Science Plan on Hazards and Disasters

Earthquakes, Floods and Landslides



ICSU
International Council for Science

Regional Office for Asia and the Pacific

Strengthening International Science for the Benefit of Society

About ICSU ROAP

ICSU Regional Office for Asia and the Pacific was inaugurated on the 19 September by the Deputy Prime Minister of Malaysia, Y.A.B. Dato' Seri Najib Tun Abdul Razak. The new office will promote the development of science throughout Asia and the Pacific and help strengthen the voice of developing countries in this region. It will also ensure that its scientists become involved in those aspects of the ICSU 2006-2011 Strategic Plan that are especially relevant for this area.

Mission Statement

ICSU mobilizes the knowledge and resources of the international science community for the benefit of society, to:

- identify and address major issues of importance to science and society
- Facilitate interaction amongst scientists across all disciplines and from all countries
- Promote the participation of all scientists in the international scientific endeavour, regardless of face, citizenship, language, political stance or gender
- Provide independent, authoritative advice to stimulate constructive dialogue between the scientific community and governments, civil society, and the private sector

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SCIENCE PLAN ON HAZARDS AND DISASTERS

Earthquakes, Floods And Landslides

Report of ICSU ROAP Planning Group on Natural and Human Induced Enviromental Hazards and Disasters

June 2008

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Preface

The impact of natural and human-induced environmental hazards and disasters on humans and the environment continues to rise. ICSU is in the process of establishing a major new international initiative on natural and human-induced environmental hazards and disasters. Keeping the above in mind and considering that the geographical area covered by ICSU Regional Office for Asia and Pacific (ROAP) accounts for more than one-half of the world population, and about 80% of all losses due to natural hazards globally, ROAP has identified work in natural and human-induced hazards and disasters as a priority. A Science Plan on Hazards and Disasters was needed to address research needs in three categories of hazards and disasters, namely earthquakes, floods and landslides.

A Planning Group consisting of experts in natural and human-induced hazards and disasters, especially of earthquakes, floods and landslides, was established. The group met twice and was engaged in much electronic exchanges to produce a draft science plan. All relevant local, regional and international programmes on these hazards were reviewed. It was noted that despite advances in the natural and social sciences of hazards and disasters, losses of lives and properties have continued to increase. It was recognized that the available scientific knowledge is not optimally utilized in forecasting hazards and estimating risks, and that greater outreach would benefit the public, particularly in a large part of the geographical area covered by ROAP.

This document is an outcome of extensive discussions among the members of the Planning Group and consultations with several other experts. We are aware that the task at hand is very complex.

The niche of the proposed Science Plan is to utilize the latest knowledge and best practices to address problems related to earthquakes, floods and landslides in the Asia Pacific region so as to prevent hazards becoming disasters. We hope to make an impact on mitigating natural and human-induced hazards and disasters in the Asia Pacific region.

Harsh Gupta
Chair
ICSU ROAP Science Planning Group on Hazards and Disasters

Acknowledgements

Many individuals and organizations contributed to the preparation of this plan. A full list of the members of the ICSU ROAP Science Planning Group is given in Annex II.

Special thanks are due to the presenters at the Regional Conference on Natural and Human-induced Hazards and Disasters organized by ICSU ROAP in September 2006 that laid the foundation for this Plan. They included Gordon McBean, Tom Beer, Chen Dehui, Cecep Subaraya, Yap Kok Seng, Daniel Murdiyarso, Joe Chung and Kenji Satake. Three other presenters, Harsh Gupta, Chamhuri Siwar and Kyoji Sassa, became members of the Science Planning group with Harsh Gupta as the Chair of the Planning Group. Additionally, Trieu Dinh Cao, James Terry, Christel Rose and Seree Supharatid also provided valuable input to the work of the group.

Thanks are also due to the members of the ICSU Regional Committee for Asia and the Pacific under the chairmanship of Anupam Varma for their ideas, reviews and comments. Interactions with Thomas Rosswall, Howard Moore and Patricia Ocampo-Thomason of the ICSU Secretariat were useful.

Vineet Gahalaut, Uma Anuradha, Nor Zaneedarwaty Norman and Hizam Jaafar contributed at various stages of the production of this document.

Executive Summary

With the passage of time, the impacts of natural and human-induced environmental hazards and disasters continue to increase. The important question is: Why, despite advances in the natural and social sciences of hazards and disasters, do losses continue to increase? Keeping this in mind ICSU created a Planning Group to make suitable recommendations for implementation.

The geographical area covered by ICSU ROAP accounts for more than one half of the world's population and for almost 80% of all losses due to natural hazards globally. The classical examples in the recent past are: the Sumatra earthquake of 2004 and the resultant tsunami that claimed some 250,000 human lives and inflicted unprecedented economic losses; two tropical storms that caused 130,000 deaths in Bangladesh in 1991; and the 2002 landslide in Nepal which affected 265,000 people. China had a massive earthquake on May 12, 2008 claiming about 70,000 lives.

ICSU had already taken a major initiative to address the issue of Natural Hazards, ROAP chose "Natural and Human-Induced Environmental Hazards and Disasters in Asia and the Pacific" as a priority area in September 2006. At the Board Meeting of ROAP in Tehran, Iran, in March 2007, it was decided that ROAP shall focus on three natural hazards, namely floods, earthquakes and landslides. There are several bodies, and national and international programmes operating in hazard-related studies; ICSU ROAP's effort is to collaborate in a few niche areas.

The group noted the special situation for the ROAP geographical area due to the presence of a large number of islands vulnerable to hazards in the region. Involvement of social scientists is necessary to ensure that benefits of current-day knowledge are appropriately implemented to reduce hazards.

We recognize that the results of basic research form the foundation of all scientific and technical interventions. We shall emphasize on the use of the available results and interweave them with social sciences to make them effective.

The major recommendations are highlighted below.

Earthquakes

Several countries in the Asia Pacific region do not have adequate earthquake recording facilities, which need to be identified and improved. The development of scenarios of present-day losses (social and economic), if earlier earthquakes recur, and building codes for earthquake-prone countries is also necessary. A major effort is required to estimate the accelerations at the surface taking into consideration the local ground conditions and use them for micro-zonation of major cities. Self-designed non-engineered homes can be improved enormously by simple inexpensive retrofitting. It is also important to learn to live with earthquakes in earthquake-prone areas. This is where promotion of public awareness plays a vital role. Artificial water reservoirs have triggered damaging earthquakes. There are ways and means now available to find safer sites. A few (four to five) case studies of earthquakes would be very helpful.

Floods

An effort is required to set up sophisticated flood prediction and warning systems as has been already done in many developed countries. It would be important to identify vulnerability of countries to flooding and develop suitable building codes and construction regulations and a robust methodology to implement them. It is also crucial to communicate information related to flood prevention and mitigation to communities for their use. The proposed flood related work would be coordinated with other existing national and international programmes.

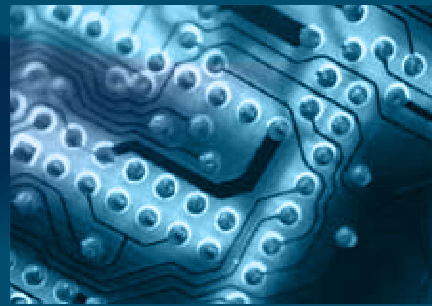
Landslides

Rapid population growth has intensified urban, mountain and coastal development in the Asia and the Pacific region, which are increasing human-induced landslide hazard and landslide vulnerability in urbanized areas. Application of landslide prevention technology is required in areas such as cultural heritage sites and other locations of high-societal values, where relocation and early warning are not possible or very difficult. The most cost-effective measure to mitigate landslide disasters is early warning and evacuation. Timely prediction and early warning technology, suitable for the Asia and the Pacific region should be developed. A few case studies of landslides would be very helpful.

Disaster Management and Capacity Building

It has been recognized that the available scientific knowledge is not being fully utilized in forecasting the hazards, estimating the risks, and the necessary outreach for the benefit of the public, particularly in a large part of the area covered by ROAP. It is important to stress the role of social sciences in understanding hazards and their mitigation; and the role of the private sector and civil societies in building and enhancing regional capacity for disaster reduction, building self-sustaining capacity at various levels for different hazards and establishing continuity in capacity building.

The science plan suggests to develop projects relevant to the problems identified. We hope to improve the situation in the Asia Pacific region with support and collaboration of all concerned so that fewer hazard events develop into disasters.



01
Background

Importance of the Asia and the Pacific (AP) Region

The geographical area covered by ICSU Regional Office for Asia and Pacific accounts for more than one-half of the world's population and for almost 80% of all losses due to natural hazards globally (Figure 1.1). The classical examples in recent years are the Tangshan earthquake of China in 1976 accounting for 242,000 human lives lost; the Kobe earthquake of Japan in 1995 claiming some 6,000 human lives and the economic losses in excess of US$150 billion; the Sumatra earthquake of 2004, the resultant tsunami claiming some 250,000 human lives and unprecedented economic losses; and the Muzaffarabad earthquake of 2005 claiming some 88,000 human lives. Japanese seismologists have estimated that a possible future earthquake of M7.5 in the vicinity of Tokyo would cost about US$1.2 trillion.

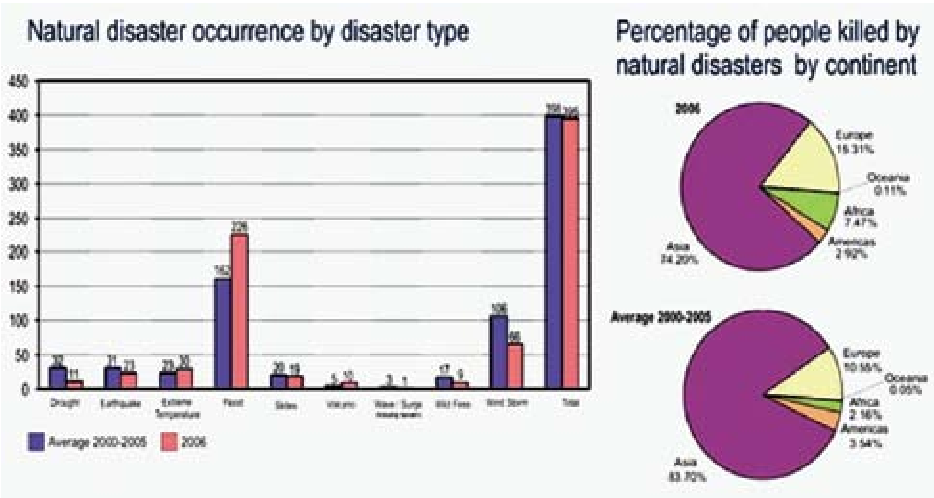


Figure 1.1 Natural disaster occurrences by disaster type and percentages of people killed by natural disasters by continent (Source: UN/ISDR www.unisdr.org; CRED www.cred.be; and EMDAT www.em-dat.net)

In addition to earthquakes, floods have been a major natural hazard in the Asia and the Pacific region. Several serious and dramatic flood events, which were mostly induced by tropical cyclones or torrential rain, have occurred. For example floods and strong winds induced by two tropical storms caused 130,000 deaths

in Bangladesh on 29 April 1991; in China material damage during the summer 1998 floods rose up to US$30 billion; in India, the Mumbai flooding with the unprecedented rainfall of 994 mm on 26-27 July, 2005 caused 1000 deaths and US$750 million worth economical losses. Asia-Pacific region also has significant landslide problems. The landslides in Nepal during 2002 displaced 265,865 people.

Another unique feature of the Asia-Pacific region is the large number of island countries and islands in the region, which are inherently more vulnerable to earthquakes, floods and landslides. At least 40 people died in the Solomon Islands after a tsunami swept ashore following the M8.1 earthquake on 2 April 2007. Tropical cyclone Ami created havoc in the island country, Fiji, and the resulting torrential rains caused the worst-ever flooding in many rivers on Vanua Leve Island of Fiji claiming 17 human lives.

High population densities, poor constructions, inadequate preparations and lack of general awareness among the inhabitants in disaster-prone areas are the major factors contributing to hazards becoming disasters. For example an M6.2 earthquake in Latur, western India, on 29 September 1993 claimed an estimated 10,000 human lives. The reasons for such a large number of lives lost were a very high population density, people living in non-engineered houses, which had little resistance against horizontal accelerations of earthquake, and the fact that the earthquake occurred at about 4 am local time when everyone was asleep inside homes. Most of the self-made homes in Latur and the nearby regions collapsed causing such a large number of deaths.

The Asian region also has to its discredit a large number of cases of triggered earthquake sequences as a result of impoundment of artificial water reservoirs. Earthquake exceeding M6 occurred at Hsingfengkiang Reservoir in China and Koyna Reservoir in India.

As far as floods are concerned, very high population densities and inappropriate uses of natural water outlets increase the flood disaster in the AP region. For example, in Bangladesh as many as 80 million people are vulnerable to flooding each year. In India a total area of 40 million hectares is at risk from flooding each year. The unprecedented flooding in Mumbai on 26-27 July 2005 was due to the 944 mm rainfall in 24 hours and the fact that the natural outlet, River Mithi, was silted and as a consequence had lost most of its carrying capacity. Another factor for the occurrence of floods is the misuse of polythene bags, covers, etc. which are disposed of indiscriminately, chocking the water outlets.

ICSU International Programme on Hazards and Disasters

With the passage of time the impacts of natural hazards continue to increase around the world. The globalization and growth of human societies and their escalating complexity and the changing climate will further increase the risks of natural hazards. The objective of the proposed research programme "Integrated Research on Disaster Risk the Challenge of Natural and Human-induced Environmental Hazards (acronym: IRDR)" would be to undertake coordinated international multidisciplinary research leading to more effective global societal responses to the risks associated with natural and human-induced environmental hazards. This would lead to enhanced capacity around the world to address hazards and make informed decisions on actions to reduce their impacts, such that in ten years, when comparable events occur, there would be a reduction in relative loss of life, fewer adversely impacted and wiser investments and choices made by civil society. The proposed Science Plan would focus on natural and human-induced environmental hazards, including hazards related to hydro meteorological and geophysical trigger events, i.e. earthquakes, volcanoes, flooding, storms, heat waves, droughts and fires, tsunamis, coastal erosion, landslides, aspects of climate change, space weather and impact by near-Earth objects, and related events.

This programme is being developed around three broad research objectives. These are:

1. Characterizing hazards, vulnerability and risk;
2. Understanding decision making in complex and changing risk contexts;
3. Reducing risk and curbing losses through knowledge-based actions.

The overall global benefits of the programme would be dependent on global capacity building and recognition of the value of risk reduction activities, which are likely to come through successful case studies and demonstration projects.

In addition, there would be three crosscutting themes:

1. Capacity building;
2. Case studies and demonstration projects.;
3. Assessment, data management and monitoring.

A preliminary report prepared by the Planning Group was discussed at the ICSU -Unions joint meeting held in Rome, Italy on 23 and 24 April 2007. There were very positive comments and interactions. It was felt that there is a need for more detailed consultations with all the stakeholders. It was therefore decided to approach the CSPR to extend the tenure of the ICSU Planning Group on Natural and Human -induced Hazards till the General Assembly of ICSU in 2008. A discussion meeting with all the stakeholders and a planning group was held from 29 to 31 October 2007 in Paris. The report of the Planning Group will be put for discussion at the ICSU General Assembly scheduled for October 2008.

Rationale of ROAP Interest in Hazards and Disasters

Realizing that the geographical region covered by ROAP accounts for more than 80% of natural and human-induced hazards globally, "Natural and Human-induced Environmental Hazards and Disasters" emerged as a priority area of work for ROAP at its inauguration meeting in November 2006. Later, detailed discussions were held and it was decided that ROAP should concentrate on Hydro-Meteorological and Geophysical Hazards.

At the 3rd ROAP Regional Committee meeting held in Tehran, Iran on 6 and 7 March 2007, there were further discussions, and after taking into consideration several issues pertaining to natural hazards in the ROAP region, it was decided that ROAP shall concentrate on Earthquakes, Landslides and Floods. The Asia-Pacific region has the highest vulnerability, globally, to these three hazards (Tables 1, 2 and 3). It was also realized that the available scientific knowledge is not being fully utilized in forecasting the hazards, estimating the risks, and undertaking the necessary outreach for the benefit of the public, particularly in the Asia Pacific region.

Table 1 Top seven countries affected by earthquakes (From: Centre for Research on the Epidemiology of Disasters, CRED, EM-DAT)

Country	Date	Killed
China P Rep	27 July 1976	242,000
China P Rep	22 May 1927	200,000
China P Rep	16 Dec 1920	180,000
Japan	1 Sep 1923	143,000
Soviet Union	5 Oct 1948	110,000
Italy	28 Dec 1908	75,000
Pakistan	8 Oct 2005	73,338
China P Rep	26 Dec 1932	70,000
Peru	31 May 1970	66,794
Pakistan	31 May 1935	60,000
China P Rep	12 May 2008	95,000
India	26 Jan 2001	20,000

Table 2 Top five countries affected by floods

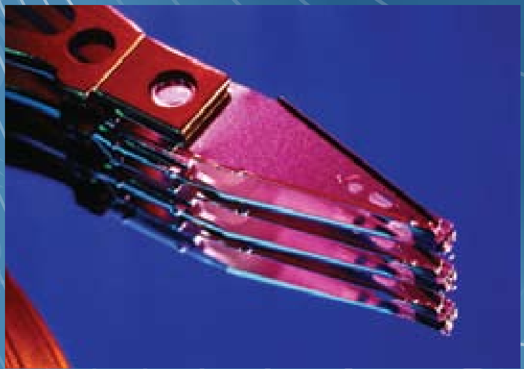
Country	Date	Killed
China P Rep	July 1931	3,700,000
China P Rep	July 1959	2,000,000
China P Rep	July 1939	500,000
China P Rep	1935	142,000
China P Rep	1911	100,000
China P Rep	July 1949	57,000
Guatemala	Oct 1949	40,000
China P Rep	Aug 1954	30,000
Venezuela	15 Dec 1999	30,000
Bangladesh	July 1974	28,700
Myanmar	May 2008	100,000

Table 3 Top seven countries affected by landslides.

Country	Date	Killed
Brazil	11 Jan 1966	4,000,000
India	Jul 1986	2,500,000
India	12 Sep 1995	1,100,000
Afghanistan	13 Jan 2006	300,000
Nepal	15 Jul 2002	265,865
Indonesia	31 March 2003	229,548
Philippines	19 Dec 2003	217,988
India	17 Aug 1998	200,000
Bolivia	Feb 1994	165,000
Brazil	30 Jul 2000	143,000

02

Vision, Aim and Objectives Of The Science Plan



Vision

The plan envisages an integrated approach to the management of natural and human-induced environmental hazards and disasters to reduce the risk of resultant losses of life and property.

Aim

The science plan aims to enhance the science of management of hazards and disasters management in Asia and the Pacific and contribute to reducing the likelihood of hazards becoming disasters.

Objectives

The Natural and Human-induced Environmental Hazards and Disasters Research Programme would undertake coordinated multidisciplinary research leading to more effective societal responses to the risks associated with natural and human-induced environmental hazards in the Asia Pacific region. The legacy of the programme would be an enhanced capacity to address hazards and make informed decisions on actions to reduce their impacts related to loss of lives and properties.

There are several ongoing efforts in the region related to natural hazards and disasters, particularly dealing with earthquakes, floods and landslides. A list of such organizations is provided in Annex III. The ICSU ROAP science plan aims to identify niches and gaps in the current efforts and discover a way to improve the situation, in collaboration with all concerned.

03

Hazards And Disasters In Asia And The Pacific

EARTHQUAKES

Introduction

Earthquakes are one of the worst natural calamities. According to conservative estimates, in recorded history, tens of millions of people have lost their lives in earthquakes and damage has run into hundreds of billions of dollars. In the recent past, the 1976 Tangshan earthquake in the People's Republic of China claimed 242,000 human lives and is qualified to be the deadliest twentieth century earthquake. The 1995 Kobe earthquake in Japan is the most expensive natural disaster and is estimated to have caused economic losses of 150 to 200 billion US dollars. The percentage of human lives lost due to earthquakes in developing countries has increased as shown in Figure 3.1.

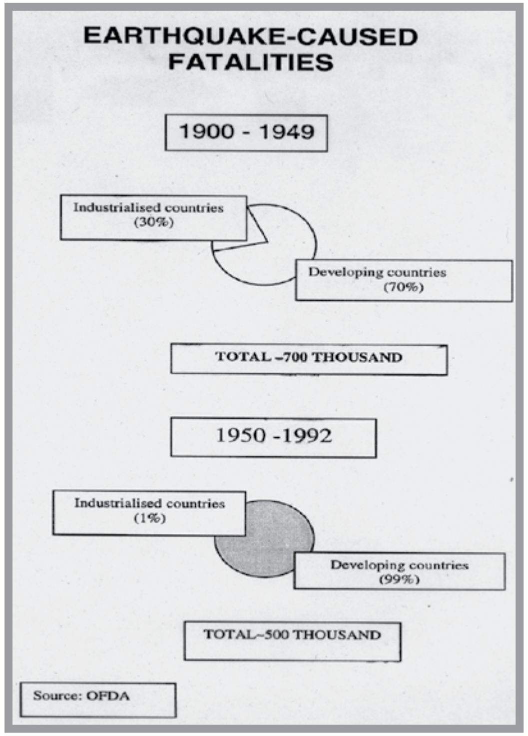


Figure 3.1 Earthquake-caused fatalities. Note the increase in the percentage of human lives lost in the developing countries. (USAID'S office of US Foreign Disaster Assistance)

Global Distribution

During the 1960s, with the deployment of World-Wide Standard Seismograph Network (WWSSN) where about 120 seismic stations with similar equipment were deployed globally, earthquake location capabilities improved by several folds and the plate boundaries in the form of narrow belts of earthquakes were recognized (Figure 3.2). Basically, there are three major belts, which account for almost 95% of earthquake activity.

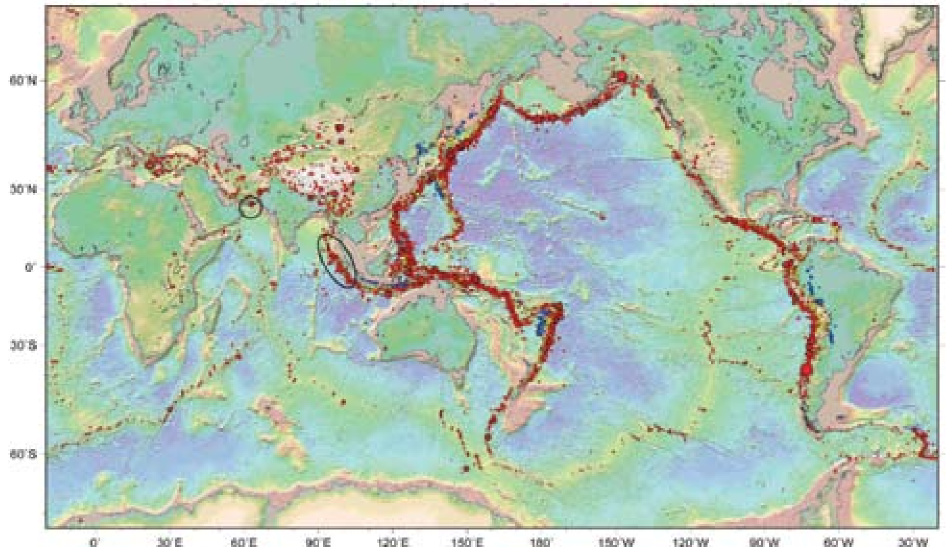


Figure 3.2 The distribution of earthquakes during the period 1900-1999 and major plate boundaries. It may be noted that globally, more than 75% of earthquake energy is released in the circum-Pacific belt, about 20% in the Alpine-Himalayan belt, and the remaining 5% through the mid-oceanic ridges and other Stable Continental Region. For a tsunami to hit Indian Ocean rim-countries it is necessary that a tsunamigenic earthquake occurs and its magnitude is larger than M 7, and the possible locations of such events are indicated in blue circle and ellipse.

The belt along which most of the earthquakes occur is called the Circum-Pacific belt which goes around the rim of the Pacific Ocean right from the southern tip of South America through Central America, California, Aleutian Islands, Japan down to New Zealand. The second most active belt is the Alpine-Himalaya seismic belt which starts from southeast Asia near Java-Sumatra, continues through Andaman Nicobar Islands, India-Burma border region, swings through north India in the foothills of Himalaya and then moves west through Iran into Greece and Italy. The third major seismic belt consists of mid-oceanic ridges, which account for small magnitude earthquakes. These can be seen in Pacific, Atlantic and Indian Oceans. Globally, hundreds thousands of earthquakes occur annually. Approximate annual frequencies of earthquake occurrence in the world are given in Table 4.

Table 4 Approximate annual frequencies of earthquake occurrence in the world (USGS)

Descriptor	Magnitude	Annual frequency in the world
Great	8 and higher	1
Major	7-7.9	17
Strong	6-6.9	134
Moderate	5-5.9	1319
Light	4-4.9	13,000
Minor	3-3.9	130,000
Very minor(micro)	2-2.9	1,300,000
	1-1.9	About 8,000 per day

Monitoring and Observations Systems

At present, there are extremes in earthquake instrumentation in the Asia Pacific region. Some of the countries are among the best equipped anywhere in the world, while there are other counties which do not have even the bare minimum. In addition to seismographs, during the last decades of the 20th century, there has been a revolutionary development in assessing the strain accumulation, which leads to the occurrence of earthquakes. The most practical and popular device is the global positioning system (GPS). Again, there are countries in the Asia Pacific region which are flooded by GPS stations, and others, which do not have an adequate coverage. There is a need to identify gaps.

One of the aims of the ROAP initiative could be to assess the need in various countries and find ways to fill the gaps.

Hazard Mapping

- Hazard Mapping

Recognizing natural disasters as a major threat to human lives and development, the United Nations declared 1990-1999 as the International Decade of Natural Disaster Reduction (IDNDR). The flagship programme of IDNDR was the Global Seismic Hazard Assessment Programme (GSHAP). Under this programme some 500 scientists from all over the world worked to prepare the Global Seismic Hazard Map, which depicts peak ground acceleration (PGA) at the bedrock given in units of meters per second square. Figures 3.3 and 3.4 are the maps of anticipated peak ground accelerations in the ROAP region. A major effort could be to estimate the accelerations at the surface and use them for micro-zonation of major cities. Figure 3.5 shows the plate motions as computed using GPS and other devices for the Asia Pacific region.

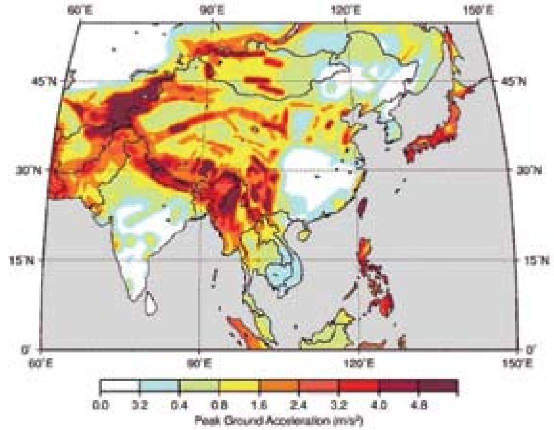


Figure.3.3 Seismic hazard map of Asia depicting peak ground acceleration (PGA), given in m/s2, with a 10% chance of exceedance in 50 years (www.seismo.eth.ch/GSHAP/)

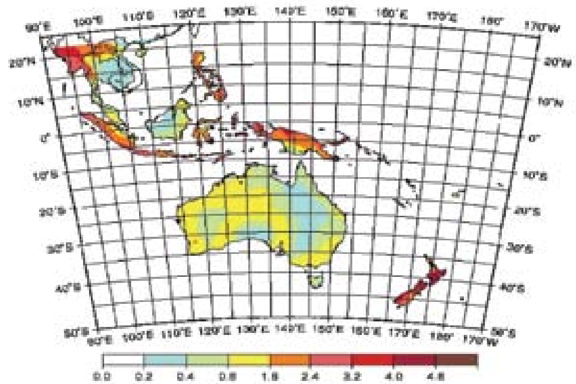


Figure 3.4 Seismic hazard map of the Australia-South Pacific-Southeast Asia region depicting peak ground accelerations (PGA), given in m/s2, with a 10% chance of exceedance in 50 years.

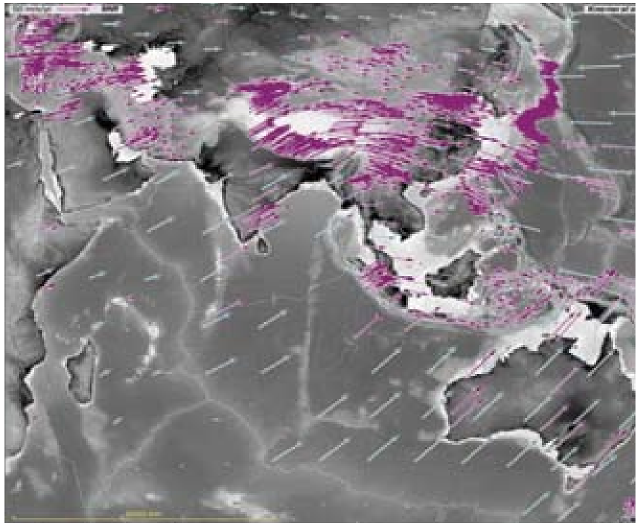


Figure 3.5 Plate motion (in ITRF 2000) in Asia and Pacific region (Kreemer et al. 2003) (Geophys.J. Int., 154,8-34)

• Earthquake Scenarios

A very important issue is to develop earthquake scenarios. In an interesting study, it was investigated that if the Kangra earthquake of 1905 in the foothills of Himalaya in India repeats, how many lives would be lost. The 1905 earthquake had claimed around 20,000 lives. It is noted that with the passage of time the population density in the Kangra region has increased several folds over the last 100 years; at the same time, the style of making homes/dwellings has totally changed. Earlier most homes were single-storied wooden houses, whereas now there are two- or three-stories non-engineered houses, which have little strength to withstand horizontal accelerations. Wood is simply not available for construction. The result is that the estimated loss of lives has increased, as shown in Table 5.

Time of occurrence	Deaths in collapsed house (%)	Deaths in part-collapsed house (%)	Total potential deaths
Midnight (sleeping)	40	20	344,000
Morning (awake and sleeping)	20	10	177,000
Noon Time (out working)	10	5	88,000

Table 5 Estimates of human lives likely to be lost if the Kangra Earthquake of 1995, which claimed 20,000 lives, was to occur today (Arya, 1992)

The Muzaffarabad earthquake of 2005 occurred in similar environment at about 9 am local time and claimed 73,338 human lives. This justifies the estimates of the lives likely to be lost in a future Kangra equivalent earthquake. Similar estimates are available for certain parts of the Asia Pacific region.

It is necessary to develop earthquake scenarios for many countries such as Myanmar, Thailand, and others.

Prevention and Mitigation

• Building Codes

Building codes exist for several parts of the Asia Pacific region. However, the most important issue is their appropriate implementation. In the Asian Seismological Commissions deliberations held in Yerevan, Armenia, in 2004, this issue was discussed at length and the conclusion was that while in the developed world the loss of human lives by earthquakes has decreased, there is an increase in the economic losses. But in the developing world, there is an increase in both, the human lives lost and the economic losses. A major cause of this is inappropriate implementation of the building codes.

So a major effort is required in assessing the current status of building codes, their appropriate development where required and implementation.

• Micro-zonation

For major cities located in earthquake-prone areas, it is important to develop micro-zonation maps, which are useful in constructing earthquake resistant structures. These maps basically depict anticipated accelerations at ground surface in different spectral frequencies. Appropriate micro-zonation has been carried out for several cities in Japan, China, India and elsewhere. Figure 3.6 gives a micro-zonation map of Jabalpur in India.

A major effort is required to make use of the GSHAP calculations which provide anticipated accelerations at the bed rock and by appropriately calculating the effect of media between the bed rock and ground surface, computing the accelerations on the ground and then estimating the risk taking into consideration several other factors such as the liquefaction potential, quality of construction, and population density. It is important to carry out this effort for major cities in the earthquake-prone areas of the Asia Pacific region.

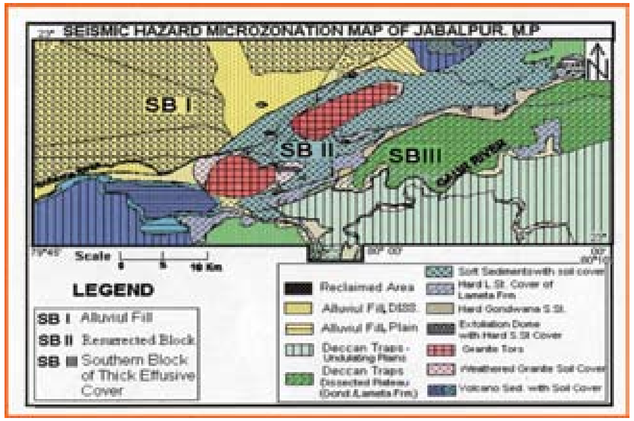


Figure 3.6 First order microzonation map of Jabalpur, M.P. (DST, India, 2007)

• Education and Awareness

It is extremely important to learn how to live with earthquakes. A lot of material is available indicating what to do before, during and after an earthquake to reduce vulnerability against it. Several countries have developed earthquake drills, which are performed to increase the level of preparedness and test the effectiveness of various countermeasure devices and schemes. For example, an exercise is conducted on 15 January every year at Katmandu, Nepal, in memory of the devastating Bihar-Nepal earthquake of 15 January 1934, which had devastated Katmandu.

• Non-engineered Structures

A large population of the ROAP region lives in self-designed non-engineered homes. Such homes are very vulnerable to horizontal accelerations generated by earthquakes. Methods are now available where such houses can be considerably strengthened against earthquakes by some simple approaches. Several years ago a training course was developed to interact with individuals in the rural areas and educate them in strengthening their dwellings. This can be undertaken as a major initiative with collaboration with UNESCO and other possible partners

• Warning Systems

Earthquakes

As of now, earthquake forecast is not possible for practical applications. However, it is known that earthquakes generate body and surface waves. Surface waves are mostly responsible for the damage. As the velocity of the surface waves is much slower (~ 3 km/s) compared with the velocity of longitudinal body waves (~7 km/s), and if the epicenter of the damaging earthquake is located some 300 km away from a major city, and there is a good network of seismic stations in the vicinity of the epicenter, the earthquake could be detected and magnitude measured in 25 to 30 s. However, the surface waves will take about 100 s to reach the city. Under such conditions, there is a lead time of about a minute, which could be utilized in shutting off the electric supplies, gas lines, and passenger trains, as well as getting people out of vulnerable spots. To implement such a scheme, a lot of infrastructure and training is required. Efforts are being made in Mexico and Japan in this direction.

Tsunamis

Tsunami warning is a reality. Occurrence of a large earthquake in a tsunamigenic zone is a necessary but not sufficient condition for the generation of a tsunami. Travel times of tsunamis from various locations to coasts have been calculated. Once a tsunamigenic earthquake is detected, warning of the time of arrival and amplitude of a tsunami at specific locations is announced. This service has been available for the past several decades for countries located on the coasts of the Pacific Ocean by the Pacific Tsunami Warning Centre. However, there have been several false alarms. Consequent to the devastating tsunami caused by the 26 December 2004 Sumatra earthquake, efforts are under way to develop robust tsunami warning capabilities in the Indian Ocean by Australia, India, Indonesia and other countries.

India has recently succeeded in setting up a state of art “Tsunami and Storm Surge Warning Centre”. The uniqueness of this system is the deployment of ocean-bottom pressure recorders at strategic locations for the two-tsunamigenic sources in the Indian Ocean. The system performed very well during the recent tsunamigenic earthquakes of M 8.4 and 8.1 on 12/13 September 2007. Table 5a gives the forecasted times of arrival and amplitudes of tsunamis at a number of locations, and the actual observations. The timely warning has now become a reality. It has been discussed and accepted that the sources shown in Figure 3.2 are the only sources for major tsunamis for the Indian Ocean rim countries. It would be useful for other Asia Pacific countries likely to be affected by tsunamis to develop facilities to receive tsunami warnings and act appropriately.

Indian National Center for Ocean Information and Services (INCOIS) 2007 generated a database of model scenarios considering various earthquake parameters. For the 12 September 2007 event scenario, Ids 28.2 and 29.2 were picked from the scenario database. They were used to calculate the estimated travel time and run up heights at various coastal locations and water level sensors, tide guages & Bottom Pressure Recorders (BPRs) and tidal stations as evident from Table 6.

Table 6 Estimated and actual times of arrival and tsunami amplitudes at a few locations as forecasted by INCOIS.

Location	Estimated arrival time (h)	Estimated water level (cm)	Observed arrival time (h)	Observed water level (cm)
Padang	1751	80	1754	60
Coco's Island	1748	40	1748	50
Sahang	1903	20	1903	30
TB 3	1903	2	1913	1
TB10A	1931	1	1941	2
TB10	1930	2	194	1
Port Blair	2010	10	2013	8
Chennai	2105	20	2110	18

- Triggered Earthquakes

Artificial water reservoirs are built all over the world for flood control, irrigation and power generation. Under certain geological conditions, these reservoirs could trigger earthquakes. Triggered earthquakes exceeding magnitude 6 have occurred at least at four sites including two in the Asia Pacific region. As of now, over 100 sites of triggered earthquakes are known globally (Figure 3.7). Ways and means are now available to find safer sites. These should be taken into consideration while searching suitable sites for artificial water reservoirs.

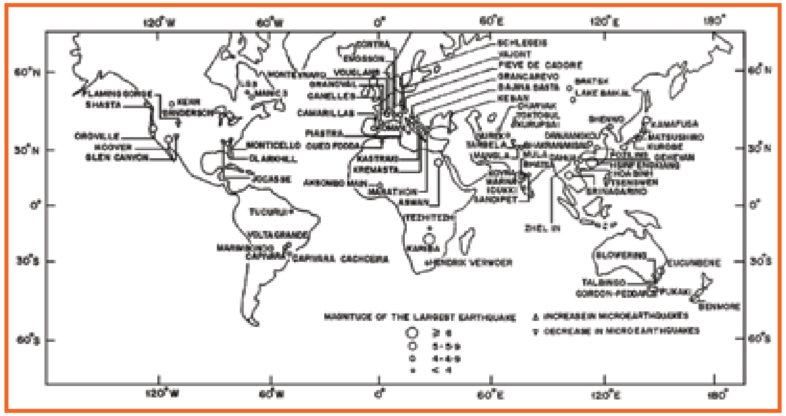


Figure 3.7: Global distribution of known sites of earthquakes triggered by artificial water reservoirs. Earthquakes exceeding magnitude 6 occurred at Hsingfengkiang, China and at Koyna, India in the Asia Pacific region (Gupta 2002)

Case Studies

It would be a good idea to have a few case studies of earthquakes in the ROAP region to understand the genesis of the disasters and the lessons to be learnt so that adequate preventive measures could be undertaken. The interesting case studies would be the Tangshan earthquake (China, 1976), Kobe earthquake (Japan, 1995), Bhuj earthquake (India, 2001), Bam earthquake (Iran, 2003), Andaman-Sumatra earthquake (2004) and the case of earthquakes triggered by artificial water reservoir at Koyna (India, 1967). A lot of material already exists for these cases. What is needed is to draw lessons to be learnt from them.

Linkages

Earthquakes, floods and landslides in several ROAP regions are totally inter-related. Such areas need a special attention. Specific projects would be developed in consultation and co¬operation with national, regional and international programmes.

Suggested Areas of Project Development

1. Assess the need of a minimum seismic and GPS network in needy ROAP countries and find ways to fill the gaps.
2. Develop earthquake scenarios for countries where devastating earthquakes could cause damage to life and property.
3. Prepare building codes, micro-zonation for major cities located in high intensity earthquake belts, and find ways and means for their implementation.
4. Educate and distribute literature as to what to do before, during and after earthquakes to reduce their impact.
5. Adopt simple inexpensive techniques available to strengthen non-engineered structures against earthquakes.
6. While constructing of artificial water reservoirs, adequate care should be taken to make use of the latest knowledge to find safer dam sites.
7. Countries located on the Indian Ocean rim should develop capabilities to suitably act on tsunami advisories.

FLOODS

Introduction

Floods are a major natural hazard in the AP region. For example, in Bangladesh, one of the most flood-prone countries in the region, as many as 80 million people are vulnerable. Many dramatic flood events have been recorded historically, mostly induced by tropical cyclones or seasonal rains, such as the tropical storms in Bangladesh in April 1991 that caused 130,000 deaths and the summer floods of 1998 in China that resulted in material damage costing US$30 billions. Floods also cause loss of top soil, which affects the fertility of land

Figure 3.8 Images of disastrous flooding in Mumbai, India, after an unprecedented rainfall of 994 mm on 26-27 July 2005, causing 1,000 deaths and economic losses of US$750 million.

Floods can be generally classified into four types:

1. Coastal floods – Fierce winds in tropical storms can drive ocean water onto low-lying coastal land. Coastal inundation can also be produced by tsunamis that are created by submarine earthquakes, landslides or volcanic eruptions.

2. Flash floods – Gullies or normally dry creek beds found in semi-arid areas can quickly become powerful fast-flowing torrents during storms.

3. River floods – Flooding along river margins is a natural event. Most floods occur seasonally, either when winter snows melt and combine with spring rains (in temperate regions) or in heavy rains of the wet/monsoon season in tropical and sub-tropical regimes.

4. Urban floods - As urban land is developed and paved, it loses its ability to absorb rainfall. In intense rainstorms, rainwater quickly becomes runoff. Inadequate man-made drainage culverts may overflow and flood low-lying urban settlements.

5. Clouud burst - Sudden copious heavy rainfall in geographically small areas can cause floods.

With the rapid economic development of the AP region, especially low-lying coastal areas, a rising toll (lives and property) from flood disasters highlights the need for reducing the potential risks and advancing the techniques of flood management. Recent developments in hydrological and meteorological sciences provide the opportunity for further improvements in flood forecasting, flood risk management, improvement in flood warning systems and Integrated Water Resources Management (IWRM).

Flood Prevention and Mitigation

An enormous amount of highly-diverse information is generated by governmental agencies, international organizations and relief agencies during the occurrence of a flood disaster. How can this information form the basis of flood disaster prevention and mitigation and how can people be educated to use this information appropriately? One area of effort is to educate communities, families and individuals on the potential hazards and actions necessary to ensure safety in the event of a hazard warning.

Mitigation research also focuses on the identification of vulnerable areas and better enforcement of building codes, construction regulations and evacuation procedures. Training, education and establishment of coordinated action plans involving all partners (such as national hydrometeorological services, emergency services, the military, international NGOs, Red Cross and Red Crescent Societies), are all part of long-term mitigation.

Demonstration Studies, Projects and Interdisciplinary Linkages

It is important to conduct post-event studies of disastrous floods 1) to understand better the disaster processes, 2) to develop new disaster-reduction strategies, 3) further improve flood prediction, and 4) enhance local and regional capacity to mitigate against such events in the future.

Candidate cases suggested are:

1. Storm floods in India. The Mumbai flood after the unprecedented rainfall of 994 mm on 26-27 July 2005 caused about 1,000 deaths and US$750 million in economic losses. This case is particularly good for investigating rain-induced flood disasters.

2. Seasonal floods in Bangladesh: Bangladesh lies across the floodplains of three major rivers, Brahmaputra, Meghna, and Ganges, forming the largest river delta in the world. The country is densely populated and when the rivers run high, much of Bangladesh can be flooded affecting a vast number of people, as in August 2007. This case is suitable for investigating floods caused by monsoon rains and melting snow from the Himalaya mountains.

The purpose of additional demonstration projects will be to show the benefit of integrated approaches, new tools, and techniques that are applicable to reduce the effects of flood disasters. Key aims are:

1. Flood monitoring in a targeted area: to demonstrate the benefits of transition from research to application.

2. Ensemble prediction of flood hazards: to demonstrate the new ensemble flood forecast with a prototype hydrometeorological ensemble forecast model driven by a multiglobal forecast model under the framework of the World Weather Research Programme of the World Meteorological Organization, for enabling risk reduction strategies in the countries most vulnerable to flood disasters.

3. Integrated flood management of a big river basin (e.g. the Yellow River in China): to demonstrate integrated basin flood management to reduce vulnerability while still preserving local ecosystems and biodiversity.

Floods are closely associated with extremes of the Earth's climate system, and the effects of global warming, climate change and increases in heavy precipitation are now being felt in many parts of the AP region. As a consequence, flood-generation mechanisms are becoming more complex. Seasonal variation and geographic distribution of many flood-causing factors add to complexity. Flood disaster management will therefore benefit from new and strong linkages with existing research programmes on, landslides, health (water-borne diseases), economic and social vulnerability.

Improving Monitoring Systems

Better monitoring of hydro-meteorological events is the foundation for reducing flood disasters. Observations create the database for numerical forecast models as well as provide long-term records for hazard monitoring. One of the main responsibilities is to develop region-wide flood observation networks, and for this it is necessary to coordinate national hydrological and meteorological services better, and to integrate them to be more efficient and effective. Part of the challenge to improve weather and associated flood forecasts is deployment of new observation systems such as automatic stations, Doppler radar, sodar, lidar, satellite-based observing systems and other GPS-GIS platforms. Collaboration with existing international programmes is also important such as GEO and GEOSS (Group on Earth Observation and the Global Earth Observation System of Systems).

Predictability, Hazard Assessment and Regional Flood Warning Systems

There are two major approaches to flood forecasting. The empirical prediction approach is based on statistical data, while numerical prediction is based on the physical laws governing the geophysical fluids (hydraulic flow and atmospheric motions). A numerical forecast system generally consists of two major parts: initialization (generating the initial conditions) and model integration for producing the forecast. Uncertainties related to initialization and model integration are two important factors, so flood predictability research should focus on quantification of these uncertainties and construction of ensemble prediction system (EPS - defined as a collection of individual forecasts made from slightly different initial conditions and/or model formulations).

Other research issues for flood forecast models are to develop: i.) Data quality control for different hydrological and meteorological observation systems; and ii.) key forecast model components, including the Land Data Assimilation System (L-DAS) and Atmospheric Data Assimilation System (A-DAS) for hydrological and meteorological forecasting. The key components can be coupled for setting up an alternative to flood-prediction systems based on in situ observations and satellite and radar remote-sensing.

Most developed countries have quite sophisticated flood prediction and warning systems, but these do not extend to the developing countries of the AP region. Efforts should be made to establish a functional regional flood warning system. This involves two initial steps: first, development of a big river basin flood warning system; and second, transfer this towards a regional flood prediction and warning system.

Major Research Activities

• Geographical Flood Hazard Mapping

Information on historical flood events is very useful for the prevention and mitigation of future disasters. A sound investigation of previous worst flood events needs to be carried out for basins, communities and villages. Based on these investigations, it is possible to draw up flood risk maps in the AP region, to be used to design or optimize structural and non-structural flood control measures.

• Investigations of Flood Mechanisms

Floods are a part of natural hydrological cycle, so research should advance knowledge of the regional influences on: i) Weather systems responsible for heavy precipitation (such as tropical cyclones, Meiyu fronts, meso-scale convection); ii) hydrology of surface runoff process; iii) Impacts of urbanization and population growth on flood vulnerability and management strategies.

• Effects of Climate Change

Several climate models indicate temperature increases of the order of 0.5-2°C by 2030 in the AP region. Models also indicate increases in precipitation for most of the region and particularly during monsoon periods. The region will be affected by rising global sea levels. The combination of these influences means that many nations within the region will have to struggle to cope with cyclones, monsoonal rainfalls and tidal extremes.

Suggested Areas of Project Development

1. Research to increase existing knowledge of the multidisciplinary influences on flood hazards in the AP region. Key areas to address are: i) advancing the capability of hydrometeorological sciences; ii) analysis of flood processes and the factors influencing societal vulnerability; iii) improving our current accuracy of predicting both extreme weather events and associated flood hazards; iv) understanding the potential impacts of climate change on worsening flood risk scenarios.

2. Improvement of flood monitoring systems at both national and regional scales by targeting the following activities: i) optimizing the in situ hydrological and meteorological networks at national levels; ii) enhancing observational networks in key flood-prone areas; iii) expanding the use of satellite, airborne and new land-based observing technologies; iv) better coordination of existing observation systems with other international programmes.

3. Contribution to the development of advanced early-warning systems. This effort should focus on: i) improving weather and hydrological forecast models; ii) developing effective communication systems of hazard warning information to decision-makers and the general public; iii) evaluating the utility of multi-hydro-meteorological model ensemble prediction systems; iv) encouraging better collaboration between national meteorological and hydrological services.

4. Enhancing preparedness and mitigation of flood hazards through: i) use of flood-hazard maps; ii) adopting integrated flood management approaches; iii) training in the use of flood hazard information to reduce vulnerability; iv) facilitating the transfer of research results to practical applications, particularly in the developing countries of the Asia Pacific region.

LANDSLIDES

Introduction

Landslides and their disaster reduction are addressed in various fields of science, engineering and administration. The new definition of Landslide is “Movement of a mass of rock, debris or earth down a slope”. It is basically the gravitational mass movement of materials comprising subaerial and subaqueous slopes.

Landslides are classified by combination of types of movements (slide, flow, fall, topple and spread) and types of material (rock, debris, earth) such as rock slide, debris slide, debris flow, earth flow and rock fall. Topple is a rotational forward movement and spread is movement mostly on a flat ground. Topple and spread are minor groups (Figure 3.9).

Landslides often travel over long distances. The type of movement may change during the process. It is expressed as debris slide–debris flow and rock fall–debris flow.

Landslide Causes

A movement of mass is initiated by "shear failure" of materials, when shear stress is equal to or greater than shear resistance on a slope. Therefore, landslides can be caused by either increase of shear stress, or decrease of shear resistance on the slope.

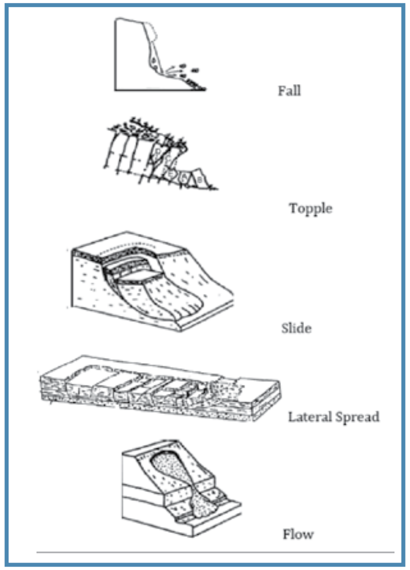


Figure 3.9 Types of movement of landslides (Cruden and Varnes 1996)

• Increase of Shear Stress

Earthquakes provide additional stresses. The shear failure may be initiated by this dynamic stress due to earthquakes and shear displacement may occur. Shear resistance after failure often decreases due to high pore-water pressure generation along the shear zone. In this case, landslide movement may continue after the earthquake shaking. It is noticed by recent research that liquefaction may take place along the shear zone due to grain crushing during shearing termed as sliding-surface liquefaction. Thus, a gentle sandy slope may be susceptible to earthquake-induced landslides.

Tectonic movement and volcanic activity may increase the angles of slopes along a fold or in volcanoes, which may increase shear stress in the long term.

Erosion and deposition in natural process and cutting and filling by humans may increase shear stress at a slope.

River erosion and coastal erosion are major causes of landslides. Development of urban, mountain and coastal areas is necessarily accompanied by cutting or filling of slopes. It may increase shear stress. In residential development, natural river beds are often filled with soil to make a flat ground. Such filling will make an unstable slope susceptible to earthquake-induced landslides even when the slope is very gentle.

• Decrease of Shear Resistance

Pore-water pressure change: Shear resistance decreases due to normal stress working on a shear surface and due to pore pressure reducing the effect of normal stress. Pore-water pressure increases by infiltration of water into the ground due to rainfall, snowmelt (natural phenomena), damming of water, irrigation, leakage of water pipes or drainage system along roads and other causes associated with anthropogenic activities.

Weathering may decrease shear resistance of rocks or deposits inside a slope in the long term. In the cut slope, newly exposed rock surfaces are affected by relatively rapid weathering.

Groundwater may flow through natural pipes or pores of grains or joints of rocks at a relatively fast speed. It may cause transportation of fine soils and decrease shear resistance and often create a meta-stable soil layer, which may be affected by liquefaction or high pore-pressure generation in dynamic loading.

• Climate Change in Landslide Initiation

This is not yet well studied. However, the following may help the landslide initiation mechanism. Global warming may intensify landslides by the retreat of glaciers which have stabilized valley-side slopes, and the melting of permafrost which has stabilized slopes in permafrost areas; increase of sea water levels would increase pore-pressure inside slopes along glacier lakes and other areas.

Natural slopes are affected by rainfalls and unstable slopes will fail. The occurrence of new landslides is governed by the progress of weathering and topographical changes due to natural and human activities.

However, climate change affects the pattern of rainfall and snow melt in many regions. Heavier and longer rainfalls may cause new landslides.

The increased frequency of heavy rains and earthquake occurrences, as is the case of the 2004 Niigata-Chuetsu earthquake after a typhoon in Japan may also cause landslides. This has caused 12 large-scale landslides amounting to displacement of more than one million cubic meters of earth. The 2006 Leyte landslide, in the Philippines, triggered by a small nearby earthquake after heavy rains, killed more than 1,000 people. Combination of earthquake and rainfall may cause catastrophic landslides as shown in Figure 3.10.

Figure 3.10 A large-scale rapid landslide triggered by a small nearby earthquake, five days after a heavy rainfall in February 2006 in the Philippines, claimed more than1, 000 lives. (Taken by Kiminori Araiba)

Monitoring and Observations Systems

Monitoring of landslide velocity is of great importance in landslide-hazard evaluation. It has been observed that velocity varies widely for different kinds of landslide.

Knowledge of landslide frequency is essential for probabilistic hazard evaluation. Therefore, it is important to date landslides. Furthermore, the evaluation of the age of the landslide permits correlating the trigger to the possible cause such as earthquake or period of intense rain. The cause of landslide trigger has changed in geological times. For example in some Alpine areas, landslides of the Pleistocene age were connected with particular tectonic, geomorphological and climatic conditions, which do not prevail now.

Predictability and Hazard Assessment

Although landslide can be mitigated by engineering works, these should be cost-effective. Hence, low-cost technology engineering design should be available, especially in the developing world. Technology transfer is to be encouraged.

To develop an early-warning system for landslides is most difficult. However, efforts in this direction need to be encouraged, especially in areas of high population density. False warnings are likely, but are a part of development.

Among elements to be considered in the system are the area that will be affected, and the possible loss of life and property. The early warning system should not only be restricted to mapping of vulnerable areas but also zoning of the potential hazards and disasters.

The system should be continuously upgraded, and public awareness increased in both urban and rural areas.

Prevention and Mitigation

Landslide may be prevented by stabilization of slope. There are three basic approaches:

1. Geometric methods, in which the geometry of the hillside slope is changed. Rock slope and soil slope geometric modifications will require different techniques.

2. Hydrogeological methods, in which an attempt is made to lower the groundwater level or to reduce the water content of the material.

3. Mechanical methods, in which attempts are made to increase the shear strength of the unstable mass or to introduce active external forces (e.g. anchors, rock or ground nailing) or passive external forces (e.g. structural wells, piles or reinforced ground) to oppose the destabilizing forces.

Linkages

• Human Activity

The DFID Landslide Risk Assessment project has attributed the rise in the annual number of landslides in Nepal since 1995 to anthropogenic activities. This is illustrated in Figure 3.11, based on a detailed landslide database compiled for Nepal for the period 1968 - 2002.

In recent years it has become increasingly apparent that humans are the key factor in the initiation of landslides.

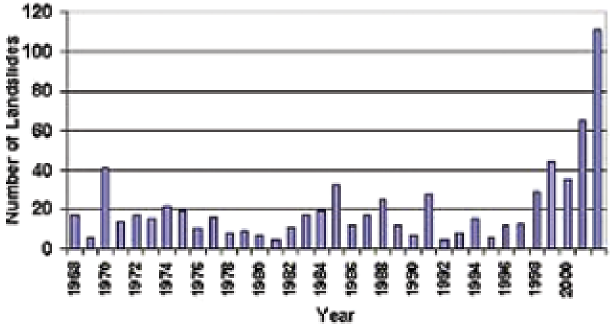


Figure 3.11 Numbers of landslides per year in Nepal

It is clear that since the mid-1990s there has been a substantial increase in the occurrence of landslides in Nepal, probably associated with human activities. Humans are a cause of landslides rath5er than a trigger for example destabilizing a slope through excavation. Extensive mountain urban development, irrigation, deforestation and forest burning also cause an increase in landslides.

• Climate Change

The IPCC's Fourth Assessment Report has underlined the vulnerability of developing countries to climate change and its consequences, particularly in the Asia and Pacific region.

Landslide research and prevention should consider climate change and variability, especially in terms of rainfall regimes and their effect on landslides.

• Cooperation with other international initiatives

Landslides are fully or partly targeted by other international initiatives. They include International Programme on Landslides (IPL) by ICL, UNESCO, ICSU, IUGS, WMO, IFI, IGCP, IOGS, IYPE and others.

Suggested Areas of Project Development

1. Development of new technologies for landslide risk mitigation:

- Reliable landslide hazard and vulnerability zonation to identify landslide risk for land-use planning to avoid landslide disasters.
- Early warning technology suitable for natural and social conditions of the Asia Pacific region to mitigate landslide disasters.
- Methods to reduce landsides or landslide prevention technology for areas such as cultural heritage sites and other locations of high-societal values.

2. Promotion of interdisciplinary studies on the relationships between landslides and earthquakes, tsunamis as well as rainfalls, volcanic activities and forest fires:

- Large landslides are triggered by earthquakes, or particularly earthquakes after rainfalls. Dynamic effects of earthquake and the combined effects of earthquake and rainfall are not yet well understood.
- Submarine large-scale landslides have caused catastrophic disasters, some causing tsunamis. Dynamics of large-scale landslides is similar to the dynamics of faults because both are "failure" of rocks or soils. The frictional heat in shearing under a high pressure may take a critical role for rapid motion, which is not yet well studied.
- Volcanic eruptions or disturbance cause landslides, debris flows and pyroclastic flows. Volcanic earthquakes trigger large-scale landslides. Forest fires also cause shallow landslides and debris flows.

3. Contribution to the developments of monitoring and observing systems of landslides from national to regional scales, from ground to satellite in cooperation with other international initiatives such as the Integrated Global Observing Strategy for Geohazards (IGOS-Geohazards).

4. Enhancement of international cooperation in education, capacity building, and technological transfer to developing countries in cooperation with other initiatives such as the UNITWIN (university networking and linking) Cooperation Programme "Landslide Risk Mitigation for Society and the Environment".

DISASTER MANAGEMENT AND CAPACITY BUILDING

Introduction

Natural disasters (e.g. landslides, earthquakes and floods) can have a significant impact on the welfare of an entire nation. Their occurrences have major socio-economic and health impacts. These include human lives lost; spread of diseases; damage to private and public properties such as crops, livestock, forests, structures and installations; causing psychological stresses and traumas and disrupting livelihoods due to loss of employments, incomes and opportunities.

For example, the recent Kashmir earthquake in Pakistan on 8 November 2005 killed 73,338 people while 106,000 were injured. In Bangladesh, floods in 1987 to 1998 caused major damage to infrastructures, agriculture, crops, livestock and dwellings, estimated between US$0.45 billion to US$2.00 billion.

Disaster risk management consists of a range of policies and practices developed to prevent, manage and reduce the impacts of disasters, and include the following:

1. Mitigation-prevention – actions taken before or after a hazard event to reduce impacts on people and property;
2. Preparedness – policies and procedures designed to facilitate an effective response to a hazard event;
3. Response – actions taken immediately before, during and after a hazard event to protect people and property and to enhance recovery; and
4. Recovery – actions taken after a hazard event to restore critical systems and livelihoods and return a community to pre-disaster conditions.

Role of Social Sciences

Within the scope of disaster management, the role of social sciences would be to strengthen socio-economic research activities on impacts of a disaster, estimating its economic losses and losses avoided due to implementation of appropriate disaster risk reduction (DRR) measures. This entails undertaking a coordinated research leading to more effective societal responses to the risks associated with natural and human-induced environmental hazards so as to make informed decisions on actions to reduce their impact.

The research plan envisages an integrated approach to natural and human-induced environmental hazards through a combination of natural, health, engineering and social sciences. The role of social sciences will be in terms of socio-economic impact analysis; enhancing capacity in disaster management and response; enhancing the roles of education, awareness and communications; and public and political response to reduce the risk.

Part of the socio-economic research would be to create a database of lessons learned from experiences, best practices and success stories, in terms of impact analysis and disaster management and risk reduction. Case studies of impact analysis, using a common research design and a common template for data collection and analysis, would be important for the region.

• Improving the quality of decision-making

Factors that can affect decision-making include the quality of the information available and the manner in which this information is processed by individuals, groups and systems. In terms of socio-economics, information on settlements and communities located along hazard zones would be useful in providing assistance to these deserving in cases of calamities.

The cost-benefit analysis has the potential to provide the decision-making 'tool' – for defining problems and scoping the costs and benefits of alternative solutions. These may improve the quality of decision-making as to whether to invest in disaster risk reduction measures, and where.

• Economic valuation of losses and damages

Attempts to quantify the monetary value of socio-economic impacts may not be straightforward. Estimates for these impacts can be broken down in terms of direct costs, indirect costs and secondary impacts. At the macroeconomic level, estimates have tended to focus on the direct costs, and the indirect costs of disaster are often not estimated.

- The Direct costs include loss of physical and human capital, the costs of relief, and clean-up operations, rehabilitation, reconstruction, replacement, rebuilding, repair or maintenance.

- The Indirect costs are due to secondary impacts, such as loss of output and investment. Macroeconomic imbalances caused by disasters often result in debt and/or poverty.

Indirect costs include all other costs incurred indirectly as a result of the disaster.

These include:

1. reduced real estate value in areas threatened by disaster;
2. loss of tax revenue on properties devalued as a result of disaster;
3. loss of industrial, agricultural and forest productivity, and of tourist revenues: a result of damage to land or facilities or interruptions of transportation systems;
4. loss of human or domestic animal productivity due to death, injury or psychological trauma;

5. costs of measures to mitigate potential disaster activities, such as earthquakes, landslides and floods;
6. the consequences of diverting government expenditure to relief efforts, etc.

The focus on direct damage is largely due to the fact that there are difficulties in accounting for indirect and non-monetary damage and because economic studies of this nature are, not surprisingly, a low priority in the post-disaster recovery efforts.

Private Versus Public Costs

The direct and indirect costs as listed above may be further classified into private or public costs depending on who bears the burden of the costs or losses. Direct private costs are losses incurred by private or corporate entities, such as damage to land and structures belonging to property owners, either individual or companies. Indirect private costs include reduction in productivity of agricultural crops and domestic cattle, and reduction in revenue due to damage or losses to crops and livestock.

Public direct costs are those borne by government agencies, at national, state or local levels, mostly for repairs or relocating highways, roads and other structures such as storm drains. These may be the largest direct costs borne by public agencies. Indirect public costs come in the form of losses of tax revenues, reduction of transmission capabilities of lifelines, reduction of productivity of forests, impact on quality of fisheries, etc.

• Macroeconomic Costs of Disasters

Several studies provide estimates of the macrolevel impacts of disasters. These include impacts on key macroeconomic variables (e.g. GDP growth), on particular sectors of the economy (e.g. agriculture), and total damage costs to physical and human capital at the national level. Macro-impacts of disaster impinge on national economic parameters such as GDP, employment, consumption, and business sentiments. Loss of potential incomes from tourism and investments may also occur. At the sectoral level, reduction in sectoral production (agriculture./ industries/services) may occur, affecting employment, household incomes, consumption, expenditure, etc. through the industry-household linkages.

The magnitudes of these impacts depend on the sizes and durations of disasters, the structure of the economy, measures taken ex-ante to mitigate any impacts, the government's policy response to the shock, and the amounts and forms of external assistance. Most assessments of disaster impacts only focus on quantifying immediate direct damage in financial terms (i.e. the non-market economic costs such as the value of lives lost, are not addressed).

The economic costs consist mainly of immediate damage assessments, in order to provide governments and donors with estimates of the amount of funds required to address emergency and reconstruction needs and by insurance companies for compensation. Long-term indirect costs in terms of flow of goods and services, reduced level of production and non-market impacts such as environmental damage and psychosocial effects are frequently omitted from such assessments (DFID, 2005).

It is estimated by the World Bank that during 1990-2000, natural disasters resulted in damage that constituted constituting between 2 and 15 percent of an exposed country's annual GDP. Table7 shows the impact of natural disasters in terms of the percentage of annual GDP for several countries around the world. The estimates are based on 'large' scale disasters as interpreted by the countries affected. The damage represents the costs of replacing physical assets at current prices. These estimates are consistent with those provided by the IMF, which demonstrated that between 1997 and 2001 the damage per large disaster was over 5 percent of the GDP on average of low-income countries (DFID, 2005).

Table 7 Impact of natural disasters on GDP, 1990-2000

Country	Date
Argentina	1.81
Bangladesh	5.21
China	2.5
Jamaica	12.58
Nicaragua	15.6
Zimbabwe	9.21

Source: DFID, 2005.

• Microeconomic Losses

The micro-impacts of disaster include effects on household resources and well-being due to loss or damage of household (e.g. house, appliances, utensils, assets, furniture, vehicles, etc.) and other assets (e.g. land, machinery, trees, etc.). The loss of crops and employment creates loss of income and security.

In the spatial and sectoral contexts in the rural and agricultural sector, there may be reduction of production of food and cash crops, affected through reduction of area and value of crops lost or damaged. There may also be reduction of livestock production due to livestock or cattle killed or injured. Public utilities and facilities may be also damaged.

For those who are working in the non-farm sector, there may be loss of non-farm employments and/or wages through loss of workdays, retrenchment, displacement or wage deductions. In the urban/industrial sector, there may be loss of business assets, investments, opportunities and products. Urban houses may be partially or totally damaged. There may be damage to public amenities (e.g. schools, phones, playing fields, community centres, religious facilities, etc).

• Role of the Private Sector and Civil Societies

The role of the private sector and civil societies is crucial in conducting vulnerability assessment and developing appropriate strategies to address calamities. Smart partnership strategy could, at local and regional levels, bring public and private sector experts and NGOs together with hazard researchers to develop vulnerability assessments and coping strategies, both pre-event mitigation plans and emergency response plans, and to provide input to establish government initiatives to evaluate and strengthen community resiliency nationwide.

The emergency response plans could serve to mobilize, within countries, government agencies and external donors and international programmes to provide the resources needed for such community-based efforts such as hazard maps, forecasts and outlooks, inventories of check lists of emergency plans, best practices of emergency plans, information on community profile, social and cultural vulnerabilities, and cost-sharing of implementation, etc.

NGOs and the private sector could also participate to enhance the 'culture of prevention' which involves activities to provide avoidance of the adverse impacts of hazards and a means to minimize related environmental, technical and biological disasters. A case can be made for preventive measures, public awareness and education related to disaster risk reduction. This can lead to changed public attitude and behaviours, contributing to the culture of prevention. NGOs, with the support of the private sector, may organize community-based educational awareness programmes on disaster prevention and emergency relief.

Capacity Building

In the context of disaster management, capacity or capability has been defined as a combination of all the strengths and resources available within a community, nation or region that can reduce the level of risk, or the effects of a disaster. It includes physical, institutional, social and economic means as well as skilled personal or collective attributes such as leadership and management. Capacity building aims to develop human skills and societal infrastructures within a community, nation or region in order to reduce the level of risk and also to manage the aftermath and impacts of disaster on human, infrastructure and estate.

In line with the strategic mission of strengthening science for the benefit of society, capacity building with regard to disaster management needs to be guided by the principle that the best scientific knowledge is made available to policy makers. In this context, scientific knowledge is effectively linked to policy-making via engagement with policy-makers and other sectors of society. Through international research collaboration, and the principles of universality of science and science for policy, access to scientific data and information related to natural disaster could be shared on a universal basis and be used to generate capacity in generating new knowledge or in adopting existing technology to minimize hazards and suffering from natural disasters.

In order to integrate science for the benefit of society related to natural disasters, the knowledge and resources of the international science community need to be garnered to:

1. identify and address major issues of importance to science and society with respect to natural disaster;
2. facilitate interaction amongst scientists across all disciplines and from all countries;
3. promote the participation of all scientists in the international scientific endeavour; and
4. provide independent, authoritative advice to stimulate constructive dialogues among the scientific community and governments, civil society and the private sector.

• Policy relevance

For policy relevance, in the event of a natural disaster like earthquake, landslide and flood, the most immediate capacity building concern is the establishment of a Disaster Response and Management Committee, whose tasks will be to coordinate and take immediate actions to assist and lessen the burden of the disaster victims. The committee will need to establish procedures and coordinate relief and support activities at the federal, state, provincial/district and local levels. Support and relief may come from welfare agencies, private sector, religious and community organizations and NGOs, and also from foreign countries and organizations. The participation of the scientific community in this committee is essential to provide informed and authoritative advice to government in matters related to scientific and technical aspects of the disaster, risk monitoring systems, trauma counselling, disaster management, conducting environmental and socio-economic impact studies, etc.

Generally, the tasks of the Disaster Response and Management Committee could be classified as follows:

Information gathering and sharing

Immediate and short-term actions include providing emergency services to cater for the dead and injured, providing food, clothing and other basic necessities, temporary shelters and relief to the victims in the case of damage or losses to their houses. Other immediate and short-term measures are establishing database of victims and families, taking stock of deaths, losses to property, crop, economic livelihood and enterprise and also providing counselling services to affected victims experiencing trauma and stress. Data sharing from all the relevant agencies need to be facilitated and coordinated by one lead agency. Data on cost estimates of damage and losses need to be recorded, tabulated and accounted for while the impacts of the disaster are still fresh in the minds of the victims and also the implementing agencies.

Data gathering and sharing also need to be established with respect to long-term planning for disaster risk reduction management which may include vulnerability and risk assessment, disaster mapping, setting early warning system and mitigation preparedness. It is in these aspects that the scientific community could play an important and leading role.

Community interest, education and awareness

Community interests and requirements need to be handled in the most delicate manner. Household coping strategies and consequences of from the disaster including reducing expenditure, selling assets, borrowing, debt, living with family members, working over time, child dropout from school, child labour, etc. need to be streamlined and accommodated by the coordinating committee.

Financial assistance for temporary housing and employment need to be arranged. For victims who are placed in temporary housing, adequate care needs to be arranged for their daily needs. Assistance has to be given for them to return to their original employment and homes. For those whose employment bases have been destroyed, temporary employment has to be found for them. Rehabilitation of damaged houses needs to be arranged. Relocation assistance to permanent housing and temporary-permanent employment need to be provided.

Community education on the causes and signs of disasters, awareness of the risks and threats of disasters and preparedness of impending disasters need to be continuously inculcated. Formal and informal education medium could be used to increase education and awareness of disasters. The role of the media could enhance awareness amongst communities, especially near the disaster-prone areas. Capacity building of the communities/support staff and local leaders, and the capacity/empowerment of disaster management agencies/support brigades need also to be in place continuously.

Suggested Areas of Project Development

For the region, the priorities for capacity building are in the areas of:

1. building and enhancing regional capacity for disaster reduction;
2. building self-sustaining capacity at various levels for different hazards;
3. establishing continuity in capacity building.

Building and Enhancing Regional Capacity fo Disaster Reduction

There is a need to assess vulnerabilities and map the status of the current capacity of preparedness for risk mitigation and disaster management at the regional and national levels. Hazards and disasters can have vastly different social consequences in different countries, regions, situations and sectors. Some countries are more prepared while some countries are less prepared due to infrequent disasters or being far away from the epicentres of disasters.

The programme would draw on ongoing or past work conducted on capacity building in risk reduction of environmental hazards. The capacity building for risk mitigation and disaster management at the regional and national levels needs to build and enhance institutional coordination; effective governing systems; equity; physical infrastructure, human, financial and technology resources; and indigenous knowledge systems. Capacity building could be developed in relation to defined geographical context of hazards.

The purpose of mapping current regional capacity for disaster reduction would be to:

1. Establish the strengths and gaps in available capacities for different risks from environmental hazards in different geographical locations and social systems. Among the questions to be addressed are i) Are existing national and international training institutions, methods and tools adequate? ii) How is adequate capacity measured in relation to known hazards in different geographical regions? iii) What are the needs, gaps and deficiencies in capacity to reduce disasters?

2. Understand why there are gaps and why other communities or geographical areas experiencing the same hazards have weak capacity, i.e. understand sources of vulnerability in terms of capacity. This would address the questions: How does capacity account for variations in resilience to hazards?

3. Establish past and ongoing capacity-building success stories that can be used in future capacity-building schemes. This would help to indicate appropriate intervention strategies required to enhance capacity in disaster reduction at various levels. This would help to address the questions: i) How do social-economic inequalities influence the capacity to manage hazards, ii) Are there any capacity-building success stories? What can we learn from them?

It is expected that from this experience, the status of capacity building in disaster reduction at the regional and national scales would be established to help map the way forward.

Building Self-sustaining Capacity at Various Levels for Different Hazards

In most cases, there are different levels of impact for different hazards. A hazard may strike a country in a rural or urban area, an entire region, or several countries at the same time. Some hazards are more frequent than others. There are also socio-economic variations in the population that are impacted by the hazards. Different capacities will be required to address these geographically and socially different exposures to the same hazards. These variations require different institutional frameworks and governance schemes. Consequently there would be the requirement of different manpower skills, planning, information gathering, access and dissemination, and resource mobilization and allocation strategies. A critical factor would be mechanisms for a capacity-enabling environment, including measures for institutional commitment to the development of activities for the development of human resources.

The task would require examining how interventions can be instituted to enhance capacity. The guiding issue would include: a) enabling, enhancing and sustaining existing capacity; b) expanding, disseminating and transferring capacity/resilience amongst communities and nations; c) building self-sustaining capacity for disaster-resilient communities and nations; d) enhancing and incorporating indigenous knowledge and capacities into natural hazard management;, and f) engaging communities to identify their own capacities to reduce vulnerability to disasters and build resilience.

Establishing Continuity in Capacity Building

It is essential that capacity building in disaster risk management and reduction be continuously established. This programme should not be externally driven but could be based on the region, country and community initiatives and resources. The programme could be built upon existing networks and structures. The capacity building could address the following:

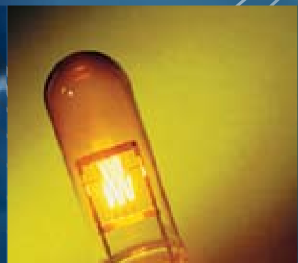
1. Capacity-enabling environment: including continuous preparedness and activeness of Disaster Management Task Force, emergency training, educational and awareness programme, engagement of private sector, civil society and community.
2. Capacity for risk mapping, monitoring, early warning and information dissemination; including engaging natural and social scientists in physical and community risk monitoring, installing early warning systems, and testing information and network dissemination.
3. Capacity for formulating and implementing disaster reduction policies backed by appropriate legal and monitoring frameworks: including activating the Disaster Task Force and Management Committee, updating and establishing clear legal and administrative procedures and coordination amongst agencies, establishing emergency funding mechanism and incentives.

4. Mechanisms for mainstreaming disaster reduction into development programmes: including setting appropriate development expenditure for disaster reduction programmes and activities.
5. Investigating and implementing innovative capacity-building schemes: including learning from past success stories in the region and elsewhere, documenting and learning from past experiences in disaster management.

04

The Plan for Asia and The Pacific

The preceding sections of this document summarized the severities and extents of hazards and disasters in the Asia Pacific region. The issue is very complex and the spectrum of conditions from one subregion to another and from one hazard to another is very wide. In the following a basket of doables is presented.



Earthquakes

1. Several countries in the Asia Pacific region do not have adequate earthquake recording and GPS monitoring of crustal deformation. Such countries need to be identified and a suitable mechanism to instrument them needs to be developed.

2. Develop scenarios of present day losses (social and economic) if earlier disastrous earthquakes recur. Also develop building codes for earthquake-prone countries where necessary.

3. Global Seismic Hazard Assessment Programme (GSHAP) was a flagship programme of IDNDR. Information on anticipated accelerations due to earthquakes at the bedrock for all the major cities in earthquake-prone areas is available. A major effort is required to estimate the accelerations at the surface taking into consideration the local ground conditions and use them for micro-zonation of major cities.

4. A large percentage of the populations in the Asia Pacific region live in self-designed non-engineered homes, which are very vulnerable to horizontal accelerations experienced during the earthquakes. This can be improved enormously by simple inexpensive retrofitting. This should be taken up as a major initiative with collaboration with UNESCO and other possible partners.

5. It is important to learn to live with earthquakes in earthquake prone areas. Several countries have developed and implemented earthquake drills. A lot of information is available as what to do before, during and after an earthquake. This needs to be appropriately spread to the public.

6. Artificial water reservoirs can trigger earthquakes. Ways and means are now available to find safer sites. Whenever a large artificial water reservoir is being proposed, necessary surveys should be conducted to find a suitable site.

7. Tsunami forecasts are now available for most Asia Pacific region countries. However, countries need to develop facilities to make use of these advisories.

8. A few (four to five) case studies of earthquakes would be very helpful.

Floods

1. An effort is required to set up sophisticated flood prediction and warning systems in the Asia Pacific region as has been done in many developed countries. This needs to be done in two steps: first, develop a big river basin flood warning system and second, transfer the big river basin flood warning system to a regional flood prediction and warning system.

2. It is crucial to communicate information related to flood prevention and mitigation to communities for their use. Equally important is to train the people to use this information.

3. It would be important to identify the vulnerability of countries to flooding, develop suitable building codes and construction regulations and develop a robust methodology to implement the same.

4. A few demonstration projects need to be selected. Two potential candidates are the Mumbai, India, flooding of 26-27 July 2005, and the flooding of Bangladesh during 1991.

5. The proposed flood-related work should be coordinated with other existing national and international programmes.

Landslides

1. Application of reliable landslide hazard and vulnerability zonation technology to identify landslide risk is necessary at country-to-community scales in the Asia Pacific region. Adequate land-use planning to avoid landslide disasters should be promoted by this technology.

2. Cooperate with the existing landslide related efforts of several national and international agencies such as ICL, UNESCO, ICSU, IUGS, WMO, IFI, IGCP, IOGS and IYPE.

3. The most cost-effective measure to mitigate landslide disasters is early warning and evacuation. Timely prediction and early warning technology suitable for natural and social conditions of the Asia Pacific region should be developed.

4. Suitable methods to reduce landside causes or a landslide prevention technology is needed in areas such as cultural heritage sites and other locations of high-societal values where relocation and early warning are not possible or very difficult.

5. A few case studies of landslides would be very helpful.

Disaster Management and Capacity Building

It has been recognized that the available scientific knowledge is not being fully utilized in forecasting the hazards, estimating the risks, and getting the necessary outreach for the benefit of the public, particularly in a large part of the area covered by Asia and the Pacific. It is important to stress:

1. disaster risk reduction and management;
2. the role of social sciences in understanding hazards and their mitigation;
3. the role of the private sector and civil societies;
4. building and enhancing regional capacity for disaster reduction;
5. building self-sustaining capacity at various levels for different hazards;
6. establishing continuity in capacity building.

5. CONCLUSIONS

This document is the outcome of intense discussions among the members of the Planning Group and consultations with several other experts. In the foregoing, we have succeeded in identifying key problems related to earthquakes, floods and landslides in the ROAP region that need to be addressed. Efforts would be made to develop suitable projects involving the concerned nations, existing national and international programmes, and experts to address the relevant issues and to find the necessary financial, physical and intellectual support. A suitable overview and review mechanism shall also be put in place.

At this stage it appears appropriate to cite a couple of success stories, among many, that show how the application of scientific and technological developments, interwoven with social fabric, improved the situation. One such example is that of mitigation of loss of human lives by cyclones on the Indian coasts. In 1977 about 20,000 lives were lost on the east coast of India during a super cyclone. Subsequently the entire coast of India was covered by radars and suitable arrangements were made to conveying the cyclone warnings. As a result only about 1000 lives were lost in 1996 and 27 in 2005 when the east coast of India was hit by cyclones similar to those of 1977. Another very recent and good example is India's "Tsunami and Storm Surge Mitigation System" set-up. This is based on the latest technology and appropriate communication approach. The earthquake of 26 December 2004 was followed by a major earthquake of M8.7 on 28 March 2005. A tsunami warning was issued which resulted in massive evacuation on the east coast of India. The tsunami warning was based on the size and location of the earthquake only. The east coast of India was not affected. This caused immense inconvenience to millions of people. Occurrence of an earthquake is a necessary but not sufficient condition for a tsunami to be generated. However, whether an earthquake has generated a tsunami or not can be examined by suitably placed ocean bottom pressure recorders and nearby tide gauges. These are now in position. As a consequence when large earthquakes occurred on 12 and 13 September 2007, it was estimated that the tsunamis generated would have very small amplitudes on the Indian coasts and there was nothing to worry. This timely estimate and issue of appropriate advisories shows the effectiveness of the system.

We sincerely hope that through an appropriate development and implementation of projects, we would have many more success stories for the ROAP region and several hazard events would be prevented from becoming disasters.

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Annexures

Annex I Terms Of References

GOAL

To provide a science plan submitted as a report to the ICSU Regional Office for Asia and the Pacific to use to further engage stakeholders in the region in activities to enhance the science of hazards and disaster management in Asia and the Pacific and contribute to similar efforts at the global level.

Terms of Reference

1. Provide an overview the current status of research activities on earthquakes, floods and landslides in Asia and the Pacific.

2. To assess the interests of the ICSU Scientific Unions, Interdisciplinary Bodies and Joint Initiatives in EFL.

3. To formulate a set of immediate, medium- and long-term objectives for H&D (EFL) in Asia and the Pacific.

4. To suggest major areas of research and development to achieve the goals of addressing and mainstreaming H&D in ICSU (ROAP).

5. To examine capacity building needs that would enable broad dissemination and application of the results of research on H & D towards achieving the goals of sustainable development in Asia and the Pacific.

6. To identify ways by which the results of the research in the priority themes can be made meaningful and more available to decision- and policy-makers and other stakeholders in the region.

7. To propose an estimated minimum budget to promote the ICSU ROAP H & D programme of activities and suggest fund-raising strategies and possible funding sources.

8. To propose a mechanism for guidance and oversight of the proposed programme of activities including ensuring there is minimum overlap and maximum complementarities with other activities in the Region.

9. Submit a Draft Science Plan in each priority theme to the ICSU Regional Committee for Asia and the Pacific by October 2007.

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Annex III

List of organizations working in natural hazard related issues with a special emphasis on ICSU family members, the UN system and relevant intergovernmental and non-governmental organizations and consortia (Source: ICSU). We do not claim this list to be complete. Keeping the length of this document in mind, only website addresses are provided.

World Summit on Sustainable Development (www.icsu.org)

Committee on Data for Science and Technology (CODATA) (www.codata.org)

International Geographical Union (IGU) (www.igu-net.org)

Scientific Committee on the Lithosphere/International Lithosphere Programme (SCL/ILP) (http://sclilp.gfz-potsdam.de/)

International Society for Photogrammetry and Remote Sensing (ISPRS) (www.commission8.isprs.org/wg2)

International Union of Geodesy and Geophysics (IUGG) (www.iugg.org)

International Association of Seismology and Physics of the Earth's Interior (IASPEI) (www.iaspei.org)

International Association of Volcanology and Chemistry of the Earth's Interior (IAVCEI) (www.iavcei.org)(www.wovo.org)

International Association of Hydrological Sciences (IAHS) (http://www.cig.ensmp.fr/~iahs/)

International Association of Meteorology and Atmospheric Sciences (IAMAS) (www.iamas.org)

International Association of Cryospheric Sciences (IACS) (http://www.cryosphericsciences.org/)

Commission on Geophysical Risk and Sustainability (GeoRisk) (www.iugg-georisk.org)

International Union of Geological Sciences (IUGS) (www.iugs.org)

International Year of the Planet Earth (IYPE) (www.esfs.org)

International Union for Quaternary Research (INQUA) (www.inqua.nlh.no)

Scientific Committee on Antarctic Research (SCAR) (www.scar.org)

Scientific Committee on Solar-Terrestrial Physics (SCOSTEP) (www.scostep.ucar.edu) (www.bu.edu/cawses)

International Union of Radio Science (URSI) (www.ursi.org)

ICSU Regional Office for Asia and the Pacific (ISCU ROAP) (www.icsu-asia-pacific.org)

ICSU Regional Office for Africa (ISCU ROA) (www.icsu-africa.org)

ICSU Regional Office for Latin America and the Caribbean (ISCU ROLAC) (http://www.icsu-lac.org/)

World Climate Research Programme (WCRP) (http://wcrp.wmo.int/wcrp-index.html)

Earth observation initiatives (www.ioc-goos.org) (www.wmo.ch/web/gcos/gcoshome.html) (www.fao.org/gtos) (www.igospartners.org) (www.noaa.gov/eos.html)

International Strategy for Disaster Reduction (ISDR) (www.unisdr.org)

World Bank Global Facility for Disaster Reduction and Recovery (GFDRR) (www.unisdr.org/eng/partner-netw/wb-isdr/wb-isdr.htm) (http://gfdrr.org/index.cfm?Page=home&ItemID=200)

GFDRR/ISDR Global Partnership with Universities, Academic Institutions, Research Organizations (www.unisdr.org/eng/partner-netw/scientific-net/ppt-Bab-Ezzoua-Algeria.ppt)

United Nations Environment Programme (UNEP) (www.gfmc.org) (www.unep.org)

UNESCO (www.unesco.org)

International Centre for Water Hazard and Risk Management (ICHARM) (www.icharm.pwri.go.jp)

WMO Natural Disaster Prevention and Mitigation Programme (www.wmo.ch/disasters)

THORPEX (www.wmo.ch/thorpex)

Inter-governmental Panel on Climate Change (IPCC) (www.ipcc.ch)

Food and Agriculture Organization (FAO) (www.fao.org/giews)

United Nations University (UNU) (www.ehs.unu.edu)

United Nations Platform for Space-based Information for Disaster Management and Emergency Response (UN-SPIDER) (www.unoosa.org/oosa/unspider/index.html)

ProVention Consortium, Advisory Committee, ProVention Forum, ProVention's thematic priorities (http://www.proventionconsortium.org)

Global Risk Identification Programme (GRIP) (www.gri-p.net)

International Institute for Applied Systems Analysis (IIASA) (www.iiasa.ac.at/Research/RAV/index.html)

International Disaster and Risk Conference (IDRC), Davos (www.davos2006.ch)

Global Alliance for Disaster Reduction (GADR) (www.gadr.giees.uncc.edu)

Global Disaster Information Network (GDIN) (www.gdin.org)

Pacific Science Association (PSA) (www.pacificscience.org)

EARLY Warning Conferences (www.ewc3.org)

Centre for Research on the Epidemiology of Disasters (CRED) (www.cred.be)

International Consortium on Landslides

International Programme on Landslides (IPL) (http://www.iclhq.org/)

Insurance industry (www.swissre.com) (www.munichre.com) (www.lloyds.com)

Annex IV Acronyms

A-DAS	-	Atmospheric Data Assimilation System
AP	-	Asia and Pacific
ASC	-	Asian Seismological Commission
BPR'S	-	Bottom Pressure Recorders
CRED	-	Centre for Research on the Epidemiology of Disasters
CSPR	-	Committee on Scientific Planning and Review
DFID	-	Department for International Development
DRMC	-	Disaster Response and Management Committee
DRR	-	Disaster Risk Reduction
DST	-	Department of Science & Technology
EFL	-	English and Foreign Languages
EM-DAT	-	The International Emergency Disasters Database
GDP	-	Gross Domestic Product
GEO	-	Group on Earth Observation
GEOSS	-	Global Earth Observation System of Systems
GIS	-	Geographic Information System
GPS	-	Global Positioning System
GPS-GIS	-	Global Positioning System – Geographic Information System
GSHAP	-	Global Seismic Hazard Assessment Programme
H&D	-	Human Resources & Development
ICL	-	International Consortium on Landslides
ICSU	-	International Science Council
IDNDR	-	International Decade of Natural Disaster Reduction
IFI	-	International Financial Institutions
IGCP	-	International Geological Correlation Programme
IGOS-GEO HAZARDS	-	Integrated Global - Observing Strategy for Geohazards
IMF	-	International Monetary Fund
INCOIS	-	Indian National Centre for Ocean Information Services
IPCC	-	Inter-governmental panel on climate change
IPL	-	International Programme on Landslides
IRDR	-	Integrated Research on Disaster Risk
ITRF	-	The International Terrestrial Reference Frame
IUGS	-	International Union of Geological Sciences
IWRM	-	Integrated Water Resources Management
IYPE	-	International Year of the Planet Earth
L-DAS	-	Land Data Assimilation System
NGOs	-	Non-governmental Organization
NHS	-	National Hydrometeorological Services
PGA	-	Peak Ground Acceleration
ROAP	-	Regional Office for Asia and Pacific
UN/ISDR	-	United Nations International Strategy for Disaster Reduction
UNESCO	-	United Nations Educational, Scientific and Cultural Organization
UNITWIN	-	University Networking and Linking
USAID'S	-	United States Agency for International Development
USGS	-	United States Geological Survey
WMO	-	World Meteorological Organization
WWRP	-	World Weather Research Programme
WWSSN	-	World-Wide Standard Seismograph Network

ICSU
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