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SPECIAL SECTION B

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ENVIRONMENTAL HAZARDS IN REGIONAL DEVELOPMENT

1.0
INTRODUCTION

1.1
IMPORTANCE OF ENVIRONMENTAL HAZARDS FOR REGIONAL DEVELOPMENT

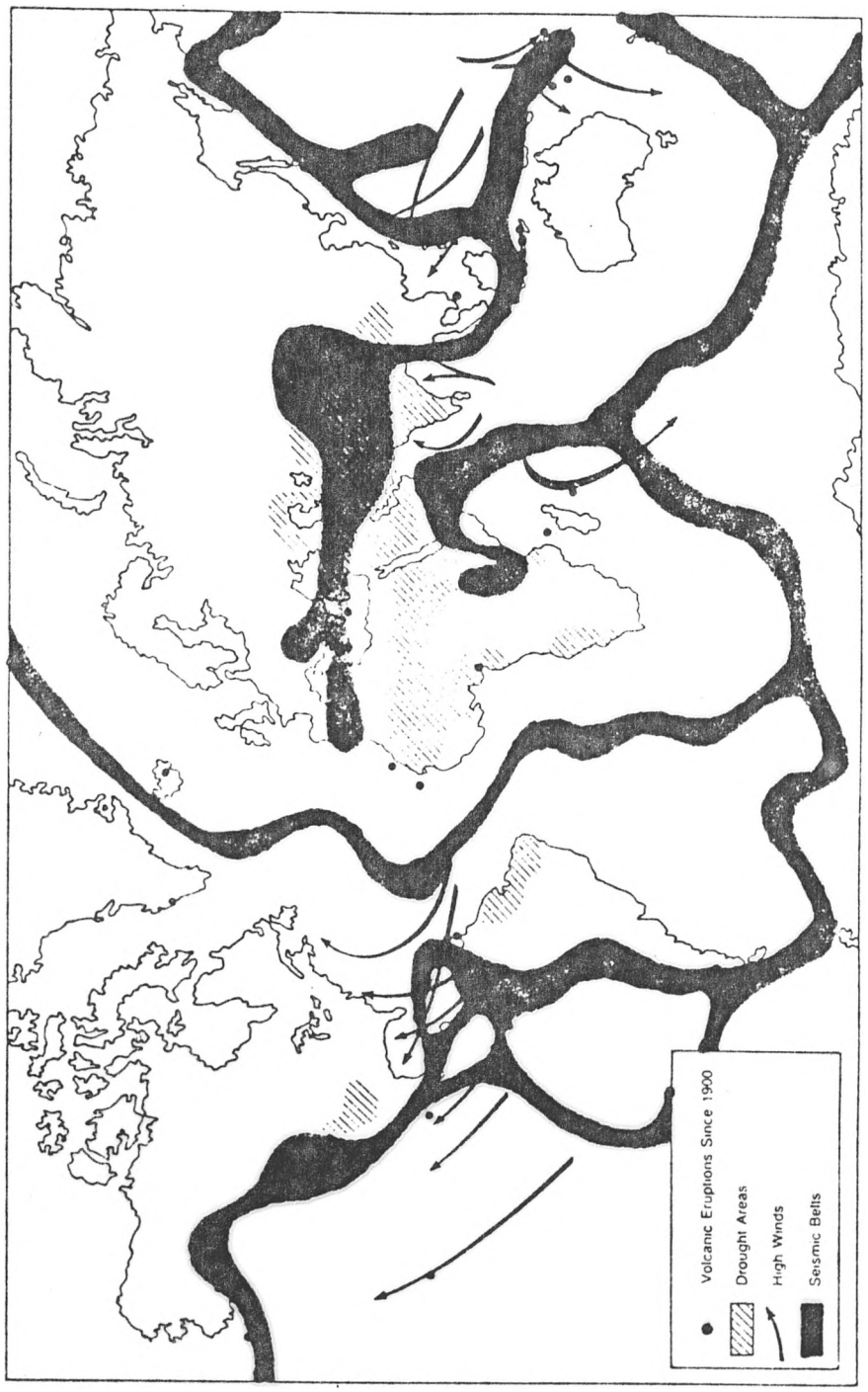
Environmental hazards endanger the lives and health of regional populations, and may result in destruction of resources and property, reduced productivity, disruption of networks and vital services, and impairment of other activities and functions necessary for overall regional development. Environmental hazards pose a major threat to lives and property in many parts of the world **(Figure B1)**. Every year these sudden and often unpredictable events bring widespread devastation to human settlements, and their impact is felt far beyond the directly-affected area.

Environmental hazards kill people, especially the poor. The most serious immediate consequences of natural disasters is the loss of human lives. The death rate is significantly higher in developing countries where communications are poor and warning systems and evacuation plans are inadequate. Furthermore, the number of deaths increases as population pressures and poverty force people to inhabit more vulnerable areas such as low-lying agricultural areas or steep slopes prone to slides.

Environmental hazards damage and destroy settlement networks. In addition to damage to homes, natural disasters may destroy or damage facilities that are critical not only for responding to disasters, but also for maintaining a safe environment and public order. Among these are communications installations; electrical generating and transmission facilities; water storage, purification, and pumping facilities; sewage treatment facilities; hospitals; police stations; and various other public and private buildings.

Environmental hazards disrupt agricultural production and damage agricultural land resources. Hurricanes and floods disrupt agriculture and destroy crops. High winds destroy some standing crops, especially basic grains, and damage orchards and forests. Flooding can damage certain crops, especially tubers, and may cause excessive erosion. Storm surges scour and erode topsoils, deposit salts on fields, and may increase salinity in subsurface water. Furthermore, access to markets for buying and selling agricultural produce may be impeded by damage to roads, bridges, railways, etc.

FIGURE B1: GLOBAL DISTRIBUTION OF MAJOR HAZARD ZONES



GLOBAL DISTRIBUTION OF MAJOR HAZARD ZONES

Land values may also change following a natural disaster. For example, if flooding or a storm surge has struck, the value of the inundated land usually declines, especially if erosion occurs or if salt deposits remain. Sites that proved to be safe (that is, above the flood level or that were protected from high flooding by levees or dams) may increase in value.

Environmental hazards disrupt economies and increase the marginality of the rural poor. Disasters disrupt economies. Consequences include the loss of investments and jobs (due for example to destruction of or damage to factories); production losses which result from the destruction of harvests or crops; the death of livestock; the closure of shops, small businesses and industrial production units, etc. During an emergency people must leave their jobs and devote their time to disaster-related activities such as search-and-rescue or caring for survivors. During this period, normal economic activities are severly curtailed even if the sources of employment are unaffected.

Income groups participating only marginally in the economy before disasters (e.g., subsistence farmers, fishermen, etc.) are affected most severely by economic losses. After a disaster, it is not uncommon for many small enterprises and farms to fail.

Environmental hazards create financial burdens on government. In addition to the cost of emergency relief and reconstruction, an increase in social expenditures for preventive and curative medicine, unemployment, housing subsidies, etc., plus a decrease in economic activities and related tax receipts, may create a heavy financial burden on the government.

Environmental hazards have long-term effects on regions. Disasters also cause indirect and secondary effects that have far-reaching long-term impacts on an entire regions. Fundamental changes may occur in the lifestyles of the people as well as in the basic direction in which the society had been moving prior to the disaster. Disaster-induced changes occur because disasters create a climate wherein changes in society (including land use, agricultural, economic, political, demographic and housing patterns) are more acceptable--or even demanded.

Long term effects on economies can increase disparities and accelerate rural-urban migration. Disasters can significantly retard the long-term economic growth of developing countries. Indirect and secondary effects on the local and national economy of a

country may include reduction in family income, decline in the production of business and industrial enterprises, inflation, unemployment, increases in income disparities, and a decline in national income.

The loss of economic activity in future years by persons who are killed or disabled will have a long-term impact on the economy at both macro- and micro-levels. The loss of economic opportunity or the need to find alternate sources of income have often caused small-scale migrations of skilled workers from rural areas into the cities. Once established in a city, few return to rebuild their homes or businesses.

Small marginal farms (two acres or less) often cannot survive a hurricane or flooding. Farmers may be forced to sell their land because they cannot afford to rehabilitate it. This may result in a substantial increase in the number of people migrating to urban areas and thus a related housing shortage.

Environmental hazards frustrate regional development. Relief and reconstruction efforts compete with development programs for available funds. In countries where disasters occur frequently, they can create an enormous financial burden.

Fiji provides a good example. In the 1970s, the country was repeatedly struck by hurricanes, which forced the government to comit a large portion of the foreign aid received to reconstruction. In the early 1980s, roughly 20% of the foreign aid was spent on overhead costs alone for reconstruction efforts from four separate hurricanes. The Economic Commission of the United Nations for Latin America has estimated that the damage caused by natural disasters in the five countries of the Central American Common Market, for example, reduced the average annual growth rate of Gross Domestic Product by approximately 2.3 percent over the 15-year period between 1960 and 1975.

1.2 OPPORTUNITIES FOR EPM

Avoidance of environmental hazards and prevention of disasters provides opportunities to assure the satisfaction of basic needs, reduce productivity losses, contribute to sustainability and relative self-sufficiency, and improve economic efficiency and socio-spatial equity in regional development. The consideration of environmental hazards in the regional planning and management process offers significant opportunities for achieving regional development goals. There are many practical reasons for considering hazard in RPM. By managing hazards adequately, the potential for widespread disasters is

substantially reduced, thereby reducing the cost of reconstruction. Hazard management can also reduce environmental degradation. Floods and windstorms, for example, can create widespread erosion; yet with adequate planning this erosion can be substantially lessened.

Considering hazards in RPM protects previous investments in infrastructure and networks. Hazard management also protects man-made resources at the regional level. Transportation networks, energy supplies, and irrigation networks are all examples of man-made resources that could be adversely affected by a hazard. In both the siting and installation of these facilities and infrastructure, regional planners must take into account the potential effects of a natural hazard and the measures that would reduce the probability or impact of such an event.

Considering hazards in RPM protects natural resources. Hazard management protects natural resources at the regional level. Food-producing areas such as agricultural and grazing lands, minerals, forests, water resources, and natural heritage and recreation areas all fall under the realm of regional planning. Hazard management protects these zones and ensures their continued availability without interruption.

Considering hazards in RPM promotes economic efficiency in the use of source development resources. Reconstruction is expensive and, because of the severity of a disaster, demands that funds be committed immediately to meet emergency and rehabilitation needs. Thus, reconstruction competes with development for available monies. For LDCs where funds are already scarce, this competition can mean having to postpone important development projects for many years. Regional planning for vulnerability reduction can reduce the financial burden as well as the material damage created by a disaster and thus benefit long-term development activities both financially and physically.

Considering hazards in RPM enhances equity. Land issues are of special concern in disasters because in many cases they have been a major factor in disaster vulnerability. Many low-income people live in areas that are particularly vulnerable to disasters such as steep, unstable slopes, flood plains or low-lying coastal areas. Following a disaster, it is usually obvious that those disproportionately affected were living on poor sites.

Considering hazards in RPM increases self-sufficiency by reducing regional vulnerability. The vulnerability of a region is determined by the degree to which its natural and man-made resources and its economy can be adversely affected by a natural phenomenon and the relative degree of probability that a hazardous event will occur. Economies are considered vulnerable if they cannot absorb the losses caused by a disaster without undue stress. Natural resources are considered vulnerable if they cannot be renewed naturally or within a reasonable amount of time without assistance by man. Man-made resources are considered vulnerable if extensive capital investment is required to replace the losses and if potential losses cannot be absorbed by the existing economic structure.

Considering hazards in RPM can accelerate development. RPM that accounts for natural hazards can lead to an acceleration of development activity and improved resilience to natural hazards through integral prevention, mitigation, and preparedness measures. This resilience promotes stability in the socio-economic order that in turn contributes to the necessary conditions for sound development planning and continuous multiplication of development benefits, as each stage of development builds on its predecessor. Moreover, human settlements in a more advanced state of development have an increased capacity to respond to the threat and reality of natural disaster because they are able to incorporate and support more advanced disaster preparedness, response, and recovery mechanisms.

2.0
FLOODS

2.1
IMPORTANCE FOR REGIONAL DEVELOPMENT

Floods are of major significance to regional development. Floods are destructive natural hazards that cause loss of life and extensive social and economic disruption. Each year, floods take an increasing number of lives and property.

Floods damage settlements and destroy resources. Floods can damage settlements, force evacuations, damage certain crops (especially tubers), damage food stocks, strip farmland, wash away irrigation systems, erode large areas of land or make them otherwise unusable, and may change the course of streams and rivers. Floods may also have a beneficial effect by depositing silt in some downstream areas. A secondary effect of heavy rainfall is mudslides. Heavy rains quickly supersaturate hillsides that have been deforested or stripped for farming and can cause immense landslides. Large loss of life may occur in these massive mudslides, especially in squatter settlements located in floodplains. In Honduras in 1975, over 10,000 people were killed in mudslides resulting from heavy rains saturating denuded hillsides.

Floods have long-term effects on regional economies and productivity. Widespread floods can have a significant effect on the long-term economic growth of the affected region. Indirect and secondary effects on the local and national economy of the area may include reduction in family income, decline in the production of business and industrial enterprises, inflation, unemployment, increase in income disparities, and decline in national income. In addition, relief and reconstruction efforts in countries where floods occur frequently can create an enormous financial burden.

Floods increase rural poverty and reduce self-sufficiency. The vulnerability of a region is defined by its exposure to flooding and the frequency of the floods. This is determined by siting, soil conditions, absorptive capacity of the watershed, and the capacity of streams to carry runoff. Rural communities and economic activities such as farms sited on floodplains of rivers or streams are the zones most at risk. Small marginal farms (two acres or less) usually cannot survive economically following a major flood. Farmers are often forced to sell their land because they cannot afford to rehabilitate it. This

may result in a substantial increase in the number of people migrating to urban areas, and thus a related housing shortage there. The loss of crops and the need to find alternate sources of income have often caused small-scale migrations of farmers and skilled workers from rural areas to cities. Once established in a city, few return to their homes or farms.

2.2 CHARACTERISTICS RELEVANT TO REGIONAL DEVELOPMENT

Flood characteristics are features of great importance to RPM and the achievement of regional development goals. Flooding is any abnormally high streamflow that overtops the natural or artificial banks of a stream. Flooding is a natural characteristic of rivers. Floodplains are normally dry land areas and are an integral part of a river system that act as a natural reservoir and temporary channel for flood waters. If more runoff is generated than the banks of a stream channel can accommodate, the water will overtop the stream banks and spread over the floodplain. The ultimate factor of damage, however, is not the quantity of water being discharged, but the stage or elevation of the water surface. Furthermore, floods can form where there is no stream, as for example when abnormally heavy precipitation falls on flat terrain at such a rate that the soil cannot absorb the water or the water cannot run off as fast as it falls.

Flash floods are local floods of great volume and short duration. A flash flood generally results from a torrential rain or "cloudburst" on relatively small and widely-dispersed streams. Runoff from the intense rainfall results in high flood waves. Discharges quickly reach a maximum and diminish almost as rapidly. Flood flows frequently contain large concentrations of sediment and debris. Flash floods also result from the failure of a dam or the sudden breakup of an ice jam. Flash floods are particularly common in mountainous areas and desert regions but are a potential threat in any area where the terrain is steep, surface runoff rates are high, streams flow in narrow canyons, and severe thunderstorms prevail.

Riverine floods are caused by precipitation over large areas or by melting of the winter's accumulation of snow, or by both. These floods differ from flash floods in their extent and duration. While flash floods are of short duration in small streams, riverine floods take place in river systems whose tributaries may drain large geographic areas and encompass many independent river basins. Floods on large river systems may continue for periods ranging from a few hours to many days. Flood flows in large

river systems are influenced primarily by variations in the intensity, amount and distribution of precipitation. The condition of the ground (amount of soil moisture, seasonal variations in vegetation, depth of snow cover, imperviousness due to urbanization, etc.) directly affects runoff.

2.3 OPPORTUNITIES FOR EPM

Floods can affect all regional settlement activities. Planning and managing settlement patterns and strengthening regional functions and linkages in a way that avoids areas threatened by floods on the one hand and prevents or mitigates man-made increase of flooding potential on the other, offers significant opportunities to satisfy basic needs, optimize resource use and maximize productivity in a region. It is prerequisite to sustained development and local self-sufficiency. Considering the hazard of flooding in planning and management provides opportunities for enhancing efficiency and equity in regional development.

Flooding is one natural hazard that is becoming a greater threat with development rather than remaining constant or being reduced as is the case with many others. Floods are caused not only by rain but also by human changes to the environment such as farming, deforestation and urbanization. These actions increase the runoff from rains; thus storms that previously would have caused no flooding today inundate vast areas. Not only do human activities contribute to the causes of floods, but reckless building in vulnerable areas, poor watershed management, and failure to control the flooding also help create hazardous conditions (**Figure B2**).

Much of the death toll and destruction created by floods is preventable, when planners understand the nature of the hazard. Based on that understanding, decisions and commitments can be made to implement mitigation measures to reduce flood damage. The role of regional planners in reducing the harmful effects of flooding encompasses reducing the physical vulnerability of the settlements, structures and economy in the region by establishing planning routines that integrate sound environmental planning with hazard reduction. Specific planning and management measures which can be employed to avoid or mitigate flood hazards include (**Figure B3**):

- Development of extensive public awareness programs to inform the public about flood hazards and illustrate what can be done to prevent a disaster;
- Land-use zoning to control development;

FIGURE B2: FLOODING AND ITS CAUSES

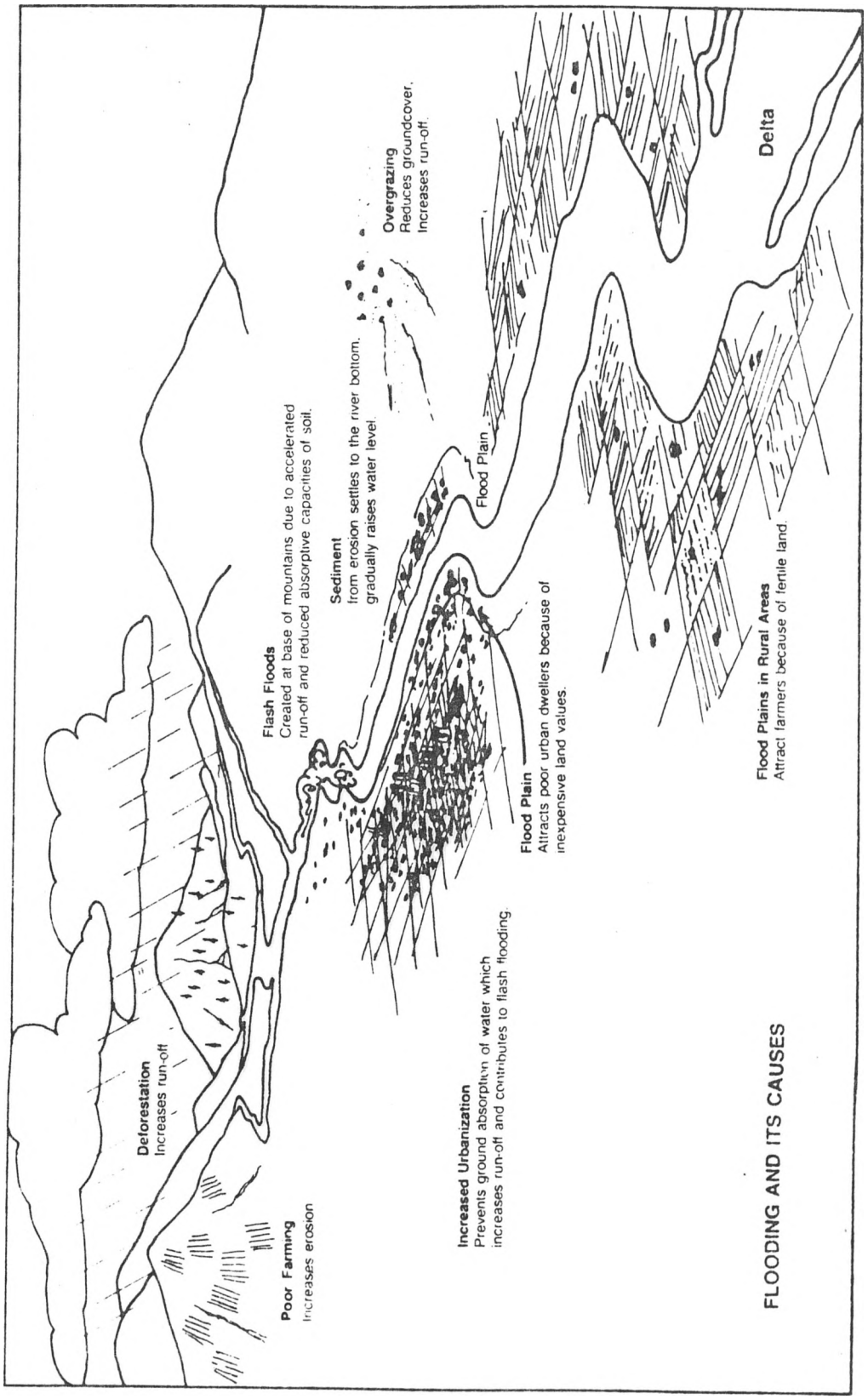
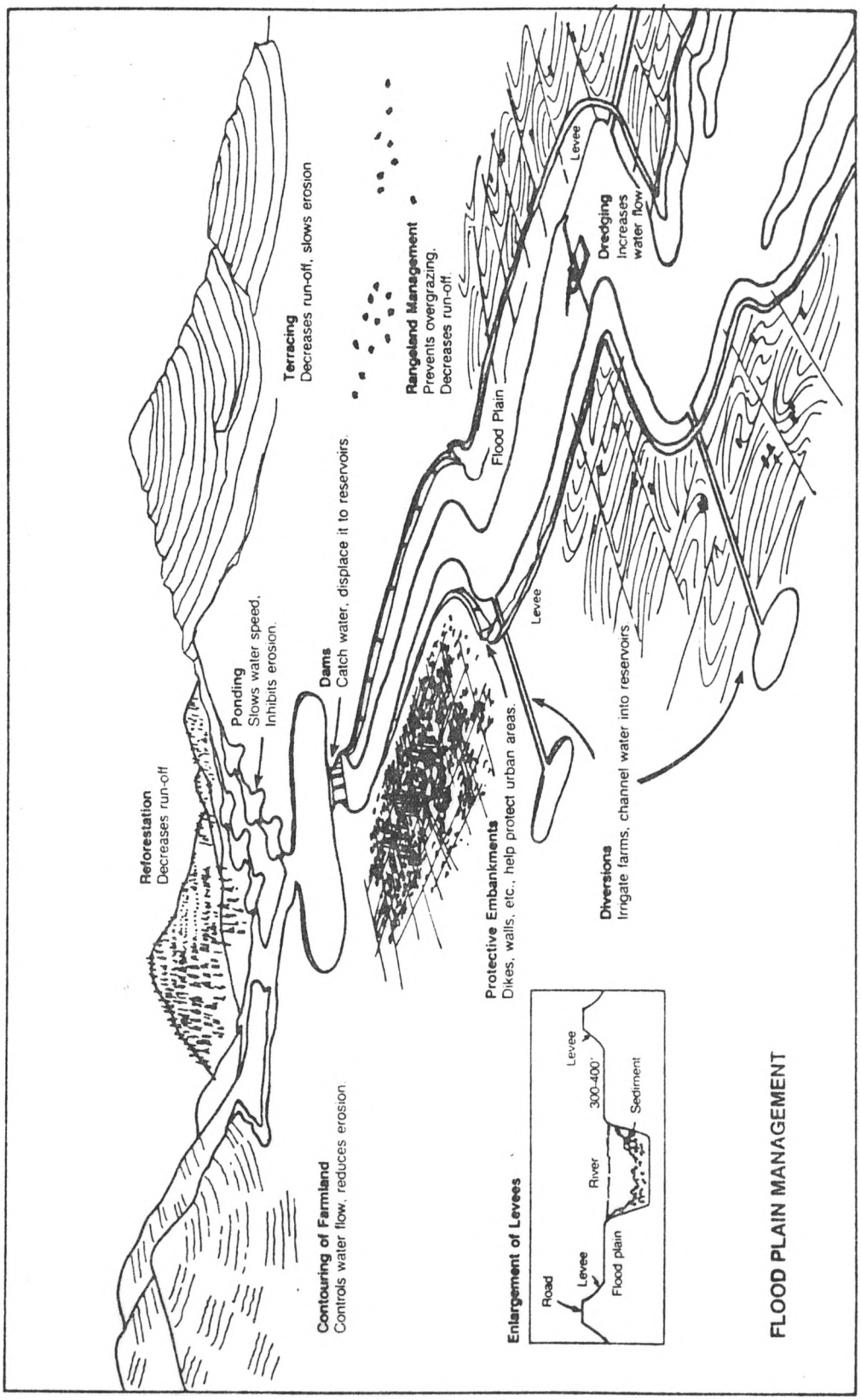


FIGURE B3: FLOOD PLAIN MANAGEMENT



- Construction of protective works such as embankments, levees or diversions to protect from flooding;
- Establishment of restrictive development regulations to ensure that any development meets certain standards that take the hazard into consideration;
- Land swaps, which would provide alternatives to development of the site;
- Establishment of incentives to encourage future development on safer sites and safer methods of construction (such as favorable taxation, loans or subsidies to those willing to develop or build on alternative sites);
- Diversification of agricultural production; identification and planting of flood-resistant crops or adjustment of planting season, if possible, to avoid coinciding with the flood season;
- Reforestation, range management and animal grazing controls to increase absorption and reduce rapid runoff;
- Construction of raised areas or buildings specified as refuges if evacuation is impossible.

3.0
EARTHQUAKES

3.1
IMPORTANCE FOR REGIONAL DEVELOPMENT

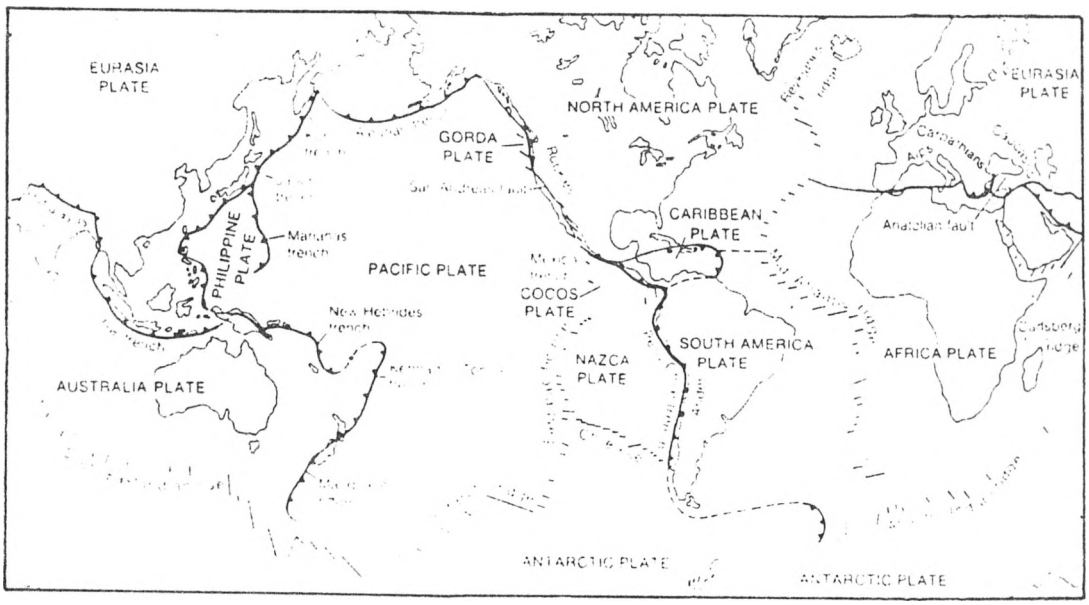
Earthquakes are of major significance to regional development. Earthquakes are one of the most dangerous and destructive forms of natural hazards. They strike with sudden impact and little warning. An earthquake can devastate an entire city or a region of hundreds of square kilometers. They can reduce buildings to a pile of rubble in seconds, killing and injuring their inhabitants.

Earthquakes damage settlements, destroy resources, and have long term effects on regional economies. The principal concern is the impact an earthquake has on housing and its inhabitants. Approximately 90 percent of the loss of life in all earthquakes is the result of structural collapse. Thus, earthquakes are generally of less concern to regional planners than to metropolitan planners. Four important exceptions are earthquake damage to transportation networks, to communications, to power generating facilities, and to dams. Widespread destructive earthquakes can have a significant impact on economic development. Because they damage man-made structures, reconstruction costs can be substantial. When thousands of buildings must be replaced, the costs can exceed the national budget. This means that reconstruction will compete with development projects for money and other resources.

3.2
CHARACTERISTICS RELEVANT TO REGIONAL DEVELOPMENT

Characteristics of earthquakes and their primary and secondary effects are features of great importance to RPM and the achievement of regional development goals. The regions of the world where earthquakes occur are characterized by certain geological aspects (**Figure B4**). The earth's crust is broken into a series of blocks or plates that are separated by deep fractures called faults. Faults form lines of weakness in the masses of rock at the earth's surface. Pressures build up below the surface which eventually force a sudden shift between two of these blocks. This sudden shift is the earthquake. The fault movement, at these meetings of plates, is the result of elastic rebound, the slow build-up and sudden release of strain within masses of rock. The place at which the stresses are released is known as the focus of an earthquake. From this point mechanical energy is initiated in the form of waves that radiate in all

FIGURE B4: DESCRIPTION OF AN EARTHQUAKE

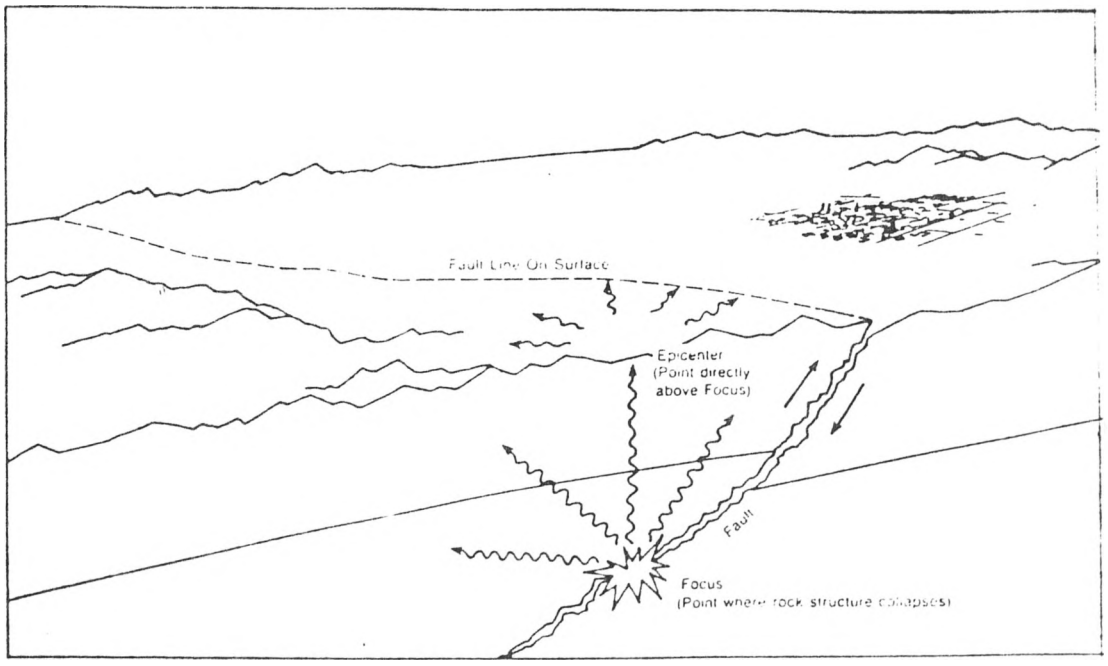


DESCRIPTION OF AN EARTHQUAKE

Subduction zone

Strike-slip (transform) faults

Motion of the earth's plates causes increased pressure at faults where the plates meet. Eventually the rock structure collapses and movement occurs along the fault. Energy is propagated to the surface above and radiates outward. These waves of motion in the earth's crust shake landforms and buildings, causing damage.



directions through the earth. When this energy arrives at the earth's surface, it forms secondary surface waves. The frequency and amplitude of the vibrations produced at the surface, and thus the severity of the earthquake, depend on the amount of mechanical energy released at the focus, the distance and depth of the focus, and the structural properties of the rock or soil on or near the surface.

Why these pressures build up and cause the movements is explained by the theory of continental drift or plate tectonics. Briefly, this theory holds that all the earth's land area once was a single mass. This mass broke apart, and the pieces began drifting. Wherever plates meet there is a high degree of earthquake activity or seismicity.

Primary and secondary effects of earthquakes are important planning considerations. The onset of a large earthquake is initially signaled by a deep rumbling, followed shortly by a series of violent motions in the ground. Often the ground fissures or cracks, and there can be large permanent displacements horizontally--sometimes as much as 10-15 meters. As the vibrations and waves continue to move through the earth, structures on the earth's surface are set in motion. Each type of structure responds differently, depending on the type of materials of which it is made.

When the waves strike, the earth begins to move backward and forward along the same line. The lower part of a building on the earth's surface immediately moves with the earth. The upper portion, however, initially remains at rest; thus the building is stretched out of shape. Gradually the upper portion tries to catch up with the bottom; but as it does so, the earth moves in the other direction causing a "whiplash" effect, speeding up the top of the building, and creating a vibration known as resonance. The resonance can cause structural failure in itself, or adjacent buildings having different response characteristics (caused by different building materials) can vibrate out of phase and pound each other. The walls of buildings without adequate lateral bracing frequently fall outward, allowing the upper floors or roof to collapse into the inside of the structure.

Another primary effect is known as liquefaction. Loose sandy soils with a high moisture content separate when shaken by an earthquake. The water then moves upward, turning the surface into a consistency much like that of quicksand. Heavy structures resting on these soils will slowly sink into the ground.

Often as destructive as the earthquake itself are the resulting secondary effects such as landslides, fires, tsunamis, and floods. Landslides are especially damaging and often account for the majority of lives lost. Tsunamis are of concern to countries in the Pacific Basin. A tsunami is a large seawave caused by an earthquake abruptly lifting the ocean floor. The waves move outward at a high velocity and can cross thousands of kilometers before they run up on shore. At sea, their low wave height gives little evidence of their existence; however, as they approach land, their velocity decreases and their height increases. In this way a 5-meter crest moving at 600 kph in the open ocean becomes a devastating 30-meter-high wave moving at 50 kph when it reaches shore.

3.3 OPPORTUNITIES FOR EPM

Earthquakes can affect all regional settlement activities. Planning and managing settlement patterns and strengthening regional functions and linkages in a way that avoids areas threatened by earthquakes on the one hand, and prevents or mitigates increase of damage on the other, offers significant opportunities to satisfy basic needs, optimize resource use and maximize productivity in a region. It is prerequisite to sustained development and local self-sufficiency. Considering the hazard of earthquakes in planning and management provides opportunities for enhancing efficiency and equity in regional development.

Fortunately, a great deal can be done to prevent earthquakes from becoming disasters, when planners consider the nature of earthquakes in regional development strategies. Specific planning and management measures which can be employed to avoid or mitigate earthquake hazards include:

- o removal of unsafe structures and/or economic activities located on unsafe sites;
- o encouragement of future development on safer sites through:
  - land use controls (zoning);
  - building codes and standards and means of enforcing them;
  - favorable taxation, loans or subsidies to qualifying building methods and sites;
  - land development incentives;
  - strategic investment in infrastructure to encourage development of safe zones;
  - identifying potential landslide sites and restricting construction in those areas;
  - verifying the capability of dams to resist earthquake forces, and upgrading as necessary.

4.0
CYCLONES

4.1
IMPORTANCE FOR REGIONAL DEVELOPMENT

Cyclones are of major significance to regional development. Cyclonic storms are among the most awesome events that nature can produce. They pose a major threat to lives and property in many parts of the world. Every year these sudden, unpredictable, violent storms with winds of over 120 kph bring widespread devastation to coastlines and islands lying in their erratic paths. A windstorm's destructive work is done by the high wind, flood-producing rains, and associated storm surges.

Cyclones cause death and injuries and damage settlements. The winds of a cyclone cause deaths and injuries from structural collapse or flying objects, with devastating effects on homes and buildings, agriculture, critical facilities and lifelines. The most dramatic impact of cyclones is the damage they cause to houses. Contrary to popular belief, few houses are blown over; instead they are pulled apart by winds moving swiftly around and over the buildings. This lowers the pressure on the outside and creates suction on the walls and roof.

Cyclones damage and destroy settlement networks and resources. Cyclones can destroy or damage communications installations; electrical generating and transmission facilities; water storage; purification and pumping facilities; sewage treatment facilities; hospitals; police stations; and various other public and private buildings. The high winds also destroy crops (especially grains) and damage orchards and forests. Storm surges also damage human settlements and force evacuation, scour and erode topsoils, deposit salts on fields, may increase salinity in the subsurface water table, and destroy many crops. Furthermore, access to markets for buying and selling agricultural produce may be impeded by damage to roads, bridges, railways, etc.

Cyclones have long-term effects on regional economies and productivity. Cyclones can significantly retard the long-term economic growth of a region. Indirect and secondary effects on the local and national economy of the country may include: reduction in family income; decline in the production of business and industrial enterprises; inflation; increase in income disparities; and decline in national income.

In addition, relief and reconstruction efforts compete with development programs for available funds, often creating an enormous burden on local and national resources.

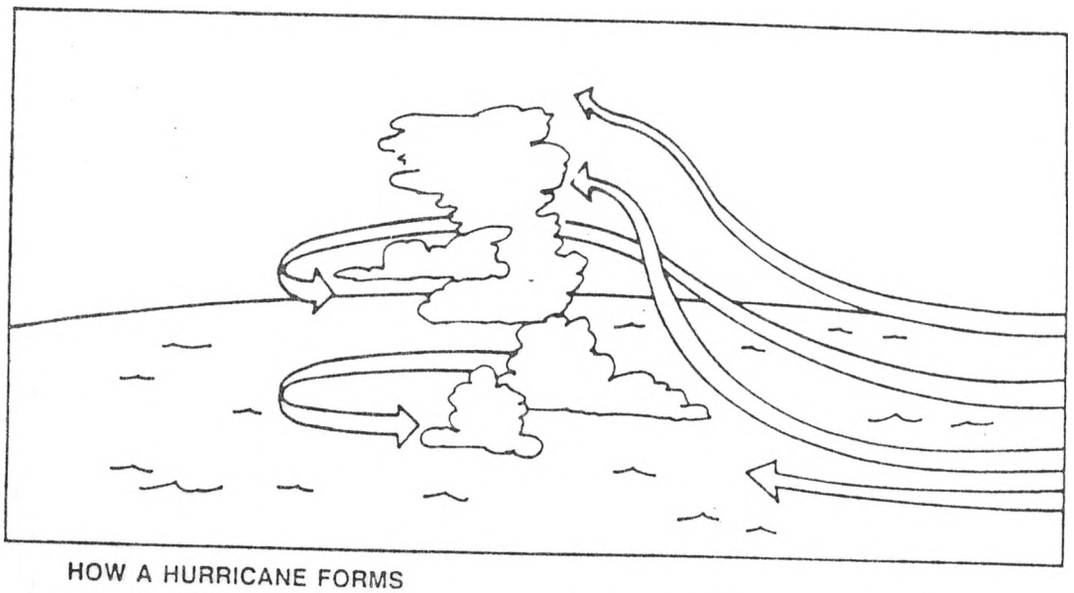
4.2 CHARACTERISTICS RELEVANT TO REGIONAL DEVELOPMENT

The characteristics of cyclones and their effects are features of great importance to RPM and the achievement of regional development goals. A cyclone (also known as a hurricane or typhoon in parts of the world) is a tropical storm in which the winds reach speeds of over 120 kph (74 mph) and blow in a large spiral around a relatively calm center or eye. Stated simply, cyclones are giant whirlwinds in which the air moves in a large, tightening spiral around a center of extreme low pressure, reaching maximum velocity in a circular band extending outward thirty to fifty kms (20-30 miles) from the edge of the center or eye of the cyclone. Near the center, winds may gust to more than 320 kph (200 mph), and the entire storm dominates the ocean surface and lower atmosphere over tens of thousands of square miles.

In order for a cyclone to form, it must have a warm sea and still air. The warm air rises--heavy, humid and full of water vapor. Its place is taken by air rushing in from the sides and, because of the earth's rotation, this moving air is given a twist so that the entire system begins to revolve. The warm rising air meets cooler air and releases its water vapor in the form of rain. It takes a great deal of energy for the air to lift the water in the first place, and now this energy is released in the form of heat. This increases the rate of ascent of the air, and a continuous cycle begins to develop. More water is released, and thus more heat. The more water and heat released, the faster the cycle goes, and it soon becomes much bigger (**Figure B5**).

Because the wind system is revolving, centrifugal force tends to throw the air outwards so the pressure in the center becomes very low, thus forming the eye of a cyclone. The pressure on the outside is very high, so the wind moves faster and faster in an attempt to fill that low pressure area. However, the faster it moves, the more the centrifugal force throws it outwards. Soon there are very fast circular winds and, once they reach 120 kph (74 mph), the system becomes a cyclone. Once this process is established, the storm begins to move forward, like a spinning top that moves along the ground. This brings it into contact with more warm sea and air, and the process becomes self-sustaining. Once a cyclone has formed, it will continue to move and

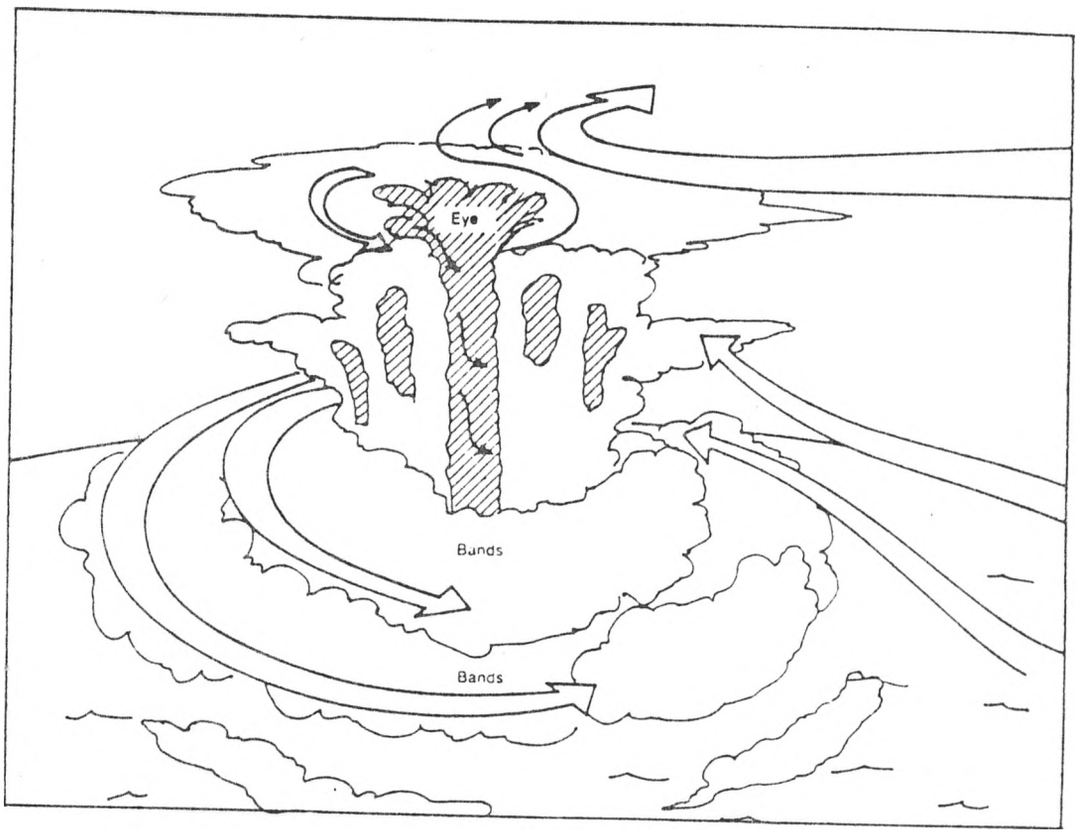
FIGURE B5: HOW A HURRICANE FORMS



HOW A HURRICANE FORMS

An atmospheric disturbance forces warm moist air of the prevailing Easterlies to rise. As the air cools, water vapor condenses and falls as rain; heat energy is released, and winds intensify

The storm grows as air spirals inward, rises, and is exhausted from the top by high level winds. Surface air converges at an increasing rate toward the low pressure at the storm center.High winds, heavy rain, and storm surges occur as the storm becomes a mature hurricane.



expand until it either moves onto the land or runs into an area where the sea is cooler. Cyclones often shift directions and become very erratic. Little is known about what makes cyclones move and change directions, but it is known that they are affected by high altitude winds and the rotation of the earth. At present, scientists do not have the means of predicting exactly where a cyclone will strike land. Therefore, they are always dangerous, as they can change direction without any warning.

Primary and secondary effects of cyclones are important planning considerations. Devastating floods from extremely heavy rainfall often accompany tropical cyclones. Flash floods of great volume and short duration may result from the cyclone's rain, especially in hilly or mountainous terrain. Runoff from the intense rainfall accumulates quickly in restricted valleys and flows rapidly downstream, often as a large "wave." Flood flows frequently contain large concentrations of sediment and debris.

Storm surges cause the most devastating type of cyclone-related flooding. A storm surge is a rapid rise of the ocean level which takes place as a cyclone approaches. A large mass of water rises above the normal level of the sea and is pushed along by the cyclone system, moving in the same direction as the storm. This movement creates a front or leading edge which may be many kilometers (miles) across and as high as 20 meters (65 ft). The high water behind the leading edge may extend backward for many kilometers. In many instances, the flooding of lowlying coastal lands by storm surges is greatly intensified by coastal topography, the torrential rain, the state of the lunar tide, and the backing up of rivers. Tidal floods can also be caused by the combination of waves generated by cyclone winds and flood runoff resulting from the heavy rains that accompany cyclones. These floods may extend over large distances along a coastline. Their duration is usually short, being dependent upon the elevation of the tide which rises and falls twice daily.

A secondary effect of flooding and cyclones is mudslides. Heavy rains quickly supersaturate hillsides that have been deforested or stripped for farming and can cause immense landslides. Even when little wave or wind damage is recorded, large loss of life may occur in massive mudslides resulting from the torrential rains, especially in squatter settlements located in floodplains.

4.3 OPPORTUNITIES FOR EPM

Cyclones can affect all regional settlement activities. Planning and managing settlement patterns and strengthening regional functions and linkages in a way that avoids areas threatened by cyclones on the one hand and prevents or mitigates potential damage from cyclones on the other, offers significant opportunities to satisfy basic needs, optimize resource use and maximize productivity in a region. It is prerequisite to sustained development and local self-sufficiency. Considering the hazard of cyclones in planning and management provides opportunities for enhancing efficiency and equity in regional development.

Cyclones are natural hazards that are not, in and of themselves, disasters. Rather, cyclones are agents or hazards that transform a vulnerable condition into a disaster. The vulnerability of a region to a cyclone is determined by its exposure to the storms, the degree to which the houses and other structures can be damaged, and the likelihood that secondary effects could occur. Communities or economic activities in unprotected, lowlying coastal areas exposed to cyclones, or on river floodplains, are considered vulnerable.

As with floods, land tenure is also a determinant of vulnerability, especially where there is a scarcity of arable or developed land and poor farmers must engage in agriculture on hazardous floodplains or steep, unstable hillsides that could slip when saturated with rain.

Reducing the harmful effects through EPM can be achieved in three ways: by reducing the vulnerability of the physical settlements and structures in which people live; by reducing the vulnerability of the economy; and by strengthening the social structure of a community so that coping mechanisms can help absorb the impact of the disaster and promote rapid recovery. Specific planning and management measures which can be employed to avoid or mitigate cyclone hazards include:

- development of extensive public awareness programs to inform the public about the hazards and illustrate what can be done to prevent a disaster;
- establishment of land-use zoning to control development;
- construction of protective works such as windbreaks to reduce the impact of winds;

- establishment of restrictive development regulations to ensure that any development meets certain standards that take into consideration the threat to the site;
- land swaps, which would provide alternatives to development of the site;
- imposition of design criteria or building standards to govern construction;
- development of incentives to relocate unsafe buildings or vulnerable activities to safe sites;
- development of incentives to encourage future development on safer sites and safer methods of construction, such as favorable taxation, loans or subsidies to those qualifying in terms of building methods or sites;
- diversification of agricultural production; identification and planting of wind resistant crops or adjustment of planting season, if possible, to avoid coinciding with the high wind season.

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REFERENCES

Berkol, Faruk, N. *Natural Disasters: A Neglected Variable in Human Settlements Planning.* Habitat, (Vancouver, Canada: UNCHS), May 31-June 11, 1976.

Center of Buidling Technology; Institute for Applied Technology; National Bureau of Standards. *Design, Siting, and Construction of Low-Cost Housing and Community Buildings to Better Withstand Earthquakes and Windstorms.* National Bureau of Standards Building Science Series 48, January, 1974.

Cuny, Frederick C. *Model Program for Economic Vulnerability Reduction and Recovery.* (Dallas, TX: INTERTECT), 1983.

Development Analysis and Programming, Inc. *Planning for Human Settlements in Disaster Prone Areas.* (Nairobi: UNCHS), December 1981.

Department of the Army Coastal Engineering Research Center. *Shore Protection Manual.* Volume I, Chapters 1-4, U.S. Army Coastal Engineering Research Center, 1977.

Ellis, Brian and Oakley, David. *Physical Planning Guidelines for Cyclone Prone Areas of Sri Lanka.* (Washington, DC: PADCO, Inc.), November 1979.

Handmer, John W. *Flood Risk Information Maps: Tools for Damage Reduction and Disaster Prevention: Interim Report on Research in Oshwa.* Working Paper No. 8, Arnprior Conference, January 1979.

Office of the United Nations Disaster Relief Coordinator. *Disaster Prevention and Mitigation: A Compendium of Current Knowledge, Volume 2, Hydrological Aspects.* (New York: UN), 1978.

Office of the United Nations Disaster Relief Coordinator. *Disaster Prevention and Mitigation: A Compendium of Current Knowledge, Volume 4, Meteorological Aspects.* (New York: UN), 1978.

Olson, Robert A. "The Influence of Social, Economic, Organizational, and Political Variables on Earthquake Hazard Reduction Policy". *Proceedings of the Seventh World Conference on Earthquake Engineering.* September 8-13, 1980, Istanbul, Turkey, Vol. 9, Socio-Economic Aspects - Studies of Specific Earthquakes - Progress Reports.

Pate, Elisabeth A. "Assessment and Mitigation of Earthquake Effects on Economic Production". *Proceedings of the Seventh World Conference on Earthquake Engineering*, September 8-13, 1980, Istanbul, Turkey, Vol. 9, Socio-Economic Aspects - Studies of Specific Earthquakes - Progress Reports.

Tag-Eldeen, Mustafa. *Predisaster Physical Planning: Integration of Disaster Risk Analysis into Physical Planning*. (Case Study: Tunisia), Royal Institute of Technology.

Urban Regional Research. *Land Management in Tsunami Hazard Areas*. Prepared for the National Science Foundation, 1982.

White, Gilbert F. *Natural Hazards: Local, National, Global*. (Oxford University Press), 1974.