Economic assessment of climate change adaptation options incorporating Bayesian networks: An integrated framework

Gregg, Jay Sterling; Zhou, Qianqian; Åström, Helena Lisa Alexandra; Kaspersen, Per Skougaard; Drews, Martin; Halsnæs, Kirsten; Garrè, Luca; Arnbjerg-Nielsen, Karsten

Publication date:
2013

Citation (APA):
Economic assessment of climate change adaptation options incorporating Bayesian networks: An integrated framework

Jay S. Gregg
Qianqian Zhou
Helena Lisa Alexandra Åström
Per Skougaard Kaspersen
Martin Drews
Kirsten Halsnæs
Luca Garre
Karsten Ambjerg-Nielsen
Purpose

• A framework for climate change adaptation decision making
• Handles complex inter-relationships between impacts and adaptation options
• Flexible structure for applied climate change adaptation decision making.
Outline

• 1. Introduction
  – 1.1 Adaptation in the context of responses to climate change
  – 1.2 Analytical structure
• 2. Scenario construction
  – 2.1. Socioeconomic scenarios
  – 2.2 Climate modeling and climate scenarios
  – 2.3 Future System Scenarios
• 3. Impacts
  – 3.1. Impact Assessment
  – 3.2 Costs
  – 3.3 Risk
• 4. Adaptation
  – 4.1 Identification of Adaptation Options
  – 4.2 Bayesian Network Approach
  – 4.3 Adaptation Costs and Benefits
• 5. Discussion and Conclusions
Introduction

Analytical Structure

Scenario Construction
- Regional Climate Model
- Socio-economic scenario
  - Downscaled Projections
  - Projected state of human controlled system

Impact Analysis
- Impact Assessment
- Adaptation Options
  - Adaptation Costs
- Adaptation Benefits
  - Impact Costs
  - Risks

Adaptation

Decision Making
Scenarios

• Socioeconomic
  – Question of scale (Global vs. Local)
  – Uncertainty bracketed with scenario analysis

• Climatic
  – Regional climate models
  – Downscaling

• Coupled scenarios
Theoretical scenario development: understanding the risks from climate change and the benefits of adaptation measures.

Adapted from Metroeconomica (2004) and the Danish Government (2008)

Reference Scenario: no modeled climate change

Alternative Scenario: Future impacts, with modeled climate change

Benefits of Adaptation

Adaptation options, with modeled climate change

Impacts relative to fixed reference

Residual Impacts

Reference Scenario: no modeled climate change
Impacts

• **Assessment**
  – characterize change in the climate variable or the extreme weather event (intensity, frequency and duration)
  – obtain spatially explicit information on asset exposure and vulnerability
  – develop asset specific thresholds and damage functions
  – quantify of both the physical and economic impacts

• **Costs**
  – Cost-Benefit-Analysis; Net Present Value with discounting
  – Multi-Criteria Decision Analysis

• **Risk**
  – probability of an extreme event multiplied by the consequence of an event
Adaptation Options

• Identification
  – Non-linearity
  – Mapping

• Bayesian Network Approach
  – used to quantify risk in the system
  – determine the probability distribution for each specific impact
  – Static → Dynamic

• Costs and Benefits
  – Priority setting
  – Uncertainty analysis
Linkages of impacts due to climate change for an urban area with adaptation options

Climate Change
- Global sea level rise
- Increased probability of extreme precipitation events
- Increased probability of storm surges

Mitigation
- Workplace flexibility
- Evacuation planning
  - Improved infiltration
  - Managed wetland and riparian zones

Increased probability of flooding
- Dykes, dams, etc.
- Emergency Response
  - Road damage
  - Traffic delays
  - Loss of productivity
  - Health and morality
- Environmental damage
  - Loss of visual amenity
  - Loss of recreational areas

Sewer Damage
- Basement flooding
- Building flooding
- Property loss
- Resettlement

Retrofitted buildings

Environmental damage

Property loss

A static ID for urban flood risk assessment
Dynamic ID for urban flood risk assessment under non-stationary conditions

- **System Configuration**
- **Asset Protection**
- **Protection Decision**
- **Protection Cost**
- **Impact on Asset**
- **Adaptation Cost**
- **Adaptation Decision**
- **Extreme Precipitation**
- **Urbanization**
- **Climate Change**

- **Present**
- **50 years**
- **100 years**

- **Flooding**
- **EAD**

Impact on Asset and Protection are interlinked with other components, illustrating the dynamic interactions under non-stationary conditions.
Discussion and Conclusions

+ The main strength of the BN approach is the ability to represent complex dynamic systems and the inter-linkages between various nodes in the system.

- Complex set of input data required for the analysis & can only deal with continuous values in a limited manner, and these types of variables are common in environmental assessment.
Status

• Submitted May 31, 2013
• One review completed
• Editor requested other reviewer names
Upcoming

• Transportation Analysis of Copenhagen