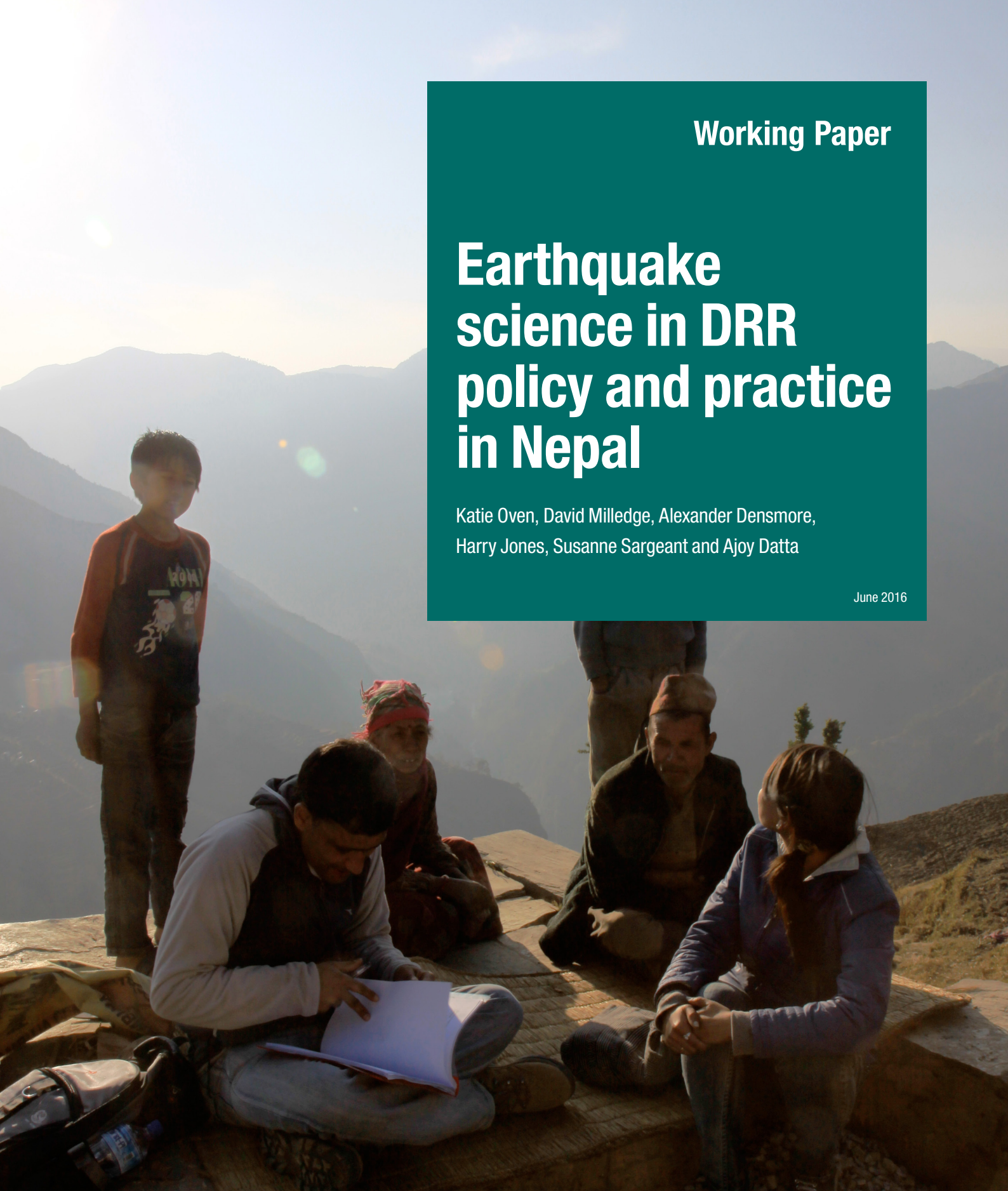


Working Paper

Earthquake science in DRR policy and practice in Nepal

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Abbreviations and acronyms

ADPC	Asian Disaster Preparedness Centre	Ms	Surface wave magnitude of an earthquake
DFID	Department for International Development (UK)	Mw	moment magnitude of an earthquake
DMG	Department of Mines and Geology, Government of Nepal	NBC	National Building Code
DRR	disaster risk reduction	NGO	non-governmental organisation
DSHA	deterministic seismic hazard assessment	NRRC	Nepal Risk Reduction Consortium
EwF	Earthquakes without Frontiers	NSC	National Seismological Centre, Nepal
GPS	Global Positioning System	NSET	National Society for Earthquake Technology (Nepal)
GSHAP	Global Seismic Hazard Assessment Program	PGA	peak ground acceleration
HFT	Himalayan Frontal Thrust	PSHA	probabilistic seismic hazard assessment
JICA	Japan International Cooperation Agency	UNDP	United Nations Development Program
KVERMP	Kathmandu Valley Earthquake Risk Management Project	UNICEF	United Nations Children's Emergency Fund
LDRMP	Local Disaster Risk Management Plan	UNISDR	United Nations International Strategy for Disaster Reduction
MoFALD	Ministry of Federal Affairs and Local Development, Government of Nepal	UNOCHA	United Nations Office for the Coordination of Humanitarian Affairs
MoHA	Ministry of Home Affairs, Government of Nepal	USGS	United States Geological Survey
MoUD	Ministry of Urban Development, Government of Nepal	VDC	Village Development Committee

Executive summary

This working paper summarises current and potential uses of earthquake science in disaster risk reduction (DRR) and resilience-building activities in Nepal. It is written for anyone with an interest in earthquake DRR in Nepal, in particular scientists who generate earthquake science and practitioners and policy-makers who could use it. The study has been undertaken as part of the Earthquakes without Frontiers (EwF) project, funded by the UK Natural Environment Research Council and Economic and Social Research Council. The project aims to support governments, non-governmental organisations and communities to build resilience to earthquakes and secondary hazards along the Alpine-Himalayan belt. It is focused on four case study countries: Nepal, the neighbouring Indian state of Bihar, Kazakhstan and China.

Nepal is a geologically active country with a long history of destructive earthquakes – most recently in the 2015 Gorkha earthquake sequence. There have been substantial advances in the scientific understanding of earthquake hazard in Nepal, but it is not clear how that understanding has informed, or could inform, national and international investment in earthquake DRR activities, and to what effect. The aim of this paper is to understand the role that earthquake science plays in DRR policy and practice in Nepal by seeking answers to the following questions:

- What earthquake science is used by DRR stakeholders in Nepal, and for what purpose?
- To what extent is earthquake DRR policy and practice in line with current scientific knowledge?
- Where and how is scientific knowledge seen as particularly useful for policy and practice, and where is it seen to be less useful and why?
- What are the drivers of and constraints on the production and use of earthquake science?
- Are there opportunities to better produce or broker scientific knowledge for policy and practice?
- What effects could better use of earthquake science deliver, and to whom?

In January 2014, we conducted a set of interviews and focus group discussions with local scientists, engineers, urban planners and representatives of major donor and practitioner organisations that are involved in DRR activities in Nepal. We found that earthquake science is widely used by those responsible for DRR in Nepal. Much of this science, however, is very general, and for most users it is used to inform broad opinions or choices

rather than specific plans. This under-utilisation happens in part because potential science users don't know what science can say (and therefore what questions to ask), and because scientists don't know what those potential users need. Many of the questions that are directly addressed by earthquake science are far removed from the questions of those involved in DRR. Where earthquake science does provide knowledge of direct relevance to DRR, the wider context around the DRR activity has at least as much influence on what can be done as the science itself.

We found that there is appreciable earthquake science capacity in Nepal, with expertise on both primary and secondary earthquake hazards. Local scientists are often less connected to DRR organisations (e.g. donors and NGOs) than are international scientists, leading to frustration and disengagement with the DRR process.

We argue that science could be used both more often and more instrumentally within resilience work to guide and advance disaster preparedness and management, and to support DRR policy priorities and activities. These potential uses can be distinguished in terms of the primary end users:

- Use of science by **donors** is focused primarily on advocacy for particular issues, reflecting the ultimate role of donor organisations in setting agendas and funding projects. There are clear opportunities for more instrumental uses of science in constructing business cases for intervention or investment, for example by informing the balance between urban and rural projects or justifying a focus on particular regions or hazards. However, the more space- and time-specific the application of science, the greater the emphasis on the precision and accuracy of the science.
- For **practitioners**, there is considerable potential for earthquake science to be used more widely in community-based DRR initiatives. There is currently an over-reliance on local knowledge, which provides essential insight but also has important gaps, particularly around low-frequency, high-magnitude earthquakes. Some of these gaps could be filled by existing earthquake science, but it remains a considerable challenge to make that science available in a format or at a scale that is appropriate to community-level activities.
- **Engineers and urban planners** in Nepal are disconnected from earthquake science, in part as a legacy of where they were trained. There is a need for earthquake engineering, and some earthquake science, to be taught

in the Nepal engineering curriculum as a way of strengthening the scientific knowledge that underpins safe construction practices and full implementation of seismic building codes. Greater application of earthquake science to engineering in practice, however, is complicated by a wider set of governance issues, such as building code implementation and oversight, lack of clarity over responsibilities for DRR, and prioritisation of disaster management over risk reduction. These are general global problems as well as being specific to Nepal.

Specific recommendations

We recommend the creation of a sustainable, government-led science advisory group, composed of national and international earthquake scientists, which could be called upon by potential users from the DRR community for advice at every stage of the disaster cycle in Nepal. This group could help to condense and assess available scientific information on earthquake hazards.

To ensure that end users can draw on expertise from this group, and from earthquake science more generally, we recommend that the model of the Nepal Risk Reduction Consortium – an existing partnership between the Government of Nepal and the humanitarian and development community tasked with coordinating DRR

activities in the country – be developed and extended as a way of ensuring explicit cooperation between government, donors and NGOs. This model provides a potential gateway for science to enter into DRR activities because it connects the relevant users and provides clear focus areas for engagement around a particular aspect of DRR, acting both as a conduit and as a point of contact for science and scientists.

We also recommend that scenarios be used more widely for contingency and logistics planning, as a specific mechanism for allowing earthquake science to be taken up and utilised by a range of end users. These scenarios can allow exploration of different possibilities – for example, the effects of earthquake occurrence during day-time or night-time hours on casualties, or the impacts of structural retrofitting efforts that are focused on particular districts or particular building types. They also have the potential to identify possible impacts that are currently not considered, such as the effects of earthquake-triggered landslides or earthquake impacts in rural districts as well as urban areas. The scenarios would be most effective if they were consensus products from a science advisory group (as recommended above), including government representatives, that could provide a collective and authoritative voice, backed up by peer-reviewed earthquake science.

1. Introduction

There has been a recent upsurge of interest in the role and use of science in disaster management and disaster risk reduction (DRR) – from risk mitigation, preparedness and early warning, to emergency response, recovery and reconstruction (e.g. Alexander, 2007; UNISDR, 2015a). The onus is often placed on the scientists to make their science ‘useful, useable, and used’ (Boaz and Hayden, 2002; UNISDR, 2013) and to communicate their research effectively to potential end users – in this case policy-makers and practitioners engaged in disaster management and DRR. While there is a growing body of literature that recognises the influence of the political economy context on DRR decision-making and action (Jones et al., 2012; Jones et al. 2016), less consideration has been given to those end users – in particular, how they communicate their science needs and access the scientific information they require. In addition, while a number of case studies have been presented as examples of good practice in the use of science for DRR (e.g. UNISDR 2013; 2015a), little attention has been given to *how* science is used and the barriers to its potential wider use. In general, the case studies that do exist tend to focus on more frequent, visible or predictable hazards, such as flooding (e.g. Lane et al., 2011; Cadag and Gaillard, 2012). Earthquakes present a particular challenge, given that they cannot be predicted, occur abruptly with no warning, have persistent long-term consequences, and occur infrequently relative to human lifetimes (Davies et al., 2015). Perhaps because of these issues, the specific uses, and limitations, of earthquake science in DRR have so far received little attention (Davies et al., 2015). The 2015 Nepal earthquake sequence, however, has highlighted the importance of addressing these challenges and of understanding how science is used in earthquake risk reduction policy and practice. That use, along with the factors that both drive and constrain the use of science, is the subject of this working paper.

1.1 Aims and research questions

The aim of this paper is to understand the role that earthquake science plays, and could play, in DRR policy and practice in Nepal. By earthquake science, we mean the science of how and why earthquakes happen and the consequences of earthquakes for the natural environment and the people who live in it (see Annex A). We recognise that there are many different forms of knowledge and expertise, including scientific knowledge (e.g. in social

science and engineering), practitioner knowledge (e.g. knowledge held by DRR professionals) and lay knowledge (e.g. knowledge held by communities and individuals) (Mercer, 2012). However, here we ask whether earthquake science in particular is being used to its full potential for DRR in Nepal, and what the main drivers of and constraints on the use of earthquake science might be. This understanding is a critical first step that must be taken before we can hope to design or facilitate stronger linkages between science and policy.

To address this aim, we seek answers to the following questions:

- What earthquake science is used by DRR stakeholders in Nepal, and for what purpose?
- To what extent is earthquake DRR policy and practice in line with current scientific knowledge?
- Where and how is scientific knowledge seen as particularly useful for policy and practice, and where is it seen to be less useful and why?
- What are the drivers of and constraints on the production and use of earthquake science?
- Are there opportunities to better produce or broker scientific knowledge for policy and practice?
- What effects could better use of earthquake science deliver, and to whom?

1.2 Our focus

Nepal has a very high level of seismic hazard and a long history of destructive earthquakes. DRR in Nepal is governed by, and involves, a complex network of actors and institutions, including both government (scientists and technical experts as well as bureaucrats) and non-government stakeholders. The latter include United Nations (UN) organisations, multi- and bilateral donor organisations, international and national non-governmental organisations (NGOs), scientists and engineers (both consultants and university academics), the private sector and the population at large. This network creates a challenging context within which to examine the uses of science in policy and practice, due to the large number of actors that can potentially generate or use earthquake science. We focus our attention in particular on scientists as the producers of earthquake science, engineers working within earthquake risk reduction,

UN organisations that are key players in earthquake preparedness and response in Nepal, donor organisations that fund DRR activities, NGOs that are implementing community-based DRR projects, and representatives of key government organisations. These groups are representative of the wider DRR decision-making community in Nepal.

1.3 Our approach

To understand how earthquake science is used in DRR, and the drivers of and constraints on knowledge production and use, we conducted a series of focus group discussions in January 2014 with the following

Key terms

We define **policy** in its broadest sense to include content; procedures; behaviours; discourse; and attitudes (Jones and Villar, 2008; Keck and Sikkink, 1998).

Governance refers to ‘the definition of issues, the formation of policies and the introduction of measures to mitigate undesirable consequences’ (Bulkeley and Mol, 2003: 144). Understanding the governance context for DRR therefore requires an understanding of the stakeholders involved (not only those engaged directly in DRR but also those from other, perhaps seemingly unrelated, sectors), the relationships among them and the role of power in these relationships; the institutional and legislative context for DRR; and the incentives and disincentives that affect the decisions of stakeholders engaged in DRR (Jones et al., 2016).

For other key terms relating to evidence-informed policy-making, see Annex B.

groups: scientists, engineers, UN organisations, donors and NGOs. We conducted follow-up interviews with government representatives from the Ministry of Federal Affairs and Local Development (MoFALD), the National Planning Commission, the Department of Mines and Geology (DMG) and the National Seismological Centre (NSC). We also drew on interviews with the Ministry of Home Affairs (MoHA) undertaken as part of a wider study on disaster risk governance in Nepal. In the focus groups, we were joined by 10 scientists, 8 donor officials (representing both multi- and bi-lateral organisations), 8 NGO practitioners, 11 representatives from various UN organisations and five engineers. The focus groups and interviews were conducted in English, with the group discussions facilitated by both natural and social scientists in each case. Recordings of the focus group discussions and interviews were transcribed and coded thematically, with selected excerpts provided in the following sections.

1.4 The 2015 Nepal earthquakes

The focus groups and interviews that underpin this work were conducted 15 months before the destructive sequence of earthquakes that hit Nepal in April and May 2015. Most, if not all, of the participants in the study have been involved in the response and recovery effort following these earthquakes. The ways in which existing scientific knowledge and understanding were used to aid that effort, the new understanding that has resulted from the earthquake, and the opportunities and barriers to the uptake of earthquake science in response and recovery – while important issues in their own right – are beyond the scope of this paper. Instead, we focus on the themes and perspectives that emerged from the 2014 focus groups and interviews.

2. Context and background

2.1 The governance of disaster risk reduction in Nepal

The governance landscape for DRR in Nepal is complex, involving a multitude of government and non-government actors. While the state is the centre of political power, the influence of international organisations is significant, with UN organisations and multi- and bilateral donors playing a substantial role in advancing the DRR agenda (Jones et al., 2014). This is unsurprising given the high dependency on development assistance, which accounts for about 26% of Nepal's national budget (MoF, 2013). The range of DRR programmes underway in Nepal – from school and hospital retrofitting to community-based DRR activities – is impressive, particularly given the competing priorities and pressures in post-conflict Nepal (Jones et al., 2016). There remain, however, questions around government ownership of the DRR agenda (Jones et al., 2014; 2016).

The current legislation for disaster management, which dates back to the 1982 Natural Disaster Relief/Calamities Act, remains focused on response and relief. Although a new Act has been drafted with greater emphasis on DRR in line with the Hyogo Framework for Action (and the more recent Sendai Framework for DRR), its ratification has not been a priority for government. Disaster response and management therefore remains the responsibility of the MoHA. Given the growing international emphasis on DRR rather than disaster management, it has been argued that a position within a development ministry would be more appropriate, to enable the mainstreaming of DRR across development activities. In the absence of a revised Act, the National Strategy for Disaster Risk Management – developed following a multi-stakeholder consultation process – has been guiding DRR in Nepal. Stakeholder coordination has been undertaken by the Nepal Risk Reduction Consortium (NRRC), a UN initiative which brings together the Government of Nepal and development and humanitarian partners, with the aim of reducing Nepal's vulnerability to natural hazards.

Some progress has been reported in local disaster management at the subnational level, with disaster preparedness plans developed in 67 out of 75 districts (MoHA, 2011). Guidelines have also been developed by MoFALD to support Local Disaster Risk Management Planning (LDRMP). However, while a growing number of Village Development Committees (VDCs) and municipalities are preparing plans, without the passing

of the revised act few resources are available to support subnational DRR activities, limiting the action that can be taken. In addition, district-level government often lacks the capacity to support VDCs and municipalities in these planning processes.

2.2 Earthquake science in Nepal

We first review the state of scientific understanding of earthquakes in Nepal, and then describe the perspectives of the scientist focus group. Further information on earthquake science can be found in Annex A.

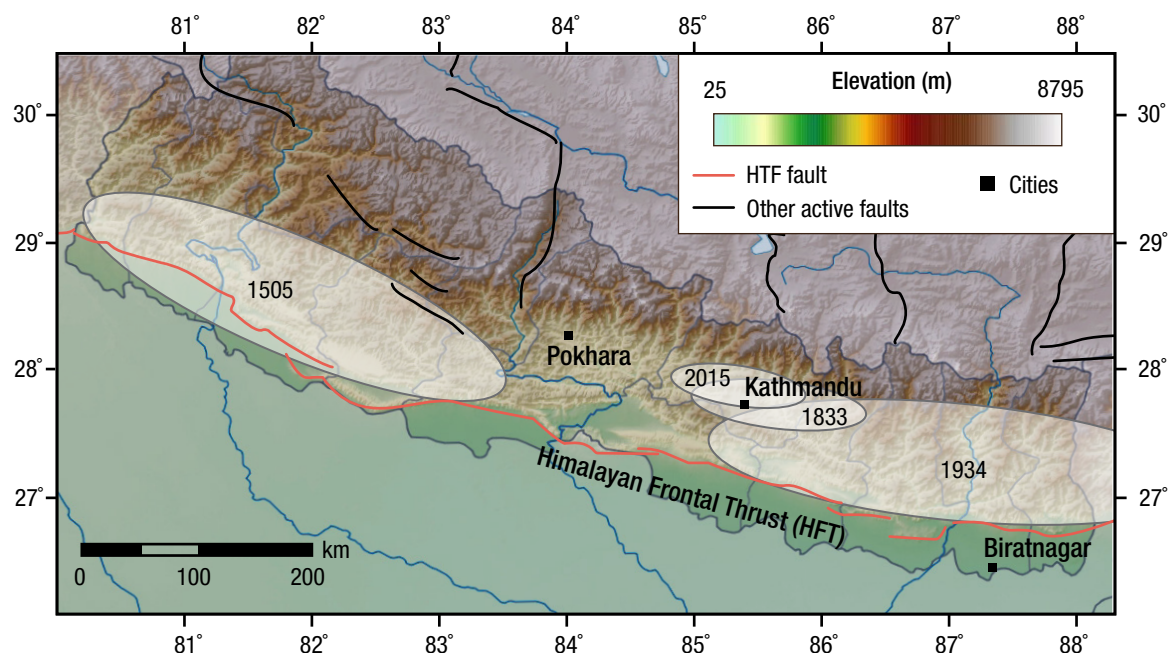
2.2.1. State of the art in earthquake science

Nepal is highly susceptible to earthquakes (Figure 1). The collision between the Indian and Eurasian plates has built the Himalayan mountain chain, and is accommodated primarily by slip on the Himalayan Frontal Thrust (HFT), which intersects the Earth's surface along the mountain front in southern Nepal and northern India (Wesnousky et al., 1999).

Ongoing convergence between the Indian and Eurasian plates means that northern India is continuously moving towards central and northern Nepal at a rate of about 18-20 mm per year (Ader et al., 2012). This means that after a period of about 500 years, the HFT needs to slip by about 9 m to accommodate the relative movement of the plates. If this 9 m of slip were to be released in a single earthquake, it would correspond to a M_w 8 event. If the Himalayan arc were to rupture only in M_w 8 earthquakes, which have a typical rupture length of around 200 to 300 km, then up to 10 earthquakes would be needed to span the whole 2,000 km width of the arc (Bilham, 2004). As the return period for each of these earthquakes is about 500 years, then one earthquake should be expected somewhere along the arc roughly every 50 to 70 years (Bilham, 2004). However, it should be noted that earthquakes do not follow a regular pattern over time, so they need not (and indeed, will not) be spaced exactly 50 years apart.

There have been eight earthquakes larger than M_w 7.5 recorded since 1500 AD across the Himalayan arc, the largest of which was the M_w 8.5 Assam-Tibet earthquake in 1950. Kathmandu has been repeatedly damaged by large earthquakes, most notably in 1255 AD and 1408 AD (Chitrakar and Pandey, 1986; Ader et al., 2012). Although ancient earthquake magnitudes are difficult to estimate, paleoseismological evidence suggests that the 1255 AD earthquake was of a similar magnitude to the

Figure 1. Nepal's active faults and approximate locations of slip patches in major historical earthquakes



Source: adapted from Taylor and Yin, 2009; Ader et al., 2012; Avouac et al., 2015. The Himalayan Frontal Thrust (red line) is the major currently-active fault along the southern edge of the India-Eurasia plate boundary. Major cities in Nepal are shown as black squares.

1934 M_w 8.1 earthquake (Sapkota et al., 2013). Some research has suggested that the discrepancy between relative plate motion and energy release in historical earthquakes along the Himalayan arc could be accounted for by unrecorded earthquakes of up to about M_w 9 (Ader et al., 2012). Paleoseismological investigations suggest that two candidate M_w 9 earthquakes occurred around 1100 AD and 1500 AD (Lavé et al., 2005; Kumar et al., 2006), although this is subject to debate (Sapkota et al., 2013). Regardless of whether such earthquakes have occurred, it is indisputable that earthquakes of greater than M_w 8 have occurred repeatedly in the past and should be expected in the future.

Earthquakes could also occur on faults other than the HFT (Silver et al., 2015). This possibility means that seismic hazard estimated on the basis of the HFT alone may be somewhat underestimated, although the extent of this underestimation is very hard to determine at present.

A probabilistic seismic hazard assessment specific to Nepal was first conducted in 1992 to inform the National Building Code, and was updated by Pandey et al. (2002). Seismic risk assessments have largely focused on the Kathmandu Valley: two studies (in 2000 and 2007) used a repeat of the 1934 earthquake to illustrate current risk, while JICA (2002) examined a wider range of feasible scenarios drawing on findings from Pandey et al. (2002). The Nepal hazard risk assessment (ADPC, 2010)

broadened the focus away from the Kathmandu Valley, drawing on the Pandey et al. (2002) hazard assessment and combining population, building type and infrastructure data with vulnerability data from past earthquakes to account for vulnerability and exposure. Table 1 summarises the main seismic hazard and risk assessments that have been undertaken for Nepal, including the development of specific earthquake scenarios. The reader is referred to the original reports and documentation for the specific results.

2.2.2. Earthquake science in Nepal from the perspective of local scientists

Nepali geologists are highly engaged with, and in many cases responsible for, much of the research on earthquake hazard across the Himalayan arc in general, and in Nepal in particular. Our focus group discussions revealed that, while local scientists are confident that they have a good knowledge of the surface locations of active faults, there is currently no single accepted fault map for Nepal. Members of the group were clear that, while fault locations are relevant to earthquake hazard, their surface expression provides only part of the picture, as faults dip under the surface. There was also consensus over which faults accommodate most of the slip and are associated with the largest and most frequent earthquakes. The group was unanimous in suggesting that the key outstanding research

need is to determine the location, amount and date of slip in past earthquakes – for example through trenching and other paleoseismological investigations. From this knowledge, it should be possible to determine the magnitude and frequency of past earthquakes along the HFT, and indicate what might be expected in future. This has been done in detail for only short sections of the HFT, and the group felt that more research of this type was needed.

Generally, the scientists agreed that it is best to assume that the whole of Nepal has a high primary earthquake hazard. However, delineating the hazard was considered useful for some purposes, such as informing the National Building Code (NBC). There was universal consensus that the hazard map on which the NBC is based, formulated as part of the Building Code Development Project (Table 1), represents a rigorous assessment of seismic hazard in Nepal. While some scientists expressed concern that the map may not reflect the state of the art of knowledge on Himalayan seismotectonics (e.g. the locations of all active faults), it was not clear what updates were needed based on this new understanding. Although the hazard map of Pandey et al. (2002) was mentioned as a rigorous assessment of seismic hazard, the group did not explicitly talk about this as an update of the NBC map. They were unfamiliar with the Nepal Hazard Risk Assessment map prepared by ADPC (2010) and were unsure about the methods that had been used to develop it, despite the map being based on the results of Pandey et al. (2002) and initiated by MoHA. The focus group participants expressed concern about the proliferation of seismic hazard maps, and called for a consensus-based hazard map for Nepal underpinned by the best available data.

There was extensive discussion within the group around appropriate methodologies for producing seismic hazard maps, including the problem of bias towards past earthquakes (the ‘bulls-eye effect’), the proper methodology for dealing with aftershocks and the importance of including earthquakes with epicentres outside Nepal. There was concern that, because hazard maps are largely based on historical earthquakes (both large and small), they can give a misleading picture that earthquake hazard is low in areas where few earthquakes have been recorded. The group emphasised that earthquakes are possible wherever there are active faults, regardless of historical earthquake activity. It was, however, unclear from the discussion whether areas of perceived low hazard in Nepal are due to the absence of previously identified active faults, the presence of creeping faults that slip continuously without generating earthquakes, or the absence of historical earthquakes in those areas.

The group affirmed that the way that seismic waves propagate through different materials during an earthquake (i.e. attenuation and amplification) is important for building design. They acknowledged that some work has been done in this area, but recognised that such work is difficult to do properly because site effects are highly localised, requiring detailed knowledge of the material characteristics at a very fine scale. In terms of wider issues around earthquake risk, there was awareness among the group that hazard is only one component of risk and that it is necessary to also consider vulnerability.

The group agreed that earthquake-triggered landslides are an important secondary hazard, but also agreed that the precise relationship – and thus the hazard – is not well understood. Earthquake-triggered landslides are an issue in all tectonically active mountain belts, with very few studies having been undertaken on earthquake-triggered landslides in the Himalaya specifically. Focus group participants recognised that landslides should be considered a dynamic rather than a static problem, in that forces on a hillslope change rapidly over the course of an earthquake and that ground motion will have implications for the stability of the hillslope. Many large landslides have been observed near active faults. But one participant suggested that that only earthquakes above M_w 8 trigger large landslides, and another noted that the 2011 Sikkim earthquake was not strong enough to trigger large landslides, though many shallow landslides were initiated. Another participant suggested, however, that it is difficult to determine the triggering mechanism of landslides based on their characteristics, such as size, depth and hillslope characteristics. These apparently conflicting views reflect an ongoing debate in the international community over whether the characteristics of landslides reflect the magnitude of the earthquake that triggered them. There was agreement, however, that the number and size of landslides increase with earthquake magnitude, with very few landslides triggered by earthquakes that are smaller than M_w 6.5.

In terms of the constraints on the generation of new earthquake science, the group noted that Nepali earthquake research is funded primarily through in-kind support from international research collaborators. There is some government funding available for monitoring, with the NSC maintaining a small network of seismometers. Beyond this, there is limited government funding other than for the salary costs of government scientists and university academics. Donors rarely fund earthquake science, whether nationally or internationally led.

Table 1. Seismic hazard and risk assessments undertaken for Nepal

Year	Project name	Commissioned/ authored by	Description
1992	Building Code Development Project	Initiated by the Ministry of Housing and Physical Planning with assistance from the UNDP through the UN Centre for Housing Settlements (Beca International Consultants Ltd., New Zealand in conjunction with Nepali counterparts)	Aim: to assess the primary seismic hazard to inform the development of the first building code for Nepal. The project carried out a probabilistic seismic risk assessment of Nepal, including secondary hazards. It included all known active faults and earthquakes from 1255 AD to 1992 AD and estimated surface acceleration (both PGA and for particular wave periods) using an empirical attenuation relationship. Results were reported for events with return periods of 50-1,000 years.
1992-1999	Global Seismic Hazard Assessment Program (GSHAP)	Assessment of hazard for India and adjoining regions undertaken as part of GSHAP	Aim: to improve global standards in seismic hazard assessment and to assist national or regional agencies to identify locations where further detailed studies might be required (Giardini et al., 1999). Nepal was included as an adjoining country to India. Hazard was expressed in terms of PGA with a 10% chance of exceedance in 50 years (corresponding to a return period of 475 years). The assessment suggested PGA values of up to 0.3 g for Nepal.
1997-2000	Kathmandu Valley Earthquake Risk Management Project (KVERMP)	Launched under the Asian Urban Disaster Mitigation Program implemented by NSET and Geohazards International	Aim: to reduce earthquake vulnerability in the Kathmandu Valley by evaluating the consequences of a repeat of the 1934 earthquake. The hazard was taken from the 1934 earthquake. Vulnerability was calculated based on past vulnerability and changes in population density and building stock.
2002	Seismic hazard map of Nepal	Pandey et al. (2002)	Aim: to update probabilistic seismic hazard assessment maps for Nepal following seismic network development in the region since 1992. Hazard was expressed in terms of PGA at bedrock for a 475-year return period. This did not account for the influence of surface geology on the shaking. The assessment suggested PGA values of up to 0.4 g in northern Nepal.
2002	Earthquake Disaster Mitigation in the Kathmandu Valley	Japan International Cooperation Agency (JICA)/Ministry of Home Affairs (MoHA)	Aim: to estimate earthquake hazard for the Kathmandu Valley using four earthquake scenarios: (i) a mid-Nepal earthquake (surface-wave magnitude Ms 8.0) filling the seismic gap identified by Pandey et al. (1999) between 82-85°E; (ii) a North Bagmati earthquake (Ms 6.0) to represent the small, frequent earthquakes that occur just north of the Kathmandu Valley; (iii) a local Kathmandu Valley earthquake (Ms 5.7); and (iv) a repeat of the 1934 Bihar-Nepal earthquake (Ms 8.4), which was included for comparison. Ground conditions were classified in order to evaluate amplification, liquefaction potential and slope stability. Hazard was expressed in terms of PGA for each scenario, and the results were used to estimate building losses, damage to infrastructure and casualties.
2007	Municipal Earthquake Risk Management Project	NSET, building on the KVERMP	Aim: to develop an action plan for reducing risk using an earthquake scenario. The project used a similar approach to the KVERMP. It was tested in the municipalities of Banepa, Dharan and Vyas.
2011	Nepal Hazard Risk Assessment	Initiated by MoHA and implemented by the Asian Disaster Preparedness Centre (ADPC), the Norwegian Geotechnical Institute and the Centre for International Studies and Cooperation, in consultation with local stakeholders	Aim: to develop a national hazard and risk profile for Nepal. Seismic hazard was assessed in terms of Modified Mercalli Intensity for 50-year, 100-year, 250-year and 500-year return periods for bedrock and based on the work of Pandey et al. (2002). An assessment of exposure, vulnerability and risk was also undertaken.

3. The use of earthquake science in DRR policy and practice

The focus group discussion with local scientists revealed a high level of engagement with, and knowledge of, earthquake science in Nepal. How, then, is this earthquake science used in earthquake risk reduction policy and practice? We consider the views expressed by each focus group in turn: representatives of major donor organisations, practitioners, representatives of various UN bodies, and engineers and urban planners.

3.1. Donors

Multilateral and bilateral donor organisations are the primary funding source for earthquake risk reduction activities in Nepal. DRR advisors based within donor organisations are tasked with developing DRR programmes, securing funding within their organisation for these initiatives, and engaging national and local NGOs to deliver the programme activities. It was noted by one participant that DRR advisors are generalists rather than specialists, often with a development (social science) background. The nature of DRR means that on any one day an advisor can be dealing with climate change adaptation, building code implementation or emergency planning with local government. It could, therefore, be argued that breadth rather than depth of knowledge is required by DRR experts within donor organisations. Participants in the donor focus group demonstrated a basic understanding of earthquake hazard, including the causes of earthquakes and their secondary effects, such as landslides and liquefaction. Some participants were confused, unsurprisingly, by probabilities and return periods and were interested to know how earthquake probabilities are calculated and the likelihood of a high magnitude earthquake occurring in Nepal in any given year. Many participants cited the National Society for Earthquake Technology (NSET) as the main source of such technical information. They were, however, relatively unaware of local scientists engaged in earthquake research that they could approach for this information. While this might reflect a range of constraints, one participant highlighted the role of gate-keepers

who may have vested interests in preventing scientific information from being shared.

Participants were generally aware of the limitations of earthquake science, recognising, for example, that earthquakes cannot be predicted. As a result, there was a feeling among some of the participants that they probably know all they need to know about earthquakes for the purposes of DRR, and that closer engagement with Earth scientists is unlikely to influence their programming and activities. This perhaps reflects the more widely held perception articulated by the former Head of the UN Mission in Nepal, Robert Piper, that ‘addressing Nepal’s vulnerability to natural hazards is first a governance problem, and only second, about funding and expertise’ (Piper, 2013). As a result, earthquake science is largely used politically by donors to persuade people or to influence their behaviour, both internally within donor organisations and externally in the interactions between organisations and government. For instance, participants indicated that donor organisations draw on earthquake ‘facts’ in business case development to make the case for earthquake risk reduction programmes within their organisation. Such facts have been used to illustrate the vulnerability of Kathmandu in relation to other cities in South Asia, the number of people potentially exposed to intensity VIII shaking and the potential loss of life, as well as the impact on development gains in the country. Donor agencies also use these facts in advocacy to keep earthquake risk reduction on the agendas of the Government of Nepal, the donor community and NGOs. Given this, there was a sense among the group that cutting-edge science is less important for their purposes than new ‘popular facts’ (e.g. headline numbers on potential earthquake impacts, or global rankings of earthquake risk) to keep the stakeholders engaged – with advocacy based largely on those facts and on the emotional response that they produce. As one participant explained, the NRRC – a partnership between government and the humanitarian and development community that is charged with coordinating DRR activities – has been active since 2011 and repeatedly uses the same material in speeches to make the case for more funding for earthquake risk

reduction. It was noted that it is becoming harder and harder to maintain stakeholder interest.

At the same time, there was awareness that DRR programmes could be more rigorously underpinned by science. As a representative from a donor organisation explained in a separate interview: ‘I’ve never really seen a seismic expert come in and say this is the seismic risk, the likely scenarios, the areas affected.’ Further to this, participants expressed concern that programming decisions might be underpinned by science that has not been subject to rigorous and independent review. Existing products like the JICA (2002) earthquake report, which explores a series of earthquake scenarios impacting the Kathmandu Valley and which was well known by the donor representatives, could provide at least some of this information. However, the donor agencies do not always have the expertise to use this more instrumentally in their programme design and implementation. This provides a clear example of how existing – and widely accepted – earthquake science is not being used effectively in DRR programming, perhaps because the donor agencies lack the capacity to make full use of the information.

Where knowledge gaps are identified by donors, research is commissioned. This research is highly targeted and policy focused. For example, the Nationwide Risk Assessment being commissioned by the NRRC has been designed to shape the future DRR agenda in Nepal through the identification of priority areas for research and action. Aware that an extensive body of research on hazard and vulnerability already exists in Nepal, the NRRC began with a ‘stock-taking exercise’ to provide an overview of what is known, and to identify where the gaps in knowledge lie and where new or updated research could usefully be commissioned. The donor representatives noted that keeping a handle on the research being undertaken by the multiple donor and practitioner organisations in Nepal is a major challenge – findings and outputs from research programmes often go unshared, or get lost over time as personnel and priorities within organisations change. This can result in similar research being commissioned by multiple donor organisations, with donors focusing on the short term rather than investing in research that is useful for all engaged stakeholders beyond the life of a specific project. Donors fund research that will provide a knowledge base upon which decisions are made and resource usage justified. They are less likely to fund ‘blue skies’ research that has little relevance to operational planning, though this is the science upon which earthquake facts are based.

3.2 Practitioners

The practitioner focus group included representatives from international and national NGOs and other stakeholders who are engaged directly in the implementation of DRR projects. Unlike the DRR representatives within the donor

organisations, practitioners were reflecting on the work of their organisations at the local or community level, and this was reflected in the way they use scientific information to support their DRR programmes. Participants in the practitioner focus group demonstrated a good understanding of earthquake hazard and risk, including why earthquakes happen in Nepal, their potential consequences and possible preparedness measures. As well as magnitude, the group recognised the importance of geology in determining localised shaking and intensity, and the impact of this shaking in terms of potential damage to buildings and loss of life. They were also aware that high-magnitude earthquakes can still occur in areas of seemingly low seismic hazard, viewing seismic hazard maps with healthy scepticism. The potential for landslides to be triggered by earthquake events was also recognised, with participants acknowledging that landslides can cause more damage than the earthquake itself, especially in rural areas of Nepal. There was some confusion in the group around earthquake probabilities and return periods, and therefore what the published hazard maps show. Participants spoke of a ‘70-year rule’, suggesting that a high-magnitude earthquake will occur in the Kathmandu Valley every 70 years. The fact that there had not been (at that time) a major earthquake in the valley since 1934, a span of 80 years, was therefore a cause for concern for some participants, who asked whether Nepal was ‘overdue’ an earthquake. While there is no scientific basis for this idea (Annex A), it is both widely reported and remarkably persistent and has provided some impetus for preparation.

There was agreement among the practitioner representatives that active faults are located throughout Nepal and that as a result, earthquakes could happen anywhere, leading to high seismic hazard across all of Nepal. Vulnerability to earthquakes, on the other hand, was seen to vary spatially and was thought to depend on a range of factors, including concentrations of people, poverty and inequality. The representatives felt strongly that addressing vulnerability was the key to reducing earthquake risk in Nepal. Vulnerability is therefore the main focus of NGO-led, community-based DRR initiatives.

The practitioners involved in the focus group discussion were largely engaged in DRR activities at the local or community level. As a result, some of the focus group participants were less familiar with national-scale hazard maps published by the ADPC, UNOCHA and others. Participants who had been engaged in more strategic-level planning were aware of these maps and associated reports – JICA (2002) was cited as a key resource – and used them in much the same way as the donor representatives – conceptually or indirectly, to inform their programmes of work (e.g. in prioritising the retrofitting of schools over other activities); and politically, to illustrate Nepal’s susceptibility to earthquakes for funding purposes and to prompt action by national and local government. However, national-scale hazard maps were unanimously considered

to be of limited use to NGOs engaged in community-based DRR. For scientific knowledge (such as a hazard map) to be usefully applied by practitioners, it would need to be available at a much finer scale that allowed delineation of hazards across a community, rather than assigning that community a single value or classification. Even then, as one participant explained:

'I think these kinds of [hazard] maps would be of limited use ... vulnerability is largely related to what's there and what's built ... I think the vulnerability is less related to this kind of stuff, and this kind of mapping, than the mapping which goes on above the ground – the physical conditions [i.e. vulnerability of building stock] and so on. So when we go and work with communities, that is what we try to do.'

Perhaps surprisingly, national-scale hazard maps were found to play little or no role in the selection of areas where NGOs undertake community-based DRR projects, reflecting the range of criteria that are used explicitly and implicitly to decide where to work.

Current approaches to community-based DRR by practitioners in Nepal are generally based on local knowledge, with minimal scientific input. The rationale behind this is that people have a good knowledge of the physical environment in which they live, and it is possible to see the vulnerability in the built environment (such as poorly constructed buildings) without additional scientific input. Focus group participants were aware that the intensity of shaking in a major earthquake will vary spatially, and that secondary hazards will be a widespread problem in rural areas, but this knowledge did not seem to impact their practice and was not seen as especially relevant for their activities.

Some studies have suggested, however, that there are likely to be local knowledge gaps around the occurrence of rare events like earthquakes and their links with secondary hazards, including landslides. As a result, these hazards may not be included, or adequately recognised, in locally driven vulnerability assessments. There may therefore be important limits to the level of community preparedness for, or resilience to, this type of infrequent hazard. Communities may also be unaware of the availability of more detailed and potentially relevant scientific information, such as localised geology and liquefaction potential. Instead, practitioner representatives described how they used basic science conceptually, to raise awareness of earthquake hazards at the community level and to address knowledge gaps and misunderstandings – for example, regarding the potential for earthquake activity. As one participant noted: 'We're getting much more basic – we're trying to get them [the community] to understand there is a serious threat here.' A more scientific or technical understanding was considered less relevant to community-based DRR activities. For example, one NGO had attempted to use

the RADIUS tool, which is designed to provide practical guidance on assessing seismic vulnerability, but found it to be complicated and difficult to apply.

3.3. UN organisations

The UN focus group members talked much more about the instrumental uses of scientific knowledge than those in other groups, reflecting the direct engagement and responsibilities of the focus group participants in disaster preparedness and response planning. Aware that an earthquake could occur at any time, participants talked about the need to be as prepared as possible. At the time that the focus groups were held, UN organisations were preparing for a repeat of the 1934 M_w 8.1 earthquake with a focus on the Kathmandu Valley, the rationale being that this is the most densely populated city in Nepal and therefore the highest priority. In planning for a Kathmandu Valley earthquake, the UN agencies rely on 'observations and experience of [the] 1934 earthquake' along with experiences in other earthquakes in the region and internationally. As one participant explained, 'it's a question of logistics' to get water, food and non-food items into the affected areas as quickly as possible, as well as the necessary equipment to support the response and recovery effort.

While the focus group participants were aware of the earthquake scenarios prepared by JICA (2002), it was not clear how these scenarios are used in disaster response planning. Instead, the participants made reference to two more practical scenarios: one in which the Kathmandu airport is functional, allowing international aid to arrive by plane; and another in which the runway is damaged, requiring the use of helicopters in the immediate aftermath. Overland aid routes have been mapped (including bridges and their susceptibility to collapse in the event of an earthquake) and plans have been developed for the movement of aid from the port of Kolkata in northeast India into Nepal. While access to the valley was identified as a priority, little consideration has been given to potential landslide hazard, which could block the arterial road corridors from China to the north and India to the south. Members of the group reported that very little information about the secondary effects associated with earthquakes was available, and this was identified as a potential area where earthquake science could make a useful contribution to disaster response planning.

Within the Kathmandu Valley, UN agencies use 'risk' maps to identify the areas of the city that are likely to be most severely affected, for example from building collapse. For this, they draw on the expertise of technical ministries in the Government of Nepal, principally the Ministry of Urban Development, which is currently preparing land use maps for the valley. The International Organization for Migration, working with MoHA, has identified open spaces in the Kathmandu Valley that could be used for humanitarian purposes in the event of an earthquake (MoHA and IOM,

2013); working with MoFALD, it has also developed a debris management plan to enable the roads to be cleared and opened as quickly as possible (MoFALD, 2014).

In terms of earthquake science, it was noted that ‘tectonics’ and ‘geomorphology’ were new and unfamiliar terms for the focus group participants. The group explained that while there are a small number of earthquake experts in Nepal, they have limited involvement in disaster response planning. Instead, participants go to them ‘when we really want to have a kind of updated knowledge of [an] earthquake’. The NSC provides information following an earthquake, including magnitude and epicentral location. However, participants noted that they use the US Geological Survey (USGS) National Earthquake Information Center to ‘really be updated’, aware that the USGS is often quicker at reporting earthquake events. Participants were aware that geological maps are available, along with maps showing the liquefaction hazard for the Kathmandu Valley (both through the DMG), but noted that this information does not currently inform disaster response planning. This is perhaps surprising, given the group’s awareness that earthquakes can have highly localised effects depending on geology.

Focus group participants could certainly see the value of scientific expertise, for example in trying to understand the causes of the Seti floods in Pokhara in 2012. A UNICEF-led water, sanitation and health (WASH) project is also drawing on scientific expertise to locate wells to provide a supply of water during emergency situations. However, in general it was noted that academic research is rarely shared beyond the academic community, with academics rarely approaching government with their data and findings. When it is shared, communication can be a challenge. On the other side, research is commissioned by the development sector when required (as with donors, this is policy focused). As one participant explained, research is needs based – when you need it, you collect it: ‘There is no continuous, systematic effort [research programme] put in place either by development partners or by the government agencies.’ One participant highlighted that this disempowers local research institutions. It was noted that in recent years there has been a growing awareness on the part of government and development agencies of the value of local research institutes in development planning. It was not evident, however, whether this awareness had led to any widespread instrumental changes in the planning process.

3.4 Engineers, architects and urban planners

This focus group included representatives from professional bodies engaged in earthquake engineering. The discussion indicated that there is generally a high level of awareness of Nepal’s susceptibility to earthquakes and secondary hazards amongst engineers and urban planners, with particular emphasis on urban hazards

such as fire associated with gas and electricity. Reference was also made to landslides and to flooding associated with the blocking of rivers by landslides. The engineers noted that scientific information is available about the earthquake hazard context in Nepal, such as fault maps and liquefaction maps. There were concerns, however, regarding the accuracy of the information available, which was described as ‘good for bringing awareness but for actual practicing they are not accurate’. In some cases, the data were considered to be out of date; in other cases, it was felt that the outputs were at the wrong scale to usefully inform earthquake engineering.

As practicing engineers and urban planners, the group shared examples of how earthquake science has been, and could be, used instrumentally in urban planning and building code development. They also recognised the social vulnerability and policy contexts in which earthquake risk reduction is being undertaken in Nepal and the barriers faced in DRR implementation. The engineers, then, had a very broad understanding of the problem: ‘only knowing the [physical] hazard is not enough’.

A key issue raised was the lack of urban planning in Nepal and the challenges associated with designing and implementing urban plans retrospectively once a city exists. One major contributing factor to what one participant called ‘the community planned cities’, where planning is led by the community with no technical input from specialists in the field of urban planning, was the Maoist insurgency. The insurgency led people to migrate from conflict-affected rural areas to the cities: ‘they [rural migrants] purchased land, they built houses without thinking will they get proper road, proper water supply, proper electricity. They just went for the safety – safety from the conflicts that were happening in the villages.’ As a result, the growing cities ‘brought us another wave of hazard, I should say social hazard’. The situation has been compounded by the absence of a stable government in the conflict and post-conflict periods.

There were also concerns about the core areas of established cities, such as Kathmandu Metropolitan City, which are densely settled. These areas, with their combination of old heritage buildings and new concrete constructions, present a significant challenge for urban planners, architects and engineers. There is also evidence of new settlements being constructed outside the main cities on floodplains, highlighting the need for risk-sensitive land-use planning.

While some of the focus group participants had contributed to the development of the NBC, the group noted that implementation of the code is not mandatory – under the Local Self Governance Act, municipalities are free to decide whether to implement the NBC. In addition, the code does not apply to the large number of rapidly expanding VDCs which formally have village status. It was felt that capacity building is very much needed at the municipal level in order to implement the building code. There were

particular concerns among the focus group participants that, despite 3,000 new engineers graduating in Nepal each year, the country does not retain enough engineers to facilitate building code implementation. In the absence of jobs, many engineers travel abroad for employment. The same trend was observed for masons trained in earthquake-safe construction practices, who, having completed the training course, can demand higher wages from employers overseas. While masons who are trained in earthquake-safe construction can charge more for house construction in Nepal, feedback from masons suggests that currently there is a lack of demand from the public.

The focus group participants felt strongly that the NBC requires updating. In particular, the Nepal Engineers' Association has proposed that Nepal adopt a standard international building code that would be adapted for Nepal and regularly updated. This could address some of the reported deficiencies in the NBC. For example, the 'Mandatory Rules of Thumb' (MRT) component, which specifies elements such as column size, beam size, reinforcement, and partitions, is designed to guide the construction of concrete and masonry buildings. The MRT are rarely followed in full, however, with poor quality designs compounded by poor construction. As a result, the engineers suggested that the MRT be replaced with standard designs for masons to copy. It was also suggested that a new government body be set up to oversee the updating of the NBC and its implementation. This is currently the responsibility of a small section within the Department of Urban Development and Building Construction – a large department with a broad remit. It was recognised that this section had limited capacity, was

largely focused on urban development, and was isolated from construction efforts overseen by other ministries, including the Ministry of Education, the Ministry of Health and Population, MoFALD, MoHA and the military. For these reasons, the group suggested that responsibility for the NBC should lie with an independent institution.

The focus group participants identified an urgent need to train more engineers to understand the NBC and to apply it in their projects. While courses in earthquake engineering are increasingly being offered through universities in Nepal, the focus group participants felt that this wasn't enough. 'We need to intensify the knowledge sharing and practicing ... between the engineers, architects and planners.' In particular, knowledge of earthquake science was considered to be limited amongst architects and planners, who tend to learn through their professional development. With international funding, the Nepal Engineers' Association has collaborated with NSET to offer training to engineers in vulnerability assessment. There is evident interest and demand from within the engineering community, but a lack of funding was identified as the main constraint.

It was also noted that currently there is no appropriate building code for bridges, hydropower or other infrastructure projects. In some cases, in particular large-scale infrastructure projects such as hydropower dams, international codes are used to guide their construction. This was seen as a particular concern for projects that are implemented by district or municipal governments, who may lack the necessary expertise to promote these codes and to ensure their implementation.

4. Drivers and constraints for using earthquake science

In this chapter, we use the focus group discussions and interviews to summarise the major sources of demand for and supply of earthquake science in Nepal, along with the factors that promote or constrain its use in DRR policy and practice.

4.1 Demand and the drivers of use

Overall, there seems to be a low demand for earthquake science among the DRR community, possibly coinciding with low awareness of what might be offered and what its value might be. As one participant asked, ‘What can you tell us beyond all of Nepal is high hazard?’ There were some examples, however, of a ‘demonstration effect’ where the use of science itself created further demand. For example, many participants identified the JICA (2002) scenario as a useful source of information (Table 1), which has driven a demand among some stakeholders for updated or refined hazard information.

DRR is often under-prioritised internationally (Wilkinson, 2012) as it typically involves actions (e.g. retrofitting key infrastructure and implementing building codes) that have very limited short-term or visible payoffs, in a context where governments and citizens have many other pressing issues to deal with on a daily basis. Earthquakes are particularly problematic because they occur so infrequently, even in a seismically active country like Nepal, making them a low-priority issue compared to daily or short-term livelihood concerns. Given the consistent dialogue efforts (and funding) of international development partners on the issue, however, low awareness seems insufficient to explain Nepali politicians’ reticence to focus on earthquake risk reduction and the limited implementation of non-externally funded work. Instead, this reticence likely stems from (1) short-termism, particularly in the transitional phase since 2007, with political attention largely focused on constitutional issues following the end of the decade-long civil conflict; (2) lack of political incentives and limited evidence of demand from the voting public for earthquake risk reduction; and (3) cultural issues, with some interviewees suggesting that

a prevailing ‘fatalism’ may also have a role in views on disasters.

Earthquake science is used selectively by government for earthquake risk reduction, and predominantly where there are resources attached. This follows partly from the low political prioritisation of earthquakes, and low institutional capacity for gathering or assessing scientific information. Some scientific information is likely to be demanded in the immediate aftermath of an earthquake (e.g. its location and magnitude) for the recovery effort. However, there are very few examples of government demand or funding for science to inform earthquake preparedness and risk reduction. The exception to this is demand from government for research and analysis to inform its submissions to international DRR initiatives of which Nepal is a signatory, such as the Hyogo and Sendai frameworks (UNISDR, 2005; 2015b).

The demand that does exist in government is uncoordinated and poorly communicated. As in many countries, responsibilities for DRR within the Government of Nepal are complicated, with multiple agencies and overlapping and confused mandates. As an example, the focus group discussions identified the Ministry of Urban Development (MoUD) as the technical ministry that provides guidance to municipalities on earthquake-safe construction and building code implementation. However, municipalities currently sit under MoFALD and, as a result, MoUD has no jurisdiction to enforce the building code. Institutional overlap and coordination challenges in Nepal are exacerbated by unstable coalition governments and the fragmented nature of politics and society. Governmental positions are often divided up to reinforce patronage networks, and individuals in those positions have minimal incentives to take a long-term view of problems as they are unlikely to remain in their posts for more than a few months (Jones, 2010; Basnett et al., 2014). Even where this is not the case, incentives to accumulate rewards and maintain ties of reciprocity, given short time horizons, override incentives to demand robust information and make well-informed decisions (Jones et al., 2016).

In contrast, earthquake risk reduction is a priority for many donors, leading to relatively strong but fragmented demand for knowledge in general, but little demand for earthquake science in particular. The focus on evidence-informed planning by donors (e.g. DFID, 2009) indicates that there is a considerable demand for analytical products to inform programming and policy dialogue. This reflects both a higher capacity to commission and interpret research in donor organisations than in government, and also incentives for the production and use of evidence in decision-making processes. The demand from donors is predominantly for scientific knowledge that can be used politically (e.g. for justifying a focus on earthquakes). Demand for instrumental uses of earthquake science is limited; some donor representatives in our focus group did not see how earthquake science could add value or usefully shape their programming, with earthquake risk reduction seen mainly as a governance problem. Multiple donor organisations with overlapping remits often have very similar evidence demands. However, lack of communication and coordination, issues of quality control (due, for example, to a lack of transparency of methods or unavailability of underpinning data), and constraints on the dissemination and use of research products result in considerable duplication. Thus, for example, multiple seismic hazard maps have recently been commissioned and published by different donors, leading to widespread repetition of similar scientific outputs and confusion among users.

It is also important to recognise that donor organisations may not have the in-house expertise to use earthquake science instrumentally in their decision-making. DRR experts within donor organisations are generalists rather than specialists, and may not have a natural science background. This highlights the need for more effective communication between technical experts and potential users of scientific information, but also prioritisation by donors and engagement with what earthquake science can provide. This requires relationships of trust to be built in order to capitalise on limited opportunities for communication.

Constraints on long-term donor engagement produce a further limitation on demand. While there are numerous donor-funded initiatives that have made some important progress, they typically proceed without significant government buy-in or ownership, with actions usually only implemented when they come with additional funding attached. There are thus limited incentives for donor-funded initiatives to take the kind of sustained action on earthquake risk reduction that could usefully incorporate, and benefit from, earthquake science.

Demand for earthquake science from both donors and practitioners is practically limited by the low spatial resolution of the most common scientific products. Outputs such as national-scale hazard maps were uniformly judged to be of limited use in designing or implementing earthquake risk reduction programmes. Even high-level usage, such as selection of areas for particular

programmes or interventions, is not common, most likely reflecting wider political constraints on decision-making. Earthquake scientists therefore need to be aware of the very limited usefulness and usability of such products.

At the community level, demand for earthquake science is variable, and is highly dependent on experience. Various examples were given in the focus groups of local government and communities taking earthquake risk reduction seriously in areas that have recently felt medium-sized earthquakes. For example, following the 1988 earthquake, Dharan municipality with NGO support began a building code implementation programme.

There is potential, but unrealised, demand for earthquake science in local disaster risk management planning. Under the guidance of MoFALD, municipalities, districts and VDCs are required to develop a Local Disaster Risk Management Plans. This involves an assessment of the hazards and risks faced by the community and an action plan for how these will be addressed. These plans are largely based on local knowledge and expertise, however, with limited technical input or instrumental use of earthquake science. This could reflect the limited availability of scientific expertise outside Kathmandu, the governance issues raised earlier, the belief that community knowledge is best placed to address the problem and that earthquake science has little to add, or a lack of understanding of what earthquake science can offer.

Demand for earthquake science is also limited by a lack of implementation of government policy. In many countries, building codes are one of the main drivers of demand for earthquake science. In Nepal, municipalities decide whether or not they will implement the NBC. For those municipalities that do, building designs must be signed off by municipal engineers but some participants reported that individuals and the private sector have relatively low interest in enforcing the building code. This reflects a combination of a low level of awareness of earthquake risk, low levels of knowledge of earthquake-safe construction practices, and concern around the perceived extra cost among individuals. When combined with limited capacity and corruption on the part of local government, this leads to formal sign-offs being given to inadequate designs. The requirement of government sign-off has had some impact; however, property developers reportedly favour building projects in urbanising VDCs where no sign-off is required. Furthermore, there is limited monitoring of whether approved building designs are implemented in practice, or of the quality of building materials. There is also limited land use planning or zoning carried out by local government in Nepal, with urban development typically proceeding in a haphazard, unplanned and often unsafe manner.

An underdeveloped insurance industry also reduces the demand for earthquake science. In some countries, the potential to take out earthquake insurance, or the requirement to check various aspects of the safety and

longevity of properties for buildings insurance, drives the demand for and the use of scientific understanding of earthquakes. Participants reported that the insurance industry in Nepal is relatively limited, although some reported that some banks are beginning to require building design sign-off and evidence of building code compliance before approving loans for property construction.

There are, however, emerging signs of demand for earthquake science from the private sector. As some Nepali businesses grow and reach a reasonable level of size and maturity, there is a nascent but growing interest in contingency and continuity planning, and in turn for earthquake risk reduction expertise. Participants reported that banks are beginning to demand that their buildings are safe. In the tourism sector, the more successful businesses are increasingly being pressured to upgrade the safety of their buildings in order to comply with international standards – for example, European tour agents are required to ensure that they only send tourists to earthquake-resistant hotels.

4.2 Supply and the drivers of knowledge production

Consultancies are the primary suppliers of policy-relevant knowledge, which is driven by donor demand. There are barriers to consultants who wish to build on previous work, including a lack of incentives to avoid repetition and practical issues such as the loss of research when the programmes that commissioned it come to an end. Work is carried out to meet specific programming needs, meaning that some issues are effectively ‘off the agenda’ due to decisions already being taken. For example, the focus areas for programmes are often decided long before any assessment of risk and vulnerability is undertaken, because NGOs are allocated specific districts in Nepal. This prevents the use of earthquake science in deciding where to prioritise earthquake risk reduction activities. In addition, NGOs often have particular missions and mandates, such as a focus on children, and must work within these.

Despite the presence of internationally recognised scientists who are active in research in Nepal, donor-funded science is largely undertaken by international consultants. To some extent, this reflects a perceived lack of technical capacity among local scientists (including scientific knowledge and project management), the persistence of existing networks of known and trusted scientists that donors call upon, and concerns around the potential for political bias. There is also minimal investment by donors in more fundamental earthquake science. This reflects their priorities (e.g. poverty alleviation), remit and short-term programming needs. The government also gives low priority to the production of earthquake science. Although some government interviewees expressed an interest in linking better with scientists and academics, there is no government funding for foundational work

or policy-oriented research. The NSC is relatively poorly funded, partly reflecting the focus of the DMG – which sits within the Ministry of Industry – on mining and oil exploration. The NSC also faces severe challenges in recruiting and retaining sufficient skilled personnel. All of these factors result in insufficient development, and prioritisation, of domestic earthquake science.

Earthquake science has given rise to effective high-level messages around primary earthquake hazard. At present, however, earthquake science cannot resolve spatial variations in primary earthquake hazard across Nepal, nor predict the timing of earthquakes. Thus, the high-level messages are widely used conceptually and politically, evolve only slowly in the face of new science, and are highly robust (e.g. plate tectonics implies that a large earthquake could be felt at any location in Nepal at any time). There is a contradictory sense among the DRR community that science must be able to say more than these high-level messages, but also that it cannot address the questions that really need to be answered (e.g. when and where the next earthquake will occur). Curiously, there has been little uptake of, or appreciation for, the understanding that has been gained by recent paleoseismological investigations along the HFT, including the fact that M_w 8 or larger earthquakes, like that in 1934, have a 500-700 year return time (Ader et al., 2012), or that the 1255 and 1934 earthquakes shared many similarities (Sapkota et al., 2013). Earthquake scientists could better serve the DRR community by agreeing these messages and communicating the consensus view in a way that the community can understand.

At the same time, it must be recognised that most primary earthquake science does not, on its own, provide new insights that are directly relevant for DRR. As in all areas of science, primary earthquake science matures through a large body of work pursuing varied interests. Taken in isolation, much of this work is not directly relevant to policy or practice, but without it our understanding of earthquakes would not move forward. It is essential, however, that earthquake scientists engage in dialogue around DRR to communicate the current state of the science in high-level messages.

The nature of earthquake science that is, or can be, produced differs between primary and secondary hazards. Most of the focus of existing earthquake science in Nepal is on the extent, magnitude and timing of previous earthquakes, on patterns and levels of shaking, and on the direct impacts of that shaking on infrastructure. There is much less information on landslide occurrence, despite wide recognition and understanding of the importance of landsliding among focus group participants. There was little consensus on key issues, such as how many landslides would be triggered in a future earthquake or where they would be concentrated, and there has been little published information on how these issues could be addressed. While there are national-scale landslide hazard maps, such as

those produced by the ADPC (2010), these are focused on rainfall-triggered landslides and their relevance to secondary earthquake hazard is not clear. In addition, these national-scale products suffer from the same lack of spatial resolution as the hazard maps.

The science around secondary hazards can resolve spatial variability at a much finer scale than is the case for the primary hazard. For example, it is possible to predict the pattern of earthquake-related liquefaction or landslide hazard at the scale of a single valley or village. Communities also typically have much greater familiarity with secondary hazards such as landsliding, due to their regular occurrence in the mountainous areas of Nepal, than primary hazards such as ground shaking. There is therefore a great deal of potential for instrumental use of science around secondary hazards (in land-use planning, for example). On this basis, there is a strong obligation for the landslide community to interact with the DRR community and to undertake research that is relevant to policy and practice.

Practitioners are not clear in their articulation of the earthquake science that could usefully inform their operational needs. Practitioners were often critical of the focus of the science being undertaken or the questions being addressed by the science community. However, in response to direct questions from scientists about their operational needs or offers to work on questions driven by these needs, the practitioners were unable to provide these. To some extent, this reflects a lack of clarity on what the science could provide and the types of questions that it could help to answer. As a result, most donors and practitioners do not know what questions to ask.

Retaining earthquake risk reduction capacity in-country is difficult. This applies to Nepali seismologists, geologists and geomorphologists, and civil engineers. There are strong incentives for academics and technical professionals to seek career progression abroad at higher profile and better paying institutions. Employment in India, the Middle East and elsewhere is more highly paid than in Nepal. These factors make it difficult for both government and the private sector to retain skilled staff and places a disincentive on training, with a large proportion of graduates then leaving the country (a common problem in many sectors). The same drivers concentrate technical expertise in the main cities in Nepal, reducing the technical capacity within rural districts.

There are excellent examples of international collaboration for earthquake science. There are some perceptions that international scientists use Nepal and the Nepali scientific community in an 'extractive' manner. However, there are also a number of examples of Nepali scientific institutions such as the NSC benefiting from partnerships with foreign institutions. These have typically grown organically and are based on individuals and personal relationships, but nonetheless have proven an important source of equipment as well as (temporary) staff.

4.3 Linking and intermediation

The national NGO NSET and engineers working in government and international development partners are the primary 'knowledge intermediary' actors. A knowledge intermediary is an actor at the interface between knowledge and policy – either as an explicit part of their job description, or through the course of their regular work programme. NSET was seen by the majority of interviewees as the main broker and communicator of earthquake science to non-expert audiences – both communities and policy-makers. The other main actors who play an intermediary function are individuals with engineering or scientific qualifications working in policy or communication roles specifically. Examples of the latter include science journalists or communications specialists within organisations, such as the NRRC Communications Platform.

Good research-policy links largely depend on personal relationships and networks. This is typical for the research-policy links across many sectors in Nepal – in many cases, formal policy processes and products have lower relevance than informal interactions and relationships. Where experts are well linked into policy and political circles, this presents various opportunities for making recommendations that may get taken up. Many Nepali academics are seen as 'politicised', with a presumption that messages and recommendations stem from vested interests. A degree of politicisation may be helpful, however, in ensuring that knowledge and recommendations are taken up by stakeholders.

Overall, there seem to be poor individual and institutional linkages between actors. This is especially the case across the science-policy divide – there seem to be weak links between Nepali academics engaged in earthquake science and government bureaucrats, politicians and international development partners through formal policy processes. It was frequently reported that key decision-makers were not aware of who worked on earthquake science in Nepal. In addition to this, poor institutional coordination (among universities, international development partners, donor organisations and NGOs) for earthquake risk reduction, and rules preventing government from working closely with NGOs, present further challenges.

The NRRC is a marked exception to the lack of institutional coordination. The NRRC is seen by a large proportion of stakeholders as a relatively functional forum for coordination and collaboration. There is some criticism that it is too driven by international development partners (Jones et al., 2014), with Nepalis under-represented in the staffing, and that NSET, as the strongest Nepali voice in earthquake risk reduction, is not comfortably integrated. It does, however, provide a crucial forum for linking governmental and NGO actors and for bridging research, policy and practice. There are other institutional mechanisms for coordination at the national level, such as

the Disaster Preparedness Network, a network of national NGOs working in the field of disaster preparedness, and the DMG's mapping committee, which is in theory required to approve all hazard maps. However, these were considered less functional and lack the capacity to play a leading role.

There remain some major challenges in accessing earthquake science and related products. Some attempts to create a knowledge 'hub' for earthquake science in Nepal are underway, led by MoHA and UNDP. The knowledge base is fragmented, however, and there are few direct incentives for the communication of research for policy and practice. Academic incentives in Nepal, as elsewhere, are geared towards publishing in peer-reviewed journals speaking to an international audience. As a result, earthquake science is typically communicated in outlets and languages that are inaccessible to the DRR community.

The rise of the impact agenda in the UK and elsewhere, driven both by research funding agencies and by the higher education sector as a whole, may help to address this issue by providing incentives for more effective communication and uptake of earthquake science, and by encouraging more innovative collaborations and partnerships between scientists and stakeholders.

Promisingly, there are a handful of reports that are extremely widely known and well-referenced. Studies such as JICA (2002), and the science base that underpins the NBC, seem to have become common artefacts – accepted by all as established knowledge and widely referenced. In many cases it is unclear what led to the success of these particular products as opposed to others, but it does speak to the potential of establishing 'consensus' products.

5. Recommendations

Strengthening the usage of earthquake science for DRR in Nepal will require simultaneous and sustained efforts in demand, supply and intermediation of knowledge. Demand needs to be better articulated, supply needs to be better matched to demand and better communicated, and the key intermediaries – NGOs, engineers and urban planners who could make direct use of earthquake science – need to be better involved. The varied drivers of and constraints on the use of science by different stakeholder groups (e.g. government versus non-government actors; or stakeholders engaged in risk reduction versus preparedness and response) make it difficult to provide one-size-fits-all recommendations. We therefore summarise our findings from the focus groups into a series of observations and recommendations below.

5.1 For earthquake science producers

The majority of cutting-edge earthquake science is unlikely to be relevant to policy-makers and practitioners engaged in DRR who face multiple, competing pressures on their time. Scientists need to avoid swamping practitioners with detail and instead identify key messages that are essential for planning. These messages also need to be packaged in the right way (i.e. prepared for a lay audience, targeted at a problem, and accompanied by guidelines for their use). To achieve this, it is necessary to identify willing interlocutors within the end-user groups who recognise the contribution that the science could make, and who understand how to gain access to the right decision-makers. Scientists should make themselves available to enter into dialogues with stakeholders and to be guided by the needs of potential users of earthquake science. Scientists could also work more collaboratively with stakeholders in Nepal, piloting and testing recommendations with local communities and intermediaries such as engineers and NGOs.

While science has the potential to deliver useful products to support DRR, some products – such as national-scale hazard maps – have been found to have limited application or uptake among end users. A stock-take to understand what is currently being used by the user community, what is needed, and the appropriate scales at which information is required would reduce the likelihood of this happening.

The historical focus of earthquake contingency planning on the Kathmandu Valley ignores the potential for both acute and long-term disruption to large areas of the country from a future large earthquake. While there are political

and logistical reasons to focus on the Kathmandu Valley, experience from the 2015 Gorkha earthquake sequence shows that earthquakes will have major, but foreseeable, impacts on other parts of Nepal, with the specific impacts varying among Terai, hill and mountain districts. Thus, the scientific knowledge required to address the earthquake risk in Kathmandu may differ from that required to address earthquake risk elsewhere in the country. A suite of scenarios, affecting both the Kathmandu Valley as well as other parts of Nepal, would allow a fuller range of earthquake science to be used for planning purposes.

There is generally some consensus among scientists around both previous earthquakes and future earthquake hazard. This consensus may not be clear to non-scientists, and it may be expressed in language that makes it hard for non-scientists to see the core messages. Communicating this consensus, and the confidence with which it is held, is important for promoting the wider use of science. For example, following the 2015 Gorkha earthquake, scientists quickly arrived at a consensus on what had happened in the earthquake and the implications for the earthquake hazard context moving forward. This consensus view did not reach many of the key decision-makers, however, who were instead subjected to a seemingly confused and contradictory array of scientific messages.

5.2 For earthquake science users

Practitioners and policy-makers should recognise that there is a large community of scientists, both Nepali and international, with scientific knowledge of both primary and secondary earthquake hazards in Nepal. The overwhelming majority of these scientists want their science to be relevant and useful for DRR activities – in other words, they want to ‘make a difference’ – but they may not be aware of what needs to be communicated, or how that communication can best be achieved. Engagement with that community, rather than over-reliance on outside consultants, would greatly aid its development and would support the national and international collaborations that have generated much of the scientific understanding of earthquake hazard.

In order to make use of the earthquake science that is available and to motivate useful earthquake science in future, practitioners need to be both willing and able to ask earthquake scientists questions.

Clear articulation of DRR policy drivers, constraints, priorities and time scales would be very beneficial in

helping to determine where and how earthquake science can be used more effectively. For example, definition of priority areas for DRR activity would help scientists to identify key messages and outputs from their research.

Science could be used to inform DRR in some areas where it is not used at present. For example, the locations and potential impacts of landslides could be included in reconstruction guidelines or building codes, in addition to primary seismic shaking. Practitioners should also recognise that research into secondary hazards, such as landsliding and liquefaction, has the potential to provide information at scales that are relevant to community vulnerabilities and needs, thus providing a mechanism for incorporating scientific knowledge into community-based DRR efforts.

Practitioners could usefully work with scientists to develop robust ways of assessing and mapping vulnerability as well as hazard.

5.3 For intermediaries

Intermediaries need to recognise their critical role in the use of science for DRR, and be prepared to take up a considerable set of challenges. They need to be aware of the latest science, and engage with scientists as appropriate to address their own limitations or gaps. They also need to be aware of practitioner needs, activities and initiatives, and be ready to assist in the translation of knowledge.

5.4 General recommendations

There is a need for a sustainable, government-led science advisory group, composed of national and international earthquake scientists, who could be called upon by potential users from the DRR community for advice at every stage of the disaster cycle in Nepal. This group could help to condense and assess available scientific information on earthquake hazard, and could usefully address the need for consensus statements (an excellent example of such

a consensus statement was prepared by the Geological Survey of Iran and is available at <http://earthquake.conference.gsi.ir/en/contents/Closing-statements/Closing-statements.html>). There are several potential international models for such a group, including the Southern California Earthquake Centre (www.scec.org). The group should not be seen as simply an additional voice in the DRR community, but instead as a way to streamline the effective use of science within existing planning by both government and NGOs. The use of earthquake science in the 2015 disaster response might be a useful entry point for this.

The NRRC was seen as a successful mode of working by many of our participants, and we recommend that this model of explicit cooperation between government, donors, intermediaries and NGOs be further developed and extended. The model also provides a potential gateway for science to enter into DRR activities; it can connect all of the relevant users, provide clear focus areas for engagement around particular problems, act as a conduit and as a point of contact for science and scientists, help to identify priority areas for research, and link with government demand for research and analysis.

Scenarios are an under-utilised resource for contingency and logistics planning. Earthquake science has the potential to provide both baseline information and to allow exploration of different possibilities – for example, the effects of earthquake occurrence during daytime or night-time hours on casualties, or the impacts of structural retrofitting efforts that are focused in particular districts or on particular building types. Scenarios also have the potential to identify possible impacts that are currently not considered, such as the effects of earthquake-triggered landslides. The effectiveness of these scenarios would be enhanced if they were consensus products from a science advisory group (as recommended above), including government representatives, that could provide a collective and authoritative voice, backed up by peer-reviewed earthquake science.

Annex A. Earthquake science

Earthquakes are caused by the relative movement of the Earth's tectonic plates, which are large, rigid blocks of the Earth's near-surface material. Although these plates are constantly moving relative to one another, their edges are usually locked together by friction, causing stress to build up along the plate boundaries. Where continental plates are colliding with each other, such as the India-Asia collision zone, the plate boundaries comprise many individual features known as faults, each of which separates different blocks of the Earth's crust (Figure 2). Eventually, the frictional strength of one or several faults is overcome and the blocks on either side of fault move suddenly, with the built-up energy released as an earthquake. During a single earthquake, a section or 'patch' of the fault can slip tens of metres, while the rupture can extend for up to several hundred kilometres along the fault (Figure 2). Earthquakes typically last for a few seconds to a few minutes, but the time between earthquakes on a single fault – sometimes called the 'recurrence interval' – can range from a few years up to tens of thousands of years.

What determines the size of an earthquake?

The size of an earthquake, usually expressed as its seismic moment, is defined by the amount of energy that is released. This is determined by the area of the fault that ruptured during the earthquake, the amount of slip on the fault, and the physical properties of the rocks involved. Seismic moment is then converted into a moment magnitude, commonly abbreviated as M_w , which provides a simple and convenient numerical scale with which to compare earthquakes.

How are the likely size and frequency of future earthquakes estimated?

The size and frequency of future earthquakes can be estimated by either examining the size and frequency of past earthquakes from historical and instrumental records and from pre-historical geological evidence (paleoseismology), or by using measuring techniques – such as GPS or satellite radar interferometry – to estimate the rates at which plates are moving and thus infer how and where stress is accumulating. Both approaches provide some insight into the potential size of future earthquakes and how often they may be expected to occur on average. It is not currently possible, however, to predict where and when a particular earthquake will happen, or how large it will be. Instead, scientists may be able to use these techniques to identify specific areas where stress is likely to be accumulating and therefore where the likelihood of an earthquake may be higher.

What is the difference between magnitude and intensity?

Moment magnitude measures the energy released by an earthquake, and is expressed as an Arabic number (e.g. M_w 8.2). Intensity is a measure of how that energy release is experienced at the surface, and how it affects people and infrastructure at a given location. It is ranked on a qualitative scale, based for example on observations of damage to different types of buildings, and is sometimes expressed as a Roman numeral (e.g. intensity IX). Importantly, the magnitude of a particular earthquake is the same, irrespective of location, whereas the intensity of the earthquake varies from place to place. This means that a location can experience the same intensity from a large-magnitude earthquake that is far away, or a smaller earthquake that is nearby.

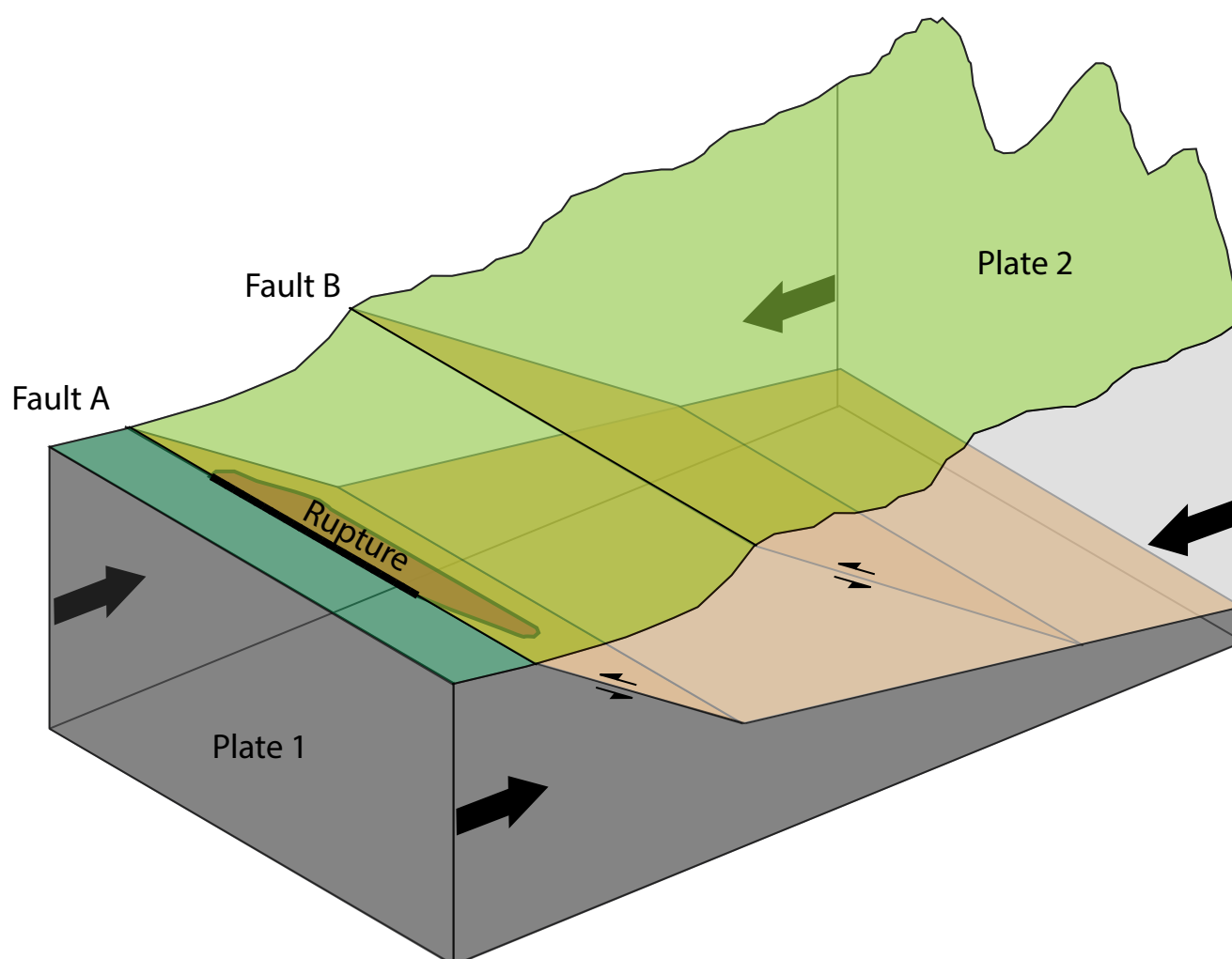
Is Nepal ever overdue for an earthquake?

No, in the sense that earthquakes do not follow a regular pattern in time, so they are never 'due' or 'overdue'. For example, the Himalayan Frontal Thrust fault in Nepal must absorb most of the relative motion between the Indian and Eurasian plates, and it does so by repeated, large (i.e. M_w 8 or larger) earthquakes. The time between individual earthquakes, however, can vary from a few years to many hundreds of years.

What is seismic hazard and how is it measured?

Seismic hazard is a measure of the potential damaging effects of some future earthquake at a specific location. These effects are often, but not exclusively, due to the shaking caused by the earthquake. Besides ground shaking, other

Figure 2. Schematic of a plate boundary where two plates are colliding



In this simplified example, two faults (A and B) are visible at the surface, and form the boundary. The relative motion between the two plates (large black arrows) causes earthquakes along the surface of the Earth, as shown by the heavy black line.

processes, such as landslides and liquefaction, can form important ‘secondary hazards’ triggered by the earthquake. Shaking can be expressed qualitatively in terms of intensity, or quantitatively in terms of peak ground acceleration (PGA). PGA is the maximum acceleration that the ground surface experiences during an earthquake, and is usually given as a fraction of the Earth’s gravitational acceleration (g). Generally speaking, a PGA of about 0.001 g is perceptible by people, a PGA of around 0.2 g causes most people to lose their balance, and a PGA of around 0.7 g will cause the collapse of all but the best-designed buildings (Worden et al., 2012).

How does local geology affect shaking?

Shaking during an earthquake is caused by the passage of seismic waves through the Earth. These waves are produced by slip on the fault, and travel away from the fault in all directions. The shaking at any particular point depends on size of the waves, and thus in part on the conditions along the pathway that the waves take to that point. Different types of rock, and the interactions between the waves and topography, can cause the waves to either be amplified (leading to locally greater shaking and intensity) or attenuated (leading to decreased shaking and intensity). For example, cities built in basins filled with soft sediment, like Kathmandu, often experience greater intensities than nearby areas on bedrock, both because the seismic waves are amplified by the sediment and because the waves are reflected off the bedrock at the edges of the basin.

What is involved in a seismic hazard assessment?

An assessment of seismic hazard involves understanding the sources that generate earthquakes in a region (i.e. the location, size and type of fault), and the characteristics of those earthquakes (e.g. frequency of occurrence and maximum magnitude). Data from past earthquakes are then used to predict how those sources produce shaking at a particular location.

Seismic hazard assessment often takes one of two forms:

- **Deterministic seismic hazard assessment (DSHA)** consists of estimating the level of ground shaking associated with a particular earthquake – for example, the PGA associated with a M_w 8 earthquake on a particular section of the Himalayan Frontal Thrust fault. This approach is scenario specific, which can help decision-makers visualise the potential impacts of an earthquake. A problem with this approach, however, is that there are many candidate faults that could affect a given location, so it is difficult to design a comprehensive set of scenarios.
- **Probabilistic seismic hazard assessment (PSHA)** consists of estimating the probability that a certain level of ground shaking will be exceeded within a given time period at the location of interest. Unlike DSHA, PSHA takes into account multiple scenarios associated with earthquakes on multiple faults, and so must express the hazard in probabilistic terms. For example, a given location might have a 10% probability that PGA will exceed 0.1 g within 50 years, or in other words the return period for shaking greater than 0.1 g is 475 years. PSHA can be conducted for a single location or a larger area, depending on its intended use (e.g. to inform building codes).

What is probabilistic seismic risk?

To understand the full effects of an earthquake, seismic hazard assessment must be combined with some understanding of how the earthquake will impact upon people and infrastructure to create risk. Probabilistic seismic risk is the probability of some adverse consequence (e.g. damage to buildings, human casualties or monetary losses) occurring due to the hazard. Accurate assessments of risk depend on reliable estimates of seismic hazard, exposure and vulnerability.

Annex B. Evidence-informed policy-making: key terms

Policy. We define policy in its broadest sense to include the following (Jones and Villar, 2008; Keck and Sikkink, 1998):

- **Content:** This refers to what is traditionally seen as ‘policy’. Policy content includes strategies and plans; specific proposals for action, including regulation; economic instruments, such as subsidies or taxes; and programmes of legislation and budgets. It also includes voluntary negotiated standards, risk governance, decisions about the allocation of public funds, and the provision of information to ‘win hearts and minds’ (Shaxson, 2009).
- **Procedures:** These refer to the way policy processes are undertaken, the way decisions are made, the spaces for dialogue and the groups of people who are invited to take part.
- **Behaviours:** These refer to the way that policy actors at all levels of governance behave, act or relate to others.
- **Discourse:** This refers to the labels or narratives used by policy actors to describe certain issues, for example in relation to the recognition of specific groups of people or endorsements of international declarations.
- **Attitudes:** These refer to the way policy actors think about a given issue, the way a debate is framed and the awareness, attitudes or perceptions of key stakeholders.

Governance refers to ‘the definition of issues, the formation of policies and the introduction of measures to mitigate undesirable consequences’ (Bulkeley and Mol, 2003: 144). Understanding the governance context for DRR therefore requires an understanding of the stakeholders involved (not only those engaged directly in DRR but also those from other, perhaps seemingly unrelated, sectors), the relationships among them and the role of power in these relationships; the institutional and legislative context for DRR; and the incentives and disincentives that affect the decisions of stakeholders engaged in DRR (Jones et al., 2016).

Knowledge. Perkin and Court (2005: 2) define knowledge as ‘information that has been evaluated and organised so that it can be used purposefully’. This can include research, statistical data, citizen or stakeholder perspectives, as well as evaluative information. The process through which knowledge is evaluated and organised, however, will be strongly influenced by power dynamics, values and beliefs. Knowledge is therefore not an external input to the policy process, and its production and use are interwoven with the politics and power dynamics of policy-making (Jones et al., 2012).

Knowledge intermediaries are organisations or individuals that operate across the knowledge–policy–practice interface (Jones et al., 2012). Knowledge intermediaries manage the ‘boundaries between knowledge and action in ways that simultaneously enhance the salience, credibility and legitimacy of the information they produce’ (Cash et al., 2003: 8086). They may have a job dedicated to this function, or may occasionally act as knowledge intermediaries in the course of their regular work (Jones et al., 2012). In either case, the role requires effective two-way communication.

Knowledge utilisation. Scientific knowledge is used in different ways by different people or groups. The large body of research into how knowledge is used in policy processes has identified a number of different types of knowledge utilisation (e.g. Weiss, 1979). We will use a typology of knowledge use drawing mainly on Johnson (1998), which includes instrumental or direct use, conceptual use and political use.

Instrumental or direct use is the utilisation of knowledge, derived in our case from earthquake science, in order to modify the design of a policy proposal, as an input to manage a programme at the operational level (Johnson, 1998) or in the creation of a specific tool that draws on this science (e.g. Kramer and Wells, 2005).

Conceptual or indirect use is a substantial change in how actors in the policy process perceive or understand the policy issue (Johnson, 1998). In our case, this change is induced by new knowledge presented by earthquake science. This can happen quickly, or over a long period of time as the stock of scientific knowledge accumulates. Scientific knowledge in this case might create debate and dialogue, possibly refocusing existing debates or causing other shifts in the understanding of a particular programme or area of work.

Political or legitimating use is the utilisation of knowledge generated by earthquake science in order to justify a political position (Rissi and Sager, 2013) or to persuade others to change theirs (Kramer and Wells, 2005). Earthquake science can thus be an instrument to support prior beliefs and preferred policy options, legitimise previous actions or prevent future actions (Rissi and Sager, 2013). The same piece of earthquake science may even be used by different stakeholders to support different positions (Johnson, 1998). Some authors have raised concerns about political misuse of knowledge (e.g. Patton, 2008; Hertin et al., 2009).

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