Geo Factsheet

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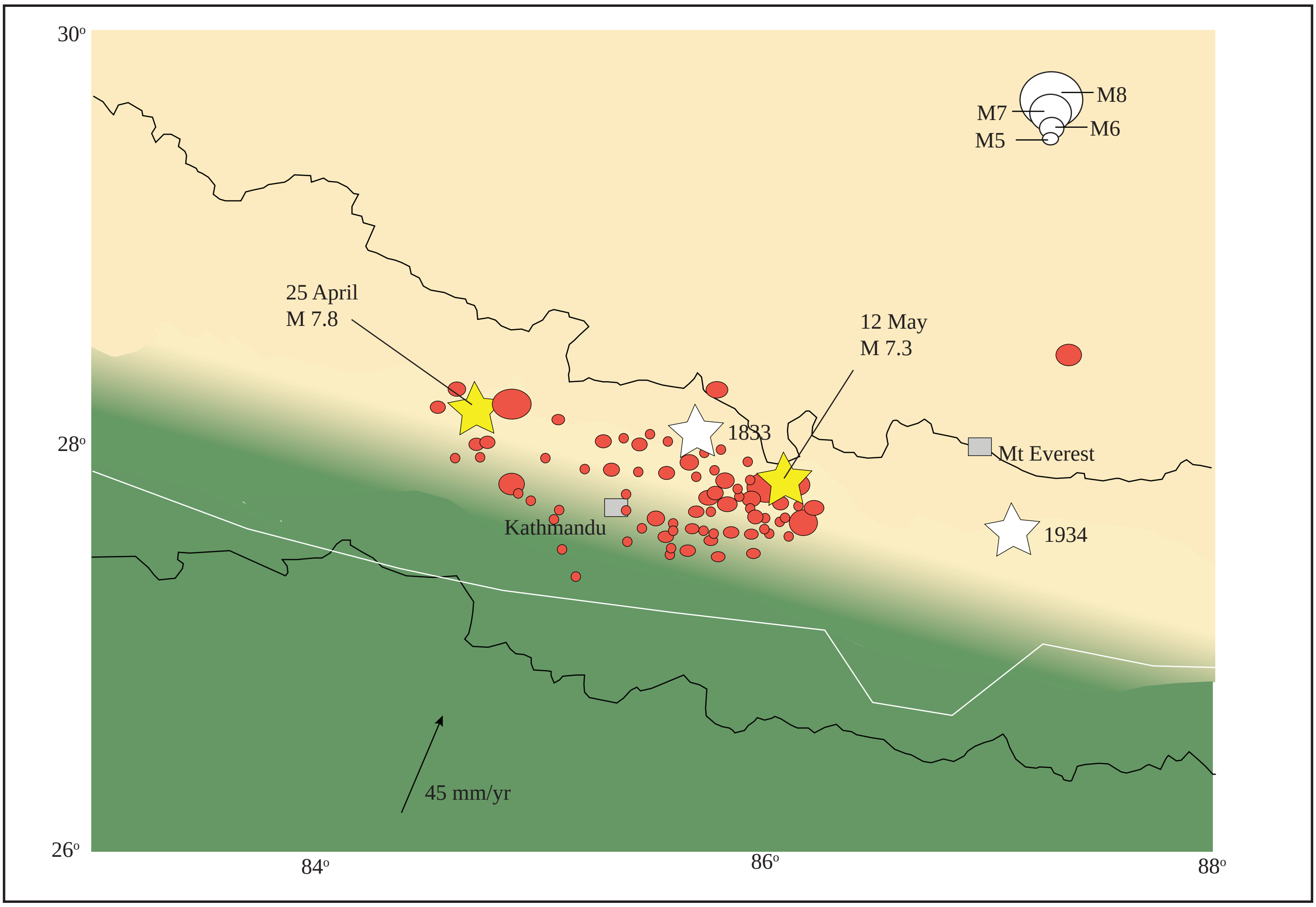
Nepal "Gorkha" earthquake, 25th April 2015

Nepal is the 11th most earthquake-prone country in the world. One measuring M7.8 on the Richter scale hit Nepal at midday on the 25th April 2015, causing thousands of deaths and widespread damage. It measured IX (violent) on the Mercalli scale; the impact made worse by underlying poverty. Geology, urbanisation and building quality are the three main risk factors in Nepal and there is need for good governance and disaster preparedness in this active seismic area. However, the earthquake was a little smaller and farther east than had been expected and is seen as a warning for future events.

Cause

The earthquake occurred at a depth of 15km due to subduction of the Indian plate beneath the overriding Eurasian plate. It happened approximately 80km northwest of Kathmandu, in the Gorkha district (Figure 1). Here the Indian plate moves northwards at an annual rate of 45mm, forming part of the Himalayan uplift. Much of the energy was transmitted 120km eastward towards Kathmandu, so the epicentre was at the western end of the affected region. GPS surveys show that the Kathmandu valley was raised 1m and that Kathmandu itself is now 80cm higher. Mount Everest sank 3cm and areas north of it have also lowered as the released strain allowed land to settle.

Figure 1. Location of earthquakes Source: USGS



There are two major fault systems in the Himalayas - the Main Boundary Thrust and the Main Central Thrust (Figure 2). The systems are 100-120km apart and run as a linear belt all along the Himalayas from Kashmir to Arunachal Pradesh. 90% of all Himalayan earthquakes occur between these two fault systems.

Figure 2. Major fault systems in Nepal

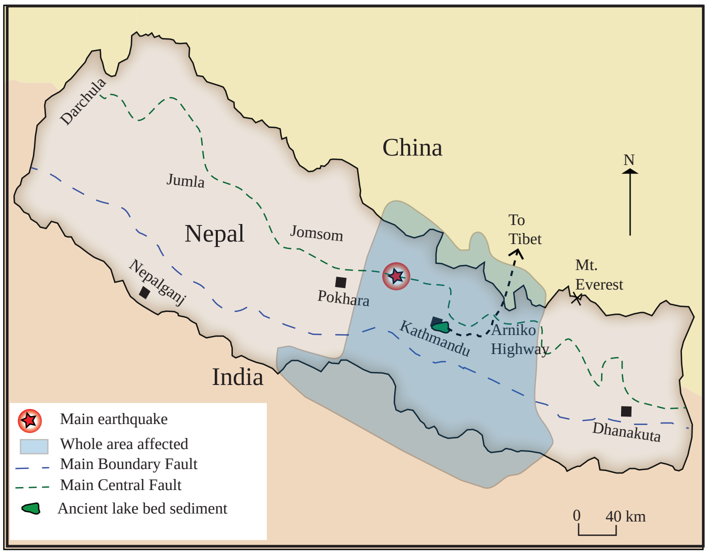


Figure 3. History of earthquakes in the region Source: www.geni.org

Year and place	Magnitude (M)	Deaths
1905 Kangra	8.0	19,000
1934 Nepal-Bihar	8.0	10,600
1988 Bihar	6.9	1,500
2005 Kashmir	7.6	86,000
2015 Gorkha	7.8	9,000

12th May 2015 aftershock

There were 300 aftershocks during the following 6 weeks, ranging from M4.0 – 6.7. However, a major aftershock of M7.3 occurred on 12th May 2015, on the eastern end of the same fault line as April’s earthquake, 80km ENE of Katmandu (Figure 2.). It had a similar focus of 15km. Generally, the magnitude of aftershocks decreases with time but despite this unexpected spike in intensity it has been classified as an aftershock, as intensity decay is not always linear. A further 200 people were killed and 2,500. It also severely disrupted the relief effort already underway.

Was it the Big One?

Scientists know that there is massive accumulated strain in the area and are expecting either a major earthquake, or a series of them, greater than M8.0. It is estimated that the Gorkha earthquake released only 4-5% of stored energy because the crust did not rupture, so pent-up energy still remains within the fault zone.

Secondary hazards

1. Landslides

In such mountainous terrain, landslides are significant secondary hazards and can be triggered by tremors or monsoon rains (June-August). A combination of rugged terrain, unstable soils and heavy rains meant that mountain villages in the Langtang region, west of Kathmandu, were buried under landslides. Langtang village itself experienced a pressure wave ahead of the breaking-off of part of a glacier. It blasted an avalanche 2-3km wide of snow, ice, rock and building materials over the village, killing 300 people. Another 250 people died under a mudslide and avalanche at Ghodatabela. Laprak, a village of 2000 people, was on a landslide that had periodically moved since 1999 and was completely destroyed. 25 vehicles on the Arniko Highway to Tibet were buried by landslides.

Continuing aftershocks increased the general instability of slopes and landslides were the main obstruction to rescue and relief operations, making many villages unreachable. They also affected the roads connecting Kathmandu to the outside world, preventing aid and daily supplies from coming into Nepal.

Despite the real risk, the landslide problem was not as severe as expected, possibly because:
- The earthquake occurred ahead of the monsoon rains, so the ground was dry and therefore more resistant to slippage.
- Shaking was less intense than expected for such a magnitude event.
- Rocks were stronger than expected.

2. Flooding

Flooding is a major secondary hazard. Landslides can block rivers creating floods upstream but when unstable debris collapses without warning, temporary lakes can drain suddenly. Even if there is no movement, moraines may be weakened by tremors. Thousands of people were evacuated due to the threat of flash floods. A lake was created on the Kali Gandaki river, and all homes 1km upstream of the debris dam were flooded.

Everest

The April earthquake moved Everest by 3cm and avalanches killed 22 climbers near base camp, the deadliest day ever on Everest. The most destructive avalanche began on Mount Kumori, a 7,000-metre-high mountain nearby, passing over the Khumbu Icefall and into base camp. Helicopters took the most badly injured to Pheriche, the nearest clinic, but this transport was hindered by bad weather and poor communications.

Impacts

The April earthquake, together with several strong aftershocks, killed nearly 9,000 people and injured over 23,000 in central-eastern Nepal. Given the magnitude of the earthquake, this was lower than expected, indicating less ground shaking or sturdier buildings than expected. If the earthquake had occurred on a Saturday at midday it would have lowered the death toll, as nearly 7,000 schools were flattened. Around half a million people were made homeless and whole villages were destroyed. The UN estimated that 8 million people, one third of the total population, were affected by the earthquake. Neighbouring countries were also affected, with 67 deaths and 300 injured in India and 4 deaths in Bangladesh. China suffered 18 deaths and 50 were injured.

90% of tourist bookings were cancelled in the immediate aftermath, as trekking routes and World Heritage sites in Kathmandu valley were damaged (Figure 4). Whilst this sector is expected to recover quickly if no more seismic activity occurs, $600million will be lost during 2015-2017.

Figure 4. Destruction of Changu Narayan Temple, oldest in Nepal, UNESCO World Heritage Site. Source: THT Online

Figure 5. Earthquake damage at Shree Birendra Secondary School, Nuwakot Source: Room to Read

Unequal impacts

- **Spatial** - poor quality housing in rural areas was more badly affected than in the cities and towns. Kathmandu valley used to have a huge lake that was infilled over time with 300m of clay. This area suffered intense liquefaction and weak buildings collapsed under ground shaking.
- **Income** - subsistence-based households in rural areas were badly affected because the paddy-planting season was about to start and stored grains were destroyed. The harvest of rice and maize had already been disappointing and the loss of family livestock – 17,000 cattle and 40,000 chickens - meant immediate hardship. The worst affected districts contained 30% of the national cottage industries. It is estimated that an extra 700,000 people will be pushed into poverty in 2015-16 and of these, 50-70% will be from already vulnerable communities in the mountainous regions.
- **Gender** - more females of all ages died due to being in their houses at the time of the earthquake. Women bore more impact because they have less assets, limited access to economic resources and fewer alternative livelihoods to aid recovery. Loss of livestock and small-scale informal enterprises impacted severely on women, and destruction of water and sanitation infrastructure required females to walk greater distances, with less time for other economic activities. The sudden drop into poverty and lack of opportunities increases the risk of child trafficking and abuse.

Figure 6. Proportional economic impact of earthquake

Sector	% economic cost of earthquake damage	
Housing	50	The total economic impact was 33% of national GDP in 2013-14
Tourism	11	
Environment	5	
Education	5	
Finance	5	
Agriculture	5	

Damage to transport and power exacerbated the impact. 14 HEP stations were damaged, causing 25% loss of electricity capacity and workers in the mountains were trapped by landslides on the roads. Major flash flooding was avoided but Nepal's only storage dam, the Kulekhani Reservoir dam, cracked and the lake lowered by 3m. Loss of power meant closure of the international airport, where tourists waited to leave.

A positive impact was the increased demand for labourers to demolish and clear debris and reconstruct buildings and infrastructure. Earnings for skilled and unskilled workers will increase due to more demand.

Immediate response

As in all disasters, the first response was by survivors who cleared rubble and hunted for food. 125,000 ex-servicemen from the Gorkha regiments of the Army were recalled for rescue operations, but were hampered by rain and tremors. The most urgent need was for transitional shelters for hundreds of thousands of people before the monsoon rains arrived in June. 16 open spaces around Kathmandu were used to construct tarpaulin shelters but the tremors made people fearful and many lived in the open where they received medical treatment or shared three to a bed in surviving hospitals.

The Nepalese government made an international appeal within hours and released 500 million Nepal rupees for relief. The International Federation of Red Cross and Red Crescent Societies (IFRC also launched their own appeal to supply shelter, relocate displaced people with their families and provide safe burials.

Nepal's National Disaster Response Framework (NDRF) instantly activated pre-existing cluster mechanisms, representing 11 sectors. The Food Security Cluster estimated that 1.4 million people required food assistance, with nearly half of these in rural areas near the epicentre. A Health Emergency Operations Centre, working with the World Health Organisation, deployed specialist teams and health kits.

However, organised relief was difficult, especially to areas outside Kathmandu, due to landslides and bad weather, so accessible villages received duplicated resources. Satellite imagery is increasingly used in disaster aftermaths but due to cloud and rain, this technological response was not possible. Also, government buildings and personnel were lost in the earthquake so preparedness was undermined. However, only a month earlier, a new humanitarian aid hub, funded by the World Food Programme, had been opened at the Tribhuvan International Airport for the anticipated receipt and distribution of resources after a disaster, so this was put to good use.

Figure 7. International response to Nepal's earthquake

Country	Response
India	Telecom companies offered free calls for rescue and relief work. Operation Maitri deployed 10 teams (450 people in total) to assist in relief. Medical and engineering teams also sent emergency supplies of blankets, medicines and drinking water.
China	62 people for search and rescue. $4million for response effort.
USA	Disaster Assistance Response Team (DART) of 128 people sent. USAID gave $10million for immediate help and later recovery.
Pakistan	Sent search and medical teams. Supplied a 30-bed field hospital, tents and emergency supplies.
UK	8-person response team. $7.6million for response.
Australia	$4million for humanitarian response supported by Australian Red Cross and NGOs.
Total of 60 countries	134 search & rescue teams, 4,240 helicopter flights, 7,500 people rescued by air, 4,700 by land, donation of emergency supplies.

References

Overview of earthquake: en.wikipedia.org/wiki/April_2015_Nepal_earthquake
Sendai Framework 2015-2030: www.unisdr.org/we/coordinate/sendai-framework
Kathmandu Living Labs: www.kathmandulivinglabs.org

Disaster risk reduction (DRR)

There are three main risks that need to be embedded in Nepal's future preparedness plans:

- Geology – Nepal needs to develop further its seismic network and mapping of landslide risk.
- Architecture – older buildings with unreinforced masonry cannot withstand ground shaking. Even new buildings did not have structural reinforcements such as steel rebar, highlighting the issue of resource availability rather than lack of education. Building codes need to be enforced.
- Urbanisation - greater and more dense urbanisation, especially rapidly expanding informal settlements, exceeds the government's ability to enforce building regulations. As a result of this there are inappropriate ad-hoc multi-storey buildings, over-reliance on concrete and loss of indigenous knowledge. This locks the poorest in a cycle of vulnerability and repeated loss. This is a poverty crisis rather than a natural disaster.

The main aim for Nepal is to build resilience in its economy, social cohesion and governance, so that the cycle of vulnerability is broken, and future impacts are mitigated. The principle of "build back better" (BBB) must be applied. Whilst planning is essential, the very nature of recovery is very dynamic and multi-faceted, so experienced people with authority to make decisions is crucial. Schools are a priority because if these are built well they can continue to educate and develop young people as social capital for the future and act as a community resource in any future disaster. In this disaster, one million students were learning in tents three months after the earthquake.

Post-disaster needs assessment (PDNA is essential to inform future risk reduction. Instruments monitoring seismicity, climate, glaciers, hydrology and ecosystems were badly damaged and will need repair, so disrupting long term monitoring programmes. The combination of satellite imagery and field data is essential for risk monitoring and early warning systems. Susceptibility maps were produced, using criteria of shaking intensity, slope angle, altitude and aspect. A feature of recent disasters is the use of social media to provide instant data of impact, essential in the distribution of aid and improving resilience. In Nepal, Kathmandu Living Labs (KLL) is using open source software (OpenStreetMap for humanitarian mapping. Satellite imagery had limited use due to thick cloud and heavy rain.

Prerequisites for swift recovery and enhanced resilience

- Strong political will
- Sustained resource distribution
- Continuous dialogue with affected people
- Income-generating activities
- Skills development
- Community involvement

Whilst knowledge transfer of recovery programmes in other countries is important, the plan must be uniquely Nepali. As Nepal's heritage is so central to tourism, the recovery is focusing on damaged or destroyed historic buildings, using cultural specialists to help communities revitalize their traditions. Equally, as one of the most mountainous regions on earth, distinct isolated villages need to focus on social capital and local governance. In particular, women's influence in the informal economy will be a critical part in reconstruction, especially as male out-migration leaves women to shoulder responsibility. With appropriate support, gender inequalities will decline, economic growth and social inclusion will increase, creating greater resilience. Figure 8 outlines the Government's 5-year recovery and resilience plan.

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Figure 8. Future disaster risk reduction strategies

Short-term (1 year) priorities	Medium to long term priorities (2-5 years)
Reconstruction of damaged Disaster Risk Reduction (DRR) assets and improvements using the Build Back Better (BBB) principle.	Improve legal and institutional arrangements.
Improve preparedness, response, relief and logistics systems.	Improve regulation enforcement in housing, private and public infrastructure, social sectors (health and education). Retrofit schools and hospitals.
Strengthen information and communication capacities for relief, response and recovery.	Improve integration of climate change adaptation and DRR.
Enhance multi-hazard risk monitoring, vulnerability assessment at community level, risk information dissemination and awareness.	Develop a seismic policy and promote seismological research. Target DRR of secondary hazards.

Reasons for concern for the future

Whilst the theory and knowledge of disaster response is well established, there are several reasons why "building back better" and enhanced resilience might be problematic to achieve in Nepal.

- **Physical factors**
  Following the earthquake, slopes are very vulnerable to landslides due to tremors and saturation from snowmelt and monsoon rains. Continued construction of hydropower projects such as the 6000 MW Pancheshwar Dam on the Mahakali river on the Nepalese-Indian border involve deforestation, silting of riverbeds, blasting and tunnelling, leading to slope failure. Climate change will result in more intense rainfall and greater snowmelt, increasing flood risk.
- **Social factors**
  Concern to provide shelters before the monsoon rains may lead to shoddy construction and there are insufficient building materials for improved resilient buildings. A deeply rooted caste system means the Dalits (lowest caste) are at risk of not receiving appropriate aid. Nepal was in the process of re-writing its constitution and minority groups' rights are currently not protected.
- **Economic factors**
  Rebuild costs are estimated at $10billion but only 50% of the initial appeal has been funded. Disaster funding is reactionary, not all appeal money materialises and most is given to short term humanitarian responses. Funding and political will wanes with time. Nepal is one of the poorest countries in the world, with a HDI of 145 out of 187. It has existing international debts of $3.8billion and creditors have not yet agreed on a debt-relief settlement. In 2014, Nepal repaid debts of $217million, money which might have been better spent on resilience.

In March 2015, following the Hyogo Framework 2005-15, which was devised after the Boxing Day tsunami in 2004, the Sendai Framework 2015-30 was adopted as the guiding policy for disaster reduction and "building back better". Immediate and short-term response is well-practiced but it is the longer term persistence of rebuilding that often stalls. Nepal is the first country to test the international community's voluntary commitment to the agreed principles.