IJESMR

International Journal OF Engineering Sciences & Management Research

GEOENVIRONMENTAL IMPACT OF GORKHA EARTHQUAKE, NEPAL: APRIL-MAY, 2015

Vinay Kumar Pandey*, Ajai Mishra
GIPL, Orbit Plaza, New Prabhadevi road, Prabhadevi, Mumbai-400025, Maharastra, India.
Department of Geology, University of Lucknow, Lucknow-226007, U.P., India

Keywords: Earthquake, Magnitude, Aftershocks, Casualty, Environmental impact.

ABSTRACT
April 25, 2015 was a black day in the history of Nepal. A major earthquake with magnitude 7.9, followed by aftershock magnitude 6.7, 5 & 4.7 intensity; had shacked the Nepal and adjoining countries; India, China and Bangladesh. More than 250 numbers of aftershocks have been observed till May 18, 2015. Due to this earthquake, Kathmandu valley uplifted vertical about 3 feet (1 meter) and the tallest mountain in the world, Mount Everest, got a wee bit shorter. This earthquake originated due to compression of the Indian & the Eurasian plate. Rescue teams from various countries tried to save the human life as well as media teams had shown an impact on the social and economical front. In this paper we tried to cover Geoenvironmental impact of this earthquake and concluded that implementing the building construction practices, according to seismic zone is only one way to save humanity & future losses by an earthquake.

INTRODUCTION
'Valley of Pashupatinath (Lord Shiva)' Kathmandu, Nepal, had shaken with historical earthquake, intensity measured 7.9 at 11:56 am Nepal Standred time (NST), on April 25, 2015 followed by 250 numbers of aftershocks (as of May 18, 2015); killed more than 8150 humans, injured more than 19000 and flattened villages, leaving hundreds of thousands homeless. Its epicenter was the village of Barpak, Gorkha district (named Gorkha Earthquake) and depth was approximate 15 km[1]. . This earthquake may be the second strongest on record in Nepal. A 8.0 magnitude earthquake occurred in January 1934 in Bihar and devastated the region.
A strong 6.7 magnitude aftershock, the largest of the more than 30 aftershocks about 4 magnitude, struck 65 km east of Kathmandu at 12:44 pm local time, followed by immediately two other aftershocks, magnitude was 5 & 4.7. A second major earthquake occurred on 12 May 2015 at 12:35 NST with a moment magnitude (M_w) of 7.3M_w, 18 km southeast of Kodari. The epicenter was near the Chinese border between the capital of Kathmandu and Mt. Everest. It struck at the depth of 18.5 km (epicenter). This earthquake occurred along the same fault as the original magnitude 7.9 earthquake on April 25th but further to the east[2]. As such, it is considered to be an aftershock of the April 25 quake[2] . Centuries-old buildings were destroyed at UNESCO World Heritage sites in the Kathmandu Valley, including some at the Kathmandu Durbar Square, the Patan Durbar Squar, the Bhaktapur Durbar Square, the Changu NarayanTemple and the Swayambhunath Stupa. Geophysicists and other experts had warned for decades that Nepal was vulnerable to a deadly earthquake, particularly because of its geology, urbanization, and architecture[3],[4]. The economic losses could be as much as $10bn, according to an estimate from US Geological Survey.

GEOLOGY AND SEISMOTECTONIC SETTING OF NEPAL HIMALAYA
Geology of Nepal Himalaya
Nepal lies towards the southern limit of the diffuse collisional boundary, where the Indian Plate underthrusts the Eurasian Plate[5], occupying the central sector of the Himalayan arc, nearly one-third of the 2,400 km (1,500 mi) long Himalayas. Geologically, the Nepal Himalayas are sub-divided into five tectonic zones from north to south, east to west and almost parallel to sub-parallel[6].These five distinct morpho-geotectonic zones are: (1) Terai Plain, (2) Sub Himalaya (SivalikRange), (3) Lesser Himalaya (Mahabharat Range and mid valleys), (4) Higher Himalaya, and (5) Inner Himalaya (Tibetan Tethys). Each of these zones is clearly identified by their morphological, geological, and tectonic features[7]. These all tectonic zones are separated from each other by the thrust faults. The southern most fault, the Main Frontal Thrust (MFT) separates the Sub-Himalayan (Siwalik) Zone from Gangetic Plains. The Main Boundary Thrust (MBT) separates the Lesser Himalayan Zone from Siwalik. The Main Central Thrust (MCT) separates the Higher Himalayan Zone from the Lesser Himalayan Zone. The South

ISSN 2349-6193
Impact Factor (PIF): 2.243

IJESMR

International Journal OF Engineering Sciences & Management Research

Tibetan Detachment System (STDS) marks the boundary between the Higher Himalayan Zone and the overlying fossiliferous sequence of the Tibetan-Tethys Himalayan Zone. The Indo-Tsangpo Suture Zone is the contact knot between the Indian plate and Tibetan (Eurasian) Plate in terms of plate tectonics (Fig 2).

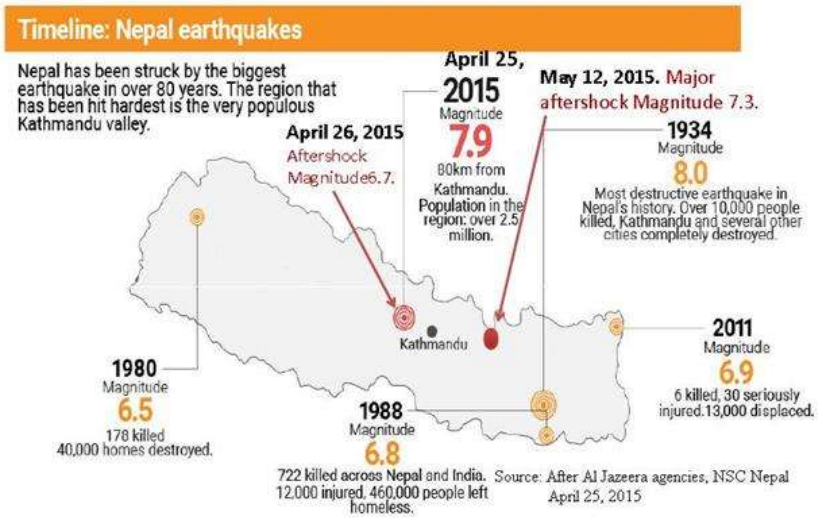

Fig 1: Location map of earthquake in Nepal (Source: After Al Jazeera agencies, April 2015)

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 suggested that it was caused by a slip along the Main Frontal Thrust[8].
The earthquake's effects were amplified in Kathmandu as it sits in the Kathmandu Basin, which contains up to 600 m (2,000 ft) of sedimentary rocks, representing the infilling of a lake[9].

Seismotectonic setup of Nepal Himalaya

The Himalaya, the highest mountain range of the world, represents an active collisional orogeny combining rapid crustal shortening and thickening, and that causes frequent strong earthquakes[10] . The Tibetan Plateau lies to the north of the Himalaya with the Indus–Ganga– Brahmaputra plain to the south of it. The Central Himalayan thrusts are the result of continent– continent collision of two mega plates of India and the Eurasia. In this region, the seismic energy is built up due to incessant collision of the Indian plate with the Eurasian plate which results in a sudden release of the stored seismic energy in large and great earthquakes.

The Nepal and its adjoining region lie at the central part of the Himalaya. The Himalayan region is divided into four major morphotectonic zones which are characterized by different physiography and stratigraphy[11]. From south to north, these are the sub-Himalaya, the Lesser Himalaya, the Greater Himalaya and the Tibetan Himalaya. A number of geoscientists have carried out geological as well as tectonic investigation in the Himalaya and its adjoining regions and published their important findings[12]-[22]. A series of reviews focusing on geology and the structural framework have been presented recently: Upreti (1999)[23] for Nepal Himalaya; Avouac (2003)[10] for Central Himalaya; Hodges (2000)[24] and Yin (2006)[25] for the entire Himalayan region, Prasad et al., (2011)[26] for an underthrust Indian crust of NW India through multi-fold seismic reflection profile in the Sub-Himalaya, and Yadav et al (2010)[27] for Hindu-Kush-Pamir Himalaya. An extremely complex geotectonic framework coupled with high seismic status has made the Central part of the Himalayas, a destination to study the complex inter-continental collision processes. The collision also caused large scale deformation and high seismicity of vast regions of colliding continents. This region displays all major tectonic features of the Himalayan mobile belt and is seismically one of the active regions in the Himalayan arc. Thrust environment is dominant in the Western and Central Nepal region, whereas, in the Eastern Nepal, it is an amalgamation of thrust and strike-slip with large thrust mechanism. In the western region thrust faulting coupled with shallow dip nodal planes reflects the Indian lithosphere is under-thrusting at a shallow angle. Here, the crustal

ISSN 2349-6193
Impact Factor (PIF): 2.243

IJESMR

International Journal OF Engineering Sciences & Management Research

shortening in north- south direction in which earthquakes are generated due to northward compression. The shortening was accommodated by the development of various NW-SE trending structures like Himalayan Arc MCT (Main Central Thrust), MBT (Main Boundary Thrust); MFT (Main Frontal Thrust). The observed change in the faulting pattern in the eastern parts of the thrust zone may indicate substantial movement along the transverse faults, as compared to that of the western region with the changes in the deep crustal structure. The thrusting decreases rapidly with increasing focal depth and deformation occur due to strike-slip motion at greater depths. The central sector of the Himalaya comprising of Nepal has a complex tectonic history[23],[24]with highly deformed upper crust and displays all major tectonic features of the Himalayan mobile belt. The region is known for its high seismic activity in which the great earthquake of 1934 (M 8.4) of Bihar-Nepal border region and a number of large earthquakes of magnitude M ≥ 6.0 have occurred during the last 100 years. The seismicity of the region is fundamentally associated with the MBT and also with a number of thrusts, normal and transverse faults. The main Himalayan seismic belt is mostly confined within the MCT and the MBT (Ni and Barazangi, 1984). Seismic activities in the Nepal Himalaya region are confined mostly in the upper crustal portion; whereas the clusters of a few intermediate events have been found between the MBT and the MCT in the Western Nepal region.

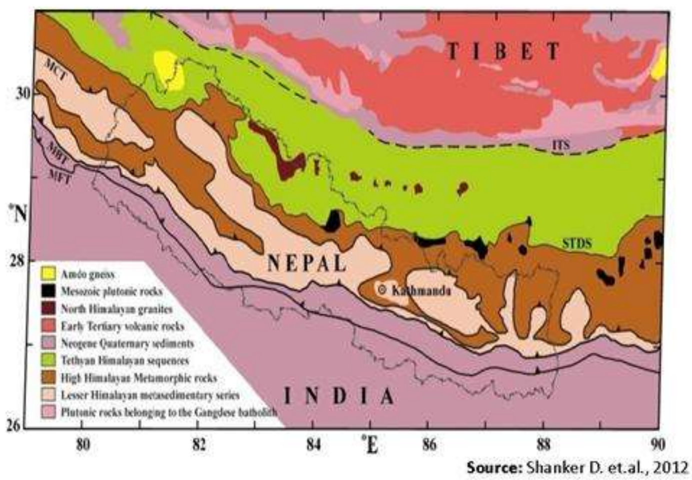

Fig 2: Geological map of Nepal Himalaya[28].

IMPACT OF PRESENT EARTHQUAKE

Earthquake, in itself, is not dangerous. However, the resulting damage to buildings & other structures and the risk of casualties from falling debris can make it extremely hazardous. Impact of earthquakes may be classified into two types: Primary & Secondry Impact.

Primary Impact: Basically three types of primary impact:-

(i) Geological impact:

A model of GeoGateway, based on a United States Geological Survey mechanism of a near-horizontal fault as well as the location of aftershocks showed that the fault was an 11° dip striking at 295°, 50 km wide, 150 km long, and had a dip slip of 3 m (9.8 ft).[29]The USGS says the aftershock registered at a shallow depth of 10 km[30].

The first good view of the aftermath of Nepal's deadly earthquake from a satellite reveals that a broad swath of ground near Kathmandu lifted vertically, by about 3 feet (1 meter), which could explain why damage in the city was so severe. The data also indicate the tallest mountain in the world, Mount Everest, got a wee bit shorter. According to the earlier analysis, a region 120 kilometers long by 50 km wide lifted upward by as much as 3 feet during the earthquake, said Tim Wright, a geophysicist at the University of Leeds in the United Kingdom. This uplift peaked only 17 km from Kathmandu, even though the city was relatively far from the earthquake's epicenter. The radar

ISSN 2349-6193
Impact Factor (PIF): 2.243

IJESMR
International Journal OF Engineering Sciences & Management Research

images reveal that some of the world's tallest peaks — including Mount Everest — dropped by about 1 inch (2.5 cm), according to the nonprofit UNAVCO, a geoscience research consortium. That's because the Earth's crust relaxed in the areas north of the Kathmandu, after the earthquake released pent-up strain[31].

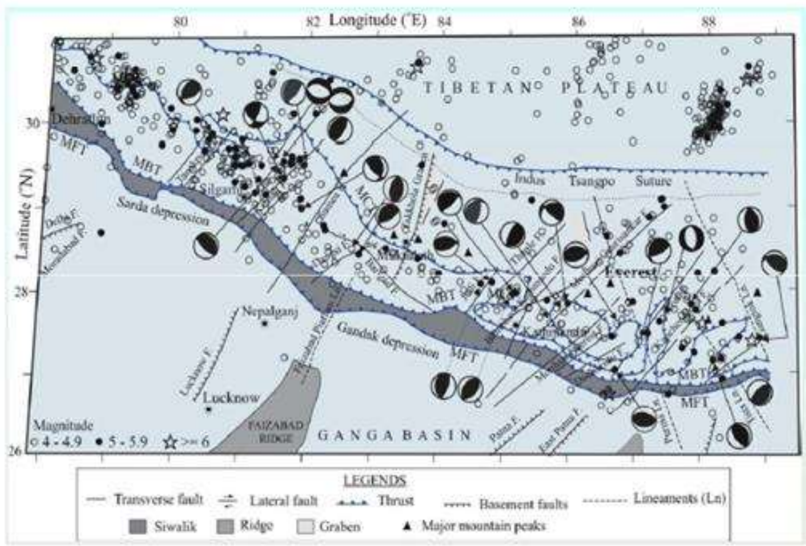

Fig 3: Seismotectonic map of Nepal Himalaya[28].

(ii) Other Natural Disasters

(a) Avalanches: This earthquake caused many avalanches on Mount Everest. At least 19 died, including Google executive Dan Fredinburg, with at least 120 others injured or missing.

In the Langtang valley located in Langtang National Park around 250 people was reported missing after an avalanche hit the village of Ghodatabela[32] and the village of Langtang. The avalanche was estimated to have been two to three kilometres wide. Ghodatabela was an area popular on the Langtang trekking route.[33] The village of Langtang has been destroyed by the avalanche. Around 300 were estimated to have died in smaller settlements on the outskirts of Langtang that were buried during the earthquake, such as Chyamki, Thangsyap, and Mundu. Twelve locals and two foreigners were believed to have survived.

(b) Landslides/Shinking of Soil**:** Earthquake disturbe the slope of hills & chances of landslide and shinking of soil may increases. Many connecting roads have been distroyed by landslide & shinking of soil. Due to this rescue team unable to reach remote areas for relief measures and casualties increases. Landslides occurred in the Trishuli River Valley with reports of significant damage at Mailung, Simle, and Archale[34]. On 4 May it was announced that 52 bodies had been found in the Langtang area, of which seven were of foreigners[35].

(c) Emission of Green house gases: Most rock contains small amount of gases that can be isotopically distinguished from the normal atmospheric gases, this can be attributed to release due to seismic-stress or fracturing of the rock. Large vertical displacements of areas of land can be understood if a mass of gas had previously held open pore spaces in the rocks below, and thereby raised the ground, and if these pore spaces had suddenly made connections to the surface and rapidly exhausted the gas. Researchers from University of Bremen (Germany) and their colleagues found a new source of methane that occurred from an earthquake which happened in Pakistan about 70 years ago. They found that this event fractured the sea-bed and released methane in the atmosphere. The study was based on data from the Makran subduction zone. A strong 8.0 magnitude earthquake that hit Pakistan in 1945 triggered a tsunami, killing about 4,000 people[36].

Same results have been found in deadly Japan earthquake in March 2011, with moment magnitude Mw = 9.0, that released thousands of tons of climate warming halocarbons, pot ential greenhouse gases and stratospheric ozone

ISSN 2349-6193
Impact Factor (PIF): 2.243

IJESMR

International Journal OF Engineering Sciences & Management Research

depleting substance, has dramatically increased shortly after the earthquake and that annual emission were significantly higher in 2011 than in other years[37].
Same in Nepal, there may be released greenhouse gases from the subsurface and by destroy of the buildings and other structures.

(iii) ***Damages of Building and other rigid structures***
Most earthquakes related deaths are caused by the collapse of a structure. Thousands of houses were destroyed across many districts of the country, with entire villages flattened, especially those near the epicenter. The Tribhuvan International Airport serving Kathmandu was closed immediately after the quake, but was re-opened later in the day for relief operations and, later, for some commercial flights. Centuries-old buildings were destroyed at UNESCO World Heritage sites in the Kathmandu Valley, including some at the Kathmandu Durbar Square, the Patan Durbar Squar, the Bhaktapur Durbar Square, the Changu NarayanTemple and the Swayambhunath Stupa. Several pagodas on Kathmandu Durbar Square, a UNESCO World Heritage Site, collapsed,[25] as did the Dharahara tower, built in 1832; the collapse of the latter structure killed at least 180 people. Manakamana Temple in Gorkha was also destroyed. The northern side of Janaki Mandir in Janakpur was reported to have been damaged. Several temples, including Kasthamandap, Panchtale temple, the top levels of the nine-story Basantapur Durbar, the Dasa Avtar temple and two dewals located behind the Shiva Parvati temple were demolished by the quake. Some other monuments, including the Kumari Temple and the Taleju Bhawani Temple partially collapsed. The top of the Jaya Bageshwari Temple in Gaushala and some parts of the Pashupatinath Temple, Swyambhunath, Boudhanath Stupa, Ratna Mandir, inside Rani Pokhari, and Durbar High School have been destroyed.
In Patan, the Char Narayan Mandir, the statue of Yog Narendra Malla, a pati inside Patan Durbar Square, the Taleju Temple, the Hari Shankar, Uma Maheshwar Temple and the Machhindranath Temple in Bungamati were destroyed. In Tripureshwar, the Kal Mochan Ghat, a temple inspired by Mughal architecture, was completely destroyed and the nearby Tripura Sundari also suffered significant damage. In Bhaktapur, several monuments, including the Fasi Deva temple, the Chardham temple and the 17th century VatsalaDurga Temple, were fully or partially destroyed. Outside the Valley, the Manakamana Temple in Gorkha, the Gorkha Durbar, the PalanchokBhagwati, in Kabhrepalanchok District, the Rani Mahal in Palpa District, the Churiyamai in Makwanpur District, the Dolakha Bhimsensthan in Dolakha District, and the Nuwakot Durbar were partially destroyed.

Secondary Impact

Secondary impact occurs as a result of the primary impact of earthquakes. We can divide it in two parts:

(i) ***Environmental Impact:*** Following impact have been shown in Nepal Himalaya:-
(a) Due to ground shaking, slope stability on hills had disturbed and increase the chances of landslide, rockfall, avalanche, Glacier lake outburst flood (GLOF) and other Hydrometerological disasters.
(b) Aftershocks have been increasing the probability of collapse the damage structures, road, bridges and landslide.
(c) Due to ground shaking and aftershocks, chances increase the rate of glacier retreat and that may occur flood in downstream areas.
Sometime it affects the water availability in water bodies, may be increased or decreased or change in river flow direction.

(ii) ***Social Impact:*** Following impact has been shown in Nepal:
(a) ***Casualties:*** Collapse of buildings, houses and other man made structure play a tremendous role in the death toll of an earthquake. More than 8150 people have been killed and more than 19000 injured in Nepal itself. 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[38]. Hundreds of people are still considered missing and more than 450,000 are displaced[39]. A total 78 deaths were reported in India[40], 25 dead & 4 missing from Tibet[41]and 4 dead reported from Bangladesh[42].

IJESMR

International Journal OF Engineering Sciences & Management Research

(b) ***Lack of a basic need for survival:*** Due to the high intensity earthquake and collapse of buildings, there are lack of a basic needs of life such as foods, drinking water, clothes, medicines and public have not even the safe place for passes his night. Rescue teams had arranged some camps for stay the public at night. People of Kathmandu valley had lost the everything which they had arranged for daily need of a life.

(c) ***Impact on health & Psychology:*** Beside the economic loss, potential impacts on individuals are: mortality, injuries, diseases (e.g. diarrhoeal, vector-borne) and infections, chemical pollution, nutrition and displaced population. Only a small part of these impacts are captured by direct health costs, there were many victims who had escaped death, but witnessed hundreds, including their loved ones, die in front of their eyes. Doctors said that the trauma remains for very long with those who survived such disasters and psycho-social care help is needed to deal with such trauma. In case of a family member being lost, people also suffer from survivor's guilt. The impact was huge and professional intervention was important.

(d) ***Impact of aftershocks and rainfall:*** Due to continued aftershocks and rainfall within 2-3 days of main earthquake; relief operation struck and unstable slopes are falling down as landslide and rock fall. Due to rainfall dead bodies started decomposed and debris of building mixed with water and various water born diseases started.

CONCLUSION

Himalaya is a most prominent seismic zone & youngest folded mountain; originated due to compression of the Indian & Eurasian plates and continue moving towards north. Due to movement in the plates, stress generates and released in the form of earthquakes along the old fault plan & sometime generate new fractures/fault in the rocks. The earthquake had left their impression in the form of huge casualties and economic loss (more than 8150 people dead and 19000 injured and estimated economic loss is as much as $10bn) with vertical uplift of Kathmandu by about 3 feet (1 meter) and the tallest mountain in the world, Mount Everest, got a wee bit shorter.

As a country, Nepal can recover the impact of this tragedy, but as human being, its unforgettable disaster and has never become free from fear of earthquakes. Implementing the building construction practices, according to seismic zone is only one way to save humanity & future losses by an earthquake.

REFERENCES:

[1]M7.8 – 34 km ESE of Lamjung, Nepal. United States Geological Survey, 25 April 2015. Retrieved 12 May 2015.

[2]M7.3 - 18km SE of Kodari, Nepal. USGS Earthquake Hazards Program

[3]Experts had warned for decades that Nepal was vulnerable to a killer quake.Washington post, Retrieved 29 April 2015.

[4]Colin Stark. Nepal earthquake: A tragedy waiting to happen – Cnn.com; CNN, 26 April 2015. Retrieved 29 April 2015.

[5] Why Earthquakes Are Devastating Nepal. video:National Geographic.com, Retrieved 2015-05-13.

[6] Geology of Nepal Himalaya. Retrieved 27 April 2015.

[7] General Geology. Government of Nepal, 2014. Retrieved 27 April 2015.

[8] Josh Fischman. How The Deadly Nepal Earthquake Happened [GRAPHIC]. Scientificamerican.com, April 28, 2015.

[9] Mughier J.L., Huyghe P., Gajurel A.P., Upreti B.N. & Jouanne F.; Huyghe; Gajurel; Upreti; Jouanne. Seismites in the Kathmandu basin and seismic hazard in central Himalaya. Tectonophysics 509 (1–2), 28 April 2015, 33-49. doi:10.1016/j.tecto.2011. 05.012., 2011.

[10]

Avouac, J. P. Mountain Building, erosion, and the seismic cycle in the Nepal Himalaya. Advances in Geophysics, 46, 2003, 1–80.

[11] Heim, A. and Gansser, A. Central Himalaya: Geological observations of the Swiss expedition 1936. Mem/ Soc. Helv. Sci. Nat., 73 (1), 1939, 1–245.

[12] Auden, J. B. Transverse in the Himalaya. Records of the Geological Survey Of India, 69, 1935, 123-167.

ISSN 2349-6193
Impact Factor (PIF): 2.243

IJESMR

International Journal OF Engineering Sciences & Management Research

[13] Gansser, A. Geology of the Himalaya. Wiley Inter-Science, London, 1964, 289.

[14] Le Fort, P. Himalaya: the collided range: Present knowledge of the continental arc. American Jour. Of Science, 275A, 1975, 1–44.

[15] Valdiya, K. S. Himalaya transverse faults and their parallesim with subsurface structures of North Indian planes. Tectonophysics, 32, 1976, 353-386.

[16] Valdiya, K. S. Tectonics of the crustal sector of the Himalaya, In Zagros, Hindu Kush, Himalaya, Geodynamic Evolution, Geodynamic Ser. Vol, 3., (Ed. H. K. Gupta, and F. Delany), AGU, Washington D. C., 1981, 87-110.

[17] Valdiya, K. S. Tectonics and evolution of the central sector of the Himalaya.Trans. R. Society, London, A326, 1988, 151-174.

[18] Wadia, D. N. Geology of India. Tata Mcgraw Hill, New Delhi. 4th Edition, 1975, 508.

[19] Krishnan, M. S. Geology of India and Burma. CBS Publishers and Distributors, India. 6th Edition, 1982, 536.

[20] Dewey, J. F., Robert, Shackleton, R. M., Chengfa, C., and Yiyin, S. The tectonic evolution of the Tibetan plateau. Phil. Trans. R. Society Londan, A327, 1988, 379-413.

[21] Sharma, C. K.. Geology of Nepal Himalaya and Adjacent Countries. Mary Martin Booksellerd, Kathmandu, Nepal, 1990, 479.

[22] Verma, R. K.. Geodynamics of the Indian Peninsula and the Indian Plate Margin. Oxford and IBH Publicating Co. Pvt. Ltd. New Delhi, 1991, 374.

[23] Upreti, B. N. An overview of the stratigraphy and tectonics of the Nepal Himalaya. Journal of Asian Earth Sciences, 17, 1999, 577-606.

[24] Hodges, K. V. Tectonics of the Himalaya and southern Tibet from two perspectives. Geolo. Soc. Ammrican Bull. , 112 (3), 2000, 324–350.

[25] Yin, A., and Harrison, T. M. Geologic evolution of the Himalayan–Tibetan orogen. Annu. Rev. Earth Planet Sci. 28, 2006, 211-280.

[26] Prasad, B. R., Simon L. Klemperer, Rao V. Vijaya, Tewari, H.C., Khare, Prakash. Crustal structure beneath the Sub-Himalayan fold–thrust belt, Kangra recess, northwest India, from seismic reflection profiling: Implications for Late Paleoproterozoic orogenesis and modern earthquake hazard. Earth and Planet Science Lett., 308, 2011, 218–228.

[27] Yadav, R. B. S., D. Shanker, S. Chopra, A. P. Singh. An application of regional time and magnitude predictable model for long-term earthquake prediction in the vicinity of October 8, 2005 Kashmir Himalaya earthquake. Journal of Natural Hazard 54(3), 2010, 985-1014.

[28] Shanker D, Paudyal H, Singh H.N. Discourse on Seismotectonics of Nepal Himalaya and Vicinity :Appraisal to Earthquake Hazard. Geosciences, Vol. 1 (1), 2011, 1-15.

[29] IRIS: Special Event: Nepal. iris.edu.

[30] Live: Death toll rises to 2200 in Nepal earthquake, India resumes rescue ops. The Indian Express, 26 April 2015.

[31] Oskin ,Becky. Mount Everest Shrank As Nepal Quake Lifted Kathmandu. http://www. livescience.com /50677-nepal-earthquake-radar-satellite-view.html, April 29, 2015.

[32] Daigle, Katy. 250 people feared missing after mudslide in Nepal village. Daily News, 28 April 2015, Retrieved 1 May 2015.

[33] Dave. Landslides in Langtang during and after the Nepal earthquake. AGU Blogosphere, 29 April 2015, Retrieved 1 May 2015.

ISSN 2349-6193
Impact Factor (PIF): 2.243

IJESMR

International Journal OF Engineering Sciences & Management Research

[34] Landslides in Langtang during and after the Nepal earthquake. .RAPPLER.COM, AGENCE FRANCE PRESSE. 29 April 2015, Retrieved 1 May 2015.

[35] Shashank Bengali & Bhrikuti Rai. Nepal quake: 52 bodies found in remote valley where trekkers missing. Los Angeles Times, May 04, 2015.

[36] http://www.natureworldnews.com/articles/3204/20130729/earthquakes-release-massive-amounts-methane.htm#disqus_thread

[37] Saito, Takuya; Fang, Xuekun; Stohl, Andreas; Yokouchi, Yoko; Zeng, Jiya; Fukuyama, Yukio; Mukai, Hitoshi. Extraordinary halocarbon emissions initiated by the 2011 Tohoku earthquake. Geophysical Research Letter. Vol 42(7), April 2015, Pages 2500-2507. Doi: 10.1002/2014GL062814.

[38] 90 Britons missing as Nepal earthquake death toll rises. The Himalayan Times, 27 April 2015.

[39] National Emergency Operation Centre. National Energncy Operation Centre (Nepal Govt.), 3 May 2015.

[40] Quake toll in India now 78. Zee News. 29 April 2015. Retrieved 4 May2015.

[41] 25 dead, 383 injured in Tibet following Nepal earthquake. Xinhua, 28 April 2015, Retrieved 5 May 2015.

[42] 4 killed, 18 Bangladesh districts affected in earthquake, says govt. Bdnews.com. Retrieved 26 April 2015.

	Dr Vinay Kumar Pandey, Doctorate in Geology, has more than ten year experience in Engineering Geology, Environmental Geology and Exploration works. He has published 9 papers in national and international journals & one book on Climate Change and Hydrometerological disaster.
	Dr Ajai Mishra is Professor in the Department of Geology, University of Lucknow, India. His specialization is on the Geo-morphology, Glaciology, Remote Sensing and Environment Geology. He has published about 40 research papers in national and international Journals & twelve Ph.D. thesis awarded under his supervision & one book.