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Research Paper

Building a More Resilient Nepal-The Utilisation of the Resilience Scorecard for Kathmandu, Nepal following the Gorkha Earthquake of 2015

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ABSTRACT

Following the Gorkha earthquake of 2015, the opportunity exists to utilise the Resilience Scorecard to assess the current level of preparedness of Kathmandu. This article will discuss the application of the UN Resilience Scorecard, with the assessment undertaken forming a baseline assessment addressing core infrastructure issues from the earthquake and evaluating core community functions. The assessment looks at initially 3 pillars of the Resilience Scorecard through 3 core components:

1. The disaster cycle: From preparedness through response recovery to developing risk scenarios.
2. The operational capacity of the financial, governmental and societal institutions.
3. The resilience of the society from urban to rural including infrastructure and natural buffers.

This paper highlights the key findings of the assessment undertaken during field visits to Kathmandu Valley following the April 2015 earthquake. The research study has found that Kathmandu has a low disaster resilience score with preliminary findings highlighting the susceptibility of critical infrastructure (i.e. roads, schools, hospitals, power, water supply) to natural hazards.

1. Introduction

The Resilience Scorecard was developed by AECOM and IBM, based on the “Ten Essentials” model for making cities resilient designed by the United Nations International Strategy for Disaster Reduction (UNISDR). The scorecard is an instrument designed to help cities measure their current level of disaster resilience, identify priorities for investment and action, and track progress in improving disaster resilience over time. It consists of 85 disaster resilience evaluation criteria. To date, it has been successfully applied to cities around the world including: Salt Lake City, US; Bandung Indonesia; Coimbatore, India; Puerto Montt, Chile; Makati, Philippines; Quelimane, Mozambique and Pemba, Mozambique.

Each evaluation criteria is broken down to set out the aspect of disaster resilience being measured, an indicative measurement and the measurement of scale (from 0 to 5 where 5 is the best practice).

The next step of this assessment is to undertake a full comprehensive assessment for all 10 pillars of the

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scorecard to establish a baseline that will enable prioritisation of future development and reconstruction efforts. It is envisioned this piece of work will be done in collaboration with the Government of Nepal to enable a set of baselines which will allow the Government of Nepal to monitor earthquake reconstruction to build a resilient Nepal.

In 2015, an earthquake with the magnitude of 7.8Mw struck the Gorkha Region in Nepal, resulting in devastation at a magnitude level killing almost 8,659people and injuring over 21,150 according to the Ministry of Home and Affairs (2015). More than 500,000 houses, 8,000 schools, and 400 health facilities were damaged, with estimated cost of US$ 7.0 Billion (GoN, 2015) and the powerful aftershocks of the earthquake resulted in significant damage to the infrastructure including landslides that blocked critical emergency access routes.

In addition, Nepal is severely affected by monsoons each year and has been identified as one of the most susceptible countries to the impacts of climate change (UNDP, 2012. Kathmandu, the capital of Nepal, is a key driver for economic growth and is currently undergoing rapid urbanisation, with an increase in population of over 5 million in the last decade.

1.1 The Resilience Scorecard

Resilience is the capacity to cope with disaster and climate impacts and thereby limiting the magnitude and severity of those impacts. Resilience has been defined by the Sendai Framework (UNISDR) as the ability of a system, community or society exposed to hazards to resist, absorb, accommodate, adapt to, transform and recover from the effects of a hazard in a timely and efficient manner. When considering in the context of cities, resilience is defined around the ability to withstand both acute shocks (natural and manmade) and chronic stresses which occur over a longer time period such as climate change, sea-level rise and socio-economic factors. Several mechanisms exist for evaluating the resilience of communities, infrastructure and cities (Francis and Whitworth, 2016), with this paper focusing on utilising the UNISDR Disaster Resilience Scorecard in Kathmandu as it is geographically and inherently prone to natural disaster event. Due to the design of the tool being easy to apply in all contexts and requires no additional resources, the project team were able to undertake the assessment of the resilience of Nepal while in the field.

The scorecards intention is a key instrument which helps to measure the level of disaster resilience; track the progress of disaster resilience over time; as well as identify priorities for investment and action. The scorecard's preliminary assessments consist of over 47 disaster resilience evaluation criteria spread over the "Ten Essentials" (**Fig. 1**). Each evaluation criteria is broken down to set out the aspect of disaster resilience being measured, an indicative measurement and the measurement of scale (from 0 to 3 where 3 is best practice) (**Tables 1-3**).

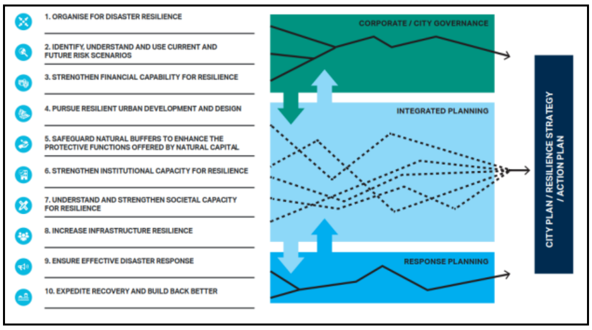

Fig. 1. An overview of the Ten Essentials for Making Cities Resilient (UNISDR, 2017), showing the interplay between the 10 essentials, governance planning and response and the development of a resilience strategy

Following the earthquake in April 2015 the level of disaster resilience in Nepal changed. There is now a great need to reset the dial and plan for future resilience through identifying necessary investment areas that will build a stronger and more resilient Nepal. This paper provides a high level review of 3 of the Essential 10 pillars of the scorecard, based on the Level 1, preliminary assessment.

1.2 The April 2015 Nepal Earthquake

At 11:56 NST (06:11 UTC) on the 25 April, an earthquake with a magnitude of 7.8Mw struck Nepal (hereafter Gorkha earthquake). The total number of fatalities was 8,659 people and 21,150 injured by the major shock and M7.3 aftershock in accordance with the Ministry of Home and Affairs (2015). Among them 4,772 females lost their lives. Besides, more than 500,000 houses, 8,000 schools, and 400 health facilities were destroyed. The intensities at the epicentre and in the Kathmandu Valley were determined to be VIII VI-VII respectively. Proceeding, the largest aftershock of a very strong magnitude 7.3 Mw with the epicenter at the border of Sindhupalchowk and Dolakha Districts about 35 km east of Kathmandu occurred on May 12 at 12:50 p.m. local time measured with VI intensity both in Kathmandu Valley and Arniko Highway (USGS, 2015). The hypocenters of the main shock and aftershock were originated from the shallow depths of 8.2 km and 18 km respectively. Damages of buildings in traditional towns, urbanized centres and historical monuments of Kathmandu Valley were also severely affected after the first major tremor (Manandhar et al., 2015; Hino and

Table 1. Key Aspects of Essential 2-Identify and Understand Current and Future Risk Scenarios

No.	Subject	Description/ Key Questions to be answered
P2.1	Hazard assessment	Does the city have knowledge of the key hazards that the city faces, and their likelihood of occurrence?
P2.2	Shared understanding of infrastructure risk	Is there a shared understanding of risks between the city and various utility providers and other regional and national agencies that have a role in managing infrastructure such as power, water, roads and trains, of the points of stress on the system and city scale risks?
P2.3	Knowledge of exposure and vulnerability	Are there agreed scenarios setting out city-wide exposure and vulnerability from each hazard, or groups of hazards (see above)?
P2.4	Cascading impacts	Is there a collective understanding of potentially cascading failures between different city and infrastructure systems, under different scenarios?
P 2.5	Presentation and update process for risk information	Do clear hazard maps and data on risk exist? Are these regularly updated?

Table 2. Key Aspects of Essential 4- Pursue Resilient Urban Development and Design

No.	Subject	Description/Key Questions to be answered
P4.1	Land use zoning	Is the city appropriately zoned considering, for example, the impact from key risk scenarios on economic activity, agricultural production, and population centers?
P4.2	New urban development	Are approaches promoted through the design and development of new urban development to promote resilience?
P4.3	Building codes and standards	Do building codes or standards exist, and do they address specific known hazards and risks for the city? Are these standards regularly updated?
P4.4	Application of zoning, building codes and standards	Are zoning rules, building codes and standards widely applied, properly enforced and verified?

Manandhar, 2015). Manandhar et al. 2016 noticed the wave propagation of the first tremor of April 25, 2015 showed the collapse and damage of structures towards the eastern direction while the aftershock caused most of the structures either collapsed or tilted towards southern direction and the combination of both during the survey. The powerful aftershocks of the earthquake resulted in significant damage on the infrastructure including landslides that blocked critical emergency access routes.

In addition, Nepal is severely affected by monsoons, fires and high winds each year and has been identified as one of the most susceptible countries to the impacts of climate change (Paudel et al., 2003, JICA, 2012). Kathmandu, the capital of Nepal is a key driver for economic growth and is currently undergoing rapid urbanisation, with a significant increase in population over the last decade. As a result, Kathmandu has both a significant level of acute shocks in the form of floods, earthquakes and landslide, but also suffers from a range of chronic shocks including climate change and a range of socio-economic factors. These unique characteristics provide an excellent case study for the applicability of the UNISDR Scorecard to evaluate the disaster resilience of Kathmandu.

2. Evaluating Resilience

2.1 Essential 2 Identify and Understand Current and Future Risk Scenarios

The aim of Essential 2 is for local governments to identify and understand current and future risk scenarios and utilise this knowledge to inform decision making. The preliminary assessment for Essential 2 is split into 4 parts, summarised in **Table 1**. Each component is ranked 0 - 3.

Since 2003, Nepal has undertaken a review of natural disasters that impact the country every two years and is reported in the Natural Disaster Reports (Government of Nepal, Ministry of Home Affairs, 2016). These reports indicate there is an increasing trend of the impact of natural hazards, with a lack of effective land use planning and unregulated development contributing to increased vulnerability to natural hazards. Furthermore, due to inadequate preparedness of the government and other stakeholders, vulnerability to natural disasters is on the rise. This is compounded by a lack of legislation to cover disaster risk reduction. However, in broad terms Government of Nepal and the Kathmandu Valley Development Authority understand the key hazards that they face, but do not have detailed knowledge of the range of scenarios that may impact the city, nor the cascading effects.

A review of the available documentation fails to identify detailed hazard mapping for Kathmandu and the surrounding areas at city government level. Although a range of maps exist within scientific literature or have been undertaken by not for profit organisations it would appear this data has not been shared in a meaningful way with city officials (e.g., Flood mapping by JICA, 2013; Landslide Risk and Earthquake Risk Mapping by European Union, 2014). Therefore, it is unlikely that there

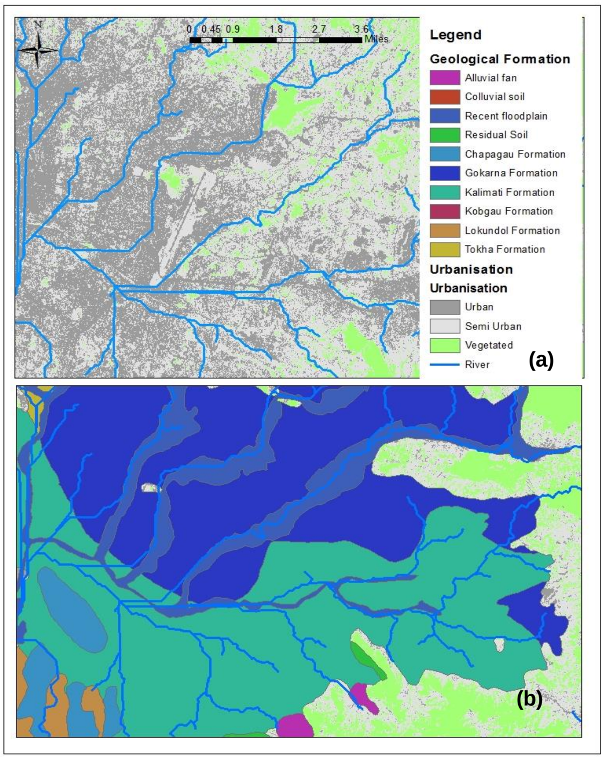

Fig. 2 (a). Processed Sentinel-2 multispectral data acquired from the European Space Agency, processed by combining 3 spectral bands to highlight urban (dark grey), semi-urban (light grey) and vegetated areas (green) of Kathmandu and surrounding areas, with an overlay of rivers and **(b)** Geological Map showing the distribution of unconsolidated and partly consolidated sediments within Kathmandu. These figures show the susceptibility of Kathmandu to flooding and the potential for liquefaction during an earthquake

is a shared understanding within the relevant Nepalese stakeholders and the risks to critical infrastructure within the built environment.

Figure 2, shows a comparison between Urban and Semi-Urban areas within the Kathmandu Valley, based on processed Sentinel-2 data and geological formations highlighting the variety of geological related hazards to building construction i.e. liquefaction, however it is unclear how this information is communicated to different stakeholders. Furthermore, **Fig. 2** shows the encroachment of urban areas towards rivers, with a high level of development adjacent to rivers and within zones of historical flood plain deposits.

Comparing against Essential 2, it can be found that the Government of Nepal understand the key contextual hazards, especially linked to earthquakes, landslides and flooding. However, detailed risk assessments are not routinely undertaken and where completed, are not clearly communicated or updated (P2.1 Score 2 out of 3). Although there is a common knowledge within key stakeholders of the risks, there is no forum for sharing information and identification of stress points (P2.2. Score 1.5 out of 3). For knowledge of exposure and vulnerability, the city only scored 1 out of 3. Although there is some documented information on disaster scenarios it is not comprehensive nor do they address city-wide exposures and vulnerabilities. Through the application of Essential 2 of the scorecard it was found that there is unlikely to be a clear understanding of the cascading impacts of a hazards and therefore the city scored only 1 out 3. The limited hazard maps evident compounded with minimal updates the city also scored low on Presentation and update process for risk information.

2.2 Essential 4 Pursue Resilient Urban Development and Design

The aim of Essential 4 is to take Essential 2 Hazard and Risk Scenarios and apply them to the assessment of the built environment and how this influences land use planning, zoning and management of urban growth to avoid exacerbating resilience issues. Furthermore, Essential 4 evaluates how the hazard and risk scenarios inform building codes for future developments and assess the resilience of existing structures. Essential 4 preliminary assessment is split in two 4 areas as detailed in **Table 2**.

From a review of **Fig. 2** that shows the Urban and Semi-Urban sprawl of Kathmandu and the geology of the area that little to no Land use Zoning (P4.1) is undertaken, with development encroaching the river network and increasing the potential flood risk of Kathmandu. The area of Kathmandu has geology of unconsolidated and partially consolidated sediments (**Fig. 3(a)**), potentially prone to liquefaction. **Figure 3(b)** is a photo of a building that collapsed during the Gorkha earthquake, with a contributing factor the underlying sediments and possible liquefaction. Although development on the steeper slopes around Kathmandu is limited, the distribution of semi-urban development highlights that development is starting to encroach upon these areas, increase the susceptibility to landslide hazards. With the increasing population there is a need to promote and pursue resilient urban design codes for new developments (P4.2), but these approaches are adopted on a limited basis.

The National Society for Earthquake Technology was created in Nepal over 2 decades ago and has advocated improved design codes, predominantly in relation to earthquakes. Nepal Design codes were developed and implemented in 1994 and in 2003, although regulation and enforcements have been limited. Further design codes have been developed since the Gorkha earthquake, focused on the private housing sector, with detailed designs for a range of housing typologies. In

Table 3. Key Aspects of Essential 8- Critical Infrastructure

No.	Subject	Description/Key Questions to be answered
P 8.1	Critical infrastructure overview	Is critical infrastructure resilience a city priority, does the city own and implement a critical infrastructure plan or strategy?
P 8.2	Protective infrastructure	Is existing protective infrastructure well-designed and well-built based on risk information?
P 8.3	Water - Potable and Sanitation	Would a significant loss of service for these two essential services be expected for a significant proportion of the city under the agreed disaster scenarios?
P 8.4	Energy	Would a significant loss of service be expected for a significant proportion of the city in the 'worst case' scenario event? In the event of failure would energy infrastructure corridors remain safe (i.e. free from risk of leaks, electrocution hazards etc.)?
P 8.5	Transport	Would a significant loss of service be expected for a significant proportion of the city in the 'worst case' scenario event? In the event of failure would transport infrastructure corridors remain safe (i.e. free from risk of flood, shocks etc.) and passable?
P 8.6	Communications	Would a significant loss of service be expected for a significant proportion of the city in the 'worst case' scenario event?
P 8.7	Health care	Would there be sufficient acute healthcare capabilities to deal with expected major injuries in 'worst case' scenario?
P 8.8	Education facilities	% of education structures at risk of damage from "most probable" and "most severe" scenarios
P 8.9	First Responder assets	Will there be sufficient first responder equipment, with military or civilian back up as required?

addition to the seismic code, development codes limited development on slopes >20°, with the aim to minimise the risk from landslides. Furthermore, since the earthquake of 2015 work has been undertaken to train and educate a range of stakeholders on the seismic and landslide risk. Despite this, development around Kathmandu is starting to encroach upon the steeper slopes. From field work, little attention appears to have been payed towards developing design codes in relation to flooding, with large areas of Kathmandu, potentially at risk. Fire is also a major problem in Nepal, with the network of small streets, the use and storage of items such as gas bottles, coupled with the poor emergency access for fire services, contribute to the impact of fires in Kathmandu, with design guidance currently only at a provisional phase.

Significant legacy issues exist within Kathmandu, where buildings have not been constructed to code and buildings have been modified and retrofitted to which no development codes currently exist. A retrofitting code was developed in 2016 (DUDBC, 2016), but requires full implementation and monitoring its application. There is a need to review existing buildings to ensure they meet code, and ensure a resilient urban design. Furthermore, with Nepal being one of the countries' most at risk from the impacts of climate change, there is a need to incorporate climate change resilient urban design into land use planning and building codes.

2.3 Essential 2 Identify and Understand Current and Future Risk Scenarios

Following the Gorkha Earthquake of 2015, critical infrastructure was affected to a varying degree, with water and electrical supply returning within 5 days, a limited loss of mobile phone coverage and a significant impact on transport, healthcare and education facilities. Essential 8 aims to provide a focus on Kathmandu's critical infrastructure and evaluate how these critical infrastructures performed following the 2015 Gorkha Earthquake. As outlined in **Table 3**, the preliminary assessment for critical infrastructure is split into 9 components, with a review provide against 5 aspects. As Kathmandu is heavily reliant on the road network for services and goods i.e. imported bottled gas, electricity supply from hydropower schemes, as well a city wide assessment, the impact of loss of services in the

surrounding areas that impacted Kathmandu are incorporated in to the assessment.

2.3.1 Essential 8 Item 8.4 Energy

Within Kathmandu, energy is provided from a variety of sources including national electricity supplies, backup generators and bottled gas for cooking. National electricity supply returned within 5 days following the

Fig. 3 (a). Photo adjacent to river and flood plain deposits showing building built on soft lake deposits with Kathmandu with **(b)** and **(c)** examples of collapsed buildings within Kathmandu in vicinity to **Fig. 3 (a)**, showing the potential impact of building on superficial deposits

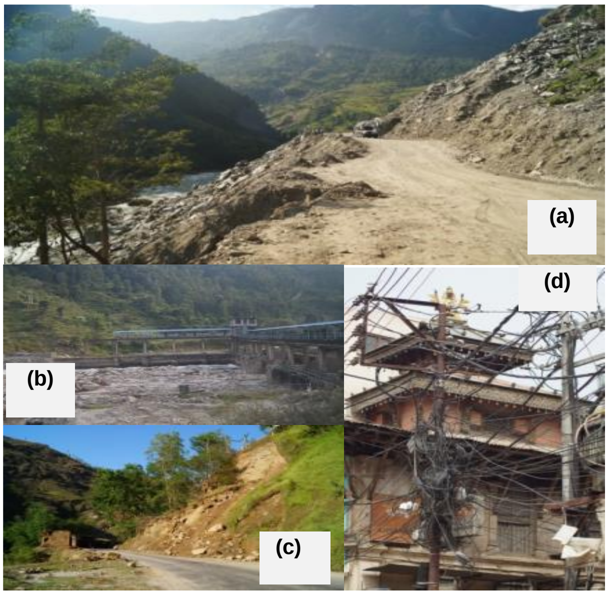

Fig. 4. Photo of the impact of natural hazards on critical infrastructure **(a)** landslide on key transport route to China **(b)** Hydro power plant affected by landslides **(c)** Landslide on road to Chautara **(d)** electric cables within Kathmandu

earthquake, although outages continued for some time. This return of service was in part due to the remarkable preparedness of the local private companies, which shows how sometimes private corporations can be better prepared for natural disasters than government and how setting up a private-public partnership to tackle natural disasters could work. As the Population was not 100% reliant on domestic services, utilising generators and bottled gas, the impact on energy supply was not as catastrophic as it could have been. This is important to note for future events, as Kathmandu progresses and houses become more reliant on energy sources, the next event will have a significantly different impact. However, as Kathmandu is partially reliant on imported gas and fuel, there were observed shortages due to increase in demand as well as due to the disruption to road corridors (as a result of earthquake linked landslides). It is worth noting that for Kathmandu the Gorkha Earthquake was not the 'worst case' scenario and therefore it could be expected that should the next earthquake occur closer to Kathmandu a loss of service for a significant proportion of the city will be substantial worse considering the poor national electricity infrastructure within the city (**Fig. 4(d)**).

Kathmandu national electricity is partly supplied by a range of hydropower schemes in the surrounding areas. Field reconnaissance identified (**Fig. 4(b)**) that the earthquake and associated landslides impacted several hydropower projects, which impacts energy supply to Kathmandu. Furthermore, several hydropower constructions projects were postponed due to the earthquake.

2.3.2 Essential 8 Item 8.5 Transport

Predominantly the road network within Kathmandu was unaffected by the earthquake, with the exception of a section of ring road on the outskirts of Kathmandu which uplifted. No reported impact to bridges was identified, with over 2000 bridges in Nepal surveyed by the Department of Roads. Several small (Figure 4(c)) landslides were observed on road network to and around Kathmandu. However, more distant road networks including a critical route to China, along the Ariniko Highway was significantly affected by both earthquake and monsoon induced landslides. The impact on imports in to Nepal, including essential supplies following the earthquake, was impacted along this route and other heavily reliant wider road networks. Therefore, it is critical for Kathmandu to consider as part of the Resilience Scorecard the impact of natural hazards beyond the city limits.

2.3.3 Essential 8 P8.6 Education

As with the healthcare system, there a range of schools that have been designed and built to earthquake code through foreign assistance with many schools having been retrofitted undertaken prior to earthquake.

Despite this 8,000 schools destroyed with many more damaged, with many schools unable to function as critical infrastructure i.e. shelters following earthquake (**Fig. 5 (a)** and **(b)**). At the time of the visit there was an ongoing assessment of Schools and hospitals by a variety of bodies including the Government of Nepal, National Society for Earthquake Technology, World Health Organization and others. Within a few weeks of the earthquake temporary schools, including tents had been set up, predominantly by the Nepal Army

Fig. 5 (a). Damage school in Kathmandu, that at the time of the visit was being demolished **(b)** Collapsed school near Chautara

3. Conclusions

Based on field visits to Kathmandu and the surrounding urban areas undertaken since the April 2015 earthquake, and dialogue with a variety of stakeholders in Nepal, an initial high level assessment of 3 of the 10 pillars of the Resilience Scorecard has been undertaken. The preliminary findings identify:

1. For Understanding Current and Future Risk Scenarios, there is a sound understanding of some hazards, but further work is requird to understanding the risks. Furthermore, there is a need to consider cascading hazards.
2. For Urban planning, it can be seen by the urban layout of Kathmandu that flooding and earthquakes including liquefaction poise a significant hazard and further work is required to ensure Kathmandu pursues a resilient urban design, mitigate the potential impacts of hazards.
3. Critical infrastructure such as roads, power supply and schools are at significant risk from natural hazards and significant work is required to ensure these systems can cope and effectively respond in the event of a natural disaster.

Overall, based on an initial assessment of a few limited aspects of the disaster resilience scorecard, Kathmandu has a low score of between 1-2. Of particular note is the susceptibility of critical infrastructure to natural hazards including many essential road routes and the impact of the earthquake on schools and hospitals despite an earthquake design code being in use in Nepal since 1994.

Many of the fundamentals to enable Kathmandu to be a resilient city exists, including an understanding of the magnitude and frequency of natural hazards, earthquake design codes and a desire following the earthquake to build back better.

References

UNISDR, 2017. Disaster Resilience Scorecard for Cities, Preliminary Assessment. United Nation Office for Disaster Risk Reduction.

UNISDR, 2015. Sendai Framework for Disaster Risk Reduction 2015-2030. United Nation Office for Disaster Risk Reduction.

Hino, T. and Manandhar, S., 2015. Expected contribution of lowland civil engineering and architecture in Nepal earthquake. Kensetsu-news Saga, No.3156: pp.6 (in Japanese).

Manandhar, S., Soralump, S., Hino, T. and Kitagawa, K., 2015. Preliminary observation of strong 2015 earthquake and aftershock in Nepal. Proc. 9th International Conference on Crisis and Emergency Management (The 9th ICCEM), September 11-14, 2015, Tokyo, Japan: 121-123.

Ministry of Home and Affairs, 2015. Earthquake in Gorkha. Kathmandu, Nepal: 29-31.

United Nations Development Programme (UNDP), 2012. Road Map for Making Kathmandu Valley Development Concept Plan Risk Sensitive: Frameworks and Processes. UNDP. Available at: http://emi-megacities.org/wp-content/uploads/2015/04/KathmanduValleyFramework.pdf

Center for Excellence, 2015. Nepal Country Overview: Nepal Disaster Management Reference Handbook 2015. Centre for Excellence. Available at: http://www.cfe.dmha.org

UNDP/BCPR, 2004. Reducing Disaster Risk: A Challenge for Development A Global Report. New York: United Nations Development Programme/Bureau for Crisis Prevention and Recovery.

Paudel, P. P., Omura H., Kubota T. and Morita, K., 2003. Landslide damage and disaster management system in Nepal. In Disaster Prevention and Management, **12** (5): 413 -419.

Japan International Cooperation Agency (JICA), Nippon Koei Co., Ltd. and Eight-Japan Engineering

Consultants Inc., 2012. Data collection survey on traffic improvement in Kathmandu valley: final report. Available at: http://open_jicareport.jica.go.jp/737/737/737_116_12082459.html [Accessed 12 September 2017].

DUDBC, 2016. Seismic Retrofitting Guidelines of Buildings in Nepal. Government of Nepal Ministry of Urban Development, Department of Urban Development and Building Construction. Available at https://www.dudbc.gov.np/uploads/.../files/0640827db55dd7e4c39b32ef67bdfa7f.

Francis, M. and Whitworth, M.R.Z., 2016. Lifeline infrastructure and the UN disaster resilience scorecard. Lowland Technology International Journal, **18** (2): 165-172.

Symbols and abbreviations

UNISDR	United Nations Office for Disaster Risk Reduction
USGS	United Stated Geological Survey