Where the Walls Come Tumbling Down

Predicting Earthquake Hazard in Vanuatu

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Introduction

The Republic of Vanuatu is an island archipelago in the southwest Pacific Ocean. It comprises a chain of 82 volcanic islands and lies on the boundary between the Australian and Pacific tectonic plates, forming part of the Pacific Ring of Fire. **Vanuatu is extremely susceptible to earthquakes**, with thousands occurring since 1973 when global earthquake monitoring began **Fig. 1**.

The Government of Vanuatu, having limited resources, has neither an extensive monitoring network nor a comprehensive field damage assessment procedure, but required a **historical earthquake disaster database** as part of the **national initiative to integrate disaster risk reduction and disaster management into national development planning.**

I developed this disaster database for my MSc project. **The results from my study are currently being used to facilitate earthquake hazard assessment and disaster management in Vanuatu**, helping to identify priority areas in which to focus disaster risk reduction efforts and direct resources.

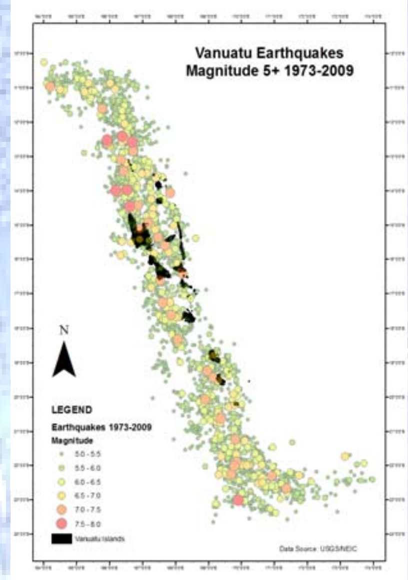


Figure 1

Objectives

The database needed to **identify which historical earthquakes affected the islands of Vanuatu** with moderate or greater levels of damage and specify the level of damage affecting each district. In order to achieve this, I addressed the following objectives:

o1. Define Parameters for Moderate Damage

Ground motion intensity is the most common measure of earthquake effects, so moderate damage was defined as Modified Mercalli intensity level 5 or greater: *felt by nearly everyone with many awakened, windows broken and objects overturned*[1].

Only earthquakes of moment **magnitude ≥5** occurring at **depths of ≤200km** were included in the database as these are the ones expected to cause **notable ground motion**, affecting the islands with **ground motion intensity ≥5**.

Figure 2

Final Intensity Model

$5.0 \le M_w < 5.5$

Depth (km)	Intensity Radius from Epicenter (km) MM V	MM VI	MM VII
10-30	[illegible]	22	7
31-60	[illegible]	2	0
61-120	[illegible]	0	0
121-200	0	0	0

$5.5 \le M_w < 6.0$

Depth, H (km)	Intensity Radius from Epicenter (km) MM V	MM VI	MM VII
10-30	[illegible]	29	[illegible]
31-60	[illegible]	22	0
61-120	[illegible]	0	0
121-200	0	0	0

$6.0 \le M_w < 6.5$

Depth, H (km)	Intensity Radius from Epicenter (km) MM V	MM VI	MM VII
10-30	[illegible]	39	[illegible]
31-60	[illegible]	38	0
61-120	[illegible]	40	0
121-200	[illegible]	0	0

$6.5 \le M_w < 7.0$

Depth, H (km)	Intensity Radius from Epicenter (km) MM V	MM VI	MM VII
10-30	[illegible]	52	[illegible]
31-60	[illegible]	52	0
61-120	[illegible]	74	0
121-200	[illegible]	28	0

$7.0 \le M_w < 7.5$

Depth, H (km)	Intensity Radius from Epicenter (km) MM V	MM VI	MM VII
10-30	[illegible]	72	[illegible]
31-60	[illegible]	73	[illegible]
61-120	[illegible]	112	[illegible]
121-200	[illegible]	110	0

$7.5 \le M_w < 8.0$

Depth, H (km)	Intensity Radius from Epicenter (km) MM V	MM VI	MM VII
10-30	[illegible]	97	[illegible]
31-60	[illegible]	105	[illegible]
61-120	[illegible]	178	[illegible]
121-200	[illegible]	179	[illegible]

o2. Develop a Ground Motion Intensity Model

A predictive method, i.e. **a ground motion intensity model**, was needed to overcome the sparse intensity data available in Vanuatu. The **requirements of the model** are to:

- show which historical earthquakes had affected the islands of Vanuatu with intensity levels ≥5
- specify the maximum ground motion intensity felt in each district.

Ground motion prediction equations relate the physical characteristics of an earthquake to the extent of ground motion they cause. I adopted the Youngs *et.al.* [1997] equation[2] for **rock site conditions** [based on shear wave velocities down to 30m, a standard measure for determining seismic site conditions][3] to **calculate the maximum distance from the epicentre of an earthquake at which the peak ground accelerations representing intensities 5, 6 and 7 would be felt.**

This was done for different earthquake magnitude and depth ranges **Fig. 2**, converting between peak ground acceleration and Modified Mercalli intensity using the United States Geological Survey standard conversion table[4].

The model was developed for earthquakes occurring both within the tectonic slab (>60km depth) and at the plate boundary (≤60km depth).

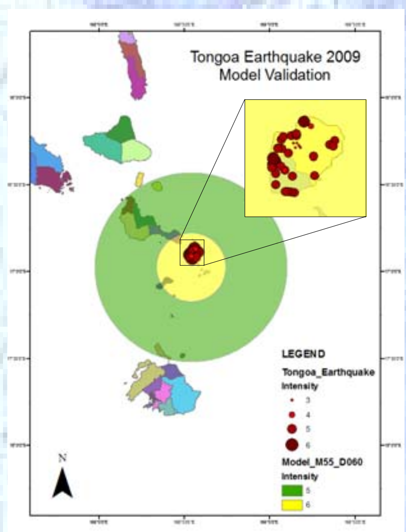


Figure 3

o3. Validate the Model and Generate the Database

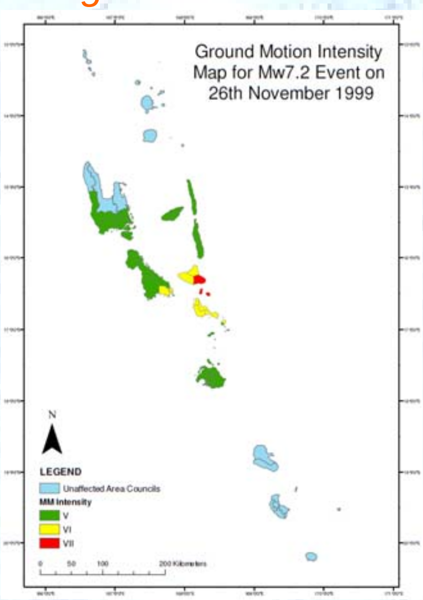
Step 1: To map the model onto the earthquake locations, **intensity radius templates Fig. 3** were made for each of the magnitude and depth ranges using geographical information system mapping software ArcGIS.

Step 2: I validated the model against the two most recent earthquake field assessments by **mapping the predicted intensity against the field data** in ArcGIS **Fig. 3**. It allowed comparison at a glance of the maximum intensity predicted by the model against the actual intensities reported. **The model was seen to represent the maximum intensity reported in each case**.

Step 3: The relevant templates were manually applied in ArcGIS to the locations of all the significant earthquakes and **spatially joined** with the district geography to **assign the predicted intensity value** and generate a **maximum ground motion intensity map** for each earthquake **Fig. 4**.

Result: The overall result of the project is a **database of 192 historical earthquakes**, the districts affected by each and their associated predicted ground motion intensities (≥5). **Each earthquake has an associated ground motion intensity map showing the affected districts. The database and maps are currently being used for earthquake hazard assessment in Vanuatu.**

Figure 4



Conclusions

The predictive ground motion model developed for Vanuatu has ***for the first time*** facilitated the generation of an **earthquake disaster database for Vanuatu**, albeit a predictive one. This database allows analysis of the temporal and spatial distribution of predicted historical earthquake damage, which can, in turn, be used to **plan and prioritise disaster management activities** and integrate them into development planning.

Important Applications

1. The model can also be used as a **rapid response tool** in the aftermath of an earthquake to give an **immediate indication** of the areas suffering damage, allowing **response to be prioritised** accordingly, and

2. The **same methods can be applied elsewhere**, for example in developing countries of similar tectonic setting with limited ground motion data and resources, for the generation of similar historical ground motion intensity databases.

References

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