To what extent is the level of development the most important factor in determining the effectiveness of tectonic hazard management?

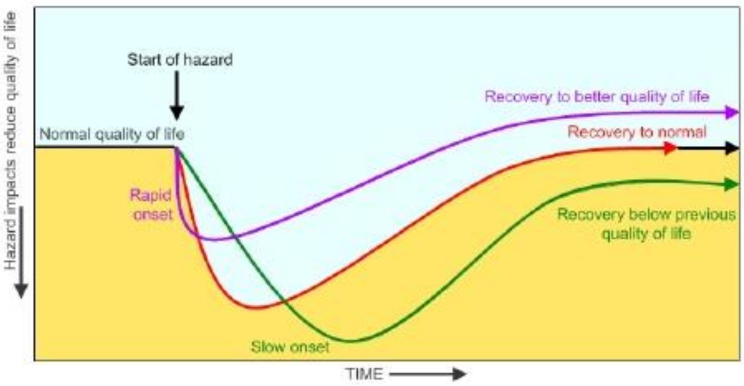
Introduction

A tectonic event is a physical occurrence resulting from the movement or deformation of the earth's crust (Dunn et al, 2009). These events are most often earthquakes and volcanic eruptions. These events become hazards when they have the potential to impact upon people (Dunn et al, 2009).
The severity of a tectonic hazard and its human impact depends on the interaction of a number of variables (as shown in figure 1). It is these factors that form the basis for successful hazard management (Bishop, 2001)

Physical Factors	Human Factors
• Geographical accessibility of the area • Type of hazard – scale/impact/magnitude • Topography of area • Climate, e.g. monsoon rain causes access problems	• Number of people involved • Degree of community preparedness • Scientific understanding • Education and training • Level of development • Infrastructure • Government competence and resources

(Figure 1, table of factors affecting management)

In addition to the factors in figure 1, the management of hazards is dependent on the level of economic development of the country/region in question. This report will primarily use the case studies of the 2011 Christchurch earthquake, the 2010 earthquake in Haiti, the 2002 eruption of Mount Nyiragongo, and the 2010 eruption of Eyjafjallajökull to examine the differing management strategies. These case studies where chosen in order to compare between countries at different levels of economic development. The variations in Parks model (figure 2) demonstrate how there can be many different outcomes from the management of a hazard. These outcomes are usually linked to the level of economic development within the country.



(Figure 2, variations in Parks Model)

Analysis

Within the management of a hazard, there are different ways it can be done. Generally, there are four different ways to manage a hazard:

Increasingly Technological →

Modify the Loss	Modify Vulnerability	Modify the Event	Modify the Cause

(Figure 3: Spectrum of management responses)

During this report, figure three will be referred to as it demonstrates the spectrum of hazard management strategies that can be applied to countries at different stages of development. Generally, the more economically developed the country is, the more technologically advanced (and, potentially, effective) its management strategies are.

<u>1 – Modify the loss</u>

Modifying the loss is only management option for many LDC's and LEDC's. For example, in the 2004 Sumatran earthquake, over 230,000 people were killed due to the tsunami when it hit with very little warning. Within the countries that were affected, there was very little community based hazard awareness, mitigation, and preparation for tectonic hazards – which lead to the main management strategy being to pledge for international aid post disaster.

<u>1 – Modify the Vulnerability</u>

The aim of modifying vulnerability is to lessen the impact of the hazard by community preparedness, land-use planning, and prediction and warning. (Bishop, 2001)

a) Prediction and Warning for Earthquakes

It is not possible to predict earthquakes. The only successful prediction was in 1975 of the Chinese Haicheng earthquake, but a second attempt in 1976 failed, leading seismologists to say that the first was more of a lucky guess. The only available forecasting for earthquakes is through monitoring methods like laser fault movement detection, observing unusual animal behaviour (e.g. toads evacuating ponds in L'Aquila, elephants evacuating the low ground in Thailand during the Sumatran 2004 Earthquake), and changes in water table heights.

b) Prediction and Warning for Volcanic Eruptions

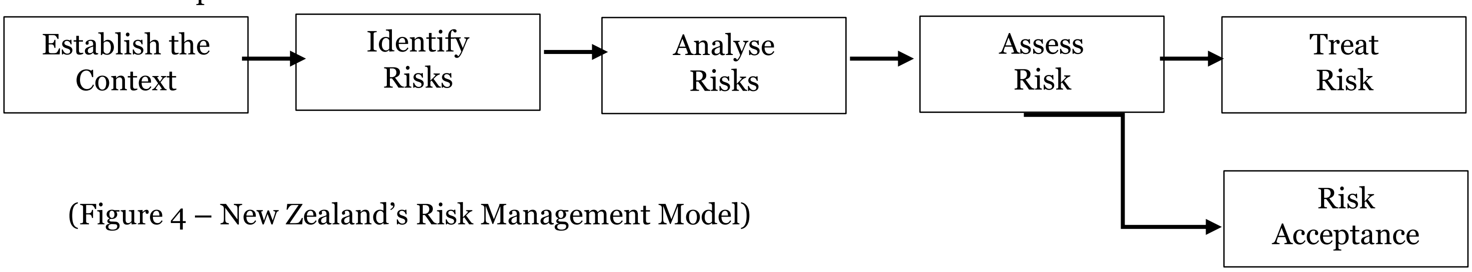
In MEDC's active volcanos, such as Eyjafjallajökull, are regularly monitored by the IMO using remote sensing and GIS for behavioural changes (such as changes in gas emission, fluctuation in hot spring temperatures, or swelling of the land), when combined with past eruption data, it can give a more precise forecast that that of earthquakes. Whereas in LEDC's monitoring is mostly based on human observation, which can lead to conflict, for example dispute over the observation of Nevado del Ruiz in 1985 lead to a lahar killing 20,000 people.

c) Community Preparedness

Both Japan and New Zealand are viewed as very advanced with preparations for tectonic hazards. Many houses in Japan are retrofitted to be earthquake mitigated with smart meters that automatically shut off the gas and electric, along with text alerts and a National Earthquake Day to practice drills. In New Zealand, there are teams of citizens trained with first aid training and evacuation plans.

d) Integrated Risk Management

New Zealand's government use the process of risk management shown in figure 4 to minimise the effects of a hazard, allowing for the return to normal (shown in Parks Model) to be possible.



(Figure 4 – New Zealand's Risk Management Model) *e) Hazard Education*

Community preparedness may not be as possible in LEDC's, where modifying vulnerability is normally applied through NGO's such as the Red Cross and Geohazards International (GI). The Red Cross use a 'Disaster Dog' program which they use to raise awareness for children about hazards. Currently, GI is working with USAID in Shimla – helping to raise awareness of the risks within the earthquake zone, ultimately reducing the death toll.

Modifying vulnerability can be possible with the correct balance of prediction, warning, preparedness, and education. Within communities where populations are rapidly growing is where the most work needs to be done in order to reduce the disaster risk.

<u>3 – Modify the Event</u>

Modifying the event uses the technological fix approach, such as hazard resistant design, and land-use zoning. (Smith, 2001)

a) Aseismic Design

In many earthquake prone MEDC's, aseismic design is used in combination with strict building regulations, and features such as flexible foundations and cross bracing, allowing for the construction of safer high-rise buildings like Tokyo Sky Tree in Japan, and Taipei 101 in Taiwan. Though these adaptations are expensive, they have saved thousands of lives, as evident from the 2011 Japanese Earthquake. However, in LEDC's, large expanses of informal dwellings and weak infrastructure leads to more vulnerable communities. For example, as a result of the Haitian Earthquake in 2010 300,000 people died – though many of whom dies due to crushed injuries from collapsed buildings.

b) Volcanic Eruption Environmental Control

Spillways can be constructed in urban areas to protect against the high temperatures of lahars and lava flows. After the 2002 Nyiragongo eruption in the DRC, artificial mounds of earth were used to elevate the land, and in Iceland and Hawaii sea water sprays are used to cool lava flows.

c) Tsunami Resistant Design

In many MEDC's, costal homes that are at risk from tsunamis are built with 'open' ground floors, allowing a tsunami wave to pass through. After the 2011 tsunami in Japan a series of 10m high sea walls and flood-gates have been rebuilt. Also, in Thailand, NGO's have been replanting the mangrove swamps along the coast after they were cleared to build shrimp farms before the earthquake and tsunami in 2004. Due to this disaster, it was found that the land behind the cleared mangroves where more devastated than those behind intact ones.

d) Land-use Zoning

Many LEDC's don't use land-use zoning, but in Japan and California businesses have been moved further inland due to tsunami risks, and public areas are reserved as public areas. In Iceland, land-use zoning is used to reduce the impacts of pyroclastic flows and ash fallout on homes and businesses. In New Zealand, after the 2010 Christchurch Earthquake, the government purchased any land and houses that remained in high risk zones, and the CERA was set up to manage the exchange of money and movement to safe areas.

e) Retrofitting for Houses

In Japan and New Zealand retrofitting is widely practiced in the form of reinforced walls and bolting furniture to the floors. Most homes also have a prepacked 'disaster supply kit'.

Modifying the event is, most often, complex and expensive for MEDC's, particularly around aseismic design. In LEDC's land-use zoning and small scale retrofitting are more widely applied, whereas aseismic design is shied away from due to the high economic costs and the countries limited technological advancement.

4 – Modify the Cause

The future of hazard management is based on modifying the cause and is predominantly researched in Japan, as they have the advanced technology needed. As stated in 2a and 2b, prediction is only really possible for small scale secondary hazards and volcanic eruption, but modifying the cause of primary hazards is not truly possible. Although USGS and ADRC in Japan are putting a vast amount of effort and expenses into this.

Methodology

My research into the management of tectonic activity and hazards was started by reading Dunn et al. (2009) A2 Geography, which provided reliable theoretical information on tectonic processes – which I used as a base when reading texts more specific to my chosen case studies, such as that in Skinner et al. (2016) AQA A Level Geography. Another useful textbook was Hazards and Responses (2001) by Victoria Bishop, which aided with knowledge on management strategies.
For information specific to my case studies, I combined a variety of secondary sources, such as Geofiles (journal), Top Spec Geography (GA publication), and the National Geographic (publication). Unfortunately, due to the nature of the topic, primary field work was not possible, but many documentaries were watched – such as 'The Power of the Planet' by Iain Stewart, which was integral for understanding Iceland's tectonics. Another documentary was Channel 4's 'The Volcano that Stopped Britain', which gave insight into the management of the 2010 Eyjafjallajökull eruption.
Another excellent resource was the A Level Geography Review Series (publication). When researching for a report, it is important to use a variety of publications, texts, and documentaries to integrate information and remove bias. The majority of my sources provide reliable, factual, and current information from professional geographers and researchers.

Conclusion

In this report a range of strategies for managing tectonic hazards have been analysed. What the report shows is that the management strategies a country applies depends heavily on the economic and technological development within it, and for many of the world's most vulnerable communities, little is able to be done in terms of mitigation and preparation – leaving them to modify the loss through aid after the disaster. Whereas MEDC's are more often to modify the event of natural disaster, saving many lives and continuing to develop future technology that further reduces the risk of a tectonic hazard, with Japan at the forefront of this with advanced mitigation schemes that saved thousands of lives during the 2011 earthquake and tsunami. This shows that the level of development is one of the most important factors when managing tectonic hazards.
Though, hazard management is a complex and costly issue through which a future where we can modify the cause of a primary tectonic hazard is something everyone wishes to see. To any extent, the advancement in forecasting will be beneficial to saving thousands of lives,

particularly in increasingly vulnerable communities.