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Tsunami resilience: Aotearoa New Zealand's path to integrated risk management and engineering design

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ABSTRACT

Tsunami threats persist along coastlines worldwide, necessitating proactive measures to safeguard lives and property. Recent catastrophic events, such as the 2004 Indian Ocean tsunami and the 2011 Japan tsunami, have underscored the potential risks of a locally generated tsunami for Aotearoa New Zealand, particularly from the Hikurangi subduction margin off the North Island's east coast. To address this threat, scientific and emergency management communities in New Zealand have shifted their focus to assess and enhance tsunami risk management. This paper presents results from a workshop held with tsunami scientists, engineers, social scientists, and emergency managers. A workshop held during the QuakeCoRE Annual Meeting in August 2023 gathered experts to explore the development of an integrated tsunami risk management system in Aotearoa New Zealand, through various tools developed including hazard assessment, engineering design and guidance, warning guidance, and mitigation activities by communities and local and national government entities. This paper offers an exploratory view of Aotearoa New Zealand's evolving strategies to manage tsunami risks.

1 INTRODUCTION

Tsunami threats persist along coastlines worldwide, necessitating proactive measures to safeguard lives and property. Recent catastrophic events, such as the 2004 Indian Ocean tsunami and the 2011 Japan tsunami, have underscored the potential risks of a locally generated tsunami for Aotearoa New Zealand, particularly from the Hikurangi subduction margin off the North Island's east coast (Dhellemmes et al., 2021; Wang et al., 2023).

To address this threat, scientific and emergency management communities in New Zealand have greatly enhanced their tsunami risk management focus (Johnston et al., 2013). The 1960 Chilean tsunami, which struck New Zealand without official warning and caused significant damage, despite occurring at low tide was a catalysis for change. From 1960 to 2004 various measures were put in place, such as becoming part of the Pacific Tsunami Warning System, which led to improvements in official warning mechanisms (Johnston et al., 2008). However, surveys in 2003 showed that public understanding of tsunami risk and correct warning-response action still had considerable room for improvement. Following the 2004 Indian Ocean tsunami there was a step change in effort, with the New Zealand government initiating an extensive review of national tsunami hazard, risk, and preparedness (Webb, 2005).

Over the last decade there has been significant local, regional, and national efforts undertaken to support new science (physical and social sciences), improved policy mechanisms (e.g., Tsunami Working Group, Tsunami Reference Group etc.) and enhance capacity building at all levels within the emergency management sector. Public education activities like the annual Tsunami Hīkoi have been expanded to help lift levels of preparedness. Consideration of engineering issues related to vertical evacuation structures has recently received enhanced consideration (Cortez et al., 2020; Lewis et al., 2020, MBIE 2020, FEMA 2019). Arguably the greatest priority is still to increase public understanding that local tsunami will not be preceded by official warnings, and that immediate self-evacuation is the best way to preserve life-safety (Blake et al., 2018; Dhellemmes et al., 2021).

2 METHOD

The full-day workshop on tsunami resilience was held during the QuakeCoRE¹ Annual Meeting 2023 Aligned Workshops on 29 August. The workshop was held in two parts to explore specific topics. The first topic, held during the morning session, focussed on developing an integrated tsunami risk management system in Aotearoa New Zealand. The second topic delved into engineering design for tsunami, as protecting critical infrastructure in inundation zones is central to tsunami risk mitigation and designing evacuation buildings to withstand tsunami impacts. The method and results presented in this paper are primarily from the workshop's morning session, focussing on the wider tsunami risk management framework.

2.1 Session Participants

A total of 28 participants attended the morning session of the workshop. The workshop was aligned with the QuakeCoRE annual meeting, which had approximately 250 attendees, all of whom were invited to attend. The annual meetings' participants are primarily researchers in engineering and social sciences relating to earthquake and disaster resilience. The workshop was also open to the emergency management sector through invitations to the National Emergency Management Agencies and the Civil Defence & Emergency Management groups.

¹ QuakeCoRE is a Centre of Research Excellence (CoRE) that focuses on earthquake resilience research. It is funded by the New Zealand Tertiary Education Commission. It brings together expertise from a range of expertise including engineering, geology, seismology, social sciences to develop a holistic understanding of earthquake impacts.

2.2 Session structure and guide questions

The workshop's first session explored how to reduce the risk from future tsunamis in Aotearoa New Zealand. It started with two presentations to help frame the context. The first presentation was by Graham Leonard (GNS Science), who provided an overview of tsunami risk management and outlined the various focus groups involved in tsunami risk management in Aotearoa New Zealand. The second presentation was provided by William Power (GNS Science), giving an overview of tsunami evacuation modelling research in New Zealand.

After the presentations, the participants were asked to form groups to discuss three guide questions that helped frame the workshop. Each group comprising 7 to 8 participants used Post-it notes and worksheets to answer the questions. The questions were explored one at a time, providing participants with approximately 15 minutes for discussion. A representative from each group summarised their answers to the wider workshop participants at the end of each 15-minute session. The following were the workshop guide questions:

- Question 1: What research questions or topics must be explored to help shape tsunami risk management policy and practice?
- Question 2: How can we leverage QuakeCoRE's research expertise to strengthen policy and practice in tsunami risk management?
- Question 3: Which sectors or stakeholders are missing from the ongoing conversation on tsunami risk management, and how can we engage more effectively?

These questions guided participants to share their knowledge, experience, and outlook on tsunami risk management in NZ. The first question asks for pertinent questions or topics that need to be addressed, the second one looks at the current research capacity within the research community, and the third explores future avenues to ensure inclusive research that will affect policy and practice.

2.3 Analysis of the workshop session.

The Post-it notes and worksheets were photographed and subsequently transcribed. The facilitators of the workshop also took notes during the session. The transcribed material was subjected to qualitative analysis involving the following steps: (1) summarising notes for each question, (2) listing and clustering keywords into themes for each question, (3) collating themes as answers to the questions, and (4) using patterns and commonalities across questions for insights.

3 WORKSHOP SESSION RESULTS

Several recurring themes resulted from the groups' answers and discussion of the questions. The following summarises the findings for the workshop guide questions.

Question 1: What research questions or topics must be explored to help shape tsunami risk management policy and practice?

Participants discussed topics that would help shape tsunami risk management policy and practice, which can be grouped into six main themes (See Table 1). The groups identified six key themes to shape tsunami risk management policy and practice. Firstly, Social Science and Public Education highlighted understanding public motivations, building trust in science, and considering cultural factors. Coordination and governance emphasised the need for motivation and high-level coordination. Structural and Infrastructure Resilience focused on exploring engineering solutions for tsunami risk mitigation. Evacuation Planning and Communication stressed overcoming barriers, identifying routes, and effective community communication. Long-term planning underscored climate change considerations and comprehensive recovery planning.

Lastly, Legislation and Policy highlighted evaluating existing frameworks and determining the effectiveness of mandatory requirements. Collectively, these themes provide a roadmap for further research areas to help build tsunami risk management strategies for Aotearoa New Zealand.

Table 1. Research themes and topics for tsunami risk management policy and practice

Theme	Topics to explore
Social Science and Public Education	<ul style="list-style-type: none"> • Understanding what motivates people to act in response to tsunami risks, • Increasing trust in science as a directive force in driving tsunami policy, • Considering cultural, political, and economic factors influencing Vertical Evacuation Structures (VES), • Developing effective public education strategies for community evacuation.
Coordination and Governance	<ul style="list-style-type: none"> • Motivating coordination at various levels, including Civil Defence/ministerial and local government, • Achieving a high level of coordination for reduction and planning, including considerations of joint ownership by local and central government.
Structural and Infrastructure Resilience	<ul style="list-style-type: none"> • Exploring structural solutions for tsunami risk mitigation, • Dual-purpose structures and infrastructure resilience for evacuation, • Assessing existing buildings for vertical evacuation use, • Mitigating the impacts on the built environment, • Retrofitting buildings as VES.
Evacuation Planning and Communication	<ul style="list-style-type: none"> • Overcoming barriers in evacuation plans, such as mobility issues, • Identifying suitable evacuation routes and safe areas on maps, • Understanding the social impact of evacuations, • Effective communication and exercises with communities about evacuation plans.
Long-term planning	<ul style="list-style-type: none"> • Considering the implications of climate change on tsunami risk, • Planning for post-tsunami recovery and incorporating it into current land use plans,
Legislation and policy	<ul style="list-style-type: none"> • Evaluating how existing health and safety legislation/frameworks inform tsunami preparedness, • Determining suitable mandatory requirements and the effectiveness of optional guidelines, • Policy and procedures not just for building structures but also for maintaining them.

Question 2 and 3: How can we leverage QuakeCoRE’s research expertise to strengthen policy and practice in tsunami risk management? Which sectors or stakeholders are missing from the ongoing conversation on tsunami risk management, and how can we engage more effectively?

All the groups emphasise the importance of leveraging QuakeCoRE’s multidisciplinary strengths. The discussion highlighted the areas where the QuakeCoRE community could connect better, which also overlapped with the third question on which stakeholders are missing from the conversation. The participants highlighted further work is needed on:

- **Policy influence and integration** – evidence-based policy setting is a common theme. The participants discussed the existence, extent, and influence of tsunami-related standards. A potential area of research strength is conducting impact assessments and stakeholder engagements to help make legislative changes.
- **Engagement** – the participants also highlighted the importance of involving researchers and practitioners in the same space and the need to connect with various tsunami working groups and collaborate with practitioners.
- **Science communication** – the participants also stressed the need to communicate research findings effectively to policymakers and practitioners. Ideas shared include ‘bite-size’ policy briefs and making workshops accessible and inviting. Better translation and promotion of research outputs to make them more accessible and useful.
- **Infrastructure focus** – the groups also emphasised the importance of infrastructure resilience, including the need for tsunami-related standards and further research projects on built environment projects.
- **Funding** – the participants emphasised the need for resources to conduct further research.

These themes collectively emphasise the need for collaborative, evidence-based, and community-oriented approaches to strengthen policy and practice in tsunami risk management.

Various sectors and stakeholders have been identified as missing or lacking from the current discussions on tsunami risk management, and strategies for more effective engagement have been proposed. Some key sectors highlighted include the need to enhance local and regional awareness, involve property owners, engage with public education, and collaborate with the Department of Conservation, and the boating sector. Other suggestions include involving individual rescue efforts, trusted scientists and engineers, political champions, and external success story representatives. Additionally, there is a call for evaluating current engagement methods and enhancing the inclusion of Iwi/Māori, socially/economically vulnerable persons, private consultants/practitioners, and critical service providers. This collective insight underscores the importance of adopting a diverse and inclusive approach, encompassing various stakeholders to enhance the effectiveness of tsunami risk management efforts.

4 DISCUSSION AND FUTURE DIRECTIONS

The insights gathered from the first workshop session provide a start for further advancing tsunami risk management in New Zealand. The identified themes collectively shape a roadmap, spanning social science, governance, infrastructure resilience, communication, and long-term planning. The workshop’s findings underscore the importance of ongoing dialogue, evidence-based practices, and a coordinated effort across diverse sectors. Future research work needs to further enhance the inclusivity and effectiveness of tsunami risk management initiatives, paving the way for a more resilient and prepared Aotearoa New Zealand.

The second part of the workshop investigated engineering design for tsunami as central to tsunami risk mitigation is the protection of critical infrastructure in inundations zones and designing evacuation buildings to withstand impacts of a tsunami. Future work is still required to explore and unpick the engineering research gaps, needs, and opportunities for Aotearoa New Zealand for tsunami resilience.

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