Visualizing Vulnerability And Valuing Adaptation Options In The Face Of

Climate Extremes

Visualizing Vulnerabilty and Valuing Adaptation Options in the Face of Climate Extremes

Visualizing and assessing potential hydro-climate events in terms of excess moisture and drought is an important first step for decision makers, particularly regarding their potential social, environmental, and economic impacts. An equally important, step is to articulate the relative value of alternative adaptation investments impact reduction on the landscape.

This presentation describes two activities being developed by Agriculture and Agri-Food Canada intended to help decision and policy makers assess watershed and sub-watershed vulnerability and adaptation options. Activity one is a methodology called the Landscape and Infrastructure Resiliency Assessment (LIRA) assesses the vulnerability of a watershed to extreme precipitation events and the value of alternative landscape adaptation strategies under uncertainty. The method uses qualitative and quantitative methods dependent on data and resource availability. The second method, a simulation process, helps integrated teams assess the impacts of extended drought and the adoption a range of adaptations and mitigations.

The Landscape and Infrastructure Resiliency Assessment project is focused on reducing the vulnerability of agricultural landscapes in Canada to extreme moisture events. It is a developmental product that was first completed as a prototype in 2008 with funding from the Canadian Federal Government (Sparks,2007). The Land and Infrastructure Resiliency Assessment (LIRA) method is a probabilistic cost-benefit process that weighs the costs of landscape adaptation, on the one hand, against the likely reduction in landscape damage costs, on the other hand. In practice, the adaptation option which posts the greatest expected Net Present Value (equalling the difference between likely damage cost savings and adaptation costs) is ranked "best" among all considered options. The LIRA method has been used to evaluate landscape adaptation options intended to mitigate damage and damage costs associated with Extreme Rain Events (EREs). The results of LIRA studies to-date suggest the impressive benefits of appropriate planning and targeted infrastructure adaptation. More case studies are underway with the intention of standardizing the process so that it maybe transitioned into operational environments if conditions allow.
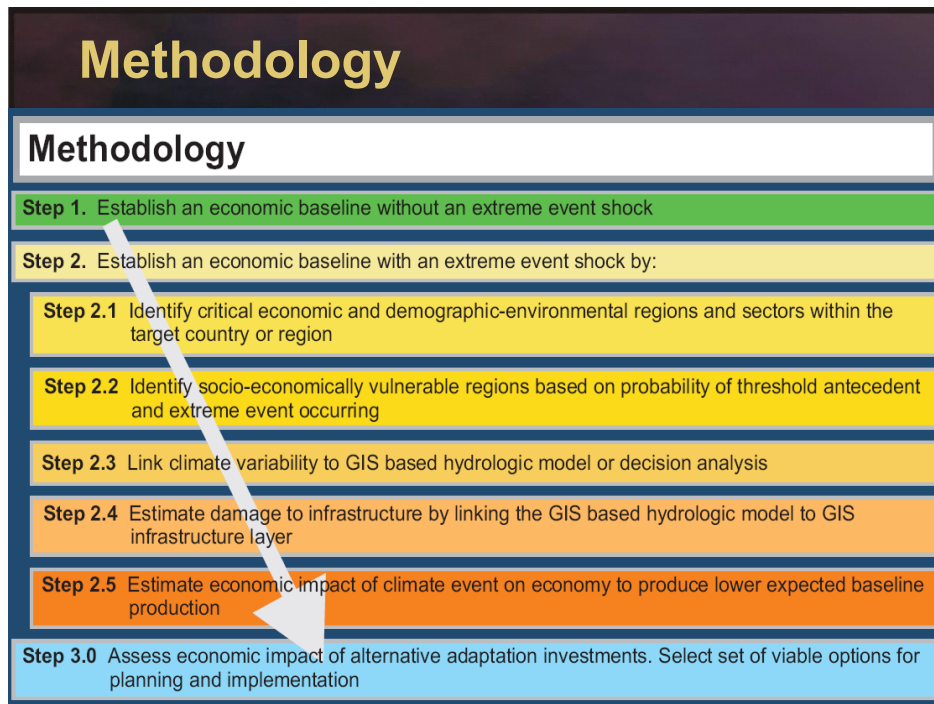
Methodology

Step 1.	Establish an economic baseline without an extreme event shock
Step 2.	Establish an economic baseline with an extreme event shock by:
Step 2.1	Identify critical economic and demographic-environmental regions and sectors within the target country or region
Step 2.2	Identify socio-economically vulnerable regions based on probability of threshold antecedent and extreme event occurring
Step 2.3	Link climate variability to GIS based hydrologic model or decision analysis
Step 2.4	Estimate damage to infrastructure by linking the GIS based hydrologic model to GIS infrastructure layer
Step 2.5	Estimate economic impact of climate event on economy to produce lower expected baseline production
Step 3.0	Assess economic impact of alternative adaptation investments. Select set of viable options for planning and implementation

Figure 1. The LIRA methodology.

Consider a watershed area vulnerable to flooding in the event of extreme rainfalls. Homes and buildings may be damaged or washed away. Crops ruined and livestock injured or killed. Citizens isolated from help and relief. Et cetera. When we improve our ability to combat such damages through various forms of adaptation (including planning initiatives and infrastructure modification), we reduce the damage and damage costs experienced should an extreme rainfall and flooding occur. At the same time, however, we incur the costs of adaptation. To ensure we do the best we can, we must carefully weigh the benefits enjoyed (i.e., likely damage cost savings) against the costs incurred (i.e., adaptation costs). The LIRA method is designed to facilitate such comparison.

Figure 2.1 illustrates the essential steps of the LIRA process to conduct the Cost Benefit Analysis. For a watershed area or region under evaluation, participants must first select an appropriate planning period and discount rate (e.g., 25-year planning period and 5% real discount rate). In step two, it is then necessary to define a set of adaptation options for study and estimate the corresponding costs – both capital and on-going costs – over the planning period. This may include planning initiatives (e.g., zoning practices to discourage development in flood-prone areas) as well as infrastructure development or modification (e.g., water retention and drainage systems, strategic culvert placement, etc.).
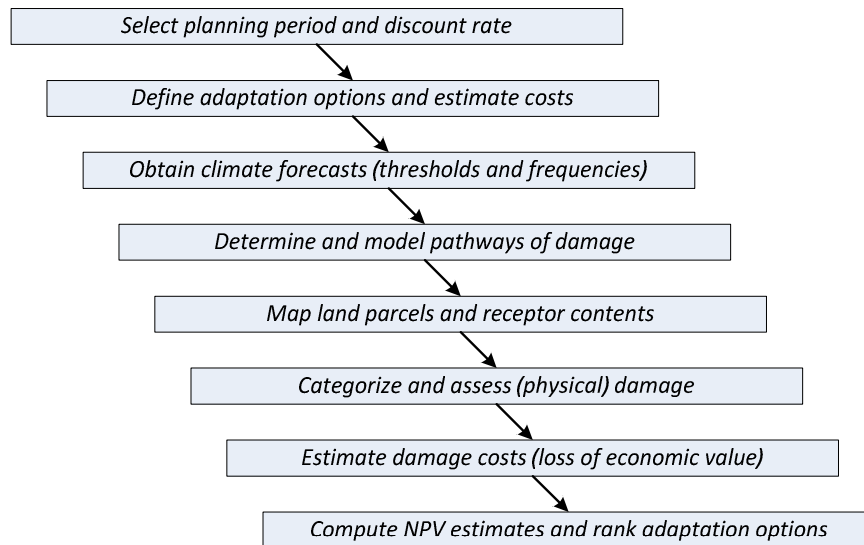
```
┌─────────────────────────────────────────────┐
│   Select planning period and discount rate   │
└─────────────────────────────────────────────┘
              ↓
┌─────────────────────────────────────────────┐
│    Define adaptation options and estimate costs    │
└─────────────────────────────────────────────┘
                ↓
┌─────────────────────────────────────────────┐
│   Obtain climate forecasts (thresholds and frequencies)   │
└─────────────────────────────────────────────┘
                  ↓
┌─────────────────────────────────────────────┐
│      Determine and model pathways of damage      │
└─────────────────────────────────────────────┘
                    ↓
┌─────────────────────────────────────────────┐
│       Map land parcels and receptor contents       │
└─────────────────────────────────────────────┘
                      ↓
┌─────────────────────────────────────────────┐
│        Categorize and assess (physical) damage        │
└─────────────────────────────────────────────┘
                        ↓
┌─────────────────────────────────────────────┐
│      Estimate damage costs (loss of economic value)      │
└─────────────────────────────────────────────┘
                          ↓
┌─────────────────────────────────────────────┐
│   Compute NPV estimates and rank adaptation options   │
└─────────────────────────────────────────────┘
```

Figure 2: The LIRA steps to conducting a cost benefit analysis

The third step in the LIRA process is to obtain regional climate forecasts of Extreme Weather Events – forecasts that may be influenced by global climate trends. In the case of rain events, defined thresholds (e.g., 75mm of rainfall within 12 hours) and frequencies (e.g., 1-in-50 year event) are needed to generate probabilistic rainfall "forecasts" over the selected planning period. These forecasts are essential to the LIRA process since damage and damage costs occur only when such extreme events actually occur (whereas the costs of adaptation are incurred regardless of future rainfall patterns).

Step four is to determine the pathways of damage through the landscape. The essential pathways here involve water flows (e.g., rivers and creeks overflowing their banks) and water ponding (i.e., areas where water is likely to be retained within the landscape). The fifth step of the LIRA process is to "map" landscape parcels and their contents (a task for which Geographic Information Systems – GIS – are ideally suited). When we "overlay" our water flooding forecasts over these maps, we quickly ascertain which landscape parcels are most vulnerable to water flows and ponding. Moreover, with a description of parcel contents, we can also initiate the process of estimating damage and damage costs.

Step six of the process is to estimate the physical damage that can result from flooding. Analytically, it is very difficult to model such damage processes. For this reason, historical record (e.g., insurance claims) and expert judgement proves necessary and useful for the purposes of "categorizing" the extent of damage over differing contents (e.g., roadways, buildings, crops, etc.) and expected flood levels. Step seven translates estimates of physical damage to economic losses. These include direct losses (e.g., cost of restoring infrastructure services and housing) as well as indirect losses (e.g., loss of income due to disruption in normal economic activities).

The final step – step eight – is to calculate the Net Present Value (NPV) of forecasted damage cost savings against the costs of the adaptation options under investigation. Since the analytical process is probabilistic in nature (resting on probabilistic rainfall "forecasts" over the planning period), the results are expressed in the form of cumulative probability distributions (or, risk

profiles) that allow decision-makers to view both the expected (average) value and statistical distribution of NPV results for each adaptation option of interest. This provides a richer set of information for decision-makers seeking to select effective, practicable and defensible adaptation options for Extreme Weather Events.

Current Status: The LIRA project has been developed in phases it is now entering into the fourth of five phases:

Phase 1 – Scoping Study - 2006

Phase 2 – Develop methodology – Regional Analysis only
(RM of Corman Park 2006-07)

Phase 3 – Develop detailed methodology – Economic analysis,
adaptation options and costing, RM participation.
- RM of Corman Park Pilot Site – funded by NRCAN, 2007-2008

Phase 4 – Standardization, 2009 to present.
- Test reproducibility of method to ensure <u>national applicability</u>
- Complete development of a manual and test a standardized methodology in pilot
        studies in Saskatchewan and Nova Scotia

Phase 5 – Possible Operational status
  - Decision makers across Canada utilizing methodology
  - To be determined if it will be formally integrated into adaptation planning.

Possible links to the International Strategy for Disaster Risk Reduction and the Hyogo Accord

The Global Fund for Disaster Risk Reduction has invested in both the Central American Probabilistic Risk Assessment project and the more general Comprehensive Approach to Probabilistic Risk Assessment each referred to as CAPRA. Each approach could possibly benefit from the use of a LIRA like approach as it is envisioned by Hill, Weiner, and Warner, 2011. In their conceptual piece they lay out a method where tools like the CAPRA activities could be aggregated to support modifications of macro economic models with and without adaptation investments.

Constraints:

Data is always a constraint particularly digital elevation maps due to the relative flat landscape in many agricultural regions of Western Canada. The application of the methodology with decision analysis is being explored to determine its effectiveness in data constrained environments.

The methodology is a diagnostic process which does not produce engineering quality analysis. It does provide insights about landscape vulnerability and threats to overall infrastructure systems. It also helps identify areas where more in-depth analysis would be beneficial.

2. The Invitational Drought Tournament

A second and more recent initiative is the invitational drought tournament. It is intended to be one of a portfolio of extremes simulation exercises intended to enhance the capacity of decision makers in different disciplines to understand the policy and planning issues associated with climate extremes which they normally do not deal with.

The tournament idea works with the idea that people in teams working towards a prize will think collaboratively regarding issue and innovative solutions to address the problem. The first prototype tournament was played in Calgary, Alberta in February, 2011.

Though work needs to be done to refine the product the initial assessments were highly positive.

Tournaments related to excess moisture events and combinations of dry and wet will be developed as resources permit.

References:

Hill, H., J. Weiner, and K. Warner. 2011. Fatalism To Resilience: Reducing Disaster Impacts Through Systematic Investments. Journal of Disasters. Publication date in 2011..

Kayter, C. 2007. Assessing the Flood Risk to a Region's Infrastructure & Environment:Finding Cost Effective Solutions

Sparks, G. 2007. Adapting to climate extreme events risks across Canada's agricultural economic landscape: an integrated pilot study of watershed infrastructure system adaptation. Natural Resources Canada. An Evaluation of Impact Assessment Procedures. http://adaptation.nrcan.gc.ca/projdb/index_e.php?class=102.