Government of Nepal

DEPARTMENT OF URBAN DEVELOPMENT & BUILDING CONSTRUCTION

&

NEPAL ENGINEERS' ASSOCIATION

Training on

POST DAMAGE ASSESSMENT, REPAIR & ASSESSMENT OF MASONRY AND REINFORCED CONCRETE STRUCTURES

GORKHA EARTHQUAKE: A Brief Compilation of Interesting Data

26-28 May, 2015

Engineer Bhawan, Pulchowk, Lalitpur

Technical Support

IOE/ NSET/ CORD

Supporting Institutions

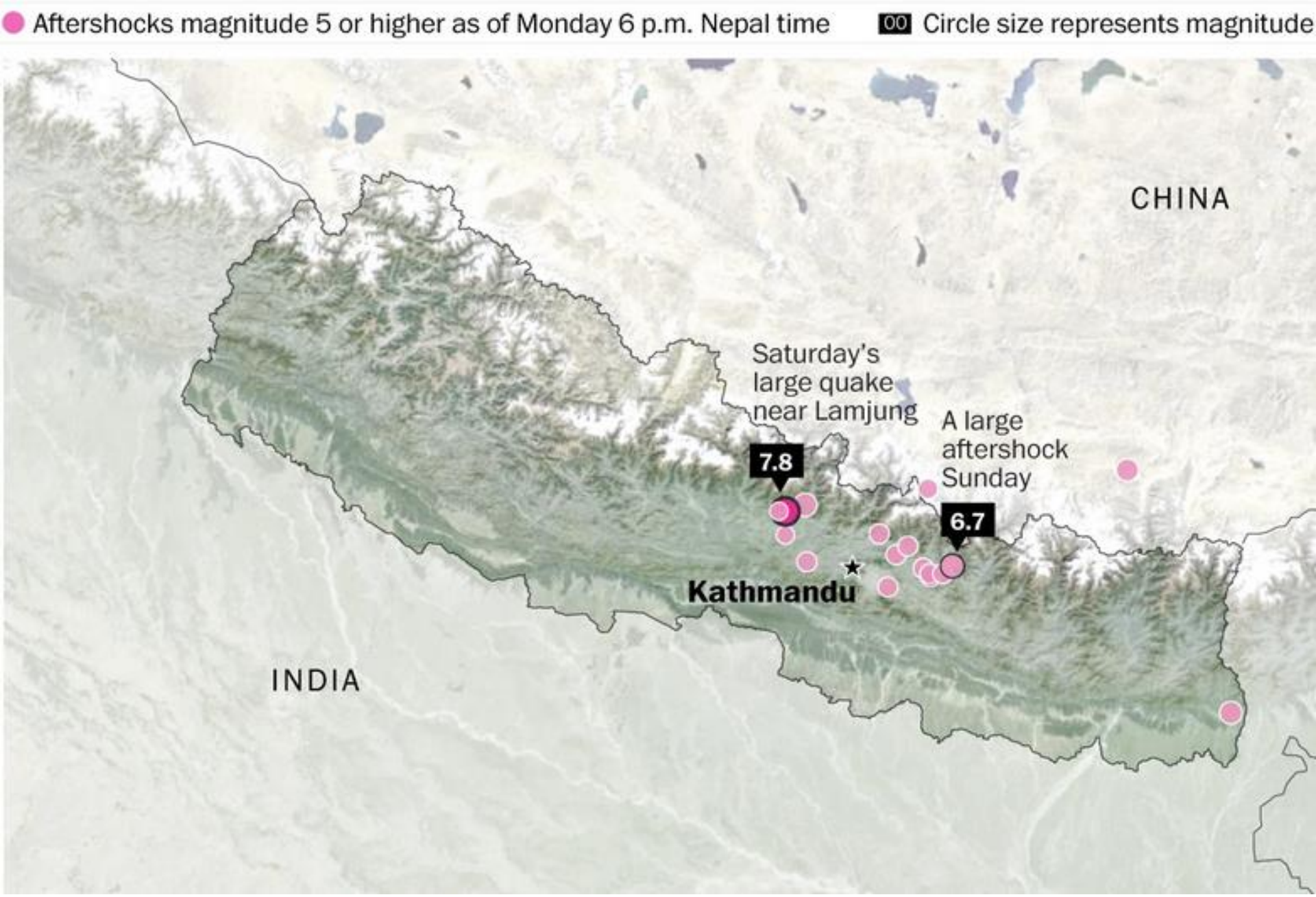
SCAEF, SONA, RUPSON, SEANep, SERDEN, NGS, ngs, NLSS, NSC & AITAAN

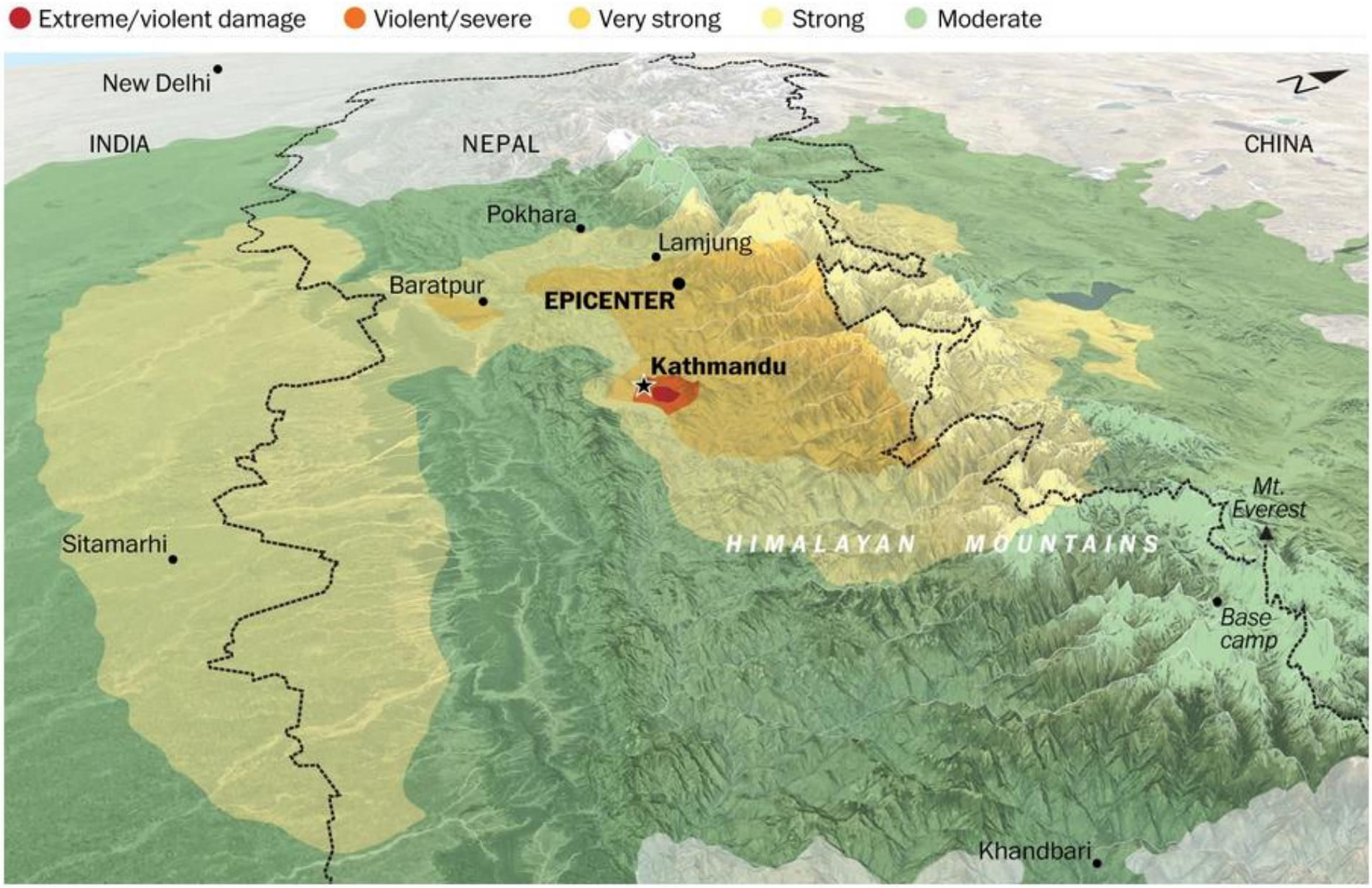
Gorkha Earthquake

- Date & Time of Occurrence: 25th April, 2015, at 11:56 local time
- Magnitude: 7.6 magnitude (M_L)
- Epicenter: Barpak, Gorkha District (north-west) of Kathmandu and south of the China border. Epicenter of main shock is approximately 34 km (21 mi) east-southeast of Lamjung, Nepal
- Hypocenter: at the depth of approximately 15 km (9.3 mi).
- Aftershocks: Dozens of aftershocks followed, including a 6.9 magnitude(M_L) earthquake on 26th April 2015 at 12:54 local time with epicenter at Dolakha/Sindhupalchowk. Aftershocks 6.8 M_L on 12 May at 12:51 with epicenter at Dolakha/Sindhupalchowk.
- No. of aftershocks: 265 (As of 25 May 2015)
- Intensity Generated: The earthquake has been found with a maximum Mercalli Intensity of IX (Violent).
- Casualties: 8,659 dead (official data as of 2072-02-11 9:00 pm)

  21,952 injured (official data as of 2072-02-11 9:00 pm)

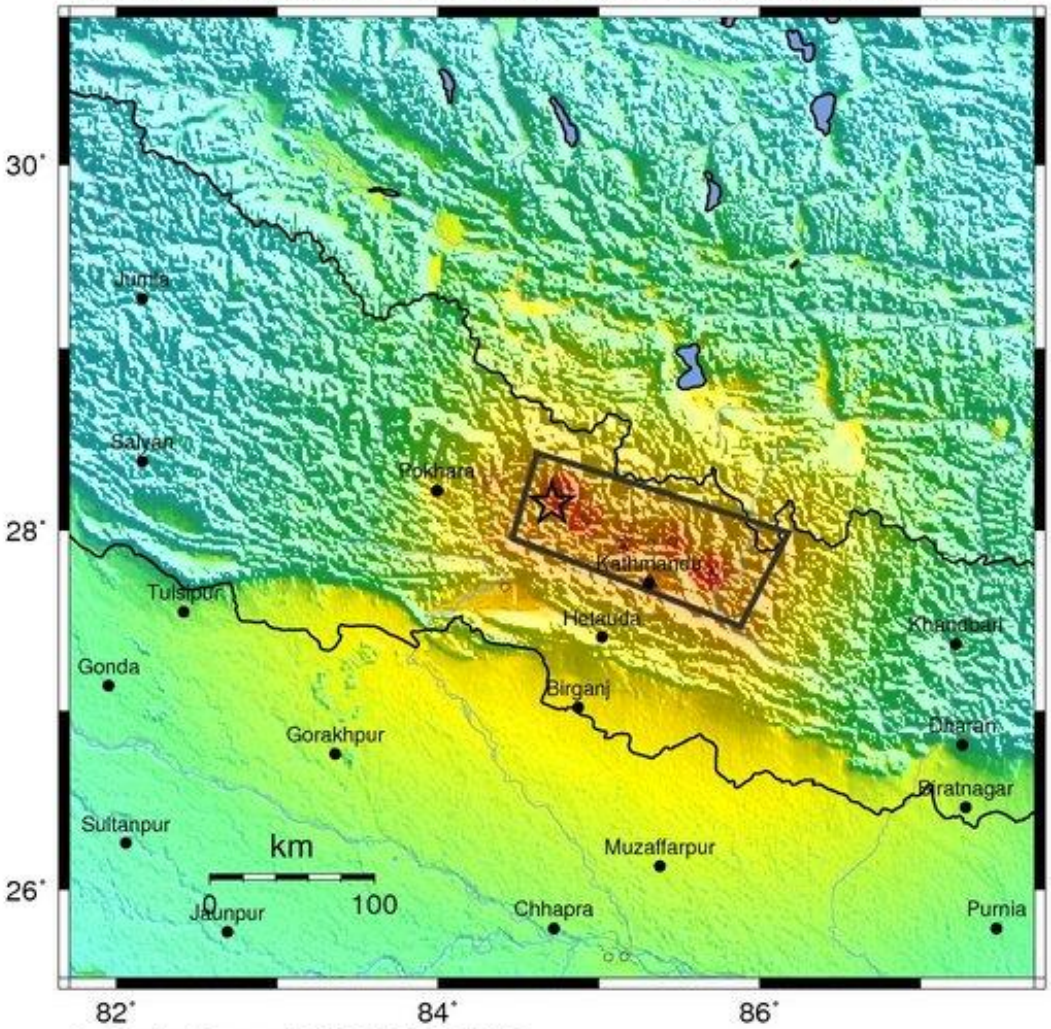

Map | Satellite
Nepal
Manaslu Conservation Area
Annapurna Conservation Area
Shey Phoksundo National Park
Langtang National Park
Sagarmatha National Park
Mount Everest
Makalu Barun National Park
Kanchenjunga Conservation Area
Valmiki Wildlife Sanctuary
Kathmandu
Bharatpur
Bhaktapur
Pokhara
Butwal
Tansen
Byas
Siddharthanagar
Rudrapur
Gonda
Balrampur
Shravasti
Itwa
Bahraich
Faizabad
Basti
Sant Kabir Nagar
Bagaha
Birgunj
Bettiah
Janakpur
Kamalamai
Bhojpur
Dharan
Triyuga
Darjeeling
Pankhaba
Jiri
Khumjung
Lahai
Daha
Narayan Municipality
Manma
Pina
Rowa
Chhusang
Jomsom
Manaslu
Ghandruk
Reni
Kankri
Rakam
Wot
Tulsinur
Ghorahi
Nepalgunj
Sanraha
Campirganj
Sanehi Ghat
G219
G318


Aftershocks magnitude 5 or higher as of Monday 6 p.m. Nepal time
00 Circle size represents magnitude
CHINA
Saturday's large quake near Lamjung
7.8
A large aftershock Sunday
6.7
Kathmandu
INDIA


Extreme/violent damage
Violent/severe
Very strong
Strong
Moderate
New Delhi
INDIA
NEPAL
CHINA
Pokhara
Lamjung
Baratpur
EPICENTER
Kathmandu
Sitamarhi
HIMALAYAN MOUNTAINS
Mt. Everest
Base camp
Khandbari

USGS ShakeMap : NEPAL

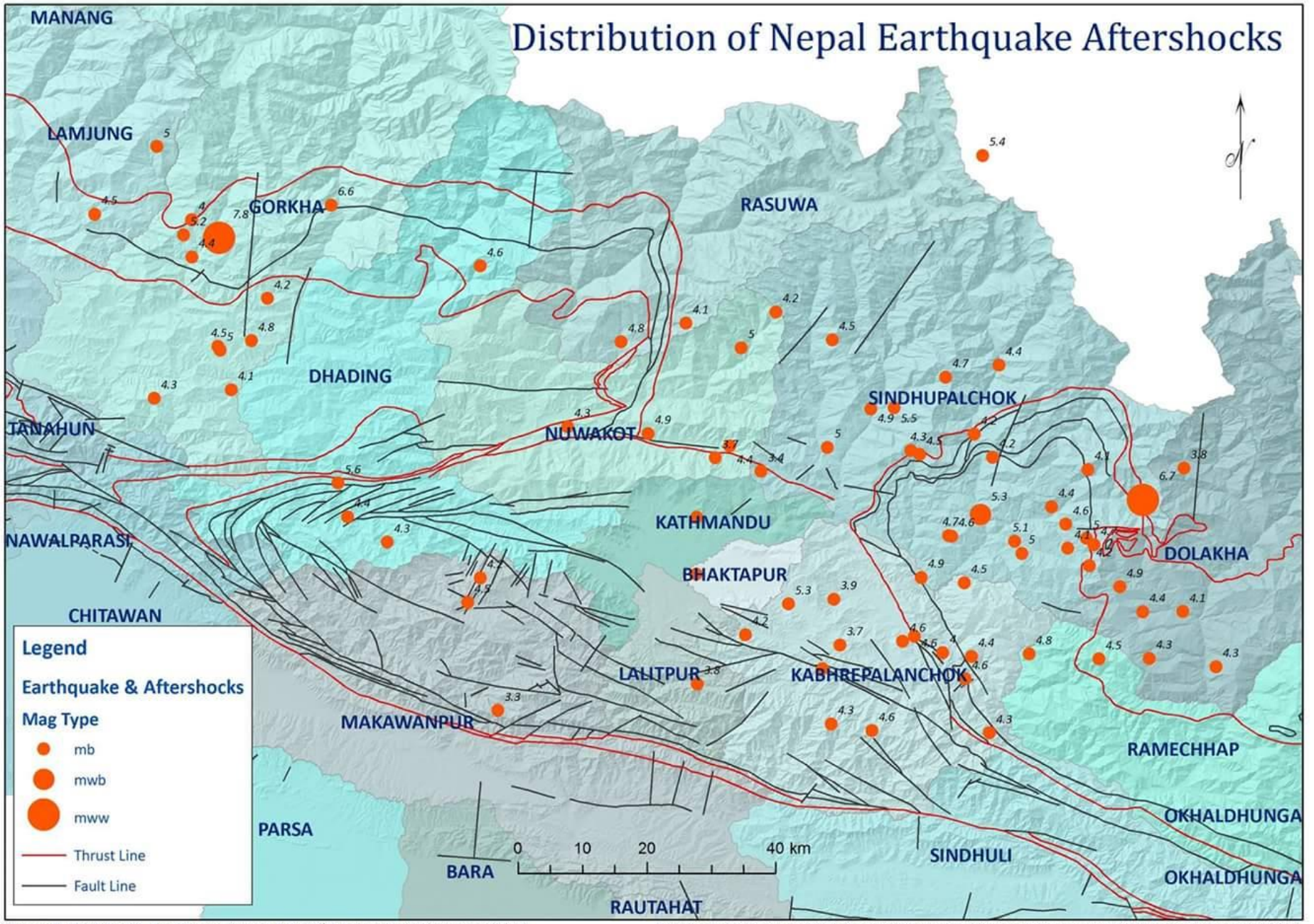
Apr 25, 2015 06:11:26 UTC M 7.8 N28.15 E84.71 Depth: 15.0km ID:us20002926



Map Version 7 Processed 2015-05-04 17:12:37 UTC

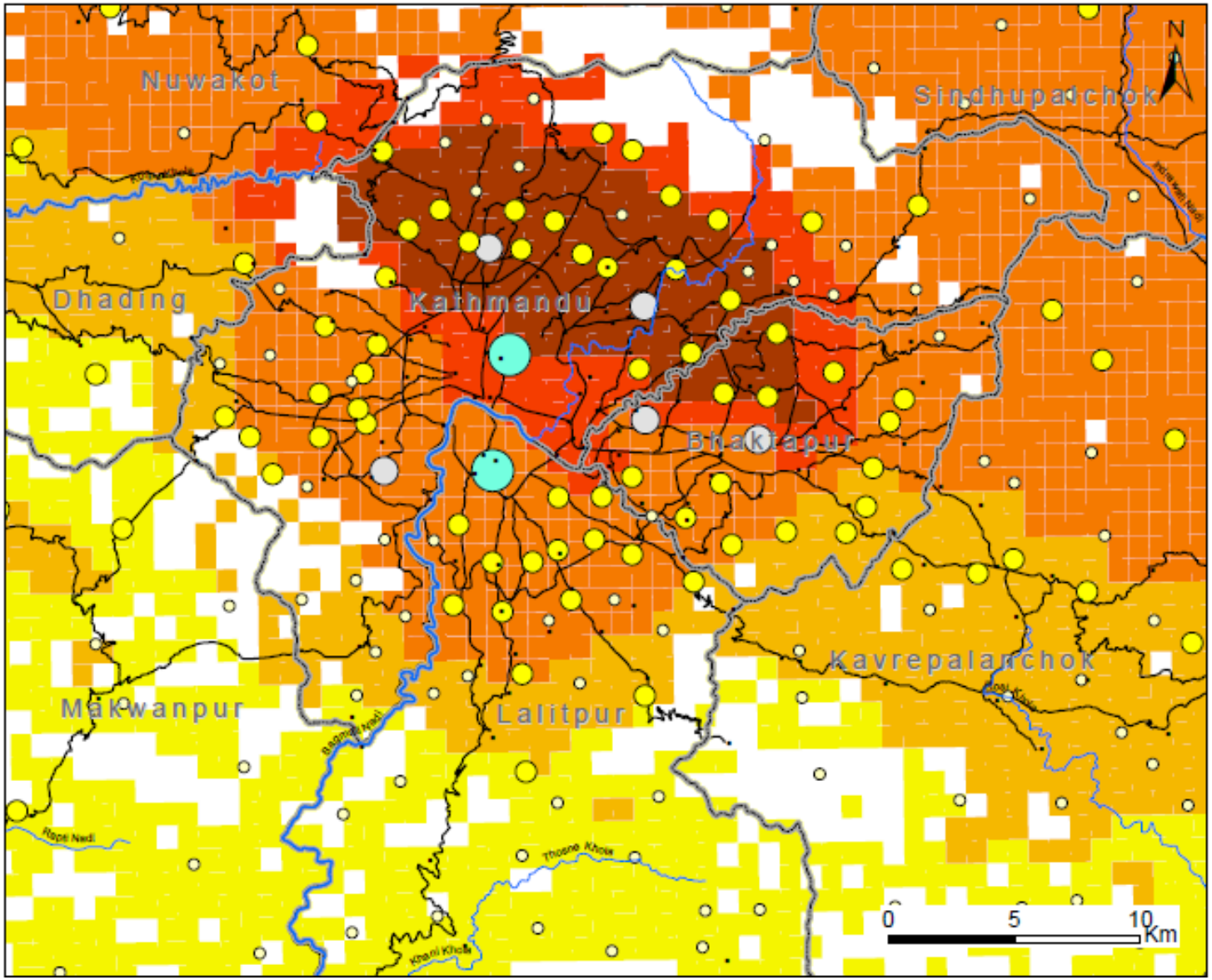
PERCEIVED SHAKING	Not felt	Weak	Light	Moderate	Strong	Very strong	Severe	Violent	Extreme
POTENTIAL DAMAGE	none	none	none	Very light	Light	Moderate	Mod./Heavy	Heavy	Very Heavy
PEAK ACC.(%g)	<0.05	0.3	2.8	6.2	12	22	40	75	>139
PEAK VEL.(cm/s)	*<0.02*	*0.1*	*1.4*	*4.7*	*9.6*	*20*	*41*	*86*	*>178*
INSTRUMENTAL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

Scale based upon Worden et al. (2012)



Prepared By: Biplob Rakhal, Fluvio Geomorphologist & Sr. GIS/ RS Analyst, Genesis Consultancy (P) Ltd.

Data Source: Earthquake location is downloaded from USGS, Other Spatial layers are retrive from Genesis Consultancy (P) Ltd.



GORKHA EARTHQUAKE 2015

GLIDE NUMBER EQ-2015-000048-NPL

Intensity Map

Modified Mercalli Intensity (MMI)

Legend

- Epicenter
- Settlements
- Major_River
- Major Roads

Population Size

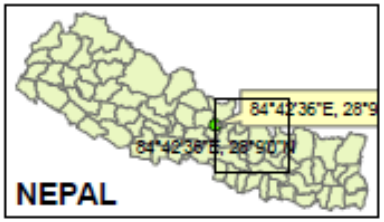
VDC/Municipality

- 0 - 5000
- 5001 - 50000
- 50001 - 100000
- 100001 - 975453

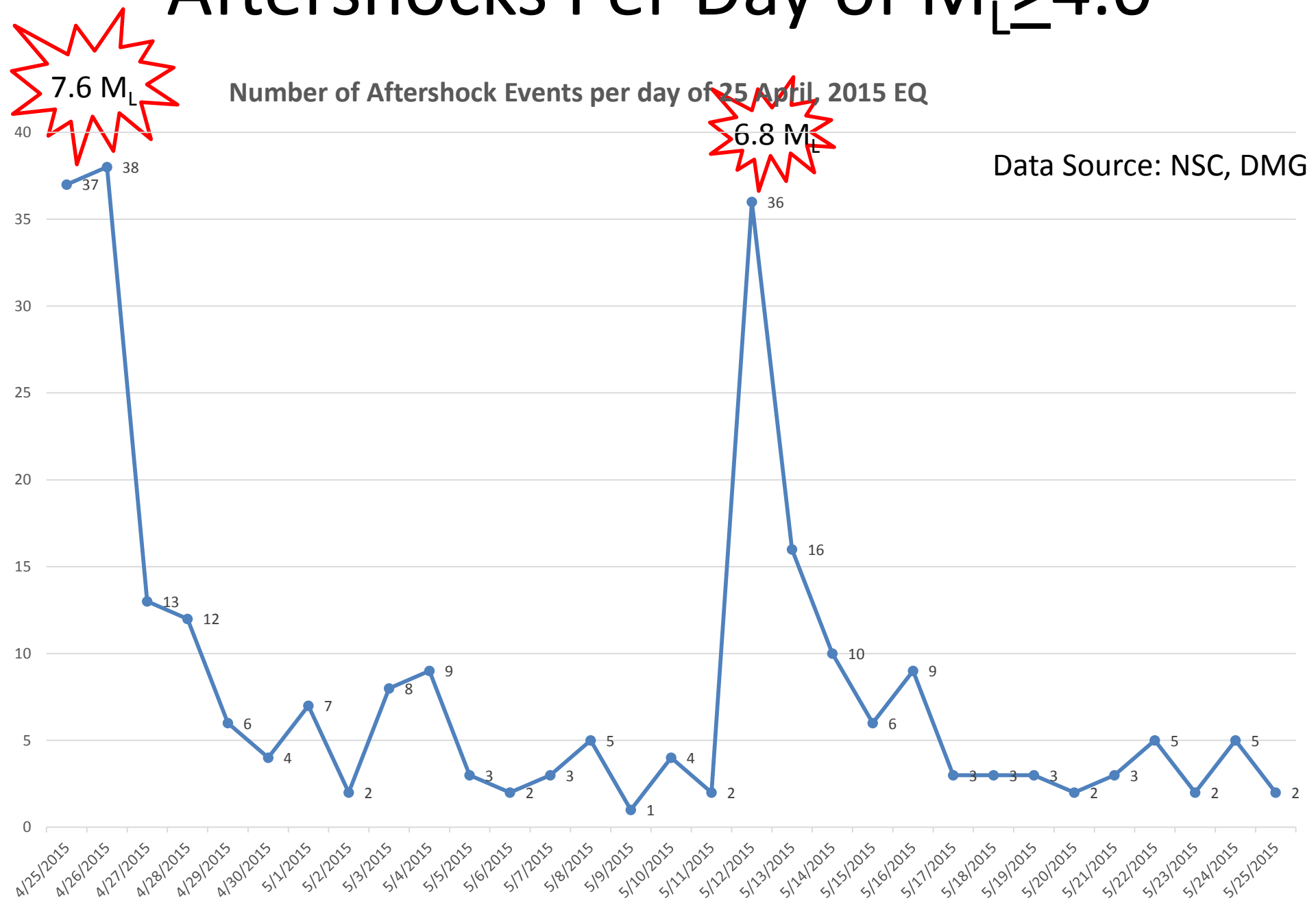
Intensity

MMI Scale

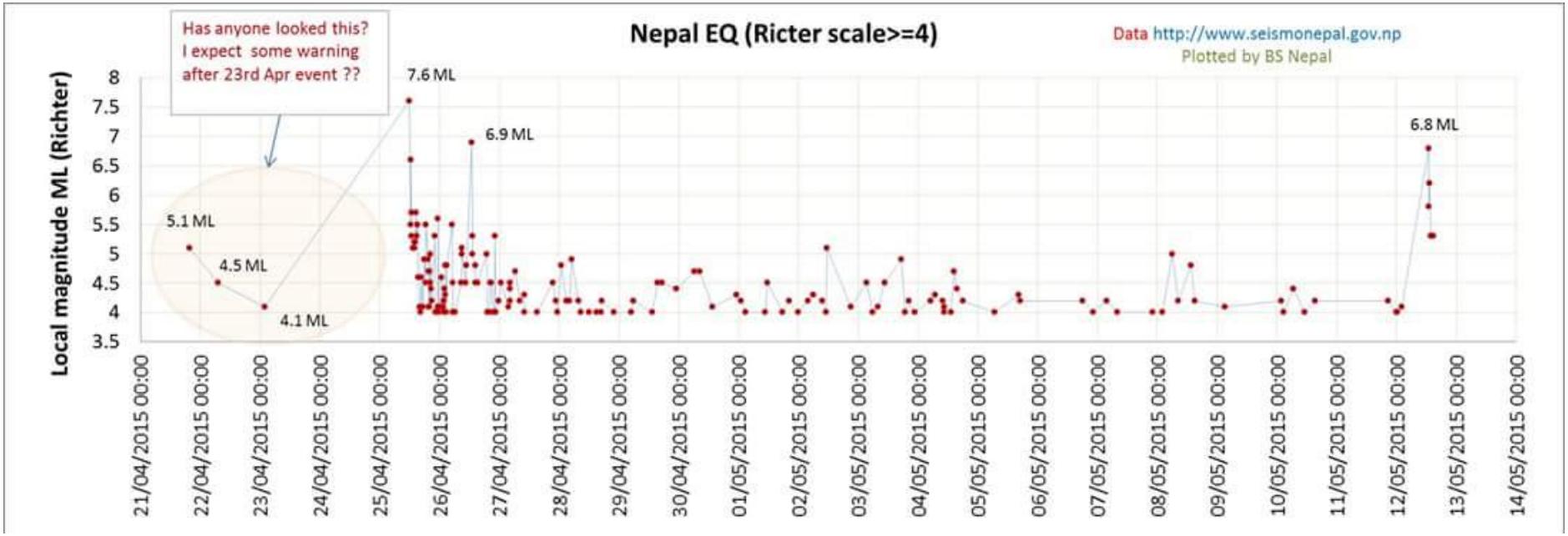
- Intensity V
- Intensity VI
- Intensity VII
- Intensity VIII
- Intensity IX



Aftershocks Per Day of $M_L \geq 4.0$



Aftershocks of $M_L \geq 4.0$



Nepal: 2015 Earthquakes

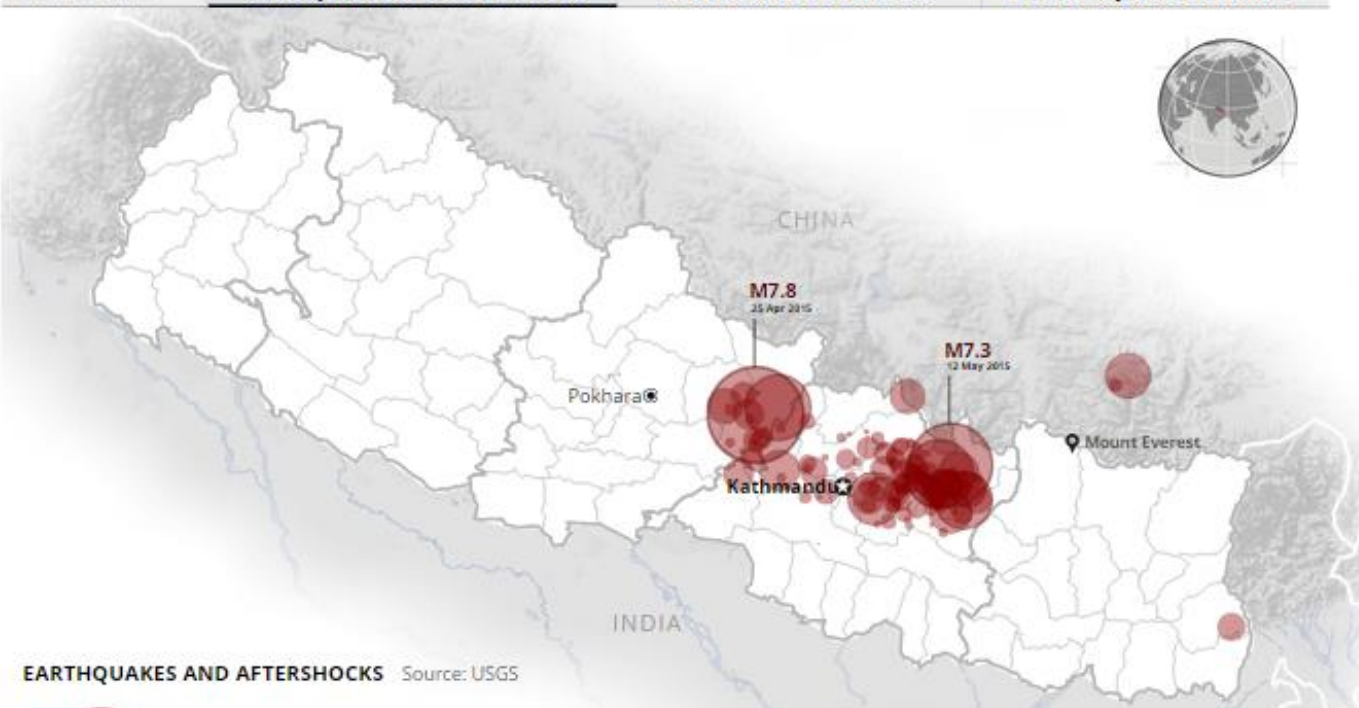
Nepal experienced two major earthquakes on April 25 and May 12, 2015 at magnitudes of 7.8 and 7.3 respectively.

Number of people killed
As of 22 May 2015
8,633

Number of people injured
Source: UNRCO/Gov. of Nepal
17,838

SHARE

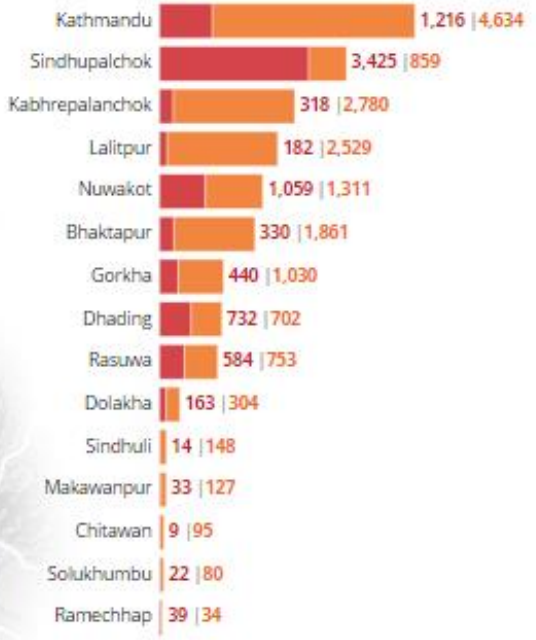
INTERACTIVE MAP | **EARTHQUAKES AND AFTERSHOCKS** | **PEOPLE KILLED BY DISTRICT** | **PEOPLE INJURED BY DISTRICT**



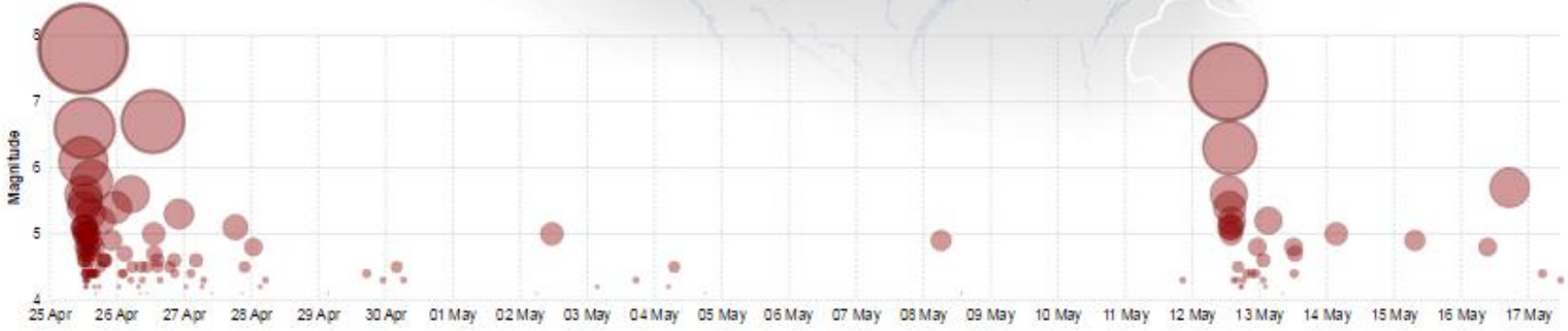
PEOPLE KILLED AND INJURED BY DISTRICT

Number of people killed | Number of people injured

limited to the top 15 districts

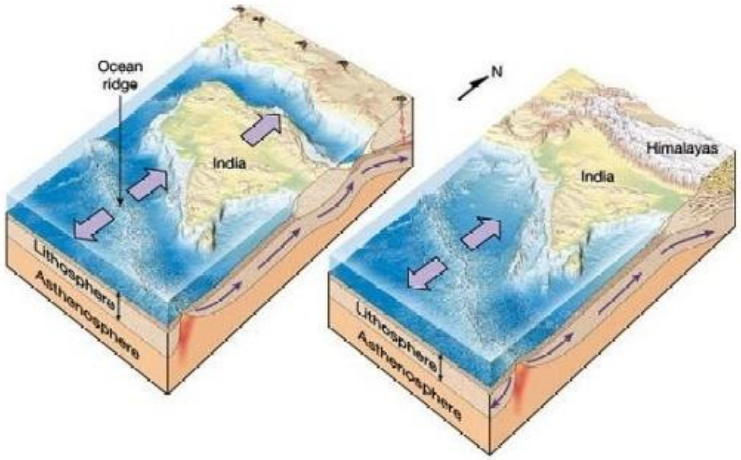


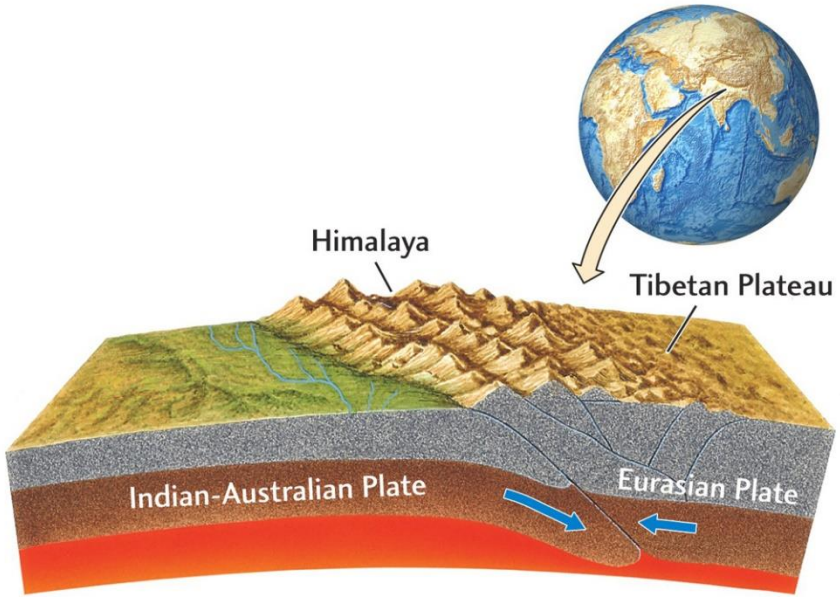
EARTHQUAKES AND AFTERSHOCKS Source: USGS



Sources: OCHA, UNOAC, UNRCO (Nepal), Government of Nepal, Mapbox

Cause of the Earthquake





- The temblor was caused by a sudden thrust, or release of built-up stress, along the major fault line where the Indian Plate, carrying India, is slowly diving underneath the Eurasian Plate, carrying much of Europe and Asia.
- Kathmandu, situated on a block of crust approximately 120 km (74 miles) wide and 60 km (37 miles) long, reportedly shifted 3 m (10 ft) to the south in just 30 seconds.

- The convergence rate between the plates in central Nepal is about 45 mm (1.8 in) per year. The location, magnitude, and focal mechanism of the earthquake suggest that it was caused by a slip along the Main Frontal Thrust.
- The earthquake's effects were amplified in Kathmandu as it sits on the Kathmandu Basin, which contains up to 600 m (2,000 ft) of sedimentary rocks, representing the infilling of a lake

Effect of the Earthquake in the Vicinity

- According to "Did You Feel It?" (DYFI?) responses on the USGS website, the intensity in Kathmandu was VIII (*Severe*).
- Tremors were felt in the neighboring Indian states of Bihar, Uttar Pradesh, Assam, West Bengal, Sikkim, Uttarakhand, Odisha, Andhra Pradesh,Gujrat, in the Indian capital region around New Delhi[and as far south as Karnataka.
- Many buildings were brought down in Bihar. Minor cracks in the walls of houses were reported in Odisha. Minor quakes were registered as far as Kochi in the southern state of Kerala. The intensity in Patna was V (*Moderate*).
- The intensity was IV (*Light*) in Dhaka, Bangladesh.
- The earthquake was also experienced across southwestern China, ranging from the Tibet Autonomous Region to Chengdu, which is 1,900 km (1,200 mi) away from the epicenter.
- Tremors were felt in Pakistan and Bhutan.

Casualties

1. Nepal

- The earthquake killed more than 8000 in Nepal and injured more than twice as many. The rural death toll may have been lower than it would have been as the villagers were outdoors, working when the quake hit. As of 15 May, 6,271 people, including 1,700 from the 12 May aftershock, were still receiving treatment for their injuries.
- *The Himalayan Times* reported that as many as 20,000 foreign nationals may have been visiting Nepal at the time of the earthquake, although reports of foreign deaths were relatively low. Hundreds of people are still considered missing and more than 450,000 are displaced.

2.India:

- A total of 78 deaths were reported in India - 58 in Bihar, 16 in Uttar Pradesh, 3 in West Bengal and 1 in Rajasthan.

3.China:

- 25 dead and 4 missing, all from Tibet.

4. Bangladesh:

- 4 dead.

Data Source: wikipedia

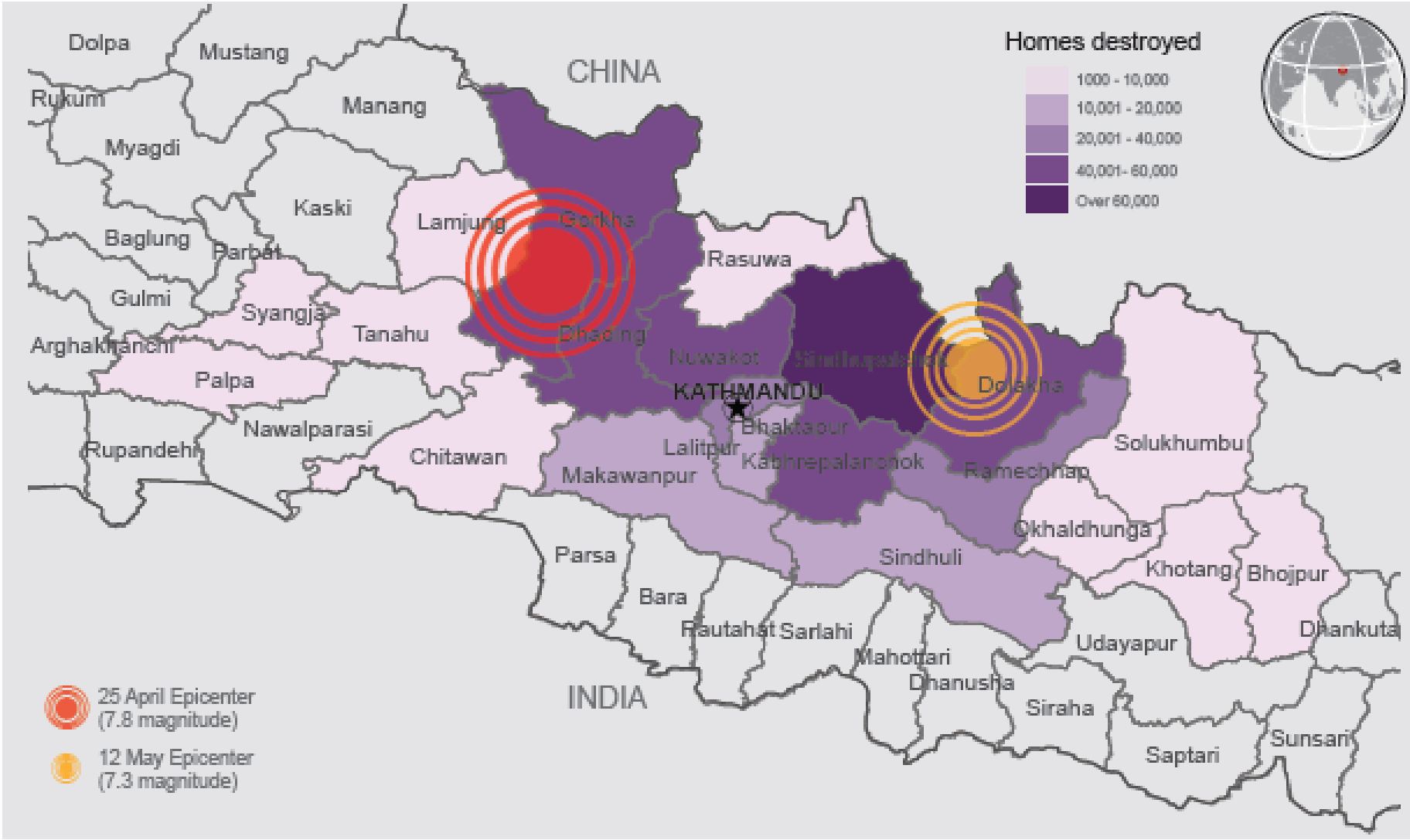
Emergency Declaration

- At 14.00 pm on 25 April, 2015 , CNDRC meeting headed by Rt'Hon Acting PM and Home Minister took place which recommend declaring of emergency and request the international support.
- Government of Nepal, cabinet declared emergency area at 16.00 hrs local time to 14 highly affected districts and appealed to International Communities for assistance. Cabinet also declared the Custom exemption to relief goods and visa fee exemption to the SAR Team members and humanitarian actors, for custom exemption, the UN model agreement has taken as a base.

Affected Districts

- The government has designated 14 most affected districts, namely Gorkha, Kavrepalanchok, Dhading, Nuwakot, Rasuwa, Sindupalchok, Dolakha, Ramechhap, Okhaldunga, Makwanpur, Sindhuli, Kathmandu, Bhaktapur and Lalitpur.
- On 10 May, an additional nine affected districts were added by the government; Tanahu, Kaski, Nawalparasi, Chitwan, Syangja, Parsa, Lamjung, Palpa and Parbat.

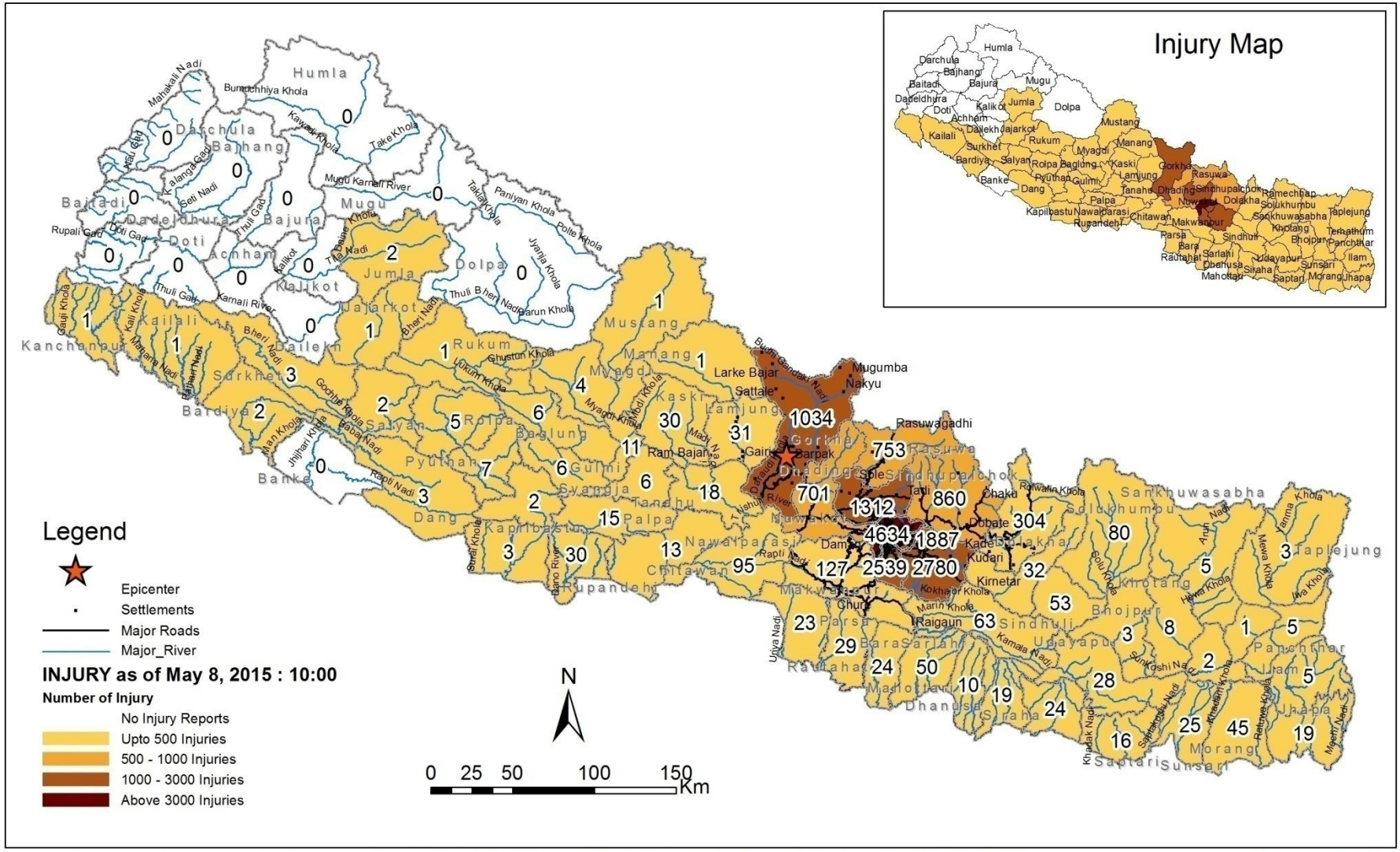
Affected Districts



GORKHA EARTHQUAKE 2015
GLIDE NUMBER EQ-2015-000048-NPL

Number of Injuries in Affected Districts

SITUATION MAP as of May 8, 2015, 10:00 AM
Data Source: National Emergency Operation Center, Ministry of Home Affairs



Desclaimer: This product is based on data gathered till the time and source mentioned herein and subject to change as per time and data.

Prepared by: National Society for Earthquake Technology - Nepal (NSET), with the support from: USAID/OFDA,
Data Source: USGS-PAGER, NSET, KVDA, CBS, DoS/GoN, NEOCenter, Ministry of Home Affairs

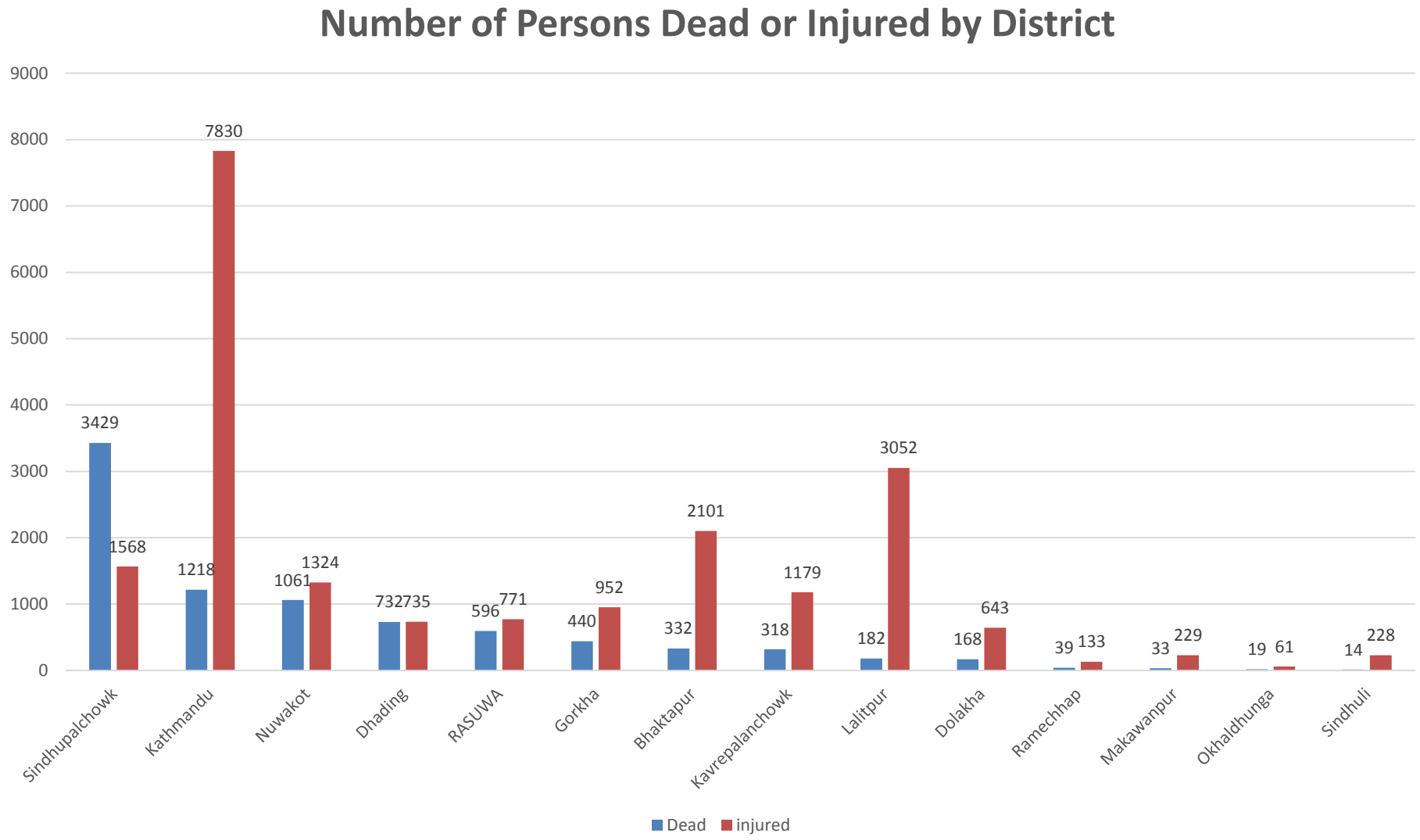
USAID FROM THE AMERICAN PEOPLE

Affected and not-affected districts

- Districts not affected:
    1. Mugu
    2. Humla
    3. Accham
    4. Bajhang
    5. Dailekh
    6. Baitadi
- Districts affected: other 69 districts

Data as of 19 May, 2015 Data Source: MoHA

Human Casualty due to EQ



Data as of 25 May, 2015 from MoHA

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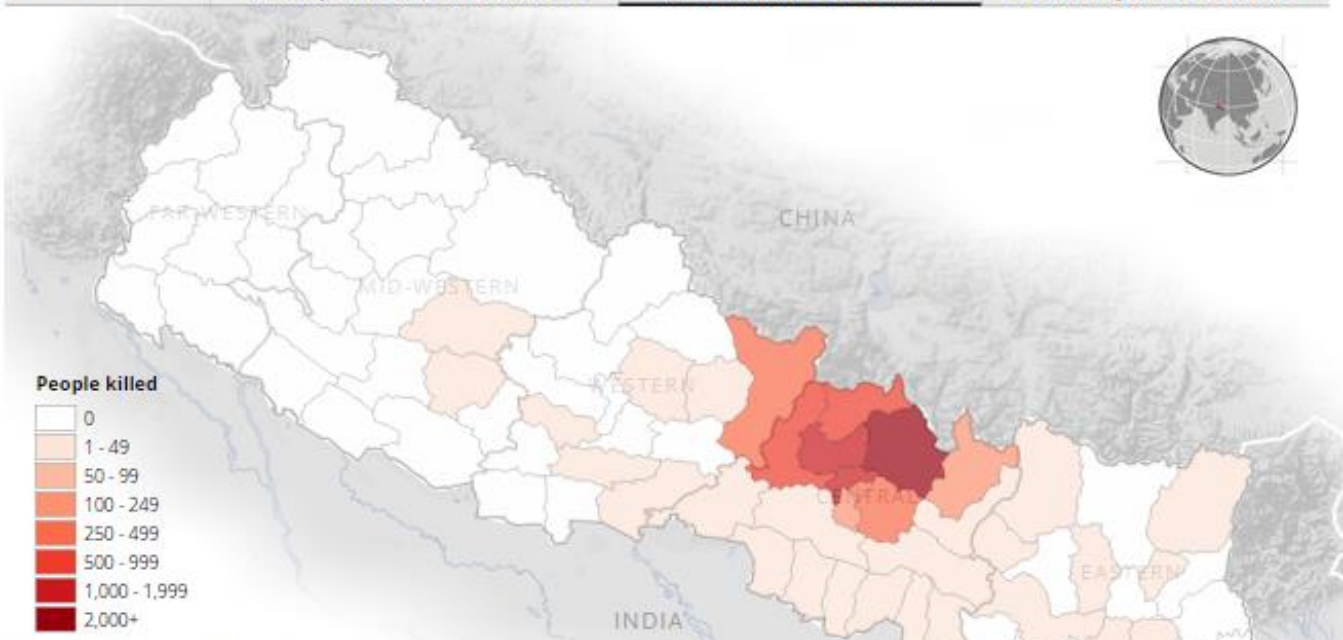

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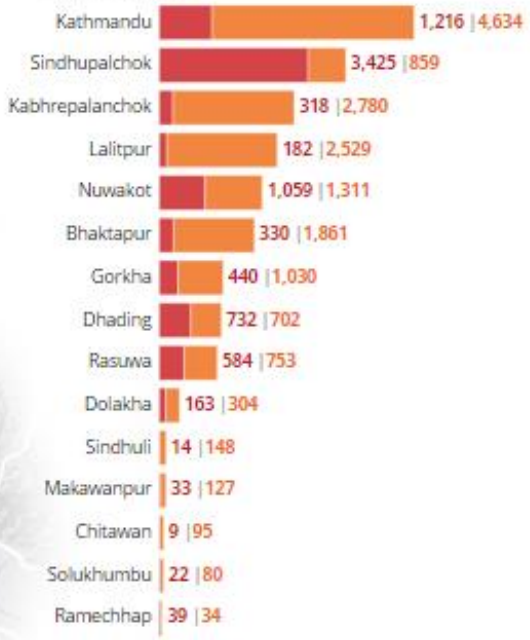
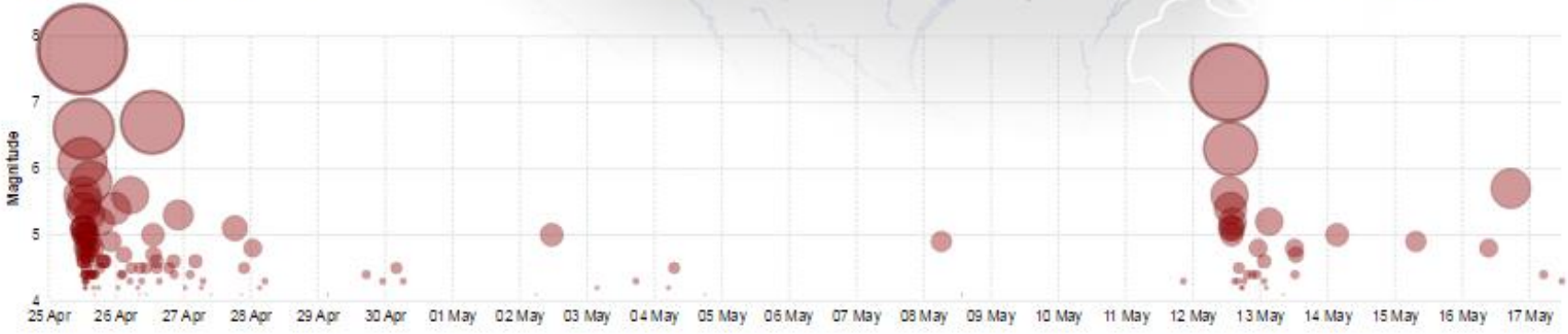
Number of people killed | Number of people injured

limited to the top 15 districts



EARTHQUAKES AND AFTERSHOCKS

Source: USGS



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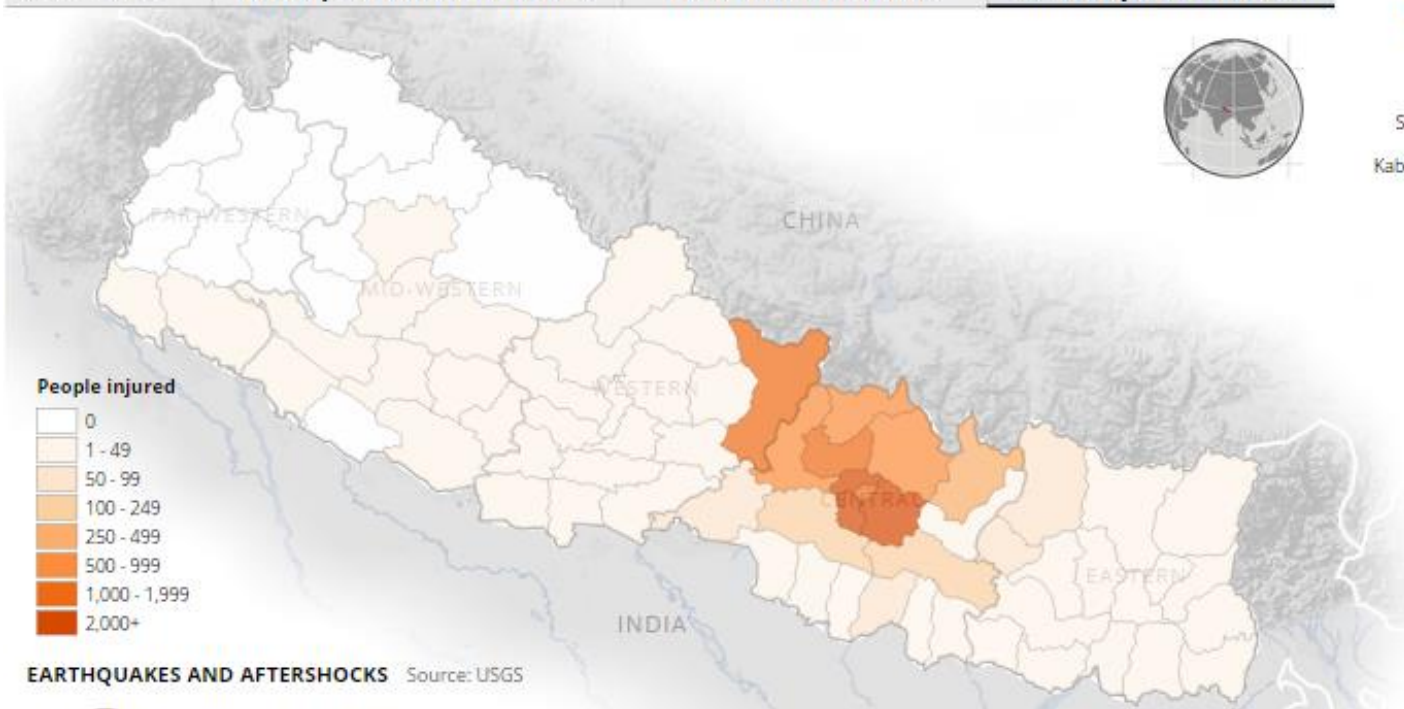

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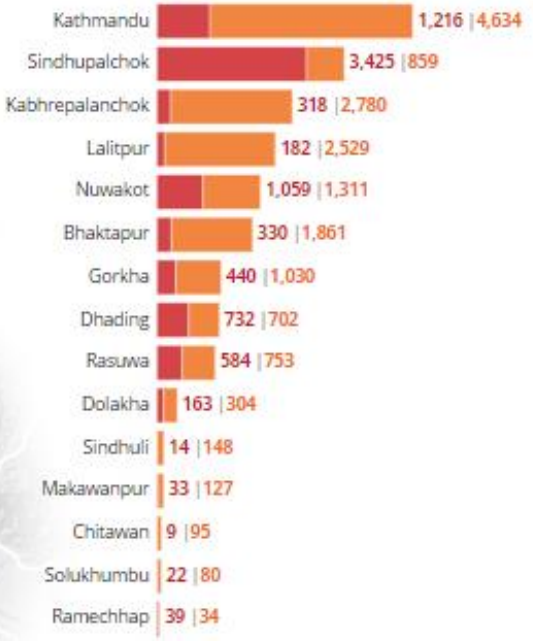


EARTHQUAKES AND AFTERSHOCKS

Source: USGS

Sources: OCHA, UNOAC, UNRCO (Nepal), Government of Nepal, Mapbox

Building Destroyed

data as of BS 2072-02-11 (25 May, 2015)

Total:

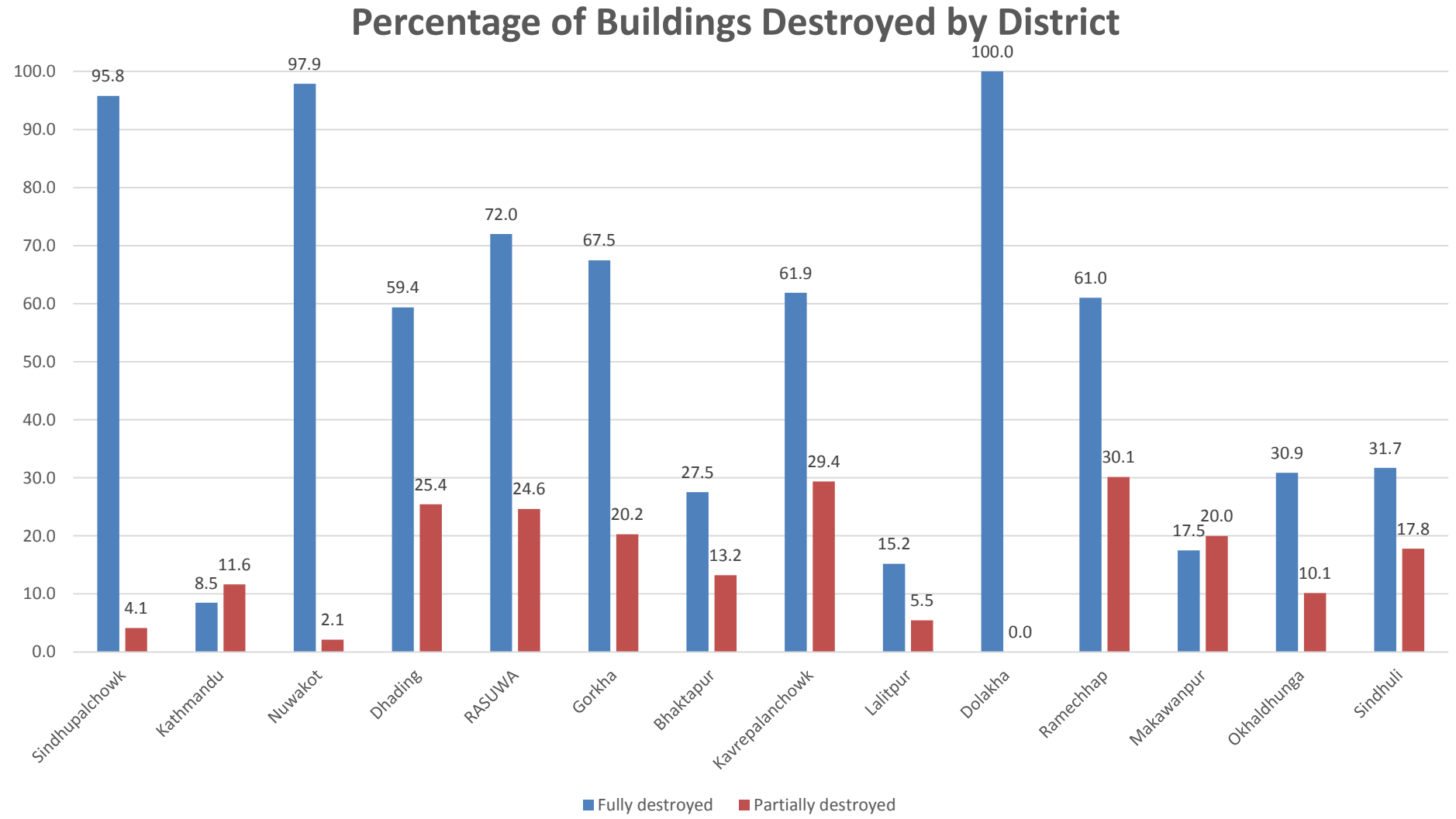
- Buildings completely destroyed: 5,01,906
- Buildings partially destroyed: 2,72,232

Government buildings:

- Completely destroyed: 1189
- Partially destroyed: 3042

A total of 57 monuments of the Kathmandu Valley have been destroyed.

Percentage of Buildings Destroyed



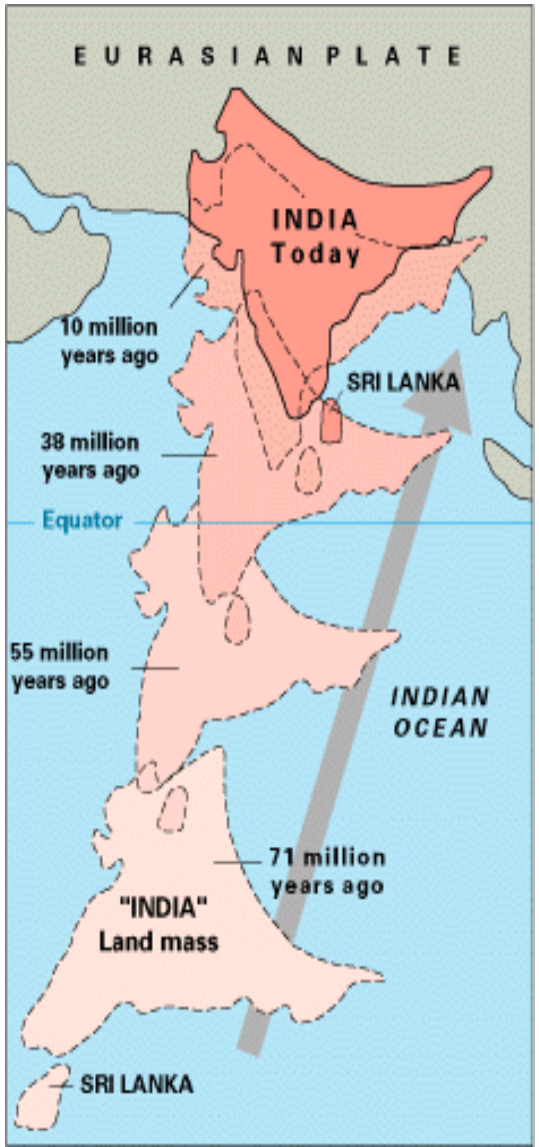
Data as of 25 May, 2015 from MoHA

Education Sectors
(DoE data as of 8 May, 2015)

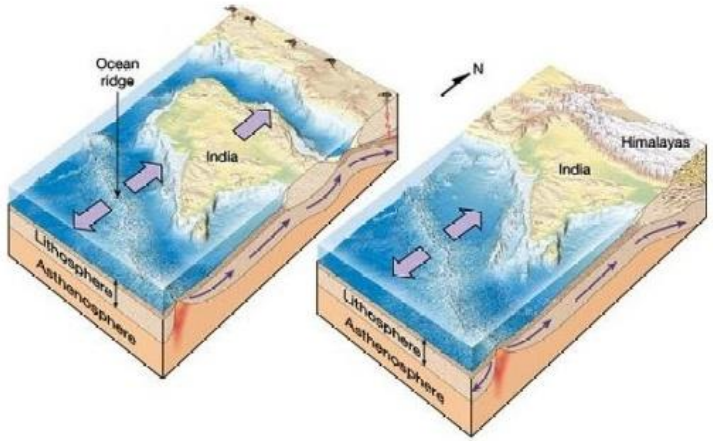
- Total number of affected schools: 5131/ 16377
- Fully damaged classrooms: 13312
- Classrooms with major damage: 5010
- Classrooms with minor damage: 6525
- Toilets damaged: 1643
- Compound walls damaged: 928
- Water supply system damaged: 1019
- Teachers died:32
- Students died: 227

Earthquake Magnitudes

Formation of Himalayas



- **About 225 million years ago, India was a large island still situated off the Australian coast, and a vast ocean (called Tethys Sea) separated India from the Asian continent. When Pangaea broke apart about 200 million years ago, India began to forge northward.**
- **About 80 million years ago, India was located roughly 6,400 km south of the Asian continent, moving northward at a rate of about 9 m a century.**
- **When India rammed into Asia about 40 to 50 million years ago, its northward advance slowed by about half. The collision and associated decrease in the rate of plate movement are interpreted to mark the beginning of the rapid uplift of the Himalayas.**



Magnitude of an Earthquake

- Several magnitude scales are widely used and each is based on measuring of a specific type of seismic wave, in a specified frequency range, with a certain instrument.
- The scales commonly used in western countries, in chronological order of development, are local (or Richter) magnitude (ML), surface-wave magnitude (Ms), body-wave magnitude (mb for short period, mB for long period), and moment magnitude (Mw or M)

Local (Richter) Magnitude (Ml)

- Richter magnitude was the first widely used instrumental magnitude scale to be applied in the USA (Richter, 1935). The scale is based on the amplitude (in mm) of the largest seismogram wave trace on a Wood–Anderson seismograph (free period 0.8 s), normalized to a standard epicentral distance of 100 km.
- Each successively larger magnitude was defined as a 10-fold increase in amplitude beyond the base level. Thus, a maximum seismogram amplitude (at a distance of 100 km) of 0.01 mm represents ML 1.0, 0.1 mm equals ML 2.0, 1 mm equals ML 3.0, and so on.
- Richter (1935) devised a nomograph to normalize the amplitudes for earthquakes closer or farther away than 100 km, based on the attenuation of seismic energy in California.

- The Richter magnitude scale accurately reflects the amount of seismic energy released by an earthquake up to about ML 6.5, but for increasingly larger earthquakes, the Richter scale progressively underestimates the actual energy release.
- The scale has been said to “saturate” above ML 6.5, from a combination of instrument characteristics and reliance on measuring only a single, short-period peak height

Surface-Wave Magnitude (MS)

- The surface-wave magnitude scale was developed to solve the "saturation" problem of Richter magnitude above ML 6.5. The measurement procedure is similar to measuring the Richter magnitude, except that the peak wave amplitude is measured for surface waves that have periods of 20 s, from long-period seismographs at teleseismic distances (Gutenberg, 1945). The surface-wave magnitude calculation does not require a seismograph record within 100 km (or nearby) of the epicenter, so the teleseismic records of many large-to-moderate magnitude earthquakes worldwide have been assigned surface-wave magnitudes.
- Because of this large data set, Ms is the typical magnitude used in empirical comparisons of magnitude versus earthquake rupture length or displacement (e.g. Bonilla et al., 1984).
- However, the surface-wave magnitude scale also saturates, at about Ms > 8.

Body-Wave Magnitude (MbLg)

- The short-period body-wave magnitude (mbLg) is the principal magnitude used in the tectonically “stable” eastern part of North America and Canada.
- This magnitude is measured from peak motions recorded at distances up to 1000 km on instruments with a passband in the range 1–10 Hz. Peak motions usually correspond to the Lg wave. This magnitude scale is little used in paleoseismology because it saturates at magnitude levels below that of Ms.

Moment Magnitude (MW OR M)

- The moment magnitude scale is the most recent scale and is fundamentally different from the earlier scales. Rather than relying on measured seismogram peaks, the M_w scale is tied to the seismic moment (M_0) of an earthquake.
- The seismic moment is defined as

$$M_0 = DA\mu$$

- where D is the average displacement over the entire fault surface, A is the area of the fault surface, and m is the average shear rigidity of the faulted rocks. The value of D is estimated from observed surface displacements or from displacements on the fault plane reconstructed from instrumental or geodetic modeling. A is derived from the length multiplied by the estimated depth of the ruptured fault plane, as revealed by surface rupture, aftershock patterns, or geodetic data. The method thus assumes that the rupture area is rectangular. The shear rigidity of typical crustal rocks is assumed to be about 3.0–3.5 1011 dyne/cm2

- The seismic moment thus more directly represents the amount of energy released at the source, rather than relying on the effects of that energy on one or more seismographs at some distance from the source.
- Moment magnitude is calculated from seismic moment using the relation of Hanks and Kanamori (1979) for southern California

$$Mw = 2/3 \log M_0 - 10.7$$

where M_w is the moment magnitude and M_0 is the seismic moment

- The seismic moment scale was developed to circumvent the problem of saturation in other magnitude scales, and is typically used to describe great earthquakes (i.e., Ms > 8).
- Kanamori (1983) composed a graph relating Mw to ML, Ms, mb, and mB.

relationship of various magnitudes to moment magnitude (Mw)