Sustainability

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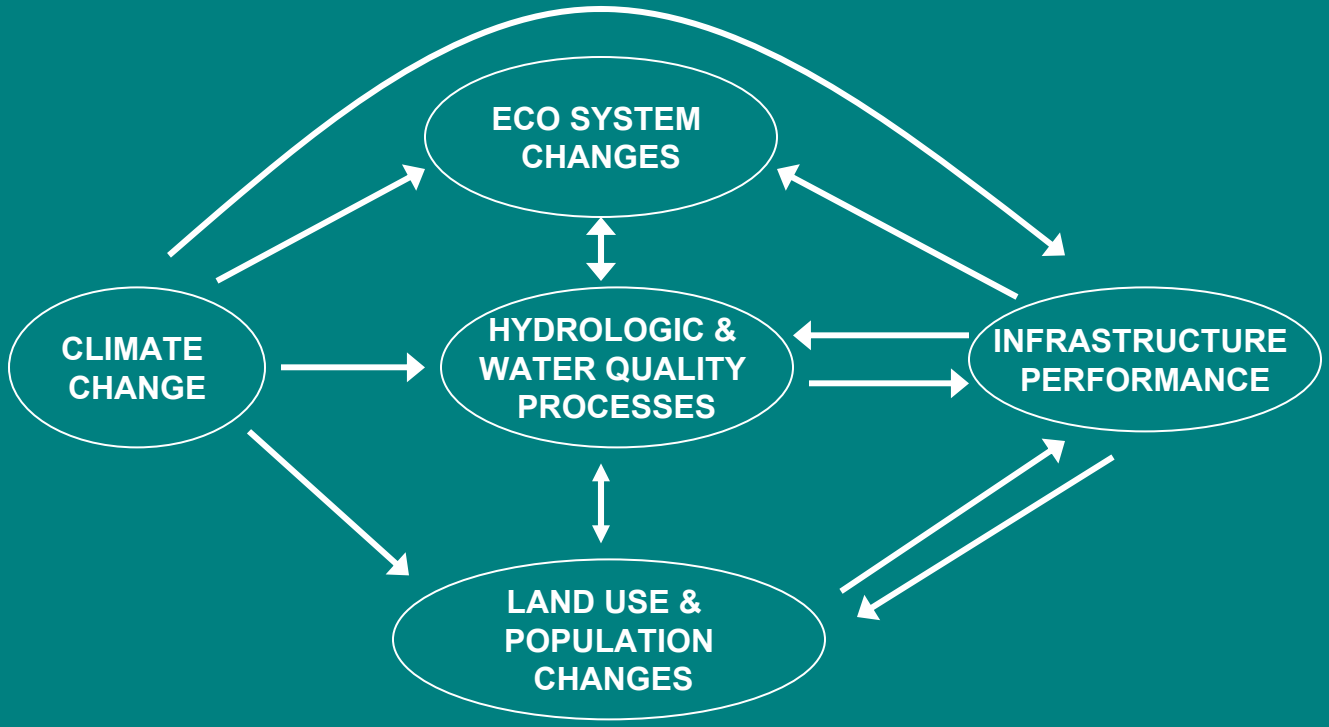
Purpose

- Discuss the issues associated with assessing the impacts of climate change on urban water infrastructure
- Examine the elements and interactions in a quantitative analysis
- Examine the research needs in this area

Climate Change Impact Assessment

- Qualitative vs. Quantitative Assessment
  - Qualitative
  - Quantitative
- Direct vs. Indirect Impacts
  - Direct
  - Indirect
- Other issues:
  - Uncertainty
  - Time frame
  - Other stressors

Climate Change – Infrastructure Interaction



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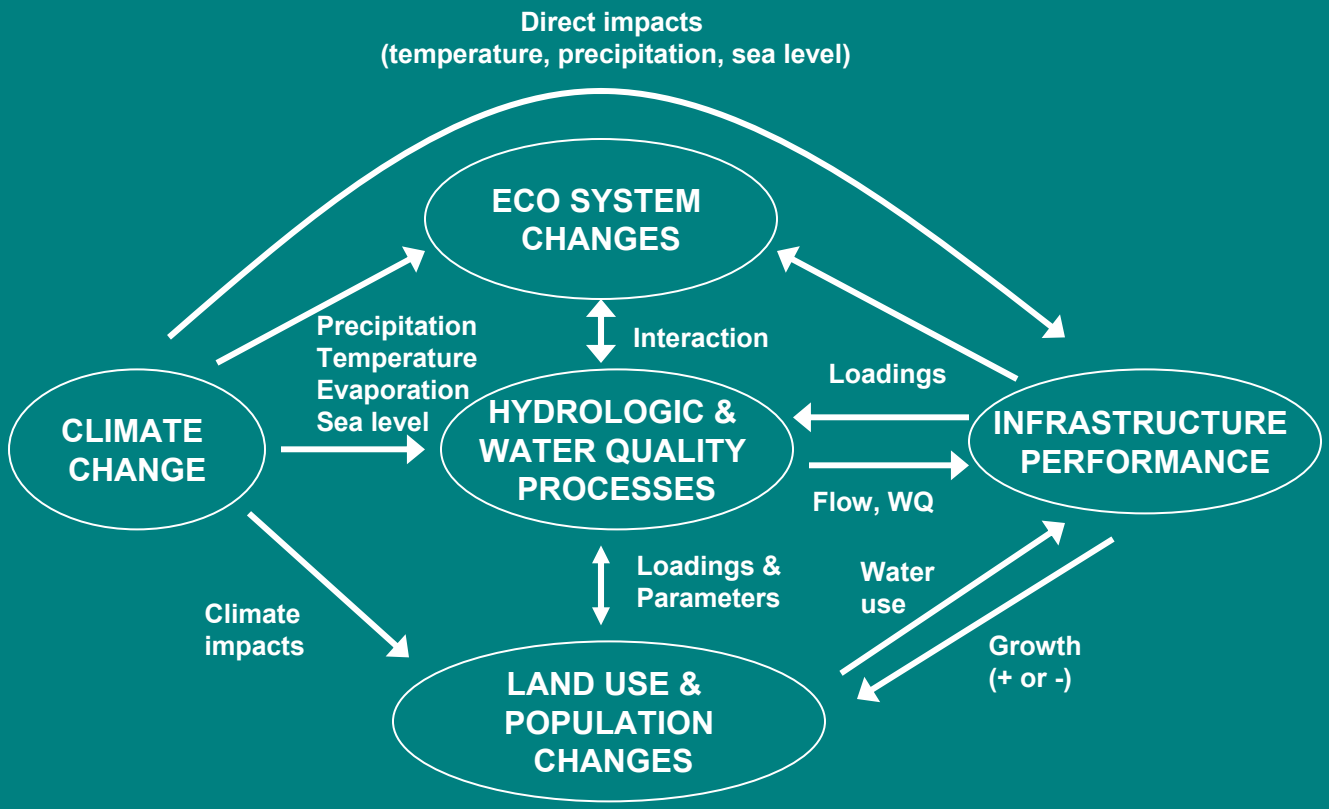


Climate change may result in:

- Increase/decrease in precipitation
- Higher/lower precipitation intensity
- Warmer/colder temperatures
- Increased/decreased snow pack
- Increased/decreased evaporation
- Increases/decreases in stream flow
- Deterioration/improvement in surface water quality
- Increased/decreased water temperatures in streams
- Improvement/deterioration in ground water quality
- Falling/rising groundwater levels
- Seasonal changes in precipitation/temperature
- Sea level rise

These changes can impact the performance of the urban water infrastructure

Urban Water Infrastructure Components

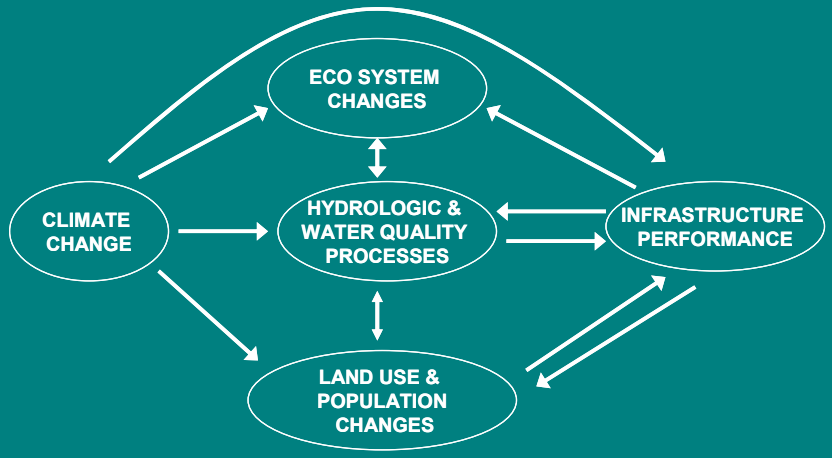
- Water supply infrastructure
  - Source water (surface or ground)
  - Water intakes
  - Treatment plants
  - Distribution system
- Wastewater infrastructure
  - Collection system
  - Wastewater treatment plants
  - Outfall
  - Receiving stream
- Stormwater infrastructure
  - Collection system
  - Combined wastewater/stormwater components
  - Treatment
  - Outfall
  - Receiving stream

What's in an Assessment of Models?

- Processes represented
- Spatial and temporal resolution & extent
- Interactions with other models
- Uncertainty
- Example models
- Issues in applying models in quantitative assessments

Model Categories

- Climate change
- Hydrologic models
- Water quality models
- Ecosystem models
- Population/land use models
- Infrastructure models
- Systems dynamics models



Climate Change Models

- Mathematical models of Earth's climate
- Coupled climate models (AOGCM) represent
  - Atmosphere, ocean, land surface and sea ice
- Downscaling: Spatial and Temporal
  - Deriving daily regional climate estimates from coarse-resolution seasonal model output
- Issues:
  - Uncertainty
  - Short-term intense precipitation events

Hydrologic Models

- Rainfall-runoff models: Predict streamflow resulting from precipitation
- Time scale: Event based or continuous
- Spatial scale: Large or small watersheds
- Examples: HSPF, HEC-HMS
- Integrated with GIS
- Issues:
  - Calibration requirements
  - Most pre-date climate change applications. Are they sufficiently accurate & sensitive?

Water Quality Models

- How water quality varies temporally & spatially due to loadings and environment
- Used in conjunction with hydrologic models
- Examples:
  - Stream water quality models (QUAL2K, WASP)
  - Integrated hydrologic/water quality models (BASINS, SWMM)
  - Integrated streamflow/WQ models (EPD-RIV1)
  - Integrated groundwater flow/WQ models (MODFLOW)
- Issues
  - Spatial & temporal resolution
  - Calibration

Ecosystem Models

- Climatic conditions determine where individual species of plants and animals can flourish.
- Types of models:
  - Biogeochemistry models: simulate changes in basic ecosystem processes
  - Biogeography models: simulate shifts in the geographic distribution of major plant species and communities
- Examples: Terrestrial Ecosystem Model
- Issues: Uncertainty, Interactions, Reliability

Land Use/Population Models

- Project temporal and spatial changes in land use and population
- Integration with GIS
- Feedback: Will climate change affect future land use and population patterns?
- Examples: Many including LTM, SLEUTH
- Reference: EPA/600/R-00/098 (2000)
- Issues: Dependability, uncertainty

Infrastructure Models

- Predict the performance of components of the urban water infrastructure
  - Water distribution systems (EPANET)
  - Urban stormwater systems (SWMM)
  - Water treatment models (WTP)
  - Wastewater treatment models
- Issues:
  - Sufficient sensitivity for climate change studies?

Systems Dynamics Models

- Mathematical models of complex systems with feedback loops. Test “what if” scenarios.
- Examples:
  - MIT Greenhouse Gas Emissions Simulator
  - C-ROADS: The Climate Rapid Overview and Decision-support Simulator
  - ASU Systems Dynamics analysis of urban vulnerability to climate change ($1.3 mil NSF grant)
- Issues:
  - Can we describe the processes in sufficient detail & accuracy to trust the results of the models?
  - Spatial and temporal resolution of models.

Research Needs

- Enumeration of qualitative pathways between climate change and infrastructure impacts
- In-depth evaluation of quantitative assessment tools
  - Current models
  - Uncertainty
  - Impact of changes in other stressors
  - Needed model development

Key Points

1. We must have a clear understanding of the mechanisms & pathways by which climate change can impact the performance of the urban water infrastructure.
2. Existing quantitative models must be evaluated to ensure that they adequately represent these mechanisms & pathways. If not, further research & development is needed
3. There will always be a large degree of uncertainty in the modeling process associated with climate change.