PRE-POSITIONING OF WATER SUPPLY SYSTEMS AND DEVELOPING EARTHQUAKE PREPAREDNESS AND RESPONSE FRAMEWORK IN NEPALESE CITIES

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ABSTRACT:
Kathmandu Valley is the most at-risk city in the world in terms of potential loss of life due to earthquakes. Studies have estimated large number of casualties and great loss of infrastructures and property in case of scenario earthquake of intensity IX MMI. In this regard, this paper presents the work implemented by National Society for Earthquake Technology -Nepal (NSET) and Lalitpur Sub-metropolitan City (LSMC) in support of UNICEF Nepal and DIPECHO for selection of evacuation sites, pre-positioning the safe drinking water accessible to the evacuation sites and a response framework during an emergency due to an earthquake, which has been an example for other municipalities of Nepal and also in the region.

KEYWORDS:
Earthquake preparedness, evacuation site, deep tube wells, vulnerability assessment, strengthening

1 INTRODUCTION

Lalitpur is one of the oldest cities in the Kathmandu Valley neighboring the capital city Kathmandu. The total area of Lalitpur Sub-Metropolitan City (LSMC) is 15.4 km^2 with total population of about 200,000 in 2008. Due to the rapid construction rate of new buildings the city area is highly expanding and has resulted rapid and unplanned urban growth with increasing vulnerability to natural disasters like earthquakes, fire, flood, landslide and others. In this context, regarding the earthquake, many initiatives have been taken by national and international organizations for the assessment of earthquake vulnerability especially in the highly populated Kathmandu Valley. Estimations also have shown thousands of deaths, several thousands of injuries, and reduction of most critical facilities and lifelines to the half of normal operation in case of a scenario earthquake with intensity IX MMI. One of the studies, *Study on Seismic Vulnerability of Drinking Water Supply System in Kathmandu Valley* by NSET in 2003 has shown that besides great losses of live, property and urban infrastructures during an earthquake especially water (drinking) supply will be a serious problem: most parts of the valley will be without piped water supply for several months and several areas could remain without water service for over one year. Thus the existing situation of water supply in LSMC and the possible impact of earthquake in water supply pipelines present the possibility of great problem of drinking water. However, research studies and experiences from the past earthquakes in the similar areas have shown that the deep tube wells (DTWs) will get less affected as compared to the surface pipelines due to earthquakes and recommended that the DTWs could be used as the alternative sources of piped water sources. Therefore, as the preparedness for possible problem due to earthquake in the future, the project DPRP for Safe Drinking Water in Lalitpur Sub-Metropolitan City was launched with the major objectives to develop the outline of a comprehensive framework of Disaster Preparedness and Response Plan via identification of potential evacuation sites and strengthening the reliable deep tube wells (DTWs) accessible from the evacuation sites for LSMC.

1.1. Methodology

The estimation of building damage/collapse and human casualties were made based on the previous studies (SLARIM, 2004-2006). Field surveys and analysis were carried out by an experts' team for the selection of evacuation sites and deep tube wells. Quality of water from the selected deep tube wells was tested in the lab and the earthquake vulnerability assessment of relevant structures was carried out by experienced earthquake engineers. Sphere hand book was taken as the reference for the standards and requirements for the services during emergency, and some modification in the context of Nepal were made. The consensus of local people, and other stakeholders was taken on the findings and decisions, conducting series of workshops and interactions. A municipal engineer was involved throughout the project and series of interaction meetings were conducted with municipal officials to make sure their involvement and ownership.

2 SELECTION OF EVACUATION SITES

In the process of urbanization, the open areas within LSMC, such as agricultural lands and public spaces, are rapidly changing in to built-up environment, creating the lack of evacuation sites during the emergencies due to major disasters like earthquake. Therefore, during the current project, to identify the potential evacuation sites, first, the project team identified and surveyed the open spaces available within LSMC. After in-depth study, conducting series of discussions with local people, owners, as well as revisiting the identified open spaces, the potential evacuation sites were selected considering population holding capacity, ownership (priority was given to public areas), accessibility, water availability, sanitary condition and surrounding environment. To provide services during an earthquake event more easily, the evacuation sites were selected in clusters (Figure 1). Thus, finally, meeting these criteria, ten open spaces in three clusters were selected as evacuation sites within LSMC. Most of these evacuation sites are currently used as playing grounds, institutions and some are bare lands with the total population holding capacity of about 70,000. However, this population holding capacity of selected evacuation sites is not enough to adjust the estimated displaced population (90,000) of LSMC due to scenario earthquake with intensity of IX MMI.

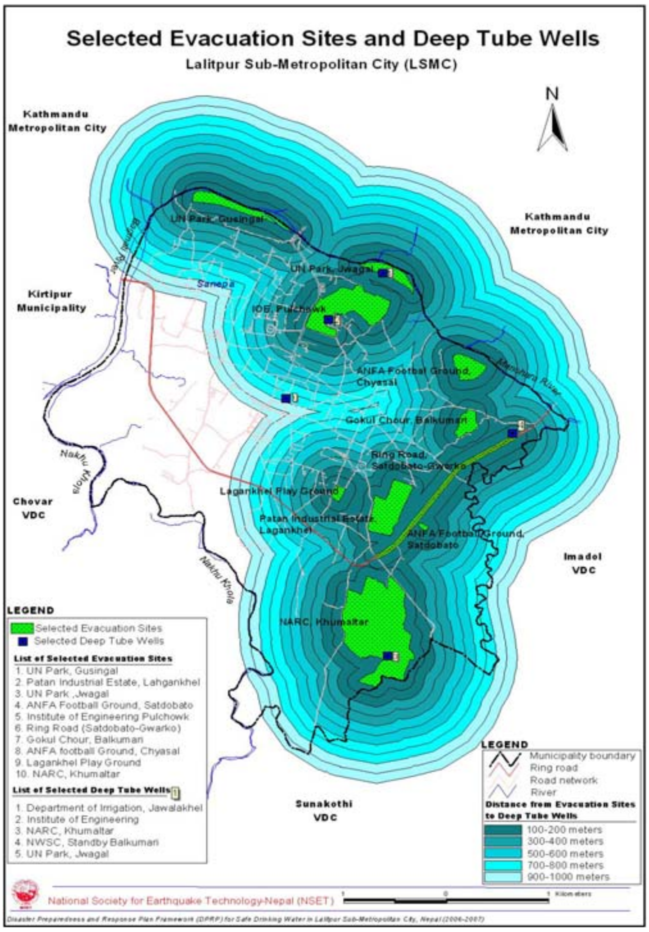

Figure 1: Selected Evacuation Sites and Deep Tube Wells

3 SELECTION OF DEEP TUBE WELLS (DTWS)

Kathmandu Valley is supposed to be a lake in the past and as the time passed this lake was filled up with the debris and other materials from the surrounding hills. Thus the valley is full of clay, silt and sandy soils except some small hillocks with exposed bedrock in between. Along the river banks and some low lands have identified as potentiality of liquefaction and almost same areas are identified with high potentiality of ground water discharge. In this background, the experts' team, including geotechnical engineer, hydro-geologist, environmentalist and geographer identified all existing deep tube wells (DTWs) within LSMC and located on the map. The identified DTWS then overlaid on the geological map, drainage map and selected evacuation site map. Applying the selection criteria of (1) considerable discharging rate, (2) within 1km of distance from an evacuation sites and (3) with public ownership and (4) existing condition and quality of water, 5 DTWs were selected as the potential emergency water sources. To ensure the functionality of DTWs after earthquake providing safe drinking water, earthquake vulnerability of the system was carried out and the structures were reconstructed/ strengthened, the quality of water was tasted.

4 EARTHQUAKE VULNERABILITY ASSESSMENT (EVA) AND STRENGTHENING OF DTW SYSSTEMS

As overlaid the selected DTWs on the intensity distribution map of the 1934 earthquake most of them fall in an area of intensity IX MMI (figure 2). As the structures lie in this high hazard zone it is very important to assure the design of the system for safety against earthquake loads. Therefore a qualitative and quantitative structural assessment of the structures was done based on visual observation and review of drawings and design details available for the con-struction. Different seismic vulnerability factors were checked and expected performance of the structure was estimated for different earthquakes intensities. Moreover based on the structural drawings and interviews with structural designers the buildings were modeled in ETABS or STAAD, special computer software developed for the analysis and design of structures. The EVA of DTWs drawn four main issues to make the DTWs an alternative drinking water supply for the evacuation sites are: (1) the foundation and understructure of the water tanks have to be robust and well anchored to prevent sliding or overturning of the same; (2) the boring site has to have a proper shed to avoid corrosion; (3) the water treatment plant as well as generator should be in an earthquake safe building (earthquake resistant design includes splints, cross bracings and bandages etc.), not too close to the DTWs (because of probable contamination) and (4) one recommendation that fits to all assessed structures is that the pipes should be provided with flexible joints at proper locations (e.g. point where the pipe enters or exits a building, sharp bending etc.). If pipes are rigidly connected at these places, it may suffer from disjointing or bursting. Thus according to EVA, the DTW structures might experience moderate to very heavy damage in earthquakes of intensity IX MMI. However, all DTW structures need improvement or reconstruction to make them earthquake safe depending on their level of vulnerability. Hence in the process of reconstruction and strengthening, the earthquake resistant components were checked in the designs for the reconstruction of structures and further provided technical monitoring for ensuring implementation in the sites.

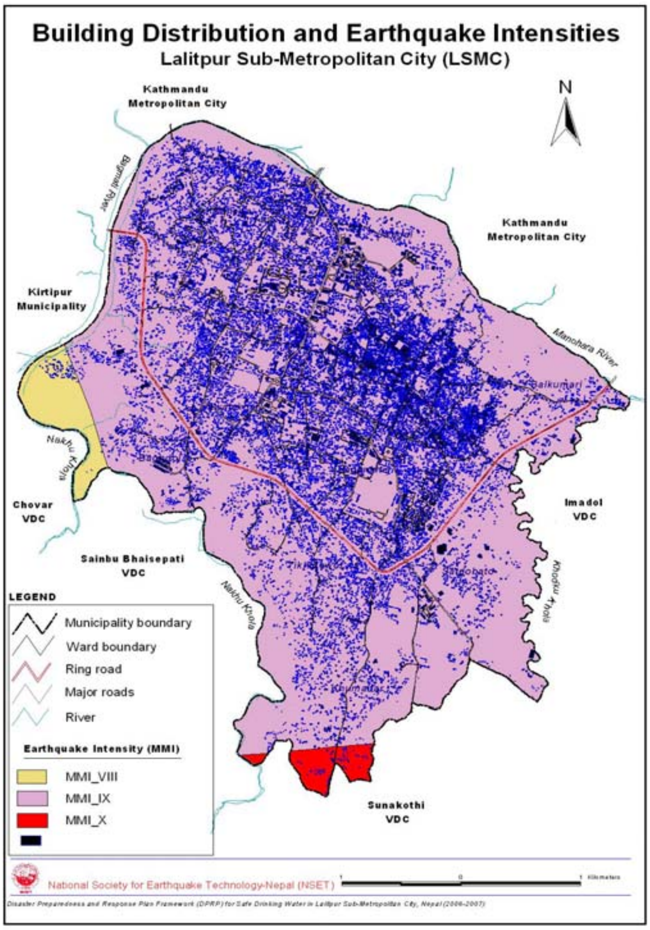

Figure 2: Building Distribution and Earthquake Intensities

Further to avoid the electricity failure after earthquake, the DTWs are provided with backup generators and 26 technical personnel are trained for operation and light maintenance of the systems.

5 STATEMENT ON WATER QUALITY

The quality of water was tested from the selected DTWs to insure the safe drinking water during the emergency due to earthquake. The overall findings were that the entire water from the selected DTWs was not found usable for drinking purpose without proper treatment due to high turbidity values, arsenic, ammonia, iron and manganese; poor sanitary conditions; lack of regular operation and washing; lack of timely disinfection of wells, storage tanks and the distribution networks were missing. Therefore the experts have drawn some recommendations to produce qualitative drinking water i.e. regular pumping washings of wells and provision of treatment units; specific waste management to avoid contamination of other water sources; and repairing the leak, cracked or weak structures. Besides, an option was put to make a provision of a mobile treatment plant during emergency that could be used any where and in case, if the existing system fails.

6 PREPARATION OF DISASTER PREPAREDNESS AND RESPONSE PLAN FRAMEWORK (DPRF)

One of the major outcomes of the project is the development of Disaster Preparedness and Response Plan Framework (DPRF) to make the system operable and sustainable for LSMC. The objectives of DPRF were to define overall procedure and identify the key stakeholders including their roles and responsibilities for earthquake disaster preparedness and response and to draw their commitments for different phases of activities. The DPRF is developed based on existing urban environment i.e. population, buildings and infrastructures, and assuming a scenario earthquake with ground shaking of intensity IX MMI, as different studies have taken for the study area (Figure 2), which has created an emergency situation (beyond the national capacity to cope with) causing about 43% buildings damaged, more than 27% collapsed, about 42,000 casualties (21% of total population) and about 90,000 population to be evacuated (about 45% of the total population). Most of the urban infrastructures i.e. electricity, telephone system and water supply system are estimated to be out of function. More than 50% bridges are impassable and more than 10% roads are damaged. Based on this scenario, the DPRF is divided in two sections to cope with. The first section (Table 1) deals with the actions immediately to be taken and the second section-B (Table 2) is for the actions mainly for relief and recovery, say after emergency period. The sections are further divided in different fields for different sectors, for instance, in the water supply sector: overall scenario/consequences due to the event, actions to be taken, method/way of actions to be taken and the responsible agencies.

Table 1: An Example of DPRF for LSMC- Immediate Response Phase

Current Earthquake Emergency Scenario	Sector	Elements of Response			
		What needs to happen to relieve the situation?	How?	Responsible agencies	
				Prime	Supporting
Within few hours after an earthquake - general chaos, people don't know what is happening, nor is the extent of the disaster understood.	Assessment	General assessment (rapid assessments) of what the situation is and the extent of damage	Members of LSMC disaster management committee assemble at the agreed command centre within a few hours and start sending information to the DDRC, who then send information to the National Command Centre	MOHA	LSMC, UN
			Aerial (helicopter) assessments	NDRC, Army	
			Rapid assessments (situation analysis) assessment at ward/ cluster level by local volunteers and fed back to DDRC.	LSMC, MOHA	NDRC, Army

Table 2: An Example of DPRF for LSMC- Recovery Phase

Current Emergency Scenario	Sector	Elements of response			
		What needs to happen to relieve the situation?	How?	Responsible agencies	
				Prime	Supporting
Some buildings are still standing but heavy damage is evident. People are afraid to go inside incase of aftershocks.	Assessments	Structural damage assessments to be made to determine if structures are safe for habitation	• Structural experts: make assessments of hospitals, schools, community buildings as a priority • Provide training to local engineers/technicians to make individual house damage assessments and categories the severity of damage at each house (Triage)	**DUDBC**	LSMC, NSET, other professional organizations

7 CONCLUSION

The very first need during emergency is considered drinking water for life. As the studies have shown in the event of major earthquakes the existing system of water supply in Kathmandu valley will not be functional creating scarcity drinking water for a month long. Therefore current effort was an effort for pre-positioning the alternative source of drinking water that could be used during/after emergency due to earthquake. In this regard, five deep tube wells in accessible distance of selected potential evacuation sites within LSMC are pre-positioned as alternative sources of emergency drinking water. These deep tube well systems are made earthquake resistant and provided with backup generators to insure functional even after major earthquake. Further to make the system sustainable, the project also provided the training for technical personnel for operation and light maintenance of the systems.
Further to make the system sustainable a response framework identifying overall procedure for response during major earthquakes, the responsible agencies including their roles and responsibilities for earthquake disaster preparedness and response. It was developed based on an assumption that an earthquake of IX MMI intensity has struck Lalitpur leading to thousands of casualties and huge damage to buildings and infrastructure. The framework serves as a guide for future course of action in case of the occurrence of a large earthquake in Lalitpur.

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