Bhutan's Country Report

for

World Conference

on

Natural Disaster Reduction

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ACRONYMS

ADB	Asian Development Bank
Chu	River
CWC	Central Water Commission,
GOI	Government of India
DGM	Department of Geology & Mines
DoF	Department of Forests
DoP	Department of Power
DoWH	Department of Works & Housing
Druk-Yul	Bhutan ('The Land of Thunder Dragon')
Dzongkhags	District Administrations
Dzong	Fortress, now Monastery-cum-Administration Block
FAO	Food and Agriculture Organisation
FYP	Five Year Plan
GDP	Gross Domestic product
GNP	Gross National Product
GSB	Geological Survey of Bhutan
GSI	Geological Survey of India
ISC	International Seismological Centre, Edinburgh
JICA	Japan International Cooperation Agency
Khola	River
Km	Kilometer
Lhakhang	Monastery
m	Meter
MBT	Main Boundry Thrust
MCT	Main Central Thrust
MFT	Main Frontal Thrust
mm	millimeter
NEC	National Environment Commission
NES	National Environmental Strategy
NORSAR	Norconsult International A.S
Nu.	Ngultrums (Bhutanese currency)
PDE	Preliminary Determination of Epicentres
PWD	Public Works Division
RGOB	Royal Government of Bhutan
SAARC	South Asian Association for Regional Cooperation
tpd	tonnes per day
UNDP	United Nations Development Programme
US $	US Dollar (1 US $ = 31.85 Nu.)
WAPCOS	Water and Power Consultancy Services, India
WFP	World Food Programme
WWF	World Wildlife Fund, Bhutan

CHAPTER I

CONTEXT AND SPECIFIC ISSUES

1.1 Country Background

The Kingdom of Bhutan - Druk Yul - in the Eastern Himalayas became known to the outside world only after the early 1960s. A small country with a population of about 0.60 million, a territory of 46500 sq kilometers (18000 sq miles) and an estimated per capita GNP of US $ 425, it is one of few peaceful countries in the world today with its own unique religious and cultural heritage. Its natural environment and rich bio-diversity are still preserved with atleast 60% of its total land surface under forest cover and about 7% of it under perpetual snow, glaciers and innumerable lakes.

Only after the early 1960s its socio-economic consditions took a historic turn when *His Majesty the King Jigme Dorji Wangchuck - the third Druk Gyalpo (1952-1972)* initiated efforts to increase links with India and other countries. The first Development Plan (1FYP) was initiated in 1961 with emphasis on establishing basic infrastructure (roads, schools and hospitals) and facilities for improving both internal and external communications. Institutional foundations were laid to pave the way for a modern economy along with social, legal and constitutional reforms.

Far reaching development in many sectors continues to take place under the present *fourth Druk Gyalpo, His Majesty the King Jigme Singye Wangchuck (1972-)*. Bhutanese people today have increased access to higher education, better medical care, other community services and greater participation in development planning and implementation. As a result, the living standards of the Bhutanese people have remarkably improved. The country's population grows at the rate of 2.3% although infant motality rate is relatively high and life expectancy low in comparison to those of other developing countries.

The Royal Government of Bhutan is implementing its 7FYP (1992-97), and its development approach is guided by the following six principles of : **self-reliance, sustainability, efficiency and development of the private sector, people's participation and decentralisation, human resource development, and regionally balanced development.**

Although Bhutan is a landlocked country between China (to its north) and India (east, west and south), its friendly relations with the Government of India and access to the diverse Indian markets through an open border have been crucial for its socio-economic development. There are now multilateral and bilateral agencies as well as voluntary service organisations (VSO, JOVC, VSA, SNV, SCF, WWF) assisting Bhutan in various sectors of its social, cultural and economic development.

1.2 Country-Specific Issues

Processes in most developing countries are often set back by a host of natural calamities. The Kingdom of Bhutan has been singularly fortunate in this respect that it has had now three decades of uninterrupted socio-economic development. This however does not imply that it is free from natural *hazards*. By virtue of its very location in the young and rising fold mountains of the Himalayas, such hazards exist which may originate from landslides, earthquakes and flash floods from glacial lake outbursts or localised rain storms

to cause havoc to human lives and properties. The risks from such hazards will increase over time and will be felt as the country's population grows perhaps at a rate > 2.3 percent and concentrate in growing urban and industrial areas in river valleys and steep mountain slopes.

The floods which originate in Bhutan can also have devastating effects in the inhabited low-lying plains of the Indian States of Assam and West Bengal adjoining Bhutan's southern foothills, and in the deltaic plains of Bangladesh. Therefore how Bhutan develops and manages its watersheds and resources is also of concern to the development interests of the neighbouring countries of India and Bangladesh.

Scientists have long established that the Himalayas lie in a seismically active belt. Recent studies (desk work by experts) in Bhutan's high Himalayas have also shown that the glaciers are retreating giving rise to numerous supra-glacial and dangerous moraine dammed proglacial lakes which have the potential for flash floods with devastating downstream effects.

Hence there is a growing awareness and need to take realistic steps to understand the nature and character of such geological hazards in Bhutan. The vulnerability of its increasing population, existing infrastructure and facilities, and the short- and long-term socio-economic consequences of these events remain to be assessed. But external technical expertise will be needed initially for such vital studies and to train local counterparts in such areas of scientific investigation. Such initiatives and actions are also expected to create additional general public awareness leading eventually to knowledge and understanding of how best possible Bhutan can be prepared to reduce the the risks from identified natural hazards, and the consequences of disasters deriving from them. From the national perspective, disaster mitigation plans and measures will also serve to protect its fragile environment and safeguard its many years of hard work and investment in development.

Bhutan's changing socio economic condition since 1961 has been accompanied by its growing urban and rural population, expanding transport and communication network and relative increase in the size and number of its development infrastructure and institutions. This means that the vulnerability of the country as a whole to existing natural hazards increases - a national development issue which will gain more importance in the near future.

CHAPTER II

NATURAL HAZARDS

2.1 Landsliding

In general intense landscaping and periodic seismic activity occur in the Himalayas. The tropical monsoon climate with spells of torrential rainfall favours faster weathering of rocks resulting in a greater magnitude of erosional activity, widespread slope instability and mass movements.

Slopes in Bhutan are susceptible to landslides particularly in the rainy season which lasts from June to September. Most landsliding occurs in the southern foothill belt from natural causes where the terrain is steep and rocks underlying the soil cover are highly fractured allowing easy seepage of water. The contributing factors are the undercutting of slopes by high-energy rivers and streams during a period of heavy rainfalls

In Bhutan landslides have so far rarely killed people but their direct and indirect effects are getting sharply felt as they leave huge and ugly scars on mountain slopes, destroying forests, eroding soils and destabilising vital life-lines and infrastructure. Such landslides in the foothill region sometimes tend to block rain-fed streams creating temporary dams which sooner or later burst with potential for disastrous downstream effects in the adjoining Indian flood plains of Assam and West Bengal.

The financial and environmental consequences of such mass movements along with their disaster potential are recognised by the RGOB as more and more human settlements and development activities are likely to shift to the steep mountain slopes in the near future as suitable land in valley bottoms and gentle slopes becomes scarce. This concern is reflected by the RGOB's pragmatic National Forestry Policy which lays strong emphasis on conservation rather than the short-term commercial exploitation of forests. The policy clearly states that atleast 60% of the country's total land area must remain under forest cover. The draft National Pasture Policy aims at encouraging pasture development and management so as to reduce overgrazing and thereby prevent the degradation of forests, soil erosion and landslides.

Of particular concern to Bhutan today are the numerous landslides and land subsidence affecting its vital north-south and east-west national highways and feeder roads in various Dzongkhags (districts) requiring relatively enormous repair and maintenance expenditure every year and a threat to the lives of the travellers and roadside workers.

2.2 Floods in the Foothills

The southern foothill region of Bhutan (tropical to sub-tropical climate) has an intensely dissected terrain with deeply eroded, steep and closely spaced gulleys, gorges and river valleys. The catchment areas in this region are numerous - characterised by intense dendritic type of drainage which collects surface run-offs very rapidly during a torrential rainfall. Rainfall per annum ranges from 3000 to about 5680 mm. This variation indicates the existence of certain pockets which receive sometimes very high localised downpour every year.

As a result, the perennial and seasonal streams suddenly rise to dangerous levels and

flow with tremendous force and momentum leading often to the flooding and destruction of the low-lying areas immediately adjacent to the foothills during the monsoons (June to September). The effects of such floods are felt by local settlements on the fertile downstream river terraces.

Rivers flow from Bhutan to the Indian plains and merge with the Brahmaputra river. Rises in river levels due to torrential rainfalls in the Bhutan foothills naturally result in a greater magnitude of transport of loose material from the foot hills and deposition/accretion in the immediate plains. Thus increases in the volume of such transported debris tend to raise the river-bed levels causing unpredictable diversion of river courses. Without river protection works such areas become dangerously prone to floods during the next rainy season.

Sudden flooding in Bhutan foothills has gained more risk potential as its important relatively more populated border towns (Phuntsholing, Gaylegphug, Samtse and Samdrup Jongkhar) and few small-scale industries are located in this belt to gain access to markets in India.

Recent Floods in the Foothills

While the floods in the central valleys may be attributed to causes other than heavy rainfall, those in the foothills are due to high localised rainfall in certain catchment areas. In the foothill region of Bhutan two major floods occurred recently: Dhuti Khola flood (Phuntsholing) in October 1991; and the Pugli-Gomtu flood in the south-western district of Samtse in July 1993. The flooding of Dhuti Khola in October 1991 is reported to have destroyed a petrol pump station and extensive and deep erosion of its banks.

In July 1993 the Samtse region of south-west Bhutan received an abnormally high amount of rainfall (209mm on 19 July and 215mm on 21 July) causing several floods in the region and in certain parts of the Indian plains of Assam and West Bengal. Within Bhutan the flooding triggered a series of landslides which caused further damages to properties and physical infrastructure amounting to about 50 million ngultrums to a cement plant. Some village houses in the vicinity of Pugli Khola were reported to have been severely affected by the flood.

2.3 Hazards from Glacial Lakes

Floods which can result from sudden outbursts of glacial lakes in the glacerised terrain of the High Himalaya of Bhutan constitute major hazards to human settlements and infrastructure in its few relatively wider river valleys. Therefore the potential and likelihood of glacial lake outbursts have to be fully recognised. Otherwise, major roads, bridges and hydropower projects in the river valleys will have been unnecessarily exposed to risks of flash floods and destruction resulting in great loss of human lives and investment followed by enormous rehabilation costs.

Glaciation and the consequent strong erosion characterise the remarkable recent uplift of the Bhutan Himalaya. All the larger glaciers in Bhutan are retreating, particularly those with their tongues reaching 4,200m (Gansser 1983). The highly glaciated region of Lunana is an example. Some of the lower parts of glaciers which are intensely covered by moraine scree are said to deteriorate forming small supraglacial lakes which will eventually form fairly large lakes. There are several glacial lakes in North and northwestern Bhutan which are dammed by recent terminal moraines some of which are still dangerously connected to large glaciers. Surging of glaciers or avalanching can break the moraine barriers of such proglacial

lakes resulting in catastrophic flash floods.

The glaciers in Bhutan in general have receded during the last century creating numerous lakes. A few disastrous glacial floods have been observed in the Pho Chu, Sankosh and Bumthang Chu valleys in the past. A large number of glacial lakes are identified in North and northwest Bhutan from comparative studies of old maps (1:50,000 Topo-sheets) and SPOT images of 1989. The largest and most alarming one which has formed over the past thirty years or so is probably the *Thanza Lake in the Lunana region* which has increased in size by 70% within a span of 5 years (1984-1989). It is estimated that it holds about 70.0 million cubic meter of water (Norconsult 1993), seven times larger than that of Dig Tsho Lake in Khumbu Himal (Nepal) before its catastrophic outbreak on 4 August 1985 (Ives 1986). The disastrous downstream impacts of a sudden release of such huge volumes of water can be easily visualised

There is very limited information on the glaciers and glacial lakes of Bhutan aside from some incidental observations made by A. Gansser (Swiss geologist) during his geological traverses in the Bhutan Himalayas in the 1960s and 1970s. The latest work on the glaciers and glacial lakes of Bhutan is a 'Desk Study ' carried out by Norconsult & Norpower for the Bhutan Power System Master Plan Project BHU/87/025 (May 1993) based on available 1962 maps and SPOT images of 1989. This valuable study provides the starting point for future work on the numerous glaciers and glacial lakes in the high Himalayas of Bhutan.

Past Floods due to Glacial Lake Outbursts

The end moraines of most glaciers in the high Himalayas of Bhutan are missing indicating that disastrous outwashes occurred frequently during the last 100 years (Gansser 1970; 1983). Such moraines ruptured by recent outbreaks of glacial lakes have been observed by Gansser (1970) in the Chhomolhari region.

In 1953 a catastrophic flood of the Pho Chu river destroyed part of Punakha Dzong - one of the largest historic buildings in west Bhutan. The origin of this flash flood was traced by A. Gansser (1979) to a drained glacial lake in western Lunana region where an ice avalanche from an overhanging glacier had hit the lake rupturing its terminal moraine.

Two major floods in Punakha are remembered both from the Pho Chu. The first one was in the summer of 1950 lasting about 24 hours. The second and more disastrous one was in the summer of 1960 which lasted for 5 days. It was the first flood which destroyed part of Punakha Dzong. Although the local people of Punakha attributed the floods to heavy rainfalls in the area, the floods are considered most likely due to glacial lake outbreaks.

In September/October 1968 there were widespread floods in West Bhutan (Punakha, Thimphu and Paro valleys) which were accompanied by a period of heavy rainfall in these regions. The flooding of the Sankosh river is said to have washed away several houses including an ancient temple (Bajo Lhakhang) in Punakha valley, the old traditional bridge of Wangdi Phodrang and a house with 12 people further downstream. This flood is thought to have been due to an outbreak or overtopping of a glacial lake in the upper reaches of the river basin. In the capital town of Thimphu the flood in the same year is reported to have swept away a few houses, shops and bridges. In Paro valley the flood has been more disastrous causing great damages to both human and aquatic life; a major portion of paddy fields in Dophu area (in one of the tributary valleys) were, for instance, completely laden with silt, sand and debris. In general the 1968 floods led to the degradation of aquatic life in the rivers of Thimphu, Paro and Punakha valleys.

2.4 Earthquakes

Four great earthquakes (> 8.0) have been recorded in the Himalayan region from 1897 to 1950. Scientists predict that earthquakes of similar (or possibly greater) intensities will occur in the Himalayas in the future. The four great earthquakes recorded in the neighbouring countries are, Shillong (1897), Kangra (1905), Bihar-Nepal (1934) and Assam (1950). The region frequently experiences earthquakes of moderate magnitudes of 5.6 to 7.0.

Being placed in the Himalayas, the Kingdom of Bhutan has been prone to earthquakes in the past and might be so to greater magnitudes in the future if scientific predictions are correct. According to some scientists the last quiet phase in the Himalayas had begun in 1952 and appears to have lasted till 1988. The disastrous earthquake in Nepal in 1988 and the most recent one 400 km southeast of Bombay in the Indian State of Maharashtra on 30 September 1993 measuring 6.5 and killing over 15,000 people indicate that the quiet period may indeed be over. Such happenings are a reminder of how catastrophic earthquakes can be and how important it is for a earthquake-prone country like Bhutan to have serious plans and programmes to reduce their drastic impacts and consequences.

Past Earthquakes in Bhutan

Although there is no local written records of past earthquakes in Bhutan, *atleast four major earthquakes* have definitely occurred before 1960. Two of these earthquakes are remembered by elder citizens. The other two were recently reported from investigations by NORSAR (1992). The magnitudes of the two previous seismic activities will remain unknown since they had taken place much before the global network of earthquake recording stations became operational in the early 1960s.

The first major earthquake in Bhutan appears to have occurred in 1897 - in the Bhutanese Calender Year of the Fire Rooster. This earthquake can be corroborated with the great earthquake in Shillong (>8.0) in the northeastern Indian state of Meghalaya. This earthquake seems to have caused widespread destruction of buildings in Bhutan. A reference to the effects of this earthquake in eastern Bhutan is made by J. Claude White in the account of his first Political Mission to Bhutan in 1906.

The second major earthquake is said to have occurred in 1931 - in the Bhutanese calender Year of the Iron Sheep. This seismic activity led to the collapse of the "Utsi' (the central block) of Jakar Dzong in Bumthang in central Bhutan. According to some verbal accounts tremors were felt intermittently in Bumthang for several days. The third and the fourth earthquakes occurred on January 21 and 27 respectively in 1941. Their epicentres were located near the southeastern border with India with respective magnitudes of 6.8 and 6.5 (NORSAR 1992).

Macroseismic data of Bhutan from 1963 to 1988 recorded by the International Seismological Centre (ISC, Edinburgh, Scotland) and Preliminary Determination of Epicentres (PDE, USGS, USA) show that over the past two and half decades Bhutan has experienced earthquakes with magnitudes rauging from 4.1 to 6.3. The highest magnitude of 6.3 was recorded on 27 March 1964 on latitude 27.13° and longitude 89.36° .

Local Perception and Awareness of Earthquake

Prior to the early 1960's the Kingdom of Bhutan remained under self-imposed isolation from the rest of the world. Under such conditions, local explanations of earthquakes

based on beliefs had developed which are now increasingly replaced by the scientific explanation.

From newspapers and radio services most Bhutanese citizens are now aware of the enormous scale of disaster which earthquakes bring to humanity in other countries, their natural causes below the earth's surface and that Bhutan lies in a relatively more earthquake-prone region. Yet it is paradoxical that a general comfortable feeling exists amongst the Bhutanese people that they will be safe. One of the reasons for this attitude is that there are no records or horrible accounts of great earthquakes striking the country in the past reminding the present generation. Hence a sense of complacency tends to prevail and the need for creating for awareness and preparedness.

It is felt that although even predictions of earthquakes can be sometimes wrong (causing false alarms and public anxiety), damages which might arise from them can be minimised drastically by adopting safer building codes and practices and creating public awareness, and some form of anticipatory planning and organisation.

CHAPTER III

VULNERABILITY TO NATURAL HAZARDS

Glacial lake outbreaks, earthquakes, flash floods and landslides constitute the main natural phenomena (geologic hazards) in Bhutan which have the disaster potential for the future. There is a need to identify and assess these natural hazards followed by vulnerabilty and risks assessments in terms of their possible impacts on important concentrations of local population and resources. Risks from the natural hazards increases over time with Bhutan's growing population and development activities in its river valleys and mountain slopes.

There are no records of natural fire hazards in Bhutan but their occurrence due to lightning, for instance, cannot be ruled out.

It is hoped that Bhutan's national commitment to environmental concerns and a policy of sustainable development will contribute greatly to the prevention of landslides and reduction of incidences of flash floods due to high rainfall in the future. At the national level, measures which can be taken to avoid or mitigate the effects of floods arising from glacial lake outbursts and earthquakes would be to begin studies which will lead to risk zoning to delineate the country's most vulnerable locations followed by enforcing landuse regulations and appropriate building codes, developing manageable warning systems and emergency plans. All these activities will involve additional costs or external assistance, or most probably the diversion of some of the country's limited resources from other critical economic sectors. Nonetheless, planners and important decision makers of the Royal Government have begun to view natural hazards and associated risks as a vital part of socio-economic development for a devastating earthquake or a flood could seriously affect a developing country like Bhutan socially and economically.

3.1 Vulnerability to Landsides

Bhutan's vulnerability to landslide hazard has become more apparent in this decade because of the following reasons:

a) Recent socio-economic development has involved relatively huge investments in infrastructure and buildings, accompanied by a corresponding growth of townships and commercial activity, all of which have served to increase the country's overall exposure to landslide impacts;

b) Development pressures have necessitated Bhutan to use its highly dissected and fragile terrain for hydropower generation, utilisation of its mineral deposits and establishment of small-scale industries, thereby exposing the infrastructure involved, employees of the projects and their activities to landslide hazard;

c) Urbanisation has begun to cause rural-urban migration to certain towns in various parts of the country exerting increasing pressure on available and suitable land for housing; this has resulted in the tendency for new peripheral settlements and hutments of squatters to be located on potentially unstable slopes;

d) Sub surface flow of water from irrigation channels in rural areas (eg. Khamdang

Block, east Bhutan) and particularly unplanned construction of roads in the past cutting across hillslopes contribute to slope instability problems or landslides.

3.2 Floods in the Foothill Belt

Floods in the foothills during rainy seasons are begining to pose a major natural risk to the border towns which have grown on river terraces. These relatively populated urban areas are expanding with increasing trade and commercial activities. Furthermore due to the discovery of mineral deposits in the region, most of the country's industrial infrastructure and projects are situated on the available tracts of flat land, close to seasonal streams which swell unpredictably during the rainy season. The floods also cause great damage almost every year to two very important bridges on the southern highways which connect four other border townships in south-west Bhutan.

3.3 Glacial Lake Outbreaks

Due to lack of specialised knowledge and specifically trained national personnel, the numerous glacial lakes which have formed more recently in the north and north-central High Himalaya region of Bhutan have remained largely uninvestigated. Previous flash floods in Punakha (west Bhutan) and Bumthang (central) valleys were largely attributed to heavy precipitation in the region while they might have been due to glacial lake outbursts in their upper reaches.

In comparison to landslides, floods which may result from glacial lake outbreaks seem to possess far greater disaster potential especially in western and parts of central Bhutan where human settlements and recent development infrastructure are clustered in river valleys.

In the light of Bhutan's plans to develop and utilise its hydropower resources which will incur enormous long term investment, foreign technical assistance and collaboration, there is the necessity for carrying out detailed studies on the newly-formed glacial lakes in the upper reaches of the country's major river basins. Such studies are considerd very vital to river valley projects in a fragile environment like that of Bhutan.

3.4 Earthquakes

If the seismic zones of northern India are extrapolated, the Kingdom of Bhutan seem to lie in one of the seismically active belts in the eastern Himalayas - making its people, its ancient religious and historic buildings, and various more recent development infrastructure all vulnerable to varying intensities of earthquakes. There are no records reflecting the earthquake history of the country except for some subjective accounts of a few senior citizens.

The old Dzongs of Bhutan and temples might be at high risk in the event of future earthquakes of high intensities. These Dzongs are massive structures - all built with roughly hewn stone and mud walls, timber frameworks without a single iron nail and wooden shingle roofs (now substituted by galvanised corrugated iron sheets). There are 14 Dzongs which were built for strategic purposes (forts) in the early 17th and 18th centuries. Some of them literally sit on rocky ridge-tops or overlooking spurs, while others like Tashichhodzong (Thimphu), Punakha Dzong, Paro Dzong and Ha Dzong are in the valleys. Although these Dzongs have somehow withstood past earthquakes some of them have developed cracks in their stone-and mud walls.

The Dzongs of Bhutan are today occupied by about 5000 Buddhist monks throughout the years. The former embody and signify the country's religious and cultural heritage and also truly reflect Bhutan's traditional architecture. Every Dzong is a museum by itself housing old statues, religious texts, paintings, artefacts and numerous antiques. In the past centuries the Dzongs served as monasteries-cum-forts but today they *also* serve effectively as district administration centres. So, the number of people living or working inside the Dzongs has increased over the years. This situation increases the vulnerabilty of the occupants of a Dzong to an earthquake if the Dzong happens to be in a seismically high risk zone.

CHAPTER IV

INITIATIVES TOWARDS NATURAL HAZARDS REDUCTION

In the case of Bhutan at this juncture it seems more appropriate to talk in terms of '*natural hazards reduction*' than '*natural disasters reduction*'. Recent prefeasibility studies carried out for the Power Systems Master Plan for the RGOB (UNDP Project) have yielded some important information on possible hazards from glacial lakes (for instance) which evidently require further investigations.

Therefore there is the need to fully identify the nature and extent of such types of natural hazards existing in the country and communicate their likely risk potential to provide the rational framework for meaningful national plans and programmes for reducing their impacts on specific human settlements and development sites. Such tasks ahead will require at the national level long term investment, commitment and technical assistance.

4.1 Relevant Government Policies

Bhutan's strict policies on forestry conservation, watershed protection, environment and its commitment to sustainable development represent a holistic approach towards preservation of its natural heritage and thereby prevent deforestation, soil erosion, landslips, and flash floods in the foothill region 22.85% of the total land area has now been declared as *protected areas* (nature parks, reserve forests and wildlife sanctuary). General awareness of nature conservation is created at national, regional and rural levels through education, existing mass media (BBS, Kuensel, DSCD) and extension workers Social and community forestry is highly encouraged as a national policy with serious penalties for forest fires and hunting. Bhutan has also set up its *Trust Fund for Nature Conservation* (1992) which will hopefully grow to support ongoing and future bio-diversity conservation programmes.

The NEC of the RGOB (established in 19) is in the process of formulating the country's National Environmental Strategy (NES) and follow-up action plans. The objective of the NES is to *'provide a long-term perspective of renewable resource management and outline an action agenda to attain sustainable development'* while reflecting *'the social and cultural values and the economic needs of the people'* (NEC 1993).

4.2 Mitigation Initiatives/Measures

Some Recent Studies on Seismicity

NORSAR has recently carried out a conceptual earthquake hazard study for the Bhutan Power Systems Master Plan (UNDP Project of DoP, RGOB 1993) based on available seismological data and published material for earthquakes in the region. This is the first study of its kind to have ever been carried out by experts in relation to earthquake hazards in Bhutan. The data used by the NORSAR for their earthquake hazard computations were acquired from the ISC in Edinburgh (Scotland) and from the PDE (the United States Geological Survey). The objective of their study was to provide conceptual earthquake loading estimates for the Bhutan Power Systems Master Plan - to estimate Peak Ground Acceleration (PGA) for four hydropower dam sites in Bhutan.

For the purpose of the seismic hazard evaluation of the four hydropower sites, NORSAR has defined 8 *Seismic Zones* (polygons) in the Himalayas and a greater part of the Kingdom of Bhutan falls in **Zone 3** and partly in **Zone 2 (extreme west) & Zone 4 (extreme east)** as follows:

Zone 1 (Tibet Plateau): covers the area North of Bhutan (463495 sq. km). This zone is believed to represent the main extensional regime North of the Himalayas.

Zone 2-4: cover the Himalayan Mountain Arc. The subdivision into three zones reflects the variation in seismicity along the arc.

Zone 4 (Arunachal) East of Bhutan is the most active seismic zone immediately bordering the country. So is also **Zone 2** (Sikkim/Nepal) West of Bhutan which is significantly higher than Zone 3 (Bhutan and part of Assam).

Zone 5 (Eastern India): covers a remote zone which historically has shown many large earthquakes, and thus contributes to the earthquake hazard in the eastern part of Bhutan.

Zone 6 (Indian Plain): is almost free of earthquakes, and is nearly insignificant in an earthquake hazard context.

Zone 7 (Shillong), is a relatively active zone, and historically this zone has produced some of the largest earthquakes in the region.

Zone 8 (Burma): is by far the most active zone modelled under the study by NORSAR. This zone is the only one which has experienced earthquakes above Ms 7 during the last 30 years.

The conceptual study carried out by NORSAR has provided valuable information which will be useful for future work on seismicity in Bhutan.

Hydro-Meteorological Network

The Department of Power (DoP) has established a hydro-meteorological network consisting of 110 meteorological stations and 23 guaging stations. The Dop is currently building up its capability to carry out flood analysis for existing hydraulic structures (dams, diversion tunnels and underground power houses). The generation of data by the existing hydro-meteorological network should enable studies in the near future to forecast floods in the country and the adjoining plains of India. There are proposals to expand the network to the upper reaches of Bhutan Himalaya to yield information on the contributions from snow-melt and glaciers. Such data may be of great value when assessing certain aspects of potential hazards from glacial lakes in the near future.

Road Bank Stabilisation & River Training

The most common structural mitigation measures undertaken in Bhutan are for stabilising road banks and river training and protection works (eg. Paro Valley, Phuntsholing

& Gaylephug). Reforestation in catchment areas and afforestation (bio-engineering techniques) on unstable sections of national highways are also tried with encouraging results.

Building Code & Practice

Bhutan has no National Building Code but its *Bhutan Building Rules 1983* serves more or less like one. It is used by the Department of Works & Housing (DoWH) to regulate all building practices in areas designated or classified as urban. It also ensures strict adherence to the *codes & specifications* adopted by the DoWH and PWD, and makes it mandatory for construction of multistoried (more than 3 storeys) buildings and structures to be supervised by a qualified Structural Engineer.

The codes and specifications adopted by the implementing agencies are similar to those of India since most of the standard building materials are imported from India. Besides, Bhutan's construction industry is very small and the so-called modern buildings constructed hardly exceed three storeys. In the light of the growing awareness of seismicity in Bhutan the need to formulate a National Building Code exists.

CHAPTER V

WARNING SYSTEM

Detailed natural hazard and vulnerability assessments are yet to be carried out in Bhutan. Only after having done this Bhutan's national strategy or plans per se for dealing with disasters will emerge. Foreign assistance is required to study the nature and the likely consequences of natural hazards in order to have them in a proper perspective and accordingly prepare to deal with their most probable impacts.

Flash floods in the foothills, earthquakes and possible glacial lake outbreaks have now been broadly recognised as natural phenomena with elements of undetermined risks for Bhutan in the future. The RGOB is fully aware that such risks can be minimised by establishing systems for observing, forecasting and warning.

Under the present economic condition of the country, such establishments with mitigation functions would involve significant additional capital and running costs which must compete with the pressing needs of the country that require allocation of its resources to fulfill the basic needs of its people, and are therefore unaffordable. Warning systems will be developed when specific natural hazards have been fully identified and their risks evaluated.

Bhutan has no seismic station or observatory to monitor and record earthquakes although WAPCOS (GOI organisation) is in the process of setting up three such observatories in the Wang Chu basin where future hydroprojects are proposed. It is hoped that with the building up of its hydrological and meteorological networks, a national capability for forecasting floods will be developed in the future.

CHAPTER VI

INTERNATIONAL COOPERATION

As far as living memory goes, Bhutan has been one of the few fortunate countries in the world that has remained *relatively* 'disasters free' from either natural or man-made causes. As a consequence, it has had three decades of uninterupted economic development with little need to allocate its scarce financial and manpower resources to deal with such risk and uncertainty. But this stand is changing with growing awareness of natural disasters in the countries next door such as India, China, Nepal and Bangladesh. Hence dangers to present and future generations from moraine dammed glacial lakes in its higher reaches and earthquakes in the Himalayan Kingdom of Bhutan can no longer be overlooked.

6.1 STATUS

The Focal Point for IDNDR

The focal point for IDNDR activities within and outside Bhutan is the National Environment Commission (NEC) - one of the top-level organisations of the Royal Government of Bhutan. The NEC has the *Minister for Planning as the Chairman, Deputy Minister for Environment, Minister for Home Affairs, Minister for Trade and Industry, Secretary of Forests and Secretary of Agricuture as the Members*. Although there is no national Committee for Disaster Management as such, for all practical purposes the NEC can also easily function as the responsible organisation lest any disaster or emergency situation arise in the future. It can coordinate with the national Planning Commission, Ministry of Home Affairs, Ministry of Social Services, Ministry of Communications, other public and private organisations to mobilise internal resources as well as seek external assistance if necessary for disaster relief operations.

Under the present circumstances, it is felt that there is no immediate need to set up a separate organisation which would be solely in charge of *disasters reduction and management* because it would mean setting up an entirely new organisation requiring additional financial and manpower resources. By virtue of its top-level composition, the NEC is already in a superior position to interact and coordinate with development sectors whose activities fundamentally involve some aspect of hazard assessment studies or reduction. A great deal of work has been done with external assistances in various development sectors upon which future comprehensive hazards and risks studies can be based.

The task at hand for the NEC is to utilise the services of some of the institutions in Bhutan[1] as well as forthcoming assistances from abroad as realistic steps towards identification of natural hazards in the country as a whole to eventually draw up plans and programmes vis-a-vis mitigation and management of hazards so recognised.

External Relations

[1] The Engineering Geology Section of Dept. of Geology & Mines (MTI), Dept. of Roads (MoC), Hydrology & Meteorology Section of Dept. of Power (MTI), Dept. of Forests (MoA), Structural Engineering Section and Urban Planning Section of Dept. of Works & Housing (MoC)

Since it's joining of the United Nations Organisation in 1971, Bhutan's links with other countries in Asia and the West have significantly increased. It has today diplomatic relations with more than 18 countries and five resident embassies abroad (New Delhi, Dhaka, Kuwait, New York and Geneva).

Although India is Bhutan's largest development partner, aid in the form of loans and grants from third countries has increased since 1981. The UN system provides a significant proportion of financial and technical aid through the UN office at Thimphu (UNDP, UNICEF, UNFPA, UNCDF, UNESCO, UNIDO, WHO, WFP, FAO, IFAD, ESCAP). Bhutan also receives from other sources multilateral (ADB, EEC, World Bank, IMF) and bilateral assistance (Denmark, Japan, the Netherlands, Austria, Germany, Switzerland/HELVETAS, U.K., Belgium, Italy, Republic of Korea and Kuwait). Most of the aid from the UN system and third countries is utilised in priority sectors such as human resource development, health & education, agriculture & forestry, population, industry and transport & communications.

6.2 ISSUES

International Cooperation vis-a-vis Natural Hazards & Risks Assessment

As of now in Bhutan there remains much to be done in the field of risks assessment with regard to probable floods from glacial lake outbursts, landslides and earthquakes. The country has neither the expertise nor the scientific establishments to carry out the prerequisite investigations related to the above natural phenomena which exist by virtue of its geologic and geographic position. To a small Kingdom of Bhutan with a very fragile natural environment, the effect of a single natural disaster can be devastating. Since all the fast flowing rivers originating in Bhutan drain towards the Indian flood plains, a major flood in Bhutan would be catastrophic to the low lying and contiguous Indian settlements in West Bengal and Assam.

Glacialogical Studies

The Geological Survey of India has helped Bhutan study the Thanza Glacial Lake in Lunana region upon the request of the RGOB. Two successive expeditions were led jointly with the Geological Survey of Bhutan in 1984 and 1986. Since this moraine dammed lake has kept on expanding since then, it warrants a much longer duration study by experts. In the Kingdom of Nepal similar scientific investigations have been made possible with Canadian assistance and more recently with Japanese grant aid (JICA). The NEC, the national focal point for the IDNDR is willing to explore the possibilities for such joint studies which would enable systematic identification of dangerous glacial lakes in the various river basins of Bhutan in the absence of a national capability to conduct and carry out such vital investigations. The long term benefit to the country would be immense.

Mountain Risks Assessment

Bhutan is a member of ICIMOD (International Centre for Integrated Mountain Development) which has its headquarter in Kathmandu, Nepal. Much work in mountain risk engineering has been done under this organisation in Nepal (field work, research and human resource development). In Bhutan Himalayas hazard mapping or assessment leading to *Regional Landslide Distribution Maps* and *Landslide Risk Maps* remains to be done. Such a mapping programme is considered vital for its end results would provide the base for landuse planning in new development sites, building regulations, engineering practices and investment decision-making

At a more specific level, landslide hazards along the highways and feeder roads of Bhutan are studied by ITECO (a Swiss Consultancy firm based in Kathmandu, Nepal) - funded by WFP/FAO/the Netherlands government - in collaboration with the Department of Roads (DoR, RGOB), and also by the Engineering Geology Section of the Department of Geology and Mines (DGM, RGOB) to a very limited extent. The DGM's Engineering Geology Section needs strengthening since it is headed and manned by the country's only qualified and trained engineering geologist.

Hence mountain risks assessment in Bhutan Himalaya is yet another area identified for assistance from Committees for IDNDR in other countries.

Seismic Studies

Since at present Bhutan cannot afford to establish, operate and subsequently maintain even a small network of seismic stations on a long term basis, possibilities will be explored to establish contacts with seismological centres in India, Bangladesh, Nepal and with other International Seismological Centres abroad (eg. ISC[2] , Edinburgh, Scotland, U.K & PDE[3] , USGS, Colorado, Denver, USA). Over time the contacts would be instrumental in gaining important information of seismic activity in Bhutan Himalaya. Such information-sharing would enable building up of the country's earthquake catalogue/history and access to relevant expertise available in these organisations.

[2]International Seismological Centre

[3]Preliminary Determination of Epicentres