Regional RiskScape: A multi-hazard loss modelling tool.

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1. Summary

The management and mitigation of natural hazards and the response to disasters has become increasingly important for local and national authorities over the last decade. Geological hazards are an ever present danger in New Zealand, which straddles the Pacific and Australian crustal plates. The frequency of severe weather-related events is increasing, not only because of global warming, but also as people historically have continued to settle in areas which are inherently at risk from natural hazards such as the coast or flood plains. To help make effective risk management decision, these potential perils require tools and a decision support system that facilitates the analysis and comparison of risks from different hazards. RiskScape is such a multi-hazard loss modelling tool, being developed in New Zealand.

The prime goal is to develop an easy-to-use decision-support tool that converts hazard exposure information into likely consequences for a region, such as damages and replacement costs, casualties, disruption and number of people affected. Consequences for each region presented in a common platform across all natural hazards can then form the basis of prudent planning and prioritized risk-mitigation measures that link directly to the severity of the risks

The development of the Regional RiskScape system has been underway for three years of its four year development phase. The paper describes the status of the development and also address problems and areas where further work is required.

2. Introduction

New Zealanders are exposed to a wide variety of natural hazards. The extremes of weather and geological forces that create its unique character also present many hazards, including earthquakes, volcanic eruptions, tsunamis, storms, floods and landslides. River flooding is the most frequent and costly peril in New Zealand, but at longer return periods, earthquakes and tsunami can produce substantial damage and loss of life e.g., 1931 Hawkes Bay earthquake. Further, the consequences of all weather-related hazard events are likely to be compounded by the effects of global warming. In particular, the major increases in risk will be in coastal areas (due to sea-level rise and associated intensification of waves and storms) and river/urban inundation (due to intensification of rainfall).

Increasingly, emergency managers and planners are demanding more quantitative information on possible consequences and the risks associated with different hazards to be in a position to compare the impacts across the different hazards before making investment decisions on risk reduction for their region. For example, a recent overview of the national tsunami risk has estimated that the potential for casualties and damage is higher than the national earthquake risk given the same exceedance probability.

3. RiskScape Framework

The prime goal is to produce an easy-to-use decision-support tool that converts hazard exposure information into likely consequences for a region, such as damage and replacement costs, casualties, disruption and number of people affected. Consequences for each region presented in a common platform across all natural hazards can then form the basis of prudent planning and prioritized risk-mitigation measures that link directly to the severity of the risks.

First off, the zone of influence of a particular hazard needs to be ascertained and its local intensity and recurrence interval established. Then the impact of events of various intensities can be calculated by overlaying the hazard exposure for each event over built-environment inventories and demographic profiles of the people exposed to such event (i.e. the receptors). Then, by reference to the fragility (susceptibility) of each inventory or people class to that exposure, the losses and casualties resulting from these events can be quantified. Conceptually, this process is relatively straight forward, but application to real-world situations is problematic, with inherent difficulties in obtaining and linking good-quality inventory and demographic datasets and comparing hazards with vastly different recurrence intervals and source mechanisms. These challenges are being met by the development of a Regional RiskScape Model through a joint-venture between GNS Science (geological/tsunami hazards) and NIWA (weather-related/tsunami hazards).

The key principles built into the RiskScape system are:

- Primarily intended for applying to regions (e.g., New Zealand has 15 regions based around river catchments);
- Usable by emergency managers and planners who may have little knowledge of the science and engineering aspects of natural hazards;
- Develop the computational “engine” using open-source software with limited GIS-like capability to avoid expensive licensing arrangements, but still provide input/output processing on a GIS platform;
- Designed as stand-alone software to be functional during a major hazard event and not be reliant on a server.
- Capability to implement external asset databases, models or loss curves. Gives the end-user the flexibility to implement RiskScape into their existing environment rather than being forced to switch to a completely new system.
- Results on the consequences (damage, disruption, casualties) will primarily be produced for aggregated areas (e.g., census meshblocks 30–50 houses). Computations at the individual building or infrastructure scale would be restricted to owners of the inventory data.
- Where possible provide truly comparable losses & casualties from different natural hazards for specified exceedance probabilities (or return periods) , as well as the ability to simulate losses from historic or prescribed scenarios;
- Ability to import directly the modelled hazard exposure fields from previous runs of sophisticated dynamic models (that may take several hours to run) or to compute these fields internally where simpler attenuation models are possible e.g., earthquake shaking;
- Concerted effort to track uncertainties at all stages of the processing that turns a hazard exposure into losses;
- Working alongside regional and local government partners over the 4-year project to provide a fit-for-purpose tool that is practically useful in risk-reduction decision making;
- Fast computational system that enables the system to also be used during a major hazard event as it unfolds or as a simulated exercise by emergency managers.

The overall concept and flow chart of the Regional RiskScape system is shown in Figure 1.

For the initial development phase (4 years), we are trialling the system with three regional/local government partners (Westport, Napier & Hastings, Christchurch) which cascade up by an order of magnitude in population. The initial natural hazards being considered are: earthquake, volcanic ash-fall, local and distant tsunami, storms (wind only), and river flooding. However, the software design allows other hazard modules to be added later.

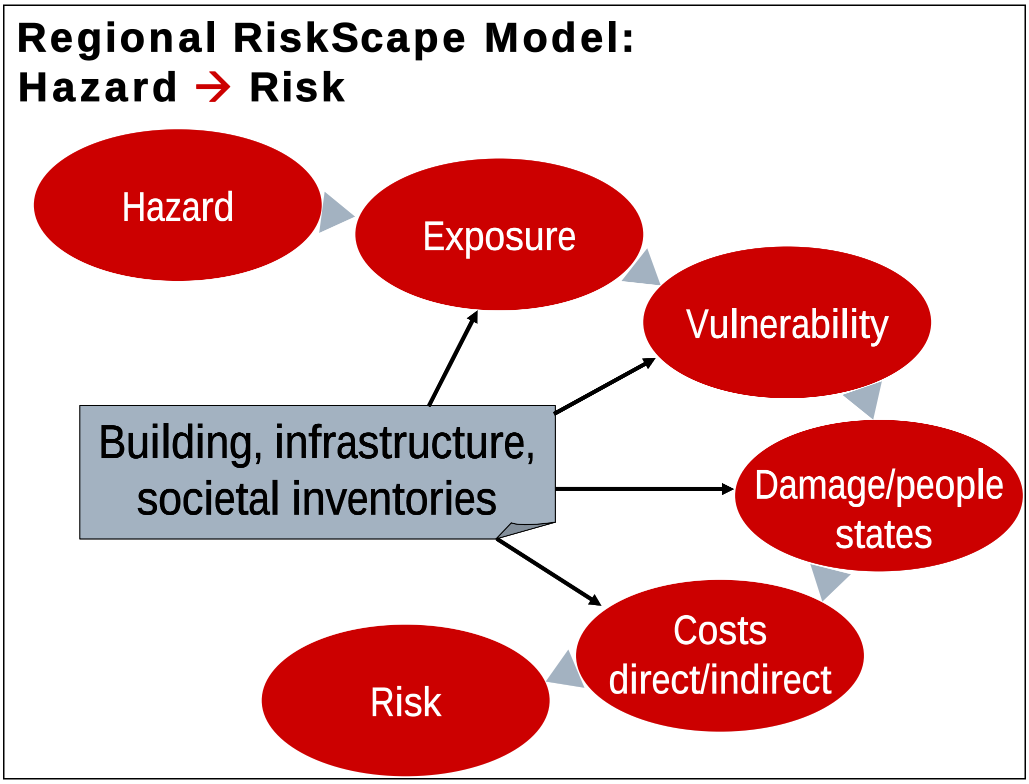

Figure 1. *Flowchart of main modules of the Regional RiskScape tool.*

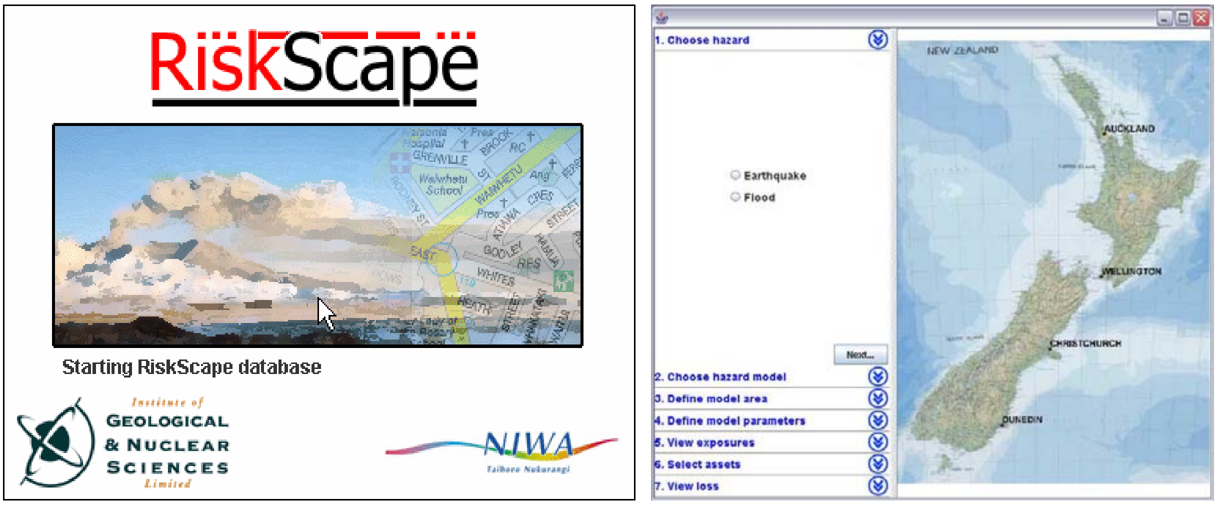

Figure 2. *RiskScape User interface*

Damages or losses are typically categorized as direct or indirect. Often the focus lies on direct damages such as buildings but the economic impacts of a disaster can be as high as the direct costs. Indirect losses arise mainly through the second order consequences of disasters, such as the disruption of economic and social activities within and beyond the area of immediate direct physical impact.

The economic effects caused by a major disaster could be significant depending on where the boundaries of the analysis are drawn. If a national perspective is taken, the economic effect of the lost trade would normally be small. However, if the analysis is confined to the affected area, the economic effects can be severe, although some sectors like the construction/building sector often benefit. Hence, RiskScape does not only focus on direct damage to our built environment but also addresses the impact on people's lives and indirect damages. That provides planners and emergency managers with a comprehensive and detailed overview of possible consequences and enables them to prepare and develop mitigation strategies in due time.

4. Issues and Challenges

The project was launched in 2004, the first prototype released to our partners in July 2006 and an operational version is expected for winter 2008 which can then be applied in other areas of New Zealand. After 3 years into the project, several issues have emerged that provide some challenges to the development and implementation of a quantitative risk assessment tool:

- Access and availability of building and infrastructure inventory data that has sufficient parameters to assign fragility classes and hence fragility curves and damage states for each natural hazard. An example is the lack of ground-floor elevations for buildings to assess flood and tsunami damage. At this stage we have calibrated a floor height relationship using building age classes as a surrogate based on field sampling surveys;
- Accurate modelling of the hazard exposure is a crucial step in the process, particularly for topographically-steered hazards such as floods and tsunami and to a lesser extent wind. A critical element of successful modelling in this context is the availability of accurate coastal and floodplain topography such as LIDAR or satellite radar altimetry;
- Each hazard sector use different ways to communicate risk, probability and uncertainty, so we have an ongoing need to work with our partners to ensure they have results from RiskScape that are appropriate for their intended use in decision making;
- Acceptance of the results including the inherent uncertainties (no matter how grim) by the end users and means by which they can be assisted in getting public and political buy-in for appropriate and cost-effective risk mitigation measures e.g. the cost-benefit may be higher for earthquake-proofing a critical bridge than adding more height to a stopbank (dyke) in a particular area to reduce flood risk (or vice versa);
- Ongoing maintenance of hazard exposure models & inventory datasets as changes in the built environment occur and revised updates on climate-change projections become available.

5. Outlook

The Regional RiskScape decision-support tool has been through a 3-year development phase. Much has been achieved in firming up the concepts and undertaking preliminary software development through the cooperative effort of two institutes working together. Field experience in sampling building attributes relevant to a wide range of natural hazards has been invaluable in assessing the minimum information required, complemented with the use of more-readily-available surrogates such as building age where possible. Key progress steps now are: a) to use preliminary results of Regional RiskScape to demonstrate to and consult with local/regional government agencies involved in hazard management about how to best streamline the tool and its outputs to suit their requirements; and b) then to proceed to fine-tune and operationalize the tool in the remaining year.

6. Acknowledgements

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