CHAPTER 5 PROTECT LIFE AND PROPERTY OF THE PEOPLE

One of the primary objectives of emergency planning is to protect life and property. In order to protect life and property through effective planning, it is first necessary to understand the magnitude of the scenario earthquake and its potential damage. Only after a better understanding of the problems in the existing socio-economic factors of the urban structure can planning for improvement be effective.

The structure of this chapter is mainly divided into three sections. The first section deals with the brief introduction of the Event Scenario. The introduction of the scenario earthquake, its ground shaking, landslides and liquefaction potentials etc. are discussed. From the results of the study on the existing status, the summary of the damage caused by the scenario earthquake to buildings, casualties, infrastructure including roads, bridges and the airport, lifeline facilities like water supply, sewerage, power supply and important facilities like communication and information including telecommunication and media, is presented. However, this event scenario is from an overall point of view, some detailed elements of the scenario are described in the related sections.

The second section of this chapter deals with the Onsite Activities after the occurrence of the Scenario Earthquake. Each subsection covers the detailed scenario resulting from the earthquake in the respective topic, based on the problems identified in the present status, followed by the proposals for improvement in order to protect life and property of the people from the disastrous earthquake. The probable difficulties during search and rescue operations are presented, covering the difficulties in international rescue as well. The underlying problems in the present status of the important components of onsite activities during earthquakes like medicine, drinking water and food, sheltering and temporary housing, public heath care, etc. are then discussed. The more sensitive social issues like cremation have also been discussed briefly. Other key functions such as security, fire-fighting, management of volunteers, safety inspections of structures and infrastructure, debris removal and disposal are also discussed.

The third or last section of this chapter covers the logistics required to support the Onsite Activities after the occurrence of the disaster. The transportation system must continue to function during and after the occurrence of the earthquake disaster, so that the onsite activities of search and rescue and other socio-economic activities can continue to function. Similarly, the electricity supply and staging areas are other factors playing an important role during the initial stage of a disaster. The existing conditions of these factors are discussed, identifying the underlying problems, and the scenario on damage to these facilities is discussed. Proposals are then made, such that these facilities for logistics during onsite activities can provide better support.

5.1 Event Scenario

This Earthquake Event Scenario outlines the impact of a possible disastrous earthquake with a magnitude of more or less 8.0 on the Kathmandu Valley. The purpose of this Event Scenario is to try to determine the ***direct phenomena*** that can be expected, based on the Earthquake Damage Estimation of this JICA Study. The Scenario intends to show the weak points of the current Kathmandu Valley and to present fundamental information for earthquake disaster management planning, in order to improve the strength of the entire Valley against an earthquake disaster.

Note that the Scenario and the damage assessments based on ground shaking caused by a specific plausible disastrous earthquake are drawn for earthquake disaster management planning purposes, based on the chain of hypotheses from a technical point of view. Also, recent technical considerations and experiences were introduced, but not sufficiently for site-specific engineering evaluations, because they lack current data required for various assumptions through the estimation process. Therefore, behaviours of facilities or people that are particularly sensitive to emergency response will require further detailed geotechnical and other studies.

Further, note that earthquakes of different sources and magnitudes or on any other faults relating to the area would result in different patterns of damage and influences.

5.1.1 Hazard Caused by the Scenario Earthquake

(1) Earthquake

One afternoon in the winter of 200x, a terrible ground shaking continued for a couple of minutes. The shaking made the ground roll upside down and people thought the world would accept its end. Most of the people could not stand still or walk at all. This earthquake was one of the most plausible ones with a magnitude of more or less 8.0. Since the Valley has been affected historically by earthquakes with a return period of about 100 years on average, and also the last two were in 1833 and 1934, older people and experts have warned the current generation about earthquakes and the vulnerability and lack of preparedness in the Kathmandu Valley.

(2) Ground Shaking

On the outcroppings of hard rock, the ground shaking showed a relatively lower MMI VII, even though this intensity could collapse the weakest buildings and slopes, but weaker buildings not easily. But in the low lands or the terraced regions the ground shook stronger in MMI VIII or even higher than VIII; weaker buildings and slopes failed. These intensities are similar or a little bit low, compared with the ones at the earthquake source region of the Gujarat earthquake in India in January 2001. Hundreds of aftershocks continued for a week. Though the intensities of the aftershocks were lower than the main event, some of the partially collapsed buildings fell down and blocked entry to these houses, preventing the people from staying inside.

(3) Landslides

In the rural areas, rock falls and landslides were generated. Several people were killed and some failures forced roads and lifelines that crossed the slope to be interrupted.

(4) Liquefaction

Liquefaction occurred along the river-beds and river banks with higher water tables and soft sand, which caused several houses and bridges to tilt and crossing pipelines to be ruptured. This phenomenon could be found frequently in the southern edge of Kathmandu Municipality and Lalitpur along the Bagmati River. Further, some river banks failed due to ground shaking, more than by the effects of the inundation. The flow in the rivers was almost the same as before the event.

5.1.2 Damage Caused by the Scenario Earthquake

(1) Buildings

Damage Distribution: Heavy damage to buildings caused by the earthquake exceeded 40% in the many rural or suburban settlements, and an especially high rate could be found in rural settlements in Kathmandu District and also in the southern part of Kirtipur municipality. This high rate of damage was caused mainly by the weakness of building types such as earthen-mud, stone and adobe. In some urban areas, the heavily damaged rates showed lower percentages, because brick with cement mortar or RC with masonry were popular. However, even RC

(Reinforced Concrete or Pillar System) with masonry and Brick with cement mortar buildings collapsed, caused by non-engineered construction, weathering by moisture, and inadequate foundations. Many houses fell down with debris of bricks, iron, timbers, furniture and dust. In densely concentrated areas, many falling buildings affected neighbouring buildings due to different vibrating characteristics.

Number of Damaged Buildings: The number of damaged buildings was much greater in urban areas than rural areas. The total number of collapsed buildings was 53,000, one fifth of the total building stock, and partially collapsed buildings were 75,000, with a combined total of almost half of the buildings in the whole Valley. Even though traditional buildings survived the 1934 earthquake, after that time many buildings were expanded to more than 4 stories or divided among brothers without engineered design, and also the long years caused the buildings to weaken against earthquakes.

Fire: Power lines in the walls were cut and sparked causing fires, and cooking stoves using fire or kerosene ignited fires. Fortunately, although fires broke out in tens of places, most did not spread due to the primarily inflammable building materials.

Blockage: One of the serious problems was that buildings along roads and highways collapsed onto them and blocked access at many places, especially at city core areas and newly developed commercial areas. Debris after the earthquake consisted of the rubble and debris of buildings, traffic, daily life disposals, waste-water, dead bodies, and so on. The volume was enormous and almost nobody was concerned and prepared to take action on it. Many civil servants were made to work on treating the debris, and even on burning dead bodies. But because of insufficient staff and the large volume, the management and disposal of the debris was not completed until more than six months after the event.

Repair & Reconstruction: The people who lost their houses or needed to make repairs to their houses or shops needed to work hard work for several weeks to several months to recover. The debris of bricks, timbers, dust and destroyed furniture was mostly reused in the recovery and the rest was thrown into rivers or open spaces. Further problems were caused in the rehabilitation and reconstruction, because the rehabilitated buildings were weaker than before. Aftershocks following the main shock increased the damage to partially damaged buildings and they sometimes killed the persons inside.

Retrofit: Already retrofitted schools were safe and suffered no damage. They saved the children's lives. This validated the retrofit methodology.

(2) Casualties

Deaths: Most of the death toll of 18,000 resulted from the collapse of houses. This was 1.3 % of the total population in the Valley, similar to the 1934 earthquake. This was a big tragedy, very similar to the consequences of the Gujarat Earthquake, where 90% of the deaths were caused by collapse of buildings made of bricks or stones.

Specifically, half of the deaths and injuries were concentrated in the urban areas of Kathmandu Municipality. The casualties were almost proportional to the number of collapsed buildings. Dead bodies mostly remained in the debris of buildings for a few days and the capacity for proper cremations was overtaxed.

Injuries: People who were seriously injured and needed medical care in a hospital were estimated at 53,000 people, and the moderately injured were around 93,000. Most of the injuries were caused by building collapse, falling objects from buildings such as bricks, window glass, water supply tanks from roofs, transformers, furniture or furnishings such as flower pots. Some were injured in the confusion of traffic or by psychological causes.

Weaknesses: Over half of the deaths and injuries consisted of elderly people, children and females. The event occurred in the afternoon and these people were at home when the disaster struck. This is also a common occurrence in most earthquake disasters in the world. Weak and ill people, and also outsiders such as tourists unfamiliar with the city and local languages should be considered when planning how to guide and protect them from the disaster event.

Medical Care and Hospitals: Injuries caused by the earthquake reached 147,000. Limited resources of doctors, nurses, medicines and other resources or facilities were critical. Over 90% of the deaths were just after the event, caused by the crash of buildings, but some died after being brought to hospitals. Almost half of the hospitals could not function because of destruction of buildings and equipment and lack of doctors, nurses and medicines. Even among the doctors, some of them were victims and could not assist in providing medical care. Assistance from outside of the Valley and from abroad helped significantly, but help arrived several days after the earthquake.

Homeless, Refugees, Shelters: Almost half of the people in the Valley lost their homes, and many gathered together at shelters or open spaces, while many others stayed at their own collapsed houses without roofs, searching for their families and relatives. Fortunately, since the earthquake occurred in winter, which is the dry season when there is less rainfall, people could stay outside without being attacked by rain, but at night, they were forced to take efforts to avoid the cold. Many affected people were forced to use river water for drinking and washing, although debris and dead bodies have been thrown into the river.

The capacities of shelters as well as materials such as blankets, tents, food and water supplies were limited and insufficient for serving all the homeless people and families for even a week. Many volunteers and assistants from other areas of the country and abroad, including international agencies, actively assisted in attending to the homeless people's daily needs but without adequate management. Other problems were epidemics and mental health. Occasionally a few mental health professionals and psychologists worked here and there to treat the patients.

There were also problems with water and food supplies, toilets/sewage, tents and temporary houses, and inadequate timely information. People who were delayed in reaching the convenient shelters were made to go to other shelters or return to their own neighbourhood. Gradually the number of sheltered people decreased but half of them still continued in shelters or temporary housing, because of losing their own houses, having nowhere else to go to that was accessible, and the relative security provided by government relief. Thus, almost 10,000 people stayed at shelters for a long time. Not only the people in shelters but also many others complained about the government's inadequate preparation and management of the crisis.

Education and Schools: Of the public schools in the Valley, 60 per cent of the schools were heavily or partially damaged, because their building structures were very poor and vulnerable. Over 40,000 children were affected. Two hundred of them lost their lives, and 10,000 children were injured at schools. The victims at private schools should be added. Many remaining schools were used as shelters for the people who lost their houses for a long time. Educational activities restarted six months after the earthquake.

(3) Infrastructure

Roads: Fortunately, there were not too many incidents of damage or cracks in highways and roads, except blockage by collapsed buildings in dense areas. Especially in urban areas there were not many embankments and slopes. However, in the western mountainsides, slope failures occurred causing blockage and suspension of access from the western side of the country as well as from India.

However, several blockages happened in urban areas also. They were caused by slope failure at the boundaries of terrace formations. In the municipality area, many houses collapsed, blocking the roads in core and commercial areas and along the main roads. And as for narrower roads connecting dwellings to dwellings, many brick walls fell down and blocked passage. Also, water and sewage leakages were frequently seen.

Bridges: In lower lands, several bridge failures happened, and liquefaction of sandy soils caused disruption of access roads. Most of the damage to bridges was in the south-western portion of Kathmandu municipality or the area along the Bagmati River. A total of 13 bridges were hard to access. Difficult access between municipalities and big settlements was the most significant problem for at least a few days, the most important days for emergency response.

Airports: The airport also suffered slight damages in the runways and some cracks in the control tower and its utility lifelines because of the stiff ground. So except for recovering from the suspension of power, the airport's functions recovered in a few days and it was again active for transportation of necessary materials and resources from outside the Valley into the country and also from foreign countries such as Japan, the United States, and other countries in Europe and Asia.

(4) Lifeline Facilities

Water Supply: Damage to water pipelines affected a total of 80% of the users in the municipal areas. It took two months to repair all the pipes and restore the water supply. During this period, water tanker trucks supplied water to the houses to compensate for the loss of supplies from broken pipelines. But the lack of access on the narrow roads disrupted the truck traffic. Therefore, insufficient supply to the people of the municipality lasted a very long time. Also, as the total amount of water was insufficient even before the earthquake, people made efforts to get water from old wells or rivers and ponds. Further, electrical power failure disrupted the pumping of water from tube-wells in the residential areas. The cost of mineral water became ten times higher than before the event. Lack of workmen for repairing the pipelines was the most serious problem in accomplishing the repairs. Foreign assistance contributed a little.

Sewage: Due to the limited distribution of sewers in municipal areas, damage to sewage lines was concentrated in Kathmandu and Kirtipur municipalities. The damage rate was less than that to the water supply pipelines. In their daily life, many residents simply cast their garbage directly into rivers rather than to appropriate facilities. Even at the time of this tragic event, the people in the Valley disposed the debris from houses etc. to anywhere on the ground. The municipality government strongly urged people to avoid doing so, but to no effect. This waste became the source of epidemics, because people without food and water were forced to use even waste and the contaminated water of the rivers. Further, power failures put the sewage treatment plants out of use, and failure of the pipelines caused by the ground disturbance resulted in several months' suspension of sewage treatment functions. For recovery, as the requirement or priority is lower than for restoring the water supply or power supply, the complete recovery of the sewerage system took six months after the event.

***Power Supply**:* Damage to power lines caused by the scenario earthquake was concentrated in the Kathmandu Municipality. Many electric power lines, mainly lower voltage lines, were disconnected at the supporting poles. Short-circuiting of lines also appeared frequently, sometimes causing fires. At the end of the day of the earthquake, the entire Valley had no power at all. However, since electricity is the most important lifeline, urgent and concentrated efforts to recover were decided upon by the management of the NEA and were implemented. Based on their efforts, within a week, power had been restored to the entire Valley, except to 10% of the area. Recovering electric power gave the suffering people new encouragement to promote rehabilitation, rescue/relief and recovery activities.

(5) Communications and Information

Telecommunications: After the event, telecommunications stopped completely except for several mobile facilities. On the next day some of the lines were restored through great efforts to fortunate areas, but still it was difficult to make telephone connections. But the earliest information of the tragedy in the Valley was transmitted by telephone calls to the world.

Many calls were attempted to and from the Valley, but during the first two or three days very few could get connected, and only portable phone facilities using satellites were operative. A couple of portable telecommunication stations were established in front of Singha Darbar. Inside the Valley many people tried to inquire about the safety of families, relatives and friends, but most of them gave up trying for a couple of days because of the suspended service and system overload. After several days most of the telecommunications except the areas where the damage was most serious had recovered. Mobile phones played an important role during the emergency days.

Media (TV, FM-Radio, Newspapers): The buildings occupied by the television broadcasting station were RC and strong. There were cracks in the walls but no major structural problems to the facilities. But furniture, equipment and lifeline facilities were damaged or disrupted, especially power which caused suspension of broadcasting. Information about the effects of the event and a small amount of preliminary safety information were broadcast, but it was seldom viewed by people because of power failure for television sets. After some days following the earthquake, television recovered to several hours a day and played a helpful role to the suffering and recovering people.

Half of the FM radio stations had their own power generators, and after recovering power the next day, they continued broadcasting about safety information, information relief supplies for victims, and requesting volunteers from the Valley.

For newspapers, damage to the buildings was moderate, but facilities and equipment for printing suffered seriously. After a few hours, several extra editions of small size were published. But the lack of resources for printing required more days for complete recovery.

5.2 Search and Rescue

Although several efforts on SAR capability build-up have been paid among various domestic parties and international donors like UN, OFDA and others, it would be very difficult to conduct search and rescue activities for the earthquake victims in the Kathmandu Valley. Rescue needs will be very high in the Old City Core of Kathmandu and Bhaktapur. In the Kathmandu Metropolitan City, Indrachowk, Asan and the surrounding area will have the most serious situation (Wards 25-28 and the perimeter area). Although these areas are relatively small (about 1 km to the east and west, and about 3 km to the north and south), the density and number of rescue needs will be very high because, in the worst case, these areas will become "mountains of debris." In these areas, when people are entrapped under collapsed RC buildings, search and rescue within 72 hours (the period within which survival can be expected) will be almost hopeless because of the lack of heavy rescue equipment and machines. Also, rescue from BM structures using human power alone will offer faint hope.

Generally speaking, the major suppliers of human and material resources for search and rescue activities from the public sector will be the military, police and fire fighters. However, compared to the expected earthquake damages, such organisations will be relatively powerless, even if they are fully activated.

The most promising rescue provider among them is the Royal Nepal Army (RNA). In fact, one of the leading personnel in earthquake disaster prevention in Nepal said "despair is only left behind to us if the Royal Nepal Army does not move." As information on the RNA is limited, it is very difficult to say how much the RNA will be able to contribute in case of a large-scale earthquake disaster. However, with our current knowledge about the RNA, when details are examined, it will become clear that there will be limitations to the contribution from their activities.

The total number of personnel of the RNA is about 46,000. Among them, at least three brigades (understood to be infantry brigades) are stationed within the Kathmandu Valley for road construction. According to a high ranking RNA officer, the number of personnel that could be mobilised immediately after the earthquake will be about 1,000 to 2,000 (the officer did not state how many soldiers are stationed within the Valley). There is one engineering brigade in the RNA. This unit is believed to have heavy equipment for search and rescue operations, but this brigade is usually stationed outside the Valley. Their deployment to the Valley after an earthquake would be delayed by the disruption to the overland routes to the Kathmandu Valley (Tribhuvan Highway and Amiriko Highway) by landslides. Concerning infantry units, the RNA has adopted an independent company system, which means that relatively highly self-contained small units (company level, understood to be about 200 officers and men) are stationed all over the nation. This will also result in delays and difficulties in redeployment to the Valley. In short, even if RNA is the most promising and powerful rescue provider in Nepal, high expectations will not be fulfilled because of the above-mentioned conditions.

Concerning the Nepal National Police, there is an Armed Police Force (special police force, basically for counter-riot operations) of about 1,300 personnel.

However, they do not have heavy search and rescue equipment, except some ropes for light rescue operations. Concerning fire fighters, their capabilities are very small. Therefore, search and rescue activities from the public sector will be seriously deficient. Even if the personnel of the RNA, police and fire fighters were to conduct their best efforts for search and rescue activities, it is inconceivable that adequate results could be achieved.

In view of the inadequacy of public sector search and rescue capabilities, it will be necessary to rely heavily on search and rescue activities carried out by inhabitants and the community-based sectors. At least concerning manpower (in terms of unskilled rescue workers), there is some potential within the Valley. However, because of the lack of search and rescue equipment, their contribution would be limited to light rescues which can be conducted without any heavy equipment. Concerning major rescue operation of people entrapped within the RC structures, without some heavy industrial vehicles or equipment, unskilled manpower alone would not be able to conduct search and rescue activities.

It is not practical to stockpile light equipment in residences and similar structures due to the likelihood of collapse. For major rescue work, industrial machines and vehicles are essential. However, because of the economic situation of Nepal as a developing county, and the need for ongoing maintenance of the machines and vehicles, their introduction will not be suited to the current Nepalese situation.

5.3 Acceptance of International Rescue

From a realistic viewpoint, the most significant heavy rescue provider will be international disaster relief teams from various foreign countries. The biggest rescue team will be sent by India, and the Indian Army will be the major component of it. However, concerning rescue activities from India, there are at least two major difficulties. The first one is that a large-scale earthquake in the Kathmandu Valley would also cause some damage in India. The second one is the fact that the overland route to the Kathmandu Valley (from the Nepal/Indian border through the Tribhuvan highway) will be seriously damaged by landslides.

Although there must be some rescue teams arriving via air routes from industrialised countries such as the United States and Japan, whether the Tribhuvan International Airport would be functional or not will be critical. Also, the number of rescue workers, heavy industrial machines and vehicles for search and rescue, and the amount of relief goods received will be heavily dependent on the extent and manner in which the international media treat the earthquake disaster and the damages caused.

Concerning international rescue operations, there are some channels for requests and acceptance, such as 1) within the United Nations system, 2) within the International Red Cross and Red Crescent movement, 3) on a bilateral basis, 4) by NGOs, and 5) others. Concerning the UN system, various UN organisations in Nepal have reached agreement on this issue in an Inter-UN Agencies contingency plan, and preparations for acceptance of foreign disaster relief teams between HMG of Nepal and UN agencies in Nepal are now underway. Concerning the International Red Cross and Red Crescent movement, the general process for international appeal for requesting relief teams seems to be defined. On a bilateral basis, India, the United States, other western countries, Japan, China, and other Asian countries can be expected to contribute. Other International NGOs will also contribute; however, it can be expected that coordination among all rescue providers will be an issue. It is probably not realistic to expect HMG of Nepal to coordinate all such activities. In the case of the 1993 landslide, UNDP (leading agency within the UN system for disaster relief) conducted inter-agency coordination activities (even among HMG agencies).

5.4 Disaster Medicine

In the acute phase of the disaster (and also in post-acute phase), medical activities within the Kathmandu Valley will be very limited and insufficient. Moreover, this lack of medical resources will continue for years after the earthquake. The main reason for this situation will be the collapse and loss of function of hospitals.

As of autumn 2001, there is no general and/or overall information of the hospitals within the Kathmandu Valley, concerning on earthquake disaster and disaster medicine. JICA Study Team, with the support of NSET-Nepal, conducted a preliminary hospital survey about the facilities and planning of hospitals, however, the collected data are not sufficient. Detailed investigations of the hospital buildings from a seismic structural engineering viewpoint are a prime task. Continuous efforts will be needed. During our stay in KV, World Health Organization (and NSET-Nepal) also implemented structural assessments of 15 hospital buildings in the Kathmandu Valley. Their assessment will continue in 2002. Mutual partnership among JICA, International Organizations and national / local government and NGOs will be critical

From the statistical survey and calculations of the Study Team using fragility curves, among about 47 hospitals within the Kathmandu Valley, five hospitals will lose their functions and 12 hospitals will partially lose their functions. Because of limited time and budget, the Study Team could only check external views of the hospital buildings. Concerning the survey of hospital functions, detailed investigations of the plumbing are essential. More detailed investigations including equipment and infrastructure will be an urgent task.

Once building and functional damages occur in hospitals, because of the lack of budget for repairs, the low level of medical services will continue for several years after the earthquake and recovery will require many resources. In the meantime, continued assistance will be needed. In addition, it should naturally be assumed that not only hospitals but also clinics, medical workers' residences, dormitories and so on, will suffer serious damage. However, a suitable counter measure does not exist at present.

Concerning educational and training programs for disaster medicine and medical workers for disasters, these have been started but are only in an early phase. There is much foreign aid in the field of medical care for the Nepalese people. However, it tends to be focused on primary health care (safe drinking water, mother-and-child welfare, etc.) and not on disaster medicine. It is natural and understandable that the primary concerns are not on disaster medicine but on day-to-day medical needs, and this means that primary health care is a more urgent concern than disaster medicine.

There are some positive efforts to establish disaster medicine training courses in Nepal. During the stay of the Study Team, WHO and the Epidemiology and Disease Control Division, Department of Health Services, Ministry of Health conducted computer-based mass casualties management simulation exercises. WHO and EDCD/DHS also have conducted regional desktop simulations and mock drills for health sector personnel in order to enhance the emergency response capability of the health sector. These are some examples of important effort for disaster medicine. These training courses should properly reflect and correspond to the daily life of the Nepalese people, especially the people in the Kathmandu Valley and other elements of the reality of Nepal, especially various kind of social infrastructure.

Concerning medical transportation, there are also many problems. In the Kathmandu Valley, there are over 100 ambulances, but in reality, they are not ambulances but taxis with a siren because there is almost no radio communication system, no Emergency Medical Technician (EMT) on board, no medical equipment, etc. Nor is there any overall ambulance control system like 911 in the United States or 119 in Japan. In case of a large-scale earthquake, emergency transportation of the patients will face a range of serious difficulties.

Shortage of materials and equipment for medical treatment is also critical. In case of an earthquake disaster, one of the most important resources for medical treatment will be water, especially purified water for irrigation of wounds. Water supply for hospitals in case of an earthquake disaster should be a high priority. Unfortunately, in the Kathmandu Valley, adequately detailed surveys for an emergency public water supply and plumbing of individual hospitals have not been conducted.

The basic concept of disaster medicine is how to maintain the balance of supply and demand of medical services within the disaster area with support from outside the disaster areas. In order to keep the balance, there are two fundamental approaches; one is transportation of medical resources from outside to the disaster area, and the other is evacuation of patients to outside the disaster area. However, in Nepal, the Kathmandu Valley is the most advanced area and medical resources outside the Kathmandu Valley are relatively limited. In this situation, the evacuation of patients is not a viable solution, nor is transportation of medical resources toward the Kathmandu Valley, other than on a limited basis and primarily from other countries. Therefore, development of a viable disaster medicine plan under the present situation of the Kathmandu Valley is harder than most other areas in the world.

As realistic counter measures, in the short term, stockpiling of equipment and making prior decisions on locations and plans for field hospitals will be suitable. In the longer term, replacement and reconstruction of hospitals around the Ring Road would be a better option.

5.5 Drinking Water and Food

5.5.1 Event Scenario and Current Status for Drinking Water and Food

After the earthquake, many people in the Valley would not be able to receive drinking water and food from outside for several days because of damage to water supply pipelines and roads blocked with debris. Although the condition of water and food supplies will be very serious after the earthquake, people in the Valley are relatively tough, compared with people in developed countries, who generally keep reserves of water and food.

Although half the number of water tanks installed in houses is damaged, drinking water of about 10 litres per person per day is made available. In the Kathmandu Valley, good social cohesion and cooperation are present and so the people share the available water for survival, for a couple of days after the earthquake.

In each house, polished rice and raw lentils are kept in stock for several days, portable cooking stoves are available in most houses, fuel for cooking is also kept in containers, and thereby, people would be able to manage to have a subsistence level of food for a couple of days with their spirit of cooperation. Details are mentioned in the following sections.

5.5.2 Piped Water

The current condition of the piped water supply in the Valley is very poor. Although piped water supply is available in the urban areas as mentioned in section 6.5, Water Supply and Sewerage Facilities, the supply is usually intermittent, only for about 2 to 3 hours in the morning and about one hour in the evening. In the dry season, the supply to urban areas is less than one hour on alternate days. Regardless of the reasons of the poor supply, i.e. aged pipelines, the uncontrolled extension of pipelines, or a lack of maintenance, the supply facilities will be seriously damaged in the earthquake, and piped water would not be available for several weeks and in some areas for up to two months.

5.5.3 Tanked Water

Because of the poor piped water supply condition, many families keep reserves of water in private water tanks or underground water storage. The water tanks, made of short-cylindrical plastic or sheet steel, with a capacity of 200 litres to 500 litres are generally set on rooftops. Underground water storage with a capacity of more than 1,000 litres is installed in relatively big and new houses, hotels, offices, and factories.

The minimum requirement for drinking water to survive in an emergency is said to be 3 litres per day per person. Although some of the water tanks will be damaged due to the earthquake, drinking water of about 10 litres would be available for each person in the urban areas as calculated below:

a) A family consists of five persons.
b) Water tanks are installed in nearly half the number of buildings/families in the urban areas. [One tank for 10 persons]
c) Stored water in a tank is 200 litres. [20 litres water reserve for one person]
d) Leakage of water would occur in 50 % of tanks. The damage ratio is the sum of the heavily damage buildings of about 20 % and partly damaged buildings of about 30 %. [10 litres are available for one person]

Therefore, it is considered that people would be able to manage to get drinking water from private water reserves in their houses for a couple of days, even if the piped water supply would be interrupted after the earthquake.

5.5.4 Delivered Water by Tankers

It is common in the Kathmandu Valley that drinking water is delivered by water tankers directly from reservoirs, natural springs, or rivers located in peripheral areas of the Valley. Details of the water sources and water tankers are mentioned in section 6.5.

Because of road blockages with debris, water delivery by tankers will not be available for at least a couple of days after the earthquake. Some people, who will not be able to get tanked water, will obtain water from the spouts or rivers.

In two to three days after the earthquake, debris blocked strategic roads will be cleared, and water tankers will be able to deliver water to major shelter sites and some neighbourhoods. Conceivable conditions on road clearing, and the resuming of water delivery by tankers are described in section 5.9.

5.5.5 Well Water

Where tanked water is not available, well water is a possible source of drinking water.

Dug wells and shallow wells are still in use in rural areas, although most of them are abandoned in the urban area due to contamination and the lowering of the groundwater level. In the urban area, it is necessary to improve shallow groundwater conditions as well as well facilities, in order to use shallow groundwater for drinking in an emergency. The improvement of groundwater conditions, however, would seem to take a long time, because of many other measures that have to be taken, such as establishing a disposal system for garbage which causes groundwater pollution, or securing alternative sources of groundwater to prevent over-extraction. In rural areas, shallow groundwater will be used after the earthquake almost as normal, since the facilities are simple and will not be seriously damaged.

Deep wells are being operated by the NWSC and private sector entities such as hotels and carpet/textile factories. Although deep groundwater extraction provides about 50% of the present water supply, previous studies on groundwater revealed the problem of over-extraction and low quality. An ADB report describes that the extraction in 1998 was more than 40,000 m^3/day, although sustainable extraction was calculated to be 15,000 m^3/day in a JICA report (1990). Many reports point out that the groundwater contains very high levels of ammonia, iron and manganese. The reports also mention that groundwater is not suitable as a source of water supply, and the high level of ammonia has never been treated in the field of waterworks.

Even if deep well facilities will not be seriously damaged in the earthquake and groundwater is useable at well sites, the well water supply will not be available, because these wells are connected to the piped supply system which will be seriously damaged.

Additional deep well construction for an emergency may not be recommendable, because of the low quality of deep groundwater and the difficulty of maintenance in normal times.

5.5.6 Water Quality

Because people in the Valley have known about the low quality of tapped water due to an insufficient purification system, they usually drink boiled water. Because fuel for boiling and sterilisation will be available for a couple of days as mentioned in section 5.3.7, people will boil water for drinking and the quality of drinking water will not be a serious problem, although some people would suffer from diarrhoea or infections by drinking unsanitary water.

5.5.7 Food and Fuel for Cooking

The staple food of people in the Valley is steamed rice and lentil soup. Most of the families (except the lowest income group) keep at least polished rice and raw lentils in stock sufficient for several days to three weeks, depending on their income level. Enough for about two weeks supply of fuel for cooking stoves, such as kerosene and petroleum gas, is also kept in containers and available to use. It is thereby considered that the subsistence level of food kept in stock in each house would be adequate.

In a few days after the earthquake, debris blocked strategic roads will be cleared, and food supply will be available, although an extreme rise in prices will occur. World-wide helping hands will also provide food after several days.

5.5.8 Proposal

In the urban areas, tanked water will be a reliable source of water to survive for a couple of days after the earthquake as mentioned above, and the following is recommendable for best use of tanked water.

a) Water tanks installed on rooftops are generally not fixed firmly to the rooftop. It is foreseeable that the tanks will be turned over and be damaged during the earthquake. In order to secure tanked water as best as possible after the earthquake, it is recommended to fix the tanks onto the rooftops properly.
b) Even if a house is slightly damaged and a water tank is undamaged, water leakage may occur through broken pipes supplying water from the tank to the taps. In order to prevent the leakage, it is necessary to take the precaution to close the valves near to the tanks just after the earthquake.
c) The piped water supply conditions in the valley will be improved considerably due to the completion of the Melamchi Water Supply Project around the year 2006. As a result of the improvement, the habit of maintaining water reserves in each house with a water tank or underground water storage may disappear to some extent. From a viewpoint of securing drinking water just after the earthquake, it is recommended to continue the in-house water storage system, even after the improvement to the piped water supply improvements.

Concerning food, most families keep a food stock. This habit of stocking food items is advantageous for survival in an emergency, and it is recommended to continue the habit, even if fast-food restaurants and 24 hour-open shops become popular in the future.

In order to realise the above-mentioned recommended points, it is important to enhance the people's awareness of survival in an emergency through information dissemination and education as well as institutional improvement such as monetary support for private water reserve facilities.

5.6 Temporary Sheltering

The scenario and damage assessment have been elaborated hypothetically in order to formulate earthquake disaster management planning, and the scenario shows the weak points of the current Kathmandu Valley against earthquakes, especially of the urban areas, as follows.

5.6.1 Evacuation

Evacuation deals with the movement of people from an endangered area to a safe area, when an emergency situation necessitates such action. Provision should be made to ensure a safe and orderly evacuation of people out of buildings that pose a collapse hazard, neighbourhoods surrounding an earthquake-induced hazardous materials release, or other threatening conditions. Since earthquakes generally occur without immediate warning (unless they are aftershocks), evacuation procedures, routes and sites really need to be outlined in advance of the quake. Site-specific evacuation procedures, such as for a school or a factory or an office building, should be established and practised regularly.

Municipalities and ward offices should prepare simple evacuation procedures, designating evacuation coordinators, safe routes and evacuation sites, and should advise the citizens of these procedures. In neighbourhoods, local citizens can identify areas at high risk during earthquakes from such factors as narrow passageways, poorly constructed and maintained buildings, and poorly secured power lines and transformers. They can also identify open areas they can walk to, where they can seek refuge and where families can plan to reunite in the aftermath of an earthquake. Responsible persons in the neighbourhood, factories, or office buildings can be designated to play a leadership role, directing the evacuation and assisting people with special needs, such as the sight-impaired, mobility-impaired, and the elderly.

5.6.2 Sheltering and Relocation

(1) Planning for sheltering and housing urban victims

In the area of post-disaster sheltering and housing, there is need for concentrated planning efforts spanning up to four phases: 1) emergency shelter, 2) temporary shelter, 3) interim housing, and 4) permanent housing. In the 1994 Northridge earthquake in Los Angeles, California, and other earthquakes including the 1999 quake in Armenia, Colombia, it is clear that the damage assessment and inspection process for housing is problematic and confusing for many displaced residents. It also remains clear that straightforward technical information on how to strengthen and repair damaged dwellings needs to be made more widely available.

To support earthquake victims in the Kathmandu Valley, planning before the earthquake for sheltering and housing the thousands of homeless is an important step for the protection of the population. Through the study of urban conditions in the Valley, sheltering and relocation plans could be formulated in terms of the following three functions in the urban area:

Function a) temporary meeting points in and around residential areas for each family such as a small park or safe "chowk(s)";

Function b) temporary safe place or facility for the people from many blocks in the community; and

Function c) large scale refuge with temporary housing space in the long term and on a regional basis, after the earthquake disaster.

It is expected that the distribution of the above facilities will be very uneven, based on the constraints in the Valley and considering regional variations and the different targets of the three functions. In addition, rapid urbanisation, high density of the residential areas, and complicated land use cause difficulties in acquiring land for all the above functions. Therefore, political leadership of the government is essential to settle the constraints on land acquisition.

For the above-mentioned function c) in urban areas, the following should be considered as a development strategy:

- Periodic identification and confirmation of available land for the large scaled refuge with temporary houses;
- Land use management of unused areas in residential areas; and
- Regularisation/resettlement of squatter houses; these are reported to be some 2,000 such households in 50 areas inside the Ring Road.

For functions a) and b), the rehabilitation or establishment of parks for the target people in the disaster should be prioritised and implemented. In addition, public schools located in the suburbs should be improved considering function b). It is also noted that the establishment of safe areas and evacuation routes, removal of obstacles, and earthquake drills, with citizens' participation are important to realise function a).

(2) The Eligible Sites for New Urban Areas

At present, the eligible sites proposed as new urban areas are located at 27 points along the perimeter of the Ring Road. They are more than 3 km to 5 km from the Central Business District (CBD) of KMC as shown in attached Figure 5.6.1. The area of eligible sites is 1,500 ha in total. Although the average estimated population density is low (the status of resettlement areas is a different stage of implementation), the expected total physical capacity of the residential areas is about 100,000 to 150,000 people. In these eligible sites, 150 hectares are in the Ichangu Narayan area, located 3 km to 4 km northwest of the CBD, and 510 hectares are in the Harisiddhi Area located south of Patan city. These are typical sites in the new urban area for transmigration from the old city core in KMC. In those sites, very little urban infrastructure has been constructed. It is however noted that those sites have development potential and will be developed on a long term basis, since the present land use is agricultural and hill areas only. The sites have advantages in terms of accessibility to the old city core in KMC. It is proposed that the urban functions as mentioned above should be considered carefully during the planing and design stages for new urban areas.

(3) Rehabilitation program after natural disasters

For implementation of the rehabilitation program including construction of temporary houses after natural disasters, the Ministry of Home Affairs is authorised as the responsible agency to carry out the program. It is reported that such programs will not function as well as anticipated due to various legal and organisational problems and the shortage of human resources. According to the Natural Disaster Calamity Act 1982, sub-committees for functions including sheltering and rehabilitation of facilities need to be established on a temporary basis after large and serious natural disasters. However, it is necessary to establish a permanent Disaster Management Council or Committee to review and assess past disaster damages and prepare rehabilitation and reconstruction plans at central and local levels for different types of disaster.

From the standpoint of urban planning against disasters, the basic issue in a housing plan is related to the process of locating and providing housing. First, people need a "good location" considering job opportunities. Then they need a piece of land where they can build their shelter. Then they look for urban amenities like water, electricity, etc. At the final stage after they have shelter, they struggle for security of tenure. In the process of providing shelter, the needs of people are summarised below:

- Good Location.
- Land.
- Building materials.
- Finances.
- Technology.
- Infrastructure and amenities.
- Security of tenure.

In view of these needs, public housing provides only one type or approach. It is based on a single need of the people, but it does not aim to satisfy their multiple needs. Under such conditions, mismatches in housing and gaps between the public authorities and the people inevitably occur. For providing shelters in the emergency, shelters that have been specifically designed are not necessary. But enough land with good location and flexible and minimum services are essential requirements. The present availability of suitable land total 1,800 ha, at more than twenty sites within 5 km of the KMC central business district.

5.6.3 Recommendations

On the basis of this information and previous observation, some suggestions as to relocation, temporary housing, and rehabilitation are as follows:

a) Peoples' needs for their livelihood and job creation must be considered in the broad sense in regard to the location factor in preparing refuges and temporary housing. The rehabilitation of the physical environment will be based on the same point of view as mentioned.
b) For the informal as well as the formal employment sectors, this location factor has to be just as important for public housing programs. In order to prepare sustainable disaster-resistant communities, short-term needs must be balanced with long-term needs in designing rehabilitation programs.
c) There have been wide gaps between government regulations and guidelines for structurally safe buildings and the economic and social realities associated with their implementation. This is a major long-term problem, the solving of which is a high priority for sustainable development.
d) Reconstruction plans, as well as relocation and rehabilitation programs must be based on a participatory process with grassroots level involvement. It has been repeatedly said that without this, seemingly well-designed plans, whether prepared in advance or not will fail to meet the actual needs of the recipient people and communities. Thus, efforts must be made to reach communities in outlying areas that may be out of the information loop and may not benefit from reconstruction efforts. Planning needs to be more active at the local level, so people are appropriately informed. New town development programs to serve as a touchstone for preparedness against disasters, should be urgently launched in appropriate areas beside greenbelt zones.
e) Likewise, a participatory approach should be used for evacuation planning at municipality, neighbourhood, and specific sites such as schools. Municipalities and ward offices should prepare and practice simple evacuation procedures, designating evacuation co-ordinators, safe routes and evacuation sites. In neighbourhoods, local citizens should identify safe routes and open areas they can walk to where they can seek refuge and where families can reunite. In schools, large buildings, and neighbourhoods, evacuation drills should be

conducted.

A typical area for resettlement is as follows:

- **Area name:** Ichangu Narayan Area.
- **Total Area:** About 150 Ha (about 3000 Ropani).
- **Program expected:** Land Pooling Scheme (LPS): Land Adjustment Project of the Kathmandu Valley by Town Development Plan Implementation Committee, KMC.
- **Location:** Good access from Ring Road. It is located about 1.5 km from Balaju, a part of Ichangu VDC of Kathmandu District. Its south-eastern margin is connected with the Ring Road.
- **Present Status:** It is cultivated land. A pre-feasibility study for new settlement area has been completed.
- **Topography:** This area is about 1330m asl and it consists of low angle poor ground sloping in a south-eastern direction. The land is suitable for new settlement. There exist a few pumps and dug wells. The water level is 8 to 15m below the surface.

5.7 Public Health Care

From the viewpoint of public health, the situation just after a large-scale earthquake will be difficult. There are several important elements in public health, such as maintaining the accessibility to safe drinking water, and assurance and distribution of the food supply. These basic concerns that constitute the foundation of public health care problems will be more important and critical than other public health problems, because in developing countries like Nepal, these basic components themselves should not be considered as granted. Prevention of epidemics, mental health and other concerns that are commonly understood as public health problems will be secondary. Overall, these health care issues in a disaster are closely related to other areas of disaster management.

5.8 Remains and Treatment of Remains

The ceremony of traditional mourning in Nepal is cremation. Generally speaking, about 300 kg of firewood and 3 hours are needed to cremate one corpse. It is said that there are 27 or more cremation sites (Ghate) in the Kathmandu Valley and every ethnic group has their own cremation site. All sites face the river or a small stream and after cremation the ashes are scattered in the river or stream. Although the ceremony of mourning is important for family members and relatives to recognise the passing of loved ones, the proper ministration of this ceremony in case of a large-scale earthquake disaster will be very difficult. The biggest difficulty will be acquisition and distribution of firewood. There is a high possibility that the Tribhuvan Highway will be closed by landslides, and main roads will be cut off by collapsed bridges. Fuel oil may be used for cremation, but the primary use of fuel will be for heating and cooking. Therefore, there will be two primary options: group cremation and group burial, with due consideration to religion and ethnicity. These religion-based group cremations/burials should be avoided as far as the situation permits, because of the mental anguish to the bereaved. However, other alternatives are unlikely. After the disaster, religious leaders with political leaders will decide how to conduct the funeral ceremonies. From a practical viewpoint, group burial is the most feasible.

5.9 Other Key Functions

5.9.1 Security

Once an earthquake has occurred, many houses and other buildings like stores and warehouses will be partially destroyed, exposing household items, equipment and goods to the open air. When people must evacuate their neighbourhoods and shop owners must abandon their damaged buildings, it is essential that security be provided to protect the victims' remaining possessions. Access to the damaged areas should be restricted so that property in the area can be protected. The police are typically assigned such duties as controlling entry to effected areas, providing perimeter control around the area, controlling traffic flow, and protecting persons and property.

5.9.2 Fire Fighting

While it can be presumed that the probability of a major earthquake-induced conflagration occurring in the Kathmandu Valley is very low, it is also true that the capability to control and suppress any fires which may be ignited by downed power lines and other sources during an earthquake is also very low. Very limited apparatus, equipment, and trained personnel resources for fire fighting are available in the Valley. Therefore, it is essential that all available resources be utilised as effectively as possible by directing them to the sites that pose the greatest danger from fire and loss of life due to fire. Thus, it is recommended that each brigade be in radio contact with the Emergency Operations Centre, the Army, and police to provide them access to the widest range of information on the overall disaster situation. (See Figure 5.9.1)

5.9.3 Management of Volunteers

In every major earthquake around the world, it has been proven again and again that initial rescue efforts were performed by local people, the majority being citizens without any special training. However, often the rescuers can also become victims due to the dangerous situations they encounter in order to help others. In order to minimise injury and death to local volunteers and to maximise the effectiveness of their efforts, it is highly recommended that municipality and national police stationed in the Valley receive orientation and training on how to manage volunteers during disaster response, especially in rescue operations. Further, in countries such as the United States there are plans and systems in place for effectively using volunteers with special skills, such as engineers, architects, amateur radio operators, health care professionals, computer specialists, etc. Similar systems can be put to use in Nepal.

5.9.4 Safety Inspections of Structures and Infrastructure

One of the most important tasks after an earthquake has occurred is inspecting the safety of major structures and elements of the infrastructure (such as dams, bridges, and electrical power plants) that potentially may have been seriously damaged in the quake. Normally there is an initial reconnaissance by police personnel and others to identify major collapses and the areas that are hardest hit by the earthquake. But when structures have been damaged but not totally collapsed, some technical knowledge and expertise are required to evaluate whether or not the structure poses an immediate collapse hazard and threat to persons in or around it. Essential facilities such as hospitals should be evaluated immediately following the earthquake by engineering personnel to determine whether the buildings can be used or must be abandoned, even if there is little apparent visual evidence of damage. For smaller and simpler structures, such as residences, a rapid visual inspection by an architect or construction expert can provide the basis for decision making on whether the building is safe or not. A pre-existing system for inspecting and posting buildings as safe or unsafe, including manuals and instructions, can be adopted from California or other earthquake prone areas and used in the Kathmandu Valley quake.

5.9.5 Debris Removal and Disposal

A major earthquake in the Kathmandu Valley will create mountains and mountains of debris which must be removed and disposed before large-scale repairs and reconstruction can begin in earnest. While recycling of building materials and other useful items can reduce the quantity of unusable debris and help to hold down the costs of reconstruction, it is also true that the total amounts of debris that must ultimately be disposed of are always underestimated.

Some of the most vexing issues regarding earthquake debris are;

- Temporary sites must be set up to allow for recycling of usable materials,
- There is insufficient equipment for collecting, loading, and transporting debris,
- Heavy equipment to move debris out of neighbourhoods may not be able to reach all locations full of rubble and debris,
- Debris in some areas may be contaminated by hazardous substances or liquids, and
- Decisions regarding the most appropriate locations for final disposal are often contentious.

Because of these issues, it is recommended that initial discussions and planning on the debris problem be conducted at the municipality, regional, and central government levels before a major earthquake occurs.

5.10 Transportation System

5.10.1 Existing Conditions

(1) Road Network

The road network of the Kathmandu Valley consists of different categories of standardised as well as non-standardised roads in the absence of a well-organised system as shown in attached Figure 5.10.1. Uncontrolled growth in the numbers of vehicles in recent years and lack of improvement and management strategies have resulted in congestion, decrease in travel speed and capacity, as well as decrease in road safety.

The main road network inside the Valley consists of corridors, one from east to west and the other from north to south, along with a Ring Road surrounding the cities of Kathmandu and Patan. Several radial roads also exist, some radiating from the city core and others from the Ring Road. Apart from these, there are urban roads, most of which are narrow and heavily built-up on both sides of the road. The east-west and north-south corridors have four lanes each within the urban area and two lanes outside of the Ring Road. The Ring Road itself is of two lanes, whereas most of the radial roads are either two-lane or undivided two-lane roads. The urban roads are not constructed to any standards and vary from narrow single-lane to two or more lanes.

The Department of Roads (DOR) within the Ministry of Physical Planning and Works (MPPW) is the prime organisation responsible for planning, design, construction and maintenance of the entire road network. According to the classification system of DOR, the road network can be classified into the National Highways (NH), the Feeder Roads (FR, major and minor), District Roads (DR) and Urban Roads (UR).

Two major National Highways, the Tribuvan Highway and the Arniko Highway, pass through the urban areas forming the major east-west corridor of the valley. The Tribuvan Highway forms the western half part of the east-west corridor and is the sole road providing access from the Kathmandu Valley to other parts of the nation as well as to the outside world. Just outside the Valley, this highway is vulnerable at a number of locations where landslides occur almost every year due to rainfall. Other huge dormant landslides also exist, the activity of which may be triggered by heavy rainfall or earthquake.

On the other hand, the Arniko Highway forms the eastern half of the east-west corridor of the Valley, crosses the Ring Road, passes through Bhaktapur district and extends to the Chinese border at Kodari. Although this highway connects Nepal to China, only a limited percentage of foreign trade occurs through this route. The alignment of this road in the vicinity of the Valley passes through favourable terrain conditions but is a narrow two-lane road. As a result frequent and prolonged traffic jams prevail in this section.

One Feeder Road (major), the Kathmandu-Trishuli-Dhunche Road, originates from Tripureshore and runs north forming a part of the major north-south corridor. In the section from Lainchaur to Balaju, this two-lane road is heavily built-up on both sides. Another Feeder Road (minor) completes the northern part of this north-south corridor from Lainchaur to Maharajgunj in the Ring Road and up to Budhanilkantha in the northern part of the Valley. Fringe type developments exist along both sides of this road with houses constructed recently.

The southern part of the major north-south corridor comprises of major urban roads from Tripureshore in Kathmandu City, that crosses the Bagmati River in Thapathali and passes through Patan City to Jawalakhel. This section of the road through urban areas is four-lanes wide with adequate footpaths on both sides. The road from Jawalakhel to Ekantakuna at Ring Road is a narrow two-lane road, whereas the diversion from Jawalakhel through Lagankhel to Satdobato at Ring Road is a much wider two-lane road. The north-south corridor after the crossing at Ring Road in the southern part is not well defined, but several parallel roads exist to the southern side of the valley.

Besides the major east-west and north-south corridors, several other radial roads exist originating mostly from Ring Road and other urbanised areas. These roads are either Feeder Roads (minor) or bituminous District Roads. In both cases they are narrow two lanes.

Major urban areas of Kathmandu and Patan are enclosed within the Ring Road, which is about 27 km in length. The Ring Road has become a vital part of the network, allowing through traffic to by-pass the core area. Basically, the Ring Road is of a wider two-lane standard, and apart from having a sufficient right-of-way with a "Green Belt" on both sides, it is a service road over most of its length. The Ring Road is classified as an Urban Road.

In addition to these, a large part of the urban transport road network is comprised of numerous urban roads, but in a less planned and managed condition and without any definite standards. Most of these roads are confined to the densely populated city cores of Kathmandu and Patan cities inside the Ring Road. The Urban Roads (major) are two to four lanes whereas most of the Urban Roads (minor) are narrow single-lane to undivided narrow two lanes.

The remaining road network in the Valley is composed of Urban Roads (gravel) and District Roads (gravel/earthen), which are of least importance in the network hierarchy but provide access to individuals and more localised areas.

(2) Bridges

Until recently, most of the bridges in the Kathmandu Valley were old, having been constructed 50 to 80 years ago. However, a total of about 11 major bridges were reconstructed by the Grant Aid assistance from the Government of Japan during the period from 1992 to 1995, and four bridges were reconstructed with the assistance of the World Bank. The locations of existing bridges are shown in Figure 5.10.2.

According to the DOR classification, structures of more than 6 m length are classified as bridges. A total of 54 bridges, 33 in Kathmandu District, 10 in Lalitpur District and 11 in Bhaktapur District exist according to the DOR database. Most of the bridges were built with various sources of foreign assistance, mainly from the Government of China (17 bridges), Japan (11 bridges), the World Bank (4 bridges), India (2 bridges) and England (1 bridge). A uniform bridge design standard does not exist and most bridges are based on the design standard of the assisting foreign country.

Most of the bridges around the Ring Road and other major links are badly affected by excessive scouring around the foundations of the piers due to lowering of the riverbed. The scouring is severe in the bridges upstream of Bagmati, Bishnumati and Dhobikhola Rivers and the bridges are vulnerable to earthquake motion.

(3) Airport

The Valley has an airport at only one location and it is the only international airport (Trivuban International Airport) in the country. The airport is built on terrace deposits with stiff ground. In case of natural disasters like earthquakes, if this sole international airport is damaged, not only the Kathmandu Valley but also the whole nation is in danger of complete isolation from the outside world.

5.10.2 Event Scenario for Transportation System

The event scenario is based on the assumption that the earthquake of intensity described in a previous chapter occurred in the present conditions.

The Tribhuvan Highway suffered damages at a number of locations outside the Valley beyond Thankot, and the road was blocked due to the debris from large-scale landslides. It took more than a week to remove the debris and to recover normal traffic movement due to the limited number of heavy equipment that could be mobilised for the removal of debris. The supply to the Valley from Terai areas and from the Indian border was halted for many days, due to the lack of other alternative routes, causing a serious shortage of goods for daily use. The highway was also blocked in the section from Kalimati to Kalanki junction from the debris of collapsed houses. The bridge over the Bishnumati river at Teku along this highway (Bridge No.20) collapsed, and it was not possible to construct a temporary access road since both sides of the bridge were heavily built-up. Damage to this bridge badly affected access from the Tribhuvan Highway and access to Kirtipur. Fortunately it was possible to detour the traffic from the Ring Road after the construction of a temporary access road over the Balkhu River (Bridge No.38) since the water level in the river was not too high. Traffic from the west of the Valley was almost completely blocked with no access to the core area and towards the east, due to the damage to most of the bridges along the Bishnumati river, cutting off most of the alternative routes going towards the west.

Though major damage in road embankments were not observed along the Arniko Highway, the highway was blocked at several locations from the fallen utility lines, poles and equipment along the roadsides since the total road width was very narrow in the section from Ring Road to Bhaktapur. Along this highway, the bridges over the Manohara River (Bridge No.6) and the Hanumante River (Bridge No.48) were badly damaged due to liquefaction and poor foundations. Unfortunately, the other alternative, old Thimi Road, was also blocked at least at three locations from the debris of collapsed houses. Along the Arniko highway, the bridge over the Bagmati River at New Baneshore (Bridge No.13) collapsed and the bridge over the Dhobi Khola River near Babar Mahal (Bridge No.23) was badly damaged which made it impossible to access the airport through this road. Though the bridges on other alternative routes to the airport from the city core were not affected seriously, such as via Maitidevi and Old Baneshore, the roads were blocked at a number of places from the debris of fallen houses. The width of open space is very limited along these roads. It was difficult to transport emergency supplies from the airport to the evacuation areas inside the Kathmandu City core. The locations of damaged bridges are shown in Figure 5.10.3.

The roads going to the Sankhu area and the Sundarijal reservoir were damaged due to slope failures and blocked from the debris of collapsed houses at several locations. Delivery of the water supply by tankers was badly hampered due to damage to the road going to the Sundarijal reservoir. Heavy equipment was deployed soon to clear the road but it took several days before a smooth operation was possible. Also, many blockages to roads in rural areas were caused by slope failures and falling rocks. However, due to the limited number of heavy equipment and operators available, removal of debris was not possible for even weeks at several locations, and debris was cleared off only with the participation of local people.

There were no major failures of the slopes along the Ring Road and it was not blocked by collapsed houses. However, at least five bridges along it were badly damaged due to lateral movements. The foundations of these bridges were badly affected by scouring and the bridges were not designed with effective earthquake resistant measures. Damage to the bridges along the Ring Road adversely affected the efficient movement of traffic from outside the Valley and access to the core areas. Detours of traffic through temporary access roads were constructed and, at some of the locations, bailey bridges were constructed for temporary use by the joint effort of DOR and the Army.

The urban roads in the old city core areas of Kathmandu, Lalitpur and Bhaktapur were totally blocked by the debris of damaged houses. It was very difficult for the water tankers to cover all the areas of city cores for distribution of water. Smaller size tankers were also not available to distribute water more efficiently. Blockage of roads also greatly hindered the rescue teams to enter the city cores and to take the injured people to the hospitals.

Due to the lack of information about actual damages to the road network and bridges, traffic management was difficult. Efficient movement of emergency supplies and timely rescue operations were greatly hampered due to insufficient damage information.

After several days of chaos, banning the movement of private vehicles except bicycles and motorcycles secured enough traffic capacity for the use of ambulances, fire engines, water tankers, vehicles for emergency supplies and government vehicles.

Fortunately, the Tribhuvan International Airport suffered only little damage to the runways and its facilities. Some minor cracks were also observed in the control tower. Except for recovering from suspension of electrical power, airport functions recovered the next day and the airport was operational for transportation of necessary relief materials and resources from outside of the Valley and from international sources, especially from countries such as Japan, the United States, and other countries of Europe and Asia.

However, the airport has very limited space for storage of sensitive supplies like medical equipment off-loaded from the international aid. The old runway, which is now a taxiway, was used for storing and dispensing of non-perishable supply materials. The refuelling of foreign aircraft which landed in the airport with international aid supplies, was not possible due to a shortage of fuel supplies, and thus foreign aircraft were requested to carry enough fuel to Kathmandu for their return trips. Some of these aircraft were also seen parked at the airport, unable to take-off on time due to limited technical assistance and space for technical repairs.

5.10.3 Strategic Road Network for Earthquake Disaster Mitigation in the Valley

The road network system must continue to function during and after the occurrence of the earthquake, so that lifelines can continue to provide emergency services and to minimise further loss of life and economic distress. The exact estimation of damage to the total length of each road link is of less important than the evaluation of the important road network system as a whole in its functional capabilities. In this context, it is of first importance to identify the road network system that will play a vital role during an earthquake. The part of important road network system can be termed the Strategic Road Network for Earthquake Disaster Mitigation in the Kathmandu Valley as shown in attached Figure 5.10.4. This Strategic Road

Network may include but not be limited to the following:

- Road network linking the Kathmandu Valley to other parts of the nation and the world.
- Road network linking the Kathmandu Valley to the international airport.
- Road network linking districts, city centres/municipalities of the Valley.
- Road network serving as a ring around the city areas.
- Basic road network important for running the socio-economic activities smoothly even after earthquake.
- Road network accessing the water sources in and around the Valley.
- Road network leading to the proposed evacuation sites during the earthquake.

Bridges are usually considered to be the most vulnerable to earthquake induced damage and the effect of any damage to bridges is the most severe in the road network system. So, it is necessary to evaluate the bridges in the Strategic Road Network.

5.10.4 Road Blockage due to Debris

Emergency clearance of debris from roads plays one of the most important roles for safe and efficient movement of vehicles involved movement of emergency supplies and rescue operations, fire fighting, etc. during search and rescue activities.

The Strategic Road Network provides the network for priority clearance work. However, depending on the availability of the equipment for debris removal and personnel available during an earthquake disaster, it will be necessary to prioritise further, within the Strategic Road Network, and also based on the actual conditions of damage.

The Department of Roads (DOR) is the only responsible organisation for planning, construction and maintenance of the road network. However, during major earthquake disasters, especially during the initial response, the operations will definitely be beyond the capabilities of DOR alone. Besides, all of the heavy equipment and their operators available to DOR resources within the Valley may not be available due to damage or inaccessibility. Assistance from the DOR resources outside of the Valley will also be required. The heavy equipment available within other agencies like Nepal Electricity Authority, construction companies and other resources shall also be analysed and coordinated in advance to ensure timely and effective response.

The amount of debris that needs to be cleared after such disaster may be unimaginably large, such that proper methods and places for disposal may become another issue, possibly raising concerns over adverse secondary effects to public health.

(1) Analysis of Road Blockage due to Debris

Analysis of road blockage due to debris from collapsed houses along the Strategic Road Network alone is shown in attached Table 5.10.1. The analysis is done in several iterations, first considering the tallest building from the Most Prominent Building Type in each mesh (size = 500 m). Only if blockage occurs due to the damage in the tallest building, a further check is done to the next tallest building and so on.

The length of blockage is calculated for the period during rescue operations only so that, if a road space of 4 m is available, the road is not considered as blocked. Although the total amount of debris that needs to be cleared from 2-lane or 4-lane roads will be for the whole width of road in the long run, clearance needed during rescue operations is taken as only to pass the vehicles used for rescue operations.

Out of a total of 42 sections in the Strategic Road Network (divided to 42 sections based on width of open space available) a total of 23 sections was found to be blocked by falling debris along the roadside. Analysis based on the GIS data showed a total length of blocked road to be approximately 5 km within the Strategic Road Network alone. At least this total length of 5 km has to be cleared immediately after the disaster in order to maintain minimum operation of safe traffic around the Valley during rescue operations.

(2) Necessity to Prioritise the Clearance Works

From the information provided by the Heavy Equipment Division of DOR, among the major equipment it has in the Valley, 3 cranes, 1 track dozer, 1wheel dozer, 1 excavator, 4 motor graders, 2 wheel loaders, 3 backhoes and 1 air compressor are in good condition and some others are under repair or very old.

Based on this analysis it is clear that the available heavy equipment at present within the Valley is extremely low. Besides, management of this equipment during a disaster will play a very big role and has to be considered very seriously. An effective road clearance plan will be required with accurate information on damages after the disaster. It will not be possible to clear the debris on all the blocked sections at once. It will be necessary to prioritise the blocked sections for effective clearance. An example of priority in debris clearance plan is shown in attached

Figure 5.10.5.

5.10.5 Road Blockage due to Collapse of Bridges

Out of the total 54 bridges, 13 bridges were estimated to collapse. Two other bridges were also estimated to be damaged seriously at the foundation and will not be operational due to uncertainty regarding their stability. Four bridges along the Arniko Highway and three of the bridges over the Bishnumati River in the southern area were estimated to collapse. The bridges over Bishnumati River will also be affected by liquefaction along the river. Though the new Bagmati Bridge will not be affected, the old Bagmati Bridge at Thapathali was also estimated to collapse. The prioritisation for emergency construction will be required in the Strategic Road Network depending on the situation.

The damage of bridges at certain locations will affect seriously the overall accessibility and movement to the critical points in the search and rescue operation system. Access to the disaster areas will be dependent upon the reestablishment of routes. Temporary construction of emergency access and/or temporary bridges will be required at critical locations, along with debris clearance, for the road network system supporting emergency response activities to function.

5.10.6 Proposals

The following tasks will be required during the rescue operation period of the earthquake disaster:

- Gather information and assess the extent of damage, primarily on the Strategic Road Network.
- Response planning based on the gathered information.
- Debris removal planning and management.
- Arrangement of heavy equipment and identification of agencies having abilities and equipment to handle the debris removal works.
- Ensure access over river crossings, where bridges are badly damaged or collapsed. Find immediate solutions such as constructing temporary bridge or access roads.

These are only some amongst the list of tasks that shall be done immediately after the disaster. In fact the tremendous amount of work that can only be effectively handled by an experienced group of personnel, who have good awareness of such disaster operations. A well-managed system and database should exist in advance before the occurrence of the disaster.

(1) Database System

At present, no agency or department of an agency exists that is supposed to carry out such tasks directly. TESU (Traffic Engineering and Safety Unit) of the Department of Roads is responsible for monitoring traffic safety in the Valley. This unit or similar unit may play a very important role if the unit could be equipped with the required software as well as hardware components and also the technical personnel resources and training. Initially, the establishment of a database system will be required, which can be utilised not only for an earthquake disaster in the Valley, but also during any kind of disaster and daily management. Regular updating of the database, defining and updating the Strategic Road Network system, regular survey and maintenance of this network and the bridges in this network, keeping information on the availability of heavy equipment, developing, planning and management concepts of debris removal during disasters, shall be some of the important tasks that this unit would be expected to undertake. These kinds of information can be used for various other purposes and shall not be considered as only the "insurance" for earthquake disasters.

(2) Temporary Bridges

It is also important to find solutions for river crossings during rescue operations where the bridges are badly damaged. Securing enough stock of temporary Bailey Bridges is very important so that they can be used immediately at locations where the bridges are collapsed or heavily damaged. Securing alternative access roads over the river crossings at strategic locations, imposing restrictions against possible encroachment at such locations etc, are some of the other important issues that shall be planned in advance, for smooth and timely response during rescue operations.

5.11 Electricity Supply

5.11.1 Existing Conditions

The power supply system in the Valley was very poor from the late 1970s to early 1980s. Frequent power failures and sudden voltage drops due to insufficient power generating capacity and an inadequate transmission and distribution system network were largely recognised.

The Government of Japan conducted a study during 1978-1979 for the reinforcement of the transmission and distribution system in the Kathmandu Valley and to establish a Load Dispatching Centre. The project was implemented during the period from 1980 through 1986 under the Grant Aid of the Government of Japan. Furthermore, after the completion of Kulekhani I, Kulekhani II, Devighat and Marsyangdi power stations, power supply in the Valley improved to a relatively reliable power supply. However, the demand started growing at a much faster rate than anticipated and the total supply and power problems started growing again.

Power supply to the Kathmandu Valley is mainly from Marsyangdi (75 MW) and Kulekhani II (32 MW) power stations through 132 kV high voltage transmission lines and, from Kulekhani I (60 MW), Trisuli (24 MW), Devighat (14.1 MW) and Sunkoshi (10.05 MW) power stations through 66 kV high voltage transmission lines. Recently, the power supply from the Khimti Khola (60 MW) power station has also been included in the national power grid, which is run by the private sector. The supply from 132 kV transmission lines is stepped down to 66 kV at the Syuchatar, Balaju and Bhaktapur substations before delivering to the distribution substations.

Most of the hydropower generating facilities in Nepal are interconnected to the Central Nepal Power System (CNPS) by 132 kV or 66 kV transmission lines. This interconnected system is operated following instructions of the Load Dispatching Centre (LDC), constructed under the Grant Aid of the Government of Japan. When a failure occurs, the operation of all switches is done under the instructions of the LDC.

The city area of Kathmandu and Patan is covered by a Ring Main System supplying reliable power. The Ring Main System consists of 11 kV double circuit lines that connect all distribution substations of the Valley. From these distribution substations, 11 kV primary distribution lines (Feeder Lines) are used to supply power to consumers on low voltage lines through 11 kV / 400 V - 230 V pole-mounted transformers.

The primary distribution lines (Feeder Lines) are of a radial feeder system and mostly three-phase, three-wire overhead lines. In some of the urbanised areas where roads are too narrow to maintain the insulation clearance to buildings, underground cables have also been laid. In urban areas where the demand is high and where important facilities such as hospitals exist, some distribution lines are connected to substations to provide backup in the supply.

Distribution transformers (11 kV / 400 V – 230 V) are installed with varying unit capacity. The unit capacity of the distribution transformer ranges from 10 kVA to 250 kVA, with most having a unit capacity of 250 kVA in urban areas and 50 kVA in rural areas.

Finally, the low-tension distribution network coming out of distribution transformers supplies the electricity at the consumer level through a 400 V / 230 V three-phase, four wire system. Low-tension lines are also of the radial feeder system and are mostly overhead. The existing electricity network is given in attached Figure 5.11.1.

5.11.2 Event Scenario for Electricity Supply

Damage to the power supply lines caused by the scenario earthquake was concentrated more to the city core areas of the Valley as shown in attached 5.11.2. It was primarily due to the fact that the city cores had the highest density of power supply lines.

The supply of power from Marsyangdi and Kulekhani was interrupted to some extent by the damage to the high voltage lines due to slope failures along the hills. Some of the transmission towers tilted or partially collapsed. Fortunately, no major damages to the high voltage lines and the transmission towers were reported to the Trishuli powerhouse.

The power supply was cut off immediately after the earthquake for safety reasons and was started after only several hours. However, most of the areas in the city cores were without electricity due to the localised damages to the power supply lines.

The debris from collapsed houses caused a large percentage of damage to the low-voltage distribution lines. The power supply lines were broken because the lines were running very close to the houses in these areas. In addition to this, the poles, where the transformers were mounted, also collapsed due to deteriorating foundations as well as from falling debris. Damages to the distribution transformers were also largely observed.

Repair work on the transformers, even in the important areas, was not possible due to the lack of spare transformers and other spare parts. The No-light departments of the administrative branches of NEA, which are directly responsible for repair work in their respective areas, were in a state of complete chaos, since they were not trained to react in such disaster situations and did not have any earthquake awareness. The technical human resources as well as the equipment available were far below the required input. In normal situations, these departments usually respond to the reports of damage by individuals and have very few personnel who know about the area and the distribution system well enough, within their jurisdiction.

The residents of the Valley are used to frequent power failure every rainy season and thus are less vulnerable in their social activities to power failures. According to the sources from Nepal Electricity Authority (NEA), the Valley residents may have to spend dark nights for as long as a week, though NEA is trying to provide intermittent power supply of at least few hours to different locations. The damage to some of its substations and switching yards inside the city cores added more to the problem.

The effects due to the damage to the supply were serious in sensitive places also. Most of the hospitals in the Valley were running without the power supply and were not prepared with alternative power sources, especially the private hospitals and nursing homes. Fortunately, it was possible to supply power intermittently to Bir Hospital, Patan Hospital, Teaching Hospital and some other major hospitals through alternative substations; thanks to the distribution ring main system with redundancy in the supply.

The power supply to the Royal Palace and Singha Durbar (where most of the ministries are located) was not affected seriously because of the redundant supply system. The power supply to the Nepal Television and Radio Nepal (both inside Singha Durbar) was restored after a short interruption.

5.11.3 Responsible Department for Repair and Maintenance

The damage to the local feeder and distribution lines, local transformers, etc. has to be repaired by providing an effective repair and maintenance system during the earthquake disaster. At present, the repair and maintenance work is done by the No-Light departments of each branch offices of NEA, in the respective areas under their jurisdiction. However, these No-Light departments have very few technicians who know about the area and the details of the supply system. No systematic data is available regarding the details of the feeders, numbers and locations of transformers and the exact demarcation of their boundaries, etc. It is also not very uncommon that due to the lack of a systematic database, repair work may become delayed when the technical staff who knows about the area well takes a leave.

5.11.4 Alternate Power Sources

Power generation in Nepal is mainly from Hydro Power plants. The method of power generation at the national level itself is of less concern to the sustainability of power supply to individuals during earthquake disasters. The possibility of other alternate power sources that can be utilised in localised areas is discussed briefly.

(1) Solar Power

NEA has two solar power plants in northwestern remote areas of Simikot and Gamgadhi, with capacities of 50 kW each. From the results of various studies, although solar power generation may be feasible in northwestern mountainous areas, it may not be feasible in the Kathmandu Valley due to inadequate sunlight in the rainy season. Nonetheless, it may be utilised in small installations like street lights or traffic signals. The Improvements of Intersections in the Kathmandu Valley by Japanese Grant Aid is being implemented by installing a solar powered traffic signal system.

(2) Wind Power

Wind power generation in Nepal is still at an experimental stage. A 30 kW wind power plant was constructed by NEA through assistance from the Danish Government in Kagbeni (north of the mid-western region near Jomsom) a few years back. But it was heavily damaged from high wind and turbulence after a few months of operation. The favourable wind speed for power generation is from 3 m/s to 25 m/s. The annual average wind speed in the Kathmandu Valley is around 3 m/s and may be unsuitable for continuous power generation throughout the year.

(3) Diesel Generators

In addition to hydro power plants, there is also a substantial amount of power generation from diesel power plants, with installed capacity of about 57 MW. They play an important role during the dry season, when the power generation from hydro power plants is severely affected. A short investigation on alternative power sources used by different organisations was carried out. The result is shown in Table 5.11.1.

Table 5.11.1 Alternative Power Sources

SN	Organisation	Power Source	Capacity	Investment (NRs)
1	Hotel Narayani	Diesel Generator	125 kVA	3.5 mill. (20 yrs old)
2	NORVIC Hospital (PVT)	Diesel Generator	150 kVA	160 mill. (recent)
3	Ministry of Home	NONE	---	---
4	Nepal Rastra Bank	Diesel Generator	5 kVA	3 mill.
5	Trivuban International Airport	Diesel Generator	250 kVA	Japanese Grant

It was also observed that a large percentage of private shop keepers in the city core areas use small portable type diesel generators to be used mainly during load shedding during the dry season. However, use of diesel generators in private houses is not noticeable, and conventional oil lamps or candles are more commonly used during longer power outages at night.

5.11.5 Proposals

The following tasks will be required during the rescue operation period of an earthquake disaster:

- Gather information and assess the extent of damage to the network and provide information to the Load Dispatching Centre.
- Provide data regarding the availability of spare parts, spare transformers and heavy equipment for repair works.
- Coordination among the No-Light departments of each branch offices for smooth operation and management.
- Prioritise and response planning of immediate repair works.

(1) Responsible Agency and Database

At present no department or agency is assigned to handle such operations either inside or the outside of NEA. The Kuleshore Branch of NEA is at present preparing the GIS database of each network at the consumer level, by its own effort. Such activities should be promoted in every branch of NEA. The Corporate Planning Department at the central level has also a small GIS Unit, which is preparing the GIS database of the network up to the distribution transmission network level. This department can play an important role and should prepare trained manpower to operate during earthquake disasters and should be equipped with required hardware as well as software facilities.

(2) Alternative Power Source

At present the residents of the Valley are facing scheduled power outages and frequent other uninformed power outages, due to the shortage of power supply. During the bad conditions of the dry season, power outages of more than 6 hours a day are also not an uncommon situation in the Valley. Fortunately or unfortunately, it can be presumed that the damage to electrical facilities during earthquake disasters, will have a lesser impact on the daily activities of the residents, compared to those in the industrialised cities where the dependency on electricity is at a maximum for their lifestyle.

Though the daily life of people can be presumed to be less affected by the temporary power outages, the important facilities like hospitals, government buildings and other agencies, which have to play an active roles during disasters, cannot work efficiently without electricity. Such agencies should be prepared with sufficient alternative power sources like diesel generators for use at a time of disaster, with a sufficient stock of diesel fuel stored at safe locations. As for the Nepal Oil Corporation, it usually has a stock of fuel for about one week in reserve, under normal conditions in the Valley. If restrictions to use private vehicles during disasters are imposed, the reserved stock of fuel can meet the daily needs for at least a week or longer.

Other alternatives such as solar power systems may also be thought of, but the cost of installation seems high, and solar power is unfavourable from the point of view of the cost and life of the battery. Besides, in case of damage to the roof of the building, the solar system is most likely to be damaged as well, and solar power systems are not as flexible as generators to set up and use at any location after the disaster.

5.12 Allocation and Prioritisation of Staging Areas

In a great disaster, rescue and relief work will need to be undertaken in many locations, requiring management and coordination of vast numbers of rescue and relief personnel, including volunteers, and enormous amounts of goods and supplies, including international donations. This requires that staging areas be established, where such management and coordination can take place. Some staging areas will be located near the source of the goods and supplies, such as Tribhuvan Airport, where international rescue and relief teams and goods will arrive. The International Convention Centre would also provide a good staging area for Kathmandu and Lalithpur Municipalities, as it provides a large area which can be blocked off from unauthorised personnel, so that stockpiles of supplies can be well controlled. There may be a need for additional staging areas where volunteers and other rescue or relief personnel can gather, check in, be assigned equipment and tasks, and where they report back to for food and rest when their tasks are fulfilled.

In addition to such staging areas, various other types of operations will have to be located in available open space areas, including temporary sheltering and feeding of persons made homeless by the disaster, the establishment and operation of triage sites and field hospitals for handling the injured, temporary morgue sites for identification of the deceased. Also required are temporary dumping sites for debris, to allow for recovery of household goods and recycling of useful items. Because of these and other potentially conflicting needs for open space, it is advisable to identify potential needs and evaluate potential sites in advance. This will allow the characteristics of the sites, such as proximity and road access to the airport, the city core and other high-risk areas, to be best matched with their potential uses.

CHAPTER 6 STRENGTHEN SOCIO-ECONOMIC SYSTEM

Urban Society in Kathmandu is Intricate

Urban societies are highly dependent on the socio-economic infrastructure. The more a city develops, the more complex its structure will be. Even damage at only one point of an urban system will initiate a chain reaction, which increases and expands to affect the functioning of the entire urban society. This has a long-term effect on the sustainability of the development process. This points out the vulnerability and weakness of urban societies.

The Kathmandu Valley is home to the national capital city, and it sustains various important functions. The Valley is in the process of rapid urbanisation. Once a major earthquake hits, it will affect social and economic functions, as well as the physical infrastructure. Moreover, by affecting the capital city, the damage will have far-reaching consequences.

Earthquake damages will jeopardise human security

It is always the case in earthquake disasters that once the power supply stops, not only electricity but also the water supply will be hindered. The lifeline systems are all inter-related, and damage in one system affects other systems as well. Communications systems will also face consequences. Inadequate or inaccurate information from various media will retard the restoration process and rootless rumours will be afloat. The blockage of roads and damage to bridges will directly hinder the aid distribution system in the Valley. Relief goods and materials for rehabilitation will possibly be stranded at the airport and the rehabilitation process will be severely affected. Building damages will jeopardise life and property and degrade amenities, thereby posing a serious threat to human security and safety.

Disaster and the economy

In the case of a disaster, there are always direct and indirect economic losses. The direct economic loss is primarily the damage to buildings and infrastructure, which would more than double due to loss of function and the cost of recovery. Thus, the efforts for reconstruction will be enormous. The indirect economic loss is that caused by the business interruption and long-term recovery process.

Strengthening the social infrastructure and its functions will lessen economic losses, which will generate ripple effects. Roads, bridges, and communications networks are the major elements of social infrastructure and require long-term vision, both in the development aspect and for disaster response strategies.

Disasters and poverty are mutually reinforcing. Poverty increases vulnerability to disasters and disasters contribute to the continuation of poverty. It is necessary to break through this vicious cycle with disaster mitigation for effective long term and sustainable development in the future.

Disaster mitigation and development

Economic loss is not just direct losses. Indirect losses and secondary effects including impacts on public finances and trade are much higher than the direct losses. The cost of losses as a percentage of total assets or of national wealth will be higher in developing countries such as Nepal. From an environmental viewpoint, a major issue is how to deal with the huge amount of debris caused by the earthquake damages. Global scale efforts made by environmental awareness will contribute to minimise industrial waste and produce other responses for the betterment of the society. Thus the impact of the direct losses, as well as the secondary and indirect effects, will be great and the country poorer. The experience of losses from disasters creates disincentives for investment.

Mary B. Anderson (1990) defined development as “the process by which a nation’s capacities are increased and its vulnerabilities reduced.” This definition clearly states the link between long-term systematic development and the impact on development from disasters, and development expenditure, is related to disaster mitigation. Any development investment should include concrete measures to improve the nation’s capacity to cope with disasters.

Disaster mitigation, incorporated into development planning, is an important step to achieve sustainable development.

Measures

For effective budgeting, effective linkages among the economic, industrial and financial circles are necessary. Infrastructure is a crucial issue to take interlinked urban systems and city structures into consideration. Some facilities and services are susceptible to disasters, and others are particular to the city. Steady steps should be taken for reinforcement with regard to budget and priority.

6.1 Building Structures

Nepal has suffered losses of life and property due to earthquake over 10 times since the 12th century. The last great earthquake in 1934 caused a tragic disaster to buildings and lives in the Kathmandu Valley, and the latest mid-class earthquake in 1988 caused moderate damage to traditional buildings in Bhaktapur. Although the Draft National Building Code of Nepal (NBC) was already prepared in 1994 following the 1988 earthquake, it is not yet being enforced. The structural regulations of the Draft NBC provide the seismic design method for the mid-class earthquake. They are mainly based on the Indian Codes. Here "great earthquake" means the strength of seismic ground motion of VIII or more in MMI (Modified Mercali Intensity), and "moderate earthquake" means VI to VII in MMI.

This chapter describes the Draft NBC of Nepal and the following items concerning major structural types of buildings in the Kathmandu Valley:

- Present status.
- Structural problems especially regarding seismic capacity.
- Proposal for improvement of the structural problems.

The major structural types of buildings classified in the Building Inventory are as follows:

- "Reinforced Concrete Frame with/without Brick Masonry (RC)": rapidly increasing numbers of buildings at urban core and fringe areas.
- "Brick with Cement (BC)": most common type and more or less half of the buildings in the area.
- "Adobe (AD)": popular in rural areas.
- Other Buildings.

6.1.1 Status of Building Structures

In the Kathmandu Valley, there are many types of buildings such as traditional compounds with a courtyard, detached, monumental houses, historical, governmental and commercial buildings. Buildings have historically been constructed as a necessity of life in accordance with the available material, economic power and rules of thumb, in the Kathmandu Valley.

(1) From the structural point of view

Most of the existing buildings have problems regarding earthquake resistance as mentioned below.

a) More than 3-story buildings of reinforced concrete with/without masonry wall (RC-H)

RC-H buildings are most common buildings constructed in the past 30 years in urban areas. The initial plan such as the size of columns and beams was probably for three-story buildings. However, existing RC buildings are extended up to four to six stories, without strengthening the columns and beams. This may be due to the rapid increase of urban population. Furthermore, the floors of the second and upper stories on the roadside extend beyond the floors of the lower stories. The walls of the widened floors are supported on cantilever beams and are located outside the RC frames. This abnormal structure causes severe twist deflection created by the eccentric moment and increases the vulnerability of the building during earthquakes.

Photo 6.1.1 RC frame with masonry

Photo 6.1.2 Cantilever Structure

b) RC type of less than four stories with/without masonry wall (RC-L)

RC-L type would have the proper size of columns and beams. If correctly designed and constructed to the draft NBC, with correct beam depth and reinforcement bars, it would resist a moderate earthquake. It seems that most building owners and constructors think that RC buildings are safe and strong enough. However, most buildings are designed without a structural engineer and are constructed by unskilled craftsmen/masons who have no knowledge of RC structural work. Most RC buildings are probably in the above-mentioned category, hence, there is concern about their stability during a great earthquake.

c) Brick masonry buildings with cement mortar joints (BC)

BC buildings are located in all areas and comprise more or less half of the buildings in the Kathmandu Valley. This type of building is generally with rigid

RC slabs for floors and roof. They are improved in structural strength when compared with other brick masonry buildings with mud joints. However, they are still poor regarding horizontal rigidity due to poor workmanship and lack of structural consideration regarding the joints between walls and roofs. Although buildings of this type less than four stories constructed with suitable workmanship and good wall balance may seem safe, those that are more than four stories are highly vulnerable during a great earthquake.

d) Brick masonry buildings with mud joints (BM)

BM buildings still remain in urban and rural areas. These buildings have very poor horizontal rigidity because of the low bond strength, high absorption of moisture at the mud joints, and the wooden floors and roof. During a great earthquake, BM buildings of less than three stories seem fragile and BM buildings of three stories or higher seem very fragile indeed.

Photo 6.1.3 BM Structure

Photo 6.1.4 Structural Mixed

e) Adobe buildings (AD)

Adobe is sun-baked brick. The AD type of building has weak points due to low bond strength and high damp absorption at the mud joints, and very poor horizontal rigidity of the wooden floor and roof system. Therefore, lacking seismic resilience, it can be said that AD buildings have high fragility during a moderate earthquake.

f) Stone masonry buildings (ST)

ST buildings are popularly seen in rural and slope areas. The stone masonry walls consist of various sizes of stones and mud joints. ST buildings are similar to AD buildings having high fragility during a moderate earthquake.

g) Other building types

One of the serious problems is mixed structures. In particular, buildings with AD or BM for the lower part of less than three stories and with BC or RC for the extended part from four to six stories are vulnerable because they are over-weight and have a weak lower structure. Other examples are ones with walls that have an existing core of adobe and outer layers replaced by BM or BC. These buildings have less horizontal rigidity and more vulnerability during a moderate earthquake.

(2) General Point of View

There are several problems from a general point of view as follows:

- The general public's consciousness regarding earthquakes and their damage is low.
- According to the economic conditions of the owners, construction contracts are customarily handled on a personal basis.
- Quality control problems are likely to occur when owners make their own arrangements for resources and construction materials and pay the workers on a piecemeal basis.
- Responsibilities for construction are not identified, because of the informal arrangements in personal contracts between owners and builders and designers.
- Improved professionalism in the building and construction trades is needed.
- There is insufficient design for seismic motion.
- There is insufficient consideration of soil, ground water and slope.
- Original stable structures are divided into smaller structures or extended to further stories.
- There are no inspections for quality control and good design and construction practices during any stage of construction by owners, designers, local officials or supervisors.
- Building permit processes do not consider seismic forces design.
- There is no systematic check at design, construction, permit and completion stages.
- Building codes/regulations and permits have no enforcement power against illegal undertakings.
- Building codes/regulations and permits do not provide incentives for stakeholders to improve buildings.
- Although there is a system for registration of engineers, the system is not effective.

- A degree in structural engineering from India or another developed country provides status but no contribution to the improvement of buildings in Nepal, because there is little requirement for improvement.
- Even though there is a system of registration of builders, only a few builders are registered, and the system is only applied to limited public construction.
- There is insufficient inspection of construction materials.
- There is insufficient checking of the mixture of concrete during construction.

However, several developments can be seen as follows:

- Since the mapping project preparing digital maps with a scale of 1:2,000 is going on in the Kathmandu Municipality, it will be able to assist in developing a detailed inventory of each house type and number of stories.
- Retrofit work has been conducted on several school buildings.
- Nepali masons have been training the masons of Gujarat, India, in ways of improving construction quality and performance.
- A limited number of public and large scale buildings have been constructed taking seismic forces into consideration.
- The Ministry of Physical Planning and Works has started training programmes for building permit processing and building code requirements.
- Municipalities intend to incorporate the codes into their Bylaws.
- In this project, the building inventory survey was applied to 1,000 buildings, though this was only 0.1 % of the total, it was possible to comprehend the nature of buildings in the Valley. This sort of survey can be usefully applied to wider areas.

6.1.2 National Building Code of NEPAL (NBC)

(1) Status

The necessity of improvement in building construction and design method was recognised on account of destructive damage caused to dwellings and schools in the 1988 earthquake in Nepal.

The Ninth **National Five-Year Plan** (1997 to 2002), published by the National Planning Commission, mentioned that the "Building Act and National Building Code will be implemented. Necessary amendments in the existing Nepal Acts related to building, housing and urban development will be made." (Section "The Formulation of Act, Regulations and Standards", Paragraph 7 "Programmes", Chapter 8 "Regional and Local Development.")

The **Building Act** (1998), the highest level of law on construction, prescribes that "The construction, additions, and alterations in all Nepal need the building permission from the concerned local government."

The committee of the Ministry of Physical Planning and Works (MPPW) provided the **Draft of the National Building Code (Draft of NBC)**, which should be at the second highest level of law on construction, in 1994. The draft prescribes the method of checking safety on normal and lateral load, including seismic load conditions. The draft also provides the easy way to apply standards in consideration of the particular conditions of each region and the following four levels of construction:

- International state-of-the-art
- Professionally engineered structures
- Buildings of restricted size, designed to simple rules-of-thumb
- Remote rural buildings where control is impractical: Building work following the guidelines.

At present, only the Kathmandu and Lalitpur Municipalities require owners to submit an application for new building construction and to get approvals for the construction of buildings of more than two stories or more than 1,000 ft^2 (about 93 m^2) of ground floor area. The Municipalities also check the building plans at the time of commencement of the construction work in accordance with their Building Bylaws. Although the Municipalities and Ward offices receive the drawings, they cannot at present check the safety and structural design of the building from structural or seismic points of view.

(2) Management Plan for Implementation

Although MPPW will proceed to implement the Draft NBC within the next fiscal year according to the schedule, the formulation and implementation of the draft NBC shall proceed in accordance with the "Building Act (1998)" through the following procedure:

- The National Building Code Committee shall prepare and submit to His Majesty's Government of Nepal (HMGN) the Code and implementation procedure.
- HMGN shall approve the Building Code, with or without any additions or deletions.

- The Committee shall send to the local authorities the Building Code approved by HMGN.
- Local authorities shall publish the NBC and make it available to the public.
- Implementation of the NBC shall be the responsibility of the local authorities.
- The Committee shall provide such technical assistance and support to local authorities as the committee deems necessary for implementing the NBC.

6.1.3 Status and Problem in Masonry Structures

"Masonry structure" means what is composed of earth, stone or brick. BC, brick structures with cement mortar joints, is representative of masonry in the Kathmandu Valley and will be mainly discussed.

(1) Status of BC buildings

Masonry structures have been used for various kinds of buildings in the Kathmandu Valley such as dwellings, schools, government buildings, factories, warehouses, temples and palaces since a long time ago. Masonry buildings are of several types, such as stone, adobe, brick with mud joints, and brick with cement mortar joints. Also, bricks are used in recent RC frame structures as structural and non-structural walls.

The load bearing brick masonry buildings used to be constructed with plentiful raw materials and rules-of-thumb in the Valley. Based on the historical caste system, people of limited means have followed and engaged in the traditional way of construction with mud joints and brick structures and the owners have trusted them. However, it would be better to change masonry buildings from mud joints to cement mortar joints in order to upgrade seismic capacity in the future.

BC buildings have been constructed for the past 30 years, and they have become currently the most common form of construction. Three stories are normal, but four to six stories can easily be found, especially in urban and commercial areas. Their structural elements in the Valley are briefly described as follows:

- Spread foundations are usually openly excavated using strip footings of stone in mud joints or brick in cement mortar joints up to ground level.
- Above ground level to the plinth level, bricks in cement mortar are used with a thickness about a half-brick larger than the superstructure wall.
- Superstructure walls are one or one and a half brick width with 1:6 (cement: sand) cement mortar. The crushing strength of bricks is usually more than 0.7 N/mm^2.

- Generally, water-soaked bricks are used. First the parallel walls are built and next the transverse walls in each story.
- Reinforced concrete slab or wooden joists are generally used for the roof and floor systems . In some cases, sloping roofs by RC slab or wooden truss systems are also used. There is no practice of using lintel and roof level bands.

Photo 6.1.5 BM Structure

Photo 6.1.6 BM Structure

(2) Seismic vulnerability of BC structures

Ordinary BC buildings are the most distinct buildings with abundant materials and rule of thumb construction. They also have a beautiful natural colour on the decorative wall and columns. However, they are structurally fragile due to design, workmanship and rules of thumb construction as follows:

a) In the design stage
   In Nepal, masonry structures have no special design by a structural engineer.

b) In the construction stage
   - The brick wall corners are not satisfactory because of both insufficient in-fill joint mortar and no interlocking bricks.
   - Inadequate unification of the walls is caused by non-filling of the joint with mortar and no interlocking bricks.
   - In the case of wooden floor and roof systems, there is no practice of using RC band beams on the lintel, floor and roof levels.
   - The number of stories is extended occasionally to four or six in the urban core, though three stories are usual.
   - Additionally, the brick wall layout is changed, when using the RC slab and beam. Floor levels are also changed between neighboring buildings.
   - The openings in walls and windows are widened without reinforcement.
   - Higher wall heights in the top story where sloping slabs are adopted.
   - There are problems in quality control
     - Using dry bricks

- Using low quality mortar
- Using broken bricks, second hand bricks
- Using different masonry types in the same building
- Using different mortar joints and bricks on different stories

6.1.4 Status and Problem in Reinforced Concrete (RC) Buildings

There are many non-engineered and a few engineered RC buildings in the Kathmandu Valley. So-called engineers and supervisors cannot identify whether RC structures are properly constructed or not, and also, they are rarely stationed at the work site for proper supervision of construction work. RC buildings in the Valley have the same basic problems in the design and construction stages as in the following detail:

Photo 6.1.7 RC Structure (beam length shortage)

Photo 6.1.8 RC Structure (lapping length shortage)

a) In the design stage

- Most of the non-engineering RC structures are constructed by incorrect rules of thumb without any design drawings.
- Even engineered RC structures with design drawings have no column reinforcing-bar details, nor instruction for positioning of bar-joints on columns and beams.
- Foundation (plinth) beams of housings are designed too small in size in concrete sections and re-bars compared with the column size.

b) In the construction stage

- After the initial survey for construction, benchmarks and reference points are not used.
- The surface of bearing soil is rough without compaction and levelling concrete.

- The centres of footings and columns are sometimes shifted to a maximum about 200 mm.
- The minimum concrete covering of re-bar is insufficient.
- The positions of re-bar's joints in columns and beams are not correct, and the positions of neighbouring re-bar's joints are not staggered.
- The lapping length of re-bar's joints is not enough.
- The angles of hooks of hoops in columns and stirrups in beams are less than 135 degrees and hook lengths are short.
- The anchorage lengths of beam's main bars are not enough.
- The anchorage of slab re-bars is not correct and some anchors are not enough.
- Formwork is rough, the material used is poor, and supports are unsteady.
- Concrete mixing work is not controlled by a site supervisor.
- Concrete placing work is performed without a vibrator on some sites.

The above problems, though basic, are very important matters for RC construction. Engineers and supervisors can improve RC structures to give adequate strength and durability with a little bit of additional effort.

6.1.5 Status and Problem of Adobe (AD) Structure

AD buildings are made of unfired brick (sun-baked brick) with mud mortar joints and are used for offices and traditional buildings such as temples and dwellings with courtyards. AD buildings have been constructed also in urban areas. They currently comprise more than half of buildings in rural areas.

AD buildings consist of load bearing walls with mud mortar joints and wooden joist floor systems and roof system and without the RC plinth beam and RC band beams constructed by rule of thumb. Their wide walls are normally one and half or two brick in thickness. They can support quite a big vertical load, but both unfired bricks and mud joints are basically very weak for lateral forces as during earthquakes. Especially wooden floor and roof systems without RC band beams on adobe walls have very low resistance to lateral forces because of the lack of rigidity in the horizontal structural components. In addition, the mud mortar and the unfired brick can become weathered with high absorption of moisture. Consequently, AD buildings are high fragile during a great earthquake.

Photo 6.1.9 AD Structure

Photo 6.1.10 AD structure with courtyard

6.1.6 Other Buildings

(1) Hospital Buildings

Although six major hospitals with multiple buildings for medical care etc. were investigated in regard to their current condition, seismic resistance and necessity of retrofitting, there were insufficient data to judge their status. Only 40% of their architectural drawings could be obtained, and few structural drawings and calculation sheets were available. Due to the responsibility of the hospital to the public, they did not want to disclose the details.

According to our visual inspection, seismic evaluation and retrofitting work will be necessary. Even without structural drawings and calculation sheets, it is clear that the existing buildings are vulnerable during earthquakes. I order to improve the buildings, it is important to investigate the structures and quantity of the reinforcing bar in the RC frame. There is information that the Department of Health Service in cooperation with WHO has studied the seismic capacity of several two hospitals in the Kathmandu Valley, as noted in Section 5.4.

(2) School Buildings

There was little chance in the Project to investigate school buildings except a couple of retrofitted ones. However, two thirds of the public school buildings in the Kathmandu Valley are made of masonry with mud joints, and most of the schools are narrow in space. Since the number of public school buildings cannot catch up with the increase of students, triple classes systems are common. The number of private schools, which should be better in seismic resistance, exceeds that of public schools. Compared with hospital buildings, the seismic resistance is expected to be lower and maintenance to be worse. Therefore, many school buildings are inappropriate for multiple uses by the community.

In Nepal, several international organisations have assisted in school building construction; but because of the lack of building code regulations, most of them may not have taken seismic forces into consideration in the design. However, both JICA and a NGO have promoted retrofit or rebuilding of school buildings in conjunction with motivating the local community raise awareness of potential earthquake disasters. This movement should be noticed.

Photo 6.1.11 Retrofit to school

Photo 6.1.12 Retrofit to school

(3) Public Buildings

Although small in numbers, the buildings of ministries at Singh Durbar, the International Congress Hall, and several public offices and ward offices could be observed. It is roughly estimated that large scale or new buildings are of improved quality, but smaller or older buildings, which are mostly unimproved, are non-resistant to earthquakes.

(4) Historical Buildings

There are many historical buildings, mainly of the Newar style in the Kathmandu Valley. Most of them consist of AD, BM with wooden beam floor and roof systems. Since the adobe and the mud have low durability and high absorption of moisture, there are many damp walls attacked by rain and ground water. Although walls with more than two bricks width are only partly lost by big windows of Newar style, some walls are delaminated because of both the unbalanced load of windows and low bond strength of joint materials. Since hard wood columns and beams units are used for entrances and big openings, it causes a small lateral resistance to earthquakes.

Bhaktapur has many historical and traditional houses that attract tourists, though most of them are highly vulnerable due to heavy deterioration of the adobe and the mud joints. Although it is appropriate policy for the Municipality to enforce citizens keeping the exterior of buildings for preserving this peculiar atmosphere and promoting traditional craftsmen to keep technology, it is an urgent theme to reinforce these houses from an engineering point of view either by retrofitting or re-construction.

Photo 6.1.13 Historical Building in Bhaktapur Photo 6.1.14 Repairing Historical Building in Lalitpur

6.1.7 Recommendations for Improving Buildings

The Kathmandu Valley has a wide variety of buildings located in both urban and rural areas that are fragile during great earthquakes. The more detailed the investigations, the greater the vulnerability of buildings can be found, especially of those that are structurally mixed. On the other hand, although the Draft NBC was prepared, it is still not being implemented. Under these circumstances, the following items for improving buildings against great earthquake are recommended.

(1) Establishment of Building Construction System

Even since it was a poor country, Japan has long made great efforts to establish Building Codes to resist earthquakes because of its active seismicity. There is a history of improving structures as well as public education and awareness raising.

Since Nepal is just at a stage of implementing its draft NBC, it should learn the lessons from developed countries such as Japan. Apart from the technical aspects, building institutions or construction systems should be arranged and publicised for the co-operation of all stakeholders.

a) For Owners

In spite of only seeking personal contracts, lower costs, appearances or popularity, it is necessary for owners to have knowledge and information to select the builders with the knowledge and capability to comply with the building code. On the other hand, it is also necessary to have economical and mental incentives to avoid higher governmental costs.

b) For Builders
   Builders that can select quality materials and work according to their expert knowledge should be prioritised, while builders without knowledge of the building codes should be avoided.

c) For Governmental Officers
   It is necessary for government officers to disseminate appropriate knowledge and information to owners and builders and to promote adequate contract relationships between them. Simultaneously, government officers should investigate the status of building construction and arrange the registration/permits of builders/engineers. In order to realise the above-recommended points, the government should consider the owner's economic condition and seek technical assistance.

d) For Engineers, Construction Corporations
   Better and cheaper but effective methodologies for construction should be offered and promoted by these people and organisations. Also, they should improve the building codes.

Based on the promotion of the above-mentioned items, responsible and trustworthy building/construction institutions and systems for effective improvement to buildings can be established in Nepal.

(2) Suggestions on the Draft National Building Code of Nepal (NBC)

The most effective and urgent measure is to execute smoothly the Draft NBC that should be implemented in the next fiscal year throughout Nepal. For this purpose the following suggestions and proposal are offered.

a) Education, training and drills
   In order to upgrade the technical foundation, the Technical Institutes in Tribhuvan University and the training centres should train and send out engineers, supervisors and craftsmen/masons to municipalities, ward offices, builders and construction enterprises. Since currently in Nepal, there are not many engineered building projects, structural engineers are not familiar with technical developments. Thus they need to be re-educated or re-trained. On the other hand, MPPW has approximately 70 engineers who should be expected to train or educate the related officers working for local authorities. For that purpose, since even the Pokhara Training Centre has no equipment, it is

necessary to provide the basic tools and testing apparatus at training centres in major regions.

b) Establishment of registers and licensing system

In order to improve and maintain the quality of structures and construction, the qualification system with not only registration but also licensing of architects and engineers shall be developed. Necessary laws shall be legislated. Simultaneously, a construction management system should be established and the registration system for building enterprises should be strengthened. Further, for greater effectiveness of the above systems, incentives should be introduced to assure higher standards, pride and prestige in the engineering and construction professions and trades.

On the other hand, for building owners, who want to avoid higher building costs, incentives are necessary for proper design and construction at reasonable costs. For this purpose, the government should disseminate appropriate information and include appropriate mechanisms for enforcement and incentives in the Draft NBC and the by-laws.

c) On the Draft NBC

Since the current Draft NBC is not perfect, at least the following items relating to seismic force and column reinforcing bars will be recommended for inclusion:

- Re-evaluation of the structural performance factor

  The structural performance factor “K” on Table 8.2 in 8.1.8 of NBC105 (1994) should be reviewed. When 4.0 for the maximum “K” in Kathmandu Valley is used, the design horizontal seismic coefficient “Cd” should become 0.64, and also when 1.0 for the minimum “K” is used, “Cd” should become 0.08. Cd=0.64 is too big, so that it is difficult for actual structural design by normal size. As well as Cd=0.08 is too small for great earthquakes, though Cd=0.08 should be the value for moderate earthquakes. Appropriate values for “K” and “Cd” must be re-evaluated, and then each value for seismic design should be systematically revised.

- Revision of sizes for plinth beams, columns and reinforcing bars

  Based on above a) and according to the current “The Draft of NBC’s Recommendation” in its 7.4.2 of NBC201 (1994) and in 7.3.2 of NBC205 (1994), most plastic hinges on RC frames in the analysis of ultimate seismic capacity are concentrated on the top and bottom of the columns except at the plinth beam level and outer end of beams on first and second floor levels.

Especially, the plinth beams are too small. For this, the following three points are recommended:

- Bigger size of plinth beams and reinforcing bars is better for both the fixed column base and strengthening seismic capacity.
- A bigger sectional size of columns in each direction with reinforcing bar on the ground and first floors is better for improving seismic capacity.
- It is better to increase the quantity of bottom beams and re-bars at the outer end of the first and second floors for improving seismic capacity.

• Guidelines and their dissemination

Fundamental and detailed improvements in the construction stages recommended below can be accomplished one by one with a little effort, and thus provide effective resistance to seismic force. Therefore, it is most effective that practical guidelines for construction and design including the recommendations below should be drafted and disseminated widely to engineers and builders and municipalities.

(3) Recommendations for Masonry Buildings

a) Re-education of structural engineers

Since structural engineers should check and design the brick masonry buildings from the seismic resistance point of view, they should re-study at the Institute and/or on construction sites. Also, site supervisors and craftsmen have to be trained by good engineers on appropriate techniques for working procedures at the training centres or on site.

b) Recommendation for construction stages

The following recommendations are for improving the permanent load and earthquake resistance of ordinary BC structures:

- Structural engineers should review or design all structural types of buildings.
- The connections at brick wall corners should interlock with each other at the joints, thus the walls will work effectively against earthquake for permanent stability in both directions.
- RC band beams should be provided at plinth, lintel, floor and roof levels for rigid brick walls. And, RC slabs and beams are to be provided instead of wooden floor systems.
- The number of stories should be kept to less than four with necessary improvements. If additional stories are allowed, special design has to be provided.

- Reinforcement for wall openings has to be provided in the design.
- The height of masonry walls has to be kept to less than 15 times the wall thickness.
- Site supervisors and skilled craftsmen should perform quality control on site at least regarding the following items:
  - Wet bricks.
  - Normal or high quality mortar.
  - Good bricks.
  - Unique masonry units to one building.
  - Unique and good quality mortar joints and bricks on every story.
- Existing masonry buildings should be evaluated and strengthened.

(4) Recommendations for Adobe (AD) Buildings

The seismic capacity of AD buildings needs to be improved significantly for resistance against great earthquakes. The following items shall be adopted for AD structures:

a) For newly constructed AD
- RC grade (plinth) beams have to be provided at least 200 mm above ground level for the damp course and unified structure composition.
- RC slabs and beams, and band beams on the lintel and the roof level have to be provided for rigidity.
- The height of buildings should not exceed two stories plus an additional attic floor in the traditional style.
- Cement mortar joints or waterproof coated bricks are better to use on the surface of exterior walls for prevention of absorption of moisture and for appearance.

b) For existing AD buildings
- Wooden joist floor systems should be replaced by RC slab, or all wooden joists should be fixed by stoppers such as dowels attached to both surfaces of the interior walls.
- Exterior surface adobe walls should be replaced by half size fired bricks with cement mortar joints or waterproof coating for prevention of absorption of moisture and for appearance.
- RC band beams on the floor in case of wooden floor and at lintel and roof level should be provided for increased rigidity of walls.

- The height of AD buildings should be kept within two stories plus an additional attic floor in the traditional style.
- Damp course elements such as RC block with a minimum 200 mm in depth and a half brick in thickness should be provided at least 200 mm above ground level on exterior walls.

(5) Recommendations for Reinforced Concrete (RC) Buildings

The following items are mostly fundamental and very important matters for RC structures since they will improve RC structures without significantly greater additional efforts and fees for engineers and supervisors. RC structures will be obtained certain strength and durability against earthquake.

a) In the design stage
    - Structural engineers should manage the design of RC structures with adequate design drawings and specifications and guide the construction avoiding rules of thumb practices.
    - Since the foundation concrete and re-bar of (plinth) beams of houses are designed too small, these must be made larger compared with column size for securing seismic resistance.

b) In the construction stage
    - After the initial survey, builders should construct using benchmarks and reference points.
    - Minimum concrete covering of re-bar should be kept adequate.
    - The overlapping length of re-bar joints should be increased.
    - The angles of hooks of hoops in column and stirrups in beams should be 135 degrees, with the proper length of hooks.
    - The anchorage length of the main bars for beams should be secured to engineer's specifications.
    - The anchorage of re-bars for slabs should be set to engineer's specifications.
    - Concrete mixing work should be followed mixing design and done under the site supervisors.

(6) Recommendations for Other Buildings

a) Recommendations for hospital buildings

   Although current hospital buildings have certain resistance to earthquakes because they are mainly RC structures, they must perform as the centre of relief activity in an earthquake disaster. Therefore, hospital buildings are recommended to be evaluated and to be improved for further strengthening.

b) Recommendations for school buildings and retrofit

Since school buildings in Nepal are very poor structures, are not constructed to a seismic design, and are without proper maintenance, they are much poorer than hospital buildings. In a worldwide context, school buildings typically suffer major damages from earthquakes. Since schools are the sites of education of children as well as for local communities, urgent investigation and necessary strengthening or rebuilding must be conducted. Practically, as existing buildings have to be used in most cases, they need to be retrofitted or rebuilt with assistance from international organisations to meet to seismic codes.

Retrofit techniques have recently been applied to schools, hospital buildings, and smaller dwellings in developing countries. In Nepal also several school buildings have been retrofitted/rebuilt by NGO activities. Some methods including jacket reinforcement are cost effective compared to the loss of life and injuries that would result from an unreinforced school during earthquakes.

Photos 6.1.15 and 16 Jacket Reinforcement

Photo 6.1.17 Retrofit to School

c) Recommendations for public buildings

Since public buildings of government offices play an important role during earthquakes, those buildings should be inspected and evaluated for seismic resistance. If necessary, strengthening or rebuilding should be urgently taken in hand.

d) Recommendations for historical buildings

Historical and traditional buildings have not only cultural and religious values, but are utilised by people in their daily lives. For this reason, these buildings have to be maintained and retrofitted to make them safe against earthquakes.

e) Improvement of seismic capacity for the existing buildings

The first steps to improve the seismic capacity for the existing buildings are as follow:

- Improvement required not only from vulnerability and high risk against earthquakes but also improvement of existing buildings should be promoted using standard materials. Seminars, training courses and workshops by the government with assistance from technical people are helpful.
- Appropriate guidelines for retrofitting shall be established, and publicised.
- Building owners who execute retrofitting and strengthening work and structural improvement of their buildings should be made to benefit from tax benefits or other government incentives.

6.1.8 Proposal for Future Projects

Based on the above investigation and analysis of the status of buildings in the Valley, the following two future projects will be proposed.

(1) Training Building Personnel for Implementation of Building Codes

The Draft National Building Code (NBC) should be implemented urgently, even though some amendments are needed. The by-laws in municipalities should include seismic resistant items from the NBC. All the related people including officials, owners, engineers, builders and craftsmen/masons should understand earthquakes, the damage they cause, and the importance of regulations.

a) Quality improvement of new buildings
Quality management should be included in the specifications. Earthquake engineering, construction knowledge and technology should be introduced.

b) Training for building construction engineers.

- Implementation of regulations and building permit system throughout Nepal.
- Reducing earthquake disasters to buildings.
- Improvement of building quality.

Table 6.1.1 A Plan for Training Programme for Improvement of Buildings

Target	Curriculum	Lecturer
Government Official Permit Officer	Earthquake Disasters, Building Damage Earthquake Engineering Building Construction Technology Regulations (By-Laws, Codes) How to Investigate, Example Training	International and Domestic Experts (Overseas Training is possible.)
Designer Architect	Earthquake Disasters, Building Damage Earthquake Engineering Building Construction Technology Regulations, Specifications	Domestic Expert Government Officer
Builder	Earthquake Disasters, Building Damage Building Construction Technology	Domestic Expert Government Officer
Owner	Earthquake Disasters, Building Damage Importance of Regulations, Permits	Domestic Expert Government Officer

(2) Inspection of Key Buildings for Earthquake Resilience

The targets should be key facility buildings, such as schools, hospitals and public buildings. The engineering inspection shall be implemented. The results should be applied as followings:

a) Class A should be rebuilt or demolished and removed within five years.
b) Class B should be reconstructed as early as possible.
c) Class C should be assisted with funds for capacity improvement.

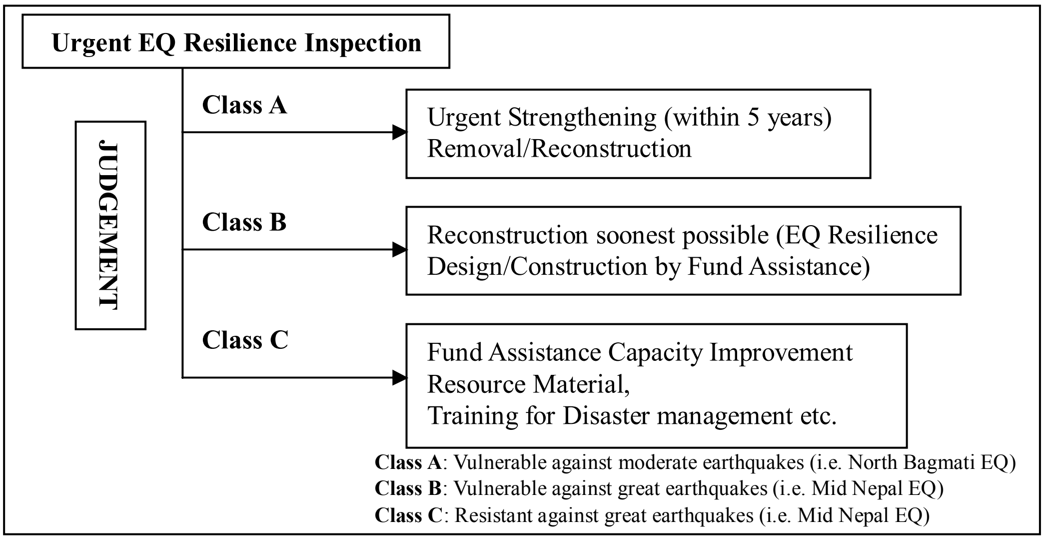

Figure 6.1.1 Inspection Flow for Key Buildings

6.2 Transportation Facilities

6.2.1 Roads

The strengthening of the road network system of the Valley against earthquake disasters can be achieved through the following two types of conceptual approaches:

- Roads to improve access to the Valley (roads from outside of the Valley).
- Roads inside of the Valley.

(1) Roads to Improve Access to the Valley

The road network linking the Kathmandu Valley to other parts of the nation and to the world is the most important during earthquake disasters. The Kathmandu Valley has to rely on supplies from outside of the Valley (national or international) for all kinds of goods for daily needs. Besides, since the Valley is endowed with only one international airport, the damage to this airport and damage to the roads linking it to the Kathmandu Valley will isolate the Valley completely. This situation is more serious than the damage to the road network inside of the Valley itself.

Though there are basically two national highways running through the Valley, as mentioned earlier, the Arniko Highway connects to the Chinese border and to some hilly districts of Nepal, through which only a small part of the international trade occurs. The initial part of the Arniko Highway from Kathmandu to Dhulikhel will become important only after the completion of the Sindhuli Road Construct Project that starts from Dhulikhel and runs to the south.

In the contrary, the Tribhuvan Highway is the sole road linking the Valley to other parts of the nation as well as to the Indian border, and subsequently to other countries. At present, there is only one road coming to the Kathmandu Valley in the section from Naubise to Kathmandu. The section of Tribhuvan Highway from Naubise to Hetauda runs through difficult topographical conditions and is not used by regular traffic, except when the other alternative, the Prithvi Highway, is blocked by landslides. Based on the Feasibility Study Report of Kathmandu Naubise Alternate Road by JICA 2001, the slopes along the existing Tribhuvan Highway (especially after Nagdhunga pass, which is located after crossing the Valley at Thankot) have high potential to cause slope failure triggered by heavy rainfall and/or earthquakes. The JICA study recommended the construction of an alternate route from Kathmandu to Naubise through a short tunnel at Bhimdhunga pass.

On the other hand, the Prithvi Highway from Naubise to Mugling is the only main road presently used by the traffic to Kathmandu from the Indian border (almost all of the inland international trade) and other parts of the country. The other alternative, the Tribhuvan Highway from Naubise to Hetauda, has very bad ground conditions and narrow lanes. But this section of Prithvi Highway is often blocked, several times of the year, by landslides during monsoon season. So this link is vulnerable to landslides at a number of locations, which may be triggered by heavy rainfall and/or earthquakes. Therefore, the study on Road Disaster Mitigation of the section from Naubise to Narayanghat is also of utmost importance as an immediate counter-measure.

Among all of the road links connecting to the Indian border, the largest part of the trade occurs through Birgunj via India's port city of Calcutta. At present, this traffic has to travel a long distance from Hetauda to Mugling via Narayanghat and then to Kathmandu via Naubise, since the existing Tribhuvan Highway from Hetauda to Naubise is not used by regular traffic due to difficult road conditions. In such a situation, the Kathmandu-Terai Alternate Road, which can provide direct access

Naubise is not used by regular traffic due to difficult road conditions. In such a situation, the Kathmandu-Terai Alternate Road, which can provide direct access from Kathmandu to Terai and to the Indian border would also be one of the most important roads. This is not only from the standpoint of the national road network, but also from the concept of providing better access to the Valley with higher reliability against earthquake disasters and national security. However, this alternative can be considered only as a long-term plan due to its larger budget requirements as well as longer time required for detailed planning and implementation, even though the planning process is recommended to be started at the earliest.

(2) Roads to Improve Mobility Inside the Valley

The Strategic Road Network for Earthquake Disaster Mitigation in the Kathmandu Valley represents the important links as conceptually presented before. The initial part of the Arniko Highway from Kathmandu to Dhulikhel will become important when a substantial traffic volume will be generated at this link, after the completion of Sindhuli Road Construction Project. This link is now a narrow two lane, whereas the traffic volume is considerably high, causing frequent traffic jams throughout the day. The Kathmandu Valley Road Development Master Plan by JICA in 1993 also recommended a bypass road for this Arniko Highway in its long-term plan (2006-2015). As a short-term measure, the widening of the existing Arniko Highway becomes important, to improve the link from Bhaktapur to its other two counterpart districts of the Valley. Sufficient right-of-way is also available at present, making it relatively easy for implementation.

The Ring Road has been playing a very important role in the smooth movement of traffic from different parts of the Valley. However, many of its sections are heavily damaged due to increase in heavy vehicle traffic. The rehabilitation and widening of the Ring Road is also recommended in view of its importance during earthquake disasters. Besides, some parts of the Ring Road are also badly damaged from on-street parking and loading-unloading of freight from heavy trucks, due to the lack of any truck terminal in the Valley. During earthquake disasters also, such truck terminals become very important for management of emergency supplies and relief material from different sources.

The urban roads included in the Strategic Road Network are for the smooth operation and management of traffic even during and after the occurrence of earthquake disasters. The improvement to intersections in Kathmandu City is being implemented soon, under the Grant Aid of Japanese Government. Improvements at further intersection locations are also recommended for smooth operation and management of traffic in the Strategic Road Network.

Other Feeder Roads and District Roads in the Strategic Road Network have been considered from the viewpoints of links to the municipalities and access to the water sources of the Valley. Proper maintenance of these roads shall be carried out regularly. One of the District Roads (Gravel) in the north part that has been included in the Strategic Road Network is also from the viewpoint of access to the water sources. The upgrading and maintenance of this link to a bituminous road should also be considered.

In addition to this, though the consideration of roadside parking does not come directly under improvement of the road network, it is one of the major causes of reduction of road capacity. Especially along the roads where the available road width is limited, on-street parking (and more seriously paid on-street parking) not only reduces the capacity but also sometimes makes the road impassable. Though the situation may not seem serious in normal conditions, the effect during disasters like an earthquake may prove such situation to be too costly when compared to the minimum attention that is needed to rectify such situations. Mobilised vehicles like fire engines, ambulance and other relief vehicles may be hindered from passing or even completely blocked by such on-street parking habits. Recommendations for the construction of parking lots, as given in the Kathmandu Valley Urban Development Master Plan by JICA in 1993, should be considered in due time. Such parking places may also be utilised for management of emergency supplies and relief materials during earthquake disasters.

6.2.2 Bridges

The damage estimation of bridges is based on an empirical analysis and assumptions and not through the evaluation by physical tests. Moreover, the damage estimation method does not consider scouring at the foundations of the bridges. From the site observations, most of the bridges around the Ring Road and several other locations are seriously affected by scouring. Detailed study regarding the vulnerability of the bridges in the Valley will be required. The strengthening of the bridges against earthquake disasters should be implemented as soon as possible, since the extent of vulnerability is very serious even to the bridges of the Strategic Road Network.

6.2.3 Airport

Nepal has only one international airport at present, which is located at Kathmandu. If the sole international airport of the country is damaged by disasters like an earthquake, not only the Kathmandu Valley but also the whole nation is in danger of isolation from the outside world.

A second International Airport was suggested by different studies, but one of the most recent studies recommended the Second International Airport to be constructed in Simra (south of the valley, near Birgunj border) among various other alternatives. This location was also justified from the Kathmandu-Terai Alternate Road, which, if constructed, will connect the Kathmandu Valley to the Terai area through a direct road link. However, the construction of a second International Airport cannot be justified only as a requirement of earthquake disaster management, due to other components of national interests and from the viewpoint of the huge investment required for such a project. Nevertheless, it is recommended as a long-term plan, though the planning process is recommended to start at the earliest.

6.2.4 Evaluation of Existing Master Plans

There are, basically, two main master plan studies, one relating to the road network development considering the whole country (PIP, Priority Investment Plan, 1997) and the other limited to the Kathmandu Valley (Kathmandu Valley Urban Road Development by JICA, 1993). The PIP study is relevant in terms of the roads to improve the access to the Valley, whereas the JICA study is related to the roads to improve mobility inside the Valley.

(1) Roads to Improve Access to the Valley

Out of all the recommendations given in the PIP Study, only the relevant ones are discussed. The PIP Study recommended three main possible projects to improve access to the Valley as top priorities.

- Alternate road for Kathmandu-Naubise section of Tribhuvan Highway to increase capacity since the existing road is impossible to widen.
- Direct link from Kathmandu to Hetauda (to the south in Terai).
- Widening of Arniko Highway in Kathmandu-Bhaktapur section, maintenance of Bhaktapur-Dhulikhel section and widening of this section after the opening of Sindhuli Road Construction Project, which is under construction from the Grant Aid of the Government of Japan.

These recommendations are important from the viewpoint of earthquake disaster countermeasures and to provide Kathmandu with alternate access roads during disaster. In addition to the recommendations by the PIP study, Sindhuli Road Construction Project has its own importance, playing a vital role in the Nepalese road network as well as from the earthquake disaster viewpoint. It is because all other alternatives for access to the Kathmandu Valley are located in the west of the Valley, only this alternative is located in the east of the Valley. From this strategic positioning, even in case of damage to one side of the Valley due to earthquake disaster, the Valley will still have access from the other side.

Besides the road network system, the international airport is also an important factor to improve access to the Valley. At present, Nepal has only one international airport, the Trivuban International Airport (TIA) which is located in Kathmandu. It has been pointed out that the existing facilities of TIA cannot meet the rising air transport demand after the year 2015. Since there are constraints on the capacity of the airspace management of TIA, an alternative international airport is inevitable at a different location.

This is not only true from the demand forecasts, but also from the aspects of national security. During times of earthquake disaster, possibly damaging the sole international airport of the country, the Kathmandu Valley and the whole nation will be in danger of isolation from the outside world. In view of this, different studies have recommended the construction of second International Airport.

Based on the Pre-Feasibility Study of Second International Airport by NEPECON for the Department of Civil Aviation, the second International Airport was recommended at Simra from among various other alternatives, which is located south of the Kathmandu Valley. From the present road network, Simra is at a distance of 250km from Kathmandu. Only a direct road link from the Valley to the new second international airport can justify its practicality. A direct road link can make the distance as short as 80km, based on study reports, and thus needs timely attention to this second International Airport, as well as the direct road link from the Valley to it and to the Terai region.

(2) Roads to Improve Mobility Inside the Valley

The road development concept in the JICA master plan study was based on the following five development policies.

a) Road development as a centre of national economy
The master plan study recommended strengthening the East-West Corridor in view of the increase in through traffic in the Valley from the national highways. Recommendations of a new Arniko bypass and second Trivuban Highway parallel to the existing one were given. It was based on the assumption that the Sindhuli Road Construction Project and the Kathmandu-Terai Direct Link Project are implemented in the near future.

b) Road development in the wave of outwards shift of the urban area
The study considered the tendency to outward shift of the urban area, would continue until it reaches the urban boundary. Urban expansion was considered to proceed along the radial roads first, and after a certain point, would direct to the area between these radial roads until it becomes a concentric land-use pattern, centred on the existing urban cores. In view of such concept, widening and upgrading of several radial roads along with the necessity of an outer Ring Road was presented, taking into account of the future urbanisation pattern.

c) Road development for the integration of three existing city-centres
Road development from the viewpoint of integrating the three city-centres of Kathmandu, Lalitpur and Bhaktapur, is based on promoting more consolidated socio-economic activities between the three cities. Widening of the old Thimi Road (Koteshore-Thimi-Bhaktapur) and construction of a shortcut from Baneshore to Thimi through a tunnel, under Trivuban International Airport were recommended.

d) Road development to streamline the traffic flow inside the cities
The road network was proposed to promote urban development inside the Ring Road as well as to disperse traffic in the central areas of the city thus avoiding excessive concentration and to reduce the traffic load on arterial roads located inside the Ring Road. However, the core area of Bhaktapur City was identified as a historic area. It shall be preserved, and as such, motorised traffic was recommended to be restricted inside.
Widening of the Kantipath and construction of the Inner Ring Road in Kathmandu City were recommended. Similarly, widening of the existing road around Bhaktapur was recommended to improve accessibility to the historic core area.

e) Road development with impending necessity to improve existing bottleneck and alleviation of transportation deficiencies
   The recommendations such as construction of the New Bagmati Bridge at Thapathali (already implemented), provision of access to the New Bus Terminal at Balaju, widening of New Baneshore – Old Baneshore road and improvement of Patan, accesses such as extension and widening of Jhamsikhel – Ring Road, widening of Jawalakhel – Ring Road and widening of Sat Dobato – Ring Road, were given.

(3) Master Plans and an Earthquake Disaster

Some of the important components of the JICA Master Plan have not been implemented, due mainly to the constraints of land acquisition in the already urbanised areas. After a certain passage of time these important concepts of the road development plan may be forgotten without any trace to anybody responsible for planning. However, the concepts in the plan may be very important to build a much more earthquake disaster proof urban society, after the occurrence of any major earthquake disaster. If such plans exist in principle, it may be possible to implement them after the occurrence of a disaster, though it is not possible to implement before the disaster itself. The rehabilitation after the occurrence of any disaster does not mean that the same disaster prone society is built back to its pre-disaster conditions such that it becomes vulnerable to similar disasters again and again.

Master plans for any infrastructure development are prepared to formulate the strategies for a specified target year. However, planning for earthquake disaster mitigation cannot specify any target year and should be continually updated with respect to time, keeping the concept of the plan, or even the concept itself shall be modified if necessary to take into account the dynamic process of development.

It is very important to note that a Master Plan prepared for any component of the infrastructure is deeply related to the Earthquake Disaster Mitigation Plan. Small consideration during the early stage of a project with minimum cost and effort can provide an enormous contribution and benefits to prepare a strong infrastructure against an earthquake disaster. This can avoid major damage to property and lives or at least the need for a huge effort and cost to be rectified after construction, without consideration of earthquakes.

6.2.5 Proposal

(1) Roads to Improve Access to the Valley

The following projects may play an important role in creating greater access to the Valley from the viewpoint of earthquake disaster mitigation. The development plans to improve access to the Valley are also shown in attached Figure 6.2.1.

a) Kathmandu – Naubise Alternate Road Project
The Feasibility Study was completed in March 2001 by JICA. The implementation of this project is recommended as soon as possible. This alternative is very important as a short-term measure since there is only one road from Naubise to Kathmandu at present. Yet, the existing road is in danger of damage from landslides that could be triggered by heavy rainfall and/or an earthquake.

b) Naubise-Narayanghat Road Disaster Mitigation
There has been no study so far for the implementation, except for some recent studies by the Disaster Preparedness Training Centre (DPTC) on some of the sections. If the Kathmandu – Naubise Alternate Road Project is not implemented in the near future, the scope of this study shall be from Nagdhunga Pass, which is situated outside of the Valley after the Thankot check-post.

c) Kathmandu – Terai Alternate Road
There have been some preliminary and pre-feasibility studies by JICA as well as from other countries like FINNIDA, but no definite policy has been formulated so far for this project. The Feasibility Study on Kathmandu – Naubise Alternate Road has also recommended the implementation of this project as a long-term measure. Based on traffic volume forecasts and the present level of traffic, it might be important to implement this project in the near future.

d) Construction of Second International Airport
Pre-feasibility Study by the Nepal Engineering Consultancy Services Centre Ltd. (NEPECON) in 1995 studied several potential second International Airport sites and recommended Simra as the best alternative location. However, a France based Apla Consultant Co., Ltd (ACCL) is conducting a Feasibility Study on developing the existing airport at Bhairahawa (west-south of Narayanghat) into an International Airport under the BOT (Build Operate and Transfer) policy. The study is expected to be completed around the end of the year 2001. Nevertheless, the construction of the Second International Airport

shall take into consideration its access to the capital as one of the important factors.

e) Sindhuli Road Construction Project
The project is already under construction from the Grant Aid of the Government of Japan and is expected to be completed by the Year 2007 (tentative). This road will play a vital role since all the alternatives discussed here linking the Kathmandu Valley from outside are located in the West of the Valley, whereas, only this alternative is located in the East of the Valley. From this strategic position, even in case of damage to one side of the Valley due to an earthquake disaster, the Valley will still have access from the other side.

(2) Roads to Improve Mobility Inside the Valley

The following projects may play an important role in improving mobility inside the Valley from the viewpoint of earthquake disaster mitigation.

a) Widening of Arniko Highway inside the Valley
The Sindhuli Road Construction Project is under construction and after its completion, traffic volume in the Arniko Highway will definitely increase in the section from Kathmandu to Dhulikhel. However, even at present the traffic volume in the section from Kathmandu to Bhaktapur has reached beyond its capacity and the widening is recommended as soon as possible.

b) Widening of Ring Road
The Ring Road has been playing very important role in the smooth movement of traffic from different parts of the Valley. However, many of its sections are heavily damaged due to the increase in heavy vehicle traffic. The rehabilitation and widening of the Ring Road is also recommended in view of its importance during the earthquake disasters. Besides, some parts of the Ring Road are also damaged from on-street parking and loading-unloading of freight from heavy trucks due to the lack of a truck terminal.

c) Construction of Outer Ring Road
Though it may seem premature to construct the Outer Ring Road, the construction at the earlier stage may be much easier in view of land acquisition and also from the viewpoint of better urban planning.

d) Construction of Inner Ring Road
A part of the Inner Ring Road, at Bishnumati Corridor, is being constructed through the loan association with the Asian Development Bank. Completion of the Inner Ring Road may seem to be difficult at present due to land acquisition through already urbanised areas. However, the concerned agencies shall be kept informed of the planning, which may be considered during the rehabilitation phase, if any earthquake disaster occurs in the Valley.

e) Upgrading and maintenance of the radial Feeder and District Roads
Upgrading and maintenance of other Feeder and District Roads in the Strategic Road Network are in consideration from the viewpoint of links to the municipalities and access to the water sources of the Valley.

f) Construction of parking lots and traffic management plan of the urban areas

g) Improvements to intersections in the urban areas
The first phase including 10 intersections is being implemented and the construction is expected to finish by the year 2003, under the Grant Aid of the Japanese Government. Improvements at other locations are also recommended in view of smooth operation and management of traffic in the road network.

(3) Bridges

The damage estimation of the bridges, presented earlier, is based on some conditional assumptions and not through the evaluation of detailed physical observations and tests. Moreover, the damage estimation method does not consider the scouring at foundations of the bridges. From the site observations, most of the bridges, especially around the Ring Road and many other locations are seriously affected by scouring.

As stated earlier, bridges are usually considered to be the most vulnerable to earthquake induced damage and the effect of any damage to bridges is the most grave in the road network system. So, the following work will be required to create more earthquake resistant bridges:

a) Strengthening of bridges in the Valley against earthquake disasters
Strengthening of the bridges in the Valley against earthquake disasters is of utmost importance and should be carried out as soon as possible. Detailed investigation is recommended before finalising the list of the bridges needing

strengthening. The method of strengthening may also vary depending on the conditions at the site.

b) Preparation and implementation of earthquake resistant design manual for bridges, such that uniformity in design is achieved regardless of the donor agencies constructing bridges in the Valley.

6.3 Electric Power Supply Facilities

6.3.1 Evaluation of the Existing Master Plan

A Feasibility Study on the Kathmandu Valley Transmission and Distribution Network Project was conducted by JICA in 1978, as the capacity to supply power of the existing distribution system was not sufficient even to meet the demand at that time. A system reinforcement project was formulated, covering the improvement of the transmission and distribution system and construction of new distribution facilities, in order to distribute the added power. The project was implemented through Japanese Grants in the periods 1980, 1982 and 1986. New transmission and distribution lines, substations, a Load Dispatching Centre (LDC) , etc. were constructed under this project. Seismic forces were also properly considered in the design. However, the demand grew at a higher rate than anticipated in the Feasibility Study in 1978 and over-loading appeared again.

A Master Plan study (target years of 10 years) was again carried out by JICA in 1991 on Extension and Reinforcement of Power Transmission and Distribution System in the Kathmandu Valley.

The construction of a LDC, Distribution Ring Main Systems, and connection between two power stations are very important steps towards building an earthquake resistant electricity supply system.

At present, there are mainly three substations (Syuchatar, Balaju and Bhaktapur) from which the supply of the power stations is transmitted to the Valley, mainly through 132 kV transmission lines. Apart from these, the Chapali and Matatirtha substations are under construction and the connection of all these substations through 132 kV line, forming a Ring Main System of 132 kV, is also under construction. This will provide a stable transmission system in the Valley.

The voltage is then dropped down to 66 kV in those substations and then transmitted to other distribution substations, mainly to four in the Kathmandu Municipality (Teku, Lainchaur, Chabahil, New Baneshore) and to Patan and Thimi substations in the respective cities.

There does not exist any Ring Main System of 66 kV among these due to the difficulty in construction of transmission towers through the city core areas. Although there exists an 11 kV Ring Main System among most of the distribution substations, the main four distribution substations in Kathmandu Municipality are not connected to form an inner Ring Main System. Besides, New Baneshore and Lainchaur are connected through a single 66 kV line each. Any damage to it will result in disconnection of this substation from the network. In such circumstances, a Ring Main System of 11 kV line is also recommended among these four substations to provide a more reliable power supply in the city core areas of Kathmandu Municipality from the viewpoint of earthquake disasters.

6.3.2 Probable Damage Levels

The damage to the electricity supply system can occur at different levels in the hierarchy of the supply system as illustrated in the Figure 6.3.1.

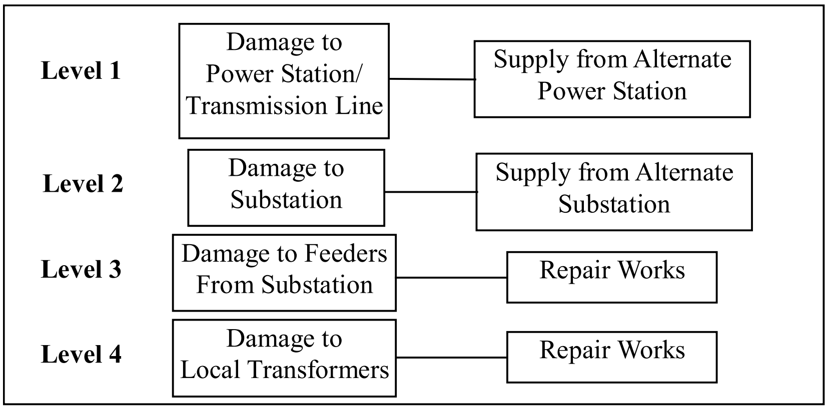

Figure 6.3.1 Possible Damage to Power Supply System

The damage in any facility during an earthquake at Levels 1 and 2 can be dissipated from the system in LDC and alternative sources may be utilised during an emergency so long as the supply capacity permits. However, the damages in Levels 3 and 4 do not have any alternative substitutes and will remain non-functional until repaired. Any damage in Level 4 shall be repaired immediately by providing an effective maintenance system. Similarly, the damage in Level 3 can be mitigated by providing an alternative at least for important areas like hospitals, government and non-government agencies that have important roles during earthquake disasters.

At present, the damages in Level 3 and Level 4 of the supply system are handled by the No-light department of each branch of NEA in their respective areas. These No-light departments have few technicians who know about the area and the details of the supply system. No systematic data is available regarding the details of the feeders, number of transformers and their locations, etc.

6.3.3 Proposals

(1) Inner Ring Main System in Kathmandu City Core

As discussed in Section 6.4.1, construction of an Inner Ring Main System of the substations inside the Kathmandu city core areas, namely Teku, Lainchaur, Chabahil and New Baneshore substations, is recommended as shown in Figure 6.3.2.

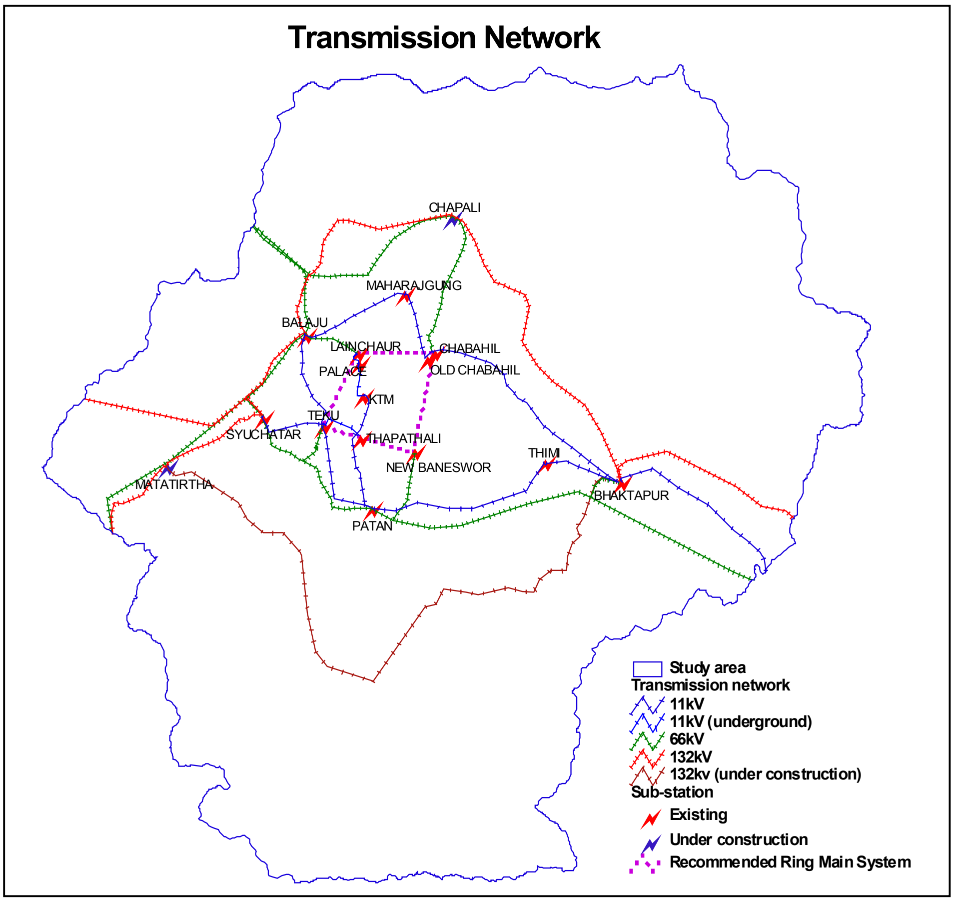

Figure 6.3.2 Recommended Additional 11 kV Ring Main System

Since these substations are located inside of densely populated core areas of the city, it may be difficult to connect them through 66 kV lines, which need relatively taller transmission towers. Connection through 11 kV lines or possibly connection through underground cable should be studied in detail.

Moreover, there already exists an underground connection between Teku and Thapathali substations and the possibility to extend it to New Baneshore should also be studied. Similarly, a direct connection between Lainchaur and Teku or a connection through KTM (Kathmandu/2) substation is also recommended to be studied in detail.

(2) Others

As discussed above, the damage in any facility at Levels 1 and 2 can be dissipated from the system in LDC (Load Dispatching Centre), with the presumption that it will not be damaged heavily during earthquake disasters since it has been designed giving consideration to earthquakes. The Ring Main Systems of distribution and transmission lines will play a very important role during the damages in these Levels 1 and 2. Damages in Levels 3 and 4, especially Level 4, can be mitigated only through the following activities to strengthen the electric power supply system against earthquake disasters in the Valley:

a) Evaluate the existing design and construction practices for the installing of substations, transmission towers and mounting poles for transformers and, prepare and enforce earthquake resistant design manuals and reinforcement plans.
b) The possibility of underground distribution systems at highly urbanised areas with narrow roads should be studied further in greater detail.
c) A study should be conducted on stand-by power supply systems for important areas such as hospitals, government and non-government agencies that play vital roles during an earthquake.
d) Stock sufficient number of transformers for emergency damage situations.
e) Adopt a computerised database system at each branch office and prepare a comprehensive database system at the central level for smooth management and efficient maintenance strategies during disasters.
f) Prepare an effective technical support system for the repair of feeder and distribution line transformers.
g) Conduct Earthquake Disaster Preparedness Training Programs in the "No Light" units of the administrative branches that are directly responsible for the immediate repair work and coordination of the activities of these local units from the central level.
h) Conduct a study on overloading of facilities under abnormal operating conditions such as outage of any facilities like transmission lines, substations, etc. due to earthquake, because it is desirable to maintain a stable power supply even in case of abnormal operating conditions. However, a benefit-cost analysis should also be conducted. The results of the damage estimations may be useful to carry out such analysis; however, a detailed database will be required.

6.4 Water Supply and Sewerage Facilities

6.4.1 Existing Conditions

(1) Water Supply System

The condition of the water distribution system in the Kathmandu Valley is very poor. At present water is supplied to the Valley from in-Valley sources of water that include a number of small storage facilities, river sources, springs and spouts, and ground water. The storage capacity is not big enough to store the wet season water to meet dry season demand. The quantity of water available from rivers and spring sources decreases as the dry season follows. Groundwater exploitation is greater than the natural recharge rate so the water table is lowering very rapidly. Although the resources are greater, and may be adequate, in the wet season, the distribution system is not properly managed resulting in inefficient distribution. Even in the wet season, the supply is intermittent in most areas with supply for only about 2 to 3 hours in the morning and about an hour in the evening. In most of the urban areas during the dry season, the supply is mostly less than an hour every alternate day.

At present there is a total of 7 water supply systems existing in the Kathmandu Valley under the jurisdiction of Nepal Water Supply Corporation (NWSC). The details of each supply system are given in Table 6.4.1.

Table 6.4.1 Existing Water Supply Systems

S.N.	System	Surface Water Source	Groundwater Source	Capacity	Service Area
1	Balaju Water Supply System	Alley, Boude, Bhandare, Panchmane, Chhahare	Balaju well, Mahadev khola-wells	5 to 10 MLD	Kathmandu Metropolitan City (KMC)
2	Bansbari Water Supply System	Shivpuri, Bishnumati	Bansbari wells	10 to 30 MLD	KMC, Dhapasi, Peripheral rural areas
3	Sundarijal Water Supply System	Bagmati I, Bagmati II, Nagmati	Dhobikhola- wells, Gokarna wells, Manohara wells	48 MLD	KMC, Gokarna, Peripheral rural areas
4	Bhaktapur Water Supply System	Mahadev-Khola	Bode wells, Jadibuti wells, Bhaktapur-Bansbari wells, Radial collector-dugwells, Lokanthali wells	7 MLD	Bhaktapur Madyapur Thimi municipalities, Duwakot, Peripheral rural areas
5	Doodh Pokhari/ Sundarighat Water Supply System	Doodh-Pokhari, Lohnkot, Shimjhwa-Springs, Nakhu khola	Solar panel wells by RONAST (Royal Nepal Academy of Science and Technology)	3 to7 MLD	KMC Kirtipur municipality, Kirtipur rural Tinthana, Peripheral rural areas
6	Shainbu Water Supply System	Satmul, Seshnarayan, Kuture-Springs	Pharping wells	20 MLD	Lalitpur and Peripheral rural areas
7	Chapagaon Water Supply System	Nakhu khola, Nallu khola, Basuki and, Muldole-Springs	---	10 MLD	Lalitpur sub-metropolitan, Sunakhothi, Peripheral rural areas

Source: NWSC, Urban Water Supply Reforms in the Kathmandu Valley, ADB Technical Assistance, Metcalf & Eddy/CEMAT consultants Ltd. Feb/2000.

Besides these, there is a number of groundwater withdrawals by private users totalling about 10 to 30 MLD.

The distribution system is complicated since the network has been constructed over many different periods, some parts of which date back to the Rana period and are as much as 100 years old. The first distribution network, which was initiated by then Rana Prime Minister Bir Samsher in 1895, is still in use. The distribution network has been expanded not with any definite plan but only to meet the increasing demand in newly developed areas. The distribution network is well defined only in places where the road network is defined. In newly developed areas, the network is extended having dead ends.

Based on the information from the study report of NWSC, Urban Water Supply and Sanitation Rehabilitation Project for the Kathmandu Valley Towns (CES Report), 1993, prepared by CES/GOPA Germany et al, (the project was not implemented due to lack of funds), the existing distribution network provides services to about 87% (as of 1993) of the total area of the Kathmandu Metropolitan and Lalitpur Sub-metropolitan municipalities. Some of the sub-urban areas of these cities have their own supply system based on stone taps. From the information from different study reports, leakage in the distribution system is estimated to be about 30% to 40% of the supply.

(2) Sewerage System

The sewerage system in the Kathmandu Valley is not well developed and is hazardous with rivers and drains heavily polluted with sewage. A very old sewerage system, almost 50 to 70 years old, exists in the Kathmandu city core areas and directly discharges into the Bagmati River. These old sewers are believed to be heavily clogged with settled sludge and debris and are not maintained properly. NWSC's inadequate income has a severe impact on the sewerage system, which generates no income other than the tariff water supply system.

Based on the estimates by City Diagnostic Report (CDR) 2001, prepared by KMC, only 17% of households in KMC are served by this old sewerage system. Another estimate from the report of Urban Water Supply Reforms in the Kathmandu Valley, 2000 (Metcaf Report) states that only about 35% of the population has access to some type of limited sewerage system or septic tank effluent collection. The rest of the households have to depend on individual on-plot facilities.

The existing sewerage system is a partially combined and partially separate system. In the combined system, storm water and foul sewage pass through the same sewer. When the foul sewage is connected to the storm water sewer that does not pass through a sewage treatment plant, the combined sewage is discharged directly to the river. On the other hand when the storm water flow is connected to the foul sewage sewer, overloading in the sewage treatment plant occurs during the wet season. In addition, the storm water flow carries a lot of garbage from the streets to the sewers which are then easily blocked, resulting in an overflow of a mixture of foul sewage and storm water on to the street.

Sewerage facilities consist of 4 existing sewage and wastewater treatment plants under NWSC and 2 from KMC. The list is given in Table 6.4.2.

Table 6.4.2 Sewerage Treatment Plants

S.N.	Plant	Capacity (MLD)	Status	Responsibility
1	Dhobighat	15.4	Not operational	NWSC
2	Kodku	1.1	Partially operational	NWSC
3	Sallaghari	2.0	Partially operational	NWSC
4	Hanumanghat	0.5	Partially operational	NWSC
5	Guheswori	17.3	Under construction	NWSC
6	Teku		Operating	KMC
7	Paropakar		Operating	KMC

Source: Urban Water Supply Reforms in the Kathmandu Valley, Metcalf and Eddy, February 2000.

6.4.2 Evaluation of Existing Master Plans

The water supply and sewerage sectors of the Kathmandu Valley can be said to be the least developed when compared to other infrastructure facilities. Though there has been a tremendous volume of study reports on this sector in recent years, the most important one is the study on Melamchi Water Supply Development, which is in a stage of implementation. This is a unique study to this date in terms that it is the first study which considers the water supply to the Valley from out-of-Valley water resources. The first Pre-feasibility Study (Binnie and Partners) was done in 1988 followed by the environmental stability study (Stanley Associates) in 1990 and the full Feasibility Study (SMEC) in 1992. Butwal Power Company (BPC) conducted the Bankable Feasibility Study in 1996 to consider the tunnel and access roads that could be constructed more cheaply, using Nepali methods of labour intensive low technology. In 1996, His Majesty's Government of Nepal (HMGN) requested the Asian Development Bank (ADB) to take the lead role in assisting HMGN to prepare the Melamchi Project. In September 1998, HMGN issued the order for formation of the Melamchi Water Supply Development Board (MWSDB).

The Technical Assistance (TA) Loan Agreement between the Nepalese Government and the ADB was signed in February 1999. The objective was to assist Nepal to prepare an investment project for execution, which would contain the following three components:

- Project management of the investment.
- Engineering for the Bulk Distribution System (BDS).
- Implementation of a groundwater artificial recharge pilot project in Bansbari and Manohara well fields.

In parallel with the ADB loan, NORAD approved a Grant Aid for the preliminary design of the Melamchi Diversion Scheme. The overall Melamchi Project, as approved by HMGN, consists of the following components with possible modifications during detailed design:

- The Melamchi Diversion Scheme, consisting of access roads, construction power, headworks, tunnel, channels, etc. (Funded by NDF, ADB, OPEC).
- Water treatment plant (Funded by JBIC).
- Bulk Distribution System (Funded by ADB).
- Distribution Network Improvement (Funded by IDA).
- Kathmandu Valley Water Source Improvement (pilot project on artificial recharging of groundwater source by Japanese Grant Aid).
- Wastewater System Improvement (Funded by ADB).
- Sociological and Environmental Improvement (Funded by ADB).

The initial capacity is 170 MLD of water supply, and there is a plan to increase it to a maximum of 510 MLD in the long term. In the first stage, the BDS is designed with mostly a single pipeline connecting each reservoir, except Sundarijal and Gokarna with double lines to avoid large diameter pipes and to provide security in case of damage to one pipeline.

The construction of the Bulk Distribution System is very important in view of earthquake disasters. This system will be able to provide water supply to a wider area (though far from the city core) during disasters even if there is damage to the local area distribution network.

In order to have greater security of the water supply and better ability to meet variation in demand, a Ring Main Option would have been desirable during earthquake disasters. But after the examination of additional costs and the extra security it would provide, the provision of a Ring Main Option in the initial stage was dropped out in the BDS design.

It was mentioned that earthquake loads have been considered for the design of Bulk Distribution System based on the Building Code of India. However, specific earthquake resistant design methods such as identification and usage of high quality materials against earthquake, water pressure, and flexible expansion joints, etc. were not mentioned.

6.4.3 Proposals

In the present condition of the water supply and sewerage network there seems to be very little that can be done to convert the present network into an efficient system against earthquake disasters. The whole network is very old with little information on the conditions of the various network components. Major overhauling of the system will be required and it is expected that the much awaited Melamchi Project will cover this work. However, it is very important that the construction work under the Melamchi Project be considered introducing earthquake resistant design concepts.

As it is inevitable for water supply facilities to suffer damage at the time of earthquake disasters, emergency water supplies from other sources should be considered during such disasters. The following work shall be undertaken to strengthen the water supply system during disasters.

(1) Distribution System by Water Tankers

At present, the water supply during the dry season is much less than the demand, and in most of the urban areas of the Valley, water is supplied by means of water tankers, which collect water directly from the water sources. At present, the tanker section of NWSC has about 12 tankers in the Valley with a capacity of 6,000 to 7,000 litres each. According to information from the NWSC officials, the tankers can provide service to the consumer at a maximum of 8 trips per day. Similarly, there are also several other private tanker services totalling about 30 to 40 tankers operating during the dry season. These private tanker services mainly obtain water from their private boring sites, which are presumed to be located at around 50 to 60 sites.

The experience of the tanker services through this system of water supply will definitely play a very important role during earthquake disasters, provided that the roads connecting to the available water sources are not affected by the earthquake disaster. After the implementation of the Melamchi Project, the demand on the tanker services is likely to lessen. As a result, such distribution systems by water tankers, especially those run by the private sector, may not exist in the future, at least to some extent. In such a situation, concerned agencies have to bear the responsibility of managing such a distribution system. The number of tankers available in the Valley may also decrease. Moreover, smaller tankers with lesser capacity may be more efficient in distribution during disasters and may be able to access the city centres and wider areas since bigger tankers may have difficulty in running through narrower roads that are blocked with debris.

(2) Preservation of Existing Wells and Spouts

The Kathmandu Valley has been gifted with enormous amounts of historical wells and spouts. Since, the lowering of the ground water table is raising serious concerns, constructing new wells, as a measure for taking out more water, is not recommended. Constructing new wells just to be used during emergencies also may not be practical nor economical. However, existing wells and spouts are abundantly available in most parts of the Valley in urbanised areas. Such wells and spouts should be preserved through effective participation of local communities. The water quality in the existing historical wells is continually degrading due to contamination in the ground water aquifer and because of lowering of the ground water table and needs serious timely consideration.

(3) Preparation of Earthquake Resistant Design Manual

A major portion of the water supply and sewerage network system of the Valley is expected to be upgraded during the Melamchi project. It is a very good chance that the earthquake resistant design concept be introduced in this project. Preparation of an earthquake resistant design manual, and its implementation in this project itself, are recommended.

6.5 Telecommunication Facilities

6.5.1 Overview of Telecommunications Network

(1) National Public Telecommunications

The public telecommunications network is operated by the monopolised Nepal Telecommunications Corporation (NTC). The trunk telephone network in the Kathmandu Valley appears in attached Figure 6.5.1. The nation-wide long distance microwave transmission network, which connects major cities outside Kathmandu city, is illustrated in attached Figure 6.5.2. The telephone exchange system utilises digital switches at all stations. Each exchange is connected by optical fibre cables, metallic cables and radio transmission systems. Most cables are buried under the ground except subscriber cables.

The optical fibre transmission system utilises the SDH (Synchronous Digital Hierarchy) system, which strengthen system reliability. For long distance communications, the radio transmission system is operated with digital microwave (PDH). The international communications earth station (Sagarmatha) is located at a western suburb of Kathumandu city; it uses Intelsat Satellite transponders over the

Indian Ocean having 19 overseas destinations. The gateway exchanges are provided in Sundhara and Patan.

A Very Small Aperture Terminal (V-SAT) has been established consisting of seven stations at the northern mountain foothill areas. For rural area communications, DRCS (Digital Radio Concentrating System) and WIL (Wireless Loop) are in operation, which is called MARTS (Multiple Access Radio Transmission System). Presently NTC holds a monopoly on the GSM mobile telephone system in the 26 cellulars, the total line capacity is 20,000 and aimed at expansion up to 70,000 lines in the near future. The private sector will take part in cellular mobile telephone services soon. According to the ITU Report 1999, the telephone density is 0.89/100, the waiting list is 278,000, and the Internet host is 153.

(2) National Television Broadcasting

Television and radio broadcasts are the most familiar media to the people. The sole national station of Nepal Television operates the broadcasting services in Nepal. The present station was established in 1985. A private television service will be opened in the year 2002.

The duration of televising is from 6:00 am to 11:00 pm by Nepal Television, and from 11:00 pm to 6:00 am the facility can be leased to a private user. The equipment and system are in quite good working condition. The number of viewers is estimated at 3,000,000 in the whole country (Numbers of TV set: 85,000, TV set density 0.37 sets/100, Data book on World Broadcasting 2000), and approximately 1,000,000 in the Kathmandu Valley.

Presently 14 TV relay-broadcasting stations have been established along the southern area of Nepal. A total of 18 relay stations are to be operational by May 2002. TV Signal transmission routes from the studio at Singha Durbar are illustrated in attached Figure 6.5.3. In order to strengthen the network, 3 diversity routes have been made up as follows.

For transmission routing, TV signals from the Singha Durbar studio are transmitted toward Phulchoki relay station, which widely televises over the Kathmandu service area. In the year 2001, satellite broadcasting (digital) can be possible in parallel; in addition the optical fibre connections with the Sagarmatha satellite earth station. The Sagarmatha earth station transmits TV signals toward the satellite and then, many TV relay stations in the Regions are possible to receive the signals and transmit to the local areas. Hence, very reliable TV networks have been realised.

(3) Radio Nepal and Private Radio Broadcasting

The radio set density of Nepal is 3.7/100, and the number of radio sets totals 810,000. The national radio broadcasting studio is located at Signha Durbar. Two (2) radio transmitting stations exist at Khumaltar and Bhasepatti. The former was established in 1966 as a medium wave transmitting station but now it is operating as a VHF FM station. The latter was established in 1988 operating a medium wave (100 kW and 10 kW) and short wave (5 kW) transmission. The 10 kW transmitter works for standby use. Transmitting radio frequencies are 576 kHz, 648 kHz, 684 kHz, 792 kHz, 810 kHz, 1143 kHz, 41 MHz and 60 MHz.

As to private radio broadcasting, there exist seven FM stations as follows:

a) Sagarmatha	Commercial	102.4 MHz
b) Kantipur	Commercial	96.1 MHz
c) One hundred	Commercial	100.0 MHz
d) Metro FM	Municipality	106.7 MHz
e) Hit FM	Commercial	92.2 MHz
f) 97.9 Kath FM	Commercial	97.9 MHz
g) Himalaya (HBC)	Semi-Commercial	94.0 MHz

The above facilities are rather small in scale, but the FM stations are favoured by many listeners, so that this media will contribute to propagation of earthquake information. The operating hours depend on each station and are sometimes irregular.

(4) Police Communications

The police communication system is an extremely important facility especially at the time of an earthquake disaster. The nation-wide police communication control centre is located at the police department in Naxal ward. The Nepal National Police Department provides a HF (High frequency) communication network between 5 Regions' local police divisions. At the department the control desk is placed for the respective Region. The operating frequencies and transmitter powers are from 2 MHz up to 12 MHz with 20-100 Watts. Inside the Kathmandu Valley area, UHF (Ultra High Frequency) band is used, while in the other areas VHF (Very High Frequency) is used. The Police Department has 2,000 fixed radio stations and 400 handheld and on-vehicle radio transceivers in total. In the 5 Regions they have more than 40 police patrol vehicles. In the Kathmandu Valley 25 vehicles are provided. All vehicles are equipped with mobile radios, but there are no mobile radios for the vehicles operating in the local areas.

According to the Police Department, the communication systems mentioned above are operating in satisfactory condition. Some elements of equipment are duplicated. Achievements of rescue operations of the past are the Thai air crash near Kakani in 1992 and the flood accident during trekking case in 1994, when the Police Department sent portable transmitters and receivers to the site, and then rescue activity was successfully performed under control of the Police Headquarters.

6.5.2 Vulnerability of the Network and Strengthening

(1) Public Telecommunications

The telecommunication facilities are installed inside and outside of the building. The major indoor facilities comprise telephone switches, multiplex and radio transmission equipment, and power supply equipment (Engine-Generator, Rectifier and Batteries). The outside facilities are the metallic and fibre cables, which connects each telephone office, underground cable duct, manhole, subscriber cable, pole for aerial cable, antenna, feeder, antenna supporting structures, commercial power cable, power transformer, etc.

An earthquake might damage the facilities mentioned above. However, it should be noted that the structural integrity of the building where the telecommunication equipment is installed is the most important factor. Unless the earthquake collapsed the station building, the indoor equipment would not be affected seriously, on condition that this equipment is well fixed on the building floor, wall and/or ceiling as a countermeasure against the earthquake. By securing the equipment, the indoor telecommunications facilities are not too vulnerable to earthquake. As the equipment modules are composed of integrated circuits (LSI etc.), they can stand against shock and vibration. Therefore, the most effective reinforcement is securing the equipment.

For the outside plant facilities, the poles, aerial cables, underground cables, and cable ducts might get damaged, as well as the antenna supporting structures. Such facilities should be reinforced after careful inspection, or newly constructed, if so required.

In view of the reliability of the communications network, the safety measures against the optical fibre transmission failures are considered with the network SDH composition, that is, the trunk network is designed with a hierarchy construction; the higher ranking trunk switches have diversity route toward further upper trunk switches. Therefore, in case where one transmission route or switch fails, the traffic can go through the alternative route. Therefore, the SDH telephone transmission network is very reliable.

(2) National Television

Indoor television equipment is neither duplicated nor has a stand-by system configuration. In the case of equipment failure, the failed portion(s) (module, units etc.) shall be replaced with spare equipment. Sometimes broadcasting service will be suspended for a long time. It is desirable to have automatic switchover stand-by equipment.

For the TV transmission network, it is quite reliable as aforementioned. There are three alternative TV signal transmission routes as mentioned below:

a) TV Studio – Purchoki (Microwave bearer)
b) TV Studio – Sagrmatha Earth Station (Microwave bearer) – Satellite
c) TV Studio – Sagrmatha Earth Station (Optical Fibre) – Satellite

It is believed that the above network provision is complete and highly reliable.

(3) Police Communication

Because of the simplified configuration of the network and high reliability of the equipment, the system has maintained good performance. However, the HF network sometimes faces unstable status or unavailability of communication caused by fading and delinger phenomenon due to the black spots in the sun. Provision and utilisation of NTC leased line is one of the choices for effective and stable communication. In the future, introduction of a V-SAT communication system is recommended. For the UHF system, there will arise problems of congestion due to the shortage of operating radio frequencies.

6.5.3 Telecommunication Projects

(1) Evaluation of Ongoing Projects

a) The NTC is implementing an expansion of the V-SAT communication network that consists of 1,000 satellite communication terminals. This network will be operational by the year 2002. The capacity of speech channels to be provided is 2 each for 900 terminals and 16 each for 100 terminals.
b) Still the telecommunication network does not cover sufficiently the remote areas.

c) For socio-economic improvement, this project is required and furthermore expansion to the remaining areas is necessary.
d) The GSM mobile cellular telephone expansion project is ongoing to provide 70,000 subscriber lines in KV at the end of year 2003.
e) Nepal television is expanding to an additional 18 TV relay stations, which will be operational in the end of year 2002. Still there are many areas where the TV signal reception is not possible, and further expansion is required to cover whole country.

(2) Evaluation of Existing Master Plan

The information on the existing master plan is not available at this time. According to the NTC, however, it has been planned to upgrade the existing PDH long distance microwave radio network into an SDH system in the whole country. The NTC is looking for the financial sources. The existing nation-wide long distance network was just completed several years ago. The remaining system life is more than 10 years. However, it is desirable to accelerate this plan early for highly reliable network composition.

(3) Proposal

The ideal situation would be to establish all at once an integrated communication system for disaster management, all in one project; however, it is not realistic. This goal should be pursued so that such systems would be realised to some practical extent, in the course of development of individual projects to construct or improve individual communications systems. In order to achieve the anticipated goal, however, it is desirable that a master plan be designed for an integrated communication system, so that the development of individual components of the system is compatible with other components. As part of this overall master plan, certain protocols should be prepared, e.g. planning of appropriate emergency frequencies.

As a realistic measure, it is proposed to establish an exclusive trunk network in the Kathmandu Valley using the multi-channel access system for both intra-police communications and administrative communications as mentioned in 4.4.1 and 4.4.2. This is suitable for an emergency communication network covering a zone of 30 km up to 50 km radius per control station. The Multi-Channel Access (MCA) radio mobile system uses plural radio frequencies shared by many users, so that it makes an efficient radio frequency usage. Performance is excellent with clear voice quality and communication security. The following communication modes are possible:

a) Simultaneous communication.
b) Individual communication.
c) Group communication.

A similar system is utilised for emergency communications in Japan and other countries.

6.6 Urban Structure

6.6.1 Vulnerability of Present Urban Structure

The characteristics of the vulnerable urban structure can be delineated in urbanisation trends which show built-up areas expanding haphazardly. Urban growth accelerated from the 1970s to 1990s, especially after the construction of the Ring Road in the long term and as more urban fringe areas were made accessible. Today urbanisation covers most of the municipal areas, including the low flood and agricultural plains.

The urbanisation process in the Kathmandu Metropolitan City has been, however, "inefficient and of less than desired density with many of the developed areas suffering from poor access and deficiency in infrastructure services," according to previous studies(KMC/ WB, KVTDC). This comes from the absence of any regulatory control over residential development pressure, and urban growth has also spilled over into the surrounding Village Development Committees' area, connecting KMC to Madhyapur Thimi and Bhaktapur municipalities in the east.

The cities have experienced a remarkable growth in their population over the past few decades in spatial and demographic aspects. Thus, the Kathmandu Municipality became a metropolitan city according to the Municipality Act of 1995 and was divided into 35 wards of which the Old City Core area encompasses 12 wards, where the most vulnerable and high-densely inhabited areas expanded (approx. 600 ha. with 700 to1100 persons per ha.). Much of the city bounded by the Bagmati River and the Ring Road, with some expansions along arterial roads at Balaju, Bansbari, Boudha, and Kalanki, covering an area of 5,000 ha, was expected to have a population of 730,000 with a growth rate of 5.6 ~ percent in year 2001.

6.6.2 Urban Space Allocation for Disaster Mitigation

(1) Urban Space Allocation Planning in terms of Risk Management

a) Chowks (court yard areas inside religious or residential building complexes)

The availability of public, semi-public and private open spaces for pubic use as an urgent and temporary utilisation in emergencies is basically a matter of no small concern to dwellers. How people should expect connecting Chowks (court yards), open squares, alleys and pedestrian paths in an emergency, needs to be revaluated in accordance with community characteristics.

b) Parks and open space

An alternative utilisation system for conventional public open spaces needs to be formulated. Such areas include the green field of Ratna Park (Tundikhel), the national stadium, long and low-levelled river bank strips, an uncountable number of road-crossing corner zones, together with corner areas at the end of bridges. From the macro aspect of open land to each human-scaled sheltering space, an allocation and implementation system for public open space re-arrangement should be a new measure undertaken as part of the disaster mitigation activities.

c) Surroundings of open space

New types of open space patterns should be prepared for emergency use including publicly utilised spaces with concern to the surrounding areas (existing/future land use) and the location factor, so several models (alternative urban plans) are to be prepared. Therefore ‘urban spatial planning’ (not only the utilisation of land for buildings, but preserving it for future functional space) is required from large and long-range strategic arterial roads to readjustment of the “haphazard” network of roads.

d) Role of disaster awareness for citizens and local government

Relevant studies of “local area plans” by local citizens’ participation, undertaken in such densely inhabited areas as in Bhimsensthan (i.e. just behind Durbar Square) area and its surroundings, are worthwhile to review and update periodically. For these model case areas, disaster mitigation means may be limited in a sense; nevertheless, alternative sets of package plans could be expected. How to evacuate every person including the handicapped should be a matter included in basic community development issues. Through recognition of people’s needs and a requirement for mitigation means in the super high density areas, an appropriate technological approach would be applied for such small-scale areas, taking into consideration the congestion from tourists and pedestrians on the road.

(2) Suggestions for Road-space Management

a) Utilisation of existing open space

The feasibility of utilisation of spatial facilities should be studied case by case. Major roads, the airport, riverside space, industrial estates and each of their surrounding spaces could be evaluated for disaster mitigation purposes, where rescue activity and sheltering will be allocated in an emergency.

b) Public announcement of sheltering routes to be established by the local government

Street use such as pedestrian walkways, running and bicycling paths (especially in an emergency) are to be delineated in detail by official local bodies, on an appropriate map at a statutory level. Not only the streets and avenues shown on the ordinary tourist maps, but also paths, tracks, and trails should be identified on a scale larger than 1: 2,000. Evacuation routes and sheltering sites could be determined and outlined on familiar maps. The distribution of narrow paths and high-density areas, and all doorways for evacuation of every building and public facility should be posted at each location.

c) Formation of a green-belt network

Formation of a green-belt network connecting open spaces (publicly or semi-publicly managed) and awareness of the danger of inadequate access on foot to such safety-net spaces from neighbourhoods should be simulated and elaborated in order to establish some alternative evacuation routes from collapse-prone and/or damaged facilities (including residential buildings).

A safety network society would be realised through the adoption of appropriate styles of community life and ordinary people's awareness of mitigation and/or prevention of disaster impacts. Through implementation of no-cost disaster preparedness activity based on public space, urban citizens will implement mitigation measures appropriate to the characteristics of their environment. Thus people could be provided their safety net space for times of emergency in public spaces planned for this use.

6.6.3 Strategy on Development and Reinforcement of Urban Structure

(1) Assignment of Intensive Development Areas for Disaster Prevention

Several separate areas within the city centre of Kathmandu should be designated as intensive development areas for disaster prevention, by strengthening the urban structure. Securing emergency evacuation routes and preserving evacuation areas in some areas of the city are effective measures that can be applied to Kathmandu. Each of these areas should be installed with facilities to reinforce the city against disasters. For instance, lifelines and continuing availability of public space are important safeguards for disaster prevention. Each of the areas will follow an integrated development scheme, to take advantage of its local resources and characteristics.

(2) Reservation of Open Spaces for Evacuation and Rescue Routes

For the urban areas, the reserving of public open space should be promoted to secure the evacuation and rescue routes in emergencies. Upon the identification of such routes, discussions should be held among the governmental authorities, local citizens and other stakeholders of the area to identify the most practical paths for escape and rescue activities during times of disaster. The assigned open space should be restricted from building construction and the public informed of its disaster preventive purpose. This process should also contribute to controlling the excessive development of high-density urban neighbourhoods in the city.

(3) Reservation of Refuge Areas in Existing Farmlands

The existing farmlands between the suburban area of Kathmandu and its four satellite cities should be assigned as a large scale greenbelt zone and a planned residential area under the land use plan. This area should be reserved as an emergency refuge for refugees from the earthquake disaster in the metropolitan area.

(4) Assignment of Bypass Routes

The four satellite cities of Kathmandu (Patan, Bhaktapur, Thimi, Kirtipur) have the potential for self-sustaining development of an urban structure. The importance of applying disaster mitigation measures to secure safe urban life is increasing in order to accommodate the growing human activities and their commensurate properties in the city centres. Under the local area plans for these cities, evacuation and rescue bypass routes should be available in more than one alternative course as shown in attached Figure 6.6.1. The areas along urban roads should be restricted from construction to secure their clearance for emergency use.

For the application of the above concepts, it is appropriate to designate central Kathmandu as the pilot area for the disaster prevention urban plan as described below.

6.6.4 Mobilisation of "Local Area Plan" for Disaster Preparedness

The objectives and goal of "local area plans" are shown on publications like a poster for preparation of community meetings that has been initiated by the Ministry of Physical Planning and Building. However, among these items disaster mitigation measures have not yet been directly identified, and the local area plans should be re-evaluated much more than before, in order to establish the specific, practical plan for disaster mitigation.

The objectives and goals of local area plans are:

- To mobilise local communities' resources and expertise for development works,
- To preserve specific areas and to manage urban expansion,
- To direct physical development of specific areas of a city,
- To develop an annual program and an allocation in the budget of local authorities, and
- To execute physical development plans at local level.

The goals of the plans are:

- To improve and develop infrastructure such as roads, water supplies, drainage, sewage and sanitary conditions suitable for the local area,
- To manage road users' movement, or local traffic and pedestrians,
- To improve conditions in housing areas,
- To preserve and improve archeologically important areas,
- To develop open spaces required for various purposes, and
- To prevent hazardous development of urban expansion areas.

6.6.5 Disaster Mitigation Measures by Urban Zones

Based on the plans for development and reinforcement of the urban structure, disaster mitigation measures in central Kathmandu will be proposed by dividing the city into eight strategic zones, considering the characteristics of the urban structure (land use) as shown in attached Figure 6.6.2 and summarised below.

A1 : The area between Durbar Square and Tundikhel Plaza (120 ha), the most densely populated area in the city (700 to 1,100 persons/ha.)

A2 : The area stretches from the low land on the east bank of the Bishnumati River, and downtown Chetrapati on the west hillside up to Thamel which is surrounding the area of A1(500 ha.), a highly populated area (400 to 700 persons/ha.).

B : The area surrounding the Tundikhel Plaza (15 ha.).

C : The Government offices area.

D : The tourism centre area (bus terminal, tourist information area).

E : Large scale agricultural fields mixed with sprawling individual residential development. Relatively low density compared with the city centre.

F : Encompasses long strips of land for recreational use (river bank).

G : Suitable vast land for future development of new settlements of the next generation for self-contained communities in earthquake resistant new towns.

The following are the disaster mitigation measures targeted for intensive development of the disaster-resistant city structure.

(1) Area A-1

- Area between Durbar Square and Tundikhel Plaza.
- The most densely populated area of the city with 700 to 1,100 person/ha. (Total area: N-S 1,500 m × E-W 800 m = 120 ha.).
- The international tourism and commercial centre developed along the new road.

a) Developmental issues

- The gradual decrease of the nighttime population by the encouraging of commercial, cultural, and administrative functions in the area.
- Urban traffic management: the essential issue is the regulation of vehicle entering the area.

b) Proposed action plan (as an example)

- The basic policy is to promote the small-scale development of greenbelts, public squares, and car parks in the area (as a triple set). The estimated population of this target area is set at 100,000 people.
- Emergency vehicle approach routes need to be planned on the basis of public participation. In a series of participatory meetings, the location and required number of access points shall be examined. The proposed locations of rescue/evacuation routes and emergency shelters are the central plaza and public parking spaces. The result of the discussion shall be reflected in the development policy of the region where industry and tourism promotion, will be key projects in the local area plan.
- Likewise, the regulation of residential buildings in the area shall be planned in accordance with the land use regulations and as detailed in the "local area plan."

(2) Area A-2

- The area stretches from the low land on the east bank of the Bishnumati River, and downtown Chetrapati on the west hillside up to Thamel. (The total area: NS 10 km × EW 500m; about 500 ha.).
- Area A-2 is a highly populated area with medium-rise buildings, which has developed toward the west of the Area A-1.
- The population density has increased to 400 to 700 persons/ha., which comes next to the most densely populated Area A-1.
- The estimated total population of Areas A-1 and -2 is 300,000.
- The Area includes Teku district at the southern end, the northern end at Naya Bazar on the northwest Thamel, and the area currently under the land pooling project. This will form the largest zone in the urbanisation process in the metropolis. (The Bishnumati River Linkage Road, a trunk road with a wide right-of-way, is planned along the river bank. This shall be the axis for urban traffic in the future.)

a) Development issues

The issues for disaster-resistant urban planning of the area can be summarised as follows:

- The development of an evacuation/rescue route network within and around the area as shown in attached Figure 6.6.3.
- The development of small scale emergency shelter space(s) within the area.

- The development of evacuation of refuges to initial areas/locations and for the preparation of future land use re-adjustment.
- The development of roadside public parking along the Bishnumati River Linkage Road.

In the implementation of the above development projects, the collaboration of the central government, municipalities, and private organisations is required. This is a subject common to Areas D and E, as well as Area A-2.

(3) Area B

- This area includes the above mentioned Tundikhel Plaza (15 ha.) and the surrounding area.
- This is a government managed greenbelt that stretches for 2.2 km. in the north-south direction with the width of 250 m to 300 m.
- The southern end of this area includes the national athletic stadium and a part of the military field. The northern end covers Rani Pokhari public waterfront landscaping area (130m × 170m:2.3 ha.), Jamal crossing and the access road of Thamel up to Tridevi Marg.

The large-scale public square and greenbelt network should be developed in Area B as disaster mitigation measures. By providing an integral development and its relevant land selection criteria, the area could become a huge symbolic greenbelt worthy of the Kathmandu metropolis. The total area should be 55 ha including a part of green areas within private properties. In order to assess the area of its value as open-space resources, a natural environment survey needs to be conducted.

The utilisation possibilities of private estates for disaster prevention purposes should be examined on the basis of establishing of national / regional master plan policies for the development of the area.

(4) Area C

(Travel & Safety Information Service Complex as an Urgent Support for the Urban Tourism Development)

The favourable locations for the development of core facilities for earthquake disaster mitigation will be selected. This will be in a rapidly growing area as Urban Tourism Attractions. The development of an information centre for disaster mitigation is recommended under the Renewal Program. For instance, a facilities complex could be developed as a public square that could be utilised as a disaster refuge. The complex should be installed with medical facilities for both emergency and regular services, with a primary health care section, disaster-related information service facilities, and exhibition and sales booth for local products; particularly the information service involves a large-scale display on disaster mitigation. As for the involvement of the private sector in the exhibition and sale of local products, the business experiences of Patan Industrial Estate (craft-industries outlet shops) can be applied.

This area, together with the adjoining Areas A, C, and D, has a favourable location as a centre for the implementation of multiple projects that will lead to an advanced program for urban reforms and environmental development. Particularly, the multi-purpose use of public facilities and spaces should be promoted. The functional extension involves the installation in the target area of advanced information technology, while maintaining integrity with the surrounding areas. For example, all the public facilities along major roads are fringed with a greenbelt of a certain width. In order to maximise the development effect, space allocation should be accompanied by the communication infrastructure.

(5) Area D

(Disaster Mitigation By-pass Route Formation Together with Urban Renewal)

An efficient short-cut route connecting the east and west of the KMC has been expected for long time because of repeating traffic congestion in Area D. Regarding disaster mitigation in urban traffic areas, this short distance with heavy traffic volume must be relieved. In order to initiate implementation, an urban renewal program should be formulated urgently before the construction of new building(s). The formation of greenbelt networks connecting open spaces (public/or semi public managed) would be applied by the public sector's initiative as a development requirement. This area, however, does not need to be delineated strictly in advance of public acceptance by the various stakeholders.

(6) Areas E, F, and G

Each area has its characteristic potential areas for establishing varied types of public open spaces, of which the current land uses are as follows:

a) Area E comprised of large scale agricultural fields mixed with rapid individual residential development, Area F encompasses a long strip of land for recreational use, and Area G is a suitable land for future development of new settlements for the next generation as self-contained communities for earthquake resistant new towns.

b) For example the Ichangu-Narayan area (new settlement area No. 5 on the map in Figure 5.6.1) has the priority of location advantage, for resettlement in the old city core. Formation of a greenbelt network connecting open spaces and providing access on foot to such safety-net spaces and to neighbourhoods, should be simulated and elaborated for establishing some alternative evacuation routes.

c) Safety networks (accomplished through community development) would be targeted by means of appropriate community life and ordinary people's awareness of mitigation and prevention of disaster impacts. Through trials for implementation of public space formation based on disaster preparedness activities, urban citizens could implement mitigation measures appropriate to their environment. People could be provided with their safety net space for emergencies on the planned space for public use.

6.7 Other Issues

6.7.1 Socio-economic Influence

Nepal is categorised among the Least Developed Countries (LDC) with a GDP per capita of around US$ 200. Nepal's main sector, agriculture, is self-sufficient. The latest national GDP is approximately 400 BNRp (Billion Nepalese Rupees, equivalent to 667 Billion Japanese Yen), and agricultural production accounts for 40%, which is followed by tourism, another major industry of the nation. There is a deficit in the trade balance due to a surplus of imports, in particular clothing and food from India. Securing the distribution networks based on roads and trucks as the main mode of transportation at the time of the earthquake disaster is the primary issue to be confronted.

Annual expenditures of the government amount to 60 BNRp (100 BJPY), including overseas grants, aid and loans. The accumulated overseas loans are estimated to be 195 BNRp (325 BJPY) in 2001, which presents a serious problem.

Epidemics, floods, and earthquakes are the major disasters which aggravate the economy in Nepal. The economic losses caused by the earthquake in east Nepal in 1988 have hampered development of the nation and amounted to 5 BNRp (8 BJPY), which is equivalent to 40% of the total annual governmental expenditures.

The Study Team has set four possible scenario earthquakes, out of which the most severe one is in the Mid Nepal Earthquake. In the event of its occurrence, the direct cost of building damage itself would total about 100 BNRp (Billion Nepalese Rupees, equivalent to 167 Billon Japanese Yen). The total cost of damage to the whole nation, including secondary costs in other affected areas, is estimated to be 300 BNRp (500 BJPY), which is equal to 70% of the GDP, five times the national budget, and 1.5 times the accumulated loans.

Moreover, disasters will result in commodity price inflation, confusion, and both economic and social disorder. The people who suffer most from disasters are almost always the poorer people in the society. Increasing demands for reconstruction may bring about monetary deficits and result in inflation. Consequently, the fundamentals of the national economy will be endangered. Strengthening of the economic base and establishing crisis management systems are the most reasonable devices for avoiding a critical situation.

Promoting the export industries of agriculture and tourism is an effective primary step along with constructing a safer city structure through urban and regional planning and provision of stronger infrastructure. Furthermore, the fundamental answer lies in the educational sector, and it is essential to design educational curricula for disaster mitigation from elementary school to the university level. This will enable not only the raising of awareness of disasters among the general public, but will also contribute to technical progress in earthquake engineering and scientific research in Nepal.

In respect to the economy, institutionalising the emergency response system is the most pressing issue. The following socio-economic measures are necessary to be delineated: agreement on controlling commodity prices; agreement with appropriate entities for expedient use of aircraft, heavy vehicles, and trucks; special loans for reconstruction and rehabilitation; incentives and special reductions in the tax system; monetary assistance for safer earthquake constructions, etc. A strong driving force and leadership at the national level are essential.

6.7.2 Vulnerable Groups in Disaster

The Kathmandu Valley has been undergoing an urbanisation process. Those who engage in agriculture are gradually decreasing, and urban dwellers are rapidly increasing. Furthermore, Nepal is a world tourist destination; hence special consideration should be given to the tourist trade. When an earthquake disaster occurs, these and other groups will have specific needs as those affected may not have proper access to food, accommodations and information.

Past earthquake experiences in Nepal and elsewhere indicate that the elderly, infants, children, patients, pregnant women, and the poor present special needs in disasters. Preparation and dissemination of information regarding potential disasters, evacuation routes, and plans for crisis management and relief for victims will reduce the impact on the people at the time of the disaster.

CHAPTER 7 CONCLUSIONS

7.1 Study Results and Conceivable Programmes for Earthquake Disaster Mitigation

7.1.1 Earthquake Disaster Assessment

The study team assessed the earthquake disaster scenario for the Kathmandu Valley to facilitate effective disaster mitigation planning. To determine the damage and impacts that would be caused by a future earthquake, data on natural and social conditions were collected and analysed.

Based on the seismic, seismo-tectonic and geological conditions around the Kathmandu Valley, the following three new fault models were selected for disaster assessment.

a) Mid Nepal Earthquake (Magnitude: 8.0)
b) North Bagmati Earthquake (Magnitude: 6.0)
c) KV Local Earthquake (Magnitude: 5.7)

In addition, d) an earthquake with seismic characteristics of the 1934 Bihar-Nepal Earthquake (Magnitude: 8.4) was modelled for comparison with the three potential earthquakes.

Seismic intensity was calculated for the four fault models as follows.

a) Mid Nepal earthquake: Except in mountainous areas, MMI VIII would be experienced in the Valley.
b) North Bagmati earthquake: Except in mountainous areas, the Valley would experience MMI VI or VII.
c) KV Local earthquake: The area along the fault would experience MMI IX. Other parts of the Valley, except the mountainous areas, would experience MMI VII or VIII.
d) 1934 Bihar-Nepal earthquake: Most areas of the Valley would experience MMI VIII, and some areas in the eastern part would experience MMI IX.

Although the liquefaction potential for all models was evaluated as relatively low, compared to a previous estimate undertaken by UNDP, the study results indicated that unimaginably huge damage would occur if a moderate to great earthquake were to strike the Valley.

It is considered that the following actions should be undertaken to improve the capacity for earthquake disaster assessment.

Table 7.1.1 List of Programmes for Earthquake Disaster Assessment

No.	Items	Reference	Responsible Organization							
		in Main Report	National Government				Local Government	Private Sectors		
Earthqauke Disaster Estimation										
ED-1	Seismological Measurements									
ED-11	Seismological observation	III-4-a	DMG							
ED-12	GPS observation	III-4-a	Survey Dept.							
ED-2	Basic data									
ED-21	Regulation of Map data	III-4-b	Survey Dept							
ED-3	Geological Data									
ED-31	Basement structure measurement of Kathmandu valley	III-4-c	DMG					Nepal Geological Society		
ED-32	Geological database	III-4-c	DMG					Nepal Geological Society		
ED-4	Infrastructure database									
ED-41	Building inventory/Census	III-4-d	MPPW					Nepal Engg Assoc.		
ED-42	Lifeline GIS database	III-4-d	MPPW	NEA	NTC					
ED-43	Bridge ledger	III-4-d	MPPW							
ED-5	Data clearing house	III-4-e	MOHA	MOCom						
ED-6	Improvement of Damage estimation									
ED-61	Historical data gathering and analysis	III-4-f	DMG							
ED-62	Strong motion observation network	III-4-f	DMG							
ED-7	Education and Research									
ED-71	Earthqake engineering laboratory	III-4-g	MOSE	MPPW	Tribhuvan Univ.			Nepal Engg. Assoc.		
ED-72	Training earthquake engineers	III-4-g	MOSE	MPPW	Tribhuvan Univ.			Nepal Engg. Assoc.		

7.1.2 Sustainable Mechanisms for Development of Disaster Management

There is a strong tendency for public authorities and organisations to act independently with little contact or coordination with other bodies; effective disaster management requires close cooperation among ministries and other governmental/societal institutions. In Nepal, several reasons were noted for the existing inadequacy of inter-institutional cooperation:

a) Lack of adequate legal framework, and thus unclear responsibility.
b) Lack of incentives for individual institutions, with inadequate funding being the greatest disincentive.
c) Lack of auditing or systems of accountability for public administration.

The biggest difficulty that Nepal faces for earthquake disaster management is the lack of sustainable mechanisms for governmental/community mitigation and preparedness actions, rather than the lack of resources. Though, there appears to be a trend that may begin to overcome this difficulty; decentralisation represented by the Self Governance Act, and disaster management actions in some communities.

It is considered that the following actions should be undertaken to improve the capacity for disaster management.

Table 7.1.2 List of Programmes for Sustainable Mechanisms for Development of Disaster Management

No.	Items	Reference	Responsible Organization							
		in Main Report	National Government				Local Government	Private Sectors		
Sustainable Mechanism for Development of Disaster Management										
SM-1	Establishment of Legal Foundation	II-3.1.5	PM Office	MOHA						
SM-2	Establishment of Disaster Management Council									
SM-2.1	National Disaster Management Council	II-3.1.5	PM Office	NPC	MOHA	MOLD				
SM-2.2	Kathmandu Valley Disaster Management Council	II-3.1.5	MPPW	MOHA	MOLD		Municipalities			
SM-2.3	Municipality/Ward Disaster Management Council	II-3.1.5	MOLD				Municipalities			
SM-3	Cooperation between Government and Private sector	II-3.1.4	MOHA							
SM-4	Preparation of Disaster Management Plan									
SM-4.1	National Plan	II-3.2.1	NPC	MOHA	MOLD					
SM-4.2	Central government Plans	II-3.2.1	All Ministries							
SM-4.3	Kathmandu Valley Plan	II-3.2.1	MPPW	MOHA	MOLD		Municipalities			
SM-4.4	Municipality Plans	II-3.2.1	MOLD				Municipalities			
SM-4.5	District Plans	II-3.2.1	MOHA				VDC			
SM-4.6	Private Plans	II-3.2.1						Hospital	School	Company
SM-5	Emphasis of Earthquake Managemenmt in National 5 Year P	II-3.2.2	NPC	All Ministries						
SM-6	Exercises and Education									
SM-6.1	Citizens	II-3.3.1	MOLD				Municipalities			
SM-6.2	School Children	II-3.3.2	MOSE				Municipalities			
SM-6.3	Civil Servants	II-3.3.3	MOLD				Municipalities			
SM-6.4	Masons	II-3.3.4	MPPW				Municipalities			

7.1.3 Maintain Governance

Once a mid-scale to great earthquake occurs, the disaster will escalate through the interaction of natural phenomena, social conditions and human reactions. If the government is unable to provide effective leadership and systematic management of response and recovery operations, the initial response will be chaotic, resulting in ineffective rescue and relief works, social distrust, and a destabilised society and the economy. As a result, it will be difficult for people to pull together, and people must be able to pull together for recovery from a disaster.

It is considered that the following actions should be taken to improve the capacity to maintain governance.

Table 7.1.3 List of Programmes to Maintain Governance

No.	Items	Reference	Responsible Organization							
		in Main Report	National Government				Local Government	Private Sectors		
Maintain Governance										
MG-1	Establishment of Real Time Earthquake Information System									
MG-1.1	Earthquake Information System	II-4.2.1	DMG	MOHA			Municipalities			
MG-1.2	Seismic Intensity Information System	II-4.2.2	DMG	MOHA			Municipalities			
MG-1.3	Earthquake Information Reporting System	II-4.2.3	DMG	MOHA			Municipalities			
MG-2	Assesment of Damage Information System									
MG-2.1	Establishment of Lines of Communications	II-4.3.1	All Ministries				Municipalities			
MG-2.2	Improvement of Daily Business Style	II-4.3.1	All Ministries				Municipalities			
MG-2.3	Preparation of Taking Aerial Photos	II-4.3.1	Survey Department							
MG-3	Empowerment of Media									
MG-3.1	Seminars and Trainning	II-4.3.2	MOCom.	Nepal TV	Radio Nepal			Media'FM	Newspapers	
MG-3.2	Amendment of National Broadcasting Act	II-4.3.2	MOCom.							
MG-3.3	Publicizing	II-4.3.3	MOHA	MOCom.				Media'FM	Newspapers	
MG-4	Establishment of Emergency Communications									
MG-4.1	Identifying the Defects of Radio Wave Propagation	II-4.4.1	MOCom.	NTC						
MG-4.2	Digital Mobil Mulch Channel Access System	II-4.4.2	All Ministries				Municipalities			
MG-4.3	Simultaineous Reporting System	II-4.4.2	MOHA							
MG-4.4	Portable Handset	II-4.4.2	All Ministries				Municipalities			
MG-4.5	Initiatiate Amateur Radio Network	II-4.4.3	MOCom.	NTC				Amatuer Radio Community		
MG-5	Preparation for Emergency Response									
MG-5.1	Control System	II-4.5.1	PM Office							
MG-5.2	Central Government EOC	II-4.5.2	PM Office	All Ministries						
MG-5.3	Municipality/Ward EOC	II-4.5.2	MOLD				Municipalities			
MG-5.4	Plans/Manuals	II-4.5.3, 4.7	MOHA	MOLD	All Ministries		Municipalities			
MG-5.5	Facility for EOC	II-4.5.3	All Ministries				Municipalities			
MG-6	Discipline Public Sector									
MG-6.1	Discipline Public Sector	II-4.6.1, 4.6.2	All Ministries				Municipalities			
MG-6.2	Line of Succession	II-4.6.3	All Ministries				Municipalities			
MG-6.3	Preservation of Vital Record	II-4.6.4	All Ministries				Municipalities			
MG-7	Preparation for Recovery									
MG-7.1	Capacity Building	II-4.8.1	All Ministries				Municipalities			
MG-7.2	Review/Evaluation of Existing Priorities and Projects	II-4.8.2	MPPW							
MG-7.3	Preparedness	II-4.8.3	All Ministries				Municipalities			

7.1.4 Protect Life and Property

This is the ultimate objective for disaster management, although many difficulties are anticipated in responding to the disaster, including search and rescue operations, medical care, cremation, drinking water and food, public health care, security, fire-fighting, management of volunteers, safety inspections of structures and infrastructure, debris removal and disposal, and provision of shelter and temporary housing. When disasters strike, individuals and organisations react and their reactions are guided by whether they know what to do, their degree of preparedness to take appropriate action, and other factors, including their confidence in the safety of loved ones. Effective means of acquiring, assessing, and disseminating disaster information are required.

The availability of logistics to support on-site activities after the occurrence of a disaster is a critical issue. The transportation system must continue to function during and after the occurrence of an earthquake disaster, so that search and rescue can be conducted and other socio-economic activities can continue functioning. Rapid restoration of electrical power and water supplies to the affected areas is equally critical. The existing conditions of these elements of the Valley's infrastructure were discussed to identify any underlying problems.

It is considered that the following actions should be taken to improve the capacity both to protect life and property of the people and to support on-site activities during the initial stages of a disaster.

Table 7.1.4 List of Programmes to Protect Life and Property

No.	Items	Reference	Responsible Organization							
		in Main Report	National Government				Local Government	Private Sectors		
Protect Life and Property of the People										
PL-1	Search and Rescue									
PL-1.1	Plan for improvement of research and rescue	II-5.2	MOHA	MOHealth			Municipalities	Red Cros	WHO	
PL-1.2	Acceptance of International Support	II-5.3	MOHA	MOHealth				Red Cros	WHO	
PL-1.3	Improvement of Disaster Medicine	II-5.4	MOHealth					Red Cros	WHO	Hospitals
PL-1.4	Food and water supply	II-5.5.8	MOHealth							
PL-2	Shelter and Evacuation									
PL-2.1	Plan for shelter, evacuation and removal	II-5.6.4	KVTDC				Municipalities			
PL-3	Medical Problem									
PL-3.1	Public Health Care	II-5.7	MOH					Hospital	Red Cross Assoc.	
PL-3.2	Remains	II-5.8	MOH				Municipalities			
PL-4	Other Functions									
PL-4.1	Security	II-5.9.1	MOHA	RNA						
PL-4.2	Firefighting	II-5.9.2	MOHA							
PL-4.3	Management of volunteers	II-5.9.3	MOHA				Municipalities			
PL-4.4	Safety Inspections	II-5.9.4	MPPW				Municipalities	Nepal Engg. Assoc.		
PL-4.5	Debris removal	II-5.9.5	MPPW				Municipalities	Nepal Engg. Assoc.		
PL-5	Transportation System (Roads and Bridges)									
PL-5.1	Database	II-5.10.6	MPPW							
PL-5.2	Temporary Bridges	II-5.10.6	MPPW	RNA						
PL-6	Electricity Supply									
PL-6.1	Database	II-5.11.5	NEA							
PL-6.2	Solar Power	II-5.11.5	NEA							
PL-6.3	Wind Power	II-5.11.5	NEA							
PL-6.4	Diesel generators	II-5.11.5	NEA							
PL-7	Staging area	II-5.12	MOHA							

7.1.5 Strengthen Socio-Economic System

Working toward sustainable development is a natural and necessary companion to working toward effective earthquake disaster management itself, because the ability to deal with earthquake disasters is highly dependent upon the fundamentals of society, economic growth and social stability, all of which are the fruits of sustainable development. Urban society is highly dependent on the socio-economic infrastructure, and any weakness makes it vulnerable to disaster. The vast direct and indirect economic and societal losses caused by disasters can be reduced by reinforcing the infrastructure through sustainable development practices.

It is considered that the following actions should be taken to strengthen the socio-economic system.

Table 7.1.5 List of Programmes for Strengthening the Socio-Economic System

No.	Items	Reference	Responsible Organization							
		in Main Report	National Government				Local Government	Private Sectors		
Strengthen Socio-Economic System										
SE-1	Urban Planning									
SE-1.1	Urban Space Allocation Detail Planning	II-6.1.2	KVTDC	MPPW			Municipality			
SE-1.2	Assignment Planning of Intensive Development Areas	II-6.1.3	KVTDC	MPPW			Municipality			
SE-1.3	Assignment Planning of Mitigation Bypass Routes	II-6.1.3	KVTDC	MPPW			Municipality			
SE-1.4	Urban Zoning for Disaster Mitigation measures	II-6.1.5	KVTDC				Municipality			
SE-2	Transportation Facilities									
SE-2.1	Roads to improve access to the Valley	II-6.2.5	MPPW							
SE-2.2	Roads to improve mobility inside the Valley	II-6.2.5	MPPW							
SE-2.3	Improvement of bridges	II-6.2.5	MPPW							
SE-3	Building									
SE-3.1	Improving Building construction	II-6.3.7	MPPW				Municipalities	Masons		
SE-3.2	National Building Code	II-6.3.7	MPPW					Nepal Engg. Assoc.		
SE-3.2	Training	II-6.3.8	MPPW				Municipalities	Masons	Nepal Engg. Assoc.	
SE-3.4	Inspection of Key Buildings	II-6.3.8	MPPW					Nepal Engg. Assoc.		
SE-4	Electricity									
SE-4.1	Network improvement	II-6.4.3	NEA							
SE-5	Water Supply & Sewerage Facilities									
SE-5.1	Database system	II-6.5.3	NWSC							
SE-5.2	Distribution system by water tankers	II-6.5.3	NWSC							
SE-5.3	Preservation of existing wells and spouts	II-6.5.3	NWSC				Municipalities			
SE-5.4	Preparation of earthquake resistant design manual	II-6.5.3	NWSC							
SE-6	Telecommunication facilities	II-6.6.3	MOCom.	NTC						
SE-7	Socio-economic influence	II-6.7.1	MOCommerce							

7.2 Cost Estimate

Regarding soft programmes such as legal/institutional strengthening and capacity building, the cost of programme implementation was based on the conceivable input of experts needed to assist the implementation. Regarding construction of infrastructure, the cost of implementation was shown if the programme directly contributes to earthquake disaster mitigation.

The cost for each programme is shown in Tables 7.2.1 to 7.2.2, and the total cost is shown in Table 7.2.3

Table 7.2.3 Cost Estimate

Item	Total Cost (million yen)
Earthquake Disaster Assessment	3,250
Sustainable Mechanisms for Development of Disaster Management	947
Maintain Governance	3,835
Protect Life and Property of the People	4,950
Strengthen Socio-Economic System	9,630
Grand Total	41,974

7.3 Evaluation of Programmes and Implementation Plan

The programmes listed above are too great in number and quantity to be accomplished within a limited time because they need a tremendous amount of resources and implementing time and, in some cases, it will take time until a consensus relevant organisations/people can be reached. It could take 50 years or even longer to actually implement all the programmes.

Some programmes must be selected from among the entire list to act as initiatives and stimulation for succeeding works. They must bring visible results to promote further endeavours to achieve, as much as possible, the goals for earthquake disaster reduction.

The proposed programmes were evaluated, based on the following factors.

a) Term
The required duration to complete the programme will be an essential issue. Each programme was rated as A: short term (1 to 5 years), B: middle term (5 to 10 years), or C: long term (more than 10 years).

b) Priority
Taking the following points into consideration, each proposed programme was rated as A: high priority, B: moderate priority, or C: low priority.
- Contribution to accomplishment of one or more of the three goals
- Significance of the problem and effectiveness of the solution (degree to which the problem to be resolved is viewed as significant and degree to which the proposed solution will successfully solve the problem; likelihood of the programme producing the desired outcome)
- Value/impact for dollar/yen spent
- Sustainability/ability to attract or generate further investments in mitigation and preparedness by others.

c) Reality
In terms of how realistic the programmes were, each was rated as A: highly realistic, B: moderately realistic, or C: not realistic; according to the following two criteria:

- Feasibility (technical, financial, political, etc.; there is reasonable assurance and consensus that the technology, expertise, materials and equipment etc. available in the country will fix the problem)
- Acceptability (likelihood of receiving the support of the responsible institutions and other stakeholders)

For evaluation of the programme, the study team applied the following point system.

Score for rating in each category is as follows.

Rating	Score
A	3
B	2
C	1

Programme was evaluated, based on the total score of the three categories as follows.

Total Score	Evaluation (Importance)
9	High
6 to 8	Moderate
3-to 5	Low

It is noted that the above-mentioned rating and evaluation are based on the study team's judgement, and other organisations/groups/personnel may have different opinions due to their particular situation. It is recommended that all relevant entities should prepare their own rating and evaluation for implementation planning. Moreover, it is highly recommended that all organisations/groups/personnel discuss and agree on overall implementation planning in order to create a safer Kathmandu and Nepal better able to resist earthquake disaster.

Since it is impossible to completely prevent earthquake disaster, continuous effort for disaster mitigation is essential. The attached Tables 7.3.1 and 7.3.2, show an implementation plan that would, with intensive effort, achieve a certain level of mitigation through the implementation of the proposed programmes.

7.4 Proposals

7.4.1 Selected Projects

The study team selected four projects for urgent implementation. The selected projects includes several high-scoreing programmes as mentioned below.

(1) Establishment of Early Earthquake Information System

Related programmes:

- Earthquake Information System (MG-1.1)
- Seismic Intensity Information System (MG-1.2)
- Earthquake Information Reporting System (MG-1.3)
- Seminars and Training for Empowerment of Media (MG-3.1)
- Publicising for Empowerment of Media (MG-3.3)
- Emergency Plans/Manuals for Preparing for Emergency Response (MG-5.4)
- Emphasis of Earthquake Management in National 5 year Plan (SM-5)

(2) Establishment of Municipality Disaster Management Institution and Exercise

Related programmes:

- Establishment of Municipality/Ward Disaster Management Council (SM-2.3)
- Municipality level Disaster Management Planning (SM-4.4)
- Municipality/Ward EOC establishment (MG-5.3)
- Emergency Plans/Manuals for Response in Municipality level (MG-5.4)
- Citizens' Resilience and self-reliance (SM-6.1)
- School Children's Resilience and self-reliance (SM-6.2)
- Civil Servants' Resilience and self-reliance (SM-6.3)
- Urban Space Allocation Detail Planning (SE-1.1)

(3) Building Improvement

Related programmes:

- Improving Building Construction (SE-3.1)
- Improving National Building Codes (SE-3.2)
- Building Training (SE-3.3)
- Inspection of Key Buildings (SE-3.4)
- Masons' Resilience and self-reliance (SM-6.4)

(4) Establishment Comprehensive Database for Earthquake Disaster Mitigation

Related programmes:

- Database for Transportation Systems(Roads and Bridges) (PL-5.1)
- Database for Electricity Supply System (PL-6.1)
- Database for Water Supply & Sewerage Facilities (SE-5.1)
- Establishment of Regulation of Map Data (ED-2.1)
- Building Inventory/Census (ED-4.1)
- Lifeline GIS Database (ED-4.2)
- Bridge ledger (ED-4.3)
- Historical Earthquake Data and Analysis (ED-6.1)

The details of the projects are described in the following section.

7.4.2 Details of Selected Projects

(1) A Project for Establishment of Early Earthquake Information System

Target Area: The whole of Nepal

Counterpart Agency: MOHA. DMG and media-related agencies will be involved in the implementing body.

Background: As shown in this study, the Kathmandu Valley would suffer serious damage with a future moderate or major earthquake. In addition to the Valley, wide areas in Nepal would be seriously damaged during the earthquake. At the time of the disaster, governmental organisations and personnel responsible for disaster management should make a prompt and proper response in order to maintain governance. For the prompt and proper response, it is necessary 1) to acquire precise earthquake information, 2) to transmit the information to organisations responsible for coping with earthquake disaster, and 3) to disseminate the information to the public through the mass media. In order to consolidate the foundation for smooth implementation of the above issue, it is necessary 4) to address the importance of earthquake disaster mitigation within the tenth National Five-Year Plan.

Overall, Kathmandu must demonstrate a central government function, be able to grasp the actual condition of damage, and must take emergency response, relief and rehabilitation etc.

Therefore, the improvement of the earthquake information reporting system and the actual nature of earthquake information and education and training of the mass media for publicising of earthquake information to citizens will have a big effect on the initial response.

With fulfilment of the above-mentioned conditions, the organisations that will have any role following a disaster will be able to make a prompt and proper response, and to ask for necessary overseas assistance and coorporation immediately.

From the viewpoint of sustainable improvement of earthquake engineering in Nepal, it is recommended to determine seismic coefficient for buildings based on actual seismic records. For the acquisition of seismic records, it is necessary 5) to install a strong motion observation network.

Components: Regarding the above-mentioned issues 1) to 5), it is necessary to implement the following programmes as shown in attached Figure 7.4.1.

For issue 1)

- Earthquake information system mainly consisting of connection between the east and west seismological networks (MG-1.1)
- Seismic intensity information system consisting of an early post-earthquake damage estimation system covering the whole of Nepal (MG-1.2)

For issue 2)

- Earthquake information reporting system consisting of an early post-earthquake information network among related agencies (MG-1.3): Earthquake information, such as the location of the epicentre, determined by DMG shall be reported to MOHA, the Royal Palace, the five municipality offices, and the mass media.
- Emergency plans/ manuals for preparing an emergency response (MG-5.4)

For issue 3)

- Seminars and training for empowerment of media (MG-3.1)
- Publicising for empowerment of media (MG-3.3)

For issue 4)

- Emphasis of earthquake management in the national 5 year plan (SM-5)

For issue 5)

- Strong motion observation network (ED-6.2): About ten strong motion seismograph stations in Kathmandu Valley and about three around Birendranagar

Duration: 2 years

Total Cost: 601 million yen for 86 man months of experts for training, seminar, and installation of facilities such as communication equipment, software development, and strong motion seismographs.

(2) A Project for New Institutional Arrangements at Municipality Level

Counterpart and Implementation Agencies:

Counter part agency : Ministry of Local Development (MOLD)

Implementation Agency : Kathmandu Metropolitan City (KMC)

Background and Target: In order to reduce earthquake risks and disasters effectively, national level organisations, mainly Ministries, are responsible for formulating an overall framework for earthquake disasters, including policymaking, coordination among different organisations and ministries, and support of local governments. In contrast, municipalities are responsible for in-front mitigation activities for citizens, which have been commonly found to be effective. Moreover, decentralisation is in progress, and empowering of local governments is in much demand. Considering the current disaster management situation in Nepal, enhancing potential for preparedness, especially an emergency response system, will have an immediate effect. This proposal targets the building of practical disaster management capacities, mainly at Municipality level, by focusing on three different elements: disaster management mechanism, facilities, and activities. Strengthening linkages with the concerned central government agencies shall be included. As the damage analysis indicates, Kathmandu city has the highest earthquake risks, thus Kathmandu Metropolitan City would be targeted.

Components:

a) Disaster Management Mechanism

- Establishment of Municipal/Ward Disaster Management Council (SM-2.3)
- Preparation of Disaster Management Plans for Municipality (SM-4.4)
- Preparation of Emergency Plans/Manuals (MG-5.4)

b) Disaster Management Facility

- Preparation for Emergency Response, Plan and Construction of Municipality / Ward EOC (MG-5.3)

c) Disaster Management Activities

- Increasing Community Resilience and Self-Reliance for citizens, school children, and civil servants (SM-6.1, 6.2, 6.3)
- Urban Space Allocation Detail Planning (SE-1.1)

Duration: 2 years

Budget: 1,512 million yen for 156 MM for experts , and EOC construction, information facilities, training programs etc.

(3) A Project for Building Improvement

Study Area: Kathmandu Valley

Counterpart Agency: Ministry of Physical Planning and Works

Background: The magnitude of an earthquake disaster is defined by the number of casualties, caused mainly by building damages. This fact has been revealed and reconfirmed through the experiences of recent earthquakes such as the Gujarat

Earthquake of India in 2001. The JICA Study on earthquake disaster mitigation in the Kathmandu Valley has pointed out the vulnerability of buildings in the Valley. It has been observed that improving the seismic resistance of buildings is the most pressing issue for earthquake disaster mitigation. The background to this can be summarised in four points.

a) A small level of intervention in the design, planning, construction, and inspection of buildings will reduce the earthquake risks significantly.
b) Proper investigation and design for strengthening or reconstruction are necessary for critical facilities, such as hospitals, schools, and government and municipal buildings.
c) Awareness raising for safer building construction, inspection and permission, technical training and education is necessary for building owners, builders, engineers, and municipal and government officers.
d) A mechanism should be established for the regular review of current Building Codes for seismic improvement and implementation of in same construction practices.

Contents: The contents of the proposal are as follows:

a) Improving building construction (SE-3.1)

- Listing improved items for planning, construction, and inspection of different types of buildings
- Preparing publicising guidelines and manuals

b) Improving the National Building Code and promoting implementation (SE-3.2)

- Analysis for revising building codes (formulation of laws should be done locally)
- Dissemination and implementation of laws and regulations

c) Dissemination of building technology (SE-3.3, SM-6.4)

- Formulation of education plans and sustainable mechanisms for the future action and implementation of building owners, practitioners, inspectors, and public officers
- Practical Training for building practitioners and masons during the construction process of a training centre.

d) Inspection of key buildings (SE-3.4)

- Listing key buildings and their inspection
- Analysis of inspections and suggestion for improved design

Duration: 2 years

Budget: 730 million yen for 110 MM for experts and training centre construction, testing equipment, educational materials, investigation cost (mainly inspection), and training fees.

(4) A Project for Establishing Holistic Database for Earthquake Disaster Management

Study Area: Kathmandu Valley

Counterpart Agency: Ministry of Physical Planning and Works, and other concerned agencies

Background: Earthquakes have a long-standing impact on the lives and livelihood of citizens, even those who may not be directly affected during the response and rehabilitation process. Soon after an earthquake, buildings, roads, and bridges need to be repaired to secure routes for personal mobility and to distribute recovery materials. Water supplies, electricity supplies and sewerage systems, which all directly affects everyday life, need to be recovered. Currently in the Kathmandu Valley, basic information, such as the location and seismic resistance of these facilities, are not clear enough as many have developed haphazardly.

This Study estimates that most lifeline systems and facilities are seismically vulnerable. As long as the current situation continues, any future earthquake can be expected to have a devastating effect, and it will have a long-term impact on lives and livelihood. Thus, there is an urgent need for improvement of the seismic stability of lifelines and other related infrastructures, including the transport network. For an effective measure, it is necessary to have an integrated information system for different lifelines and infrastructure systems.

For this purpose, the target facilities are listed below.

a) Transportation system (road, bridge)
b) Electricity supply system (power generation, transmission, distribution facilities and networks, distribution area)
c) Water supply & sewerage facilities (trunk facilities, distribution network and area)
d) Standard map information (base maps, standard map)
e) Building data (location, number, typology, structure, age etc.)
f) Geographic information system (GIS), data registration
e) Records of historical earthquakes

Contents: The contents of the project are as follows:

a) Establish a database of the transportation system (PL-5.1)

- Compile data for current roads and bridges
- Establish database of location, networks, structure, type, age

b) Establish a database of the electricity supply system (PL-6.1)

- Compile data for the current electricity supply system (trunk lines, distribution networks etc.)
- Establish a database of location, networks, structure, type, age

c) Establish a database for water supply & sewerage facilities (SE-5.1)

- Compile data on the current water supply & sewerage facilities (trunk lines, distribution networks etc.)
- Establish database of location, networks, structure, type, age

d) Regulation of Map data (ED-2.1)

- Examine standard format of maps
- Unify the format of map data
- Plan for preparing standard maps (preparation of new maps, adjustment of old maps)

e) Execution of Building Inventory, Building Census (ED-4.1)

- Plan investigation of current conditions of buildings
- Establish a building database by investigating buildings of Kathmandu Valley
- Prepare guidelines for conducting a building census at 5-year intervals

f) Establishing Lifeline GIS database (ED-4.2)

- Prepare a GIS database system of the above mentioned facilities.

g) Preparation of bridge ledger (ED-4.3)

- Prepare a bridge ledger out of the bridge database to be utilised for maintenance, construction plan and design

h) Compilation and analysis of historical earthquake records (ED-6.1)

- Compile historical earthquake records in Nepal, such as the 1934 and 1988 earthquakes. Damage records would be utilised for analysis of building strength and transmission of earthquake motions, public awareness raising and dissemination.

Duration: 2 years

Budget: 1,550 million yen for 108 MM of experts, and software (database, GIS), Local Investigation (building inventory, data entry), education materials, training fees.

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