Damage caused by the earthquake in Nepal. Photo by UNDP

EARTHQUAKES AND LANDSLIDES IN NEPAL

The earthquake which hit Nepal on 25th April 2015 was the worst the country had experienced in 90 years. SHEAR has been working to improve understanding of, and planning for, the causes and impacts of these disasters.

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Summary:

SHEAR projects have been conducting research to improve the understanding of aftershock and landslide risks, so that disaster risk reduction planning can be improved, and resilience strengthened.

SHEAR research partners at the **University of Cambridge** monitored and analysed the sequence of aftershocks to determine how risk had developed.

The **University of Durham** is working with the National Society for Earthquake Technology in Nepal to assess the ongoing risk of landslides posed to households in Nepal.

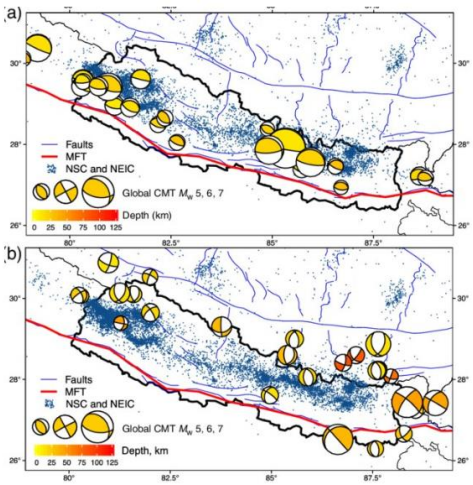
Cascading Hazards

Following the earthquake which occurred on 25th April 2015, affected communities, policy and decision makers, and responding governmental and non governmental agencies were faced with a series of aftershocks and ongoing landslides.

In the 45 days following the initial shock, the National Seismological Centre recorded 553 earthquakes of local magnitude greater than 4.0. Some of these aftershocks were still occurring months later, such as the magnitude 5.2 earthquake that hit the Solukumbhu district on 28th November 2016.

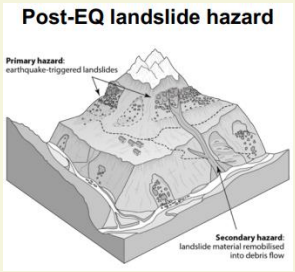
The initial shock and resulting aftershocks in turn triggered over 22,000 landslides across 14 districts of central Nepal. Damage to the hillslopes caused by the earthquakes has led to increased risk of landslides during subsequent monsoon seasons for an estimated five to ten years.

These cascading hazards impact immediate response and longer term reconstruction and recovery efforts. Responsible agencies such as the National Reconstruction Agency need accurate information to guide their planning and decision making.

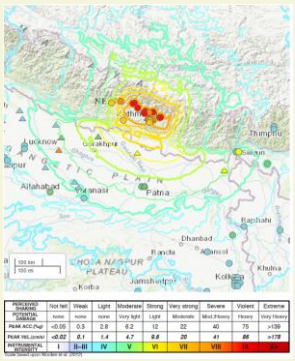


Earthquakes from the Global Centroid Moment Tensor (CMT) catalogue, with shading by depth, and size scaled by magnitude, from the beginning of the catalogue in 1976 to the end of 2016. Top: Thrust earthquakes within 150 km of the Main Frontal thrust (MFT); Bottom: nonthrust earthquakes within 250 km of the MFT. Image from Stevens et al., 2018 (see reference).

Clearing rubble in the response to the 2015 earthquake. Photo by UNDP



Earthquakes without Frontiers diagram illustrating primary and secondary earthquake-triggered landslide hazard.



USGS Earthquake Hazards Program ShakeMap illustrating ground motion and shaking intensity following the initial shock

Resilience to Changing Risk

SHEAR projects have been working to better understand the earthquake and subsequent impacts by: i) understanding the fault system that caused the earthquake; and ii) mapping how landslide risk evolves in the aftermath of the earthquake and what this means for post-disaster recovery and reconstruction.

Nepal Earthquake Seismicity

SHEAR partner University of Cambridge conducted monitoring of the ground and fault movement which occurred during and after the initial earthquake using seismometres and GPS measurements. This enabled the sequence of aftershocks to be tracked and analysed to improve understanding of the structure of the Main Himalayan Thrust fault. The analysis found that the main shock had differed from previous earthquakes as it had not ruptured to the surface, meaning that there was still substantial risk for further shocks in surrounding areas. In particular, the fault south of Kathmandu has remained locked, and is expected to fail in a future large earthquake, though its timing cannot be predicted. The findings have been presented to DFID, UNESCO and authorities in the Nepal government, and will guide a new building code which will support resilience to future shocks.

Nepal Landslide Mapping

Durham University and the National Society for Earthquake Technology in Nepal have used satellite imagery to develop comprehensive inventories of landslides between 2015 and 2019 across the area most badly damaged by the 2015 earthquake. This is being used to monitor how post-earthquake landslide hazard changes after each monsoon season, as loose material is remobilised by rainfall. Data has been used to model potential landslide runout during monsoon rainfall to identify areas at greater risk of being impacted by landsliding. Using the locations of approximately 1.1 million individual buildings located within the area impacted by the earthquake,current and changing landslide risk has been assessed at individual household level. This information has been translated into an atlas of maps, for use by both those living with landslide risk but also those tasked with mitigating and managing these risks.

Next Steps

SHEAR partners are continuing to develop detailed case studies exploring how households and communities living with ongoing landslide risk could benefit from the data generated, focusing on their questions, concerns and needs. Case studies are exploring how the landslide risk data and maps can inform and support planning by communities and by organisations responsible for managing landslide risk, through for example, land use planning or relocation. In the future, the landslide database and model outputs will be used by national government departments in Nepal, DFID Nepal and UN agencies to assess impacts on infrastructure, such as roads and hydropower.

Stevens, Victoria, Shrestha, Surya N., and Maharjan, D. K., (2018) 'Probabilistic Seismic Hazard Assessment of Nepal', *Bulletin of the Seismological Society of America*, 108(6) https://doi.org/10.1785/0120180022

Earthquakes without Frontiers project, part of the NERC and ESRC Increasing Resilience to Natural Hazards (IRNH) programme

Current research into earthquake triggered landslides at Durham University's Institute of Hazard, Risk and Resilience

Current research into active faulting in earthquakes and other geophysical, geodynamic and tectonics research at the University of Cambridge's Department of Earth Sciences