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Risk modelling as a tool to support natural hazard risk management in New Zealand local government

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ABSTRACT

Due to New Zealand's exposure and vulnerability to natural hazards, it is important for local government to have tools that enable effective use of its natural hazard risk information. This paper explores the use of risk modelling as a tool that can support local government to better understand, manage, and communicate natural hazard risk. Focus group sessions were held with emergency management and other natural hazard practitioners in councils across New Zealand to understand their perceptions on the value of risk modelling tools, particularly 'RiskScape'. While practitioners see the value in the use of risk modelling relating to communication, decision making, planning and emergency response purposes, they also see a number of challenges. Challenges identified for the use of risk modelling relate to how emergency management and natural hazard risk is perceived and managed, issues with connecting information and developing data, and the capability of risk modelling software. Underlying these challenges is the recognition that while risk modelling can help span the science-policy interface, it is the problems with this interface that slow its development. However, with ongoing mutual engagement, risk modelling can become an effective tool to communicate natural hazard risk and better inform natural hazard policy and procedure.

1. Introduction

> *'Sometimes it does us a power of good to remind ourselves that we live … where two tectonic plates meet, in a somewhat lonely stretch of wind-swept ocean just above the roaring forties. If you want drama – you've come to the right place'* (Sir Geoffrey Palmer, cited in [47]. p.2).

New Zealand is an island nation in which events such as earthquake, volcanic activity, tsunami, flooding, storm, and landslide occur with sufficient intensity that substantial damage and loss of life results [32]. Given the severity of natural hazard risks, it is an increasingly important focus for national and local government to ensure natural hazards are understood and managed effectively. However, local government understanding and management of natural hazard risk is fraught with challenges, including uncertainty over how natural hazards should be managed [40,61], scarce data on natural hazards [51,70], and limited appreciation of natural hazard risks [40,70].

Underlying these challenges is the disconnect of 'science to policy'. While scientists, policy-makers and practitioners agree on the importance and value of science informed policy and practice, bridging the science to practice gap is not a simple task and depends on a mutual spirit of partnership and interest between the scientific and practice communities (Vogel, 2007). Kilvington & Saunders [31] reflect on this in their review of how natural hazards science is incorporated in land use planning in New Zealand, recognising that "despite genuine and ongoing efforts to improve the relationships between science information users and producers, research agencies still struggle in many ways to fully transition their communication practice towards new ideals" ([31]. p4.).

Along with this, the need for improved risk communication between science, policy and practice has been increasingly recognised [29,35,76]. However, much of the research has focussed on the tenets and mental models of risk communication [20,30,4,41], and while there has been a call for the use of tangible heuristics and models to support decisions for effective risk management [67,76], little is known about how effective risk models are as a communication tool for natural hazard risk management.

The term 'risk modelling' can be applied to many frameworks and guidance. Within this paper, we focus on risk modelling as a software application, based on a risk assessment framework, to assess the consequences of a natural hazard event. Risk modelling is important as

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understanding the impacts and consequences of a natural hazard event is an essential building block for resilience [10]. This paper explores the perception and use of risk modelling, with specific reference to the 'RiskScape' model, as a tool to support local government in New Zealand to better understand and communicate natural hazard risk.

This paper begins by explaining the structure for how natural hazard risk management is applied within New Zealand local government. It details the role of emergency management, known in New Zealand as CDEM (Civil Defence Emergency Management), within that natural hazard risk management function, and recognising the complicated legislative environment in which this takes place. We then describe risk modelling as a tool to support natural hazard risk management and introduce the RiskScape modelling tool. From here we explain our use of focus groups to gather data on how natural hazard risk practitioners perceive risk modelling, and examine three key themes that emerged from analysis of the results: 1) 'CDEM within and across councils'; 2) 'Drivers and needs for risk modelling'; and 3) 'Risk data sources and pathways'. We discuss our findings, setting out the challenges and opportunities for the use of risk modelling, and how these are driven by the existing disconnect across the science-policy interface. We conclude by giving recommendations for how the science-policy interface can be improved in local government, to better enable its use of natural hazard risk modelling, which can then inform improved natural hazard risk policy and procedure.

2. Local government natural hazard risk management

The responsibility for natural hazard risk management in New Zealand is devolved from central government legislation to local government for application, with local government operating under a tiered structure of regional and district councils. Regional councils manage a larger geographic area and are comprised of between one to ten district councils. As such, regional councils play more of a directing role, developing regional policy which the district councils comply with. (Fig. 1)

While regional and district councils have slightly different functions, both tiers of local government fulfil responsibilities including:

- sustainable well-being;
- environmental management;
- emergency management and civil defence preparedness;
- infrastructure, including roads, water, sewerage, and storm water;
- environmental health matters including building control, public health inspections; and
- controlling the effects of (including hazardous substances, natural hazards and indigenous biodiversity), noise, and the effects of activities on the surface of lakes and rivers [28].

Natural hazard risk management is spread across all of these responsibilities, and is achieved through a combination of national and local policies, plans and strategies. It requires many council roles to work together in a coordinated way, and consists of high level and widely interpretative policy guidance [40]. Given the breadth of natural hazard policies and the differences in how they are managed, there is no formal approach for how hazard risk management is achieved, or which council function owns it [1,40].

Within this complicated policy environment sits Civil Defence Emergency Management (CDEM). CDEM in New Zealand promotes the sustainable management of hazards and encourages communities to manage natural hazard risk via a framework of Reduction, Readiness, Response and Recovery, known as the 4R's. By addressing the consequences of these hazards, the focus can move to measures for reducing the risks and for managing the impacts when they occur. The framework for how the 4Rs are applied is led by The Ministry of Civil Defence & Emergency Management (MCDEM) through the CDEM Act, via CDEM Groups [39]. CDEM Groups are a partnership of the district and regional authorities across a region, in conjunction with emergency services, utilities management groups and other government departments to identify hazards and risks. CDEM Groups develop Group Plans to manage those hazards and risks following a risk based approach:

> *The requirement to practice sound risk management is implicit throughout the CDEM Act. CDEM Groups are required to apply risk management to their planning and activities. Whilst planning is not a linear process and may involve many iterative steps, it is expected to follow a risk management based approach* [45].

MCDEM is also the national focal point for New Zealand's implementation of the Sendai Framework for Disaster Risk Reduction 2015–2030 (UNISDR, 2015; [46]). This involves providing leadership within a multi-sectoral, holistic approach to implementing disaster risk reduction and coordinating progress reporting, as required under the monitoring regime of the new framework.

3. Natural hazard risk modelling

Natural hazard risk modelling involves combining hazard impact scenarios with exposure data and vulnerability functions. The output is an estimate of loss, depicted in various ways including economic cost; human casualties or fatalities; building damage states; societal disruption; and other types of consequence given the severity of the hazard.

Demand for natural hazard risk modelling has significantly increased over the last few decades [67]. Researchers, policy-makers and practitioners increasingly seek to use risk modelling to scope the consequences for hazard scenarios they know people are exposed to but have little historical information about. Pondard and Daly [59] illustrate how risk modelling can give a more comprehensive insight into natural hazards and their socioeconomic consequences, setting out three key benefits:

1) A clearer overview of geographical concentrations of natural hazard risks, across different frequencies and magnitudes;
2) Quantification of potential physical damage, business interruption and casualties; and
3) Identification of key risk drivers.

As such, a clearer, more comprehensive picture of the uncertainties and consequences of natural hazards provides policy-makers and decision-makers with a better starting point to communicate and decide on how they manage the cost and benefits of risk reduction measures [18,32,52,59,65].

However, risk models also come with a number of limitations relating to the development and modelling process itself and their uptake and application by users. A model is only a representation of reality and is therefore defined by a series of assumptions. These assumptions are informed by imperfect historical records, our incomplete knowledge of natural processes, limitations in how the model describes those natural processes, as well as perceptions around exposure and vulnerability. Furthermore, each of the components within a risk model has its own set of associated uncertainties. Table 1 outlines these components as set out by Van Asselt [72] in her figure – 'Uncertainty in the modeller's and decision-maker's view':

As these uncertainties compound, the modelled output may move further away from 'accuracy', providing only an order of magnitude estimate [23], which may not give much assurance for stakeholders and decision-makers. Also, the application of risk modelling tools relies on sound data being available in a format that can be input into the model; the technical capacity to employ the modelling tool to produce results that are relevant and accessible; trust from users in the validity of the results; and mandate from decision-makers to use the tool [68]. If any aspect of this is inhibited, then confidence in the practice of risk modelling can be diminished.

The RiskScape risk modelling tool has been developed over the last