How long is your piece of string - are current planning timeframes for natural hazards long enough?

Wendy Saunders, GNS Science, Lower Hutt; School of People, Environment and Planning, Massey University, Palmerston North
w.saunders@gns.cri.nz

1. Introduction

The purpose of the Resource Management Act 1991 (RMA) is to promote the sustainable management of natural and physical resources. Sustainable management means managing the use, development, and protection of natural and physical resources in a way, or at a rate, which enables people and communities to provide for their *social, economic*, and *cultural wellbeing* and for their *health and safety* (emphasis added). These principles of sustainability can also be thought of in terms of effects under s3 of the RMA, which includes effects of high probability; and low probability with high potential impacts (or consequences) from a natural hazard event.

In order to manage the risks from natural hazards and their consequences, first the likelihood of an event needs to be addressed (i.e. risk = likelihood x consequences). But how likely must an event be, for it to be considered in land use planning? For many natural hazards there is no standard return period for planners to plan for. For example, while case law points to a 100- year timeframe for coastal erosion, a 50-year timeframe (based on the minimum intended life of a building under the Building Act 2004) is thought to be adequate for flooding in some districts. For events where no forecasting or warnings can be provided (e.g. active fault rupture, some tsunami events), scientists recommend a longer timeframe should be used – from 500 to 20,000+ years.

This paper will outline the various terminology around return periods; current timeframes used in planning for natural hazards; the role of emergency management tools for residual risk; possible reliance on the Building Act 2004; and a discussion on individual levels of tolerable risk. While case law has provided some guidance on what return period to use for some natural hazards, with the advent of climate change these judgements may need to be revised in the future.

2. Return period, AEP or probability of occurrence?

There is a confusing array of terminology used to explain probabilities. Table 1 provides an example of terms used, and their definitions.

Table 1: Terms and definitions used to explain probabilities

Term	Definition
Likelihood	Chance of something happening, can be expressed as probability either quantitatively or qualitatively
Probability of occurrence	Measure of the chance of occurrence expressed as a number between 0 and 1, where 0 is impossibility and 1 is absolute certainty (ISO., 2009, p7). Often expressed as a percentage.
Annual exceedance probability (AEP)	Probability that an event of specified magnitude will be equalled or exceeded in any year (Australian National Committee on Large Dams Inc, 2003, p134)
Return period or recurrence interval	The expected mean time between occurrences that equal or exceed a defined event. Often used to express the AEP of the event (i.e. 1/return period) (Willows and Connell, 2003, p116)

It has been argued that a statement of probability, referring to the percentage chance of an event happening within certain time frame (e.g. 1% chance of occurring in 100 years), is more meaningful that the misleading term 'return period', which refers to a time frame, e.g. 'the 100-year event' (Ericksen, 2005). It is therefore recommended that the statement 'probability of occurrence' is used about events, rather than the more commonly used 'return period'. Probability of occurrence is also defined and accepted by Standards New Zealand (Standards

Australia/New Zealand, 2009) and referred to in RMA case law (e.g. Dye v Auckland Regional Council, CA86/01).

To reinforce the different representation of risk in these terms, Table 2 shows the probability of occurrence of an event within a 50-year time frame. The 50-year timeframe is commonly used as the default timeframe for some hazards in New Zealand, partly due to the Building Act requirement that buildings shall have an intended life of a minimum of 50 years. The qualitative description is based on terminology provided by Standards New Zealand (Standards New Zealand, 2004).

Table 2: Comparison of AEPs, return periods and probabilities of occurrence within 50 years (Smith, 20 October 2009, pers com)

AEP	Return period (years)	Probability within 50 years	Qualitative description
1/2500	2,500	0.02 or 2%	Rare
1/500	500*	0.1 or 10%	Unlikely
1/100	100	0.39 or 39%	Possible
1/50	50	0.63 or 63%	Likely
1/20	20	0.92 or 92%	Almost certain

* A more accurate representation is 475 years which has a probability of 0.99, rather than 500 years which has a probability of 0.95. Within New Zealand, 475 years is used within the Building Act, while 500 years is used within some planning contexts.

As Table 2 shows, "events happen on average, not on schedule" (Smith, 20 October 2009, pers com). Consider the fourth row in the Table. An event that occurs once every 50 years, on average, has an annual probability of 1/50 of occurring in any one year. The probability that it will occur within a 50-year interval, however, is not so simple to calculate. It may occur within that time, but it may not. The probability must therefore be less than 1.0 which would indicate complete certainty. The accurate calculation of the probability actually results in a value of 0.63. This is likely to occur, but is by no means certain.

3. Current planning timeframes for natural hazards

Choosing the appropriate probability of occurrence as the basis for land use planning is difficult for communities, planners, and politicians (who tend to focus on outcomes within political cycles, rather than long-term outcomes) alike (Deyle et al., 1998). Deciding which probability of occurrence should be used often represents a value judgement that may be difficult to deal with in the political arena. At one end of the scale are hazards that produce modest levels of damage on a relatively frequent basis, generally with a recurrence interval of less than 20 years; at the other end are catastrophic events at the other end of the scale, that occur less frequently, perhaps once every 500 years or less, but produce devastating levels of damage and consequences (Deyle et al., 1998). These high-consequence, low-likelihood events are the most important (and difficult) public hazards to manage (Slovic et al., 2000), as has been acknowledged in New Zealand. In the Environment Court case *Save the Bay v Canterbury Regional Council* (C6/2001), the Court recommended a greater recognition of catastrophic natural events, stating that 90% of damage to the environment caused by natural hazards occurs in 10% or fewer of events. The Court suggested that "authorities should recognise this inverse relationship in the preparation and wording of their plans".

Anticipated environmental outcomes (endpoints) may move beyond what was originally assessed (Johnston and Paton, 1998). Some hazards (such as flooding, coastal erosion, tsunami and landslides) are likely to be influenced by climate change and associated transient (i.e. moving) end points. The implication for risk decisions in land use planning is that timeframes that were appropriate in the past may need revising in the future, due to increased knowledge, climate change forecasts, and changing risk profiles.

There is no consistent all-hazard probability of occurrence for land use planners to use as a basis for planning for natural hazards events in New Zealand. While some hazards have similar return periods, their likelihood, consequences, forecasting and warning capabilities may be different (Table 3). For example, high rainfall events can be forecast, flood warnings can be given, and evacuation of communities at risk is possible – unlike the situation for earthquakes. Likelihood and consequences are based on guidance provided by Standards New Zealand (Standards New Zealand, 2004).

Table 3: Comparative land use planning timeframes for selected natural hazards in New Zealand

	Planning timeframe (years)	Warnings available	Map extents	Affected by climate change	Likelihood	Consequence
Flood	20 - 100+	Yes	Yes	Yes	Almost certain	Minor
Coastal erosion	100	Yes	Yes	Yes	Likely	Minor
Active faults / earthquake	</= 20,000	No	Yes	No	Possible	Major
Tsunami (local and distal)	</+ 2,500	Yes (distal only, natural warning for local source)	Yes	Trigger is not, but dune/ ecosystem health is	Possible	Moderate /Major
Landslide	</+ 2,500	No	Yes	Yes	Possible	Minor/ Moderate

4. The role of the Building Act 2004

Under the Building Act, buildings have a minimum intended lifetime of 50 years, and are required to be constructed to withstand a 475 year return period earthquake (i.e. a 10% probability of occurrence in 50 years). Critical facilities are required to be constructed to withstand a 2,500-year (2% chance of occurring in 50 years) earthquake event. Because the Building Act applies a 1/50 AEP, often land use planning policy applies a 50 year return period for some hazards (i.e. flooding).

There is also a reliance on the Building Act, rather than land use provisions, to protect people's health and safety. Within RMA case law from the Environment Court (*Petone Planning Action Group Incorporated v Hutt City Council, W020/2008)*, it is stated that "… the performance of the structure and the safety of people in earthquake events, is to be left to compliance with the Building Code and Standard … risks to safety from earthquake shaking, liquefaction and tsunami would be appropriately addressed and mitigated in the Building Code process and assessment in accordance with NZS1170.5:2004" (NZS1170.5:2004 is the New Zealand Standard *Structural Design Actions Part 5: Earthquake Actions*). The decision was summarised as follows: "… we conclude that the consenting to the proposal on condition of compliance with the Building Code and NZS1170.5:2004 would enable people to provide for their safety against risks from earthquakes and other natural hazards". However, NZS1170.5:2004 only considers earthquake, so this standard has limited relevance to other natural hazards. The implication of this is that planners should adhere to the purpose of s5 of the RMA and provide for people's health and safety. In addition, both regional and territorial authorise have responsibilities for controlled land use to avoid, remedy and mitigate the risks from natural hazards under s30 and 31 of the RMA. However, the RMA does not provide details on the appropriate timeframe for natural hazard planning.

5. Discussion

So how should planners manage time frames for natural hazards? The default 50 year timeframe in the Building Act is not enough to enable people and communities to provide adequately for their health and safety, social, economic or environmental needs for future generations. With no national standard or other central government guidance on timeframes for land use planning for natural hazards in New Zealand, differences in management occur across the country. Given these differences, there are some key questions that need to be considered:

- What is a tolerable level of risk?

- Who should decide?
- What responsibilities and duty of care do Councils have?
- Should planning for natural hazards be consequence-driven rather than probability-based?
- Should baseline natural hazard risk and consequences be standardised for the whole country, or based on a community's tolerable level of risk?

When entering a discussion on risk, firstly a tolerable level of risk should be quantified and qualified as a baseline. To aid this process, Table 4 provides quantification of individual risk, based on international best practice from the U.K., Netherlands, Australia, and New Zealand. Suggested land use activity status is also provided, based on the level of risk. For determining societal risks, the categories could be moved down one row (e.g. an activity may be controlled at an individual risk level, but may rise to discretionary if societal risk (or cumulative risk) becomes an issue).

Table 4: Individual tolerable levels of risk and suggested consent activity status (Saunders and Berryman, 2010)

Tolerability	**Risk level (individual annual fatality risk)**	**Significance**	**Suggested land use planning activity status**[1]
TOLERABLE	10^{-6} to 10^{-7} per year or lower	Unlikely to be nationally significant unless there are some very special features at risk	Permitted
	~10^{-5} to 10^{-6} per year	Many New Zealanders probably already face natural risks at home and at work of this scale. Precaution may warrant avoiding new consents to add to the numbers where possible. Government needs to note that if it helps one group of people at these sorts of risk level "on safety grounds" then it might face large numbers of equally valid claims for help in future.	Controlled
GENERALLY TOLERABLE	~10^{-4} to 10^{-5} per year	Some New Zealanders probably already face natural hazard risks at home/work of this scale. Definitely avoid new consents to add to the numbers. Government helping out at these sorts of levels on safety grounds might open up further claims.	Discretionary
	~10^{-3} to 10^{-4} per year	Reaching the higher end of tolerability for non-beneficiaries in regulatory regimes focused on man-made hazards. Government should not be comfortable if risks at this level are being imposed on people without their consent, or with people being induced to accept risks at this level (tolerable with individual consent)	Non-complying
INTOLERABLE	~10^{-2} to 10^{-3} per year	Widely regarded as intolerable even for beneficiaries of an activity with a degree of control over the risk. There need to be special reasons to tolerate any kind of individual risks at this scale from any cause.	Prohibited
	Above ~10^{-2} per year	Intolerable for almost any accidental cause in any developed country. Even if the risk is entirely for the benefit of the exposed person special care is warranted to ensure the recipient really understands and accepts the risk.	Prohibited

[1] Activity status (consent categories) become more restrictive as risk increases. Categories are defined by the Resource Management Act 1991 (s77B), namely:
Permitted - a resource consent is not required for the activity if it complies with the standards, terms, or conditions, if any, specified in the plan or proposed plan.
Controlled - resource consent is required and must be granted, with conditions limited to matters that have been specified in the plan; and the activity must comply with the standards, terms, or conditions, if any, specified in the plan or proposed plan.
Discretionary - resource consent is required for the activity; the consent authority may grant the resource consent with or without conditions or decline the resource consent; and the activity must comply with the standards, terms, or conditions, if any, specified in the plan or proposed plan.
Non-complying - resource consent is required for the activity; and the consent authority may grant the resource consent with or without conditions or decline the resource consent.

Prohibited - no application may be made for that activity and a resource consent must not be granted for it.

This table can be used for a risk-based approach to land use planning, and/or to aid a precautionary approach, and is a guide only – individuals and communities can have different risk profiles and levels of acceptance, based on perceived benefits of their actions and/or choices. For further guidance on using this table with a Land Use Importance Category table (which includes consequences for health and safety, social, economic and environmental with a scale of low- and high-consequence hazards), see Saunders and Berryman (2010).

For effective risk reduction, the first step is to avoid hazardous areas, as even with warning and evacuation, property is still affected. Once a land use has been permitted, and buildings have been constructed, the land use will continue indefinitely beyond the 50-year default timeframe for buildings. If planning within a sustainability context, which implies planning for future generations, then planners need to plan beyond 50, and even 100 years. Any decision on approaches to managing risks from natural hazards, via a combination of land use planning and emergency management, needs to be undertaken with full participation of the community, including landowners, representatives from the market, scientists, and interest groups.

Emergency management provides a range of tools for managing risk once land use options have been exhausted. Emergency management can provide warnings and evacuation procedures, which reduce the risks for human life. However, these measures do not reduce the risk to economic, social and environmental consequences (e.g. damaged buildings, business interruption, etc). Under the Civil Defence Emergency Management Act 2002, emergency management manages response, recovery and readiness for events, while land use planning is primarily responsible for risk reduction (Saunders et al., 2007). Emergency management is therefore predominantly concerned about life safety issues, or the 'ambulance at the bottom of the cliff' once a land use has been realised.

Councils have a responsibilities and a duty of care to know their hazards and risks, control land use activities, and to ensure communities have access to that information via Land Information Memoranda (LIMs), district/city/regional plans, and reports. A barrier to information-sharing with the community can be the challenge of translating scientific knowledge into 'plain English'. To aid this translation, maps, descriptions and/or photos of consequences can assist with this transfer of knowledge and understanding.

As noted above, there is currently no national standard or guidance on what levels of likelihood for hazard events should be used. Planners, together with emergency management officers, need to discuss the options and consequences with scientific experts, to gain an understanding of the levels of likelihood and risks. Once this is achieved, the community (market, civil society and other key stakeholders) need to participate in the decision-making process to agree on an acceptable – or tolerable – level of risk.

6. Conclusion

This paper has discussed the various terms used to describe probabilities, and recommended using the term 'probability of occurrence'. There is no standard timeframe for planning for natural hazards in New Zealand, and there is limited case law on the subject. This lack of national policy direction or guidance has resulted in an ad-hoc approach to planning for risk reduction, with time frames ranging from 50 to 25,000+ years for various hazards being used by different authorities.

This poses the question – is a national standard with a baseline, consequence approach required to aid risk reduction in land use planning?

The implication of using the Building Act's 50-year timeframe as a default, is that while a building may only have a minimum intended life of 50 years, a land use is often there indefinitely. A building may be replaced if damaged by a natural hazard event, but the land use is likely to continue on for future generations. Therefore, planners must consider carefully the actual sustainability of the land use, rather than the limited timeframe of a building on that land.

Case law has discussed some appropriate return periods for use in regional and district planning documents. These cases point to a 100-year planning horizon for coastal erosion and coastal flooding, and could provide a benchmark for other natural hazards (e.g. flooding). For hazards such as flooding, coastal erosion, tsunami, and some landslides, warnings (natural and official) and evacuation can protect people from harm, but not property. A balance needs to be reached between allowing a land use to proceed in an at-risk area; constructing buildings to withstand the hazards; and having emergency management procedures in place when required. Planners should adhere to the purpose of s5 of the RMA and provide for people's health and safety by ensuring risks are not increased by a land use.

Based on international best practice, tolerable levels of risk have been evaluated to assist the decision making process. These can be used with a risk-based and/or precautionary approach to natural hazard planning. Any decisions on risk levels must involve a participatory process with communities and key stakeholders, such as through planning document preparation processes.

To further assist planners, future research is required based on 'auditing' every RMA plan in New Zealand, to learn what probabilities of occurrences are being used, and understand how risk reduction is included in plans. This audit may assist in identifying the tolerable level of risk in different communities, which may assist in determining a national standard, or providing a helpful reference or guidance to other communities evaluating the level of risk for similar natural hazards.

Acknowledgments

This paper draws on research being currently undertaken as part of a PhD degree in 'Natural hazard risk governance for land use planning: an innovative approach'. The research is funded by the FRST Natural Hazards Platform, and the Zonta/BRANZ scholarship. The paper has benefited from guidance provided by Bruce Glavovic (PhD supervisor, Massey University); Warwick Smith (GNS Science); Chris Peace (Risk Management Ltd); and review from Julia Becker and Jane Forsyth (GNS Science), and Hamish Wesney (Boffa Miskell).

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