programmes. Recently, the Water Induced Disaster Prevention Technical Centre (DPTC) has started conducting roving seminars in different districts and village centres to make the authorities and local representatives aware of water-induced disasters, including landslide problems.

Technical Consulting Services

In recent years, quite a number of technical consulting services have been actively engaged in the field of landslide studies, stabilisation, and landslide hazard mapping. The number of qualified and experienced persons/professionals in engineering geology, applied geophysics, geotechnical engineering, civil engineering, bioengineering, etc, available for landslide studies and management in the country, is rather limited.

Institutions Concerned with Landslide Research, Monitoring, Warning, Management and Training

Public Agencies

Department of Mines and Geology

The Department of Mines and Geology of His Majesty's Government of Nepal was established in 1941. It is responsible for the geological mapping of the country, mineral exploration work, mining, petroleum exploration, and study and mitigation of natural hazards such as landslides, debris flows, soil erosion, and earthquakes. There are over 40 geologists working in the Department. It has a separate engineering geology section responsible for the study of landslides and related phenomena and supported by a well-equipped geotechnical laboratory. There is also a well-equipped seismological centre. The Department started systematic landslide inventory survey and slope stability mapping in 1986 to get an overview of those areas of Nepal most affected by landslides as a basis for future infrastructural planning. New landslide inventory sheets were introduced based on the IAEG recommendations, after having been adapted to the special conditions of the Himalayan range. A database on the landslides of Nepal has been maintained. The German Technical Assistance Programme in the Department aims to investigate and monitor selected landslides, create a landslide inventory in the Lesser Himalayas by using remote sensing and Geographical Information Systems' (GIS) technology, and prepare the engineering and environmental geological maps of Kathmandu Valley. The Department is also carrying out a detailed study and monitoring of a landslide in Chalnakhel in the southern part of the Kathmandu Valley.

The Department of Mines and Geology, with its geologists, engineering geologists, geotechnical engineers, mining engineers, and a well-established geotechnical laboratory and infrastructure, has a very wide scope for advanced studies on landslides and soil erosion, as well as hazard and risk mapping, in Nepal.

Department of Roads

The Department of Roads is actively engaged in the study, monitoring, and mitigation of landslide hazards along road corridors. The Road Flood Rehabilitation Project (RFRP), the First and Second Road Improvement Projects, and the Arniko Highway Maintenance Project (AHMP) are some of the important projects run by the Department, and they have completed a considerable amount of work on landslide stabilisation, particularly along the Arniko Highway and the Kathmandu-Mugling section of the Prithvi Highway. The Department has a Maintenance and Rehabilitation Control Unit (MRCU) which has introduced a slope monitoring programme with the help of a database created for the Naubise-Mugling section of the Prithvi Highway.

The rapid expansion of roads during the last four decades has had an adverse impact on the physical environment of Nepal. The initiation of a large number of landslides and increase in soil erosion, which

has degraded the quality of the physical basis of the influence area, are the price the country is paying for the development of road transport. Many of the roads were built unplanned, follow geologically unfavourable alignments, and they are environmentally disastrous. More recently, the Department of Roads has realised the importance of carrying out a terrain-evaluation study before the final selection of the alignment of any road. Studies in engineering geology and hazard mapping have now become routine tasks for planning and designing mountain roads.

The Department has a well-equipped geotechnical laboratory. Though the Department is working extensively on landslide studies, monitoring, and mitigation, there are no full-time engineering geologists working.

Water-induced Disaster Prevention Technical Centre

The Water-induced Disaster Prevention Technical Centre (DPTC) was established in 1991 under the Ministry of Water Resources, with the objective of strengthening His Majesty's Government of Nepal's capacity to cope with water-induced disasters through technology development, provision of training, and establishment of databases. The Centre carries out activities related to watershed management with emphasis on erosion control, landslide study and prevention, and river training. One activity of the Centre is the provision of in-country training to various professionals in related fields. The Centre has a modern experimental laboratory for hydraulics at Godavari and a training centre in Kathmandu. The Centre is presently undertaking studies in various parts of the country on river training work as well as the study and monitoring of landslides along the Kathmandu-Trishuli road and in Butwal. Regular training courses are being conducted for engineers and overseers.

The Centre has no permanent staff of its own and is run by Japanese experts and personnel deputed from various ministries and government departments.

Department of Soil Conservation

The Department of Soil Conservation was established under the Ministry of Forest and Soil Conservation in 1974. The main objectives of the Department are to contribute to maintaining ecological balance by reducing pressure from natural hazards, such as floods and landslides, through proper watershed management and to assist in maintaining land productivity by implementing soil conservation activities (DSC 1994b). The Department has 42 District Soil Conservation Offices that plan, implement, and monitor soil conservation and watershed management activities.

The Department of Soil Conservation is basically engaged in the stabilisation of natural and cut slopes through afforestation, reforestation, and construction of checkdams and other low-cost structures.

The Bagmati Watershed Project is one of the projects of the Department of Soil Conservation. It is helping the local people of the Bagmati Watershed in slope stabilisation and soil erosion control. After the disaster of 1981 in the Lele-Bhardeo area, the Bagmati Watershed Project has been actively engaged in the stabilisation of landslides and control of debris flows and gully erosion.

Department of Irrigation

The majority of the hill irrigation projects in Nepal have suffered severely from canal failures caused by landslides and seepage. Inadequate geological investigations are the main causes of such failures (Sharma 1981). In recent years, there has been a great increase in the demand for hill irrigation projects in the country. The problem of landslides and seepage will further aggravate the situation if proper investigation and construction methods are not enforced. Seepage along the canals is also becoming a frequent landslide-triggering agent in many areas. The Department of Irrigation has prepared a survey and mapping manual (DOI 1990) for irrigation projects in Nepal, which includes geotechnical studies for canal routes and headworks.

Nepal Electricity Authority

The Nepal Electricity Authority (NEA) conducts prefeasibility, feasibility, and detailed studies of the country's hydropower projects. During various stages of the study, the Authority assesses the slope stability of dam sites, reservoir sites, and powerhouse sites. The Authority has several geologists, geophysicists, and geotechnical engineers working on various aspects of slope and underground excavation stability, and it also has a well-equipped geotechnical laboratory.

The stability of the slopes surrounding the Kulekhani Reservoir was studied by the Authority, and a few slope-stabilisation measures were implemented for active landslides in October 1983 when the Kulekhani Reservoir was about to experience its first ever full-supply level. Some landslides were found to be active on the slopes just upstream from the intake. To stabilise the slide, removal of material from the crown, cable anchoring, sub-horizontal drains, crack filling, and improvement of surface drains were carried out by the Authority (Marui 1985). Similarly, the landslides near the Sunkoshi Hydropower Project were also studied and stabilised.

Tribhuvan University

The Department of Geology was established in 1967 at the Tri-Chandra Campus, Tribhuvan University, Faculty of Science, to teach geology at the undergraduate level (B.Sc.). The graduate course (M.Sc.) was added later, in 1974. At present, the M.Sc. course is conducted at the Central Department of Geology, Kirtipur Campus, and the B.Sc. course at Tri-Chandra Campus. Together, the departments have about 25 geologists. The Central Department of Geology has well-equipped laboratories for engineering-geology, petrology, geophysics, and hydrogeology. The Department is strengthening its laboratory and human resources for research in the field of engineering geology. It publishes a regular bulletin containing research papers on geology and engineering geology.

The Institute of Engineering, Tribhuvan University, teaches a Bachelor of Civil Engineering (B.E.) course which includes engineering geology. The Institute has a well-established geotechnical laboratory run by geotechnical engineers.

International Organisations

International Centre for Integrated Mountain Development

The International Centre for Integrated Mountain Development (ICIMOD) is the first centre of its kind in the field of mountain area development. It was established in 1983 and began its professional activities in 1984. The recognition of the alarming environmental degradation of mountain habitats and consequent increasing impoverishment of mountain communities led to the establishment of the Centre. As an institution focussing on integrated mountain development, ICIMOD is concerned with the identification of hazardous areas, hazard mitigation, and improving disaster preparedness.

The Mountain Risk Engineering (MRE) programme was introduced and a manual was prepared by ICIMOD during 1988-1989, and a nine-week long pilot training programme was conducted for engineers and geologists from the HKH countries. A Mountain Risk Engineering Handbook was published in 1991 (Deoja et al. 1991), and a second training course was conducted. The Centre has also conducted several training programmes on slope stability, hazard assessment, and the use of GIS technology for Mountain Risk Engineering. It has published several occasional papers and publications on erosion, landslide, GLOFs, and other mass movements. It has also conducted workshops and seminars on similar topics.

Other National and International Organisations

The Home Ministry, His Majesty's Government of Nepal; National Committee on the International Decade for Natural Disaster Reduction (IDNDR); National Committee for Man and the Biosphere (MAB);

Environmental Protection Council (EPC); Water and Energy Commission (WEC); Nepal Geological Society, the World Conservation Union (IUCN); and Economic and Scientific Commission for Asia and the Pacific (ESCAP) are some of the national and international organisations that also deal with various environmental issues, natural hazards, and their mitigation.

Scope for Research and Training in Nepal

Research Programmes

The study of natural disasters, such as landslides, should be based on an integrated approach and should include specialists such as geologists, engineers, geotechnicians, hydrologists, and geophysicists. The International Centre for Integrated Mountain Development (ICIMOD) can play a vital role in this respect. ICIMOD can conduct training courses in the study and management of landslides for this region and facilitate the exchange and dissemination of relevant information among the HKH countries. ICIMOD could be a focal point for research within the region. In collaboration with the institutions and universities of the HKH Region, it can also conduct research programmes and develop academic curricula suitable for the study and management of landslides. Government and non-government organisations, as well as academic institutions in the region, should place more emphasis on landslide study and research. The long-term output of such studies and research will undoubtedly improve the overall level and skill of landslide study and management in the region. Preparation and wider dissemination of audio-visuals to generate awareness among the people about landslide disasters are equally important.

The research programme should focus on the following aspects.

1. Working out the unified landslide classification and study methodology suitable for this region; landslide related data collection, storage, integration, and distribution within the region; and preparation of landslide study and management handbooks, manuals, and instructions for various target groups

2. Study of active and old landslides; development of programmes for landslide mapping (landslide inventory study) on a scale of 1:25,000 or more in the vulnerable parts of the country (especially where important infrastructures or settlements are located); and preparation of hazard maps and risk maps

3. Study of and research on the relationship between various factors (i.e., rock type, slope, geological structure, soil type, rainfall, and seismicity) and the occurrence of landslides in various physiographic regions of the country; classification of rocks and soil according to their landslide susceptibility and geotechnical properties

4. Programmes for the systematic study, monitoring, and control of selected active landslides; research on the appropriate measures to be taken for effective landslide mitigation and control (i.e., engineering and bioengineering methods)

5. Exchange of experiences on landslide studies in various countries, development of appropriate academic curricula, and their implementation through academic institutions

Training Programme

At present, Nepal is facing serious problems due to landslides and related mass movements. According to the data provided by the Home Ministry, every year more than 1,000 people lose their lives as a result of landslides and related phenomena. The average annual loss of property as a result of these disasters is estimated at Rs 10,000 million, which is about 20 per cent of the GDP of the country. This clearly indicates that there is an urgent need for landslide study, mapping, management, and training in the country.