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An Overview of Disaster Management during the April 25, 2015, M_w7.8 Nepal Earthquake

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ABSTRACT

At 11:46 A.M. local time on April 25, 2015, a destructive earthquake with a moment magnitude (M_w) 7.8 struck central Nepal. The epicentral region of the earthquake was located in the Gorkha region. Due to this event, more than 8000 people were killed and 22,000 were injured. Following this destructive earthquake, some affected areas including Kathmandu, Bhaktapur, Gorkha and Pokhara were visited by the first two authors during 6-11 May 2015 in order to assess the performance of disaster management and emergency responses to the 2015 Gorkha earthquake. Based on the observational assessments, the physical damages to buildings and historical monuments are pointed out briefly. The logistics, disaster management performance, along with emergency responses such as the shelters, health, food, treated water and medical supplies are also described. Meanwhile, several key lessons learned from the 2015 Nepal earthquake response are highlighted. In addition, a new design of emergency tents is proposed which is suitable for earthquake-prone areas specifically in south Asian regions like Nepal.

Keywords: Nepal, Earthquake, Disaster Management, Emergency Response

Introduction

Nepal is located on the southern slopes of the Himalayas in South Asia. Nepal's neighbor to the north is China and to the south, east and west is India. This country has an area of 147,181 square kilometers and a population of approximately 26.5 million (1). The World Bank also placed the population of the country at 27.8 million in 2013. With respect to the topographic condition, environmental degradation, adverse geo-climate conditions, population growth, urbanization and unsustainable development practices, Nepal is extremely at a high risk of natural disasters (2).

The country experiences intense natural disasters such as earthquakes, floods, landslides, avalanches, fire, drought, and epidemics killing hundreds of people each year. The first five major cities in Nepal are Kathmandu, Pokhara, Biratnagar, Bharatpur and Lalitpur. The population of the Kathmandu Valley has growing rate of 4 to5 percent (3, 4).

Tectonically, Nepal is situated in the India-Eurasia plate collision boundary where the rate of convergence between the Indian and the South Tibetan plates is 17.8±0.5 mm/yr and 20.5±1 mm/yr

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in the central/easternNepal and in western Nepal, respectively (5). On April 25, 2015, a severe earthquake hit central Nepal (M_w) of 7.8. The earthquake was followed by numerous aftershocks including a large M_w7.3 quake on May 12. The epicenter of the M_w7.8 mainshock was reported in the coordination of 28.147 N and 84.708 E in Gorkha (6) while aftershocks occurred toward Kathmandu. On the basis of the official statistics published by the Nepal Disaster Risk Reduction Portal (7), the 2015 Gorkha earthquake claimed more than 8,000 lives, injured over 22,000 people, made hundreds of thousands of people homeless and also inflicted significant damage to buildings and infrastructures of Nepal **(Table 1)**. In addition, many of the world's cultural heritage sites, historic monuments and temples were almost completely destroyed or damaged. Meanwhile, the earthquake left an urgent need for freshwater, food items, shelter, medical help and other aids.

Table 1. Statistics of life and property losses during the 25 April 2015 earthquake (7).

District	Total No. of Houses	Total Population	Death	Injured	Govt. Houses Fully Damaged	Govt. Houses Partially Damaged	Private House Fully Damaged	Private House Partially Damaged
Sindhupalchowk	66688	287798	3532	1573	710	37	63885	2751
Kathmandu	436344	1744240	1226	7952	85	277	43502	56024
Nuwakot	59215	277471	1109	1050	15	14	75562	4200
Dhading	73851	336067	678	1218	93	58	81313	3092
RASUWA	9778	43300	660	771	8	4	11368	267
Gorkha	66506	271061	449	952	227	36	59527	13428
Bhaktapur	68636	304651	333	2101	5	51	18900	9054
Kavrepalanchowk	80720	381937	318	1179	48	31	49933	23714
Lalitpur	109797	468132	180	3051	217	198	17444	8064
Dolakha	45688	186557	177	662	517	0	48880	3120
Ramechhap	43910	202646	42	134	54	56	26743	13173
Makawanpur	86127	420477	33	229	46	177	20035	17383
Solukhumbu	23785	105886	22	100	75	142	9172	11137
Okhaldhunga	32502	147984	20	61	18	38	10031	3107
Sindhuli	57581	296192	15	230	92	231	18197	10028
Chitawan	132462	579984	10	143	0	40	472	754
Sunsari	162407	763487	9	35	5	83	7	375
Parsa	95536	601017	6	50	0	12	0	35
Lamjung	42079	167724	5	40	39	48	10695	11535
Mahottari	111316	627580	4	16	10	14	500	600
Rautahat	106668	686722	3	38	0	9	70	199
Kaski	125673	492098	3	38	10	45	1793	4947
Morang	213997	965370	2	59	0	51	3	112
Bhojpur	39419	182459	2	13	22	65	3194	6316
Sarlahi	132844	769729	2	70	7	27	0	0
Bara	108635	687708	2	62	1	0	50	0
Taplejung	26509	127461	1	7	0	69	4	28
Jhapa	184552	812650	1	25	0	46	95	144
Terhathum	22094	101577	1	14	0	60	180	1901
Udayapur	66557	317532	1	35	63	684	37	1069
Siraha	1179622	637328	1	39	0	20	0	540
Dhanusha	138249	754777	1	45	0	8	4	47
Nawalparasi	128793	643508	1	41	0	14	910	3500
Palpa	59291	261180	1	16	2	24	1434	2665

District	Total No. of Houses	Total Population	Death	Injured	Govt. Houses Fully Damaged	Govt. Houses Partially Damaged	Private House Fully Damaged	Private House Partially Damaged
Gulmi	64921	280160	1	11	81	277	2624	5114
Shyanja	68881	289148	1	23	9	49	5003	11829
Myagdi	27762	113641	1	10	0	0	115	1077
Baglung	61522	268613	1	14	2	4	1952	1963
Rolpa	43757	224506	1	2	0	6	62	159
Rukum	41856	208567	1	6	0	47	117	328
Other Regions	-	-	0	194	212	705	18444	51320
Total			**8856**	**22309**	**2673**	**3757**	**602257**	**285099**

This study reports observations from the disaster management efforts and responses to April 25, 2015, Gorkha earthquake based on a visit epicentral region in Gorkha district and the affected cities performed by the first two authors during 6-11 May 2015 **(Figure 1)**. Based on the observations, emergency responses such as shelters, public camps, treated water, health amenities are presented in detail. Finally, lessons learned are explained and a newly designed tent is proposed which can be used in earthquake-stricken regions of Nepal.

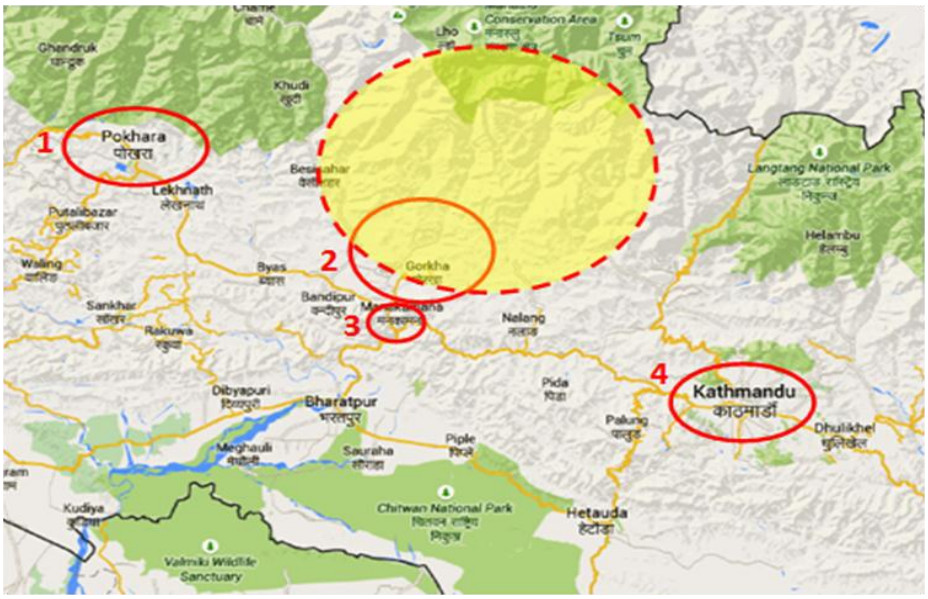

Figure 1. Visited regions of the current study shown on Google map. 1): Pokhara, 2): Gorkha and adjacent affected villages, 3): Abu Khaireni UN logistic camp and 4): Kathmandu and Bhaktapur. The yellow circle shows the 25 April 2015 earthquake macroseismic area.

Disaster Management Efforts in Nepal

With regard to Nepal's severe vulnerability to natural disasters like earthquakes, landslides, avalanches, floods, etc, several central institutions are involved in disaster management at various levels and Regional Natural Calamities Relief Committee.

In 2009, the government released a National Strategy for Disaster Risk Management in Nepal (NSDRMN) (9), which is a national framework with a commitment of the government for protection, growth, and promotion of national heritages and physical infrastructures.

In addition, the government also launched the Nepal Risk Reduction Consortium (NRRC) in 2009. The establishment of the NRRC was probably the first effort that brought together national and international key partners and stakeholders in support of the Government of Nepal and engaged them in a number of concrete actions to make a safer and more disaster resilient society. In this respect, the NRRC developed a disaster risk reduction action plan in line with the Hyogo framework for action (10), focusing on urgent and viable flagship priorities (11):

In order to check the NRRC's progress and achievements, the Government of Nepal performed a review on the efforts. (12)".

Damages of the April 25, 2015 Earthquake

Nepal earthquake was practically destructive, with widespread damages to many buildings, mostly within the central part of the country. In this section, based on a visit to the macroseismic region by the first two authors, the most important observations of the physical damages are mentioned very briefly.

Following the 2015 earthquake, several earthquake-induced landslides, avalanches, ground fissures, and fault ruptures. Based on the observations, the earthquake triggered some new landslides along the intercity road from Kathmandu westward to Gorkha and Pokhara. At about 62 km west of Kathmandu, a relatively large landslide could be observed with an approximate size of 100m width * 50m length (**Figure 2**).

Figure 2. An observed landslide with about 100m width and 50m length, 62 km west of Kathmandu.

Because of the continued aftershocks occurred throughout Nepal in the first weeks, the country also had a continued risk of landslides. Moreover, the earthquake sparked an avalanche on Mount Everest and a huge avalanche in the Langtang valley, blocking mountain routes, killing several individuals and missing hundreds. Furthermore, a typical ground fissure was observed at a distance of about 9 km southeast of Kathmandu toward Bhaktapur with a NE-SW direction and 2-meter vertical displacements (**Figure 3**).

Figure 3. A typically observed ground surface fissure with NE-SW direction between Bhaktapur and Kathmandu.

In all the visited areas, there were many low-resilient buildings that were fully collapsed, tilted or severely damaged. The fourteenth day after the earthquake, large amounts of debris from destroyed buildings were not cleaned, making the affected areas to be so unsightly and polluted. The destructions in Gorkha District as well as Langtang village in a 60-kilometer distance northeast of Kathmandu. In Kathmandu, Unfortunately, disorganization and confusion in some developed regions were more evident than other less developed regions. For instancebusiness and shopping centers and residential complexes sustained major damages (**Figure 4**).

Figure 4. Severe damages to the building in Kathmandu.

Figure 5. Destroyed historic/cultural world heritage Durbar Square of Kathmandu

According to the geology of Kathmandu basin, an amplification effect is expected (13, 14). The western part of Kathmandu is located in the vicinity of river flowing in the Kathmandu Valley where also the old and historic texture of the city exists. The geology of this region is prone to amplify seismic waves by fine and thick alluvial deposits so that the effects of the earthquake can be exacerbated, leading to more damages.

The 2015 Gorkha earthquake almost destructed all the world heritages in the Durbar square of Kathmandu, as well as the 183-year-old nine-storey Dharahara tower at the center of Sundhara **(Figure 5)**. A similar situation was observed in the Bhaktapur Durbar Square situated about 12 km southeast of Kathmandu (**Figure 6**). Visiting the Swayambhunath Buddhist temple (also known as the Monkey Temple) (**Figure 7**), some important parts of the temple and one of its adjacent towers were found to be destroyed.

Figure 6. Destructed historic monuments at Durbar Square of Bhaktapur.

Figure 7. Damaged Swayambhunath Buddhist temple west of Kathmandu.

Logistics and Disaster Managements

During the recent decade, many Nepalese teams and specialists had active participation in different national and international training programs and studies, workshops, and The National Society for Earthquake Technology of Nepal (NSET) has published many training programs and studies in different aspects of disaster risk reduction and management such as Nepal earthquake risk management program, disaster preparedness for safer schools, comprehensive risk assessment and action planning, technical assistance to municipalities in building code implementation, a solid waste management project in Dharan municipality, Comprehensive list and details of these programs and studies are available online at www.nset.org.np. Such admirable programs and activities have helped Nepal to deal with disaster risks and improve preparedness. However, considering some catastrophic evidence and consequences of 2015 earthquake, the country still faces challenges such as lack of attention to building codes and development of unplanned urbanization. Moreover, the Nepalese modern professional NGOs are also taken into account as a small limited minority comparing to 26.5 million population of the disaster-prone country.

Following the 2015 earthquake, some meetings were held with authorities and Water Organization of Kathmandu to check the running emergency management performance. Although Nepal's National Strategy for Disaster Risk Management was adopted in 2009 and several governmental authorities are involved in this context, weakness of organizations and poor resources made it practically impossible to deal with such a major earthquake in an efficient way. In the first two weeks after the earthquake, there was almost a lack of well-trained efficient national relief teams and appropriate equipment for such an immediate emergency situation. However, organized Nepal's army played a key role as it was ordered by the government to cooperate in the relief efforts. It was actually the best thing to do in the earthquake conditions for the country.

Foreign relief teams played an important role in emergency management. The first team that arrivedin Nepal was from India (the neighbor country) and then from China, USA, Japan, France, Germany, England, Indonesia and Turkey. It was observed that during the earthquake, the UN played a very important role in the coordination of relief teams. Based on the authors' observations, there was a great discipline and organization in the UN office in Kathmandu (UN House) who was responsible to manage the large-scale relief operations in earthquake-affected regions.

Figure 8. The UN logistic camp at Abu Khaireni village in Gorkha district.

At Abu Khaireni, south of Gorkha district, the United Nations World Food Program (WFP) had established a logistic camp to control and distribute donations such as food, health packages and emergency shelters to the earthquake-stricken area (**Figure 8**). This logistic camp was also responsible to coordinate the headquarters of the national and international agencies and NGOs by holding a meeting between relief teams and response clusters at 8 o'clock each morning. Despite the good discipline among the working groups, there was a shortage of vehicles to transport the donated facilities. Only one helicopter and 20 to 25 trucks were employed per day to transfer relief packages to the epicentral area, meanwhile, the trucks were not always available regularly. According to the head of the camp, during the first 72 hours of the emergency period, one helicopter and 40-50 trucks were needed per hour, while after passing the period, it was estimated that more than seven times of this amount of equipment were needed in order to deliver the aid to begin reconstruction and rehabilitation in the affected areas. Meanwhile, the Nepalese government's facilities in this context are limited and it is not possible to increase the capacity and supportive equipment.

In addition to the lack of enough transfer facilities such as enough helicopter and trucks, intercity roads had low quality and minimum standards so that passing 140 kilometers distance from Kathmandu to Gorkha lasted about 5 hours. Due to the failure of communication in the first moments of the earthquake, it took an hour to send the first SOS messages and help requests from the epicentral region to Kathmandu and four hours to receive the first aids in the city of Gorkha and adjacent villages.

About the media and communications some points are highlighted:

The first news about the earthquake occurrence and its damages were released around the world using the internet through photos and text messages published by the Nepalese social network users at the moment and early minutes of the tremor (**Figure 9**).

International media had an important role to cover the news and documenting almost every moment of this event around the world (15).

During this earthquake, Nepalese people had a highly sensitive reaction to Indian media's coverage of the earthquake. Nepalese took Indian media's coverage into account as advertising, offensive and smattering news and wanted the media back home using different banners installed around Kathmandu (with #IndianMediaGoHome in social networks).

It is expected that disaster managers face some post-disaster challenges in the next months of the earthquake. Remained debris should be completely cleaned to avoid aggregating harmful animals and insects which spread diseases. Half-ruined buildings should also be demolished since they can be a death trap, killing the ones who do not notice the possible sudden collapse of these buildings in probable subsequent aftershocks. In addition, With respect to the cold winter and

mountainous conditions of Nepal, disaster managers should provide and organize all the basic amenities and needs for the affected people especially those who are at higher risk such as children and the elderly. These logistics and basic needs can be prepared through the coordination with neighbor countries, China and India. Simultaneously, a preliminary assessment of the damage to all affected villages and urban areas should be finalized to provide an operational plan for the distribution of aids.

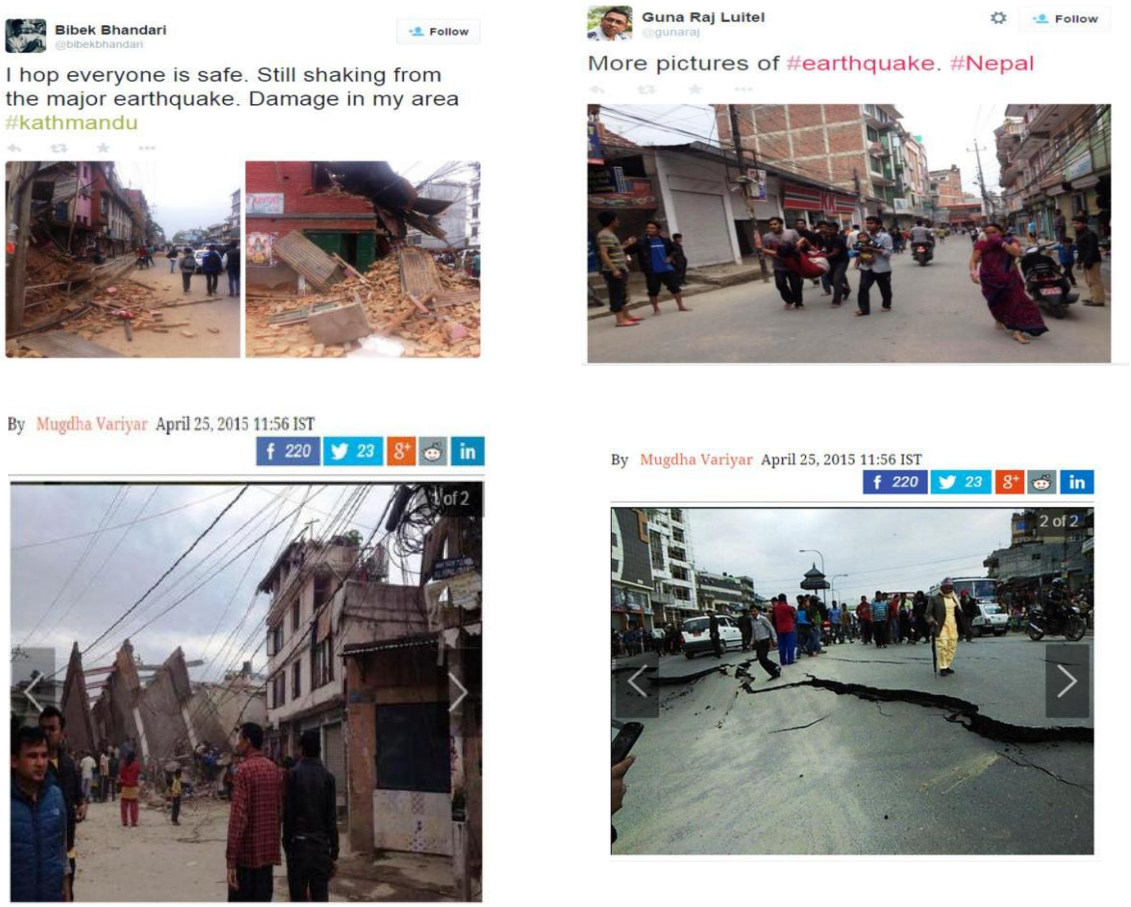

Figure 9. The first news of the 25 April 2015 earthquake released worldwide by Nepalese social network users at the moment and early minutes of the event.

Responses

Following the April 25, 2015 earthquake, many national and international search and rescue (SAR), relief and emergency response clusters and NGOs arrivedin Nepal. The first foreign relief team was the Indian group that landed on Kathmanduin the afternoon of the mainshock day. Fortunately, Kathmandu and Pokhara airports were open and and expanded throughout the affected areas. Approximate timing of major humanitarian responses from 25 April- 1 May 2015 of the earthquake is proposed in UNOCHA, Situation Reports (15- 22) (**Table 2**).

Based on the observations in the first two weeks after the earthquake, about a quarter of the affected people had good access to facilities such as safe drinking water, warm food, and basic medicines. Among the visited cities, the Capital of Nepal, Kathmandu, had faced more damages with an asymmetrical pattern. In the following, different aspects of the emergency settlement within the visited cities and villages are described.

Table 2. Approximate timing of major humanitarian responses from April 25 - to May 1, 2015 of the earthquake (15-22).

	Effort	Date
Humanitarian Needs and Logistics	GON held a meeting of their Central Natural Disaster Relief Committee (CNDRC) at 2:00 pm. (just two hours after the major earthquake) and declared an emergency to 14 districts: Gorkha, Sindhupalchowk, Dhading, Kavre, Dolakha, Nuwakot, Ramechhap, Sindhuli, Rasuwa, Kathmandu, Lalitpur, Bhaktapur, Makwanpur and Okhaldhunga. GON made official requests to Governments of India and China for assistance. GON also requested international assistance including - Search and Rescue capacity; medical teams, supplies and tenting for hospitals, and dead-body bags;heavy equipment for rubble removal and helicopters for transport - access to blocked areas	25 April 2015
	Coordination centers were established in numerous locations including the NEOC, Humanitarian Staging Area, the international airport and the UN office. The Kathmandu and Pokhara airport remained open and the main feeder roads outside of Kathmandu Valley were accessible.	26 April 2015
	The Nepal Army established a Multi-National Coordination Centre (MNCC) at the Army Headquarters coordinating foreign military elements.	27 April 2015
	The focus of the response shifted outside of Kathmandu to cover the most affected districts. In the first four days, the relief capacity provided by India was dominant in the early stages of the response: 13 aircrafts and 7 choppers, buses and trucks carrying medical supplies and relief items, and a mobile hospital were dispatched since the earthquake hit on Saturday. According to media reports the Government of India sent 22 tonnes of food, 50 tonnes of water, and 10 tonnes of blankets, together with other relief items.	28 April 2015
	Despite the heavy rain, the first UNHAS helicopter flight delivered food and shelter items from Kathmandu to Gunda VDC in the Gorkha District.	29 April 2015
	The cluster provided transport to support the establishment of a base camp to be used by first responders. Transport was provided to deliver shelter kits from Saurpani VDC to Balua VDC in Gorkha District.	30 April 2015
Search and Rescue (SAR)	Indian Super Hercules was sent at 6:00 pm local time as the first arrived foreign search and rescue (SAR) and relief team.	25 April 2015
	Helicopters of Nepal Army, Private Sectors, and neighboring country India mobilized for Search and Rescue (SAR) operation to provide immediate relief package to the highly affected districts and the injured people were treated in nearby hospitals. Several international SAR teams from India, Pakistan, China, and the United States landed and began SAR operations or debris management.	26 April 2015
	UK SAR team (90 personnel) arrived. 4 personnel from OCHA Regional Office and 2 personnel from ECHO came to support coordination. Japan SAR team with dogs and Finland SAR team (30 personnel) income with ETA.	27 April 2015
	On this day, International SAR teams rescued 14 people from the rubble. At the	28 April 2015

	Effort	Date
	moment, the following countries were registered as having SAR Capacity in Nepal: Belgium, China, France, Germany, Hungary, India, Italy, Japan, Netherlands, Norway, Poland, Russia, Singapore, Spain, Switzerland, Turkey, UK, and the USA. The SAR teams were not yet arrived in Kathmandu were encouraged to stand down as the current committed support was sufficient to cover all affected sites.	
	SAR was still limited outside of the Kathmandu Valley. Some villages could only be reached by foot with some areas taking up to four to five days to reach. Fuel to transport SAR teams was limited. According to the Ministry of Home Affairs, 16,824 security personnel from the army and police were deployed for the rescue operations. As of 29 April, they are supported by a total of 54 international SAR and foreign medical teams (FTMs) with 1,719 personnel, according to the Reception and Departure Centre. National and international rescue and relief efforts expanded to nine districts (Sindhupalchowk, Kathmandu, Nuwakot, Dhading, Bhaktapur, Lalitpur, Kavrepalanchowk, Gorkha and Rasuwa). CCCM site profiling and officials were deployed to the 16 identified campsites in the Kathmandu Valley.	29 April 2015
	Five days into the response, search and rescue teams saved an additional two lives from the rubble.	30 April 2015
Food	The government was unclear on emergency food stocks.	25 April 2015
	The Government concentrated on food distribution efforts in the Kathmandu Valley and Food Security Cluster members concentrated in districts affected outside of the Valley.	26 April 2015
	Food trucks were on their way to affect districts outside the Kathmandu Valley. Food distribution started on 28 April 2015. 4 food assessment teams were deployed to cover Gorka, Lamjung, Sindhupalchowk, Rasuwa, Nuwakot, Dhading, Dolakha, Ramechhapp, Kavre, Bhakapur and Lalitpur.	27 April 2015
	Approximately 120 MT of food was available in the country. The food cluster dispatched food assistance to Gorkha and Dhading with existing in-country food stocks and was also organizing air support (via two helicopters) to get food to the areas unreachable via road transport. Around 30 MT of high energy biscuits and some fortified food (rice-soya blend) received from Dubai. Sindhupalchowk and Nuwakot were the priority districts for the cluster.	28 April 2015
	On 29 April, distribution of 100 metric tons of food began in Gorkha and Dhading district. Two helicopters were available to transport food to areas inaccessible via road.	29 April 2015
	Two helicopters were on standby in Gorkha and Dhading districts to deliver additional food assistance in hard to reach areas. The five core response interventions (breastfeeding, complementary feeding, therapeutic feeding for children with SAM, supplementary feeding for children with MAM and micronutrient supplementation) started in the affected districts.	30 April 2015
	835 metric tons of food was delivered to 11 districts: Bhaktapur, Dhading, Dolakha, Kathmandu, Lalitpur, Gorkha Lamjung, Rasuwa, Ramechhap, Nuwakot, Sindulpalchowk. The Cluster has agreed to standardize the food packets distributed by all partners which will include: 400g of rice, 60g of lentils, 25g of oil and 7.5g of salt per	1 May 2015

	Effort	Date
	person per day	
Water, Sanitation, and Hygiene	The WASH cluster provided 20 tanks (30,000 L) that would reach 1500 people in 3 camps in Kathmandu Valley. The WASH cluster agencies agreed to provide additional water tanks to all 16 campsites. ENPHO was requested to monitor water safety compliance. The cluster identified 11 priority districts with supply lists. KUKL started working to restore water supply, supplemented with water tanks.	26 April 2015
	Government assessment teams were deployed to eleven affected districts with support from cluster agencies meanwhile the distribution of emergency WASH supplies (Hygiene kits) was Limited in Dhading and Bhaktapur. The related Cluster required 25,000 Hygiene kits, 20,000 Tarpaulin, 40 tanks of 2500 ltrs, two Generators for the operation of deep boreholes for water supply, 20,000 packets of aqua tabs, household water storage containers, additional emergency pumps, and equipment.	27 April 2015
	Cluster members put up 90 toilets in temporary camps and distributed 200 hygiene kits in Bhaktapur district. WASH supplies (hygiene kits 220 sets, Aqua tabs – 5 cartons and chlorination sachet 2640) were received in Dhading. 2000 Tarpauline, 3000 hygiene kits, 3000 aqua tabs, 2000 plastic buckets (20lts and 10 ltrs), 1500 bottles of Piyush were supplied in Gorkha. Piyush (water purification drops) was distributed by several partners in the affected areas and a water treatment plant was prepositioned. Water tankers started the distribution of water supply in the temporary camps.	28 April 2015
	Partners distributed 100 hygiene kits in Sindhupalchok, built temporary toilets in Tundikhel and provided WASH supplies for 500 families in Sinamangal. Aqua tab and hygiene kits were dropped by helicopter to seven remote villages in Dhading.	29 April 2015
	To this date, the Cluster provided 11,552 individuals access to a sufficient quantity of water for drinking, cooking and personal hygiene in the Kavre and Kathmandu districts. The Cluster also provided a total of 100cu.m water supply in Tundikhel, Kirtipur, Rangashala (Stadium), Sano Gaucharan, Narayan Chaur camps in the Kathmandu District; and Durbar Square and Saraswati Kamal Binayak Camps in Bhaktapur District.	30 April 2015
Shelter	5 shelter camps were been established in areas belonging to the Armed Police Force which had water sources. GON also identified 16 open spaces around Kathmandu to be used as camps.	26 April 2015
	7,760 tarps were delivered to District Operation Centers for onward distribution to the affected people.	27 April 2015
	Agencies distributed 8.000 tarpaulins and 1.000 shelter kits in various affected districts.	28 April 2015
	Cluster partners distributed shelter items to the affected people. This included 21,151 tarpaulins and 4,000 NFIs (blankets and solar lamps) across the affected districts.	29 April 2015
	Approximately 450 shelter repair kits were distributed.	30 April 2015

	Effort	Date
	Daily camp management and mapping of IDP needs in camps and spontaneous settlements were ongoing in the Kathmandu Valley.	1 May 2015
	GON mobilized all hospital staff and deployed small teams to hospitals in Kathmandu and intended to set-up displaced camps in Kathmandu Valley and outside. Chitwan and Pokhara hospitals dispatched the first national medical teams to worst-affected areas – Gorkha and Lamjung.	25 April 2015
Health	A 24-hour emergency health operations room was set up at the Ministry of Health. It coordinated with the national emergency operations center at MOHA. Ministry of Health and Population (MOHP) was responsible for mobilizing medical human resources and making hospitals capable to perform. Coordination with bilateral partners went through MOFA to MOHP; coordination with international agencies and NGOs went directly to MOHP. American medical team (8 personnel) stationed in Nepal to deploy with medical kits. Post-earthquake diseases were a concern. Immediate priorities were managing dead bodies and injured people (many head and spinal injuries required airlifting). Diarrhea was an issue in Kathmandu Valley due to exposure to elements Four (national) teams were sent to Gorkha where it was estimated that in some areas, 80 percent of houses were gone and one international medical team mobilized to Dhading district to support health response efforts. There was a need for surgeons, orthopedics, and paramedics, as well as logistics support. World Health Organization (WHO) prepositioned surgical kits which were distributed. USAID and DFID had medical teams in, also a UNICEF WASH team. Only 27 drugs out of 40 and 70 free drugs and consumables list were available. Drugs and consumables could be supplied in UNICEF emergency health kits, with one kit serving around 10 thousand people for three months.	26 April 2015
	The health Cluster mobilized ten tents for the MoHP and central-level hospitals and delivered four IEHK to the MoHP. Five surgical kits have been distributed to different hospitals and 450 body bags handed over to Nepal Army. (WHO) provided funds and the emergency team which coordinated health response.	27 April 2015
	The Government requested that any foreign medical team that has not yet arrived in Kathmandu to stand by. More than 20 Cluster partners supported the response by providing specialized personnel and medical supplies and body bags, water filters and purification materials, setting up and providing basic construction materials for field hospitals. Injured people from Sindhupalchowk and Dhading were airlifted to Dhulikhel hospital and field workers were deployed to more remote affected areas. Foreign Medical Teams set up temporary hospital facilities in the affected areas (e.g. Pakistani Army ran a temporary hospital in Bhaktapur).	28 April 2015
	Medical teams and field hospitals were ready and waiting for the Government's advice to dispatch if and when needed and reproductive health kits have been provided which will address needs for 90,000 people.	29 April 2015

Effort	Date
Temporary health services were provided in makeshift tents outside the district headquarters in the worst affected areas. Surveillance of acute diarrhea was established in the 16 Kathmandu camps and affected districts.	30 April 2015
Field hospitals were established in Dhunche (in Rasuwa District), Chautara (Sindhupalchowk) and Bidur (Nuwakot District). The Cluster provided support to establish a surveillance system for epidemics. The Government investigated reports of a diarrhoeal outbreak in an IDP camp on the southern outskirts of the Kathmandu Valley. Samples were collected and sent for laboratory testing.	1 May 2015

Emergency shelters

In all Nepal's earthquake-stricken cities, finding appropriate locations for setting up emergency shelters was performed in two ways:

a): If the private damaged houses did not collapse fully and it was possible to bring the essential appliances outside, the owners tend to stay beside their houses; so they set up their temporary shelters next to their houses. Most of these emergency temporary shelters were only plastic sheets that were distributed throughout the cities and people themselves had set them up as tents without side walls using remained bamboo reeds and wooden beams of their houses (**Figure** 10). A large number of these kinds of emergency shelters were observed in which there were no basic hygiene amenities such as toilets and bathrooms. The residents refuged to these tents only at night or during rain. The Food and clean drinking water were provided by the affected people themselves in an extremely difficult way and there was no humanitarian assistance in these shelters.

Figure 10. Handmade temporary tents that owners had made using plastic sheets, bamboo reeds and wooden beams beside their houses in urban areas.

b): If the houses were completely destroyed and it was not possible to find intact appliances or due to the specific circumstances of the region (narrow alleys and houses with very low area), it was not possible to find an open space and provide safe emergency shelters and tents, and the people tended to migrate to their relative houses in the other regions or stay in public camps in the cities. In Tundikhel Parade, Nepal's Army was responsible to manage a camp and a Japanese team was responsible to provide health services. In Bhaktapur, a public emergency camp was set up in a small park in which a German team named NAVIS, was fully responsible to manage all the issues of the camp. In both of the public emergency camps in

Kathmandu and Bhaktapur, two types of tents donated by China and India were used. It was observed that the Chinese tents had better quality and design than the Indian ones. All the Chinese tents were made of resistant steel frames with a two-layer cover, a surface waterproofing cover and an internal thermal insulation cover, while the Indian tents were made of a single layer canvas cover. With regard to the weather conditions in Nepal such as cold winter and heavy rainfall, the quality of the used tents is very important for the residents of the camps. Although the Chinese tents had a very good quality, unfortunately they were not set up correctly in Kathmandu so the rainwater had penetrated into the tents and all parts of the the tents and also the clothes got wet (**Figure** 11).

Figure 11. Emergency tents in public camps of Kathmandu and Bhaktapur donated by China (Right) and India (left)

In the affected villages of the Gorkha district, the damage was estimated to be more than 80%. During our visit, there were no emergency shelter tents and only some plastic covers were distributed instead of tents. In order to set up temporary shelters in these villages, some people had made frameworks using bamboo trunk which were covered by plastic sheets. Most of these shelters lacked side walls and would simply be blown away by the first gust of wind. Some of the villagers skilled in carpentry and masonry often tried to build very basic cottages using the remaining materials of their building debris. Most of these houses had a wooden skeleton with bamboo straw sidewalls. Doors and windows of the destructed houses were also used as the doors and windows of the new houses and metal corrugated sheets or plastic coating were used to cover the ceiling (**Figure** 12). In none of these villages, there were no appropriate tents such as tents which were installed in the cities of Kathmandu and Bhaktapur.

Figure 12. Handmade temporary tents that owners had made using remained parts of their houses in rural areas.

Drinking water supply

Even before the earthquake, a clean drinking water supply has been one of the oldest essential

problems in Nepal. About 50% and less than 30% of the population has good access to treated water during rainy and dry seasons, respectively. After the earthquake, treated water was distributed daily by local and international NGOs among the affected people of Kathmandu. According to a senior official of the water organization in Kathmandu, the country is only able to provide one-third of the needed treated water during the annual rainfall and only a quarter of the treated water in dry seasons for the population. Although, the depth of the groundwater level in some parts of Kathmandu was measured to be about 3-6 meters (**Figure** 13), it is not useable due to the water pollution especially the existence of heavy metals. Thus, treated water is distributed throughout the city using tankers.

Figure 13. Groundwater level mostly in western parts of Kathmandu with about 3-6 meter depth.

In the two emergency public camps of Kathmandu and Bhaktapur, the supply and distribution of treated water were performed by German and French teams. In Kathmandu, drinking water was treated by a German team in the location of water organization in Central Kathmandu and carried to the public camp by tankers (**Figure** 14). The German team had provided a water filtration system at Kathmandu's Water Organization which could provide 10,000 liters of clean water per hour for people's usage. German specialists expressed that they could enhance the capacity of their water filtration system into 120,000 Lit/day but there were not enough facilities to distribute even that 10,000 Lit/Hour of clean water. Kathmandu's Water Organization had promised the German team to have 5 trucks to distribute clean water daily, but actually, less than 5 trucks were available. Without the occurrence of an earthquake, Kathmandu is a city where there are so polluted water supplies extracted from wells. Moreover, about 360 million liters of clean water are needed per day; while only 130 and 90 million liters of clean water are daily available in rainy and dry seasons respectively. In Bhaktapur, water was extracted from in-situ wells (**Figure** 15) and was refined and distributed by the German team.

Figure 14. Providing treated water in the Water Organization of Kathmandu by a German specialist team and distribution of it throughout the city by trucks.

Figure 15. Providing treated water in Bhaktapur from extracted water of in-situ wells by a German team.

In rural areas, although water distribution networks were very basic and public water taps were often used throughout the villages, fortunately, this primary water distribution network was not damaged seriously and still provided the services. Therefore, water supply and distribution in rural regions was not the primary priority of crisis management.

Providing health services/toilets and bathrooms

In the camp of Kathmandu, residents had to use the public restrooms of Tundikhel Parade, while these services lacked appropriate quality and standards. In the camp of Bhaktapur, two emergency health services were initially set up which were closed during the first week of use, due to the wrong location of these two services (up of the slope toward the camp), and the wastewater penetrated into the camp. After a while, the health services installed for tourists were used instead (**Figure** 16).

Figure 16. Prepared health services in the public camp of Kathmandu.

After the earthquake, one of the basic needs of the contact groups is to use proper facilities for washing and bathing. Lack of attention to these basic needs may not have tangible feedback during the first two weeks, but over time, due to the incidence of skin diseases, especially infectious diseases like fungal, it poses serious problems to crisis managers which will be very costly and time-consuming. Unfortunately, there were no bathrooms in both camps of Kathmandu and Bhaktapur and families act to wash their children in the outdoor area (**Figure** 17). In addition, no toilets or bathrooms were set up in the visited villages, and most villagers had to use the rural health services commonly which were remained intact after the earthquake.

Figure 17. Washing and bathing outside the public camps in Kathmandu and Bhaktapur.

Collection and disposal of wastewater and sewage

In both camps of Kathmandu and Bhaktapur, wastewater of toilets were driven into some absorption wells. These absorption wells were designed and dug for health services. Considering the number of camp residents, these temporary health services would be out of service soon. Thus, camp managers should think about some new absorption wells or water treatment devices. There was no sewage system to collect the wastewater generated from washing in the camp of Kathmandu and this wastewater was abandoned in the area as surface water. This wastewater was full of mosquito larvae and will certainly trigger outbreaks in the camps during the next few months. But in the camp of Bhaktapur, better quality services were provided.

Health and medical needs

In aspect of environmental health, camps were entering a phase of a high risk just in two weeks after the earthquake. Existence of surface wastewater in the environment, lack of a hygienic bathroom, lack of periodic spraying to control insects and the lack of basic facilities for washing clothes and dishes may cause a serious problem in the camps.

Free distribution of medical services especially for women as well as the distribution of birth control devices was an important issue. In both camps, there were some special tents for medical needs where German and Japanese doctors took care of patients.

In the villages, the distribution of basic amenities of life was neglected by crisis managers and the distribution of hygiene and medical supplies was very unfavorable, lower than the basic necessities of life. This may lead to widespread diseases in the affected areas in a few months, impress especially malnourished children as the first target and intensify respiratory prevalent diseases in the region.

Food supply

In both camps of Kathmandu and Bhaktapur, the production and distribution of hot food were performed by local and international NGOs (**Figure** 18). Although the food was distributed in the camps freely, families often were reluctant to receive these foods and they tend to cook in their tents. Therefore, managers of the camp had started to distribute raw materials for cooking by families.

Apart from the lack of interaction and coordination for the management of donation distribution in the affected rural areas, fortunately, food, especially rice and cereals, were distributed well in the affected villages. The volume of input aids was considerable and most of the donations were delivered to the UN camp (established in at the beginning of sidetrack of the main road to the city of Kathmandu and Pokhara toward Gorkha) to be distributed throughout the affected region. Some parts of the donations that were sent to the region by donors directly weretaken over by

the Nepal military at the entrance of Gorkha and were distributed in the damaged villages.

Figure 18. Preparing hot food by international NGOs in public camps.

Providing basic amenities for life

Given that all camp residents in the city of Kathmandu and Bhaktapur were families whose houses were completely destroyed, providing basic amenities of life for them might be certainly a priority for crisis managers while this could not be seen in the first 12 days after the earthquake. Supplying waterproof mats, blankets, warm clothes, underwear for women and children and basic cookware are the main priorities that should be supplied as soon as possible (**Figure** 19).

Figure 19. Lack of appropriate basic amenities for life in emergency public camps.

There is a complicated and dangerous wire system transmitting electric power in Kathmandu (**Figure** 20).

Figure 20. A dangerous and complicated power wires system in Kathmandu

In the emergency shelter, wooden beams remained from the roofs were used for the main framing of the unit and also the remained bricks were used for walls. In the construction of the entrance door and the roof of this unit, free plastic and canvas coverings distributed in the area by the government were used. Being able to withstand harsh conditions in mountain areas, particularly cold weather and torrential rains, is one of the advantages of such units (**Figure** 21).

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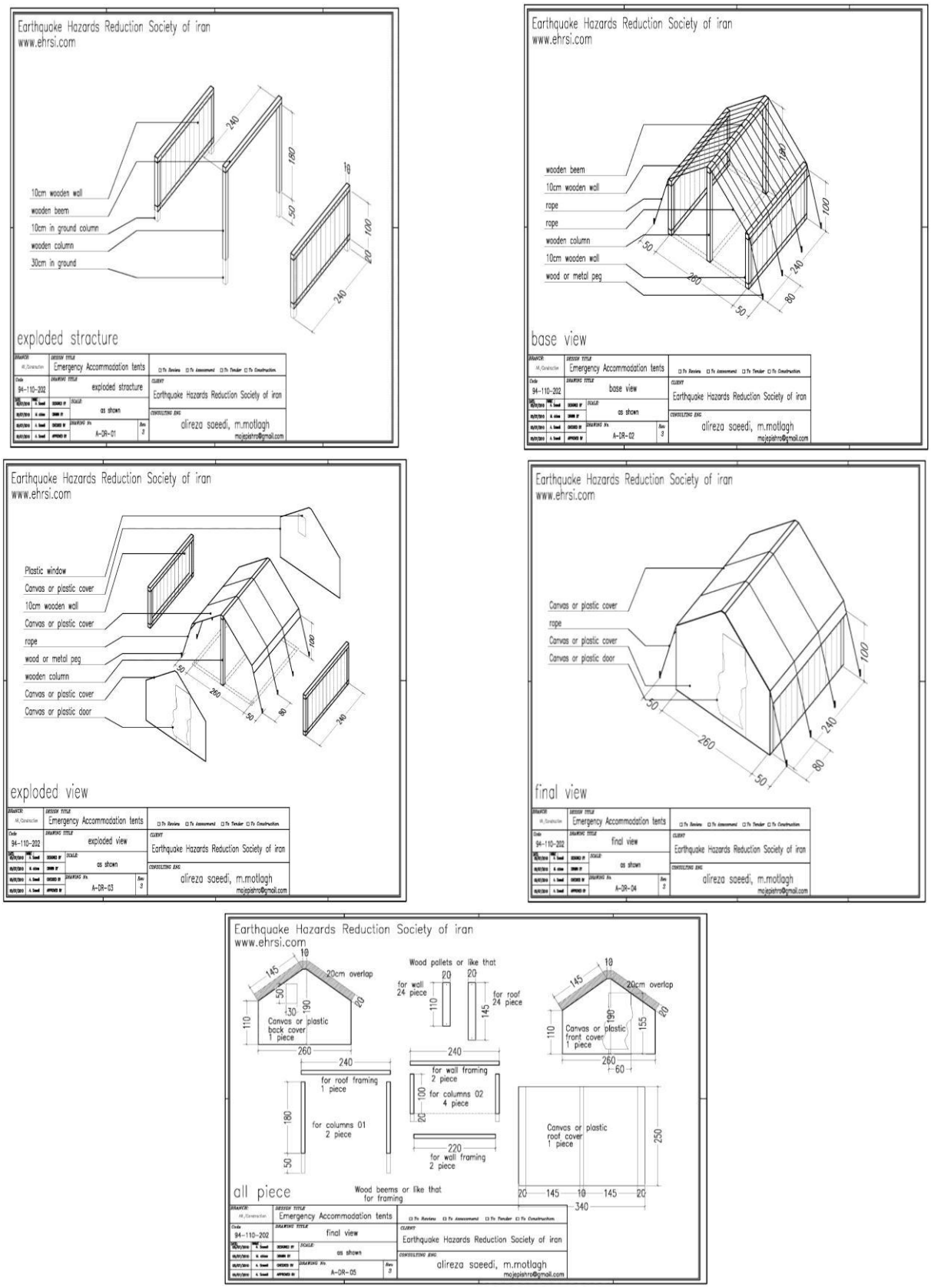

Figure 21. A new design of emergency tents to be used in Nepal's emergency camps.

Proposal: Temporary accommodation

Emergency shelter is the first and the most important need of a family affected by an earthquake. Most of these shelters must be able to provide a secure place for survivors to live in until the damaged houses are reconstructed.

Due to the fact that Nepal could be considered as an economically poor country and the earthquake-affected people often live in rural areas whose economic conditions are poor, any emergency shelter must be designed at low cost and the cheapest materials one can find in these areas after an earthquake are those that remained unharmed and could be found in building rubble.

It is worth to say that most of the buildings, especially in rural areas have walls built of stone and brick, and the roofs often have wooden beams with metal or gravel roofing. Having analyzed the building rubble in earthquake-stricken areas in Nepal, it was attempted to design an emergency shelter at Earthquake Hazards Reduction Society of Iran. The materials needed for construction of this shelter are collected from the materials remained in building rubble of destroyed buildings.

Conclusions

On 25 April 2015, an intense M_w7.8 earthquake struck central Nepal imposing large damages to the structures and infrastructures, causing life and property losses. Nepal's infrastructures are mostly traditional and so weak based on a process of non-sustainable development. Thus, Nepal can be considered as a symbol of vulnerability and resiliency of all the developing countries in terms of natural disasters especially earthquakes. This complicated situation could also be seen on 12 January 2010 M7.2 Haiti earthquake which claimed about 300,000 out of 2 million people of Port-au-Prince.

In this study, based on the visit of 1st and 2nd authors to the epicentral region including rural areas and cities containing Kathmandu, Bhaktapur, Gorkha and Pokhara during 6 to 11 May 2015, the states of disaster management, logistics were assessed and the emergency and disaster management measures are evaluated. It seemed that national organized emergency plans could not be implemented efficiently in the case of this major disaster. The United Nation organization arranged the disaster management efforts. In the context of emergency responses, international teams and NGOs performed well, while during our visit time, some problems like distribution of treated water, lack of enough helicopters to deliver relief packages, repeated power outages, health problems in the temporary shelters (shortage of shower/no controls wastewater) and remained earthquake debris left in the demolished sites were still evident. Finally, some key lessons that can be learned from the earthquake were mentioned and we proposed a new design of emergency tents that can be used in earthquake-stricken regions of Nepal during the future month.

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Conflicts of interest

The authors of this paper announce no conflict of interest.

Authors' contributions

M.Z. was the leader of reconnaissance visit and study. The M.Z. and A.S. authors have visited the epicentral region in Nepal. F.K. and P.P. authors have compiled the demage data and loss estimations. The design of emergency tent is performed by A.S. author.

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