Comparative Risk Assessment Using the Seriousness, Management, Growth (SMG) Model

M. Daly[1]

[1]GNS Science, Wellington, NEW ZEALAND

E-mail: m.daly@gns.cri.nz

Abstract: *In the absence of detailed quantitative information about hazards and risk, it can be difficult to assess and compare the level of risk across a variety of different natural and technological hazards. This often prevents agencies responsible for managing risk in their respective areas from taking the first step to prioritise the risks they have to manage. Local government must make decisions based on the information they currently have, which may be qualitative and variable in accuracy and quality across different hazards. This paper describes a model used in New Zealand which enables a comparative risk assessment to be undertaken in the absence of detailed hazard and risk information.*

Keywords: *hazard, risk, risk profile, comparative risk assessment, New Zealand.*

1. INTRODUCTION

For a district or province to manage risks effectively, it is important to understand the risk management context within the area, to know what can happen, what hazards and risks are most important and what risks should be managed as a matter of priority. Developing a clear understanding of the district's risk profile is fundamental to guiding the appropriate application of resources and effort to reduce risk, and prepare for and manage a disaster.

The risk profile provides a broad picture of the social, natural, built and economic environments within the district's area and outlines how the various hazards are likely to impact on the area's communities. The risk profile includes an analysis of the likelihood and consequences (the risk) of those hazards and an evaluation of current and potential reduction, preparedness, response and recovery decisions and actions in relation to the district's prioritised risks.

In the absence of detailed quantitative information about hazards and risk, it can be difficult to assess and compare the level of risk across a variety of different natural and technological hazards. This often prevents agencies responsible for managing risk in their respective areas from taking the first step to prioritise the risks they have to manage.

New Zealand is currently developing a range of quantitative risk assessment tools (e.g. Riskscape) which will provide objective and quantifiable information to assist decision makers to prioritise and manage risks. These tools require asset data and quantitative hazard models which require time and resources to compile.

In the meantime, local government must make decisions based on the information they currently have, which may be qualitative and variable in accuracy and quality across different hazards.

New Zealand local government uses a tool called SMG (*Seriousness; Management; Growth*) to help compare and prioritise risks. This paper describes the SMG methodology.

2. RISK ASSESSMENT

Risk assessment involves the specific steps in the risk management process of hazard identification, an initial description of risks, risk analysis and risk evaluation. A detailed description of the risk assessment process is provided in the AS/NZS 4360 risk management process standard.

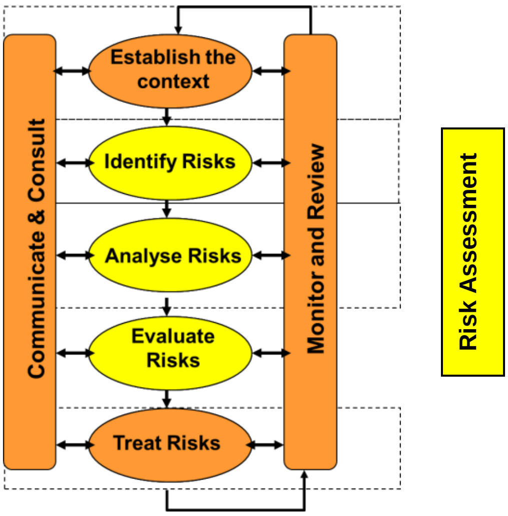

Figure 1 The risk assessment (yellow circles) process (after AS/NZS 4360 risk management process standard)

2.1. Risk Management Context

Ideally, districts should provide a comprehensive summary of the natural, social, built and economic environments within their respective areas. The purpose of summarising these environments is to give the district a clear and agreed picture of the broad parameters within which disaster risk management operates. A description of each of the environments above should include a summary of at least the following factors:

- *Social:* population, social structures, vulnerable groups, ethnic diversity and Indigenous peoples.
- *Natural:* geography, geology, and climate.
- *Built:* residential, commercial, key lifelines utilities, and industrial and agricultural infrastructure,
- *Economic:* regional economy, growth, employment, income, tourism and resources.

Particular attention should be paid to trends in any of these factors which may add to risk in the future.

2.2. Risk Identification

Start by identifying hazards of relevance to the area. It is recommended that the breakdown of hazards be within the three commonly accepted hazard categories – natural, technological and biological.

Develop descriptions of the hazards and risks. Risk descriptions are essential for communication with partners and are the basis of accurate risk assessment.

2.3. Risk Analysis

Once completed, the hazard identification and risk descriptions will help to inform risk analysis. Risk analysis involves considering the likelihood and consequences of each type of hazard (defined by the risk description above), as the first stage in determining priorities.

Qualitative analysis of risk is recommended using the following measures of consequence (Table 1) and likelihood (Table 2).

Table 1 Measure of consequence of impact

Level	Descriptor	Detail description
1	Insignificant	No injuries, little or no damage, low financial loss.
2	Minor	First aid treatment, minor building damage, medium financial loss.
3	Moderate	Medical treatment required, moderate building and infrastructure damage, high financial loss.
4	Major	Extensive injuries, high level of building and infrastructure damage, major financial loss.
5	Catastrophic	Deaths, most buildings extensively damaged and major infrastructural failure, huge financial loss.

Table 2 Measure of likelihood – generic

Level	Descriptor	Detail description
A	Almost certain	Is expected to occur in most circumstances.
B	Likely	Will probably occur in most circumstances.
C	Possible	Might occur at some time.
D	Unlikely	Could occur at some time.
E	Rare	May occur only in exceptional circumstances.

A quantitative measure of likelihood is unlikely to be useful for an initial risk analysis, but should be considered as part of more detailed hazard-specific risk management at the local level, for example for flood risk management.

2.3.1. Qualitative Risk Matrix

The qualitative risk is determined using a risk analysis matrix, defined by two factors; likelihood and consequence. The levels of risk defined in the matrix are a modification of the risk analysis matrix in the AS/NZS 4360 risk management standard.

The use of the modified qualitative risk analysis matrix below (Table 3) is recommended:

Table 3 Qualitative risk analysis matrix

Likelihood of Occurrence	Consequence				
	1	2	3	4	5
	Insignificant	Minor	Moderate	Major	Catastrophic
(A) Almost Certain	Moderate	High	Very High	Extreme	Extreme
(B) Likely	Low	Moderate	High	Very High	Extreme
(C) Possible	Low	Moderate	Moderate	High	Very High
(D) Unlikely	Very Low	Low	Moderate	High	Very High
(E) Rare	Very Low	Very Low	Low	Moderate	High

The process for risk analysis using the above matrix is usually a collaborative effort involving key stakeholders who can draw upon previous risk analyses, new hazard and risk information and experience. The result of the analysis will rate each hazard risk as either very low, low, moderate, high, very high or extreme, as shown above.

Auckland (New Zealand) used the above approach to group it's hazards and came up with the list shown in Table 4.

Table 4 An example of a qualitative risk analysis matrix from Auckland, New Zealand (Auckland CDEM Group Plan DRAFT 2010-2015)

Hazard	Risk Analysis		
	Likelihood	Consequence	Risk Rating
Lifeline Utility Failure: Electricity	C	5	Very High
Human Epidemic	C	5	Very High
Volcanic Eruption: Distant Source Eruption	B	4	Very High
Cyclone	B	4	Very High
Flooding: River/Rainfall	A	3	Very High
Erosion: Coastal Cliff	A	3	Very High
Erosion: Landslide/ Land Instability	A	3	Very High
Volcanic Eruption: Auckland Volcanic Field	E	5	High
Animal Disease/Epidemic	C	4	High
Crash: Aircraft	C	4	High
Earthquake	D	4	High
Lifeline Utility Failure: Water/Waste	C	4	High
Hazardous Substance Spill	B	3	High
Introduced Species/Pests	C	3	Moderate
Lifeline Utility Failure: Communications	C	3	Moderate
Lifeline Utility Failure: Fuel	C	3	Moderate
Lifeline Utility Failure: Roading	C	3	Moderate
Criminal Acts: Terrorism	C	3	Moderate
Criminal Acts: Civil Unrest/Riot	C	3	Moderate
Crash: Rail	C	3	Moderate
Flooding: Tsunami (regional/local)	D	3	Moderate
Crash: Road	B	2	Moderate
Drought: Agricultural	B	2	Moderate
Flooding: Tsunami (distant)	B	2	Moderate
Fire: Urban	C	2	Moderate
Lifeline Utility Failure: Airport	C	2	Moderate
Lifeline Utility Failure: Gas	C	2	Moderate
Lifeline Utility Failure: Port	C	2	Moderate
Flooding: Storm Surge	C	2	Moderate
Drought: Water Supply	C	2	Moderate
Lifeline Utility Failure: Gas	C	2	Moderate
Dam Failure	D	2	Low
Crash: Marine	D	2	Low
Fire: Rural	B	1	Low
Tornado	B	1	Low

2.3.2. Thresholds for prioritization of risks

Once the risk analysis is complete and each hazard has been rated for risk, the district reaches a decision point regarding the cut-off level of risk for further evaluation. This decision is entirely at the discretion of each district, and most may decide to include at least moderate-rated risks for further evaluation. As an example, the district may decide to undertake risk evaluation only for those risks rated high, very high or extreme, and may decide not to do a risk evaluation for risks rated moderate, low or very low.

2.4. Risk Evaluation – application of the SMG model

Risk evaluation provides a useful way of determining priorities for significant district or provincial risks.

The SMG model involves prioritising risks by evaluating each risk across three different criteria: Seriousness, Manageability and Growth (SMG).

Table 5 shows a typical matrix used to evaluate risks using the SMG model. The hazards in the left hand column of the matrix are those determined using the qualitative risk analysis above and applying an agreed threshold as discussed above in 2.3.2.

Table 5 SMG Model Matrix

HAZARD	RISK PRIORITY FOR ACTION											
	SERIOUSNESS					MANAGEABILITY					GROWTH	
	Social	Built	Econ omic	Natural	Sub-Total	Reduction	Prepared-ness	Response	Recovery	Sub-total	Sub-total	TOTAL
EQ												
Tsunami												
Flood												
Landslide												
Volcanic Eruption												

The process for risk evaluation using the above risk profile matrix is as follows:

2.4.1. Seriousness

Assign a consequence rating (number from 1-5) to each of the four environments within Seriousness of the matrix. Tables 6 – 7 provide examples of how the ratings can be derived for the social and economic environments using the city of Bengkulu and district of Pesisir Selatan (Sumatera Barat).

Table 6 Seriousness: Social Environment
Based on Morowali Population of 206,322 – 2015, source: Badan Pusat Statistik

Level	Description
1	No deaths; **0 – 100 affected** *(0.05% of affected community injured / displaced)*
2	No deaths; **< 300 affected** *(0.05 – 0.15% of affected community injured / displaced)*
3	0-50 deaths; **< 1000 affected** *(0.15 - 0.50% of affected community injured / displaced)*
4	0-100 deaths; **< 4000 affected** *(0.5 - 2% of affected community injured / displaced)*
5	0->100 deaths; **> 4000 affected** *(>2% of affected community injured / displaced)*

Table 7 Seriousness: Economic Environment
Based on Morowali GDP per capita of Rp 68.03 million – 2015, source: Badan Pusat Statistik

Level	Description
1	Costs less than 0.5% regional GDP **< US$5 M**
2	Costs between 0.5% and 2% regional GDP **US$5 - $20 M**
3	Costs between 2% and 5% regional GDP **US$20 - $50 M**
4	Costs between 5% and 10% regional GDP **US$50 - $100 M**
5	Costs greater than 10% regional GDP **>US$100 M**

Table 8 Seriousness: Built Environment

Level	Description
1	Little or no damage
2	Light damage to buildings and structures; services remain on-line, but unavailable for a period or hours
3	Variable damage to buildings and structures; services off-line for several hours to days
4	Heavy damage to buildings and structures; services off-line up to several months
5	Extensive damage to buildings and structures; many remaining buildings and structures are unrecoverable; all essential services off-line, and some cannot be recovered

Table 9 Seriousness: Natural Environment

Level	Description
1	Few or no effects
2	Short-term localised effects to ecosystems, requiring clean-up or restoration
3	Damage to multiple ecosystems, temporary or localised landform changes
4	Loss of a significant ecosystem, or damage to multiple systems and ecological effects. Regionally significant and permanent landform changes requiring modified land use
5	Permanent loss of multiple ecosystems and irreversible ecological effects, multiple regionally significant landform changes requiring modified land use

2.4.2. Manageability

The manageability rating is developed from 1 to 5 based on the combination of management difficulty and current level of effort being applied (Table 10). The rating is developed and entered on the matrix for each of Reduction, Preparedness, Response and Recovery. The sub-total represents an average manageability value and has a minimum value of 1 and a maximum value of 5.

Table 10 Manageability

Management difficulty	Current effort (4Rs)	Rating
Low	High	1
Low	Medium	2
Medium	High	
Medium	Medium	3
High	High	
Low	Low	4
Medium	Low	
High	Medium	
High	Low	5

In considering the degree of management difficulty and current effort, consideration is given to the types of management interventions used across the reduction, readiness (preparedness), response and recovery spectrum. Figure 2 shows some examples of what these interventions are.

2.4.3. Growth

The growth rating is shown in Table 11. A rating is developed from 1 to 5 based on the combination of the probability of occurrence of the event arising and the changes in community exposure to the event.

This aspect of the model provides for climate change (e.g. an increase in the probability of storms, flooding and coastal erosion) and changes in community exposure such as population increase and density.

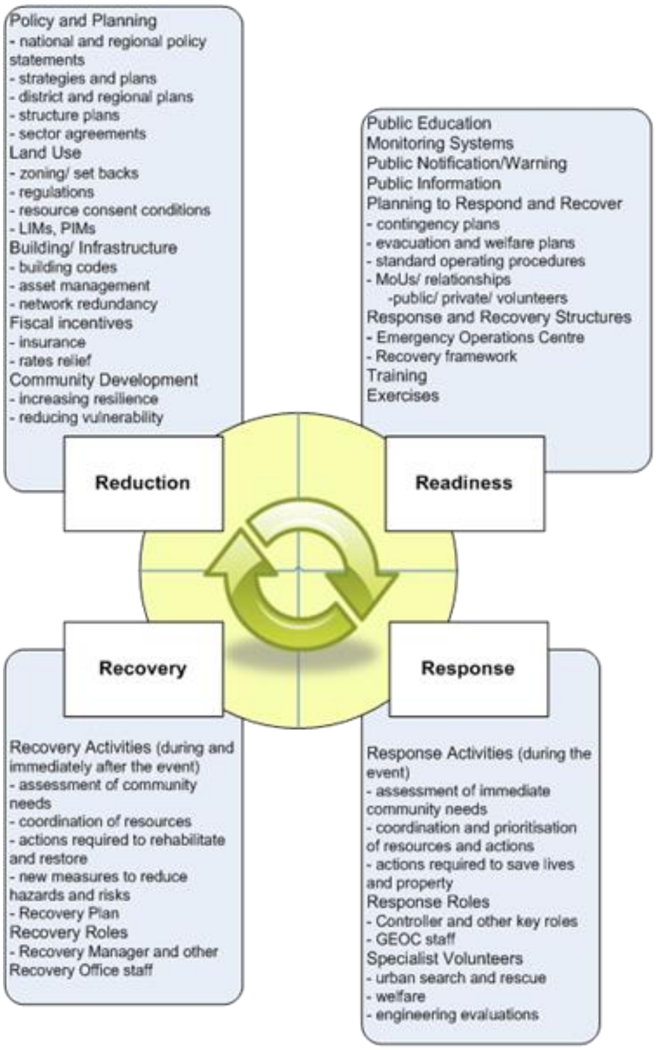

Figure 2 Types of interventions across the reduction, readiness (preparedness), response and recovery spectrum

Table 11 Growth

Event occurrence probability rise	Changing community exposure	Rating
Low	Low	1
Low	Medium	2
Medium	Low	
Medium	Medium	3
Low	High	
Medium	High	4
High	Low	
High	Medium	
High	High	5

2.4.4. Weighting the Criteria

The Seriousness criterion should be weighted higher than either Manageability or Growth. For the purposes of disaster risk management, seriousness should always be the key driver and is inherently more important than the other two criteria. It is recommended that Seriousness be weighted twice as important as the other two criteria, thus making it half of the overall rating.

The Seriousness criteria should be amended to reflect the relative importance of the four factors – social, built, economic and natural environments. The following weighting is recommended for use in New Zealand:

- Social – 50% of the total value, due to the high priority of protection of human life and safety and community readiness, response and recovery.
- Built – 25% of the total value, due to the importance of protecting lifeline utilities and other critical infrastructure in relation to social concerns.
- Economic – 15% of the total value, reflecting a secondary priority and the fact that the built environment will normally account for most of the economic damage.
- Natural – 10% of the total value, reflecting the relatively low level of concern within the disaster risk management sector (noting that environmental concerns are primarily covered within other sectors).

Note that these weightings are arbitrary and should be set to reflect the values of the community.

2.4.5. Risk Total

Once all the rating values have been completed, the sub-totals in the yellow columns in Table 5 are added to provide the risk total for each hazard identified. The matrix can then be sorted to give a list of hazards ranked by risk. This ranked list can then be used to help underpin the approach to risk management.

Table 12 shows a completed SMG matrix as developed for Auckland in 2009.

2.5. Advantages and Disadvantages of the SMG model

The SMG model was first used in New Zealand 12 years ago and has proved to be very effective in engaging a large number of agencies in a discussion about hazards and risks. It provided a more systematic assessment of risks and attempted to quantify what was acceptable, for example, the number of lives lost and economic damages. Crucially it has enabled identification of critical gaps in understanding about some hazards and risks which have been systematically filled over the last decade.

However, it does have its limitation as a method. It's often not systematic enough and information is variable across hazards. Subjective judgement is often used to fill gaps in information and there can be an over-reliance on the numerical rating system. The final totals are only intended to provide a comparative risk ranking, not an absolute risk score.

More work is required to define 'acceptable' evaluation criteria. Doing this requires community consultation and input into what these should be. This can be a lengthy (but necessary) process.

With more quantitative risk models becoming available, the SMG model may eventually be replaced. However, it remains a good method for engagement across agencies and for building shared ownership of risk.

Table 12 Example of a completed SMG matrix (for Auckland, New Zealand)

Hazard Identification	Risk Priority for Action											
	Seriousness					Manageability					Growth	Total
	Social	Built	Economic	Natural	Sub-total	Reduction	Readiness	Response	Recovery	Sub-total	Sub-total	
Natural Hazards												
Volcanic Eruption: Auckland Volcanic Field	5	5	5	4	9.8	1	2	4	5	3	3	15.8
Volcanic Eruption: Distant Source	4	4	4	3	7.8	3	4	4	4	3.75	4	15.55
Lifeline Utility Failure: Electricity	4	4	5	2	7.9	4	3	3	3	3.25	4	15.15
Cyclone	3	3	3	2	5.8	5	4	4	5	4.5	4	14.3
Human Epidemic	5	1	5	1	7.2	2	2	2	5	2.75	4	13.95
Lifeline Utility Failure: Roading	3	3	3	1	5.6	4	3	4	2	3.25	5	13.85
Earthquake	4	4	4	2	7.6	3	3	5	5	4	2	13.6
Lifeline Utility Failure: Water/Waste	3	2	4	4	6	4	3	4	2	3.25	4	13.25
Lifeline Utility Failure: Communications	3	2	4	1	5.4	4	3	4	3	3.5	4	12.9
Major Crash Road	4	2	2	1	5.8	3	3	1	1	2	5	12.8
Erosion: Landslide/ Land Instability	3	3	3	1	5.6	5	5	1	1	3	4	12.6
Hazardous Substance Spill	3	2	3	4	5.7	5	5	1	1	3	3	11.7
Lifeline Utility Failure: Fuel	3	2	4	1	5.4	3	3	4	3	3.25	3	11.65
Flooding Tsunami (regional/local)	3	3	3	2	5.8	3	4	4	4	3.75	2	11.55
Criminal Acts Terrorism	3	2	3	1	5.1	4	3	3	2	3	3	11.1
Criminal Acts Civil Unrest/Riot	3	2	3	2	5.3	3	3	2	3	2.75	3	11.05
Dam Failure	4	3	3	3	7	2	2	4	4	3	1	11
Major Crash Aircraft	4	2	3	3	6.5	1	1	4	4	2.5	2	11
Animal Disease/Epidemic	4	1	4	2	6.1	3	3	4	5	3.75	1	10.85
Flooding River/Rainfall	3	3	3	2	5.8	2	3	2	4	2.75	2	10.55
Introduced Species/Pests	3	1	3	3	5	3	3	3	4	3.25	2	10.25
Fire Urban	3	3	3	2	5.8	1	2	3	3	2.25	2	10.05
Lifeline Utility Failure: Airport	2	1	3	1	3.6	4	3	4	2	3.25	3	9.85
Lifeline Utility Failure: Gas	2	1	3	1	3.6	4	3	4	2	3.25	3	9.85
Lifeline Utility Failure: Port	2	1	3	1	3.6	4	3	4	2	3.25	3	9.85
Erosion: Coastal Cliff	2	3	3	2	4.8	2	4	1	1	2	3	9.8
Flooding: Storm Surge	2	1	3	1	3.6	4	4	4	4	4	2	9.6
Drought: Agricultural	2	1	3	2	3.8	2	3	1	4	2.5	2	8.3
Major Crash Rail	4	1	2	1	5.3	1	1	3	3	2	1	8.3
Drought: Water Supply	3	1	3	1	4.6	1	3	3	2	2.25	1	7.85

3. ACKNOWLEDGMENTS

This paper has drawn upon the New Zealand Ministry of Civil Defence and Emergency Management's Guideline on CDEM Group Plan Review (MCDEM, 2009).

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