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Natural Disasters and Their Mitigation Measures

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***Abstract:* Objectives:** *The present study described the disaster management and mitigation measures for all natural disasters and gave historical account of all natural disasters.*
Design and methods: *This was a descriptive study.*
Results: *The research paper deals with natural disasters and divided in mitigation measures for earthquakes, floods, drought, landslides, avalanches and cyclones. A brief description of the historical account and recent disasters has been explained. The disaster management and mitigation measures required for saving lives and reducing loss of property have been discussed.*
Conclusion: *It can be concluded that management and mitigation measures described for all natural disasters are beneficial for implementation for saving lives and reducing loss of property.*
Keywords: *natural disasters, management and mitigation measures, description, saving lives, loss of property.*

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I. Introduction

Disaster is defined as an occurrence arising with little or no warning, which causes or threatens serious disruption of life, and perhaps death or injury to large numbers of people, and requires therefore a mobilization of effort in excess of that normally provided by the statutory emergency services. Earthquakes, droughts and famines are the major killers in India in 1970-80’s. The major natural disasters that repeatedly and inceasingly affect India are drought, floods, earthquakes and landslides. Mitigation is one of the positive links between disasters and development. Mitigation has become a collective term used to encompass all actions taken prior to the occurrence of a disaster (predisaster measures). This includes long term risk reduction and preparedness measures. Mitigation measures can help a community reduce future economic losses. The risk reduction measures of mitigation are often placed in the pre-disaster time frame. Infact, the most opportune time to implement mitigation is in the period after a disaster [1].

An **earthquake** is a sudden motion or trembling of the ground produced by abrupt displacement of rock masses, usually within the upper 15 to 50 km of the Earth’s crust. Most earthquakes result from the movement of one rock mass past another in response to tectonic forces. The recent earthquakes in India in Kashmir, Bhuj, Lattur, Jabalpur caused immense loss of life and damage to property. Earthquakes are among the most powerful events on earth and the most destructive of natural disasters. They are the deadliest and least predicted. Earthquake waves are generated at same time by the rebounding of the adjacent sides of fault at rupture surfaces, as well as by rubbing and crushing. The body and surface seismic waves propagate outwards in all directions from the focus when a fault rupture causes the ground to vibrate at frequencies ranging from about 0.1 to 30 Hertz (cycles per second). Buildings vibrate as a consequence of the ground shaking, damage takes place if the building cannot withstand these vibrations. In terms of human and economic losses, the seismic shaking is most significant factor contributing to overall earthquake hazard. Shaking contributes to losses not only directly through vibratory damage to man-made structures but also indirectly through triggering of secondary effects such as landslides or other forms of ground failures. Earthquakes are described in terms of their magnitude and intensity. Earthquake magnitude is a measure of strength of an earthquake i.e. the strain energy released at its source. Earthquake intensity is a measure of the observed effects of the earthquake on man, buildings and the earth’s surface at a particular place.

For examples, **Albania** is a country of high seismic activity, one of the most active in the Mediterranean Region. In only last forty years, Albania has been hit by eight destructive earthquakes of a magnitude of greater than 6.0 which caused human losses and considerable damages. The strongest earthquake of a magnitude of 7.2 occurred on 15 April, 1979 and its epicenter was situated between Albania and Montenegro. Outputs of seismic hazard assessment for a site by analytical methods are presented through computed accelerograms and their spectra. The seismic zoning map of Albania on a scale of 1:500000 is based on research and studies which integrate seismological and geological data. Investigations for seismic hazard assessment at the local level (seismic microzoning) took place in some towns situated in high seismic potential zones and in some sites of important construction.

In **Mexico**, on 19 September, 1986, a magnitude 8.1 earthquake occurred off the Pacific coastline of Mexico. The earthquake and its aftershocks are estimated to have killed atleast 10000 people, injured 50000 and made 250000 homeless. The event caused US$4000 million worth of damage of which 7% was insured, making it one of most disastrous ever to have affected the insurance industry. It was determined that 7400 buildings in Mexico city were damaged by the earthquake, of which 770 were total losses and 1665 severely damaged. Within the investigation areas detailed mapping of the location of damaged buildings revealed that the most severely affected ones were largely confined to that part of the lake bed where the clay thickness exceeded 37 m. All in all, the Mexican damage experience demonstrates that within the confines of an individual city exposure to the earthquake hazard can vary considerably, and emphasizes the value of detailed analysis of the geological conditions that underlie major cities in seismic zones. Through such analysis it is possible to identify subsoil units that are likely to increase the destructive forces of earthquakes. Data concerning these units should be incorporated into hazard assessments and used as basis for implementing measures aimed at reducing the severity of an earthquake impact (e.g. planning, design and construction regulations). Such work is urgently required in a number of seismic regions of the Third World, where inadequate earth-science data foe areas of rapid population growth and urban expansion is a cause of genuine concern.

About half of India’s total area of 3.3 million square kilometers lies within a seismic zone. The most susceptible regions for earthquake are the northern regions, from Kashmir to Assam. Apart from this, Kutch region, Andaman and Nicobar Islands are also prone to earthquakes. The very recent Bhuj earthquake in Gujarat and the Killari, also known as **Lattur earthquake in southeast Maharashtra** are still fresh in peoples mind for their intensity and immense loss of life and property. A devastating earthquake of magnitude 6.4 occurred in the early morning of 30 September, 1993 in the southern part of lattur district of Maharashtra state. The earthquake caused widespread damage in some 80 villages. More than 11000 human bodies were extricated from debris. The Lattur earthquake though not of high intensity it is considered as the deadliest earthquake in the so called stable continental landmass of India. The final estimate of death toll was put at 50000. Because of the absence of seismic stations in the near vicinity, there was no seismic record of these tremors. The cause of high death toll was due to the fact that earthquake occurred at 4:00 am when most people were asleep and moreover their dwellings were constructed out of large rounded boulders set in mud walls and foundation was loose black cotton soil. The load bearing capacity of the black soil on which the affected houses were built was very low. The roofs of the houses were also thickly covered with mud. These thick walls just crumbled, bringing down roofs and killing people.

The **district Nashik of Maharashtra** is known for exhibiting mild to moderate seismicity. Some of the major seismic events were of magnitude 6.5 in 1846 and magnitude 6.3 in 1938. The Kalnan Taluka of Nashik district experienced a series of large number of micro-earthquakes in middle of December 1994 and reached a peak in March 1995, of about 20 to 30 micro-earthquakes per day. The fear psychosis amongst the common people was accentuated due to fact that the Killar-Latur area which had experienced the devastating, magnitude 6.3 earthquake on 29-09-1993, was preceded by a large number of micro-earthquakes which produced rumbling noise. In the early hours of 22 May, 1997 a destructive earthquake struck the city of Jabalpur in central India leaving 48 people dead and 10000 people injured. More than 50000 houses were damaged including about 7000 houses completely destroyed in and around Jabalpur city. The magnitude of this earthquake was 5.8 as obtained by NGRI. The epicentral region lies along the seismically active Narmada-some deep fracture zone which passes through central India. The northeast-southwest oriented Railway Bridge over Narmada river got wildly damaged. A devastating earthquake hit the Bhuj region of Gujarat on 26 January, 2001. The origin time was 08:46:53IST. The earthquake epicenter was located at 20 kms ENE of Bhuj with focal depth of 22 kms. The earthquake measured 8 on the surface magnitude scale from 86 observations around the world. This is the largest earthquake in this region, the only one with a similar magnitude being the 1819 kutch earthquake. The other great earthquakes in the Indian region in the past are the 1897 Shillong earthquake (M 8.7), 1905 Kangra earthquake (M 8.6), 1934 Bihar-Nepal earthquake (M 8.7), all falling along the Himalayan belt and in northeast India.

A **flood** is too much water in the wrong place, whether it be an inundated city or single street or field flooded due to a blocked drain. Among the trigger mechanisms are dam or levee failures; more rain than landscape can dispose of; the torrential rains of hurricanes; tsunami; ocean storm surges; rapid snow melts; ice floes blocking a river and burst water mains. A key driving force in the yearly increase in flood disasters is the rapid rate of deforestation. Physically, a flood is a high flow of water which overtops either natural, or artificial, banks of river. However, such an event cannot be described as a hazard unless it threatens human life and property. For hydrologist, flood magnitude is best expressed in terms of peak river flow (discharge) whilst hazard potential will relate more to maximum height (stage) that water reaches. A general definition states that a flood is a body of water, which rises to overflow land is not normally submerged. According to figures from US office for Foreign Disaster Assistance (USOFDA), floods affected 5.2 million a year in the 1960s compared with 15.4 in 1970s-an almost threefold increase. Over 1964-82, floods killed 80000 people and affected 221 million worldwide. In 1983, the League of Red Cross and Red Cresescent Socities launched eight international appeals to assist a total 1.6 million flood victims in five Latin American nations as there were major floods in Bangladesh, China, Inida, Nepal and Pupua New Guinea and flooding was also in Argentina, Bolivia, Cuba, Ecuador, Paraguay and Peru.

There are four types of floods: flash floods, single vent floods, multiple event floods and seasonal floods. There are two causes of floods: a) Physical causes: It could lead to river and coastal floods. River floods may occur due to atmospheric hazards such as rainfall, snowmelt and icejam, seismic hazards such as landslides and technological hazards such as dam failures. Coastal floods occur due to atmospheric hazards such as storm surges. Atmospheric hazards, especially excessive rainfalls, are the most important cause of snow and a rapid temperature rise, **the Fraser River in British Columbia, Canada,** produced a major flood. The most dangerous melt conditions often arise from rain falling on snow to give a combined flow. This occurred in **Romanian floods** of May 1970, when the Transylnanian basin was devastated by heavy rain from a deep depression plus snowmelt from the Carpathian Mountains. Urbanisation increases the magnitude and frequency of floods. Deforestation appears to be a likely cause of increased flood runoff and an associated decrease in channel capacity due to sediment deposition. b) Human causes: In order to achieve immunity from flood hazard, no intensive land use should ever occur on floodplains. Improper agricultural practices such as shifting cultivation also help in causing soil erosion and increased surface runoff. Obstruction to free flow of water in rivers due to embankments, river banks and narrow bridge openings also help in causing floods.

For examples, one of the worst floods in Indian history occurred in 1840 when an earthquake occurred in the upper **Indus valley**. In 1970, a cyclone and a tidal wave in the **Bay of Bengal** caused the greatest sea flood disaster in history. Huge waves struck the coast of Bangladesh and killed about 266000 people. There are three broad regions of India which are flood prone: North east India, North India and Central India. **The Floods in Brahmaputra:** The Brahmaputra valley in Assam represents an acutely flood prone region. The single most cause for frequent occurrence of flood in this region is the extremely dynamic monsoon region and the unique physiological setting of the basin. During the period 1954 to 1996 there were devastating floods. As much as 70% of flood loss in Assam is accounted for by crop damage. **Floods in North Bihar Rivers:** The rivers of North Bihar (Kosin, Baghmat, Gandak, Kamalabatan) causes havoc due to severity of floods every year. The damages caused by floods to crop, private properties, public utilities and loss of life is enormous in this area.

Recent Floods in Madhya Pradesh: The newspapers of 19 August carried an account of the disaster caused by floods due to incessant rains in Balghat district of Madhya Pradesh. Atleast 40 villages were evacuated in district following torrential rains. **Floods in China:** In the Yangtze in the South and the Yellow river (HuangHo) in the north, China is coping with two of world’s most intractable streams of water. An 1871 flood on the Yangtze pushed the water 85 metres (275 feet) above its normal level in the gorges downstream from Chongqing, and a river streamer caught on rock was left 35 metres (120 feet) above the river when waters subsided. A 1954 flood caused the evacuation of 10 million people in the lower valleys. The Yellow River also known an “China’s Shame” has killed more people than any other single feature of the Earth’s surface, in 1887, the Yellow River flooded, killing between 900000 and 2 million people by drowning and starvation due to loss of crops and in 1931 one of the world’s worst floods left 1-3.7 million people dead. In 1938, the leeves were branched on purpose to stop the invading Japanese army. This held back the invasion, but killed 500000 of the local population.

Drought is a so-called ‘creeping’ hazard. This is because droughts develop slowly – often over a period of months and also have a prolonged existence – often over period of years for major events. Drought has more similarities with long term environmental degradation than with many other environmental hazards. For examples, the 1975-76 drought over **north-west Europe** lasted no longer than 16 months whereas the more recent drought in **African Sahel region** was created by persistently dry conditions over atleast 16 years from 1968, leading to widespread. As recently as 1973 **Bijapur in India** was hit by one of the worst droughts in our recorded history. Drought may be defined most simply as any unsual dry period which results in a shortage of water. A “major” drought is one that diminishes crop yields by as much as 30% and a “severe” drought would cause a loss of crop and animal production of about 8%. Rainfall deficiency is, therefore, always the ‘trigger’, but it is the shortage of useful water-in soils, in rivers or reservoirs which creates the hazard. Floods in the heavily populated northern, eastern and coastal zone often make headlines, but over 80% of subcontinent is chronically drought prone. The 1972-73 drought left as many as one million people died of starvation. In 1967-68, drought related crop failure caused relatively little suffering when compared to 1972-73 droughts. Maharashtra is one of the worst affected state.

Causes of drought in India: a) ELNINO effect: The periodic appearance of warm and sealine oceanic currents in the eastern pacific west of Peru. b) A negative swing in the South Oscillation Index which measures the difference in the pressure between Port Darium in northern Australia and Tahiti in French Polyneisa. c) A combination of two known as ENSO. **Drought Types:** a) Meteorological drought this type is dominated by a shortfall of precipitation. There is often no direct ecological or economic impact and there is no effective human response. b) Hydrological drought mainly affecting water resources and urban water supplies. Responses are mainly from municipalities or local authorities and may involve management of both the supply of, and the demand for water. c) Agricultural drought characterized by widespread regional effects in the DCs (Developed Countries) but mainly affecting farm production. Any direct response is typically at national government level and relies on loss-sharing measures. d) Famine drought this is the most severe disaster type, which at worst, results in deaths from starvation. It is mainly confined to the LDCs (Least Developed Countries) which are dependent on subsistence agriculture. The characteristic response is international aid. **Drought Reduction:** The standard long-term defence against hydrological drought has been the construction of dams and reservoirs for the artificial storage and transfer of water supplies. The emphasis on engineering solutions is symbolized by the global spread of large dams, and associated increase in regulated rivers, especially during the period 1945-70. One consequence is that over 40% of the stable riverflow in Europe, North America and Africa is regulated by reservoirs. Storage reservoirs have also been used to maintain urban water supplies. Short term adjustments used by water authorities during hydrological droughts are aimed mainly at the domestic consumer. They include both supply management and demand management practices. An agricultural drought occurs when soil moisture is insufficient to maintain average crop growth and yields. Indices of agricultural drought should be based on soil moisture measurements, but these are often assessed indirectly by water balance calculations. Within the Developed Countries, agricultural droughts can have severe impacts. Sweeney (1985) estimated that the 1984 drought on the Canadian Prairies was the worst since the 1930s and cost in excess of $2.5 billion. The 1982-83 drought peak in Australia created significant losses. At farm level, severe drought will disrupt normal activities and cause serious financial problems, including a diversion of capital from farm development to drought-reducing strategies, a fall in liquidity and a debt. At the regional and national levels, the most visible consequences of agricultural drought are in the reduced outputs of crops. During 1982, national wheat production in Australia fell by 37% compared with the average for the previous five years. In 1988 the USA experienced one of its most costly agricultural droughts because of lack of precipitation and the extreme heat in the Midwest. The US Department of Agriculture reported that the 1988 average corn yield was 31% below the progressive upward trend which is driven by improved technology. More than one-third of the American corn crops were destroyed, a loss put at $4.7 billion. The soyabean yield was 17% below trend, the largest decline over the past 60 years, at a cost of atleast $3.7 billion. Agricultural drought on this scale within Developed Countries can disrupt world trade in food commodities.

Rural areas rarely have either the massive water storages, or the options for reducing demand, that are available to most cities in the Developed Countries. Therefore, the most prudent long-term drought strategies are those which relate agricultural production and management practices to withstand unexpected shortfalls of precipitation. This involves the adoption of appropriate stocking rates, so that the pasture is not easily exhausted, the build–up of a reserve of fodder and the improvement of on-farm water supplies. The installation of an irrigation system may offer some security against drought but the reliability of supplies may not be high enough to provide complete drought proofing. Sustained dryland farming is also dependant on soil conservation measures against water and wind erosion. A grassn or legume cover is an effective control against water erosion, as are strip cropping and contour cultivation which retard the flow of water down the slope. Wind erosion can be greatly reduced by maintaining a trash cover at the soil surface and the use of crop rotations and shelter belts to lower the wind velocity at the soil surface.

The general term **landslides** covers a wide variety of land forms and processes involving the downslope transport of soil and rock under the influence of gravity. Different types of landslides move down-slope at a wide range of speeds. The more rapidly moving landslides may pose a greater hazard to life because they can destroy dwellings or damage roads quickly and with little warning. Slower moving landslides will gradually cause increasing amounts of damage, but the expected movements can be anticipated. Much of the damage and often the loss of life during earthquake and intense storm is due to landslides. For example, in the May 1970 earthquake in **Peru**, which took 70000 lives, about 20000 people perished in the avalanche of debris from north peak of Nevado Huascaran. Economic losses due to landslide have been estimated at more than $1 billion per year in several countries. In **United States**, the landslides threaten public safety in more than half the states, causing 25-50 deaths per year. **Landslides can be classified** according to two criteria: types of movement and types of material. Type of movement: Falls are masses of rock and/ or other material that move down-slope primarily by falling or bouncing through the air. Topple is an overturning movement that, if not blocked by other masses, will result in a fall or slide. Slides result from shear failure along one or several surfaces. The slide materials can be broken up and deformed or remain fairly cohesive and intact. A cohesive landslide is called a slump. Types of material: Materials are divided into two classes: Bedrock and soils (which are subdivided into debris and earth). **Typical Causes of Landslides:** External: a) Geometrical change: Gradient, Height, Slopelength b) Unloading: Natural, Maninduced c) Loading: Natural, Maninduced d) Shocks and vibrations: Single, multiple/ continuous. Internal: a) Progressive failure (internal response to unloading etc.) – Expansion, swelling, fissuring, strain softening, stress concentration b) Weathering- Physical property changes- communication, swelling, chemical changes c) Seepage erosion – Removal of cements, removal of fines d) Water regime change – Saturation, rise in water table

For examples, the landslide that affected **Hongkong** in 1966 and 1972, killing 64 and 138 respectively were in part the consequence of new road cuttings, as was the **Turkey** landslide of 1988 which left 66 dead while 1986 failure at Senesi, Basalicata, **Southern Italy**, which destroyed three blocks of flats, killing eight, is considered to have been triggered by excessive slope remodeling and construction. In India, the incidence of landslides in **Himalayas and other hill ranges** is an annual and recurring phenomena. There is a variation in the degree of landslide incidences in various hill ranges. The landslide incidences are high to very high in Himalayas, High in North-Eastern hill ranges, high to moderate in Western Ghats and Nilgris and low in the hill ranges of Eastern Ghats and Vindhyas. A landslide on National Highway-I A near Batote, Jammu occurred on June 21, 1995 and caused loss of 80 lives.

A snow **avalanche** results from an unequal contest between stress and strength on an incline. The strength of the snowpack is related to its density and temperature. The snow layers have the unique ability to sustain large density changes. The shear strength decreases as the temperature approaches 0 degree Celsius. As the temperature rises further, and liquid meltwater exists in the pack, the risk of slope failure grows. Most snow loading on slopes occurs slowly. This gives the pack some opportunity to adjust by internal deformation, because of its plastic nature, without any damaging failure taking place. The most important triggers of pack failure tend to be heavy snowfall, rain, thaw or some artificial increase in dynamic loading, such as skiers traversing the surface. For a hazardous snowpack failure to occur, the slope must be sufficiently steep to allow the snow to slide. Avalanche frequency is thus related to slope angle, with most events occurring on intermediate slope gradients of 30-45 degrees. Most avalanches start at fracture points where there is high tensile stress, such as rock outcrop.

Avalanches are started by one of two quite distinct slope failure processes. a) Loose snow avalanche this occurs in cohesionless snow where intergranular bonding is very weak thus producing behaviour rather like dry sand. Failure begins near the snow surface when a small amount of snow, slips out of place and starts to move down the slope. The sliding snow spreads to produce an inverted V-shaped scar. b) Slab avalanche this occurs where a strongly cohesive layer of snow breaks away from a weaker underlying layer, sometimes called the lubricating layer, to leave a sharp fracture line. The initial slab may be up to 10 m in thickness. An avalanche comprises three elements: a starting zone where the snow initially breaks away, the track or actual path followed and a runout zone where the snow decelerates and stops. Because avalanches tend to recur at the same sites, the threat from future events can often be detected from the recognition of previous avalanche paths in the landscape. Clues in the terrain include breaks of slope and eroded channels on the hillsides and evidence from damaged vegetation. Like landslides, snowpacks can be stabilized onslope by a variety of techniques but they also offer opportunities for artificial release. The advantages of artificial avalanche creation are two-fold: firstly, they can be released at pre-determined times, when ski runs and highways are closed, so that snow can be cleared away with minimum inconvenience; secondly, and more importantly, the snowpack can be released safely as several small avalanches rather than allowing the snowcover to build up to become a major threat. Explosives can be used to test the stability of the snowcover but are most often employed to trigger controlled avalanches, including the destruction of cornices which may overhang ski slopes. Explosives are most effective when placed in the starting zone. Despite the advantages of the controlled release of snow, it is preferable if the snowpack remains intact. But the use of defence structures has been the most commonly adopted adjustment to avalanches throughout the world. These structures seek either to retain the snow on the mountainsides or, if an avalanche should occur, to deflect the snow moving across the lower slopes away form humans and their works. The wide variety of defence structures can be classified into: snow fences above the starting zone, supporting structures in the starting zone and direct protection structures in the track and runout zone. Dry avalanches tend to travel in a straight line whereas wet-snow avalanches hug the contours more and become chanelled by gullies. Ice avalanches have three modes of release: frontal block failure, ice slab failure and ice bedrock failure. For example, ice avalanche occurred from the Allalian Glacier at **Mattmark, Switzerland**, when ice crashed down on accommodation huts, killing many of the local workmen employed in the construction of the Mattmerk dam. Other major snow/ ice/ rock avalanches happened at **Huascaran; Cordillera Blanca in Peru** in 1962 and 1970.

A tropical **cyclone** is an intense tropical storm with windspeeds of over 118 kilometres per hour – Force 12 on the Beaufort Scale of Wind Force. Cyclones usually tear away anemometers (wind gauges), so their speeds are rarely measured accurately. Such tropical windstorms are called hurricanes in the Caribbean, Atlantic and North American regions; cyclones in the Indian Ocean; typhoons in the Pacific; and baguio around the Philippines. All of these are the same phenomena. A cyclone begins to form when moist air heated by the sun rises form the surface of the warm tropical seas and is funneled upwards in a natural updraft. As this moist air rises, it cools and condenses into rain. This condensation feeds back into the air large amounts of heat, which add to the force of the storm's updraft and which stokes the power of cyclone. Air continues to go to spiraling up, and hot moist air rushes in from all sides to replace it and to feed the updraft. The winds spiral around an "eye", an area of calm and light rains a few kilometers across. Cyclones are low pressure systems or depressions around which the air circulates in an anti-clockwise direction in the northern hemisphere, but in a clockwise direction in the southern hemisphere. The central area around which the air circulates is called the eye of the storm. The atmospheric pressure in this area is extremely low. It has diameter ranging from about 20 km to more than 40 km. In the eye area, weather conditions are relatively quiet with light winds and small amounts of cloud. In the ring from the perimeter of the eye to the storm's outer boundary, violent winds and torrential rains are to be found which may persist for many hours. The depth of a cyclone from its top to sea-level ranges between 10 and 20 kms. The average duration of a cyclone is nine days. During this period it may travel over a distance of 10000 km. Due to much lower energy supplies, it will subside over land. When a tropical cyclone approaches land, risk of serious loss or damage arises from winds, rainfall and surges.

For examples, **Cyclone experience of Bangladesh:** In the black night of 29 April, 1991, a strong cyclonic storm reaching a speed of 235 km per hour accompanied by 12-20 ft. high tidal surges hit one of the offshore islands and coastal areas of Bangladesh. The cyclone and tidal surge claimed 1,380,000 lives, numerous cattle and caused colossal damage to houses, trees, property and all infrastructures including coastal embankments and roads. Between the years 1877 and 1976 a total of 612 cyclonic storms occurred in Bay of Bengal. In **India, Andhra Pradesh** is worst affected state according to the records. On 27 October, 1949, Machilipatnam was struck by a cyclonic storm which killed 800 people and a million acres of paddy were damaged. On 7-8 November, 1969, another destructive cyclone with 3 meter high tidal wave ravaged the entire coastal region. 250 people were killed, 35,000 livestock lost and 40,000 houses damaged. A cyclone crossed South Andhra Pradesh coast near Barua on10 September, 1972 resulted in death of 100 people. Another cyclone crossed Andhra Pradesh coast near Sri Harikota in the early night of 22 November, 1972. On 4 November, 1976, the cyclone crossed Andhra coast just north of Machilipatnam. In this loss of life was 18 and there was considerable damage to houses and crops. 19 November, 1977 was the darkest day in the history of Andhra Pradesh in the past. The low pressure formed in the Bay of Bengal on November 16 changed its course more than 30 times, picked up momentum and finally crossed the coastline at Vetapalem on the evening of November 19, 1977. The death toll was 10,0000 and nearly 2.5 lakh of cattle and 4 lakhs of poultry perished. The extent of crop damage was 12.12 lakh hectare and total loss was estimated around Rs. 10000 crores. On 12 May, 1979, Andhra Pradesh experienced another major cyclonic storm with a core of Hurricane winds. The cyclone on November 12, 1984, swept coastal Andhra, leaving behind 565 dead, 516 in Nellore district alone and damaging property worth Rs. 207.87 crores. The 30 October, 1971 cyclone hit the Orissa coast near Paradeep. About 10000 people lost their lives, 50000 heads of cattle perished and 8 lakh houses were damaged. Chandbali cyclone of 6-12 October, 1973 caused heavy rains and floods in Orissa. About 1.5 million people were affected by flood and more than 60000 houses damaged in north Orissa. On 28 September, 1974, a cyclone hit Paradeep of Orissa coast and only widespread rain occurred. The cyclone of 12 September, 1976 crossed Balasore district of Orissa. About 40 persons lost their lives and 4000 heads of cattle perished in these areas. Sevral thousands of houses were damaged. On 27 August, 1978, the cyclonic storm crossed north Orissa coast between Chandbali and Balasore. It was a weak storm only some trees were uprooted in Balasore district. Severe cyclonic storm of 7 August, 1979 crossed Orissa near Balasore. Severe cyclonic storm of 4-11 December, 1981 affected Balasore, Cuttack and Puri districts. About 2800 villages were affected. On 3 June, 1982, a severe cyclonic storm hit it again. On 16 October, 1985, a severe cyclone crossed north Orissa near Balasore and cyclone of 8 November 1986, touched south Orissa coast. **Tropical cyclone hazard: South China Sea:** The tropical cyclones in this region in 1989 resulted in 1249 fatalities, tens of thousands of people being made homeless and an estimated financial loss of US $ 1.713 billion, some locations sustained little cyclone-related damage or loss of life, such as Hong Kong (8 fatalities), while others, such as the Philippines (328 fatalities) were badly affected. The Philippines suffered 39 violent storms over 1960-81, with 5,650 killed.

Cyclone Hazard Assessment and Mapping: The records available for examination, after statistical analysis, should give fairly precise indications as to months of the year when a tropical cyclone may strike the country. The analysis should also provide frequencies of wind strengths in specific ranges of wind speed and direction, frequencies of the coast and frequencies of river flooding in different areas. For preparedness purposes, several forecasting techniques are available: observation systems such as weather radar, satellite data, aircraft reports, subjective techniques, computerized techniques, or numerical modeling. Hydrologists and geomorphologists will provide information on sea front topography and geomorphology of the affected coastal land areas.

Cyclone Warning System in India: The cyclone warning service of the India Metorological Department is now over a hundred years old and is one of the most important functions of the Department. At present the cyclone warnings are provided through the Area Cyclone Warning Centres located at Kolkata, Chennai and Mumbai and Cyclone Warning Centres at Bhubaneshwar, Vishakhaptanam and Ahmedabad. The zone of responsibility of each office is clearly demarcated. Cyclone warning bulletins for All India Radio/ Doordarshan and cyclone advisories for the north Indian Ocean to Bangladesh, Burma, India Maldives, Pakistan, Sri Lanka and Thailand are being issued from the Meterological Office at New Delhi. The office in New Delhi also issues tropical cyclone advisories for the tropical cyclones in southwest Indian Ocean to Mauritius. **Cyclone Tracking:** In India, tropical cyclones are tracked with the help of regular observation from water network of surface and upper air observing stations; Ship's report; Cyclone detection Radars; Satellites; and Reports from the commercial aircraft. A network of 10 Cyclone Detection Radars have been set up along the Indian Coast. **Dissemination of Cyclone Warning:** Warnings to the state government and Album Page Warnees are issued in two stages In first stage, a 'Cyclone Alerts' is issued normally 48 hours before the commencement of adverse weather alone the coast. Port and fisheries warnings start much earlier. These warnings are disseminated through landline telegrams of special high priority; repeated broadcasts through All India Radio in different languages; bulletins to the Press; Posts and Telegraph Departments and Coastal Radio Stations; Telephone, telex and teleprinters wherever available and wireless network of the police. Tropical **Cyclone Warning Strategy in India:** Management Strategy-Cyclone Disaster Management has to encompass following areas: Science of Skill (S); i.e. understanding of the physics of the cyclone, capability to detect it and predict its behaviour; Capacity to warn vulnerable people in time, which depends on good communication system ©; and measures for cyclone preparedness both in advance and during a cyclone, as well as relief and rehabilitation after the cyclone. This may be called Response (R). Thus, effective disaster management involves interaction between people from various disciplines who have to understand and coordinate with one another. The effectiveness (E) of the warning may be expressed as the product of three factors S, C and R. Hence even if one or two of these qualities is perfect the product will be zero if third quantity is zero.

Precautions before and during cyclone: a) Strictly follow the signs of warning flashed by the Government and fully co-operate even if you have to leave your building and belongings behind for evacuation to a safer location. b) In case evacuation is not essential, try to cover the house with a finishing net normally available in the hut firmly anchored to the ground. The uplift capacity of anchor should be enhanced by using gunny bags filled with the sand. Alternatively, tie down the structural members of the house, by fixing the guy ropes to the ground with the help of pegs. c) All loose articles such as bicycles, garden furniture etc. should be removed from outside the buildings and held down to ground by ropes or chains. They may otherwise get lifted and fly to cause injuries or break glass panes. d) As for possible all windows and doors should be kept tightly shut throughout the cyclone period. e) Windows and doors should be prevented from blowing away by reinforce in them with wooden strips. Past paper or adhesive tape on to the glass panes to minimize the chances of their breaking and flying of. f) Avoid going into the sea or towards the sea coast. Keep torch, match box, lantern, transistor, radio, sufficient food stock and drinking water handy [2].

1.1 Aims and Objectives

1.1.1 To describe the disaster management and mitigation measures for all natural disasters such as earthquakes, floods, droughts, landslides, avalanches and cyclones.

1.1.2 To create awareness about the disaster management and mitigation measures for all natural disasters such as earthquakes, floods, droughts, landslides, avalanches and cyclones for benefit of the society, saving lives and reducing loss of property.

II. Methods and Material

2.1 Study area: Study material of M.Sc. Disaster Mitigation provided by Sikkim Manipal University of Health, Medical and Technological Sciences, Sikkim, India

2.2 Study period: May 2008 – Nov 2008.

2.3 Study design: Descriptive study.

III. Results

The disaster mitigation measures for all natural disasters are given below:

Earthquake Mitigation Measures:

The standard mitigation measures are: a) Hazard Zone Mapping b) Monitoring, Forecasting, Warning: The Indian Meteorological Department is the key agency in India for monitoring earthquakes. It maintains 56 Seismological Stations. Five regional meterological offices control 32 seismological observations in different parts of India. c) Structural Mitigation Research and Development: Based on past experiences, special structural measures resistant to earthquakes were developed. These codes incorporate guidelines for design and construction of earthquake resistant buildings in different seismic zones of the country. d) Emergency Management: The basic responsibility for undertaking relief and rescue operations lies with the State Government concerned. However, the Government of India is intimately involved at every stage in providing financial, technical and material support. The Central Relief Commissioner maintains close liaison with concerned central departments/ agencies as well as the state government's representative in coordinating relief measures [3].

Earthquake disaster mitigation Programme Components: It will reduce the impact of a severe earthquake on the community, can be divided into three phases**:**

1) Preventive Phase Before Disaster: This phase should involve the following actions:

- Preparation of earthquake catalogues and epicentral and geologic-tectonic maps.
- Analysis of seismic risk and seismic zoning for general purposes.
- Development of antiseismic codes of design and construction of various structures.
- Education and training of engineers and architects in earthquake enginnering principles and use of codes.
- Promulgation of laws and bye-laws for providing earthquake resistance features in all new construction according to the code.
- Development of methods for seismic strengthening of existing structures, particularly in the structures considered critical for the community.
- Development of simple methods for upgrading the seismic resistance of traditional non-engineered construction and their dissemination to common builders and owners by mass communication techniques, demonstration, extension work, etc.
- Earthquake insurance for buildings and structures to reduce the economic impact on individuals. Build in accordance with urban planning regulations for risk areas.
- Installation of seismological observations for monitoring seismic activity with a density of instruments capable of recording and locating all earthquakes bigger than a selected magnitude.
- Ensure that all electronical and gas appliances in houses, together with all pipes connected to them, are firmly fixed.
- Avoid storing heavy objects and materials in high positions.
- Hold family evacuation drills and ensure that the whole family knows what to do in case of earthquake. Prepare a family emergency kit.

2) During an Earthquake:

- Keep calm. Do no panic.
- People who are indoors should stay there but move to central part of the building.
- Keep away from stairs, which might collapse suddenly.
- People who are outside should stay there, keep away from buildings to avoid collapsing walls and away from electronic cables.
- Anyone in a vehicle should park it, keeping away from bridges and buildings.

3) Emergency Phase After Occurrence of Disaster:

- Maintenance of law and order. Obey the authorities instructions.
- Evacuation of people. Do not go back into damaged buildings since tremors may start again at any moment.
- Give first aid to injured and alert the emergency services in case of fire, burstpipes, etc. Medical care for the injured.
- Recovery of dead bodies and their disposal. Do not go simply to look at the stricken areas: this will hamper rescue work.
- Keep emergency packages and a radio near at hand. Restoring lines of communication and information.
- Make sure that water is safe to drink and food stored at home is fit to eat (in case of electricity cuts affecting refrigerators and freezers). Supply of food and water and restoration of water supply lines.
- Temporary shelters like tents, metalsheds.
- Restoring transport routes damage.
- Cordoning off severely damaged structures liable to collapse during aftershocks.
- Temporary shoring of certain precariously standing buildings to avoid collapse and damage to other adjoining buildings.
- Immediate actions to prevent certain chain-reactions from developing, such as release of water from the reservoir behind a damaged dam to avoid flooding of areas if the dam fail, emptying of containers of toxic or inflammable gases or liquids, treatment of environment for preventing spread of diseases, etc.
- Collection of scientific data from field observations as well as from instrumentation specially deployed in affected area to monitor the aftershocks and preparation of proposals about reconstruction requirements and strategy to be adopted and whether reconstruction opportunity could also be utilized for affecting socio-economic development of damaged area.

4) Consolidation and Reconstruction Phase:

- Detailed survey of building for assessment of damage and decision regarding repair, restoration and strengthening or demolition.
- Repair, restoration and seismic strengthening or demolition.
- Selection of sites for new settlements.
- Adoption of strategy for new construction, such as, through contractors, through self-help, construction of core houses only, or supply of construction materials only, etc.
- Execution of the reconstruction programme.
- Preview of existing seismic zoning maps and risk maps.
- Review of the seismic codes and norms of construction.
- Training of personnel, engineers, architects, builders and artisans [4].

Flood Management or Mitigation Measures:

Measures to mitigate flood damage could be classified as either structural or non-structural. **Structural measures** were those involving the construction of enginerring facilities, such as reservoirs, dams, retarding basins, leeves and flood walls, channel improvements, catch modification and by-pass floodways. The purpose of such measures were to control the water through storage, modifying the rate of flow, improving river flow conditions and confining the flow within certain boundaries.

Non-structural measures comprised all other means which did not require construction of engineering facilities. They included flood forecasting and warning systems, planning controls, such as zoning and building regulations, acquisition of land and relocation, flood insurance, public information and education, disaster preparedness and flood adaption. Effective flood forecasting and warning systems could enable a community to prepare for a possible flood, thereby minimizing damage and averting death or injury. The development of computer-based information technology, during recent years has provided the disaster managers greater access to the information they need. The disaster management reactivity comprises of four distinct functions of mitigation, preparedness, response and recovery [5].

Geographical Information System (GIS) was extensively utilized to prepare for expediting relief efforts apart from preparing the maps of the disaster of flood damaged area. The National Hazards Management Information System (NHMIS) Division of the National Information Centre (NIC) Bhubaneshwar has been actively involved in developing a suitable GIS. The usefulness of flood hazard mapping and risk assessment as a tool in floodplain management such a tool was an essential step in developing a floodplain management programme. The objective of such a assessment was to prepare flood hazard maps which delineated areas subject to inundation by floods of various frequencies. Such maps could be utilized for floodplain regulation and flood insurance as well as the calculation of flood risks which were the expected annual damage from floods of different magnitudes in a locality. The need for large scale typographical maps of the preparation of flood hazard maps was stressed. In that connection, the possibility of using remote sensing techniques was suggested. The procedures also included hydrologic analyses to determine flood probabilities. The importance of a thorough evaluation of flood damage to various elements (housing, transportation, crops, infrastructure) for assessment of their vulnerability was emphasized.

What to do beforehand: While town planning is a government responsibility, individuals should find out about risks in the area where they live. For example, people who live in areas downstream from a dam should know the special signals (such as foghorns) used when a dam threatens to break. Small floods can be foreseen by watching the water level after heavy rains and regularly listening to weather forecasts. Forecasting of floods or tidal waves is very difficult, but hurricanes and cyclones often occur at same time of year, when particular vigilance must be exercised. They are often announced several hours or days before they arrive.

During a flood:

- Turn off the electricity to reduce the risk of electrocution.
- Protect people and property as soon as the flood begins, take any vulnerable people (children, old, sick and disabled) to an upper floor and whenever possible, move personal belongingupstairs or go to raised shelters provided for use in floods.
- Beware of water contamination – if the taste, colour or smell of the water is suspicious.
- Evacuate danger zones as ordered by the local authorities it is essential to comply strictly with the evacuation advice given. Authorities will recommend that families take with them the emergency supplies they have prepared.

After a flood: When a flood is over, it is important that people do not return home until told to do so by the local authorities who will have ensured that buildings have not been undermined by water. From then on it is essential to:

- Wait until the water is declared safe before drinking any that is untreated.
- Clean and disinfect any room that has been flooded.
- Sterilize or wash with boiling water all dishes and kitchen utensils.
- Get rid of any food that has been in or near the water, including canned foods and any food kept in refrigerators and freezers.
- Get rid of all consumables (drinks, medicines, cosmetics, etc.) [6].

Drought Mitigation Measures:
Drought mitigation, then, is preemptive, while drought relief is reactive. **Drought disaster mitigation should be conducted in four broad steps:**

1) Early warning and vulnerability assessment – identifies areas and groups that might be at risk and establishes consensus among people and government.
2) Rapid water/ food security assessment – verifies the findings of the vulnerability assessment, determines the level of vulnerability and identifies the types of interventions that might be appropriate.
3) Intervention translates the findings of the rapid water/ food security assessment in action and establishes the criteria for determining success.
4) Monitoring and outcome assessment documents project progress, undertakes changes in response to performance, and determines whether project goals have been achieved.

Mitigation Strategy: The objective of this approach to early warning and vulnerability assessment for mitigation are:

- To identify groups that might be at water/ food security risk and to estimate the type and magnitude of risk.
- To determine the nature and sources of drought vulnerability as it varies among groups and through time.
- To suggest appropriate mitigative actions based on the assessments. The purpose of vulnerability assessment is to identify those areas and populations that might be at greater relative risk. A number of early warning systems (EWS) have been developed for monitoring potential drought emergencies so that an alert notice might be issued. A mapping approach is appropriate because drought has both temporal and spatial dimensions. Indicator selection is best performed by a panel of experts convened for the vulnerability assessment. The panel can assemble a list of socio-economic groups to be affected by droughts as well as indicators of risk and coping ability, by group where possible. Data preparation involves the entry of tabular and statistical data into a spreadsheet or data base system, the digitization of map data, and the entry of satellite image data in a geographic information system (GIS). A suitable drought management system has an 'assessment system' and a 'response system'. The assessment system operates regularly through task forces and the response system operates with existing government departments.

The assessments are produced continuously throughout the drought periods, but responses are made only when the needs and impacts are identified and assessed. Under assessment system the task forces identify onset of drought and advise an apex body at government level to declare the existence of drought and its impacts. After the declaration of onset of drought, the response system would act for drawing up of appropriate drought strategies. Taking district/ taluk as a unit, the assessment and response activities will be coordinated by a nodal agency named as Drought Management Services (DMS). The water availability task force (WATF) is supposed to analyze the water availability situation, identify onset of drought and also advice to declare drought or not and activates impact assessment task force (IATF) to assess extend of drought damage on various sectors. The WATF receives relevant data/ information from Integrated Drought Information Service (IDIS) and utilizes it for analysis and interpreatation of scarcity conditions. Various existing threshold drought indices may be used for determination and identification of meterological, hydrological and agricultural drought. **The tasks of IDIS are:**

- Collection, processing and storage of meterological, hydrological and allied data and disseminate the some to users, planners and researchers for drought management.
- Monitoring of drought impacts on agriculture, water supply, fodder, forest, hydroelectric production, etc.
- Monitoring of water quality conditions, health and other problems.
- Identify gaps in data and their measurements, and suggest remedial efforts to concerned agencies.

The task forces need to be created under assessment system are Water Availability Task Force, Impact Assessment Task Forces and Review and Reporting Task Force.

Drought Mitigation Mechanism: The drought mitigation strategies may be divided into three categories. Selection of strategies may depend on drought situation of areas. Arid and semiarid areas, where even one crop is difficult to grow, need constant attention through consistent implementation of both short-term and long-term measures.

- Short-term Measures: The short-term drought measures may range from providing food, fodder and fuel, intense groundwater exploitation programs for domestic and livestock consumption and life saving irrigation, soil moisture conservation measures, supply of drinking water through tankers, crash employment programmes and appropriate contingency plans to raise crop and fodder with limited water. They may also include strengthening of public distribution system, public health measures and supplementary nutritional programmes to nursing mother and children, and public awareness camping for frugal use of water for domestic and irrigation purposes.
- Long-term Measures: The long term drought proofing measures are essential to combat permanent drought effects. These include programmes for installation of tubewells, construction of ponds and percolation tanks for irrigation and domestic water supply purposes, desilting of tanks and canals, establishing soil conservation and water harvesting structures, regulations on landuse, afforestation, grassland and waste land development, measures to reduce water loss through seepage and evaporation, and groundwater exploitation policies, etc.
- Cloud Seeding: Another method known as 'cloud seeding' is being used to produce rain. It has been tried for changing the climate in drought affected areas. To produce rain, iodine crystals are scattered among clouds from aircraft. The water-vapour molecules in the clouds cluster around the crystals and make them heavy. Eventually the overloaded crystals fall to earth as rain. Unfortunately, this method works well only in areas where rainfall readily occurs naturally. Karnataka Government proposed to go for cloudseeding in the Cauvery catchment area during the present drought. However, it is not known whether the proposed cloudseeding was carried out or not. Mostly it was not done. Tamil Nadu had gone for cloudseeding thrice in the 80s and 90s to mitigate drinking water scarcity [7].

Landslide Disaster Mitigation Measures:

The priority is given to landslide hazard assessment and mapping in settled areas. The approach is selective and planning-oriented. It is a rational and economic tool for mitigation as it indicates problems only where disasters are likely to occur. Landsliding is considered to be one of potentially most predictable of geologic hazards.

Assessment and mapping of landslides: Landslide hazard zoning has been pursued actively for only about 20 years and is still in an experimental stage. Historical information on geologic, geomorphic and hydrological situation makes it possible to estimate the frequency of occurrence, extent and consequences of future events in similar situations. The more accurate the data on specific sites, the better the impact of failure can be predicted. The simplest type of map consists of a general purpose geological map, showing conventional geological formations, with remarks in the map explanation or the accompanying tabular text about the relative stability of the geological units. Other investigations have used the factors of lithology and slope to produce a map on slope stability.

Hansen identified three main groups of techniques to landslide hazard assessment:

- Geotechnical investigations, involving the detailed analysis of surface and subsurface conditions and ground materials.
- Direct mapping involving the analysis of landforms and the information may be obtained by air-photo interpretation, ground survey or literature review and additional information may be included on the type, size age or state of activity of the recognized failures.
- Indirect mapping, which requires the collection of data on the causes and mechanisms of landsliding so that assessment of slope instability can be made by the application of known landslide-including parameters. There are land systems mapping, risk maps and zonation mapping also. Majority of landslide incidences in India falls in category of rainfall induced landslides.

Landslide Disaster Management Measures:

For reducing landslide risks, the major measure is regulation of landuse, protection of infrastructure in landslide-prone areas is feasible, but often requires expensive engineering measures. Some techniques for reducing landslide hazards are:

- Discouraging new development in hazardous areas by disclosing the hazard to real-estate buyers, posting warnings of potential hazards, adopting utiliting and public-facility service-area policies, informing and educating the public and making a public record of hazards.

- Removing or conventing existing development through acquiring or exchanging hazardous properties, discontinuing nonconforming uses, reconstructing damaged areas after landslides, removing unsafe structures and clearing and redeveloping blighted areas before landslides.
- Providing financial incentives or disincentives by conditioning federal and adopting lending policies that reflect risk of loss, requiring insurance related to level of hazard and providing tax credits or lower assessments to property owners.
- Regulating new development in hazardous areas by enacting grading ordinances, adopting hillslide-development regulations, amending land-use zoning districts and regulations, enacting sanitary ordinances, creating special hazard-reduction zones and reduction zones and regulations, enacting subdivision ordinances and placing moratoriums on rebuilding.
- Protecting existing development by controlling landslides and slumps, controlling mudflows and debris flows, controlling rockfalls, creating improvement districts that assess costs to beneficiaries and operating monitoring, warning and evacuating systems [8].

Avalanche Disaster Management Measures:

- **Forecasting and Warning:** For avalanche, site-specific warnings are more common and between 20 and 30 countries have systems in operation which employ both forecasts and predictions. Forecasts tend to be used increasingly for day-to-day management of winter sports areas whilst predictions are normally used as an aid in hazard land zoning. Avalanche forecasting involves conducting regular snow stability tests and evaluating the results in conjuction with weather forecast information. Local meteorological data form another important input into the evaluation phase of the avalanche forecast. These monitoring operations may well be conducted on a daily basis for major ski resorts and in especially dangerous areas. As with all forecasting and warning schemes, there is a basic need for public education and awareness.
- **Community Preparedness:** In most avalanche hazard areas some search and rescue organization exists. This is because action needs to be taken quickly to free buried victims, since the probability of survival is related to the time buried beneath the snow. The chances of survival decline rapidly after one or two hours, even when the victim is trapped close to the surface. The overall survival rate after complete burial is less than 1 in 5. An avalanche search is a complex operation, with most victims being found by probing the snow with metal rods. The chances of a victim being found are increased if search dogs are available. Detection is also improved if the victim has used an avalanche beacon or bleeper or has been attached to a brightly coloured avalanche cord which extends up to snow surface.
- **Land Use Planning:** Many avalanche tracks function as landslide gullies during the spring and summer. Avalanche zoning employs historical data of avalanche occurrence for the identification of hazardous locations and supplements this information with terrain models and models of avalanche dynamics to determine more detailed degrees or risk. Where sites are near established settlements, avalanche frequency will be a matter of local knowledge. At more remote locations, vegetation can provide valuable clues. Once potential sites have been identified, and frequency estimates made, initial mapping is usually undertaken at a scale of about 1:50000 with aid of air photographs. The maps are accompanied with a detailed description of the terrain and vegetation for each avalanche site, together with an assessment of the hazard impact. Where avalanches threaten settlements, it is necessary to zone the area at a larger map scale and adopt related planning regulations. The length of the runout zone is a critical factor here since it determines whether or not a particular site will be reached by moving snow. The zoning methodology is well established in many countries. For example, the Swiss use a three-zone, colour-coded system, as detailed. Similar planning regulations have been adopted for communities in the Rocky mountains of the USA [9].

Cyclone Disaster Management and Mitigation Measures:

The last requirement of the efficient warning system is the prompt action by the government and public on the warnings issued. Structural measures like construction of cyclone shelters, embankments, dykes, reservoirs and coastal afforestation are some of the long-term mitigation measures for cyclone disasters. To motivate people not to live in the major cyclone disaster prone areas, establishment of developmental project away from the cyclone prone areas, proper legislation, land-zoning, insurance cover and proper education of public about cyclone warning systems and disaster mitigation measures are some of the long term measures of non-structural type. Short term preparedness measures are timely warnings and timely and effective rescue, relief and rehabilitation at the time of disaster. In all these efforts, the role of India Meteorological Department is to organize, issue and communicate timely warning to the concerned authorities and public. Rest of the actions pertain to other agencies like state and Central government and voluntary agencies. An extensive programme for afforestation of coastal areas has been in operation since 1977. Warnings are issued when the tropical cyclone poses a threat to lives and property. Now, the India Meteorological Department established in 1875 has installed cyclone surveillance Radars at Kolkata, Paradeep, Vishakhapatnam, Machilipatnam, Chennai and Karaikal in the east coast and at Cochin, Goa, Mumbai and Bhuj in the west coast. In April 1982, The Indian National Satellite (INSAT-IA) was positioned over the equator, which kept a continuous watch of cyclones and transmitted their pictures every half an hour to the Meteorlogical Data Utilization Centre at Delhi. Satellite picture receiving (APT) equipment of Delhi, Mumbai, Pune, Chennai, Vishakhapatnam, Kolkata and Guahati are receiving satellite pictures of cyclones from the Polar-orbiting satellites of the U.S.A. and U.S.S.R.

- **Assessment:** It is a pre requisite to effective post-disaster management. An estimate of the loss is necessary so that resources could be mobilized and distributed to the effected areas.
- **Planning:** Besides the provision of infrastructural facilities for effective disaster management, the administrative machinery should be entrusted with the necessary powers to carry out disaster management programmes.
- **Financial arrangement:** It is the backbone of disaster management programme. The Government of India supplements the efforts of the State Governments under a set of well established norms governed by the recommendations of successive finance commissions.
- For cyclones following long term, medium term and short term measures be taken:

Long term measures: Strengthening of houses, developing a system of land planning and regulation to reduce the risk, plant trees at some distance from houses to serve as wind and tide breakers and loose material lying around inhabitations should be tightly fastened or removed.
Medium term measures: Communication network for early warning is the most important and should be finalized well in advance of the cyclone season, public education regarding cyclone and arrangement of emergency stores and first aid centers.
Short term measures: Contingency plans to be finalized, to issue regular warning and ensure that they are taken seriously, evacuation from vulnerable areas and public health and sanitation measures.

- **Voluntary and Non-Governmental Organisations:** Non-governmental organizations are mainly concerned with rendering relief works such as shifting of victims to safer places, running relief camps, distribution of clothes, gratuitous relief for damaged houses, distribution of utensils, medical aid and distribution of housing materials, etc [10].

IV. Discussion

M. R. Zolfaghari et al. (2015) presented a new methodology to implement the concept of equity in regional earthquake risk mitigation programs using an optimization framework. It presented a framework that could be used by decisionmakers (government and authorities) to structure budget allocation strategy toward different seismic risk mitigation measures, i.e., structural retrofitting for different building structural types in different locations and planning horizons. A two-stage stochastic model was developed here to seek optimal mitigation measures based on minimizing mitigation expenditures, reconstruction expenditures, and especially large losses in highly seismically active countries. To consider fairness in the distribution of financial resources among different groups of people, the equity concept was incorporated using constraints in model formulation. These constraints limit inequity to the user-defined level to achieve the equity-efficiency tradeoff in the decision-making process. To present practical application of the proposed model, it was applied to a pilot area in Tehran, the capital city of Iran. Building stocks, structural vulnerability functions, and regional seismic hazard characteristics were incorporated to compile a probabilistic seismic risk model for the pilot area. Results illustrated the variation of mitigation expenditures by location and structural type for buildings. These expenditures were sensitive to the amount of available budget and equity consideration for the constant risk aversion. Most significantly, equity was more easily achieved if the budget was unlimited. Conversely, increasing equity where the budget was limited decreased the efficiency. The risk-return tradeoff, equity-reconstruction expenditures tradeoff, and variation of per-capita expected earthquake loss in different income classes were also presented. This relationship has been confirmed in the study of natural disasters and their mitigation measures as mitigation measures for earthquake have been described as the standard mitigation measures are: a) Hazard Zone Mapping b) Monitoring, Forecasting, Warning: The Indian Meteorological Department is the key agency in India for monitoring earthquakes. It maintains 56 Seismological Stations. Five regional meterological offices control 32 seismological observations in different parts of India. c) Structural Mitigation Research and Development: Based on past experiences, special structural measures resistant to earthquakes were developed. These codes incorporate guidelines for design and construction of earthquake resistant buildings in different seismic zones of the country. d) Emergency Management: The basic responsibility for undertaking relief and rescue operations lies with the State Government concerned. However, the Government of India is intimately involved at every stage in providing financial, technical and material support. The Central Relief Commissioner maintains close liaison with concerned central departments/ agencies as well as the state government’s representative in coordinating relief measures. Thus, the earthquake mitigation and management measures can be implemented before, during and after earthquake for reducing loss of property and saving lives [11].

R Jr. Gilbuena et al. (2013) showed that in recent years, the practice of environmental impact assessment (EIA) has created significant awareness on the role of environmentally sound projects in sustainable development. In view of the recent studies on the effects of climate change, the Philippine government has given high priority to the construction of flood control structures to alleviate the destructive effects of unmitigated floods, especially in highly urbanized areas like Metro Manila. EIA thus, should be carefully and effectively carried out to maximize or optimize the potential benefits that can be derived from structural flood mitigation measures (SFMMs). A utility-based environmental assessment approach may significantly aid flood managers and decision-makers in planning for effective and environmentally sound SFMM projects. This study proposed a utility-based assessment approach using the rapid impact assessment matrix (RIAM) technique, coupled with the evidential reasoning approach, to rationally and systematically evaluate the ecological and socio-economic impacts of 4 planned SFMM projects (i.e. 2 river channel improvements and 2 new open channels) in Metro Manila. Results showed that the overall environmental effects of each of the planned SFMM projects were positive, which indicate that the utility of the positive impacts would generally outweigh the negative impacts. The results also implied that the planned river channel improvements will yield higher environmental benefits over the planned open channels. This study was able to present a clear and rational approach in the examination of overall environmental effects of SFMMs, which provides valuable insights that can be used by decision-makers and policy makers to improve the EIA practice and evaluation of projects in the Philippines. This relationship has been confirmed in the study of natural disasters and their mitigation measures as mitigation measures for flood have been described as structural measures were those involving the construction of enginerring facilities, such as reservoirs, dams, retarding basins, leeves and flood walls, channel improvements, catch modification and by-pass floodways. The purpose of such measures were to control the water through storage, modifying the rate of flow, improving river flow conditions and confining the flow within certain boundaries. Non-structural measures comprised all other means which did not require construction of engineering facilities. They included flood forecasting and warning systems, planning controls, such as zoning and building regulations, acquisition of land and relocation, flood insurance, public information and education, disaster preparedness and flood adaption. Effective flood forecasting and warning systems could enable a community to prepare for a possible flood, thereby minimizing damage and averting death or injury. The development of computer-based information technology, during recent years has provided the disaster managers greater access to the information they need. The disaster management reactivity comprises of four distinct functions of mitigation, preparedness, response and recovery Thus, the flood mitigation and management measures can be implemented before, during and after flood for reducing loss of property and saving lives [12].

W. H. Huang et al. (2013) showed that zoning seasonal drought based on the study of drought characteristics can provide theoretical basis for formulating drought mitigation plans and improving disaster reduction technologies in different arid zones under global climate change. Based on the National standard of meteorological drought indices and agricultural drought indices and the 1959-2008 meteorological data from 268 meteorological stations in southern China, this paper analyzed the climatic background and distribution characteristics of seasonal drought in southern China, and made a three-level division of seasonal drought in this region by the methods of combining comprehensive factors and main factors, stepwise screening indices, comprehensive disaster analysis, and clustering analysis. The first-level division was with the annual aridity index and seasonal aridity index as the main indices and with the precipitation during entire year and main crop growing season as the auxiliary indices, dividing the southern China into four primary zones, including semi-arid zone, sub-humid zone, humid zone, and super-humid zone. On this basis, the four primary zones were subdivided into nine second-level zones, including one semi-arid area-temperate-cold semi-arid hilly area in Sichuan-Yunnan Plateau, three sub-humid areas of warm sub-humid area in the north of the Yangtze River, warm-tropical sub-humid area in South China, and temperate-cold sub-humid plateau area in Southwest China, three humid areas of temperate-tropical humid area in the Yangtze River Basin, warm-tropical humid area in South China, and warm humid hilly area in Southwest China, and two super-humid areas of warm-tropical super-humid area in South China and temperate-cold super-humid hilly area in the south of the Yangtze River and Southwest China. According to the frequency and intensity of multiple drought indices, the second-level zones were further divided into 29 third-level zones. The distribution of each seasonal drought zone was illustrated, and the zonal drought characteristics and their impacts on the agricultural production were assessed. Accordingly, the drought prevention measures were proposed. This relationship has been confirmed in the study of natural disasters and their mitigation measures as mitigation measures for drought have been described as drought disaster mitigation should be conducted in four broad steps: a) Early warning and vulnerability assessment – identifies areas and groups that might be at risk and establishes consensus among people and government. b) Rapid water/ food security assessment – verifies the findings of the vulnerability assessment, determines the level of vulnerability and identifies the types of interventions that might be appropriate. c) Intervention translates the findings of the rapid water/ food security assessment in action and establishes the criteria for determining success. d) Monitoring and outcome assessment documents project progress, undertakes changes in response to performance, and determines whether project goals have been achieved Thus, the drought mitigation and management measures can be implemented before, during and after drought for reducing loss of property and saving lives [13].

F. Karsli et al. (2009) reported that mountainous topographic character and high frequency of heavy rain were the main factors for landslide occurrence in Ardesen, Rize. For this reason, the main target of the present study was to evaluate the landslide hazards using a sequence of historical aerial photographs in Ardesen (Rize), Turkey, by Photogrammetry and Geographical Information System (GIS). Landslide locations in the study area were identified by interpretation of aerial photographs dated in 1973 and 2002, and by field surveys. In the study, the selected factors conditioning landslides were lithology, slope gradient, slope aspect, vegetation cover, land class, climate, rainfall and proximity to roads. These factors were considered as effective on the occurrence of landslides. The areas under landslide threat were analyzed and mapped considering the landslide conditioning factors. Some of the conditioning factors were investigated and estimated by employing visual interpretation of aerial photos and topographic data. The results showed that the slope, lithology, terrain roughness, proximity to roads, and the cover type played important roles on landslide occurrence. The results also showed that degree of landslides was affected by the number of houses constructed in the region. As a consequence, the method employed in the study provided important benefits for landslide hazard mitigation efforts, because a combination of both photogrammetric techniques and GIS was presented. This relationship has been confirmed in the study of natural disasters and their mitigation measures as mitigation measures for landslide have been described as Hansen identified three main groups of techniques to landslide hazard assessment: a) Geotechnical investigations, involving the detailed analysis of surface and subsurface conditions and ground materials. b) Direct mapping involving the analysis of landforms and the information may be obtained by air-photo interpretation, ground survey or literature review and additional information may be included on the type, size age or state of activity of the recognized failures. c) Indirect mapping, which requires the collection of data on the causes and mechanisms of landsliding so that assessment of slope instability can be made by the application of known landslide-including parameters. There are land systems mapping, risk maps and zonation mapping also. Majority of landslide incidences in India falls in category of rainfall induced landslides Thus, the landslide mitigation and management measures can be implemented before, during and after landslide for reducing loss of property and saving lives [14].

C. M. Rheinberger et al. (2009) reported that a method for optimizing avalanche mitigation for traffic routes in terms of both their risk reduction impact and their net benefit to society. First, introduced a generic framework for assessing avalanche risk and for quantifying the impact of mitigation. This allows for sound cost-benefit comparisons between alternative mitigation strategies. Second, illustrated the framework with a case study from Switzerland. Findings suggested that site-specific characteristics of avalanche paths, as well as the economic importance of a traffic route, were decisive for the choice of optimal mitigation strategies. On routes endangered by few avalanche paths with frequent avalanche occurrences, structural measures were most efficient, whereas reliance on organizational mitigation was often the most appropriate strategy on routes endangered by many paths with infrequent or fuzzy avalanche risk. Finally, keeping a traffic route open may be very important for tourism or the transport industry. Hence, local economic value may promote the use of a hybrid strategy that combines organizational and structural measures to optimize the resource allocation of avalanche risk mitigation. This relationship has been confirmed in the study of natural disasters and their mitigation measures as mitigation measures for avalanche have been described as a) Forecasting and Warning: For avalanche, site-specific warnings are more common and between 20 and 30 countries have systems in operation which employ both forecasts and predictionsLocal meteorological data form another important input into the evaluation phase of the avalanche forecast. These monitoring operations may well be conducted on a daily basis for major ski resorts and in especially dangerous areas. As with all forecasting and warning schemes, there is a basic need for public education and awareness. b) Community Preparedness: In most avalanche hazard areas some search and rescue organization exists. An avalanche search is a complex operation, with most victims being found by probing the snow with metal rods. The chances of a victim being found are increased if search dogs are available. Detection is also improved if the victim has used an avalanche beacon or bleeper or has been attached to a brightly coloured avalanche cord which extends up to snow surface. c) Land Use Planning: Avalanche zoning employs historical data of avalanche occurrence for the identification of hazardous locations and supplements this information with terrain models and models of avalanche dynamics to determine more detailed degrees or risk. Where sites are near established settlements, avalanche frequency will be a matter of local knowledge. At more remote locations, vegetation can provide valuable clues. Once potential sites have been identified, and frequency estimates made, initial mapping is usually undertaken at a scale of about 1:50000 with aid of air photographs. The maps are accompanied with a detailed description of the terrain and vegetation for each avalanche site, together with an assessment of the hazard impact Thus, the avalanche mitigation and management measures can be implemented before, during and after avalanche for reducing loss of property and saving lives [15].

J. K. Mitchell (1985) showed that Hurricane Iwa (23rd November 1982) produced Hawaii's costliest natural disaster and revealed serious flaws in the area's hurricane preparedness, response and mitigation programs. Twenty-eight months later, a follow-up study showed that impacted communities and facilities had been reconstructed with only selective and limited attention to mitigating future coastal storm hazards. Prospects for the reduction of hazard vulnerability on oceanic islands through post-disaster mitigation measures were assessed in the light of Hawaii's experience. This relationship has been confirmed in the study of natural disasters and their mitigation measures as mitigation measures for cyclone have been described as long term measures were Strengthening of houses, developing a system of land planning and regulation to reduce the risk, plant trees at some distance from houses to serve as wind and tide breakers and loose material lying around inhabitations should be tightly fastened or removed. Medium term measures were Communication network for early warning is the most important and should be finalized well in advance of the cyclone season, public education regarding cyclone and arrangement of emergency stores and first aid centres. Short term measures were Contingency plans to be finalized, to issue regular warning and ensure that they are taken seriously, evacuation from vulnerable areas and public health and sanitation measures Thus, the cyclone mitigation and management measures can be implemented before, during and after cyclone for reducing loss of property and saving lives [16].

V. Figures and Tables

Table 1: Number of earthquakes worldwide, 1991-2008 and mortality figures, 2000-2008

Magnitude	2000	2001	2002	2003	2004	2005	2006	2007	2008
8.0-9.9	1	1	0	1	2	1	1	4	0
7.0-7.9	14	15	13	14	14	10	10	14	9
6.0-6.9	158	126	130	140	141	140	142	172	101
5.0-5.9	1345	1243	1218	1203	1515	1693	1712	1885	775
4.0-4.9	8045	8084	8584	8462	10888	13917	12838	12275	6518
3.0-3.9	4784	6151	7005	7624	7932	9191	9990	9876	6031
2.0-2.9	3758	4162	6419	7727	6316	4636	4027	3593	1809
1.0-1.9	1026	944	1137	2506	1344	26	18	43	8
0.1-0.9	5	1	10	134	103	0	2	2	0
No Magnitude	3210	2938	2937	3608	2939	864	828	1807	899
Total	22256	23534	27454	31419	31194	30478	29568	29671	16150
Estimated deaths	231	21357	1685	33819	284010	82634	6605	712	87736

Table 2: Significant flood loss events 1990-1998

Date	Country	Total Losses	Deaths
10 June-30 Sep. 1998	India, Bangl., Nepal	5020	4750
May-Sep. 1998	China	30000	3656
21 June-20 Sep. 1993	China	11000	3300
May- Sep. 1991	China	15000	3074
27 June-13 Aug. 1996	China	24000	3048
Oct.-Dec. 1997	Somalia	-----	1800
4 Sep.-2 Oct. 1992	India	1000	1500

Table 3: Administrative districts frequently affected by droughts in India

Andhra Pradesh	Anantapur, Chittoor, Cuddapah, Hyderabad, Kurnool, Mehaboobnagar, Nalgonda, Prakasm
Bihar	Munger, Nawadah, Palamaum Rphtas, Bhojpur, Aurangabad, Gaya
Gujarat	Ahmedabad. Amrely, Banaskanta, Bhavanagar, Bharuch, Jamnagar, Kheda, Kutch, Meshana, Panchmahal, Rajkot, Surendranagar
Haryana	Bhiwani, Gurgaon, Mahengragarh, Rohtak
Jammu & Kashmir	Doda, Udhampur
Karnataka	Banguluru, Belgaum, Bellary, Bijapur, Chitradurga, Chickmangalur, Dharwad, Gulbarga, Hassan, Kolar, Mandya, Mysore, Raichur, Tumkur
Madhya Pradesh	Betul, Dtia, Dhar, Jhabuva, Khandak, Khargaon, Shahdol, Shahjapur, Sidhi, Ujjain
Maharashtra	Ahmedanagar, Aurangabad, Beed, Nanded, Nashik, Osmanabad, Pune, Parbhani, Sangli, Satara, Sholapur
Orissa	Phulbandi, Kalakhandi, Bolangir, Kendrapada

Table 4: Landslide fatality data by country for 2007

Country	Total number of deaths	Average number of deaths (rainfall induced)
China	677	13.0
Philippines	92	3.5
Vietnam	130	2.9

Indonesia	465	12.6
Nepal	168	3.9
India	352	5.3
Bangladesh	150	8.8
Pakistan	273	17.0
Afghanistan	43	8.6
Colombia	73	5.5
Peru	40	8.0
Mexico	74	9.3
Brazil	56	3.7

Table 5: Hurricane deaths in the Bay of Bengal region

Region	Date	Deaths
Andhra Pradesh	10 Oct 1679	20000
Bangladesh	7 Oct 1737	300000
Bangladesh	13 Nov 1970	500000
Andhra Pradesh	26 Nov 1977	> 10000
West Bengal	29 Apr 1991	140000

Table 6: Changes in the number of category four and five hurricanes for periods 1975-89 and 1990-2004 for different ocean basins

Basin	1975-1989	1990-2004
East Pacific	36	49
West Pacific	85	116
North Atlantic	16	25
South West	10	22
Indian Ocean	24	57

VI. Conclusion

It can be concluded that disaster management and mitigation measures for all natural disasters such as earthquakes, floods, drought, landslides, avalanches and cyclones mentioned above in the paper can be implemented before, during and after disasters for saving lives, reducing loss of property and benefit of society.

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