Report

The role of scientific evidence during the 2015 Nepal earthquake relief efforts

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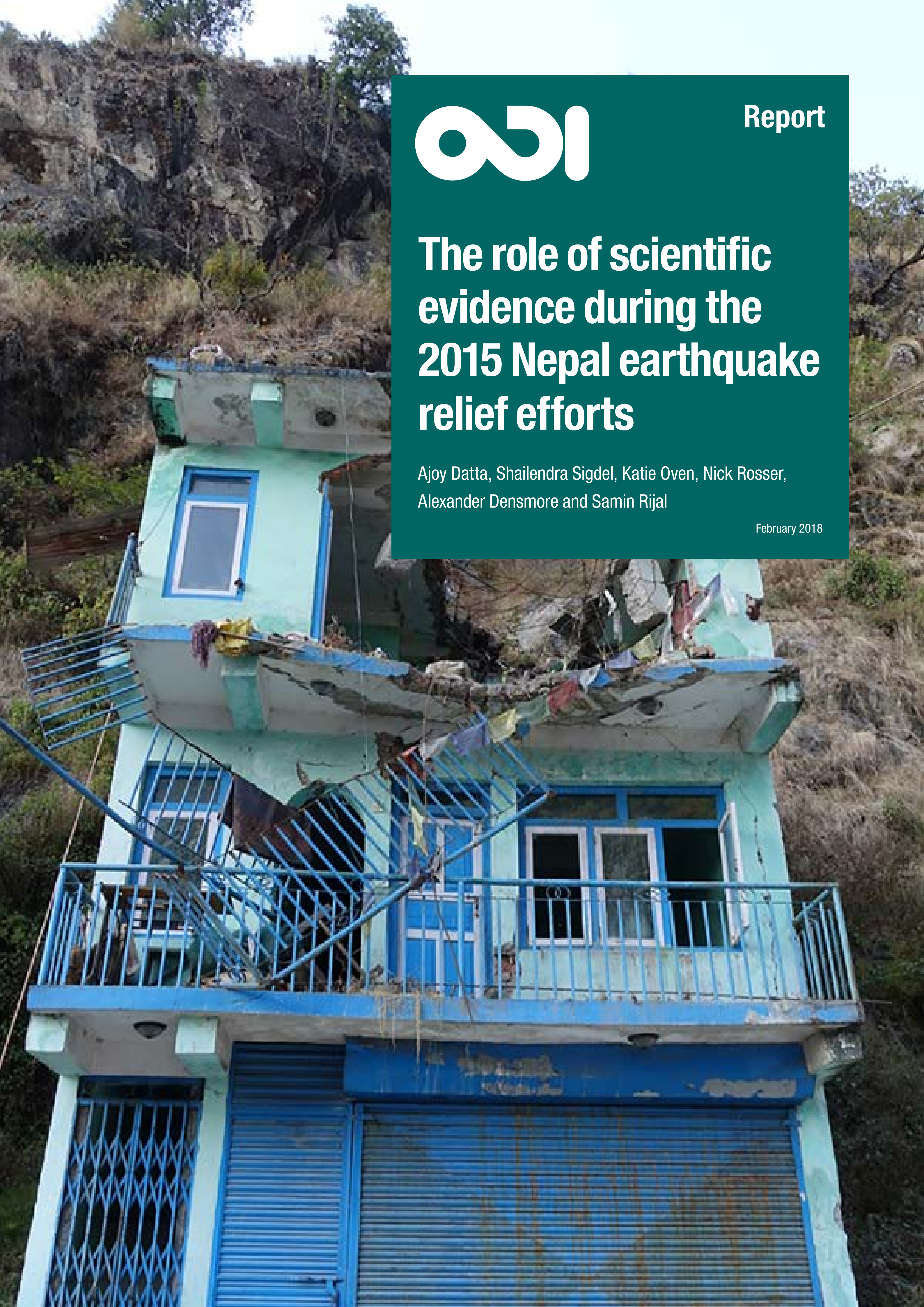

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Cover photo: Valley bottom house damaged by rockfall during the April and May 2015 earthquakes. Liping Bazaar, Sindhupalchok, Central Nepal.
Credit: N. Rosser, November 2015.

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Acronyms

ACAPS	Assessment Capacities Project
BGS	British Geological Survey
CNDRC	Government of Nepal's Central Natural Disaster Relief Committee
DAC	Disaster Assessment and Coordination
DDRCs	District Disaster Relief Committees
DEOCs	District Emergency Operating Centres
DFID	UK Department for International Development
DMG	Department of Mines and Geology
DRR	disaster risk reduction
EC	European Commission
ESRC	Economic and Social Research Council
EwF	Earthquakes without Frontiers partnership
FDM	Foundation for Development Management
GIS	geographic information system
GoN	Government of Nepal
HC	Humanitarian Coordinator
HCT	UN-led Humanitarian Country Team
HDDS	NASA Hazards Data Distribution Service
HDX	Humanitarian Data Exchange
IASC	Inter-Agency Standing Committee
ICCG	Inter-Cluster Coordination Group
ICIMOD	International Centre for Integrated Mountain Development
IM	information management
INGO	international non-governmental organisation
IOM	International Organization for Migration (UK)
MIRA	Multi-Cluster/Sector Initial Rapid Assessment
MNMCC	Multi-National Military Coordination Centre
MoHA	Government of Nepal's Ministry of Home Affairs
Mw	Moment magnitude
NASA	National Aeronautics and Space Administration
NDRF	Nepal Disaster Response Framework
NEAU	Nepal Earthquake Assessment Unit
NEOC	Government of Nepal's National Emergency Operating Centre
NERC	Natural Environment Research Council
NGO	non-governmental organisation
NPC	Government of Nepal's National Planning Commission
NSC	National Seismology Centre
NSET	National Society for Earthquake Technology
OCHA	United Nations Office for the Coordination of Humanitarian Affairs
ODI	Overseas Development Institute
OSOCC	On-Site-Operation Coordination Centre
PAGER	USGS Prompt Assessment of Global Earthquakes for Response
PDNA	Post-Disaster Needs Assessment
RC	Resident Coordinator
SHEAR	Science for Humanitarian Emergencies and Resilience
UN	United Nations
UNDP	United Nations Development Programme
UNICEF	United Nations Children's Fund
UNISDR	United Nations International Strategy for Disaster Reduction
UNRCO	United Nations Resident Coordinator Office
UN-SPIDER	UN platform for Space-based information for Disaster Management and Emergency Response Knowledge Portal
USGS	United States Geological Survey
WFP	World Food Programme

Executive summary

In the immediate aftermath of a sudden-onset disaster, such as that caused by an earthquake, disaster managers[1] need to determine as quickly and as efficiently as possible how many people have been affected, where the affected population is located, and the level and type of assistance that will be required. They also need to understand the evolving hazard context and associated security conditions that could shape the response.

To answer these questions, disaster managers require a range of information. This includes scientific information, likely to be produced by geoscientists, which describes: the hazard dimensions, including location and intensity; how the hazard context may evolve over time; and the nature of any secondary hazards, such as landslides. Importantly, disaster managers need this information in a timely manner and a format that can be clearly understood without any specialist technical training. But how, and how much, do managers acquire and use this information?

Focusing on the 2015 Gorkha earthquakes in Nepal, this report explores the extent to which scientific information was used during the disaster response. We set out to understand the key actors involved in the response effort, their information needs and how these were communicated to scientists and other knowledge providers, the scientific information that was produced, and how this information was shared.

Nepal makes an interesting case as a great deal is known about earthquake hazard and associated risk. A number of research-informed programmes were also underway before the earthquake, which aimed to reduce seismic risk. This report is based on 40 in-depth interviews with disaster managers within the Government of Nepal, the Nepal military, the UN agencies, international and national non-governmental organisations, information managers, and scientists.

Relief efforts in the 2015 earthquakes were initiated immediately, with needs assessments conducted concurrently. This was in a context where disaster managers were under significant pressure to act and where pausing to consider scientific evidence and its implications for the response was challenging. Further, given the time required to produce robust scientific evidence, promoting the uptake of any science produced in the timeframes required was difficult.

What demand there was for scientific evidence about the earthquakes was concentrated largely at the national level within the Humanitarian Country Team (HCT) and the wider humanitarian community, who often sought information from overseas experts; and within the Government's Central Natural Disaster Relief Committee, which sought information from government institutes within Nepal. District-level Disaster Relief Committees, seen as one of the most influential groups in directing relief efforts, articulated no apparent demand for scientific evidence.

At the national level, disaster managers sought information about the impact of the earthquake to target the response and support logistical operations, and information about possible aftershocks and landslides, which had implications for the personal safety and security of staff. There was, however, a clear gap in understanding what useful operational information scientists could provide and over what timescales.

In the absence of scientific information, disaster managers relied heavily on their past experience and practical judgement. Scientists were able to feed into later needs assessments, which focused primarily on the knowledge of local people receiving humanitarian support. However, their involvement was limited by a lack of understanding among scientists of the information needs of the disaster response community and the needs assessment process itself, as well as disaster managers' limited knowledge of what information scientists might offer.

During the weeks following the earthquake, disaster managers were inundated with information – including scientific information – which was channelled through formal disaster response processes. Examples included maps, which indicated the location and intensity of earthquake-triggered landslides. However, this information (often relatively technical) was not always presented or packaged in a way that encouraged its use by disaster managers. Information managers within the HCT, technical clusters and the Inter-Cluster Coordination Group, who were responsible for managing the flow of information after a disaster, were potentially important brokers between the humanitarian and science communities. However, they tended to be generalists rather than specialists, and did not always have the hazard-specific knowledge and expertise required to access and communicate the scientific information produced.

Evidence in the form of expert advice from trusted scientists, brokered by disaster managers who were committed to the use of science, was considered to be particularly useful. Even so, scientific information that did find its way into discussions among specific groups within the humanitarian community tended not to be shared beyond these groups, reflecting the wider siloed nature of response operations.

1 Defined broadly to include people involved in managing the response to a disaster, ranging from civil servants to international agency staff.

In light of our findings, we set out a series of recommendations for disaster managers and management, disaster risk reduction (DRR) managers, given the importance of pre-disaster preparedness work and scientists with the aim of improving managers' ability to make decisions during future emergencies.

Given the successful brokering of advice received from trusted scientists, we make the case for building longer-term relationships between disaster managers and scientists *before* sudden onset disasters (such as those caused by earthquakes) occur. We suggest this happens through deliberative dialogue to discuss the information needs of decision-makers, what scientists know and are able to say about the hazard, and how this information could support decision-making. Such discussions are essential for building common understanding, establishing trust as well as sound judgement upon which decisions can be made during a future disaster response.

More specific recommendations include the need for:

- Scientists to form a group and identify a focal person to facilitate coordination with government, DRR and humanitarian actors. We suggest scientists engage proactively with the humanitarian response community to understand the decision-making architecture as well as what evidence/expertise might be most useful to disaster managers, when and in what form.
- The United Nations (UN) to appoint a science officer at a regional level, possibly through the UN Office for the Coordination of Humanitarian Affairs, who could ensure that the recommendations here are followed through. They could also maintain a directory of in-country and international scientists with the expertise and capacity to support managers in preparing for and responding to disasters.
- Donor agencies to consider funding a science officer, periodic science for disaster response fora (at national, regional and global levels) to improve connections between relevant stakeholders, and the production and sharing of good practice stories in relation to the use of science in humanitarian response.
- DRR managers to identify, produce, archive, and regularly update secondary datasets to help disaster managers make quick estimates of damage, loss, and associated needs immediately after a disaster.

1. Introduction

1.1. Background

In the immediate aftermath of a sudden-onset disaster, such as an earthquake, disaster managers – that is, those involved in managing the response to a disaster, from civil servants to international agency staff – need to determine as quickly and as efficiently as possible:

- how many people have been affected
- where the affected population is located
- the level and type of assistance required.

They also need to understand the evolving hazard context and associated security conditions that could shape the response.

To answer these questions, disaster managers require a range of information. This includes scientific information (Box 1), which is crucial for describing the dimensions of the hazard, including its location and intensity, how the hazard context may evolve over time, and the details of any secondary hazards such as landslides. Importantly, managers require this information quickly, in a format that can be clearly understood without specialist, technical training.

Although disaster managers require a range of information drawing on both social and physical science disciplines, this report focuses on the natural and physical sciences (especially geology and geophysics). These disciplines have the potential to generate information and provide expertise that could help disaster managers prioritise resource allocation within extreme time constraints.

Pressures to ensure that humanitarian response is better informed by evidence have emerged from several sources. The United Nations Office for Disaster Risk Reduction (UNISDR) states that it is the responsibility of member states to bring together policy and science communities in an effort to reduce disaster risk and reduce or prevent impact from disasters (Aitsi-Selmi et al., 2015). Some donors, such as the UK Department for International Development (DFID), also see value in using innovative techniques and technologies to inform and improve their humanitarian responses to disasters (DFID, 2012). Simultaneously, scientists – motivated by a combined desire to further research interests, aspiration to help and increasing pressure to increase the utility and impact of their research – often generate and promote use of disaster information.

Yet despite willingness on both sides to generate and use scientific evidence during humanitarian crises, the challenges of doing so are well documented. Evidence is not always available in the right format, may not be widely communicated or easily accessible to disaster managers (DFID, 2012). Additionally, evidence may arrive too late to be able to influence decision-making in real-time operations, or might not be considered of value by disaster managers, who are more focused on immediate actions (ibid.).

The 2015 Gorkha earthquake in Nepal provides an opportunity to explore some of these challenges associated with acquiring and using scientific evidence during a disaster response. The hope is that such analysis will help inform future efforts, both in Nepal and internationally, with respect to sudden onset disasters like earthquakes.

Nepal is an interesting case: a great deal is known about earthquake hazard and risk in the Himalayan region, and a number of research-informed programmes to reduce seismic risk were already underway before the earthquake. One such programme was the Earthquakes without Frontiers partnership (2012–2017), funded by the UK's Natural Environment Research Council (NERC) and Economic and Social Research Council (ESRC), which brought together scientists, policy-makers and practitioners engaged in DRR. However, the humanitarian response efforts following the 2015 earthquake involved many new managers who were less familiar with ongoing DRR and development work. And the extent to which disaster managers engaged with and used science to inform their decision-making and operations was unclear.

Box 1. What is scientific information?

We define scientific information as information produced by or drawing on a method or procedure, consisting of systematic observation, measurement and experiment, and the formulation, testing, and modification of hypotheses (Oxford English Dictionary in Knox-Clarke and Darcy, 2014). Our focus here is on scientific information generated after an earthquake that describes impacts that may be salient to a disaster response. For example, the mapping of landslides from satellite imagery to produce a landslide inventory.

Earthquakes generate a wide range of hazardous phenomena – from ground shaking and surface rupture to secondary hazards such as landsliding, liquefaction, flooding, and changes in river and groundwater flow. As such, scientific information on earthquake hazard may be drawn from many different disciplines, including seismology, geology, geomorphology, hydrogeology, and engineering geology.

1.2. The earthquake

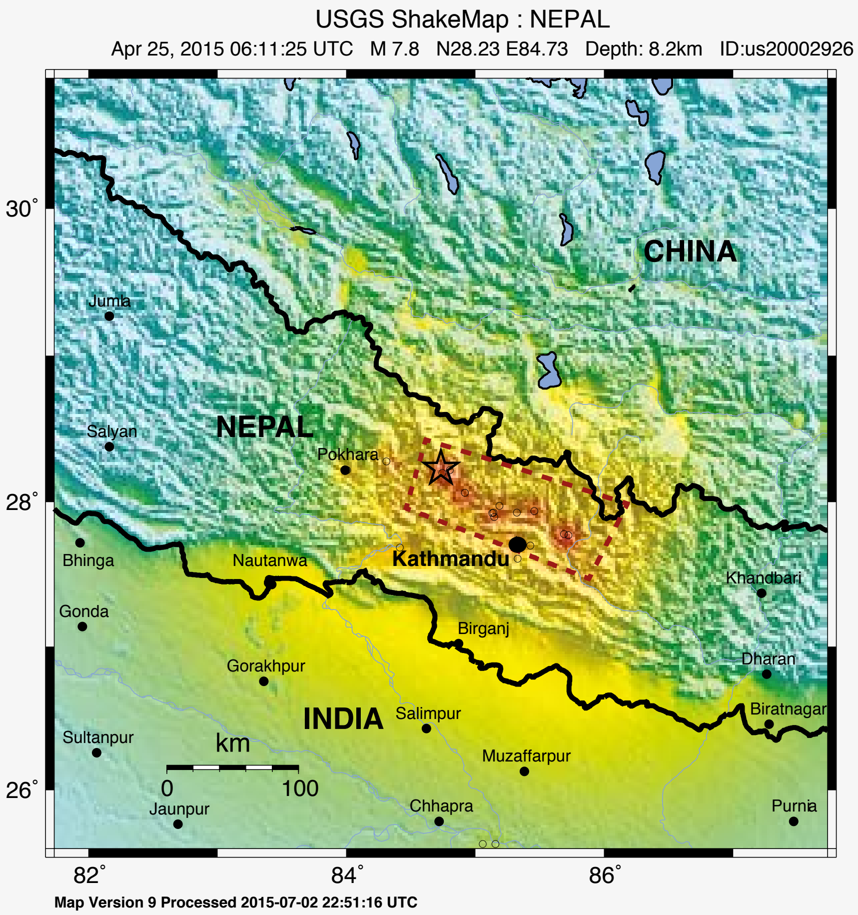
The 2015 Nepal earthquakes occurred on 25 April (M_w 7.8) and 12 May (M_w 7.3) 2015. The shaking caused significant damage and loss of life across large areas of the Central and Western administrative districts of Nepal. According to the Post-Disaster Needs Assessment (PDNA) undertaken by Nepal's National Planning Commission (NPC) with support from development partners, 8,790 people were killed and 22,300 injured (NPC, 2015). As is often observed of large earthquakes, its effects were not concentrated around the epicentre of the 25 April main shock, as might be expected or inferred from media reports (Figure 1).

Instead, it later became clear that the earthquake's impacts were concentrated in a band running east to west from Gorkha to Dolakha districts, with the hardest hit districts located to the north of the Kathmandu Valley (Figure 2). This band is now known to map broadly onto the surface projection of the fault rupture (shown as a red dashed rectangle in Figure 2).

Figure 1. Media depiction of the epicentre of the 25 April 2015 earthquake

Source: BBC (2015)

Figure 2. United States Geological Survey 'ShakeMap' of the 25 April 2015 earthquake



PERCEIVED SHAKING	Not felt	Weak	Light	Moderate	Strong	Very strong	Severe	Violent	Extreme
POTENTIAL DAMAGE	none	none	none	Very light	Light	Moderate	Mod./Heavy	Heavy	Very Heavy
PEAK ACC.(%g)	<0.05	0.3	2.8	6.2	12	22	40	75	>139
PEAK VEL.(cm/s)	<0.02	0.1	1.4	4.7	9.6	20	41	86	>178
INSTRUMENTAL INTENSITY	I	II-III	IV	V	VI	VII	VIII	IX	X+

Scale based upon Worden et al. (2012)

Source: Modified from USGS (2015). Note: This ShakeMap was produced within 30 minutes of the earthquake occurring.

Of Nepal's 75 districts, 31 were affected, of which 14 were declared 'crisis-hit' (NPC, 2015) approximately two weeks after the main shock (interview with government informant, January 2017). According to the Asia Foundation's independent impact report, the earthquakes caused widespread building collapse – especially in rural areas where houses were commonly constructed from mud mortar (The Asia Foundation, 2015). Poor households and farmers were the most severely affected in terms of loss of life and livelihood. In terms of public infrastructure, school buildings were the most affected.

While the earthquake shaking caused an instantaneous threat to life due to building collapse and ground liquefaction, landslides were a significant secondary hazard (Collins and Jibson, 2015). In the 2015 earthquakes, as in other recent earthquake events in mountain regions, landslides were responsible for a substantial portion of the total casualties and damage, isolating mountain valleys for days and sometimes weeks after the main shock.

In mountainous areas of Nepal, secondary hazards also include the possibility of landslides that block valleys and rivers, which poses the risk of breach and flooding to extensive areas downstream. After the 25 April earthquake, scientists highlighted the need to rapidly assess the areas of major landslide occurrence to identify the locations (and stability) of any potential landslide dams (Kargel et al., 2015). Fortunately, only two minor landslide dams were formed, and both failed without posing significant risk to downstream communities.

While on the whole, the impact of the landslides on agricultural production was limited:

> *'[It] was severe, however, in places where landslides swept away the terraces, and cracked the fields and trails leading to them. Many people in those places reported that they would not return to their fields out of fear, at least until a formal landslide risk assessment is conducted. Further, many draft animals were killed or injured in the earthquakes, and people could not farm without them. The loss of other livestock was also a problem for farmers. This not only meant the loss of consumable goods like milk and meat but also income losses for those relying on the sale of livestock as a source of income.' (The Asia Foundation, 2015: 18)*

The 25 April earthquake occurred some 60 days prior to the onset of seasonal heavy rain associated with the South Asian summer monsoon. Monsoon rainfall is known to trigger fatal landslides that kill around 200 people annually (Petley et al., 2007). The damage to the landscape as a result of the 2015 earthquakes rendered hillslopes even more susceptible to landsliding, as evidenced by

Damage caused by landslides in Sindhupalchok District, Nepal. Credit: © N. Rosser, 2016. Reproduced with permission.

cracked ground in many places in the earthquake-affected districts. While this effect was anticipated by scientists (see, for example, Marc et al., 2015), the spatial extent and precise impact on rates and patterns of landsliding were unknown. As such, there was a finite window of fair weather, after which post-earthquake landslides were likely to pose a notably higher risk to those on the ground as the summer monsoon rains started. Knowledge about the spatial extent of these monsoon impacts, and the timescales over which they were likely to occur, was therefore of great potential value to humanitarian responders.

1.3. Objectives

Our research set out to understand: (1) the decisions that were taken by disaster managers in response to the 2015 earthquake, their information or evidence needs, and how these needs were communicated; (2) the scientific information that was produced and how this information was communicated; and (3) how the science was used or not and why. In our analysis, we often expand our focus to include other forms of evidence (such as assessments undertaken by disaster managers) and other types of science (including social-science-based information) so as to understand more fully the potential opportunities for scientists (broadly defined) to make a substantive contribution to the humanitarian response.

This report aims to advise: disaster managers about the potential value of scientific evidence in disaster response; scientists and intermediaries (such as communication and information managers) looking to make their research more 'useful, usable and used' (Boaz and Hayden, 2002) in the context of humanitarian crises; and donors about how they could better support and facilitate the use of scientific evidence in disaster response. We define information managers broadly as staff from the UN system often seconded to clusters during an emergency who are responsible for managing the flow of information. During an emergency this typically involves compiling information about who is doing what, and where (also known as the '3Ws').

1.4. Methods

A total of 42 semi-structured interviews were conducted with more than 50 stakeholders in January and February 2017. These stakeholders included:

- disaster response managers from UN and international agencies, INGOs, national and local NGOs, donor agencies, central and district levels of government, and the Nepali military
- scientists from within and outside Nepal
- information managers from international and UN agencies.

Where we received permission from the interviewee to do so, interviews were recorded and transcribed. Where respondents preferred to speak in Nepali, we transcribed the interview in Nepali and then translated this into English. Transcripts were manually coded with the key themes identified.

Preliminary findings were shared with stakeholders in Kathmandu in June 2017. This took the form of three focused meetings with 25 representatives from the following stakeholder groups (many of whom had been interviewed as part of the research): (1) scientists from the UK and Nepal, (2) international and national NGOs (including the Nepal Red Cross Society), and (3) donor and international agencies.

2. Establishing the decision-making context

Key reflections

The disaster response mechanisms in Nepal are well developed but complex, with actors meeting within and across a range of governmental and non-governmental spaces and at multiple levels. Despite this interaction, our findings suggest that information and evidence is not always shared between groups. It is therefore essential that scientists wishing to engage with disaster managers understand the humanitarian response architecture and engage with multiple groups as required. Similarly, while humanitarian organisations saw the clusters as useful for acquiring evidence about the earthquake impacts, there was limited understanding among disaster managers about how the evidence might be used to inform response operations.

By looking at the key groups involved in the disaster response, this chapter establishes the decision-making context following the 2015 earthquakes. We identify three broad overlapping groups of managers involved in the response from the Government of Nepal's Ministry of Home Affairs (MoHA), the Nepal and foreign militaries, and the humanitarian community. The latter included managers from UN agencies, NGOs and INGOs, and donor agencies.

2.1. Key decision-making groups

Disaster managers were organised into a number of groups and sub-groups that operated with varying levels of coherence. At the national level within government these groups included the Central Natural Disaster Relief Committee (CNDRC) and the National Emergency Operating Centre (NEOC). At a district level, these groups included District Disaster Relief Committees (DDRCs) and District Emergency Operating Centres (DEOCs). The Nepal and foreign military organised themselves into the Multi-National Military Coordination Centre (MNMCC), which was run by the Nepal military. Pre-earthquake, Nepal was home to a significant number of national and international NGOs as well as international agencies, comprising managers either directly or indirectly involved in DRR. These managers, together with those flown in from overseas as part of the international 'surge', organised themselves into several internationally recognised groups, as set out in the Nepal Disaster Response Framework (NDRF) (GoN, 2013).

The NDRF summarises the disaster response coordination mechanisms in Nepal.[2] As per the international humanitarian coordination system, the UN agencies, INGOs, international agencies and civil society organisations in each of the main sectors of humanitarian action – for example, water, health and logistics – are organised into clusters. There are 11 formal clusters in total,[3] each of which is led by a government ministry and supported by a UN or international agency.

Clusters receive strategic guidance from the HCT, which is a strategic and operational decision-making and oversight forum established and led by the Humanitarian Coordinator. The HCT includes representatives from the UN, International Organization for Migration (IOM), INGOs and the Red Cross and Red Crescent Movement. Agencies that are also designated cluster leads should represent the clusters as well as their respective organisations on the HCT. The HCT is responsible for agreeing on common strategic issues related to humanitarian action, and reports to the On-Site-Operation Coordination Centre (OSOCC). Together with the MNMCC, the OSOCC reports to the NEOC, which in turn reports to the CNDRC.

In practice, based upon the findings from the interviews and focus groups undertaken, we identify the following groups as particularly coherent in their functioning and influential in the response, especially in terms of, facilitating the use of scientific evidence. These are:

- the humanitarian clusters organised at the national and sub-national levels, especially the Logistics Cluster and

2 The Nepal Disaster Response Framework (NDRF) can be downloaded from the United Nations Office for the Coordination of Humanitarian Affairs: https://reliefweb.int/report/nepal/nepal-national-disaster-response-framework-27-jun-2015.

3 Health; logistics; nutrition; protection; shelter; water, sanitation and hygiene; camp coordination and camp management; early recovery; education; emergency telecommunications; and food security. See www.humanitarianresponse.info/clusters.

the ICCG, which brought together cluster coordinators from all 11 clusters

- the Humanitarian Country Team (HCT)
- an informal group comprising the UN Humanitarian Coordinator, officials from key donor agencies and the UN Resident Coordinator's Office (RCO)
- the Red Cross Movement which brought together the Nepal Red Cross Society, the International Federation of Red Cross and Red Crescent Societies, and various Red Cross societies from countries around the world.

The main focus of the report is the role and use of science within the humanitarian community.

2.2. Group dynamics and decision-making processes

Immediately after the earthquake, the HCT met formally at UN House in Patan, relatively frequently at first, with participation by invitation only. Although consensus-based decision-making was preferred within the UN system, the Resident Coordinator (RC), who assumed the role of Humanitarian Coordinator (HC) immediately after the earthquake, was reported to have chaired meetings in a relatively 'robust' manner, shaping discussions and potentially emphasising scientific evidence. This was in contrast to discussions within government circles, where managers preferred a collaborative approach to decision-making whereby all participants were 'veto players'. This reportedly made decision-making a lengthy process.

Within the HCT, donor officials and the Chair of the Association of International NGOs were said to be particularly vocal and influential – reflecting a combination of extensive in-country experience, being well-connected professionally and being part of a large, well-resourced INGO. The National Society for Earthquake Technology (NSET), a national NGO with expertise primarily in earthquake preparedness and risk reduction, participated during these early meetings, sharing their estimates of building damage.[4]

Discussions within the HCT and the clusters are reported to have suffered due to a rapid turnover of staff, at least during the early stages of the response. This was inevitable given the rate at which 'surge' staff flown in to bolster humanitarian response capacity had to be replaced due to the emotional and physical pressures of a disaster response context. For instance, one INGO 'had six short-term operations managers deployed in the first six months, so terrible in terms of continuity and retention of organisational role and decision-making knowledge' (interview with INGO official, January 2017).

Aid agency officials from the European Commission (EC), the US, and the UK, among others, met with the HC and other officials within the RCO to discuss the response following the earthquake. These donors had a long history of providing developmental support to Nepal and made funding available to members of the humanitarian response community following the earthquakes (interviews with donor officials, January 2017). Through funding channels, they also had the potential to influence the way in which disaster managers worked, including the extent to which they adhered to cluster guidance or government policy.

Meetings between the HC, donors and the RCO were seen by some key informants as a useful forum for understanding the response at a strategic level and to identify gaps in relation to funding and available evidence on impacts and needs. According to one donor official, 'it was probably one of the most useful forums … to see if the perspective we have on the response is relatively strategic, where are the gaps? Where are the funding issues? What's the latest information from various field trips? Are there any emerging risks?' (interview, February 2017).

National-level clusters differed in their effectiveness, in terms of how quickly they were set up, how many people they were able to attract to meetings, the role of government managers, the quality of discussion, and how influential they were in shaping decisions. On the whole, attendance at cluster meetings was high immediately after the disaster, but decreased before levelling off after about two months (Logistics Cluster, 2016). Interviewees reported that discussions within cluster groups had to accommodate a wide variety of interests, and cluster lead agencies were particularly influential in shaping the agenda. The role of government varied from cluster to cluster with, for instance, officials from the Ministry of Health playing an active role in the Health Cluster.

One key informant from an international agency suggested that, despite some drawbacks, the cluster system was an important coordination mechanism:

> *'National cluster colleagues … had been a little bit pushed aside by all the internationals coming in. But we [referring to in-country international staff] know each other very well. We have trust in each other. It is a very strong institution in a way, especially because the government counterparts are changing so often. I am here for three years now, I have five heads of NEOC I have worked with. Of course, everybody is coming in with zero knowledge about the specific topic' (interview, January 2017).*

Key decisions were being made at multiple levels of governance. Below the national level, humanitarian response hubs were established in three locations, each covering between three and five administrative districts. The aim was to manage relief operations by being 'closer to the action' (interview with international agency representative, January 2017). Each hub included most, if not all, of the 11 clusters that had mobilised nationally (interviews with two officials from international agencies and two officials from INGOs). However, these did

4 NSET has some capacity in disaster response but this is not NSET's main role/area of expertise. During the early part of the response, NSET subsequently had a limited role in the immediate (formal) UN-led response undertaking building damage assessments. Nonetheless, it did have many demands placed on it by donors, international agencies and NGOs.

not function as hoped due to a mismatch with formal government structures. Participants at cluster meetings came mainly from the district level in which the centres were based and were primarily interested in the welfare of their own citizens, which shaped the distribution of relief. As a result, a few weeks into the response, the three large hubs were replaced with a greater number of smaller hubs located in the headquarters of the most affected districts.

Despite these challenges, the cluster system was seen as an important space for discussion, especially given the familiarity of cluster members within the humanitarian response community – particularly at the national level. Some saw the clusters as useful for acquiring evidence about the earthquake impacts and beneficiary needs, helping them to identify 'who was doing what' and learn about good practices. Others, however, felt they were less useful, seeing the clusters as cumbersome and time consuming. Our findings reaffirm those of Knox-Clarke and Campbell (2015) who suggest that, while group decision-making can be slow and cumbersome, clusters and leadership teams are more likely to consider a broader range of evidence than individuals, and can make decisions quickly especially where these decisions are made by representative sub-groups.

3. Demands for evidence

Key reflections

Our findings suggest that demand for scientific advice was concentrated in the HCT within the humanitarian community and in the CNDRC within government. Importantly, DDRCs – which are seen as the most influential group in directing relief efforts – made few demands for scientific evidence. This may have been because they thought there was little need for it, but also because there may have been limited awareness of what science had to offer. Those on the HCT and the CNDRC sought information along parallel tracks, with the former seeking advice from overseas experts, and the latter seeking expertise from government institutes. Our analysis pointed to a tension between the need for aggregate information for fundraising and to understand the broad impact of the earthquake, and the need for more granular information.

On the whole, disaster managers required scientific evidence about the earthquake, possible aftershocks, landslides that were triggered and implications for personal safety and security, as well as to support logistical efforts. Demands were unpredictable, showing little correlation between the type of scientific information sought and the time that had elapsed during the response. The nature of the demands for scientific information often revealed a lack of understanding about what science can and cannot say – for example, the fact that future earthquakes cannot be predicted. Nevertheless, we suggest that, through sustained engagement with relevant stakeholders, scientists can build up trust and potentially influence how disaster managers define their problems, and subsequently their demands for scientific evidence.

Producing and communicating scientific information on its own is unlikely to lead to a better-informed disaster response. The use of science is more likely to be driven by disaster managers and their needs. This chapter outlines disaster managers' questions and their information needs during the first three to six months of the earthquake response.

3.1. Evidence about the earthquake

Within the CNDRC and HCT, managers required information to help them understand the nature of the earthquake that had occurred, and the current and future hazard – particularly in terms of aftershocks and possible future earthquakes – to ensure the safety and security of their staff. This information was sought in a context of increasing amounts of sometimes contradictory or alarmist information about the earthquake and how the impacts were likely to evolve over the following days and months. Some of this (mis-)information was published by social and mainstream media. One international agency official suggested that 'supposedly very intelligent people [were] believing in predictions that were suddenly popping up about new earthquakes' (interview, July 2016).

Government managers sought expert advice from the National Seismology Centre (NSC), while those within the humanitarian response community looked to international scientists and geoscience institutes, such as the US Geological Survey (USGS) and the British Geological Survey (BGS). In both cases, seeking scientific advice was recognised in their formal protocols: according to the NDRF, for example, the NSC in Nepal is responsible for providing information on an earthquake within the first hour of it occurring. (In practice, a senior scientist from the NSC was invited to a meeting of the CNDRC at about 14:00 local time, about two hours after the earthquake.)

Some earthquake-model outputs that predict impacts, such as USGS's Prompt Assessment of Global Earthquakes for Response (PAGER) system, were reported to have been used by some within the humanitarian response community. One international agency official stated that 'The starting point with an earthquake response is usually USGS [ShakeMap, PAGER] as the best information source' (interview, February 2017). But exactly *how* this information was used and the extent to which it informed decision-making is less clear.

Frustrated by the inability of some technical or scientific institutions within the Government of Nepal to predict the likelihood of aftershocks, some managers turned away from such institutions as information providers. As one government scientist explained:

> *'… up to 11 days, [the disaster managers] were listening to me very nicely … [the] President visited our lab, Ministers [especially the] Land Minister visited almost twice a day and [the] Secretary [for the Ministry of Industry] was coming every day … Then when this aftershock happened [referring to the second earthquake] … they lost the belief [in the] scientist' (interview, January 2017).*

This reflected a view that scientific expertise was valued solely for its ability to *predict* future events, and overlooked how scientific outputs could complement other information sources – for example, by identifying areas that were most likely to be affected by post-earthquake landsliding, so that response efforts could be prioritised.

3.2. Evidence of earthquake impacts

Almost immediately after the first earthquake struck, all three groups of disaster managers focused on trying to understand the extent of damage, the number of people killed and injured, and where they were located, to scale and focus the response. Key users of this information within the humanitarian response community included those responsible for securing funding to support the response, triggering appeals and developing strategies for INGOs and agencies – many of whom had been flown in. Information was needed within the first 48 to 72 hours: 'in the first 48/72 hours … you're issuing a [flash] appeal and you've got a response, the beginnings of partnerships [with] implementing agencies across the sectors' (interview with international agency representative, February 2017).

Managers from the humanitarian response community as well as the military appeared to be more interested than those in government in identifying the most affected areas or prioritising the most vulnerable groups (interviews with three disaster managers from INGOs and international agencies in January 2017). For example, one international agency official asked:

> *'Can [government] actually drill down and say, "We are going to look only after those who … are actually displaced and currently live in the open or with host families?" Or can we say that certain programmes only focus on supporting lactating women in those areas?' (interview, February 2017).*

3.3. Evidence about landslides

Evidence of widespread landslide impacts after the earthquake, and the occurrence of the earthquake 60 days before the anticipated onset of the annual monsoon, led to demands for evidence around landslide risk and how this might evolve during the rains. This included anticipating the potential scale of impacts, the footprint and likely timing. These demands arose mainly from members of the HCT rather than the clusters, and were prompted at least partly by UK-based scientists with whom some HCT members had been working before the earthquake.

But even within the HCT there were those who were unconvinced that landslide risk was worth considering. For instance, one donor official said: 'It's not about landslides … but … how many houses that have been affected', suggesting that the focus was on the impacts of the earthquake at a particular moment in time and not the evolving risk context.

The International Centre for Integrated Mountain Development (ICIMOD), an inter-governmental research organisation, was asked by the NEOC to provide information, including satellite imagery, showing the location of earthquake-triggered landslides despite limited expertise in these hazards. This perhaps reflects the established connections between ICIMOD and the government, their high-level profile as a research institute in the country, and their technical expertise in remote sensing and related geoscience fields. However, the information requested by government officials was difficult to pull together in the necessary three to five days.

The military search and rescue and medical trauma teams working through the MNMCC asked the Nepal military for maps of roads and settlements. However, the Nepal military did not have the capacity to respond to all requests. According to one military representative 'We had 34 country [overseas] teams all asking for maps and we said that it [the demand for maps] was never meant to be that heavy. The Canadians filled that gap' (interview, January 2017). Kathmandu Living Labs, a Nepal-based NGO that focuses on using digital mapping technologies for humanitarian aims, also made map data and satellite imagery available to the army from the first day of the response (Nepalese Army, 2015).

3.4. Differences in demands for evidence

Some managers – especially those working for donor agencies who were responsible for strategy – required quite general, synoptic information. Other managers, such as those within the INGO and NGO community who were focused on resource deployment to specific localities, required more granular information.

Members of the Logistics Cluster were also eager to support their respective organisations in the delivery of relief materials, and very quickly sought information on the damage caused by landslides and other impacts to individual settlements and strategic roads (see Knox-Clarke and Campbell (2016) for a detailed discussion of this tension in relation to broad evidence requirements).

Within the first seven to 10 days of the response, information about the impacts of the earthquake began to emerge, and senior officials in government started asking senior scientists from the National Seismological Centre 'Why is the damage more in the east and not to the west? Why was Kathmandu not affected as you [might] think?' (interview with government official, January 2017).

Approximately one month after the earthquake, some managers started to consider future earthquake risks, the residual risk to Kathmandu, and preparedness planning and programming around DRR more generally, notably where DRR professionals in-country had been drawn into the response effort. For example, one international agency official asked:

> *'What does this [the Gorkha earthquake] mean for government operational agencies planning? How do we reawaken the preparedness agenda? How do we get it back on the priority list with everyone, of course, saying, "Well, the earthquake wasn't as bad as you said it would be and it's done now"?' (interview, July 2016).*

However, these interests appeared to be more prevalent among members of the HCT than members of clusters, with their specific humanitarian focus and remit.

3.5. Articulating evidence needs and emphasis on science

One donor official suggested that there 'aren't clear ways in which either the operational practitioner [and scientists] come together and decide what the key knowledge gaps are or operational questions …' (interview, February 2017). But often the difficulty lay in the fact that disaster managers were unable to predict what evidence they would need in the future, and only knew what evidence they needed currently – usually driven by a specific problem or need (interview with donor official, July 2017).

Critically, disaster managers generally attached little importance to drawing on scientific information during humanitarian crises. As one key informant explained:

> *'Our bandwidth [amongst humanitarian actors] right now is tiny and we are fighting to give time to this [earthquake science] … We haven't yet got to the point that most leaders in the development and humanitarian community have the vision to understand why, in a crisis, it's important to give capacity to this' (interview with international agency official, July 2016).*

4. Production of evidence

Key reflections

The need to initiate relief efforts immediately after the earthquake meant that it was extremely difficult to produce robust scientific evidence in the short timescales required. In this context, empirical approaches to generating estimates of earthquake impacts were useful. Advice from credible and trusted scientists who could make sense of partial information and extrapolate from previous studies and experiences helped disaster managers to understand the evolving hazard and its implications for logistical operations.

Drawing primarily on beneficiary knowledge, the humanitarian community made considerable efforts to map damage and loss, and identify need, while simultaneously distributing relief. However, despite the apparent opportunities for scientists to feed into and inform such assessments, a lack of understanding among scientists of the information needs of the humanitarian community, together with limited knowledge among disaster managers about what scientific information might offer, hampered their involvement.

In the aftermath of the 2015 earthquakes, there were numerous efforts to provide advice, collate existing data and information, and to undertake new research to help inform the earthquake response. This chapter summarises some of these efforts in order to explore the extent to which evidence responded to demand from disaster managers.

4.1. Calculating the shaking caused by the earthquake

Calculating the shaking caused by an earthquake can help disaster managers to estimate its impacts. However, direct observations of shaking were limited to a small number of functioning instrumental records across the country (Dixit et al., 2015). As a result, even when the best data became available, high-resolution descriptions of the character of the earthquake were limited. The USGS PAGER model that predicts impacts, and other related empirical models, rely in part on these input data. Poor quality or limited input data therefore restricts the degree to which such models can be used at a local level; they are of greatest value for providing an overview of the shaking distribution at a national or regional scale.

4.2. Estimating earthquake impacts

Officials from the RCO produced estimates of likely impacts on the basis of standard definitions and responder experience using a 72-hour assessment protocol. The assessment aims to 'provide a quick overview of how a population has been affected by a crisis, including who is likely to be at greatest risk of mortality and acute morbidity and why; and to identify priorities … for an initial comprehensive humanitarian response … ' (IASC, 2007: 4). However, this is sometimes completed in 24 hours (interview with international agency official, February 2017).

Efforts to estimate likely impacts emphasised the importance of having access to secondary data *before a disaster occurs* to determine the disaster extent and scale, and to establish the number of people affected (OCHA, 2013). This phase balances 'the need for accuracy and detail with the need for speed and timeliness' (OCHA, 2013: 116). Secondary datasets – for example, census data, data on vulnerability, such as the human development index, and topography – were cited as critical sources of information. The RCO and OCHA overlaid this secondary information with data on the earthquake itself, such as shaking intensity from the USGS ShakeMap, from which they could then predict losses.

However, according to some respondents who represented NGOs engaged in the response effort, secondary data from the population census did not provide up-to-date information, which led to significant uncertainties in estimated need. Moreover, not all baseline data was easily accessible. For instance, the data from the 2014 Multi-Cluster Indicator Survey, which provides internationally comparable, statistically rigorous data on the situation of children and women, was not made publicly available in the immediate aftermath of the earthquake (NEAU, 2015a). When large datasets such as the number of potentially vulnerable groups (for example, older people, disabled people, and particular ethnic and caste groups) living in different areas, were available and accessible, they had not been processed or organised in a format that could be used quickly (interview with international agency representative, February 2017).

4.3. Collecting and analysing actual impact data

Responsibility for collecting and sharing information on damage and losses fell to the NEOC. However, NEOC faced challenges in becoming operational quickly, with Campbell and Thapa suggesting that the '[N]EOC [was] defunct with no-one to contact' (2015: 17), and the Nepalese Army (2015) reporting that NEOC had limited capability in coordinating operational activities. (Both comments refer to the first few days after the earthquake.)

NEAU (2015) suggested that, early on in the response, government authorities disagreed about how they should be categorising damage, with different authorities issuing conflicting figures. In their review, Campbell and Thapa (2015) noted that information on damage and loss published by the government was not considered by key informant interviewees to be reliable or up-to-date. Instead, respondents from a range of organisations reported that the picture of impacts was built up via a number of parallel institutional structures comprising the Nepal military, the Nepal Red Cross, the government and the humanitarian community.

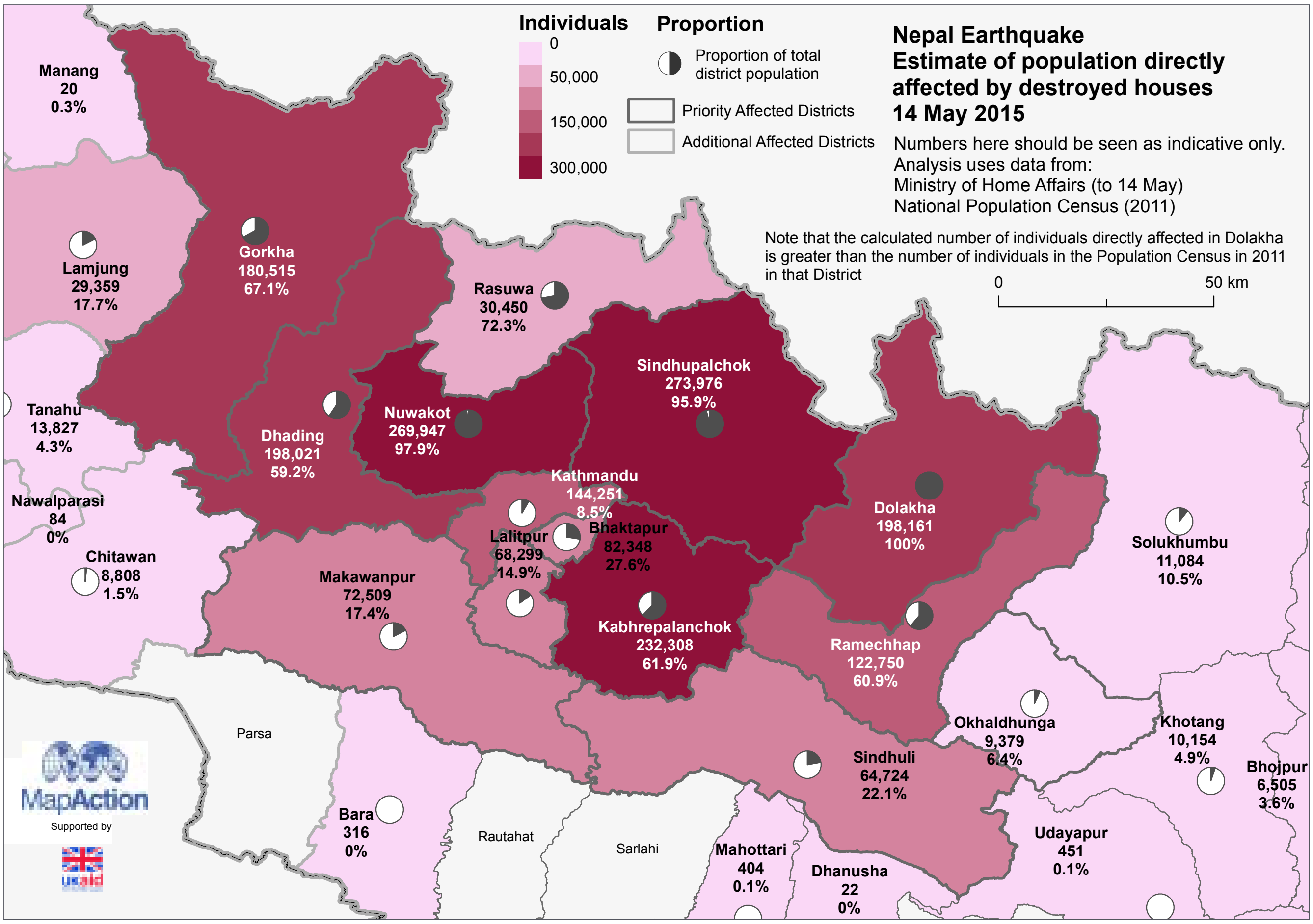
Among these structures, there appeared to be no systematic approach to the collation of information, as well as a reliance on fragmentary human intelligence, aerial assessments conducted by the military and anecdotes from personal contacts (interview with international agency official, January 2017). For instance, one international agency official indicated that he built up a picture of impacts through:

> *'… a lot of personal contacts, direct contacts with NGOs, there was a lot of folks, for example, who we would meet, who had family in a village and people may have hiked up the village to try to check and see if things were okay and they would report back' (interview, February 2017).*

Reports of impacts in more remote areas were more disparate due to a much more irregular flow of information to and from these areas, leading to delays in relief operations. And the absence of reliable and comprehensive information on the earthquake impacts may explain a misconception that the damage would be greatest around the epicentre and why a lot of initial efforts were concentrated there.

Nevertheless, two weeks into the response, the CNDRC formally identified the 14 most affected districts based on data being received by NEOC (Figure 3). We were, however, unable to find out why these 14 districts had been identified as the 'most affected', particularly when it was known that the impacts of the earthquake extended beyond this area. The methods used to identify these districts are also unclear.

Figure 3. The 14 most affected districts



Source: MapAction (2015). Based on estimate of damaged buildings. Analysis using data from: Multi-National Military and Coordination Centre, Ministry of Home Affairs, Nation Population Census (2011).

Crowdsourced information collected in the first few weeks of the response rapidly gained profile in Nepali social media. For instance, Tomnod and OpenStreetMap initiated campaigns to map damage to infrastructure, with the outputs reported to have been used by the military (Nepal Army, 2016, in Williams et al., 2018). However, some managers within international agencies were concerned about the accuracy of the data, as damages incurred because of the 2015 earthquake was often difficult to distinguish from damages incurred as a result earlier events.

One international agency official suggested that a 'decent' picture of the impacts emerged about a month after the earthquake:

> *'I will tell you an emergency after a month starts to stabilise … we have most of the information and it starts, what we say, to stabilise … we have the big picture … after that, I'm not saying that it's [satellite images] not useful, but we already get bits and pieces of information here and there' (interview, January 2017).*

4.4. Providing expert advice and producing formal assessments

Despite the lack of systematic impact data, a considerable amount of other evidence was produced in a relatively robust manner during the response. This evidence was used, for instance, to inform specific agency actions and understand the nature of the earthquake and its secondary impacts in more depth. We explore these efforts, first within the humanitarian community, with a focus on international organisations; secondly among Nepali organisations, with a focus on scientific efforts by both governmental and non-governmental entities; and finally, within the international scientific community.

4.4.1. Humanitarian response community

Immediately after a sudden-onset disaster such as that caused by an earthquake, it is normal for a Multi-Cluster/Sector Initial Rapid Assessment (MIRA) to be carried out jointly by members of the HCT. MIRA is a needs assessment tool designed to guide the collection and analysis of information on affected people and their needs in order to inform strategic response planning (IASC, 2015). Although remote sensing is mentioned as a possible source of information, the formal MIRA process, as set out by the Inter-Agency Standing Committee (IASC, 2015), contains no explicit reference to the scientific community as a possible source of information. Furthermore, the MIRA guidance suggests that practitioners include geographical characteristics such as the distance of communities from the epicentre (IASC, 2015). This is important because, as discussed in the introduction, the 2015 main shock had impacts that were not radially distributed around the epicentre.

In the case of the 2015 Nepal earthquakes, the HC and senior government officials chose not to undertake a MIRA due to a perception that communities in some areas might be unhappy with managers collecting information rather than distributing relief materials (NEAU, 2015a; interview with international agency official, January 2017). A large number of formal field assessments were, however, completed – either by volunteers or by disaster managers from about 70 different agencies – to inform the relief efforts, but without a great deal of coordination. The assessments included two district-wide multi-sector assessments conducted by government and the Nepal Red Cross in Gorkha and Sindhupalchok, two of the 14 most-affected districts identified by the Nepalese government. Overall, most assessments were focused on these 14 districts, which highlights the influence of the government pronouncement on this (NEAU, 2015a). Moreover, these assessments drew primarily on the knowledge of beneficiaries, with uncertainty regarding their geographical coverage and completeness.

In the first weeks after the earthquake, evidence was aggregated and presented at the district rather than village development committee level. The effect of this was to mask significant intra-district variability, and to spatially average out the most intense localised impacts over large district areas (NEAU, 2015a). For example, the majority of human losses in Sindhupalchok District appear to have been concentrated in small areas in steep valley bottoms, and not broadly across the whole district. This spatial variability may have been masked by how the data was presented and communicated. Significant local-level (sub-km) spatial heterogeneity is a widely recognised characteristic of earthquake impacts.

A PDNA began on 10 May 2015, formally led by the National Planning Commission and supported by the World Bank, United Nations Development Programme (UNDP), and the EC (NPC, 2015). This was seen as an opportunity to look forward and inform the longer-term recovery strategy and reduce the risk of future disasters rather than purely to respond to the current crisis (interview with international agency official, February 2017). However, as with the MIRA, this process did not formally include scientific information, nor did it promote consultation with the scientific community.

As well as the formal needs assessments, the Logistics Cluster identified access constraints due to road blockages and landslides, which were plotted in frequently updated maps. The primary source of this data appeared to be from World Food Programme (WFP) operatives on the ground, the cluster lead agency, and so was itself limited by access.

4.4.2. National scientific initiatives

The Department of Mines and Geology (DMG) within the Government of Nepal has expertise in seismology, including the monitoring, characterisation and reporting of earthquakes. They were therefore able to provide information to the CNDRC and NEOC about the magnitude and characteristics of the earthquake immediately following the event.

Soon after the earthquake, the relatively large number of skilled and well-trained engineering geologists, geologists and geotechnical engineers in Nepal – both academics and consultants – were engaged in a series of studies that required technical scientific inputs. These included appraisals of hydropower dam integrity (undertaken for the private sector); site-specific assessments of slope stability; highway corridor surveys; and wider efforts to generate district-level geohazard assessments funded by international agencies (such as the UNDP). These efforts generally aimed to inform recovery planning, and have been reported on in both academic and grey literature. However, efforts fell somewhat short of a national-scale assessment and tended to be fragmented with no consolidated point or channel through which to share information with disaster managers.

A large group of Nepali geologists, subsequently sponsored by MoHA and the DMG, was mobilised to undertake a landslide mapping exercise encompassing all earthquake affected areas about a week after the earthquake. This group identified almost 500 settlements in 18 districts that were thought to be at particular risk and in need of resettlement. This triggered, at least in part, members of the HCT to demand further information about landslide risk. The group's findings were presented to parliament, with many parliamentarians objecting to the need to relocate certain communities. Some key interviewees questioned the methods used to undertake the study, and outputs from the exercise were not, to our knowledge, made publicly available.

The government also mobilised technical staff, including engineers, health workers and environmental experts (together with engineers from NSET), immediately after the earthquake for ad hoc damage and needs assessments. These were generally limited to site visits and on-the-ground assessments. Government institutions did not, by and large, have the capacity to access and analyse remotely sensed imagery. This limited their ability to make use of the imagery that became available through the Disaster Charter, a worldwide collaboration through which satellite data is made available to those affected by disaster events.[5] While a range of technical organisations and academic research groups in Nepal do have some capacity to handle geospatial data and use it regularly, this expertise is largely concentrated in ICIMOD and NSET which were able to empirically model the likely impacts that had occurred, especially in relation to building damage in urban centres.

4.4.3. International scientific initiatives

In the hours and days after the main shock, individuals and groups from around the world mobilised resources to establish what had happened and what might happen next. These included teams from China, India, Japan, the US (including the USGS, the National Aeronautics and Space Administration, the University of Southern California, the University of Michigan, and the Geotechnical Extreme Events Reconnaissance Association) and the UK (Durham University, the Centre for Observation and Modelling of Earthquakes, Volcanoes and Tectonics, the University of Ulster, the University of Cambridge, and the BGS). These efforts have in part now been variously published in the formal scientific literature (see, for example: Avouac et al., 2015; Collins and Jibson, 2015; Gyawali and Adhikari, 2017; Kargel et al., 2016; Martha et al., 2016; Roback et al., 2017; Robinson et al., 2017; Tiwari et al., 2017; Williams et al., 2018).

Those engaged in this work tended to be from organisations with a formal disaster response remit (such as the BGS), those with pre-existing research and personal connections to Nepal (such as Durham University), or those whose research was naturally of relevance to the disaster. Scientists and experts were concerned mainly with understanding the geophysical aspects of the earthquake, including the spatial distribution and amount of fault slip and the pattern of ground motions; the distribution and sizes of landslides that were triggered; and the impacts, including types and patterns of building damage.

We note the involvement of Nepali experts in published outputs from international geohazard assessments, often building on longstanding academic collaborations. However, the capacity of scientists on the ground to contribute to this work in the very initial period of the response was less clear. The highest profile academic outputs that relate to the Nepal 2015 earthquake were largely led by senior and non-Nepali international scientists.

As well as undertaking formal research, individuals from some of the aforementioned groups provided expert advice to the HCT and cluster groups to help disaster managers understand the earthquake, the likelihood of aftershocks, the implications for personal safety and security, as well as implications for logistical efforts. Given the need to launch relief efforts quickly (an issue we return to in Chapter 6), expert advice was seen as very helpful.

The focus of scientists and their motivation for undertaking formal research were wide-ranging, from the collection of time-limited data immediately following the earthquake to assessments of specific hazards such as glacial lake outburst floods. Some teams used satellite imagery that was released through Disaster Charter, or via commercial satellite operators and platforms, such as Google Crisis, to produce geospatial products like landslide maps or radar interferograms of coseismic deformation. NASA, via its Hazards Data Distribution Service (HDDS), made efforts to widen access to and standardise the availability of remotely sensed data.

Not all of these efforts to study the hazard included an explicit intention to inform the immediate humanitarian relief effort. Others did, but were ineffective for a variety of reasons. One disaster manager from a donor agency suggested that:

5 See more on the activation of the Disaster Charter after the main shock here: www.disasterscharter.org/web/guest/-/landslide-in-nep-2.

'Some scientists did not want to collaborate in terms of data because of competitiveness to publish papers. Very little of the data from the seismological monitoring kit placed after the earthquake has ever been made publicly available' (interview, February 2017).

Crucially, each group targeted different timescales for generating outputs – from days to months, or even years, after the event itself. These efforts were only partly coordinated, usually via pre-existing relationships and knowledge of research expertise, which led to duplication of efforts and parallel initiatives for communicating outputs.

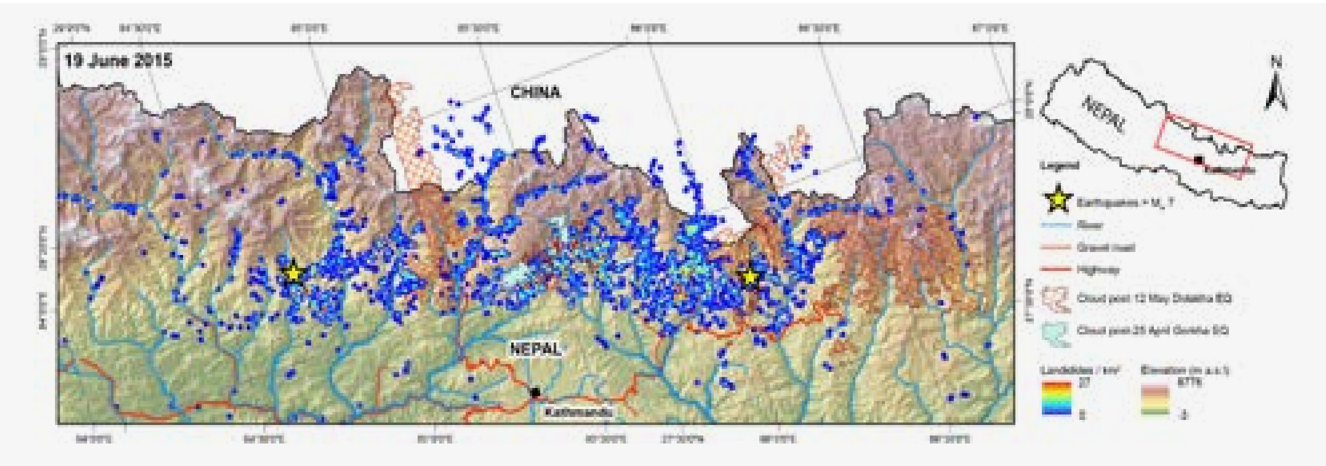
Landslide assessment was an area where many scientists felt that they could contribute and one in which disaster managers' lack of expertise was quickly recognised. Several groups began mapping landslides using science-based protocols, assuming that such information might be useful to those managing the relief effort. While some groups were interested in mapping individual landslides, others were focused on rapid identification of their broad-scale impacts (Williams et al., 2018). Groups of international scientists reported that they had passed landslide assessments on to various interlocutors – from the Prime Minister of Nepal to the UN RCO to ICIMOD (Kargel et al., 2015). To take one example, Durham University and BGS produced and shared four maps over a six-week period between 4 May and 19 June 2015. The last of these is shown in Figure 4, with the accompanying notes summarised in Annex 1.

Figure 5 shows when the Durham University and BGS landslide maps were published in relation to key events, such as the main shock, key aftershocks and key humanitarian impact assessments. The first iterations of the maps were published on 4 May, which was outside the 72-hour assessment window used by agencies such as OCHA. New data emerging with each iteration was accompanied by qualitative explanations prepared for a broad, non-expert audience.

In addition to packaging the key messages from this research – some of which was also translated into Nepali – landslide data was also fed directly into the humanitarian mapping agency MapAction and uploaded to event-specific data repositories, such as the Humanitarian Data Exchange (HDX, https://data.humdata.org/group/nepal-earthquake). Some of the scientists producing information on landslide impacts recognised that one challenge was the lack of a single recognised repository or data portal, meaning that any update to the maps or dataset required simultaneous uploads to a number of different outlets.

Another related challenge was the lack of an accepted international protocol for the generation and provision of landslide-related information in the aftermath of an earthquake in a mountainous region. This is despite similar coordination efforts led by the UN platform for Space-based Information for Disaster Management and Emergency Response (UN-SPIDER) for other types of geohazard.[6] Intermittent cloudcover over the area of interest was also an issue as it slowed down data collection at a time when relief efforts were scaling up quickly (See Williams et al., 2018).

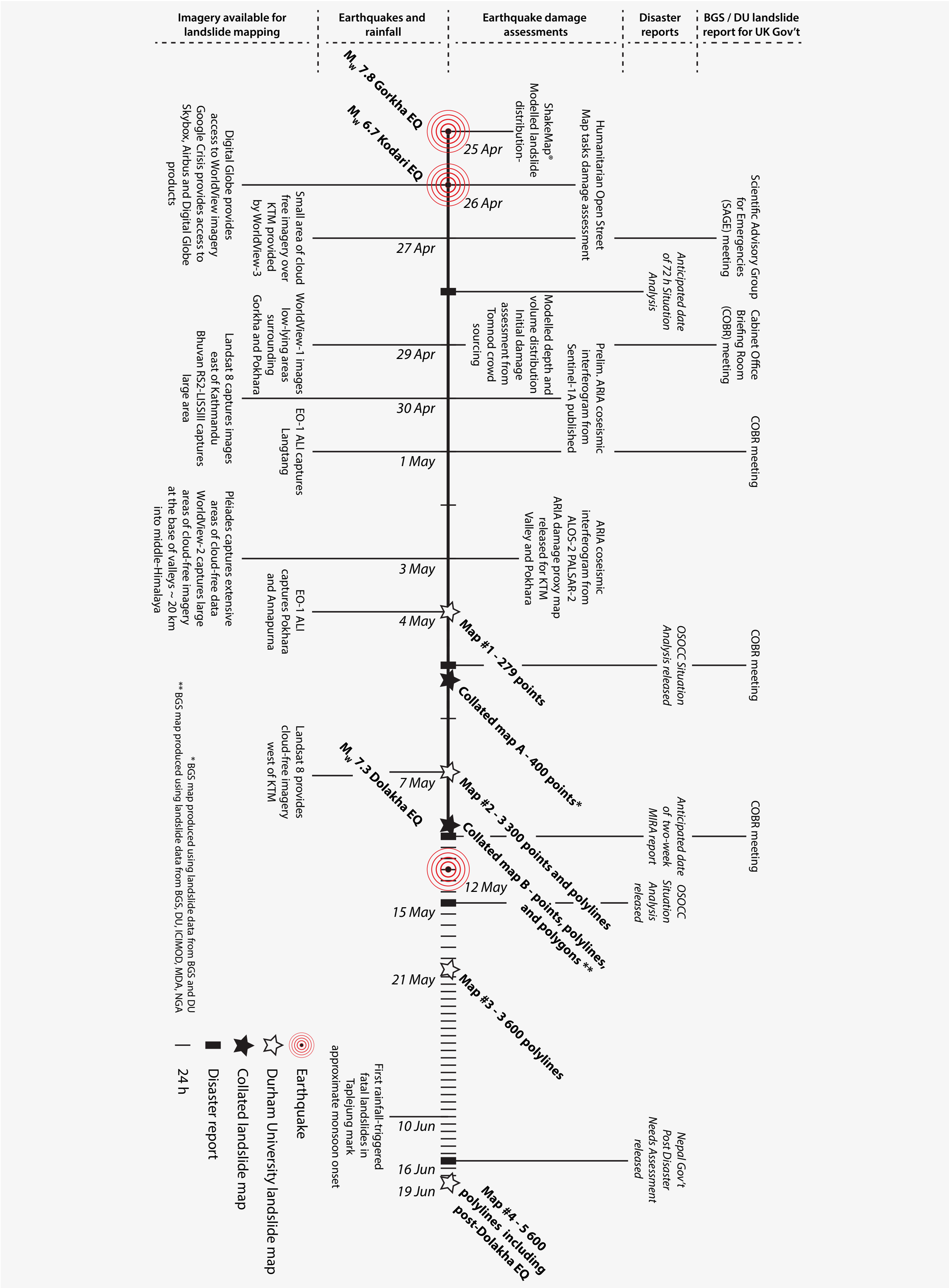
Figure 4. Landslide map published by Durham University and BGS on 19 June 2015



Source: Williams et al., 2018. Extract from map released on 19 June 2015 containing landslide data from both earthquakes, comprising ~4,500 triggered by the Gorkha event, ~300 by the Dolakha event, and ~800 that could be attributed to either. Orange hatched pattern highlights areas that could not be mapped following the Dolakha earthquake event. Turquoise pattern (district north of Kathmandu) highlights areas that remained unmapped following both earthquakes.

6 UN-SPIDER is a programme that ensures all countries and international and regional organisations have access and the capacity to use all types of space-based information to support the full disaster management cycle.

Figure 5. Timeline showing when the Durham University maps were published in relation to key events



Source: Williams et al., 2018.

5. Acquiring and sharing evidence

Key reflections

Three points are worth noting here. First, managing information during a disaster response demands a certain level of understanding. Actors need to know how the response is likely to unfold, anticipate cluster coordinators' and disaster managers' evidence needs, know what scientific information might be useful and over what timeframes, and know who might be able to provide this information and how it might inform ongoing relief operations. Information managers, a potentially important broker between the humanitarian and science communities, tended to be generalists rather than specialists, and did not always have the disaster-specific knowledge and expertise required to access and communicate the scientific information produced.

Second, and in light of this, evidence that was considered to be particularly useful was expert advice that came from trusted scientists, who were adept at communicating complex concepts, and was brokered by disaster managers who were committed to the use of science in policy and practice. Third, scientific information that *did* find its way into discussions among humanitarian teams tended to not be shared beyond the group, which reflects the siloed nature of response operations.

In this chapter, we explore who acquired scientific evidence, and how this evidence was communicated to disaster managers during the early response and shared more widely.

5.1. Key knowledge brokers

Within the humanitarian response community, the **RCO** played an important role in acquiring and sharing scientific evidence within HCT meetings (and the Inter-Cluster Coordination Group), and providing briefings for HCT participants. As one disaster manager from a donor agency explained, the RCO 'played a role in guiding, coordinating, articulating, trying to broker relationships …, trying to get information and evidence into HCT sessions' (interview, February 2017).

In what was an unusual move in a disaster response context, officials from the RCO – including an experienced disaster response manager and an information management (IM) specialist – sought information from a group of academics and scientists located in a number of mainly overseas institutions. As one informant explained: 'I've done this for 25 years. I can't tell you of another case that I'm aware of where we've managed to do this …' (interview with experienced disaster response manager, July 2016). This stemmed in part from pre-existing relationships and trust that had been established during a long-term research project, as well as an appetite among officials in the RCO for scientific evidence and among scientists to inform the response effort.

The RCO was able to channel information requests and questions from the HCT and cluster groups to the group of scientists to address specific information gaps, understand the degree of scientific consensus and avoid the generation of contradictory advice. As described in Chapter 2, questions arose around the scale and geography of the initial impacts as well as future risks. The scientists in turn synthesised and explained the scientific information (for example, around the likelihood of future aftershocks) and were able to tailor the generation of new information to the needs articulated by the RCO (for example, about the evolving landslide risk). Consequently, officials from the RCO could use their engagement with scientists to good effect by articulating scientific information describing the earthquake to others and challenging misinformation where appropriate, for instance around the likelihood of future earthquakes.

Within clusters, coordinators were supported by **IM specialists** who were deployed by cluster lead agencies. IM specialists included both local and international staff who are normally engaged in core development programming and not necessarily preparing for or responding to disasters. They tend to have general skills in qualitative and quantitative research methods as well as geographical information systems (GIS). They also have expertise related to their specific cluster theme. However, and perhaps unsurprisingly, IM specialists lack specific knowledge of earthquake science and the current state of wider scientific research and knowledge on secondary hazards and risk. During the response, their role comprised mainly coordination, through mapping who was doing what, where and when (also known as '3W mapping').

In terms of acquiring and interpreting evidence, the onus was on cluster coordinators to make specific demands of IM specialists. This was because the IM specialists tended to have a limited understanding of both humanitarian response planning and management, and the scientific information that was available. Yet, it is unclear whether cluster coordinators were in any more of an informed position to make demands for scientific evidence.

Various **working groups** focusing on specific issues were set up within the cluster system. Of relevance to this study were the Information Management Working Group and the Assessment Working Group, also known as the Nepal Earthquake Assessment Unit (NEAU).

The IM Working Group was set up by OCHA to provide information to support the clusters' work and provide aggregated information for national and global audiences. The Working Group brought together IM coordinators, mapping specialists and data specialists from UN agencies, the International Federation of Red Cross and Red Crescent Societies, and INGOs. There was some limited participation from a government official from the Department of Survey in the Ministry of Land Reform and Management. A senior member of this group often attended the HCT.

The main task of the IM Working Group was to promote disaster managers' use of the best available data. This included responding to requests from disaster managers to prepare briefings for upward reporting:

> *'People are like [sic] "There's a donor briefing tomorrow, I need to have A, B, C and D" … that's just normal. It's unavoidable that there are these ad hoc requests for … Under-Secretary General of the UN or the head of IOM is coming or whatever and we need a presentation with all the latest stuff and the latest maps …' (interview with international agency official, February 2017).*

The IM Working Group were expected to coordinate flows of information among disaster managers, but this presented challenges, with members of the Group unsure of how to work with granular levels of information that could have had operational significance:

> *'So, what happens all day long is somebody comes into the tent, or office or whatever, and says, "My colleague was just in ABC village in the mountains and said it's totally destroyed." It's kind of like, "Okay, that seems like useful information but I'm not sure what I do with that". I don't keep a list of … villages in Nepal … That's not easy for me to digest in any meaningful way' (interview, February 2017).*

The NEAU comprised staff from OCHA, MapAction and Assessment Capacities Project (ACAPS) – an independent, not-for-profit initiative that undertakes humanitarian needs assessments. Jointly hosted by the RCO and OCHA and funded by DFID, one of the NEAU's main tasks was to provide monthly situation updates and to bring together and share the needs assessments being conducted by various disaster managers. Many of these updates were shared via online portals (see also section 5.3). This group was most likely to seek scientific evidence and share it with disaster managers (interview with donor representative, July 2017), as illustrated in Box 2. It remains unclear, however, whether the NEAU had a physical presence in the HCT, clusters and other groups – a factor which arguably might have increased its influence.

Box 2. The inclusion of landslide maps into Nepal Earthquake Assessment Unit updates

Landslide maps produced by Durham University and BGS were incorporated into the NEAU situation updates on 23 June, 10 July and 27 July as the monsoon evolved. The 27 July update indicates that the NEAU used the landslide map to calculate the numbers of people who were exposed to different levels of landslide hazard. The NEAU also published a Monsoon Hazard Analysis on 23 June, which contained messages about living with landslides for communities at risk, taken directly from guidance in a Durham University blog post on 28 April. A final NEAU update on 27 August recognised explicitly that 'landslide frequency [had] increased as a result of the earthquakes, and based on experiences in other contexts, the heightened risk of landslides is likely to persist for several years.' This is a key recognition of the state of scientific knowledge around earthquake-triggered landslides, and is a direct reflection of consistent statements by Durham University and other scientific actors in the months following the Gorkha earthquake.

NEAU (2015b).

5.2. Presenting and communicating scientific evidence

Evidence was shared with the clusters and the HCT **primarily in the form of written briefings or situation reports** (known as 'sitreps'), maps and infographics. Within government groups, such as the CNDRC or NEOC, participants were **more reliant on discussion**. For instance, one local government official pointed out that the 'map was on one side, and when it came to work, we did it traditionally [through conversation]', while another said they 'did not see anything [of] importance of the map while making decision' (meetings with two local government officials, January 2017). One Nepali international agency official suggested that this tendency was rooted in sociocultural norms:

> *'You see very few Nepali people using the map, we don't have that kind of behaviour or have grown up with the map … we don't have that schooling or that [habit of] looking at a map … We can go anywhere. [For example] I can go to Solokhumbu, but I will ask 100 people' (interview, January 2017).*

Briefings for the HCT were often produced by the RCO and the IM Working Group, and by the information managers for each cluster. Given the large volume of information that managers had to consider, **short briefings were essential** and included no more than the 'absolute need-to-know' messages: 'Whatever we're talking about, whether it's conflict risk or whatever, you do need to boil it down, so that kind of product [short briefing notes] is what is needed' (interview with international agency official, February 2017). Another official emphasised highlighting key messages: 'I suppose, then, it's about the skill of ensuring that you're extracting the absolute "need-to-knows" and you're finding a way to communicate that in a couple of sentences, which people hear' (interview with international agency representative, July 2016).

Briefings covered **a range of information** including affected areas and populations, the needs of affected communities, information on access routes and a summary of which humanitarian actors were doing what. Scientific hazard information acquired from UK scientists also formed part of the briefings – especially during the early stages of the response:

> *'We're doing about 15 different things at once, which means we always have something to say at these meetings. We're not just going to report on the science … The science itself would be one of 20 things in that update' (interview with international agency representative, July 2016).*

Box 3 describes briefings or factsheets produced by the RCO, which provided information on earthquake and landslide risk, drawing on inputs from the group of scientists that they consulted.

Box 3. UN RCO factsheets highlighting earthquake and landslide risk

The RCO produced fact sheets on earthquake and landslide risk and specific guidance for staff to ensure safety during operations. These were based on discussions with Durham University and were distributed at the HCT meeting on 2 May 2015. The factsheets emphasised that the earthquake did not change the basic likelihood of a future large (Mw 7–8) earthquake in Nepal, and that large numbers of aftershocks (some of them potentially greater than Mw 6) should be expected. They also described the likely distribution of landsliding, though no landslide maps had yet been released, and stressed that increased rates of landsliding above 'normal' monsoon conditions should be expected in the coming months. Finally, they outlined guidance on how to incorporate scientific knowledge of landsliding into operational decisions, such as the siting of temporary shelters and advice for personal and staff safety.

A **variety of actors** made considerable efforts to produce geospatial data and maps to inform response efforts.

- The WFP used its GIS capacity to translate field data from disaster managers or their field teams into maps to inform logistical efforts.
- The IM Working Group invested considerable time in producing a range of maps based on information from a variety of sources including the UN Department for Safety and Security, cluster members, and the NEOC. The group would decide on a daily basis what sorts of information might be worth turning into infographics which could include maps. The IM team 'would meet around lunchtime and decide what today's map is going to be about. Sometimes [X] had ideas like "UNICEF has new school data. The World Health Organization has this" [or] they'll say, "Well, today's situation report is going to focus on evacuation centres, do you have anything for that?"' (interview with international agency representative, February 2017). Maps showed, for example, areas which government deemed to be most affected by the earthquake (in terms of loss of life and casualties); the deployment of urban search and rescue teams; and which militaries were present, what they were doing and what resources they had.
- MapAction responded almost immediately to a UN request for assistance, posted within 24 hours of the main shock, to produce maps in support of the Disaster Assessment and Coordination (DAC) team, HC, the HCT and cluster members. MapAction team members liaised with scientists at Durham University to incorporate landside data that had been produced with other available datasets.
- NSET deployed a three- to four-person team to produce maps of building damage across affected municipalities.

The IM Working Group tended to produce maps for national and global audiences, often in the form of an infographic, that highlighted strategic issues. MapAction produced maps that were more useful for disaster managers to plan and manage their relief efforts in a particular area. A representative of an international agency explained:

> *'[MapAction] maps are much more likely to go into the hands of NGOs who are heading out tomorrow to some place, OCHA's maps are much more likely to be in someone's presentation, on a website, printed for donors … it's different audiences and different products"' (interview, February 2017).*

Maps were presented during HCT and cluster meetings, often shared in hard copy and made available online. However, there tended to be little distinction between the various approaches used to compile the maps. For instance, the source of the raw data underpinning the maps (such as remotely sensed data or observational data) was often unclear.

5.3. Sharing evidence beyond meetings

With disaster managers meeting in different groups and at both national and district levels, connections between them were vital to ensure scientific evidence was considered widely. Formal mechanisms existed to **facilitate coordination between these groups**. For example, members of the NEOC and the Nepal Red Cross Society were invited to meetings of the HCT. The Nepal Red Cross Society was less directly engaged in HCT discussions and their attendance was irregular, especially in the early stages of the response, potentially because they were busy working through their own structures. However, the International Federation of Red Cross and Red Crescent Societies attended HCT meetings throughout the response and bridged different parts of the Red Cross Movement and the HCT.

While the NEOC was mandated to coordinate with the humanitarian community, this was far from effective. One international agency official suggested that government wanted to be seen to be taking control without foreign assistance: 'They were struggling with a desire to show that Nepal could do it on its own …' (interview, February 2017). The HC did see senior government officials soon after the response, but it was unclear what was said. According to one international agency official:

> *'The interaction between the international community and the government was reduced to a few liaison points, as opposed to liaison in every functional area … when you restrict interaction to a couple of liaison points, that person is going to the meeting with a long list of issues' (interview, February 2017).*

The government and the international community, through the cluster system, subsequently responded to the crisis in the very early stages more or less on 'parallel tracks', potentially duplicating efforts and not realising complementarities.

The relationship between national and sub-national clusters was uncertain. And so too were the links between sub-national clusters and DDRCs, where many key decisions at the district level were taking place. One key informant from an international agency was particularly sceptical: 'These operating centres, they were mainly for the international community. How much they fed in or how much the government took from those services, I am not sure. I don't think they took much' (interview with international agency official, January 2017).

Those within the humanitarian response community uploaded meeting minutes, situation updates, maps and other materials to a variety of **online portals** to use as a reference and to inform the work of those not physically present at meetings. Such platforms were numerous, provided different types of information and included HumanitarianResponse.info, HDX, ReliefWeb, and PreventionWeb, as well as portals for each cluster such as logcluster.org. The government set up its own portal where it aimed to publish its own situation reports. However, a report analysing the implementation of the National Disaster Response Framework during the response to the Gorkha earthquake, states that, in practice, reports were not drawn up by government officials. Instead, they were reliant on situation reports and 3W matrices provided by humanitarian clusters (Bisri and Beniya, 2016).

Some disaster response managers working for donor agencies and INGOs generally knew what type of information could be found on each portal. For instance, one disaster manager from a donor agency explained that HumanitarianResponse.info, set up by OCHA, held primarily operational information, such as a calendar with meeting times and minutes, supplementary documentation and links to other portals. HDX, on the other hand, was a data repository, while ReliefWeb cross-posted or linked to news articles. Global platforms such as logcluster.org were important for facilitating a global response – a necessity, given the scale of the earthquake and the damage it had caused.

For others – including managers working for government, local, and national NGOs, as well as scientists – knowing which portal to go to was harder. Finding useful data (scientific or otherwise) without knowing what was available was challenging. One international agency representative suggested that HDX, in particular, was seen as a 'dumping ground', adding 'It's hard to navigate … Does it do the matchmaking you need? No' (interview, February 2017). Limited internet bandwidth was a further challenge, preventing managers from accessing information quickly.

Even if resources were found, they tended to be seen as abstract on their own, without an explanation of what was important or useful and why. Furthermore, given the weak connections between different humanitarian groups, much of the evidence produced during the response, including scientific outputs, was consumed primarily by those within HCT and cluster groups at the national level. This was a concern, given that the DDRCs were seen as influential in managing the relief efforts.

Informal interactions (either face-to-face or by telephone) were important for knowledge transfer. For instance, one disaster manager from an international agency described how, during the first few days of the response, briefings would be conducted at 22:00 because many people were staying together for safety reasons, and that these briefings would contain the latest expert advice from scientists (interview, July 2016).

With regards to **engaging the wider public**, Nepali scientists from technical institutes, informed by earthquake science, worked with journalists from Radio Nepal to share what was known about the hazard. However, scientists were never in control of the messages that would ultimately be shared, which in turn made some hesitant.

6. Decision-making and the use of scientific evidence

Key reflections

In general, disaster managers had limited understanding of scientific outputs (including terminology), their potential significance and operational implications. Crucially, however, managers also had to initiate relief operations quickly and could not wait for robust evidence of impacts to emerge. In any case, scientific evidence was unlikely to provide clear recommendations for managers about what they should do to respond. So, they improvised, using what was often considerable practical judgement and experience. This judgement was in turn informed by both intrinsic factors and pressures felt through relationships with others around them. With major decisions having already been made, by the time evidence started emerging it mostly served to validate the general picture of impacts that disaster managers had built up in their minds. If evidence was used, it was used to make adjustments to strategies and, with managers often facing a deluge of information from an expanding response, evidence was often ignored or overlooked.

This chapter assesses the expertise and capacity of disaster managers to engage with the scientific information being produced, and considers how scientists could better support managers in their decision-making in response to sudden-onset disasters, such as those caused by earthquakes.

6.1. Scientific literacy

Although, as already described, scientific information in the form of factsheets, maps, and summaries was shared with people in the HCT and the clusters, some disaster managers were unable to make sense of the scientific terminology. One international agency representative said 'as a humanitarian responder, it was quite difficult to understand what they [scientists] meant by all the shaking intensity and what it means' (interview, February 2017). Some felt that information that was purely analytical was not useful:

> *'Saying there will be a landslide sometime in the next five years isn't really helpful to them … Your average logistician is going to see us [advisors and scientists] as airy-fairy, pie-in-the-sky. From his perspective, intellectuals have nothing useful to say because we're not talking about trucks' (interview with international agency representative, July 2016).*

In relation to maps, those that were produced using remote sensing data were not necessarily seen by disaster managers as distinct from maps based on ad hoc reports from people on the ground. That is, differences in the quality of the maps were not always recognised. Many of the interviewees struggled to make sense of information that was presented spatially – even if some of the questions they were seeking to answer were spatial in nature:

> *'Government officials, they have no practice [in using maps] … for example, if I'm saying a particular location, they are not asking for the map, they are just getting a pen and paper and asking where is the village' (interview with local government official, January 2017).*

This may reflect the fact that potential users did not always understand what the maps were showing.

In some cases, not enough was done to add context to maps through the use of secondary data – for example, maps could have been overlaid with the location of potentially vulnerable groups and road networks. Interviewees felt that more could have been done by the producers of maps (including scientists) to point out clearly what the implications or options might be for key actors – be they logistics managers, or those working at a more strategic level. One international agency representative agreed, saying 'it would not be super obvious to a very operational person in an NGO … I've seen these maps and maybe I've even created maps, that even very technical people can't understand because they're just not clear' (interview, February 2017). The interviewee went on to say that when engaging with decision-makers, 'A bit of spoon-feeding helps. That goes with everything not just maps, trying to explain what they are and how they could be used.' For example, they would say to decision-makers, '"We have these maps, what they're showing are those areas ... have experienced a landslide because of this …"' (ibid.).

6.2. From evidence-informed decision-making to improved practical judgement

Disaster managers were not able to wait for robust scientific evidence about impacts to emerge before acting. One donor official said that 'rather than rolling out an assessment team and then typing up, analysing and waiting for the report, people will die if we do that' (interview, January 2017). An international agency representative also emphasised the importance of reputation management, saying that they 'received a lot of pressure from donors, from the media, from everyone around the world. Everyone wants to see that people are being helped … the reputational risk plays a big factor in the decision-making process' (interview, February 2017).

With disaster managers on the ground often only for short periods of time, they were expected to act quickly. This meant they had little time to fully consider scientific evidence (or other evidence of a strategic nature). This was exacerbated by the need to, for instance, spend time negotiating the government's 'one door' policy, which required all aid materials and funds to be channelled through the government (Kathmandu Post, 2017).

Meanwhile, discussions held within formal groups, such as the HCT or clusters, and any consensus reached or guidance issued were shaped by a range of factors. These included:

- the diversity and influence of group participants
- how effectively discussions were facilitated, the provision of evidence to inform discussions (and subsequently the role of information managers in brokering information)
- how the content of the discussions was shared with those not present at meetings
- the connections and knowledge sharing with other groups.

The extent to which scientific evidence did inform decision-making was complex, with the evidence (and how it was interpreted) simultaneously *shaping* as well as *being shaped by* conversations between group members.

Moreover, the extent to which guidance issued by formal disaster management groups was influential in informing the focus and priorities of disaster response activities is unclear. For instance, some managers chose not to work through formal decision-making groups, with one international agency representative saying, 'some partners … decided, "Okay, [the cluster system] is so cumbersome, and bureaucratic: I will choose to take my own organisational route"' (interview, January 2017).

Disaster managers were driven by a humanitarian 'impulse' and the desire to do their job well, but also by a high degree of anxiety, and had to act swiftly. This was facilitated by the high degree of autonomy given to many in the humanitarian response community. Managers improvised in conditions of uncertainty using practical judgement. This judgement was in turn informed by a number of intersecting factors that could both constrain and enable their use of scientific evidence and engagement with scientists. We have grouped these factors into:

- **Intrinsic factors,** which are internal to disaster managers and include principles held by groups or individuals, assumptions or 'shortcuts', the use of estimates, conception of the hazard, preparedness, past experience and approach to risk.
- **Extrinsic factors,** which comprise mainly social and political pressures, and include historical factors, guidance and policies issued by various actors such as the government, humanitarian agencies and donor agencies; pressures to compete with other organisations (for funding, responsibility and media coverage); pressures from other actors through informal relationships; and pressures from social and other forms of media.

In each case, we have considered how these factors might shape disaster managers' demands and their ability to use scientific evidence.

6.2.1. Intrinsic factors

Principles to inform priority setting

These included a need to keep people alive, to prioritise the most vulnerable and to work with government authorities, especially the DDRCs. As a donor official explained:

> *'The most critical thing is: are they breathing? You keep them breathing because you can't live without breath for four minutes. You've got to get them water because you can only live without water for so many days. You've got to get them shelter because if the elements are bad you can't survive for very long' (interview with donor official, January 2017).*

These views were shared by other respondents:

> *'Things are not good for any of these people and they will all require assistance, but we need to prioritise, at this point, the operation – where we go first' (interview with international agency official, January 2017).*

> *'To work in the country, we had to consider the government. Without DDRC approval no one can work anything in the districts. That is the mandate for everyone' (interview with INGO official, January 2017).*

> *'Don't go out anywhere and only assess. You have to take some relief materials. The needs are so high everywhere you go' (interview with INGO official, January 2017).*

Different priorities were, however, noted in relation to the distribution of relief. While managers in the humanitarian community tended to prioritise the most vulnerable, especially in the early stages of the disaster when relief items were limited, government managers preferred to hold back distribution until they could take a 'blanket' approach or distribute equally what resources they had. In a situation where managers prioritised the most vulnerable, scientific information illustrating, for instance, where the shaking resulting from the earthquake was likely to have been intense (in a specific district or across a larger region) could be useful, especially where actual impact data was limited.

Assumptions

These included assumptions that the worst-hit area was likely to be at or close to the epicentre, that people would require shelter in the event of an earthquake, that those in rural areas would require more assistance than those in urban areas (where NGOs were more active) and that, prior to the monsoon, relief materials had to be 'pushed up' the mountains as far as large trucks could go. A number of key informants suggested that with an earthquake, one could make assumptions about how people might be affected, with one INGO representative saying: 'in a rapid onset disaster …, you can be sure that people will need shelter, water, sanitation, support, warm clothes, things like that' (interview, January 2017).

Estimates

Some disaster managers made estimates of the most affected populations and their locations by combining information from international sources, such as the USGS ShakeMap, with secondary information, such as population density and food and nutrition vulnerability. Based on estimates of those affected, agencies were able to start making decisions about the quantity of relief items required. One international agency representative said:

> *'We have standards [or formulas, which we use to calculate an] estimated number of people requiring assistance, what that means upstream in terms of the quantity of stock we're going to need, the number of teams we're going to need, the amount of storage that we'll need at various, different points' (interview, February 2017).*

However, the quality of these initial estimates was not checked against measured assessments collated later.

Ideas about the hazard context

Parts of Rasuwa and Sindhupalchok districts were left isolated due to landsliding, leaving thousands of households potentially vulnerable despite response efforts elsewhere (Williams et al., 2018). In these cases, disaster managers did not appear to recognise the potential for landslides to cause significant damage, so did not view maps locating earthquake-triggered landslides as important. Better articulation by scientists that landslides could be a proxy for measuring damage and loss, and how damage and loss was distributed, may have resonated more with key humanitarian actors and led to more concerted efforts in landslide-affected areas.

Preparedness

Immediately after the earthquake, some managers focused initial relief and search and rescue efforts in the Kathmandu Valley. This was perhaps unsurprising given the valley's five-million-strong population and the fear among politicians of unrest. However, the main impacts of the Gorkha earthquakes were concentrated in rural areas outside of the valley.

Experience

Disaster managers, especially those who had flown in from overseas as part of the 'surge', often had considerable experience in managing emergencies in other contexts. However, this did not necessarily include experience of earthquakes, working with scientists, a detailed knowledge of Nepal's geography, or of the kinds of information that might be useful and where it might be sourced. For example, one information manager had previously been responding to the Ebola outbreak in West Africa, and had very little knowledge of earthquakes or landslides, which was the focus of their new role.

Risk aversion

Many disaster managers were reluctant to consider scientific evidence (for example, in the form of maps of landslide location and intensity) that indicated where roads and trails were likely to be damaged by landslides. Being aware of such issues may prevent urgent supplies from being delivered. As one representative from an international agency explained:

> *'Surprisingly, these organisations are very risk averse. They're all frightened of legalities … They're all terrified that if there's a landslide and someone gets seriously injured, they'll get sued. There's always some of them that would rather not know. The thing is 90% of the time, the convoy's going to go anyway' (interview, July 2016).*

Disaster managers, especially those in government, were also reluctant to highlight relative risk because of potential political implications. An international agency official suggested that, 'politically, [the government] don't want a nationwide picture because they don't actually want to say, "This place is at more risk than that place"' (interview, January 2017).

6.2.2. Extrinsic factors

History

Some managers from the humanitarian response community decided to work in areas of Nepal where their organisation had existing programmes, so as to deliver certain forms of relief, such as food, or to focus on specific target groups, such as disabled people. In these cases, scientific evidence that identified the areas of greatest earthquake impact or greatest need was less likely to be used.

Guidance issued by government

Disaster managers felt strongly obliged to conform to government policies and guidelines. This included guidance that defined the most severely affected districts as well as requirements to channel aid materials and funds through the government. This suggests that scientists ought to share any scientific evidence with government actors (such as MoHA) as it could inform their policies and guidelines, and in turn the operational response.

Guidance issued by humanitarian agencies

Managers in INGOs and agencies were often influenced by more senior officials in regional and international teams within their own organisations, in structures that were sometimes set up temporarily to cope with the increased demand for capacity. Many of them were also subject to guidance issued by foreign affairs ministries in other countries (such as the UK's Foreign and Commonwealth Office) to ensure the safety and security of their own citizens.

Some agencies, such as UNDP, had standard operating procedures for crisis response. In the case of UNDP, these were under revision at the time of the earthquake. The NEOC had also developed a set of standard operating procedures to guide its work in the case of an emergency. However, the procedures tended to be of limited use during this emergency: 'There are certainly protocols for how we do certain aspects of our job. An awful lot is context dependent, however, and the protocols only go so far' (interview with international agency representative, January 2017). Another international agency official suggested that the UN was full of guidance notes that were not widely read. Instead, experience and preparedness efforts were viewed as much more effective for guiding behaviour.

Guidance issued by donors

Donors could use funding as a means to influence grantees to encourage the use of scientific evidence. Grantees could also benefit from access to advocacy and support to influence or negotiate the implementation of government policy. However, donor officials reported that in reality they had limited influence over grantees after the earthquake. In part, this was because members of the humanitarian response community (and especially large INGOs) were able to mobilise considerable funds through private channels via social media.

Competitive pressure

Managers would often choose to work independently to distinguish themselves from other organisations, enabling them to provide a stronger account of their own work to regional and international headquarters and overseas funders. As one donor official said, 'the NGO sector is quite competitive, generally speaking, in terms of relationships [and] position[s]' (interview, January 2017). This was supported by an international agency representative who said that even in an emergency situation, there is 'intense rivalry and intense competition on everything' (interview, July 2016). Some organisations bolstered their visibility by bringing in temporary media engagement teams.

Informal relationships with others, including scientists

Despite being part of formal groups within, for example, the HCT and cluster system, disaster managers were also influenced by other, less formal groups comprising people from a variety of sectors. For example, representatives from NSET conveyed information about building damage to their friends and acquaintances in government agencies (interview with NGO representative, January 2017), and one INGO representative said he 'was closely working almost with all the government authorities including the Home Minister, Ministry of Federal Affairs and Local Development' (interview, January 2017).

The presence (or, indeed, absence) of trust was considered by respondents to be critical. Trust is especially important in a crisis, where the number of relationships increases dramatically. The ability of evidence producers and scientists to penetrate disaster managers' trusted networks is key if they are to be influential. As one UK donor representative highlighted:

> *'I wouldn't put some of those relationships [with Nepali scientists] in my top 10 people that I need to constantly be regularly checking in with, and I think that's probably similar for other donors. And there aren't necessarily easy ways of interfacing with that community' (interview, February 2017).*

On the other hand, the fact that scientists from overseas were invited into discussions by the RCO shortly after the main shock was in part testament to the relationships that they had built up over previous years (interview with an international agency official, July 2016).

Pressures from social and other forms of media

Many disaster managers received information about the severity of the main shock, aftershocks, building damage and casualties through social media, including Facebook and Twitter, and traditional local media outlets such as *Kantipur* and *Nagarik*. These sources were particularly important during the early stages of the response. However, some of this information was misleading. For example, considerable airtime was given to news about the destruction of key heritage sites in Kathmandu in the first few days of the response, which influenced early search and rescue efforts (even though most of the damage was outside the Kathmandu Valley). There was also evidence from interviews conducted during our research of 'herd behaviour' – that is, where disaster managers were influenced by their peers to, for instance, head to the epicentre or to Sindhupalchok District during the early stages.

By the time scientific or other evidence was presented to disaster managers through formal groups within a few days, many humanitarian agencies had already initiated relief efforts. In some cases, new evidence served to help managers either to validate or adjust their strategy and approach, rather than prompt potentially extensive changes. 'Learning by doing' was subsequently crucial. For instance, the army distributed what relief they had to areas they thought were most affected, before adjusting based on information that was coming in from affected districts (interview with army representative, January 2017). However, this process of adjustment was far from straightforward. One donor official highlighted, ‘We didn’t necessarily [change course] in that first month or two based on other resource information … the initial decisions had been made. The wheels were already churning’ (interview, February 2017).

Within weeks, disaster managers were having to deal with a growing quantity of evidence, which they found difficult to make sense of and to act on. Some well-resourced INGOs took several months to reorient their response to serve some of the worst-affected districts, even though the districts were identified and announced two weeks after the earthquake. As illustrated by one INGO representative:

‘When I came in, in around July, and another international person came in to be the response manager, and we looked at the [affected area analysis] data from the government, we really realised that where we were targeting our efforts was not where the greatest need, or the greatest impact, was, so we made a deliberate shift of our response and our funding into Gorkha and notably Sindhupalchok, Dhading, Dholaka and Nuwakot. Yes, so that was from some of the data that was coming out from the government, and also the Inter-Agency Assessment that they put together very early in the response’ (interview, January 2017).

7. Recommendations

The challenges associated with producing and using robust scientific information immediately after an earthquake mean there are no 'quick fixes' to the challenge of making such evidence 'useful, usable, and used'. As the previous section highlights, disaster managers are under many pressures and demands, which limits the extent to which they can pause, reflect and consider scientific information and its implications for disaster response. At the same time, scientists may face difficulties in producing the most appropriate information in the timescales and formats required by managers.

However, there are opportunities to ensure that disaster response processes are better informed through sustained efforts from both scientists and disaster managers. We describe these here, beginning with general recommendations, before focusing on more specific recommendations for disaster managers and management, DRR managers (given the importance of pre-disaster preparedness efforts) and scientists.

7.1. General recommendations

Evidence-use studies often recommend the deployment of brokers who specialise in the 'translation' of knowledge to bridge the gap between scientists and decision-makers (in this case, disaster managers). However, as discussed, information managers, who often assume this role, may have a limited understanding of the science and of the evolving humanitarian context, reflecting their focus on mapping who is doing what, where and when (the '3Ws').

While information managers undoubtedly have a valuable role to play, we suggest there is much to be gained through direct engagement between disaster managers and relevant scientists during pre-disaster preparedness and DRR work, to explore if and how science could usefully inform decision-making processes in times of emergency. We suggest that this engagement should focus on addressing and aligning two key questions:

- What information and expertise are needed by disaster managers and when?
- What information and expertise could be provided by scientists and over what timeframes?

A commonly held belief is that scientists and disaster managers are likely to find it hard to engage with one another. For example, scientists may struggle to communicate evidence to managers in a way that is accessible, while managers may not master the expertise required to absorb complex scientific evidence. We argue that these challenges can be overcome through direct engagement, the development of mutual understanding and the building of trust, and that this is best done before the pressure of a disaster.

7.2. Recommendations for disaster managers and management

We suggest that disaster and information managers engage scientists on the following issues:

- clarifying emergency response procedures, disaster managers' information needs and associated timescales, as well as the decision-making context disaster managers are likely to face
- the scientists and science that could feed into and inform the disaster response, defining the kinds of contributions they could make through engagement with key interlocutors
- the use of empirical models (e.g. of earthquake-triggered landslides) to quickly predict likely impacts of disasters when they occur
- the types of assumptions managers might reasonably make in the event of a sudden onset disaster to aid their decision-making
- guiding humanitarian principles and how these might shape the needs for scientific evidence
- the use of remotely sensed data to provide an objective measure of impact intensity across the entire area affected and to make assessments of local conditions that can inform logistics planning
- the value of crowdsourced data in informing relief efforts
- how scientific information could be usefully combined with other forms of information produced after a disaster such as the 72-hour emergency assessment approach, the MIRA and the PDNA
- the use of science to understand the longer-term evolution of post-earthquake risk over the months and years after the event
- what risk and uncertainty mean in practice, how these are communicated, and the dilemmas managers face in managing risk and uncertainty.

Engagement around these issues could be facilitated:

- by inviting scientists to provide training and education for disaster (and information) managers
- by providing training and education for scientists
- through deliberative workshops
- through the attendance of disaster managers at strategic interdisciplinary geoscience conferences, such as annual meetings of the American Geophysical Union

- by pairing disaster managers with scientists (through a coaching relationship)
- through short-term placements of scientists with cluster lead agencies, or disaster managers within scientific institutions
- through joint scenario-planning (such as the civil/military 2016 Tempest Express earthquake simulation exercise held in Kathmandu).

To better facilitate the use of science, we suggest that an in-country UN team (e.g. the RCO or HCT) identify what might be called **'policy entrepreneurs' –** that is, disaster managers who are committed to using science in policy and practice, who have the 'ear' of both scientists and disaster managers, and who have sufficient knowledge of the humanitarian architecture to know how and when to present scientific information and advice. They would become key interlocutors between disaster response processes, on the one hand, and scientists, on the other.

To more formally champion the engagement of scientists and disaster managers, we suggest the UN **appoint of science officers** at national, regional and global levels. The number and scope of each post should reflect the in-country disaster response capacity, and the potential value that science could add in disasters anticipated in that region or country.

Their role would include maintaining a **locally relevant directory of scientists** for disaster response and identifying opportunities for engagement both before and during a disaster response. The science officer could also adopt the role of a **'gatekeeper'** for overseas scientists after a disaster, giving them advice about if, when and where their expertise would be beneficial, and which disaster managers to connect with. A national, regional or global science officer could **maintain engagement with progress in the scientific world**, and play a role in advocating for scientists to make research more 'useful, usable and used' in disaster response.

Our research identifies a pivotal role for **donor agencies** in enabling and enhancing the use of science in disaster response. We suggest that donors support the engagement of scientists and disaster managers:

- By providing funding for the (national, regional, global) science officers.
- By investing in periodic and thematic science fora, bringing together managers from across different communities as well as information managers, relevant scientists and other knowledge providers to discuss some of the issues identified above. Such fora could also be a place to play-out disaster scenarios to stress test the current ability of using science in disaster response in various settings.
- Through funding the production and sharing of good practice narratives from scientists and disaster managers about how humanitarian relief efforts have been informed by scientists and through scientific inquiry. This might include, for example, promoting the production of UNISDR Scientific and Technical Advisory Group case studies and demonstrations of data use via the Committee for Earth Observation Satellites Disasters Working Group.
- By directly supporting UN-led efforts to systematise international protocols for using science after disasters. This could include, for example, directly supporting the UN-SPIDER platform, which facilitates the use of space-based technologies for disaster management and emergency response.

7.3. Recommendations for DRR managers

Our findings speak directly to ongoing disaster preparedness efforts. Secondary baseline data is often required in order to make post-disaster scientific information useful, and is invaluable. For instance, the ability to overlay community locations and exposure information (e.g. population data) with models of likely shaking intensity or landslide location in the hours immediately after an earthquake is vital for relief prioritisation. Without recent and systematic census data, even the most potentially useful scientific information can be rendered ineffectual.

To minimise this possibility, we suggest DRR managers work collaboratively to identify, produce, archive and regularly update secondary datasets to help disaster managers make quick estimates of damage, loss, and associated needs immediately after a disaster. This exercise will inevitably bring developmental benefits, and feed into government planning, as well as enabling improvements in disaster response. We recommend that actors within the DRR sector (within government and beyond) take the lead in compiling these datasets, and in making them freely and openly available.

This recommendation also aligns with recent proposals made by OCHA at a regional level to delay a large-scale MIRA until the second or third week after a disaster, and to instead focus on strengthening the availability of secondary data to inform initial response assumptions in terms of needs and fundraising (communication with donor representative, July 2017).

7.4. Recommendations for scientists

We strongly encourage scientists to consider the ethics associated with conducting research in the aftermath of a disaster, which can lead to a 'gold rush' (see Gaillard and Gomez, 2015). While we recognise that some data is time-limited, it is nonetheless important that scientists seek to **distinguish between the science that could usefully inform a disaster response and science that may be less urgent or of more academic interest.**

We also suggest scientists use a **clearly-defined protocol** for responsive, disaster-focused hazard mapping. For example, we identify a clear need for protocols for post-earthquake landslide mapping, similar to the protocols for flooding that were published by United Nations Office for Project Services. The absence of a set of protocols or templates that describe standard procedures for collecting and analysing information about particular hazards can result in evidence that is spatially incomplete, inconsistent and inhibited by limited communications (UN-SPIDER, 2015).

With regards to influencing disaster managers and the relief efforts they are coordinating, we suggest that scientists **decide how far they are willing to go in order to engage** in the humanitarian response. Some may feel they can only go as far as producing science and working with a 'knowledge broker' to translate their findings into more accessible 'products'. Or, they could increase the likelihood of informing the response by participating directly in decision-making, explaining and discussing the available scientific information and its operational potential.

To coordinate the efforts of the science community in-country – in this case, Nepal – we suggest that the science community **form a science advisory group** to consider the issues in this report, and facilitate their engagement with disaster managers in government, the military and the humanitarian response community. This group could also coordinate scientists in times of disaster to avoid duplicating efforts and resources. If this group includes overseas scientists, the latter (and their funders) need to consider mechanisms to enable collaboration with in-country counterparts on genuinely equitable terms.

Our work shows the vital role of interlocutors between managers and scientists. We suggest that the science advisory group **identifies a focal person** to coordinate the group and play the role of interlocutor with the government and wider development and humanitarian community. The focal person need not be a senior scientist, but should at least understand the science underway and its potential uses in a disaster response. In the absence of a national facilitator, the appropriate UN agency could facilitate or support this science group.

Given the complex disaster preparedness and response architecture, we suggest **scientists take steps to make themselves and their work known to the humanitarian and DRR communities** (especially the aforementioned policy entrepreneurs) through the nominated focal person. This should be the mechanism through which scientists gain exposure to relevant groups that make decisions about the response to an emergency. Scientists with work of value for dealing with geohazard-related disasters need not be limited to geologists and geophysicists, but could include scientists relevant to other elements of the response process, such as public health experts.

During the response to the 2015 Nepal earthquakes, scientists were able to share information with the RCO and HCT through networks that had been established prior to the earthquake. While the RCO and HCT may have been the most appropriate route in this context, it is generally more likely to be via the ICCG. The ICCG is a key group where 'sense-making' and understanding of the 'big picture' tends to take place. It is also where information from the clusters is discussed. In Nepal, the Logistics Cluster (co-led by the WFP and the MoHA), the IM Working Group (led by OCHA) and the NEAU were also seen as important coordinating groups.

Disaster managers require scientific information in a format that can be clearly understood without any specialist technical training. It is essential therefore, that scientists **package information**, including maps, in a way that clearly communicates their potential operational use and can be included in briefing notes and situation reports for disaster managers. Defining the best means to communicate this science can only be done effectively in collaboration with disaster managers. We recommend that:

- Scientists consider how disaster managers think about issues and therefore how scientific advice might be **framed** or presented, to ensure that messages are processed more easily.
- As information shared with one group may not always be accessible by others, scientists will have to be prepared to **engage with multiple groups** (government and humanitarian community) at different levels (national and local).
- Both scientists and disaster managers recognise that **some scientific outputs will gain utility over time**, rather than being immediately useful. For example, while a detailed landslide inventory collected in the days after an earthquake may be too granular to inform the prioritisation of the distribution of relief, it may become useful for planning relocation and resettlement weeks or months later.

Finally, a word of caution for scientists: given the complex dynamics of humanitarian groups and how they function, information or advice provided by scientists to a manager is unlikely to be used instrumentally. As such, **evidence of use is unlikely to be clear and unambiguous**. However, scientific information and advice can be used to ensure better *informed* decision-making.

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Links to online portals

Humanitarian response info: https://www.humanitarianresponse.info
HDX: https://data.humdata.org
Reliefweb: http://reliefweb.int
PreventionWeb: www.preventionweb.net/english

Annex 1. Durham University landslide mapping activities

The following is a summary of outputs from the landslide mapping team undertaken by Durham University (DU) in collaboration with the BGS. These outputs were published on the Earthquakes without Frontiers blog (http://ewf.nerc.ac.uk/blog/), with the raw data available on the Humanitarian Data Exchange (HDX) website for download.

25 April 2015 – Nepal earthquake: likely areas of landsliding
(http://ewf.nerc.ac.uk/2015/04/25/nepal-earthquake-likely-areas-of-landsliding/)

- DU scientists summarised the outputs of two landslide models developed and run by Tom Robinson (University of Canterbury, New Zealand) and Rob Parker (University of Cardiff) used to identify where the hardest hit areas in terms of landsliding might be, based upon shaking predicted by the USGS ShakeMap system.

28 April 2015 – Landslides in the Nepal earthquake: preliminary guidance for relief and response
(http://ewf.nerc.ac.uk/2015/04/28/landslides-in-the-nepal-earthquake-preliminary-guidelines-for-relief-and-response-activities/)

- DU scientists assembled preliminary guidelines for relief and response workers and emergency planners in Nepal. This was informed by initial models of landslide likelihood, fragmentary initial mapping of landslides from the first available post-earthquake satellite imagery, and experience following the 2005 Kashmir (Pakistan) and 2008 Wenchuan (China) earthquakes.
- The summary of the observations highlighted valleys in the High Himalaya susceptible to landslide dams, and landslides in the foothills which could hamper movement only main road corridors.

5 May 2015 – Nepal earthquake: update on landslide hazard
(http://ewf.nerc.ac.uk/2015/05/05/nepal-earthquake-update-on-landslide-hazard/)

- The first map of landslide intensity produced by DU, BGS and the University of East Anglia was published. This map displayed the density (number of landslides per unit area), calculated from those new landslides identified from satellite images captured after the earthquake. The map was intended to emphasise the relative intensity of landslide impacts within the earthquake-affected districts. The map was accompanied by a summary of the locations affected, including the locations of large valley blocking landslides, the impact of landslides on major road corridors, and an explanation of the likely limitations in the data.
- DU scientists set out a series of recommendations for scientists, governments and humanitarian responders: inspect valleys for valley blocking landslides in the field, undertake a survey of major transportation corridors to identify where the problems are most likely to arise during the monsoon and validate findings from satellite imagery with field-based observations.

8 May 2015 – Nepal earthquake: update on landslide hazard
(http://ewf.nerc.ac.uk/2015/05/08/nepal-earthquake-update-on-landslide-hazard-2/)

- An updated map of landslide intensity produced by DU, BGS, ICIMOD, NASA and the University of Arizona was published, with high-resolution versions of the map available for download. The map included more comprehensive coverage across the earthquake-affected area as more of the ground was visible in imagery captured without cloud cover. The map was accompanied by a summary of the spatial distribution of landsliding including a list of confirmed or potential valley blocking landslides, a list of valleys with relatively intense landsliding including affected village development committees, and a summary of the impact of landslides on major road corridors.
- DU scientists set out a series of recommendations for scientists, governments and humanitarian responders: inspect valleys for valley blocking landslides, undertake a survey of major transportation corridors to identify where the problems are most likely to arise to prepare for clearance, and validate findings from satellite imagery with field-based observations.
- Scientists highlighted the need to plan ahead for the 2015 monsoon when significantly more damaging landslides might be anticipated to occur.

10 May 2015 – Preliminary guidelines for relief and reconstruction posted in Nepali (also uploaded to the NSET website)
(http://ewf.nerc.ac.uk/2015/05/10/landslides-in-the-nepal-earthquake-preliminary-guidelines-for-relief-

and-response-activities-from-28-april-in-nepali-%E0%A4%A8%E0%A5%87%E0%A4%AA%E0%A4%BE%E0%A4%B2%E0%A4%AE%E0%A4%BE-%E0%A4%AD/)

12 May 2015 – Nepal: update on landslide hazard following 12 May earthquake
(http://ewf.nerc.ac.uk/2015/05/12/nepal-update-on-landslide-hazard-following-12-may-2015-earthquake/)

- DU scientists summarised the landslides that might be expected including possible locations following the 12 May earthquake.

28 May 2015 – Nepal: updated landslide inventory following 25 April Nepal earthquake
(http://ewf.nerc.ac.uk/2015/05/28/nepal-updated-28-may-landslide-inventory-following-25-april-nepal-earthquake/)

- DU and BGS scientists published an updated landslide density map. This included a summary of the number of landslide identified up to the 12 May (not including those triggered by the 12 May earthquake), the spatial distribution of the landslides, observations of large-scale valley blocking landslides, and the need to plan for heightened landslide activity in the 2015 monsoon. District-level landslide maps were also produced for five of the hardest hit districts, which showed the mapped location of individual landslides.
- DU scientists recommended that cracks that may have developed during the earthquake, which had been reported by many on the ground, are monitored to identify areas that may be at risk on continued movement and instability.
- All maps and landslide shapefiles were made available for internet download.

30 June 2015 – Updated landslide inventory following 25 April and 12 May Nepal earthquakes
(http://ewf.nerc.ac.uk/2015/06/30/updated-30-june-landslide-inventory-following-25-april-and-12-may-nepal-earthquakes/)

- DU published an updated landslide intensity map which included landslides triggered by both the 25 April and 12 May earthquakes.
- The accompanying guideline included a summary of the number of landslides identified up to 30 June 2015, and the spatial distribution of landslides including districts most severely affected.
- DU scientists recommended the continued monitoring of cracks in the ground to identify areas that may be at risk.
- All maps and landslide shapefiles were made available for internet download.

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Cover photo: Valley bottom house damaged by rockfall during the April and May 2015 earthquakes. Liping Bazaar, Sindhupalchok, Central Nepal.
Credit: N. Rosser, November 2015.

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