

Socioeconomic Consequences of the 2015 Gorkha Earthquake

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Abstract

The Context: Nepal is highly susceptible to a number of disasters including the earthquake which is the most dangerous among all disasters. The Gorkha earthquake of 25 April 2015 took the lives of more than 9 thousand people, and enormously affected the socio-economic and other multiple sectors of the country.

Objectives: The objectives of this research were to see the impact of the earthquake into the daily and family life of the individuals who were directly affected. Another objective was to analyze and show the critical gaps and responsible factors that would contribute towards seismic risk reduction to enable various stakeholders to enhance seismic safety in Nepal and other earthquake-prone countries. Moreover, this paper aims to identify the deficiencies in the disaster management system in Nepal taking into account the causes and consequences of the devastating earthquake of 25 April 2015 and suggest appropriate policy and advanced technical measures.

Research Method: From May to July 2015, earthquake-affected persons in Kathmandu valley (Kathmandu and Lalitpur cities) (n=250) were administered a structured questionnaire. The Street Intercept method was used. Data were collected on the loss of human lives, injuries, types of physical infrastructure damage and the impact of the Gorkha Earthquake 2015. Chi-square tests and logical regression were used to find out the correlation between the above issues and aspects. Besides the on-site survey interview method -- secondary source of data and information has been used for this study.

Results and Discussions: The study results show the need of earthquake resistant infrastructures and advocacy campaign, while the weak structures have been found as the major cause of infrastructure collapse in the earthquake which caused enormous loss of human lives and properties. In addition to the economic loss, the affected people had the physical, mental and other societal problems. Hence, the government should take necessary measures to address the above issues. It is deemed necessary to ensure the construction of earthquake resistant public and private infrastructures and advocacy programs. Specifically, the government must confirm that the building compliance has been strictly followed. The responders of the survey reported about the unjust distribution of relief materials and other supplies. Most of the responders had no fair knowledge about the causes and consequences of earthquake and other disasters. Hence, disaster awareness programs are extremely necessary. The current findings highlight the need for further research to see the detail ramifications of the above problems.

Recommendations and Conclusions: This study emphasizes the need for strict compliance of town planning bye-laws and earthquake-resistant building codes. Thus, the formulation and implementation of proactive disaster management legislation focusing on disaster preparedness are highly necessary.

Key Words: *Infrastructure, Impact, Legislation, Proactive, Susceptible, Socio-economic.*

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1. Background

Nepal is one of the 20 most disaster-prone countries in the world. Among 200 countries in the world, Nepal ranks 11th and 30th, respectively, with regard to relative vulnerability to earthquake and flood (UNDP/BCPR, 2004). According to the Global Earthquake Safety Initiative, Kathmandu is exposed to the greatest earthquake risk per capita among 21 megacities around the world, basically due to the building collapse and inadequate preparedness.

An earthquake disaster is the most terrifying disaster for Nepal but the country is not limited to just earthquakes; there are also disasters such as floods, landslides, fires, avalanches, windstorms, hailstorms, lightning, glacier lake outburst floods, epidemics, droughts etc. There have been many occurrences of earthquake disasters in Nepal that have caused heavy human life losses and physical property damages, adversely affecting the overall development of the country.

Nepal's proximity to earthquake hazards is mainly due to her young and fragile geology. The disaster vulnerability of the country is so serious that Kathmandu, the capital city of Nepal, is number one among the 21 mega cities in the world from the point of view of earthquake risk. Haphazard and unplanned settlements and poor construction practice are the other reasons that have made her highly vulnerable to earthquakes. (Upreti 2015).

Nepal has the chronological history of devastating earthquakes since 12th century. Since then Nepal has encountered 16 major earthquakes, including the latest devastating Gorkha-Nepal earthquake of 25 April 2015. Still there are the scars of sorrows that the earthquake of 2015 has left among the affected population. This is, in fact, a wakeup call for policy-makers, development experts, civil society and the general public that had not considered unplanned development and haphazard construction as the major causes of loss and damage due to this earthquake.

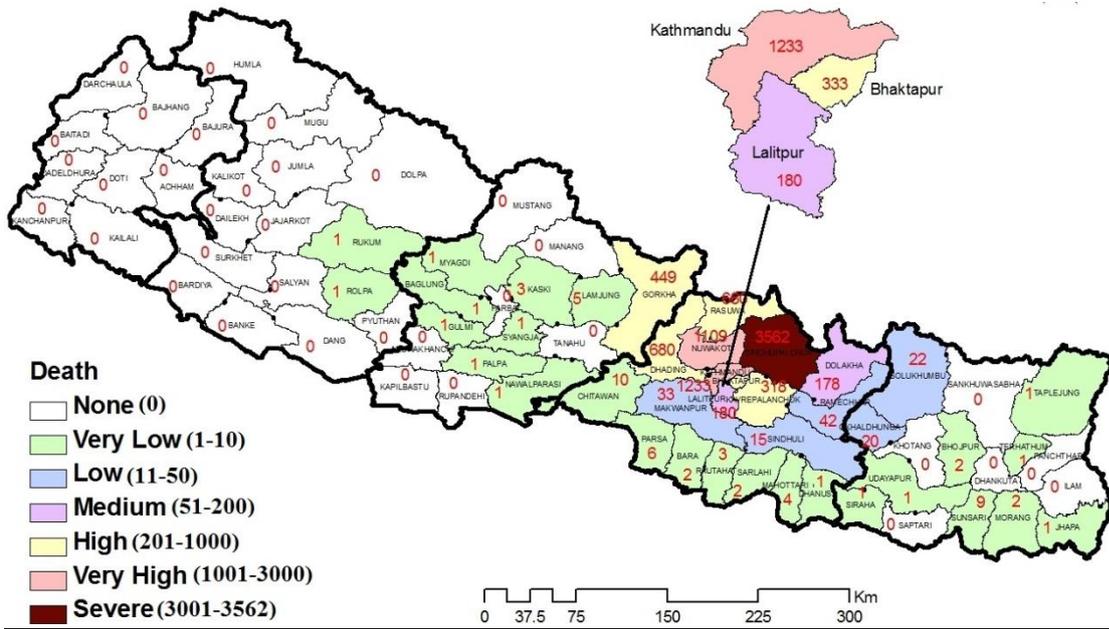
2. A Brief Account of the Gorkha-Nepal Earthquake

A 7.8 ml earthquake struck Nepal on 25 April 2015 at 11:56 am local time. The epicenter was near the Barpak Village of Gorkha district which is 81 km northwest from Kathmandu. The devastating earthquake killed 8,896, with missing 198 and seriously injured 22,302 people and rendered millions homeless. More than six hundred thousand households were fully damaged leaving around three hundred thousand partially damaged. Mostly, old, non-engineered, adobe and masonry buildings were collapsed and/or were severely damaged by the earthquake. In addition, some engineered buildings also damaged or collapsed due to poor workmanship and quality of construction materials. The earthquake severely affected 14 districts (Gorkha, Dhading, Rasuwa, Nuwakot, Kathmandu, Lalitpur, Bhaktapur, Kavrepalanchowk, Sindhupalchowk, Dolakha, Sindhuli, Makawanpur, Ramechhap and Okhaldhunga) and another 31 districts affected to varying extents. (NDR 2015)

Please see Map 1 below for the number of people deceased and the impact of the earthquake in different districts of Nepal.

Map 1

Human Deaths by the Gorkha-Nepal Earthquake



Source: Ministry of Home Affairs, the Government of Nepal

The 25 April earthquake was followed by a number of aftershocks throughout Nepal, with one shock reaching a magnitude of 6.7 on 26 April at 12:54 am local time. The 25 April earthquake affected the entire Nepal and also affected some parts of India, Bangladesh and the Tibet Autonomous Region of China. Tremors were also felt in Bhutan and Pakistan. This earthquake was the largest to hit Nepal after the Nepal–Bihar earthquake of 1934. All these major earthquakes confirmed that the casualties were caused mainly due to the collapse of infrastructures.

On 26 April 2015, the Government of Nepal declared the 14 districts as catastrophic area and appealed for international humanitarian assistance including search and rescue.



Photo : By Gyanu Chhetri

Dharahara (before and after the earthquake) which was the icon of the Kathmandu city

On 12 May 2015 at 12:50 local time another strong aftershock measuring 7.3 magnitudes struck with the epicentre in Sunkhani of Dolkha district. The epicentre was 76 km northeast of Kathmandu. This area was already affected by the 25 April quake. The initial quake was followed by several aftershocks including a 5.6 magnitude. This quake toppled already weakened buildings, triggered a series of landslides, which further hampered relief efforts. This quake alone killed more than 100 people.



Photo : By the Author

According to the Department of Survey of the Government of Nepal, the movement of tectonic plates that triggered massive earthquake in the country on 25 April caused the altitude of Kathmandu Valley to increase by 80 centimeters. In total 438 numbers of aftershocks with Local magnitude ≥ 4 have been recorded till 6 March 2016.

Table 1
Losses Due to the Gorkha-Nepal Earthquake

Particulars	Losses./Amount
Persons dead	970
Missing	98
Injured	2,302
Affected Families	86,456
Displaced Families	49,815*
Houses Damaged (Fully)	104,930
Houses Damaged (Partially)	88,856
Total Material Loss	NPRs. 706 billion US\$ 7 billion#

Source: Ministry of Home Affairs; Situation Report* of NRCS & PNDA# Report, NPC, the Government of Nepal.

As shown in Table 1 above, an estimated value of properties (damages and losses) caused by the earthquakes is NPR 706 billion (US\$ 7 billion). Of that amount, NPR 517 billion (or 76 percent of the total effects) represents the value of destroyed physical assets, and NPR 189 billion (24 percent of the total effects) reflects the losses and higher costs of production of goods and services arising from the disaster. These estimates are based on the aggregation of information and data collected across sectors of social and economic activity and checked to avoid duplication of numbers. (PDNA Report 2015, NPC).

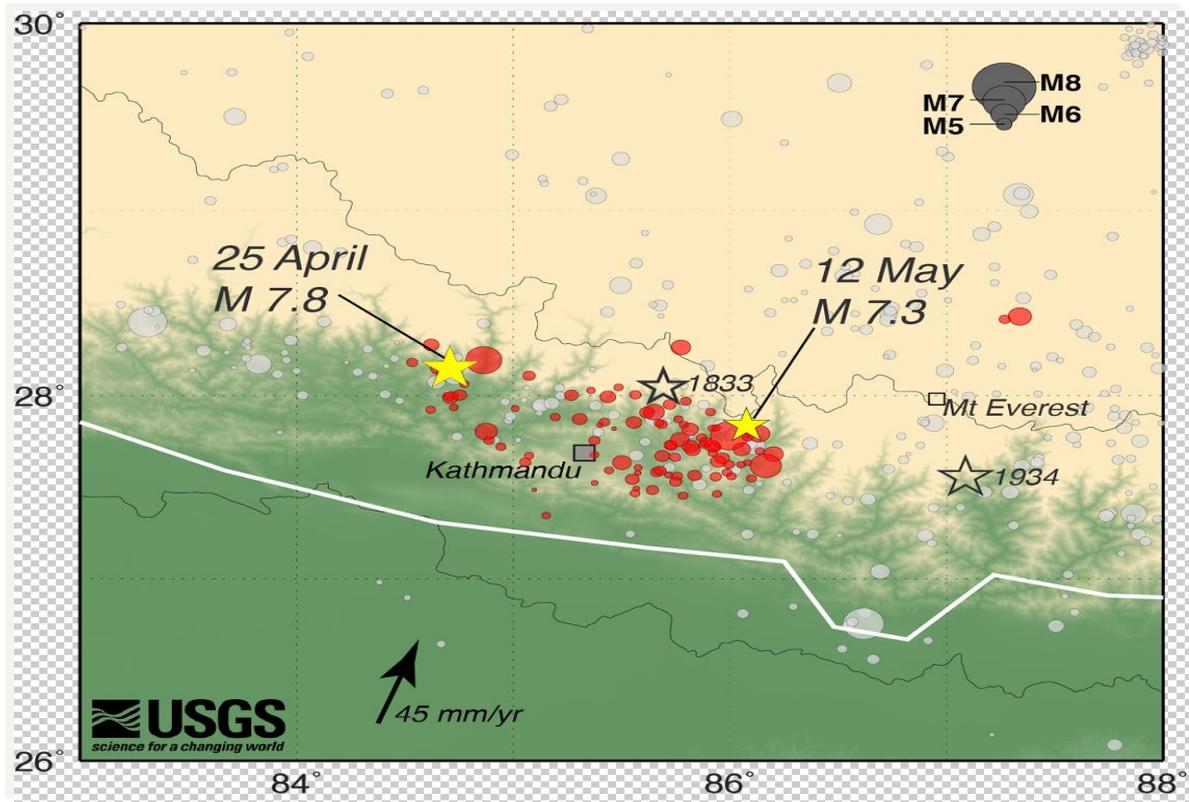
3. Causes, and Consequences of the Earthquake

The Gorkha, Nepal earthquake of 25 April 2015 occurred in a geological collision zone, where the Indian tectonic plate pushes north into the Eurasian plate, moving the ground an average of 2cm a year. Over decades, stress built up along a stretch of the fault line, which is called the Main Himalayan Thrust (MHT) fault, close to Nepal's capital Kathmandu. In this area, the boundary between the two plates had become locked - stuck together by friction and so immobile - building up energy that only a major earthquake could release. Increasing population, unplanned settlements, poor quality of construction, untrained human resource, lack of search and rescue equipment and medical services are the other major causes of the earthquakes.

Some other new data also revealed that the devastating quake that hit Nepal in 25 April did not release all of the stress that had built up underground and some of this stress has shifted west to an area stretching from the west of Pokhara in Nepal to the north of Delhi in India. The research is published in the journals Nature Geoscience and Science. Its authors say more monitoring is now needed in this area. Therefore, a major earthquake there is already long overdue: the last happened in 1505 and is estimated to have exceeded M8.5. The researchers say the new stress that has moved there could already be adding to the tension that has been

building up over five centuries. Please see Map 2 below for the scale of the 25 April 2016 Gorkha-Nepal Earthquake and the major aftershock of 12 May 2016.

Map 2



Source: USGS

Prof Jean-Philippe Avouac of University of Cambridge believes that the quake on 25 April only released part of this pent-up pressure. "If the earthquake had ruptured the entire locked zone all the way to the front of the Himalayas, it would have been a much larger earthquake. This is a place that needs attention, and if we had an earthquake today, it would be a disaster because of the density of population not just in western Nepal but also in northern India, in the Gangetic plain. We don't want to scare people, but it is important they are aware that they are living in a place where there is a lot of energy available," says Prof Avouac.

4. Response

Although there was chaos, confusion and distress -- immediately after the earthquake, National Emergency Operation Centre (NEOC) at the Ministry of Home Affairs was activated at level-IV by following the National Disaster Response Framework, 2014 and Standard Operating Procedure (SoP). Soon after the quake the Home Minister, other Ministers, Chief Secretary, Secretaries, high level officials and the chief of security forces were present at the NEOC. Within two hours, the Central Natural Disaster Relief Committee (CNDRC) meeting was held and made necessary decisions for immediate relief and response. Soon after, the cabinet meeting endorsed the decisions of CNDRC including declaration of catastrophic area

and appealed for international assistance. Central Command Post was established under the leadership of Home Secretary. Security forces were mobilized immediately for Search and Rescue (SAR) operation with heavy equipment and helicopters. Helicopters were used in remote areas for SAR operation from Nepal Army, India, China, U.S.A. and private sector. Altogether 66,069 Nepal Army personnel, 41,776 Nepal Police, 24,775 Armed Police Force and 22,500 Civil Servants were mobilized for response. In total 7,606 people were rescued by 4,299 flights of Nepal Army, foreign and private sector helicopters. A total of 12,295 people were rescued by air lift and land routes. (1 month report of MoHA on 26 May 2015).



Photo : By the Author

Social workers providing cash assistance to the earthquake affected people

Likewise, various volunteer groups, local people, youths, civil societies, media and political parties provided significant assistance to the affected people during the response phase. Several International and local NGOs, Red Cross and Red Crescent Societies and United Nations Organizations also supported for the response. There has also been a considerable amount of aid distributed by various social organizations, private and corporates. This includes skilled technical personnel such as doctors, nurses, engineers as well as unskilled personnel and in-kind contributions. Despite the lack of sufficient search and rescue equipment and resources, Nepalese security forces played a significant role in search and rescue and relief works.

5. Some Issues Associated with the Gorkha-Nepal Earthquake

Despite the hard work of Nepalese security forces and others, the response work was found a bit slow and unsystematic. A key criticism was of a slow and inadequate relief effort, which failed to reach in due time to many of the affected people of remote, rural and hilly areas. It was mainly due to the lack of a robust road network and transport resources, especially adverse weather condition, and a serious bottleneck at the airport. Major delays were also caused by bureaucratic procedures and even bitter mutual accusations - both in public and

private—over who was to blame and who should be in control of resources. Thousands of people in the affected districts were lacking even the most rudimentary shelters. Many people were exposed to risks due to poor shelter, poor hygiene, and trauma. During monsoon and chilling winter exposed many temporary households to extreme weather, cold and increased diseases, but also to further collapses of houses damaged during the earthquake. As a result hundreds of people died during the severe winter.

There were serious issues of food items distributed by some agencies. Earthquake victims of some districts complained that the rice provided by the World Food Program (WFP) through Nepal Red Cross Society (NRCS) was “substandard and inedible”.

After few months of the devastating earthquake, agitation in Tarai region of Nepal and ban on supply of fuel and other consumable goods by India had further worsened the situation. This was a major set-back indeed. The economic loss by the blockade by India was three times more than the loss caused by the earthquake.

6. International Cooperation and Disputes

On 26 April 2015, the Government of Nepal declared an emergency in the worst affected districts and made a request for international humanitarian support. Due to some of inaccessible landscape and difficult terrain in Nepal, it risks adding a human induced calamity to a devastating natural disaster. During the course of search and rescue efforts, an American helicopter crashed near the Nepal-China border resulting in the sad demise of five American soldiers, two Nepali soldiers and five injured earthquake victims.

There were also some misunderstanding between Nepal government and the international community for some time right after the earthquake. The only international airport at Kathmandu was over crowded by various aircrafts. In the meantime, the British government wanted to bring Chinook helicopter for rescue and relief assistance and the Government of Nepal declined the assistance due to the lack of space at the airport. Hence, the British Government was not happy for not being allowed to send its helicopter in Nepal. On the other hand, the donor communities didn't fully trust the government; questioning its ability to deliver services. At the same time the government wasn't happy because the donor communities wanted to distribute relief assistance directly through their agents. On the other hand, Nepalese government wanted any assistance to be collected into the Prime Minister Relief Aid Fund and then channel to the affected areas. In fact, the government wanted to adopt one door policy. However, the relationship between the Nepal Government and International Community did improve as time passed.

7. Foreign Aid Commitments and the Ground Reality

There was a donor community meeting on 25 June 2015 in Kathmandu, Nepal. The highest-profile international donor conference ever held in the country amassed more than 300 delegates from 56 nations, development partners and the donor community. In a major boost to Nepal's reconstruction and recovery efforts, development partners and the donor community pledged \$4.4 billion in aid. This has come as a huge relief to the reconstruction

and recovery bid and brought cheers to the government. However, till now, except a small portion, the committed amount has not been provided by the international community to the Government of Nepal.

8. National Reconstruction Authority (NRA)

The post-earthquake reconstruction could not gain momentum immediately due to institutional constraints and the lack of adequate resources. At that time there were no elected representatives of people at local levels and the lack of clear policies and procedures also slackened the speed of reconstruction. Therefore, to tackle this situation -- in 25 December 2015, National Reconstruction Authority (NRA) was established for a period of five years to lead and manage the reconstruction and recovery of the earthquake. The overall goal of NRA is to complete the reconstruction works damaged by the earthquake, and to promote national Build Back Better (BBB) interest. NRA has formulated a Post Disaster Recovery Framework (PDRF) (2016-2020) on the basis of Post Disaster Need Assessment (PDNA) report of National Planning Commission (NPC). The government has allocated adequate budget for reconstruction and recovery activities. Similarly, almost all of the affected families have received grant on installment basis to reconstruct their damaged houses. Most people have taken ownership of this reconstruction campaign.

The NRA signed the government's private housing grant agreement with 782,979 beneficiaries, out of which 497,133 have completed rebuilding their houses while 196,969 houses are currently under construction as of 2 June 2020. Out of the 7,553 earthquake-damaged schools, 3613 have been rebuilt, and 1719 are under construction. Similarly, out of the 379 damaged public buildings, 220 have been rebuilt and 147 are under construction. Likewise, out of the 753 damaged cultural heritages, 100 have been reconstructed and 329 are under construction. In the same way a number of health institutions, security buildings and drinking water systems have been reconstructed and some of them are under construction.

9. Methodology of the Study

From May to July 2015, a field survey was carried out in various parts of the two cities of Kathmandu valley namely; Kathmandu and Lalitpur. A total number of 250 persons affected by the earthquake were interviewed by using a well-structured survey questionnaire to see the impact of earthquake in their personal, family and daily lives. To take the interview, the Street Intercept method was used. The interviewed persons were selected randomly. Mostly the household head were the main responders. However, the other family members also participated during the interview and assisted in answering the questions. The questionnaire focused more on the loss of human lives, injuries, types of physical infrastructure damage and the impact of the Gorkha Earthquake 2015 on their economy, family, daily and personal life. Chi-square tests and logical regression were used to find out the correlation between the above issues and aspects. The interviewees were from different households and each of them had their own individual house.

Besides the individual interview of the above mentioned 250 persons various other secondary sources of information from government and other means was used to supplement the primary data and to see the socio-economic and other impacts of the earthquake.

10. Discussion and Results of the Study

Among the 250 responders 90 persons were fully aware and 160 persons were partially aware of the causes and consequences of the earthquakes and other disasters. Houses of the 50 persons were fully damaged and the houses of the 200 persons were partially damaged. Most of them were middle class people. The types of losses e.g. loss of the family members, physical injury and property losses of the responders were common or similar among them. 12 persons among the 250 responders were in traumatic situation due to the shock of the loss of family member(s), severe injury, and entire property damage. Mostly the nightmare and traumatic situation caused by the disaster was serious among the elderly, children and adolescents. Disruption in the education and livelihood of the students and wage earners was one of the major worries of the responders and their children.

All most all responders had some knowledge about the need and importance of earthquake resistant building, but their houses were mostly old and non-engineered. So their buildings were not earthquake resistant. Hence, the study results show the need of the construction of earthquake resistant infrastructures, because the weak structures have been found as the major cause of infrastructure collapse in the Gorkha earthquake which caused enormous loss of human lives and physical properties.

Majority of the responders were unhappy about the relief material distribution mechanism. They were telling that there was unfair distribution of relief package.

Sadly, this earthquake and the resulting education gap will afflict the affected peoples disproportionately in dense urban centers with *socioeconomic* disparity.

In addition to the economic loss, the affected people had the physical, mental and other societal problems. There were psychosocial consequences of that devastating earthquake disaster. Hence, the government should take necessary measures to address the above issues. The current findings highlight the need for further research to see the detail ramifications of the above problems.

On the basis of the response of the 250 responders and the secondary source of information, following challenges, gaps and lessons or way forward have been presented below:

11. Challenges, Gaps, Lessons Learnt and Way Forward

The residual impact of the 2015 Gorkha-Nepal Earthquake is still going on. The nightmare and traumatic situation caused by the disaster upon many people particularly among the elderly, children and adolescents is still there and may remain for a prolonged time.

The following challenges and gaps were identified after the earthquake:

- 11.1 Nepalese people showed resilient capacity to respond and self-recovery from the earthquake. However, more investment on community preparedness is crucial to build resilient communities.
- 11.2 In post-earthquake recovery and reconstruction, addressing the issues of land ownership and entitlement was found as a complex issue that needs to be addressed. Government compensation package settled for land entitlements deprived many disaster survivors' families from getting the government aid.
- 11.3 Education sector is the second most affected sector hit by the earthquake in terms of damages. The education sector needs more investment and rigorous policies to ensure their disaster resilience.
- 11.4 Search and Rescue (SAR) works carried out by the security personnel of Nepal and foreigners was commendable. But it was slow and inadequate while they failed to reach in due time in the remote, rural and hilly areas and it was not well-organized. Of course, sometimes it was compounded by the lack of equipment, road network, transport, and well-trained and skilled human resources.
- 11.5 Delay and serious lapse in damage and need assessment was felt all the time. There was a gap between the need of the affected people and delivery of *quality* services.
- 11.6 Open spaces for temporary settlement of the displaced population were not adequate.
- 11.7 Although there were a number of international SAR teams -- they could not contribute considerably as expected. There were 4,521 team members from 34 countries but they were able to save only 16 lives that also with the help of Nepalese security personnel. The performance and outcome of the foreign team was quite low in comparison to the investment upon the foreign teams.
- 11.8 Emergency warehouses, prepositioning of relief materials with proper inventory were also lacking.
- 11.9 Debris management was found as one of the big problems basically because of the lack of debris management equipment, tools and techniques.
- 11.10 Accurate and proper communication between District Emergency Center (DEOC) and Central Emergency Operation Centre (EOC) was not effective.
- 11.11 A weak database and an absence of modern technology were other limitations for effective response.
- 11.12 Lack of training for professionals in earthquake resistant construction practices and absence of licensing system for engineers and masons was evident.
- 11.13 Long administrative and/or official process between the government and donor agencies slowed down the response works.
- 11.14 Lack of awareness, preparedness and response capacity as well as coordination among disaster management stakeholders was felt from time to time.

The biggest lesson Nepal learnt from this earthquake is that the threat of earthquakes will never end while Nepal is in seismically very active zone. The best way to be safe from earthquake hazards is to build earthquake resistant infrastructures. There should be no COMPROMISE in building earthquake resistant infrastructures. Hence, this is high time to Build Back Better (BBB) and to ensure that existing structures and infrastructures are retrofitted to better standards.

12. Recommendations

In view of the major disasters like the devastating earthquake of 25 April 2015, Nepal should adopt long-term and sustainable efforts to mitigate the hazards. Although disaster management and risk reduction may be considered expensive in the light of competing demands for resources in a developing country like Nepal, this is high time for the government to invest on considerable activity and resources into preparing for and responding to familiar and unexpected emergencies and disasters before the human and economic consequences of inaction are extensive, unmanageable and more expensive. This paper suggests some basic principles and guidelines to reduce the impact of the potential future earthquake disaster not only in Nepal but also for other earthquake prone countries as well. Following are the basic and fundamentals for earthquake management in Nepal:

- 12.1 *Construction of earthquake resistant infrastructures:* All most all casualties during the earthquake were due to the collapsed infrastructures. It was found that there is weak law enforcement and poor monitoring of building codes and town planning. Therefore, it is highly necessary to ensure the construction of earthquake resistant public and private infrastructures. Specifically, the government must confirm that the town planning bye-laws and building codes have been strictly followed.
- 12.2 *Education curriculum:* It was also felt that due attention needs to be paid for the structural mitigation measures in the engineering education syllabus.
- 12.3 *Public awareness and preparedness programs:* Many people have no fair knowledge about the causes and consequences of earthquake and other disasters. Therefore, public awareness programs throughout the country through various levels of the government and private sector is desirable in order to let the general public know about the causes and consequences of disasters in human lives and assets. Lives would be saved by carrying out drill exercise to the school children in order to react in the event of an earthquake and in ensuring that at least school buildings are appropriately constructed to survive seismic shaking.
- 12.4 *People centric public policy:* In course of the formulation of the public policy on Disaster Risk Reduction (DRR), people centric approach should be adopted.
- 12.5 *Selective seismic strengthening and retrofitting of existing priority structures and lifeline structures* – a priority list for structural safety audit, seismic strengthening and retrofitting is required.
- 12.6 *Capacity development* through education, training, research & development (R&D), documentation and information sharing should be prioritized.
- 12.7 *Effective and efficient response and coordination during and after emergency:* It has been realized that in the past the government did not paid due attention to Disaster Risk Reduction (DRR). DRR has not been a priority for the government. The government was found too weak in preparedness at all levels. Inadequate legal instruments and poor implementation of existing legislations have also been identified as a factor for losses and damages. There was some weaknesses in planning, coordination and management among disaster management stakeholders during the response phase of the earthquake, which need to be improved in the future.
- 12.8 *Insurance policy:* Insurance is essential to support for the vulnerable communities or affected families at the time of post-disaster period.

12.9 Build Back Better (BBB): Build Back Better should be the motto to enhance the resilience of the country and communities by integrating disaster risk reduction measures into the restoration of physical infrastructure and social systems and into the revitalization of livelihoods, economies, and the environment.

The above basics are necessary to reduce the impact of earthquakes in the short-term as well as in the medium and long-term. They recognize the enormous challenge in improving seismic safety because of the inadequate numbers of trained and qualified civil engineers, structural engineers, architects and masons proficient in earthquake-resistant design and construction of structures. They also recognize the need for imparting training in earthquake-resistant design and construction to faculty members in professional courses and for creating mass awareness on earthquake and other disaster risk reduction features in non-engineered construction in earthquake prone areas.

13. Conclusions

As the impacts will affect landscape, people, society, and livelihoods in Nepal – there is no choice but to adapt to disasters. Living not only with earthquakes, but also with many other disasters in daily life is the destiny of Nepalese people. Yet, the Nepalese and their neighbors and friends all over the globe, have to reconcile themselves to the fact that tens of kilometers beneath where they live, the Indian and Eurasian plates will continue their tussle again and again. In that journey, they must build on the fundamental strengths they possess—social capital and community resilience. The earthquake is also as an opportunity to plan for a better preparedness for future disasters. Effective implementation of Building Codes to make earthquake resistant buildings and other infrastructures is highly desirable. Educating the people to Build Back Better (BBB) must be the priority. Hence, for BBB, the government should call on experts inside and outside the country to engage in interdisciplinary collaboration. Non-governmental organizations, the private sector, experts, intellectuals, media and international community can contribute in the rebuilding and disaster-preparation efforts by working collaboratively and effectively.

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