What WORKS is Earthquake Preparedness and Risk Reduction and NOT Earthquake Prediction: Lessons Learned from Nepal's Gorkha Earthquake of 2015

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ABSTRACT

The Nepal Gorkha Earthquake sequence of 2015, with a magnitude M_W 7.8 and with a maximum intensity of IX revealed all vulnerabilities and confined all possibilities on the need for a proactive approach, especially in developing countries. The following lists the major learning:

a) Main strategy for reducing earthquake risk is to stop building up vulnerabilities, reduce existing vulnerabilities, and prepare for residual risks

b) Poorly constructed non-engineered masonry buildings are the major sources of earthquake risk; a combination of traditional indigenous knowledge and modern science and technologies can help improve seismic performance of new as well as existing buildings,

c) Earthquake awareness and education are key elements in earthquake risk management; a good basic awareness on earthquake can dispel many unwanted myths and indulgence such as preoccupation on short-term earthquake predication

d) Schools are the best places to demonstrate the efficacy of earthquake risk reduction: messages on earthquake risk management and preparedness taught in schools gets propagated into the society by the process "from teachers to students – from students to parents, and - from parents to the community"

e) Prevalence of non-engineered buildings in developing countries demands special approach in vulnerability reduction and building code implementation – training of masons and petty contractors is as important as training and education of building engineers.

The Gorkha earthquake was "unusual" in terms of consequences. The death toll and building destruction was much lower than what was anticipated. There may be various reasons for this, however, persistent efforts on earthquake risk reduction in the past two devades was definitely a reason for this "lucky" end result.

Key words: *Gorkha earthquake, awareness, training, preparedness, earthquake risk reduction, masonry, non-engineered buildings, building code, school earthquake safety program*

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1 INTRODUCTION

1.1 General

Nepal faces a multitude of natural hazards: the Natural Calamity (Relief) Act 2030 (1982) lists earthquake, fire, storm, flood, landslide, heavy rain, drought, famine, epidemics, and events such as industrial accident or explosion or poisoning as "disaster". The corresponding risk in terms of human casualty as well as loss of assets is extremely high because of the high levels of existing physical and social vulnerabilities, and also due to continued building up of vulnerabilities, and lack over the years of any systematic hazard preparedness (MOHA 2011; MoHA 2015).

Disaster risk management was not a priority in Nepal until after the 1988 M6.6 Udaypur Earthquake and the 1993 floods. After these events, in 1993 the 1st National Conference on Disaster Management developed the first national plan for disaster management, and between 1992-94 the government developed the National Building Code. International initiatives such as the International Decade of Natural Disaster Reduction (IDNDR 1990-1999), as well as earthquake events in neighbouring countries have also encouraged Nepal to address disaster risk management seriously. In preparation for the 1st United Nations World Conference on Disaster Reduction, the Nepal government developed and later enacted the National Action Plan on Disaster Management (NAP)[2].

In this course of events, the National Society for Earthquake Technology – Nepal (www.nset.org.np) was established in 1993 by a group of Nepalese professionals related with building code development process, largely in response to the significant global paradigm shift to a proactive approach to disaster risk reduction. NSET's aim was to help the government of Nepal and the people in future earthquakes and to help implement the National Building Code. NSET focused on conceptualizing, designing and implementing simple and doable risk reduction initiatives that centred on enhancing earthquake awareness and risk perception of people (NSET 2002). NSET absorbed international knowledge on hazard and risk of Nepal, contextualized the global knowledge to the local conditions, translated the scientific knowledge into simple everyday language, and disseminated the knowledge using community schools, teachers, students and leaders of society (NSET 2001; NSET 2002, NSET 2009). Thus, from the very beginning, NSET's works linked people and their aspirations for safety with scientific knowledge on one hand, and with the government's policies in disaster risk reduction. For example, NSET simplified the complicated concepts associated with the national building code and began to convince people of the benefits of its enforcement. This was an uphill and long term task.

The usefulness of the initiatives and innovativeness of NSET's long-term efforts were tested by the Mw 7.8 Gorkha Earthquake in 2015. In this condition of immense shock, we are proud of the positive impact of the earthquake risk management efforts implemented by NSET and national and international partners, and the efficacy of the approaches, philosophy and methodologies adopted in Nepal in the past 24 years. The Gorkha earthquake sequence has provided enough proof of the fact that understanding the risk, implementing risk reduction initiatives at individual and household to community levels and to be prepared for residual risk is much better a strategy than only talking about the hazards and risks.

This paper aims to provide an introduction to the earthquake hazards in Nepal, a brief on history of the earthquake risk management efforts made in Nepal by NSET and other stakeholders and how these works helped Nepal to face and manage the Gorkha earthquake sequence of 2015, which also helped us to better understand the earthquake vulnerabilities and to look forward to long term

2 Nepal developed the National Action Plan (NAP) for Disaster Management based upon a series of expert consultations and Nepal Government presented the NAP to the UN World Conference on Disaster Reduction, Yokohama, 1994. The government of Nepal in 1996 formally adopted the NAP.

earthquake risk reduction by building back better not only in earthquake affected districts but also in areas likely to be impacted by future earthquakes.

1.2 Incorporating the Understanding of Seismic Hazard and Risks in the National Building Code of Nepal

Modern knowledge on earthquake hazard in Nepal started with the survey of the effect of the devastating M8.3 Bihar-Nepal Earthquake of January 1934 (Rana 1935, Auden 1937, Dun et al. 1939). While Major General Rana, a Nepali administrator with scientific acumen, gave detailed accounts of casualty and damage due to the 1934 earthquake and for the first time, indicated the high seismic risk in Nepal and suggested methods of constructing earthquake-resistant residences to minimize this risk, the social memory of the devastation faded quickly over the years. Only In 1978, the Department of Mines and Geology (DMG) started a systematic study of earthquake hazard by establishing the National Seismological Centre (NSC) that uses a nation-wide network of short period seismographs, accelerometers, GPS instruments, and conducts geologic studies such as earthquake intensity surveys and active fault trenching (Sapkota et al 2012; Pandey et al 1995; Pandey et al 2002; Sheehan et al. 2008; Dixit et al 2015; Bettinelli et al. 2008; Lave et al. 2005; Monsalve et al. 2006; Adhikari S. R et al. 2016; Rajaure et al. 2016; Rajaure et al. 2017; Adhikari et al. 2015; Gualandi et al., 2015).

Another milestone in understanding seismic hazard of Nepal was the Seismic Hazard Assessment and Risk Evaluation conducted under the Nepal Building Code Development Project (BCDP, 1994) that prepared a consolidated earthquake catalogue for Nepal, inventoried the reported active faults, and developed the probabilistic seismic hazard maps (Fig. 1) that served as the basis for the formulation of the National Building Code (NBC) of Nepal. For the first time, the country learned about the high earthquake risk and objectively realized the need for conjunctive efforts towards earthquake risk management.

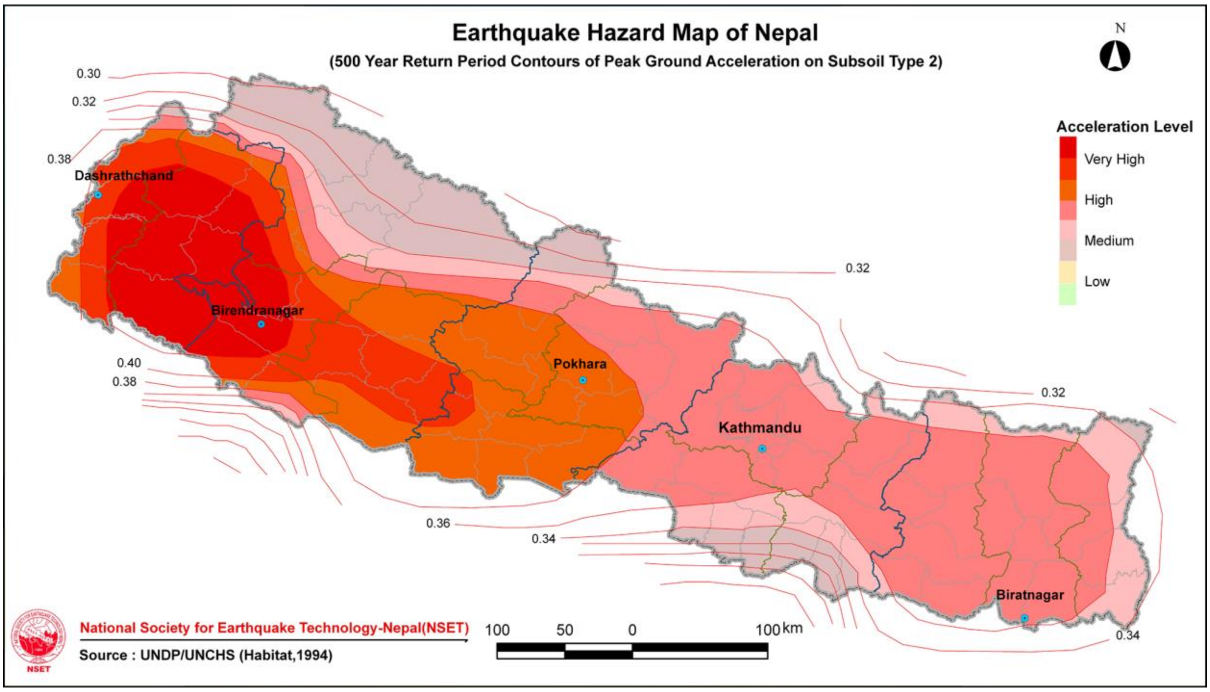


Figure 1: Probabilistic Seismic Hazard Map of Nepal showing PGA values with 10% probability of exceedance in 50 years (BCDP, 1994, recolored and redrawn by NSET)

The NBC (formulated in 1994 and approved in 1998) recognized the prevalence of non-engineered buildings that used traditional construction materials such as bricks and stones in mud or cement mortar and adopted a unique approach by establishing four different criteria of standards for four different types of buildings, namely:

a. Standards for the construction of modern and large State-of-the-Art Buildings, mainly in urban areas,

b. Standards for Engineered Building Design and Construction in urban and urbanizing areas,

c. Mandatory Rules of Thumbs for Low Rise Residential Buildings, in urban and urbanizing rural areas,

d. Guidelines for Rural Construction

By adopting these criteria, NBC aimed to improve seismic performance standards for 100% of the building stock of Nepal, including the majority of private residential buildings less than 3 stories high or less than 1,000 square feet of plinth area, and the rural 1-2 stories mud-based or timber-based constructions. In a context where there had been no implementation of the NBC, a cautious initiation of the NBC was initiated, thus moving from nothing to something. The NBC was the beginning of a process to gradually move from a non-engineered level in Nepal to pre-engineered or semi-engineered level, and then finally to a 100 % engineered level for significant structures in at least the metropolitan areas (Parajuli et al, 2000).

1.3 The Gorkha Earthquake of 2015

The massive M7.8 Gorkha earthquake occurred on Saturday 25 April 2015 with an epicenter located near Barpak, about 150km northwest of Kathmandu. The rupture propagated eastward and an M7.6 aftershock occurred on May 12, 2016. The earthquake triggered avalanches in Mount Everest region and in the Langtang valley. Villages were flattened and people were made homeless across31 districts, with 14 districts suffering the highest impact. Infrastructure was damaged throughout the earthquake zone. Historic neighborhoods and heritage sites were destroyed in the Kathmandu Valley. As a result of the earthquake, 8,790 people died and more than 22,300 people were injured. Assessments showed that at least 498,852 private houses and 2,656 government buildings were destroyed. Another 256,697 private houses and 3,622 government buildings were partially damaged. In addition, 19,000 classrooms were destroyed and 11,000 damaged (NDRF, 2016???). The devastation was great in rural areas and some urbanizing settlements along the northern axis from the epicenters of the main and the aftershock of May 12, 2015. In Kathmandu, the devastation was well below expectation – partly because of the long period nature of the seismic waves against the low heights of the majority of the buildings, low intensities of shaking, and also due to the "lucky" timing on Saturday when the schools were closed and people were in their full consciousness. Damage to the critical facilities including the only international airport was minimal without significant disturbance to the services.

It was the largest shaking in the country after the 1934 Nepal Bihar Earthquake. Apart from the casualty, social, and psychological impacts, the earthquake badly impacted on the geological and geotechnical conditions, lifelines, private and public buildings, hospitals schools and other public services, cultural heritage and historical monuments.

The earthquake vividly demonstrated the inherent resiliency of Nepalese people and society, and also the benefit Nepal accumulated because of the persistent efforts of the government and the people in planning and implementing organized approaches for earthquake risk management starting from the efforts to formulate the national building code and implement earthquake awareness measures such as the annual Earthquake Safety Day since early 1990s.

2 EARTHQUAKE RISK MANAGEMENT EFFORTS IN NEPAL IN THE PAST TWO DECADES

2.1 Start Up Earthquake Risk Reduction Program of Nepal

The Kathmandu Valley Earthquake Risk Management Project (KVERMP); implemented by NSET in 1997-1999 in close collaboration with GeoHazards International (GHI) and the Asian Disaster Preparedness Center (ADPC) and in partnership with the US Office of Foreign Disaster Assistance (OFDA) was another milestone program that included: 1) development of an earthquake scenario and an action plan for earthquake risk management in the Kathmandu Valley, 2) a school earthquake safety program, and 3) awareness raising and institutional strengthening (Dixit, Dwelley-Samant et al. 2000).

The simple earthquake scenario developed by KVERMP simulated a repeat of the 1934 level of shaking in Kathmandu Valley, and estimated that approximately 60% of all buildings in Kathmandu Valley would likely be damaged heavily, almost half of the bridges in the valley would be rendered as impassable, and 10% of paved roads would have moderate damage, such as deep cracks or subsidence. Further, it estimated heavy damage to water supply system and other critical facilities such as electricity, telephony, hospitals and roads (NSETa, NSETb, Dixit et al, 2000). The loss estimation and a descriptive earthquake scenario helped much to communicate earthquake risk and its internalization as well as for motivating people and government to plan and implement organized approaches for earthquake risk management in the country.

2.2 Building upon the Lessons of KVERMP

KVERMP paved the way for the implementation of several milestone programs such as: the school earthquake safety program (SESP), annual earthquake safety days (ESD), mason training for earthquake resistant construction (MT), a program for enhancement of emergency response (PEER), community-centred disaster risk management program (CBDRM), municipality earthquake safety program (MERMP), public private partnership for earthquake risk management (3PERM), community level disaster preparedness and planning, and collaboration with the dense network of community and private FM radio stations to propagate earthquake safety messages. Figure 2 provides a glimpse of the various innovative initiatives implemented by NSET and the outputs achieved. There is an accelerated growth in implementation – the outcome in the year 2016 is significant in many cases as compared to the cumulative output achieved in the past two decades. More on NSET's works since 1997 can be learned from the publication Safer Society, 2014, and its web site www.nset.org.np.

2.3 School Earthquake Safety Program (SESP)

2.3.1 Introduction

SESP started with an assessment of seismic vulnerability of school buildings in Kathmandu Valley against the stipulations of the national building code, and upon finding that none of the approximately 1,100 school building complied to the code, NSET started exploring simple ways of improving seismic performance of existing largely non-engineered masonry buildings constructed of traditional materials such as adobe, brick and stones. The success of the first-ever retrofitted school building of Nangkhel of Bhaktapur was followed by an ever-growing interest of all stakeholders from the mason and petty contractors to the government departments and donor agencies including the local private sector business. SESP has evolved over the years to encompass the following components:

a. Seismic retrofitting and or earthquake-resistant reconstruction of the physical structures;
b. Seismic retrofitting of the non-structural elements;

c. Training to masons, carpenters, contractors, supervisors, engineering technicians, and building design engineers/architects on earthquake-resistant design and code-compliance construction technology and seismic retrofitting;

d. Earthquake awareness programs targeting teachers, students, community members, and government officials working in the educational system;

e. School disaster emergency preparedness and response planning, safe evacuation drill, first aid, and extension of earthquake awareness to the community.

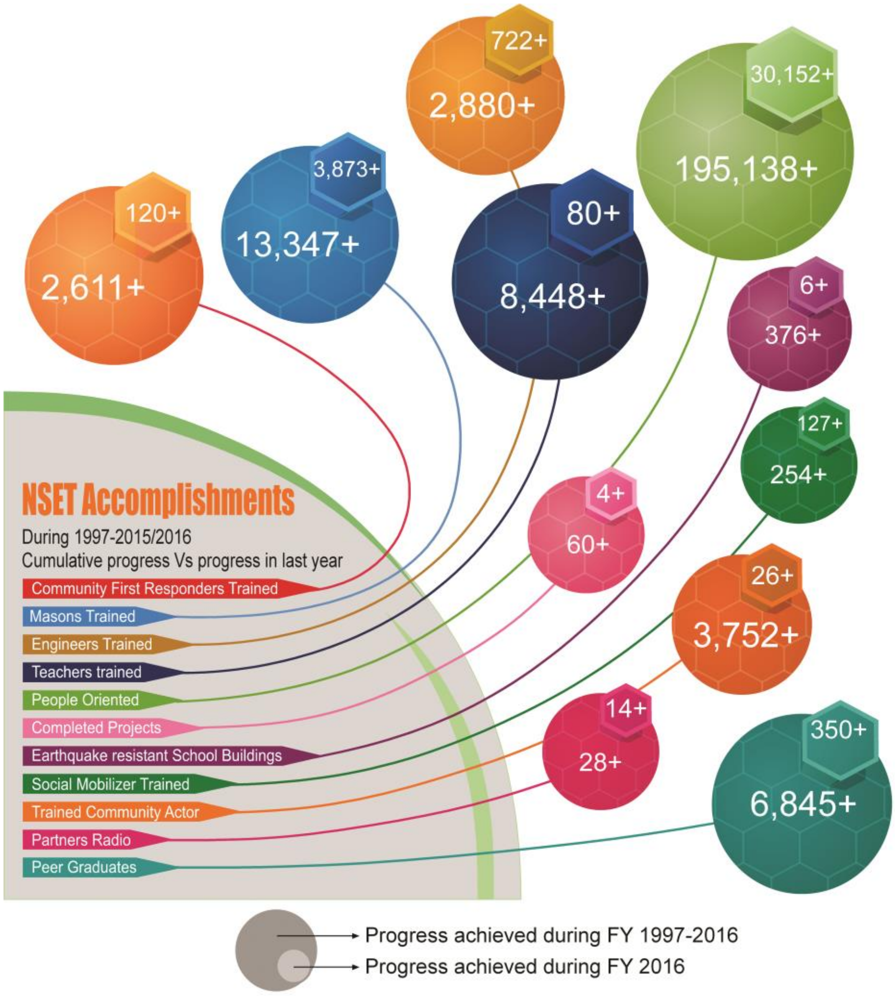


Figure 2: Earthquake Risk management efforts and achievements by NSET in Nepal in the past two decades

We believe that the following approaches and operational principles additionally helped enhance stakeholders' engagement in, and ownership of, the program:

a. Preferential use of local resources construction materials and respect to local building typologies and encouraging capacity building of local masons and contractors,

b. Fostering collaboration amongst government agencies, non-governmental organizations (NGOs), community based organizations (CBOs) and the business community by involving them in the decision making process at all stages;

c. Following strict technical and financial transparency: being always ready to answer the following questions –what is being done? How and who is doing this? Why it is being done? What time, technology and resources are required? How much resources on what aspect are being utilised?

SESP has at present become a regular annual program of the Ministry of Education: the number of school buildings retrofitted annually grew gradually from 3 per year by NSET to more than 150 per year after 2010 (ADB/GON, 2010). Subsequently, a national strategy for school earthquake safety was developed and enacted.

The following provide evidence of sustainability and institutionalization of school safety in Nepal:

1. School Safety has become "business as usual" for the Ministry of Education. Currently the school building retrofitting is running in 23 districts outside of Kathmandu Valley. There is a remarkable improvement in institutional capacity of the Ministry of Education's Department of Education (DOE) and the District Education Offices (DEO) for implementing SESP and for scaling up the program to the whole country. Almost all the pertinent staff have received training. A unit to deal with issues of Disaster Risk Management has been established in the Department of Education of Nepal Government. The following types of activities have become embedded into schools – earthquake drills, teacher training on school safety in a time of disaster, school emergency preparedness plans and retrofitting (as mentioned earlier).
2. There is significant increase in the number of agencies and institutions, both public and private, working in aspects of school safety. Similarly, the number of supporting partners, nationally and internationally, is on the increase. Many institutions have made school safety as their priority, many others have incorporated mason training as an integral component of their programs.
3. About 300 school buildings have been retrofitted after 2010 as part of the government–led program. 10,000 teachers, and 2,000 masons have been trained on aspects of school retrofitting and disaster preparedness; and around 500,000 students have been sensitized on methods of disaster safety. SESP has thus been firmly institutionalized in Nepal (NSET/GFDRR, 2010).

2.4 Building Code Implementation Program Nepal (BCIPN)

2.4.1 Introduction

The urban governance of Lalitpur and Dharan became the pioneers to announce and enforce the National Building Code (NBC) around the year 2003. It was difficult and the concept was new for all. However, these municipal government developed a comprehensive program for earthquake safety and special units within the municipal system that implemented earthquake awareness and helped people to understand the benefits of code compliance. NSET and other professional groups supported this initiative. By the year 2012, the need for building code implementation was realized by many urban and urbanizing settlements of Nepal, and the government approved NSET's proposal for providing technical assistance to 30 municipalities and three fast-urbanizing rural settlements to implement the building code under the program "Building Code Implementation Program for Nepal (BCIPN)".

BCIPN gradually evolved to include the following components:

a. Community awareness on i) earthquake risk and long-term benefits of complying to the code stipulations while constructing new buildings, ii) the need of earthquake preparedness and prepositioning of essential emergency materials such as a "Go Bag" rather than spend time and monetary resources on such apparently attractive indulgence as "earthquake prediction".
b. Capacity building of all stakeholders involved in building production process including the design engineers, materials traders and manufacturers, builders, petty contractors and masons, as well as the municipal organization responsible for issuing building permits.
c. Policy research and improvement for facilitating implementation of the national building code including a system of monitoring, reward and control.

NSET developed a three-pronged strategy for assisting municipalities enhance capacities in: a) awareness and risk communication, b) technical and institutional services, and c) policy improvements for institutionalizing the process. We helped with the following main activities, notably, i) development of a system of improved building permit process, ii) development of a mechanism for code compliance check in the permit process, and iii) development of a building code implementation guideline and a checklist.

Earthquake awareness initiatives and methods were developed and implemented differently for the various specific target groups such as social leaders, community groups, house owners and mothers' groups. Different training programs were developed for the different actors of building production, namely, engineers, technicians, masons etc. As a part of the strategy, clear outcome and impact level achievement indicators were set to make the monitoring and evaluation system more objective and an overarching target of full code compliance in a minimum of 70% of new buildings in program municipalities was established.

These synergetic efforts implemented by the 30 municipalities, mobilizing resources and efforts of NSET, local communities, local builders and masons, and stakeholders in the private sector, under the guidance of the Ministry Of Urban Development and the Ministry Of Local Development, was successful in bring about fundamental successes in improving risk perception and also in code compliance.

2.4.2 Changes in Risk Perception Over the Years

There has been a significant enhancement in the level of knowledge and positive attitude of the population in the BCIPN municipalities with respect to earthquake awareness. As of now, almost 2/3rds of household have acquired some knowledge about the ways of improving earthquake safety conditions of the household. A representative chart of such progression in earthquake awareness for Bharatpur municipality appears in the following Figure 3. Such significant enhancement of knowledge and attitude of the population created the conducive environment for compliance to the NBC, which is reported in the following section.

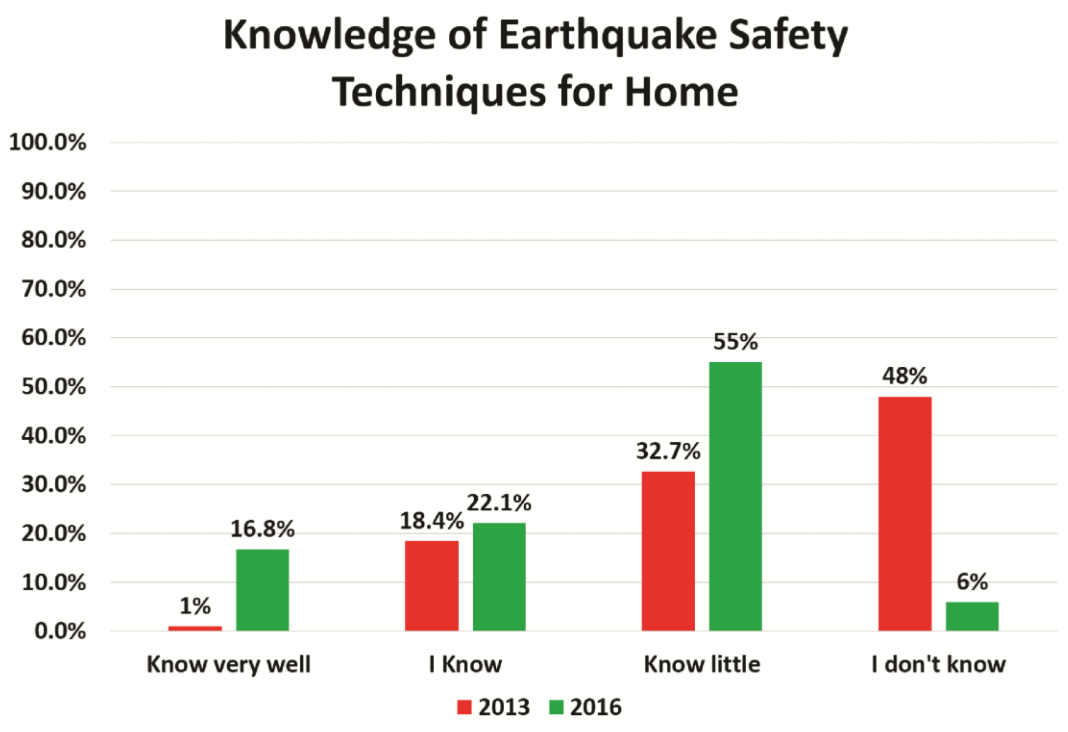


Figure 3: Change in knowledge level on earthquake safety techniques during 2013-2016 in Bharatpur Municipality[3]

2.4.3 Success in Code Compliance

Under the BCIPN, NSET and the respective municipalities focused on enhancing capacity in the municipal organizations in checking the drawings, submitted and conducting field inspection. After three years in this pursuit, NSET and the project municipalities conducted surveys to measure the success in achieving building code compliance using a methodology adapted after the USA and India methodologies that use three attributes of vulnerability, namely: building configuration in plan and elevation, strength of the building elements and materials, and the ductility of the structural elements. Weights were assigned to the individual criteria to make a cumulative total of 100. A total score of 20 or less is considered as code compliant, more than 20 and less than or equal to 30 as partially compliant / close to compliance, and scores over 30 considered non-compliant. The buildings designed and constructed in three time periods, 2012, 2014, and 2016, were analysed separately. The results in ten municipalities show encouraging results. For example, Figure 4, pertaining to Bharatpur municipality, shows a significant improvement in code compliance expressed in the quality of the drawings submitted, the building permit applications and, more significantly, in the way the building is actually constructed on site.

The quality of the building plan improved from a compliance rate of 4.2% in 2012 to a compliance rate of 86.9% in 2016. The progression of code compliance increased from a meagre 6.3% in 2012 to 53.8% in 2016 with non-compliance reducing from 81% to 23%. This is a real success. These results indicate that Nepal's municipalities can actually enhance the seismic performance of new buildings. Municipalities can achieve results if they are provided with technical assistance for capacity enhancement and for improvements in municipal institutional structure as well as in municipal policy and legal environments.

[3] Baseline Study Report on Risk Perception Survey in the municipalities; Building Code Implementation Program in the municipalities of Nepal (BCIPN), September 2015; an in-house report of NSET/BCIPN.

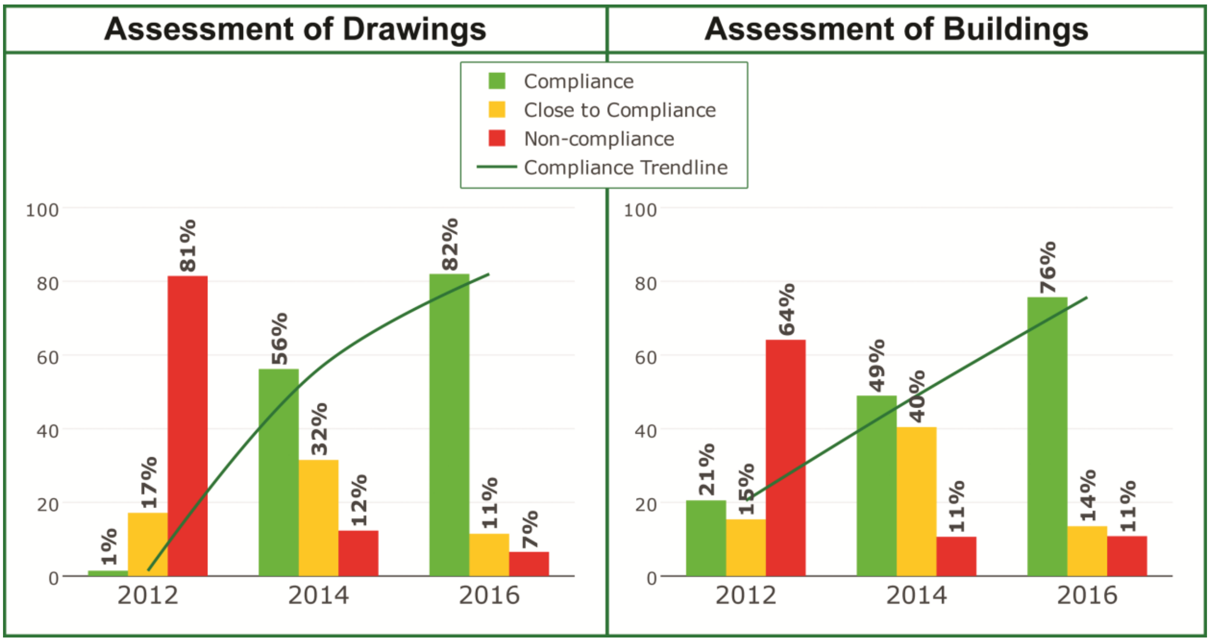


Figure 4: Building Code Compliance – the change in Bharatpur Municipality in the period 2012 to 2016[4]

2.4.4 Challenges for Institutionalizing Building Code Compliance

In the aftermath of the 2015 Gorkha earthquake, the demand on building code compliance has grown high: building back resilient more than 800,000 destroyed residential buildings within a time span of five years is a huge task. This equates to building more than 100,000 earthquake resilient houses per year in the 31 earthquake-affected districts. This is on the top of the national target of building code enforcement in about 25,000 new buildings per year in all urban settlements of Nepal. This demand has further increased because the government has made the compliance to the national building code mandatory for both rural and urban building constructions in Nepal.

The surge demands a corresponding enhancement in national capacities in design, construction, supervision and compliance checking and control. This in turn demands improving the policy and legal environments, increased efforts in formal and informal education, and enhanced capacity to learn from the on-going construction process to create the scientific basis for updating the building code. The need for scientific research in building construction materials, design and construction processes has also become obvious.

Its very encouraging to see that more and more urban as well as rural municipal councils of Nepal have made commitments to improve the building permit process by publicly declaring mandatory enforcement of the building code. Most of the municipalities have, to varying degree of success:

- Incorporated BCI as an important heading in the annual municipal planning with an allocated budget;
- Established a separate BCI unit within the municipal organizational structure allowing for recruitment of more building code technicians;

4 Building Code Compliance Assessment Report, 2017 – an in-house report of NSET/BCIPN

- Started an education program targeting the general population especially prospective house-owners who are considering constructing a house or repairing an old one. The programme focuses on the benefits and process of the national building code and building permits process;
- Started a registration and licensing system for local builders and masons.

2.5 Enhancement Of Emergency Response Capacities

2.5.1 Introduction

NSET also strived to work towards enhancing national and local capacities in emergency response and implemented two programs the Program for Enhancement of Emergency Response (PEER) and community-based disaster preparedness program in the past two decades.

PEER is a regional training program that was introduced to Asia in 1998 by the United States Agency for International Development / Office of U.S. Foreign Disaster Assistance with an aim to reduce disaster mortality by enhancing emergency response capacities of countries by institutionalizing standard training in Medical First Responder (MFR), Collapsed Structure Search and Rescue (CSSR), Community Action for Disaster Response (CADRE), and Hospital Preparedness for Emergencies (HOPE) and Swift Water Rescue (SWR) courses. PEER is geared towards development of a training system (curricula and training equipment) with the aim of developing national instructors who will be able to continue the training programs in national training institutions for formal national level emergency responders (Tandingan and Dixit, 2012).

NSET works under the direction of the Ministry of Home Affairs (MoHA, 2013) to implement the program. To date, PEER has trained more than 1,100 MFR-CSSR professional responders in Asia (NSET, 2015). Of these, approximately 245 are from Nepalese Army, Nepal Police, Nepal Armed Police Force and the Nepal Red Cross Society; all mandated with emergency first response tasks. Most of the PEER graduates/instructors have become catalysts in promoting PEER, designed similar training curricula for their organizations and have delivered similar emergency response trainings for their response personnel.

In addition to implementing the PEER training programs, NSET has also been conducting training programs on emergency preparedness at the grassroots levels: we impart training on Basic Emergency Response (BEMR), Community Search and Rescue (CSAR), Damage Assessment Trainings (DAT), Vulnerability and Capacity Assessment, Community Fire Response Trainings, developing and testing emergency response plans and prepositioning emergency supplies at different levels (Jimee, et al., 2012). So far NSET has provided earthquake preparedness orientation programs for more than 37,000 people, has produced more than 1,400 CSAR responders, more than 300 BEMR responders and more than 100 DAT graduates.

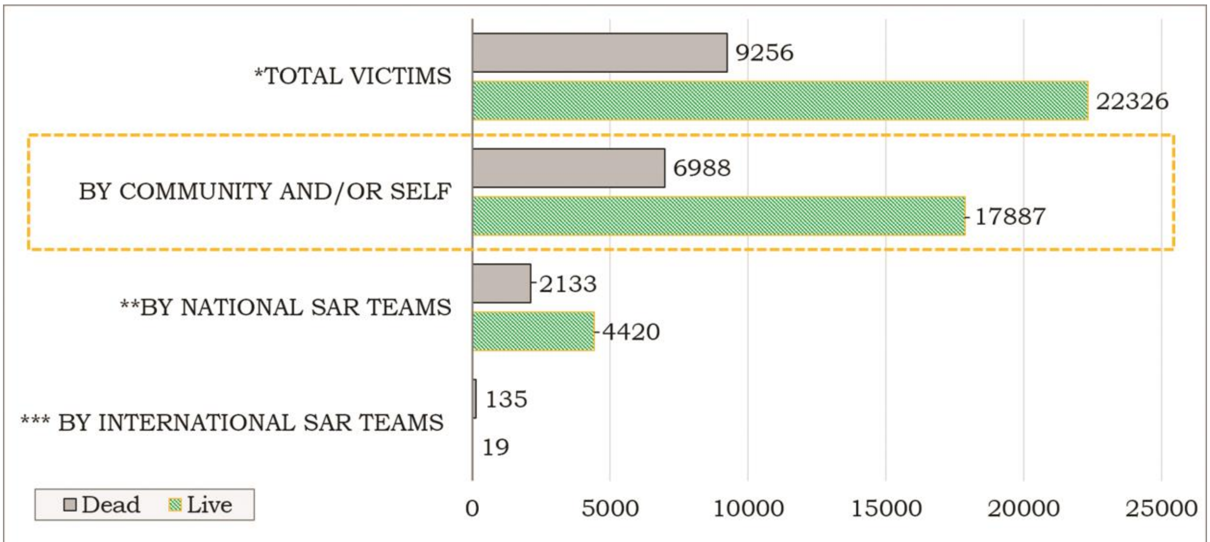
2.5.2 PEER Reflections in Gorkha Earthquake

The Gorkha earthquake inflicted huge damage, prompting the government to declare a state of emergency in a third of the country's territory. The 15 years of PEER investment in Asia was put to a test by this challenging episode in Nepal's history. We are proud that the national capacity developed in the past two decades and the national actions on emergency preparedness were crucial, albeit "not enough," for responding to the dire situation. Primary PEER partners in Nepal, namely, Nepalese

Army (Nepalese Army, 2015a, Nepalese Army, 2015b), Nepal Police, Armed Police Force (APF, 2015), Nepal Red Cross Society and NSET were all in full action thanks to years of preparedness during which PEER helped embed the basic SAR skills in local and national responders. PEER-trained professionals provided leadership to the trained or yet-to-be-trained security personnel to undertake search and rescue operations.

Due to this foundation, national responders were able to assist the international Urban Search and Rescue (USAR) teams, as they understood international SAR practice, guidelines, techniques, and the goals of searching for and rescuing victims using the safest techniques. It was obvious that the main difference in the work of the national responders' teams and the international SAR teams was the difference in access equipment, mainly the heavy-duty and more sophisticated SAR equipment used by the international teams. Some national response teams worked independently on-site and also assisted the international USAR teams with their understanding of the context and environment. The performance of the national responders, notwithstanding the problems of logistics, was commendable (Figure 5). Had the Gorkha earthquake occurred a decade earlier, the performance of SAR would almost certainly have been much less effective.

The Gorkha Earthquake once again revealed the importance and usefulness of community SAR volunteer responders. It was clear that community volunteers are in fact the first responders, and that they need to be trained in the training programs listed above together with the training of First Aid. Additionally, the earthquake also revealed the need to train security forces from the private sectors including those from tourism and travel business, industry, hotels, river rafting etc. a learning that NSET has been propagating for two decades.



*Source: *Nepal Police, 2 July 2015, **Reports by Nepalese Army, Nepal Police and Armed Police Force June 2015 ***report by Nepalese Army, June 16, 2015*

Figure 5: Extricated Victims and Recovered Dead Bodies by Different SAR Teams

(Source: Bret Lizundia et al., 2015)

2.6 The Gorkha Earthquake of 2015

The M7.8 Gorkha Earthquake was not unexpected. People of Kathmandu and Nepal were geared towards expecting a large event. However, it was not in active memory of people and the government.

The devastation was great in rural areas and some urbanizing settlements along the northern axis from the epicenter of the main shock on April 25, 2015 to that of the largest aftershock on May 12, 2015. In Kathmandu, the devastation was well below expectation – partly because of the long period nature of the seismic waves against the low heights of the majority of the buildings, low intensities of shaking, and also due to the "lucky" timing on Saturday when the schools were closed and people were in their full consciousness. Damage to the critical facilities including the only international airport was minimal without significant disturbance to the services.

It was the largest shaking in the country after the 1934 Nepal Bihar Earthquake. The impact was huge and people continued to be scared due to the frequent aftershocks. Apart from the social, and psychological impacts, the earthquake impacted on the geological and geotechnical conditions, lifelines, private and public buildings, hospitals schools and other public services, cultural heritage and historical monuments.

2.7 Search and Rescue

In Gorkha Earthquake 2015, as in many other earthquakes, Search and Rescue work was done largely by the community members. More organized Search and Rescue operations done by groups of responders belonging to the three national security organizations, namely the Nepal Army, the Armed Police Force and the Nepal Police. Red Cross mobilised huge number of volunteers and trained responders to work with community teams and security forces. NSET also mobilised squads of trained rescuers to assist operations of Security Forces in Kathmandu. Total 76 fully equipped and self-sufficient international SAR teams with a total of more than 4.300 responders quickly arrived Kathmandu via the international airport and assisted in SAR operations (EERI,2016; Nepalese Army, 2015 and APF, 2015 publications).

Remoteness of the impacted area with difficult terrain, damaged roads and poor accessibility as well as adverse weather hindered effective SAR. Lack of SAR equipment was another gap felt by all agencies. The newly drafted national disaster response strategy as well as the series of disaster simulations implemented by the government in collaboration with civil and military organization of friendly countries were very helpful in coordination and understanding the impact. Training of the national responders of Nepal and SAARC countries under the USAID/OFDA funded and NSET implemented Program for Enhancement of Emergency Response (PEER) helped maximize the efforts amidst limitations and coordinate efforts with international teams.

2.7.1 PEER Reflections in Gorkha Earthquake

The Gorkha Earthquake inflicted huge damage, prompting the government to declare a state of emergency in about a third of the country. The more than 15 years of PEER investment in Asia has been put to test during this challenging episode in Nepal's history. The national capacity developed in the past two decades and the national discourse and actions on emergency preparedness were found very handy, albeit "not enough," for responding to the situation.

Nepal PEER partner organizations mobilized response teams for SAR as commanded by the government. PEER trained professionals were providing leadership to the trained or yet-to-be-trained security personnel to undertake search and rescue operations. Primary PEER partners in Nepal, namely, Nepalese Army, Nepal Police, Armed Police Force, Nepal Red Cross Society and NSET were all in full action. Years of preparedness during which PEER helped embed the basic SAR skills in local and national responders; and because of this foundation, national responders were able to assist the international Urban Search and Rescue (USAR) teams as they had good understanding of international SAR practice, guidelines, techniques, and the goals of searching and rescuing victims using the safest techniques. It was obvious that the main difference in the work of the national responders' team and the international SAR teams was the difference in access to equipment, mainly the heavy-duty and more sophisticated SAR equipment used by the international teams. Some national response teams worked independently on-site and also assisted the international USAR teams with their understanding of the context and environment.

EERI (2016) reported the performance of the national responders, notwithstanding the problems of logistics, was superb. Had the same level of earthquake happened a decade earlier, the performance of SAR could have been much less effective.

The Gorkha Earthquake once again revealed the importance and usefulness of community SAR volunteer responders. It was clear that community volunteers are in fact the first responders, and that they need to be trained in the training programs listed above together with the training of First Aid. Additionally, the earthquake also revealed the need to train security forces from the private sectors including those from tourism and travel business, industry, hotels, river rafting etc. – a learning that NSET has been propagating since two decades.

2.8 Medical Response

With more than 25 hospitals and 1,000 other health facilities destroyed in the worst affected districts, the health cluster under the coordinating leadership of WHO and Ministry of Health conducted rapid assessments, coordinated deployment of medical teams including 131 Foreign Medical teams and establishment of including several field hospitals and primary care centres, and provision of health services delivery, outbreak surveillance, distribution of essential medicines and awareness on sanitation, and other diseases prevention works.

A review one year later stated that the health sector's response to the earthquake was rapid, well-coordinated and tailored to the needs of the affected population. The main lesson learned was that the retrofitting of the Kathmandu hospital and training of staff in mass casualty management and emergency response plans helped greatly in the background of more than 80 per cent of health facilities in the worst affected districts were destroyed. Strengthening emergency preparedness for disaster response including preparedness plans and training for all health facilities should be done at all levels across the country for which there is a need for stronger policies to ensure disaster risk reduction measures are implemented and all staff trained.

2.9 Relief

The Nepal government led the earthquake response largely through the Ministry of Home Affairs (MOHA) of the government of Nepal. Government led the relief and rehabilitation efforts by mobilizing national as well as international resources as stipulated by the Natural Calamity (Relief)

Act 1980. This included among others, a) financial support to the families with casualty and damaged or lost houses including conceptualization of Special Loans for Earthquake Victims, b) facilitating temporary shelters and relief camps for individuals and the community, c) Conceptualization of relief packages including National Reconstruction and Rehabilitation Fund (NRRF), d) development of an early plan for Rehabilitation and Reconstruction Plan backed by the NRRF, e) coordination of relief efforts by several national and international organizations and benevolent charities, conceptualization of the National Reconstruction Consultation Committee (NRRC), f) information management including collection of data and its dissemination g) maintenance of law and order, h) management of the Prime Minister's relief Fund, i) Formulation of PDNA, and j) Coordination of response by other line ministries including development of indicative list of priority relief items, issuance of Earthquake Victim Identity Card, concept for deployment of volunteers etc. Thus the government approached the response in a comprehensive way leading to the organization of the International Donors' Conference on earthquake reconstruction and rehabilitation in Kathmandu on 25 June 2015.

d. Responding to the concerns of the national parliament, the government put into effect an Integrated Action Plan for Post-Earthquakes Response and Recovery, 2072. Consisting of forty main work stream, some of which are listed below:

- Special focus on construction of temporary emergency shelters for special groups of people in the affected areas such as senior citizens, single women, families with diseased, pregnant and new mothers, people with disability.
- Provision of shelters and free education for orphans of earthquake victims.
- Classification of victims for providing support based on the level and nature of impact.
- Provision of free seeds and subsidies for fertilizers and tax exemption for affected farmers
- Review, updating and effective enforcement of National Building Code, 2060 and land-use policy.
- Organized demolition of damaged structure.
- Commitments to build a memorial to the Gorkha earthquake victims

2.10 PDNA

Nepal started a comprehensive assessment of the damages and losses caused by the earthquake for planning the earthquake recovery and reconstruction and developing the reconstruction strategy very soon after the emergency response was taken under control. Post Disaster Need Assessment (PDNA) was done with the support of Nepal's long standing development partners, the National Planning Commission of Nepal in collaboration with the government agencies as well as the civil society and non-governmental organizations, private sector businesses, and international donor agencies operating in Nepal. PDNA identified recovery needs, developed first cost estimates for these needs and recommended implementation arrangements. PDNA took a long term goal of enhancing national resilience to disasters, promulgated disaster risk reduction and Build Back Better as the cardinal principles, emphasized awareness raising, improvements in national DRR systems in the short, medium and long terms.

The Ministry of Federal affairs and Local Development (MOFALD) led the Early Recovery process in coordination with MOHA and other agencies of the early recovery cluster. The Earthquake Early

Recovery Programme focused on (i) Debris management, (ii) Reconstruction of community infrastructures, and (iii) Restoration of public service delivery. Emergency livelihoods and economic recovery is taken as a crosscutting issue that is to be considered as the central focus of all activities under these 3 pillars. The programme focussed on mobilizing grassroots level organizations such as Local Service Providers, Civil Society Organizations, Ward Citizen Forums and Citizen Awareness Centres under the overall leadership of the district and village level governing bodies. MOFALD developed the following guidelines for early recovery activities:

- Appropriateness to local context including cultural context,
- Long-term sustainability
- Directed towards strengthening existing local institutions and mechanisms (VDCs, Municipalities, DDCs, WCFs, CACs and other local government offices)

For the first time in Nepal, the government could organize post-earthquake building triaging in Kathmandu Valley and some other urban settlements by mobilizing professionals after a brief training.

NSET carried out detailed damage assessment of more than 200,000 earthquake-damaged buildings in Kathmandu and also in several districts and captured seismic performance of different building typologies at different intensities of shaking. This has yielded lots of information Nepalese building typologies, leading to formulation of fragility curves (Guragain, 2016).

Arranging for temporary housing was another area that the country managed without much controversies. The effort consisted of a) mobilizing human resources and financial support, b) technical support including definition of standard design and materials standards, c) provision of training for the construction of temporary shelter including toilets, water supply (water tank, water pipe, water reservoir, maintenance of water supply, assessment of safeness of water, temporary schools and health centres/health posts, d) provision of human, technical, and material support for the repair/renovation of the partially damaged houses and office buildings, e) establishing temporary work place for the local government institutions including assessment, repairs, human resources and office facilities, f) development and distribution of temporary ID card for those who lost it, g) continued governance assistance for example by establishing a public hearing desk at DDCs and municipalities and conducting regular public hearing, h) strengthening of coordination mechanism among international and national partners including NGOs, i) ensuring .child protection, gender, equity and social inclusion and compliance to international norms for several other cross-cutting issues..

Proven international practices such as cash for work, emergency livelihoods and economic recovery, equal opportunities of training for women, on-farm and off-farm activities, and establishment of institutional mechanism and training cash for work, and equal pay for equal work for women, (i) On-farm activities such as vegetable and other short-term farming, support for seeds and fertilizers, renovation of small-scale irrigation and other agro-infrastructures, and training on livestock and vegetable farming. (ii) Off-farm activities such as fast food production, weaving, bamboo crafts, small groceries, training on masons, plumbing, electrical and electronics good maintenance; and 5. Support to National Level ER Planning Given the large-scale impact of the earthquake in almost half part of the country; the recovery efforts would require engagement over a period of at least two to five years.

Lessons from the previous disasters' response such as Jure Landslide 2014 and Koshi flood 2011 show a significant g of human resources were done rather satisfactorily.

Unfortunately, concept of transitional shelter wa not very actively articulated in the society. This led to unrealistic expectation among the population as well as at the political leadership on the possibility of provision of shelter before “the next monsoon” or “before the next winter”.

2.11 Key Lessons Learned from Response to Gorkha Earthquake

The following could be considered as the main lessons learned from emergency response to Gorkha earthquake.

1. Preparedness paid. Preparedness initiatives undertaken by the government agencies were helpful for the government and the people in facing the earthquake and organizing response.
    a. The government could handle more than 60 international Search and Rescue (SAR) teams from different countries. Preparedness efforts towards multinational coordination, civil-military synchronization, simulation planning and joint disaster drills carried out in the past were instrumental for the state of disaster preparedness of our security agencies - despite serious lack of resources and prior experiences of handling disaster of such magnitude, the government could take over effective control and managed the situation adequately. The National Disaster Response Framework (NDRF) and the experience of developing district disaster response plans in almost all of the 75 districts and the Local disaster risk management plans in several districts and village development committee also helped in this.
    b. Training imparted to the three securities agencies in Medical First Response (MFR), Collapsed Structure Search and Rescue (CSSR), Hospital Preparedness for Emergencies (HOPE), Dead Body Management (DBM), and a host of community based disaster risk management programs by several national and international partners were extremely helpful and prepared the players to home into the tasks quickly after the earthquake.
2. The Cluster system did work: The cluster system which encouraged preparedness sector wise helped a lot by quickly activating with response in their respective areas. The Shelter cluster could muster the strengths with the members and helped the government in providing advices, emergency action for providing immediate shelter to the population affected. Similarly, the Education cluster quickly took stock of the situation and developed concepts of temporary, semi-permanent and permanent learning centres and helped government muster resources to construct these so as to restart disrupted education process at the earliest.

Disaster awareness initiatives implemented in Nepal and organized efforts of Nepal Government especially since the UN Yokohama World Conference on Disaster Management, and the country’s active implementation of the Hyogo Framework of Action as well as the commitments made towards fulfilment of the Sendai Framework for Disaster Risk Reduction (SFDRR) as well as other global initiatives such as SDGs and Climate Change adaptation did help in enhancing peoples’ perception of risk and made them at least mentally prepared for impending disasters. During the Gorkha earthquake, people were scared but kept calm, and no panic or looting issued, which indicated an enhanced understanding of the hazard and trust to the government among the population had strengthened. Because of certain level of preparedness, the government started managing the disaster immediately after the event within its capacity. The earthquake, did however, reveal serious lack of capacity in terms of pre-positioning of SAR and other heavy equipment, food and non-food items, and readiness of a functioning voluntary system.

3 RECONSTRUCTION

The earthquakes of 25 April and 12 May 2015 in Nepal affected almost half of the country including isolated mountainous areas causing approximately 9,000 people lost their lives and more than 22,000 people injured. Rapid visual damage assessment, detail damage assessment and post disaster needs assessment were conducted after the earthquake. The Government of Nepal formulated the Act Relating to Reconstruction of the Earthquake Affected Structures 2015 and National Reconstruction Authority was established. Post Disaster Recovery Framework developed and reconstruction is started. This section summarizes the lessons from damage assessment, highlights the key strategies of the Post Disaster Recovery Framework and describes a program for technical assistance to housing reconstruction and its preliminary lessons.

3.1 Damage Assessment

The Post Disaster Needs Assessment (PDNA) conducted by the Government of Nepal shows widespread destruction of housing and human settlements resulting nearly 500,000 houses destroyed and more than 250,000 houses partially damaged (PDNA, 2015). The PDNA shows total loss of 7 billion USD by the earthquake and about 3.5 billion USD is from housing sector. This indicates the significant volume of reconstruction is in housing sector and proper understanding of buildings damage was necessary formulation of housing reconstruction strategy.

The main typologies of buildings in the affected area are stone masonry with mud mortar, some buildings with stone and brick masonry with cement/sand mortar and few reinforced concrete buildings with masonry infill. Figure 1 shows the building typology distribution in 31 districts which were affected by April 25, 2015 earthquake in Nepal. It shows that about 58% of the buildings are mud based masonry, i.e. stone in mud, adobe or brick in mud; 21% are cement based masonry either stone with cement-sand mortar or brick with cement-sand mortar and about 15% are reinforced concrete with masonry infill. There are other types of buildings that are only about 6% (CBS, 2011). Among the damaged buildings, about 96% of the buildings were masonry and about 4% reinforced concrete buildings with masonry infill based on preliminary analysis conducted for preliminary damage and need assessment (PDNA, 2015).

Just after the earthquake, though mainly in Kathmandu valley, many organizations provided rapid visual assessment of the buildings and suggested people on possibility of continue using the buildings or evacuation is required. However, the information on possibility of repair/retrofit or demolition was not covered by the rapid visual assessment.

NSET conducted detail damage assessment of over 150,000 buildings in 12 different municipalities of different locations from high intensity to low intensity of the Gorkha earthquake impact. The survey covered 100% of the buildings in the surveyed locations and the Fig04.1 6 shows the distribution building typology versus damage grades.

“insert Fig04.1 Here”

Fig04.1 : Overall Damage Grade Distribution vs Building Typology

Damage assessment result shows that the damage was focused in rural area for non-engineered masonry buildings like stone in mud and brick in mud especially in rural areas where there is limited access to engineering professionals.

3.1.1 Key Lessons for Reconstruction from Damage Assessment

Following key lessons can be drown analysing the damage statistics:

Focus on appropriate technology: Most of the buildings damaged during Gorkha earthquake are masonry non-engineered buildings. It is difficult to transport modern construction materials in remote areas. Even in recent years, people are constructing stone in mud buildings. So, it is important that the reconstruction techniques should cover stone in mud buildings with proper use of locally available materials for disaster resistance.

Technical Assistance is key for safer construction: Widespread damage of non-engineered buildings indicates that the construction workers are not known about the earthquake resistant techniques. So, it is recommended to plan a massive training programs and plans for training of existing masons. At the same time, it may require to train new masons, as the need for reconstruction is many times more than regular construction.

Comprehensive program considering different aspects of technical support is important: The technical support should be comprehensive covering awareness of homeowners, capacity building of construction workforce and support on system development at the local governments to establish a system of compliance check during reconstruction. The awareness of homeowners can help create demand for safer construction, as homeowners will control the construction of houses. The trained construction workforce will supply the demand and the local governments can make the process more sustainable through the system in place.

3.2 Reconstruction Act and Establishment of National Reconstruction Authority (NRA)

The Government of Nepal Legislature Parliament enacted the Act Relating to Reconstruction of the Earthquake Affected Structures 2015 in December 20, 2015 (Nepal Gazette, 2015). The Act provisioned establishment of National Reconstruction Authority with clear functions, duties and powers. The act also formed National Reconstruction Advisory Council prime minister as the chairman and several members including relevant ministers as members. Steering committee and executive committee with clear duties and responsibilities were also formed.

3.3 Post Disaster Recovery Framework

The Post-Disaster Recovery Framework (PDRF) was prepared under the leadership of the NRA, in consultation with key stakeholders aiming to provide a systematic, structured and prioritized framework for implementing recovery and reconstruction (PDRF, 2016). It is prepared as a common framework meant to serve all of government, as well as national and international partners and other recovery stakeholders. The PDRF outlines five strategic recovery objectives that are listed as (PDRF, 2016):

1. Restore and improve disaster resilient housing, government buildings and cultural heritage, in rural areas and cities

2. Strengthen the capacity of people and communities to reduce their risk and vulnerability, and to enhance social cohesion
3. Restore and improve access to services, and improve environmental resilience
4. Develop and restore economic opportunities and livelihoods and re-establish productive sectors and
5. Strengthen capacity and effectiveness of the state to respond to the people's needs and to effectively recover from future disasters

3.4 Baliyo Ghar a Program of Technical Support for Housing Reconstruction

In the wake of the April 25 earthquake and its subsequent aftershocks, the GON has identified the huge need and demand of trained human resources to complete its goal of "Building Back Safer". The Housing Reconstruction Technical Assistance Program (Baliyo Ghar) program is an initiative to support the government's goal by providing technical support on a wide range of activities implemented by NSET and supported by USAID. The objective of the program is to ensure disaster-resilient construction of houses through awareness, training, demonstration and support on code compliance. The program duration is for five years from October 01, 2015 to September 30, 2020.

The "Baliyo Ghar" intends to develop disaster resilient construction guidelines and training curricula, train construction workforce and implement awareness campaign; leading to standard national resources for training and awareness, enhanced local capacity, and changed perception of communities towards safety; thereby supporting on disaster resilient earthquake reconstruction and finally contributes towards making disaster resilient communities in Nepal.

The following are the main guiding principles for Baliyo Ghar Program:

- Country-led policies and processes
- Strategic planning, standardized implementation and involvement of all stakeholders.
- Inclusion and access
- Integrating DRR
- Flexibility and context specific approaches

With these guiding principles, the program is assisting mainly in three areas of work. A) Support on policy formulation and development of curricula and guidelines at the central level: the program supported development of Fund Disbursement Guidelines, developing Information Booklets, Posters and Pamphlets related to the grant distribution. Baliyo Ghar contributed in preparing Standard Operating Procedure (SOP) for building inspection; manual for inspection, Technical Posters incorporated 10 Tips for Earthquake Resistant, development of 7-days masons training curricula for urban and rural masons etc. B) Capacity Development: the program trained more than 1100 engineers as potential trainers, more than 4000 masons trained on earthquake resistant construction, and trained about 200 social mobilizers who continue providing orientation to people. C) Awareness and House to house support: the program reached to about 50,000 people through direct orientation on need and possibility of resilient construction.

3.5 Preliminary Lessons from Reconstruction

By the one and half years of implementation, there are some issues that are noted as important lessons for consideration in the coming years.

- There is 10-20% of reconstruction of housing after one and half year after the start of reconstruction. The compliance rate is much higher in the area where the comprehensive technical assistance is provided in comparison to the areas where there is no technical assistance.
- Technical consultation and awareness activities at household level are key for safer construction as it helps sensitize house owners on need and importance of safer construction. Before the consultation, many people were found thinking that earthquake resistant construction using local construction materials was not possible. Those who heard and had knowledge on earthquake resistant technologies are found believed that such construction requires huge investments. Through door-to- door campaigns and orientation programs, it was possible to change the mind set up of community.
- Demonstration models are found as proof of the concept of 'Seeing is believing'.
- Scarcity of construction material and escalation of price is taking place in some locations. For example: People are demanding and using more timbers for construction from the Community forest and Conservation offices/areas whereas conservation offices are controlling it. The alternative technologies need to be explored and promoted.

In remote villages where there is no access of road to transport construction materials, the local community has been facing technical challenges due to unavailability of construction materials for earthquake resistant component.

3.5.1 Performance of retrofitted buildings in April 2015 Gorkha earthquake

Of the approximate 300 school buildings retrofitted in Nepal, nearly 70% are located in the areas impacted by the Gorkha earthquake. Of the schools affected by the Gorkha earthquake that were retrofitted and seismically reconstructed, no collapse or serious damage was reported. Even those schools located near the epicentre remained in a condition that allowed them to be immediately used after the earthquake. Almost all of the retrofitted school buildings were utilised during the earthquake response as emergency shelter, warehouse, health posts, or as safe offices.

This contrasts sharply with poor performance of the un-retrofitted schools, including those located nearby retrofitted ones. During the Gorkha earthquake, about 80% of the un-retrofitted schools were damaged beyond repair. Although detailed studies on each of the schools is yet to be completed, it can be simply said that retrofitting did enhance the building resilience significantly and the retrofitting technology successfully passed the test posed by the Gorkha earthquake.

4 CONCLUSIONS

Through this chapter there has been an undercurrent of the painstaking and conscientious process to raise earthquake awareness, preparation and mitigation in Nepal. There have been a variety of actors involved on a national and international level. All were necessary and helped Nepal to be prepared. Much work remains to be addressed. Our message is that we will continue to work in this manner, conscientious and engaging with all actors who will help Nepal to be a country that is aware of its hazard risks and the implications for its people, economy and social implications.

Organized approaches in earthquake risk management in Nepal were triggered by the M6.6 Udaypur earthquake and by the hazard and risk assessment undertaken for the formulation of the national building code. Subsequent assessment of the potential loss due to a scenario earthquake in Kathmandu Valley and subsequent action planning to manage the identified losses scenario helped raise earthquake awareness at policy levels. Initial efforts towards vulnerability reduction such as the school retrofitting program demonstrated social and technical feasibilities that helped gradual engagement of people and neighbourhoods in risk reduction initiatives. These initiatives were initially cantered in Kathmandu Valley, but soon interest grew in other parts of the country.

Earthquake awareness grew significantly especially at the community level in the past two decades. More and more municipalities and rural settlements started enforcing the national building code using incremental approaches for safety and guided by the policy and regulations that the central government promulgated over the years. An initial effort and success in the Kathmandu valley in the late 1990s and early 2000s thus reverberated steadily throughout the country at varying levels of acceptance and action over the past two decades.

These experiences greatly helped Nepal to face the 2015 Gorkha earthquake sequence in the way it did – communities provided neighbourhood level support and the government responded to the earthquake with a certain level of preparedness for handling the international support in search and rescue and early recovery. In developing institutional and policy structures for reconstruction, and despite numerous economic and political problems, the country is trying to implement earthquake reconstruction and rehabilitation using internationally accepted approaches.

Working on a central level is essential. Working with the Ministry of Education and institutionalising a range of initiatives targeting schools and students will support Nepal long term. For example, the earthquake sequence showed the effectiveness of retrofitting school buildings in Nepal. Almost all of the retrofitted school buildings were utilised during the earthquake response as emergency shelter, warehouse, health posts, or as safe offices. This contrasts sharply with poor performance of the un-retrofitted schools, including those located nearby retrofitted ones. During the Gorkha earthquake, about 80% of the un-retrofitted schools were damaged beyond repair.

Working on a municipal level is essential to implement the NBC. Through long term engagement with some municipalities, NSET has been able to document substantive improvement in both the number of plans approved that meet ERC guidelines but more importantly, these plans have been implemented. This is a real success and indicates that Nepal's municipalities can actually enhance the seismic performance of new buildings if they are provided with technical assistance for capacity enhancement and for improvements in municipal institutional structure as well as in municipal policy and legal environments. In some cases as of 2016, 75% of new residential construction is in compliance with the building code (from 21% in 2012). The key lessons learnt from 1998 – 2015 include awareness raising, capacity building and enabling municipal policies are key to success, the institutionalization of the building code implementation is a long term undertaking in Nepal, and lastly, working with champions at all levels of government and society helps to institutionalise the process.

The government has recognized the value of earthquake preparedness and risk reduction and has declared mandatory compliance of the national building code for all building construction in the country rural or urban. This is a tall order, and demands lots of efforts in earthquake risk management and building code implementation in areas beyond the 31 districts affected by the Gorkha earthquake. It demands careful documentation of the lessons learned on the successes of the past and their usefulness as demonstrated by the Gorkha earthquake. It also requires policy and legal practices, including the national building code as well as working practices at the local government levels for smooth integration of earthquake risk management in local governance and citizens' actions.

Following the earthquake, the central government has made institutionalization of the building code implementation at the municipal level mandatory and the governing councils of more than 50 of the 217 municipalities have accepted as policy the necessity to enforce the NBC. In other locations, the local authorities are deciding how to interpret the NBC and how to manage implementation. Since most of the 217 municipalities are new entities as of 2015, the 217 municipalities face a difficult task to implement the NBC with limited financial, technical and human resources. External support is necessary to provide more support to a larger number of municipalities.

Nepal has gathered much experience and developed capacities as well as methodologies to face this challenge. The 2015 Gorkha earthquake sequence and the process of proper reconstruction will help internalize DRR into the lives of the people, not only in the earthquake affected areas, but also in areas yet to be shaken by the next earthquake.

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