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SPECIAL SECTION H

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Title →

ENVIRONMENTAL HAZARDS AND METROPOLITAN DEVELOPMENT: CONSIDERATIONS FOR INITIATING AN EPM ROUTINE

1.0
ENVIRONMENTAL HAZARDS AND METROPOLITAN DEVELOPMENT

1.1
ENVIRONMENTAL CONCERNS

1.1.1
Importance to MPM Goals

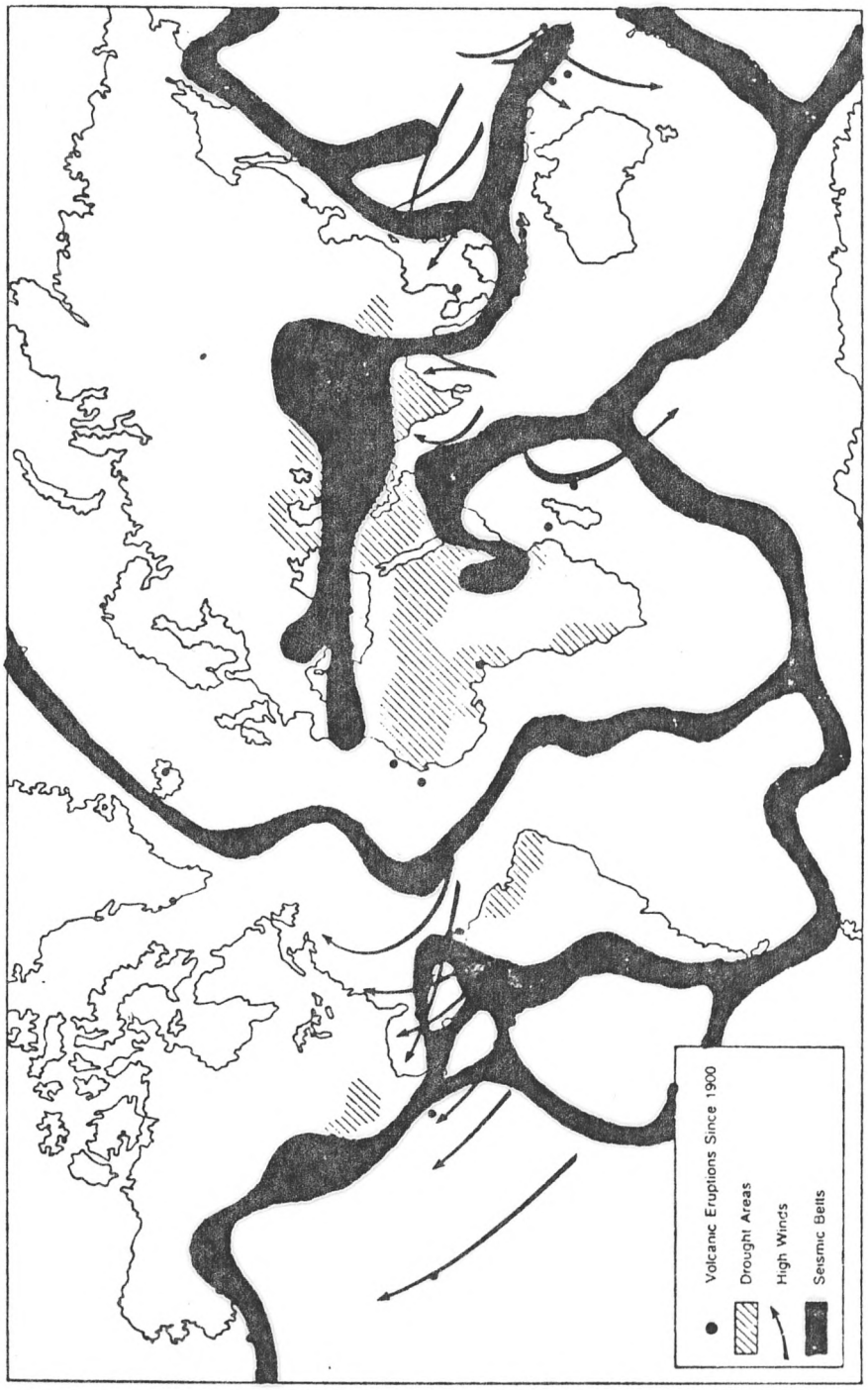
Natural hazards such as cyclones, earthquakes, and flooding occur throughout the world and can pose major threats to metropolitan areas (**Figure H1**). The social consequences are the most dramatic, and include the loss of lives, injuries and displacement of persons from their homes and work. These disasters disrupt not only individual lives, but also the overall life of the community.

The economic consequences of natural hazards can be divided into two levels. The micro level, which represents losses to individuals and families, can include the loss of property, lands, housing, and cash reserves. These losses in-turn cause an increase in personal debt and create dependencies on municipal social services. In its broadest sense, economic losses at the micro level represent a loss of opportunity for it often means that individuals and families must redirect their effort simply to reacquire what they have lost.

At the macro, or community level, economic losses necessitate a diversion of resources into reconstruction and rehabilitation. They increase the public debt, delay development, and may retard the extension of municipal services.

Natural hazards also may have a cultural significance. The threat represented by the hazard may force adaptations in housing and urban development patterns. For example, in flood-prone areas, houses may have to be built on plinths or stilts in order to prevent inundation. Changes in housing styles may be required in order to make houses more earthquake or cyclone resistant. Urban development patterns may have to be modified to allow for safe zones to be created in hazardous areas and the basic construction patterns such as the typical Latin pattern of building houses immediately adjacent to each other may have to be modified in order to promote better hazard resistance.

FIGURE H1: GLOBAL DISTRIBUTION OF MAJOR HAZARD ZONES



GLOBAL DISTRIBUTION OF MAJOR HAZARD ZONES

1.1.2 Linkages to Other Environmental Concerns

The management of natural hazards is an important consideration in environmental planning activities. Concerns are usually divided into three areas.

Health - Environmental hazards may pose a threat to facilities necessary to maintain a safe and healthful environment. Of special importance in the siting of facilities related to the provision of utilities and waste disposal areas. For example, sewage disposal plants exposed to flooding could spread infectious diseases and could contaminate wide-spread areas if not protected properly.

Spatial Considerations - Metropolitan development patterns and spatial requirements may be affected by natural hazards considerations. Unstable hillsides may best be developed as parks or open spaces rather than housing in earthquake or mud slide zones. Flood plains, likewise, should be restricted to low-density development such as warehousing or light industrial uses that could withstand flooding and recover without undue stress on the economy. In earthquake zones, housing and subdivision patterns may be altered to provide access in escape areas should violent tremors occur.

Safety - Natural hazards pose special threats to hazardous materials, nuclear facilities, and toxic waste disposal areas. The siting of these facilities in relation to threats from natural hazards must be given clear attention in metropolitan planning.

1.1.3 Consequences of Neglecting Hazards in MPM

Unless hazard management becomes a routine part of metropolitan planning, the following adverse consequences are likely to occur:

- Improper siting of facilities - This could occur in areas where natural hazards could damage or destroy the facility.
- Increase risk - Increased risk may be a result of the improper placement or development of areas threatened by natural hazards or may be a result of induced risk, such as increased flooding due to an increase in impervious surfaces (such as roofs, roads, etc. resulting from development).
- Increased disaster recovery costs - If natural hazards are not avoided or their impact reduced through proper planning the magnitude of the disaster and the recovery costs will be much greater. Conversely, if hazard management is integrated with metropolitan planning routines,

post-disaster costs can be substantially reduced. It should be remembered that the steps to integrate hazard management and metropolitan planning provide a basis for disaster mitigation and preparedness.

- o Increased development costs - The cost of protecting built-up areas in hazard zones through engineering works or retrofitting of structures is much greater than avoiding these areas and limiting development within them.
- o Importance of hazard management in relation to MPM goals - By integrating hazard management with metropolitan planning routines the overall goals of metropolitan planning are easier to attain. Conversely, without this integration, the cost of hazard management would be impossible to attain (and probably not politically feasible).

There are a number of options available to metropolitan planners for controlling and managing hazards in the local context. The choice of which option to select depends on the type of disaster, whether or not there is a warning period, the communities land-use needs for a particular site, and what alternative sites are available.

1.2 CHARACTERISTICS OF ENVIRONMENTAL HAZARDS

The hazards of primary concern to metropolitan planners are earthquakes, cyclones, and flooding. In order to understand each and to successfully integrate hazard management and environmental planning it is important to understand the effects of each hazard and the factors that contribute to making the hazard a potential disaster threat.

1.2.1 Earthquakes

Earthquakes occur along the major fault lines formed by the intersection of the great tectonic plates. The primary effects of earthquakes are:

- o Ground Shaking - This destroys buildings and other man-made structures unless special anti-seismic design features are incorporated in the structures (**Figure H2**).
- o Liquefaction - This occurs in loose sandy soils with a high moisture content. The soils separate and water moves upward giving the surface a consistency much like that of quicksand, and heavy structures resting on the surface slowly sink into the ground.

FIGURE H2: HOW AN EARTHQUAKE DAMAGES A BUILDING

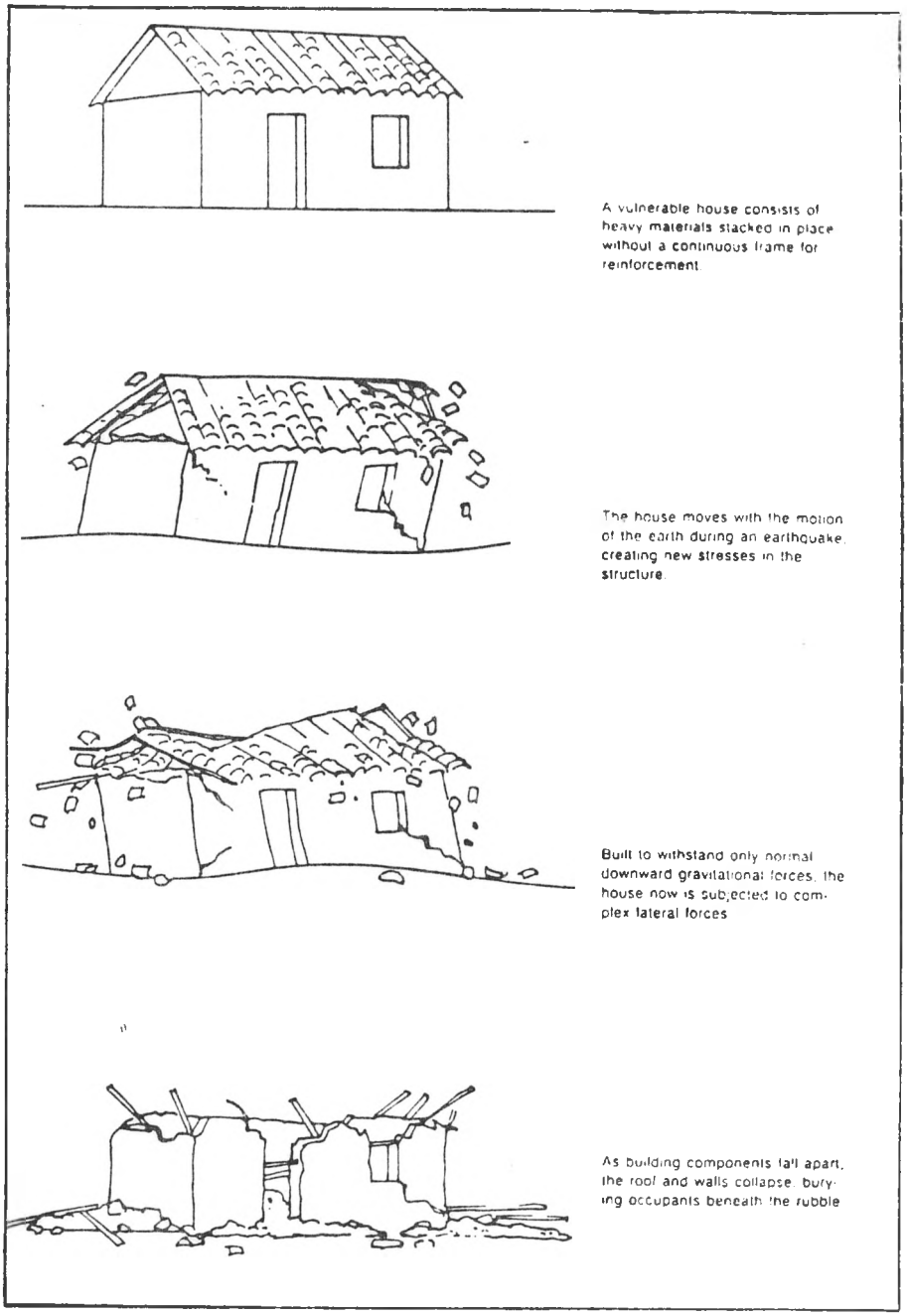
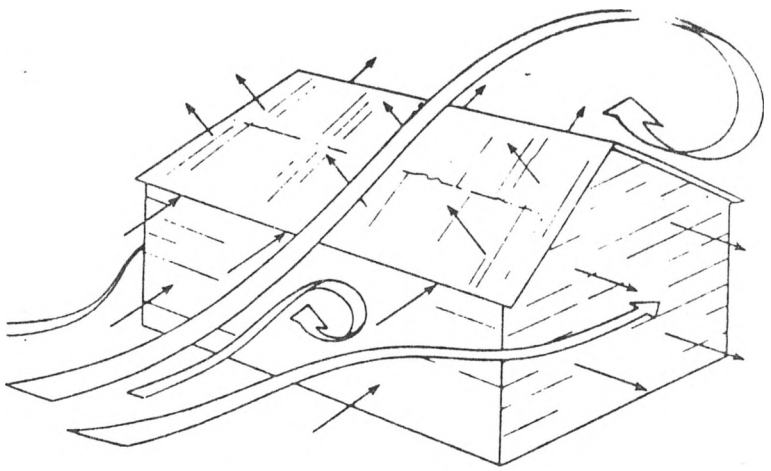
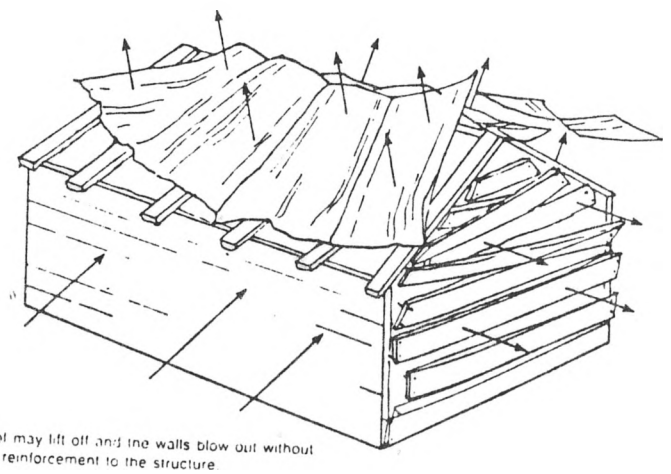


FIGURE H3: HOW HIGH WINDS DAMAGE A BUILDING



Wind blowing into a building is slowed at the windward face creating high presure. The air flow separates as it spills around the building, creating low pressure or suction at end walls, roof and leaward walls.



The roof may lift off and the walls blow out without special reinforcement to the structure.

Secondary effects include:
- o landslides;
- o fires which result from damaged electrical facilities or chemical or fuel storage facilities being damaged;
- o tsunamis, which are large seawaves caused by an earthquake abruptly moving the ocean floor.

Contributing factors to increasing the level of damage are:
- o siting of man-made structures on areas subject to landslides, liquefaction, or strong ground emotion;
- o poor construction practices;
- o urban designs unsuitable for high risk areas (for example the clustering of buildings immediately adjacent to each other, thus permitting the transfer of forces from one building to another).

1.2.2
Cyclones

Cyclones are huge tropical storms in which the air moves in a large, tightening spiral around a relatively calm center of extreme low pressure (the eye) reaching maximum velocity in a circular bank extending outward 30-50 kilometers from the edge of the eye. Near the center, winds may gust to more than 300 kilometers per hour and the entire storm system can dominate the ocean surface for tens of thousands of square kilometers. Figure H1 depicts those areas that are threatened by tropical cyclones.

The primary effects of cyclones are:
- o damaged to structures as a result of high winds (**Figure H3**);
- o damage to communities and marine facilities in low-lying coastal areas as a result of wave or storm surge damage. (A storm surge is a rapid rise in the water, sometimes several meters above normal, that can produce flash-flooding in coastal low lands. The waves and currents erode beaches and barrier islands, undermine buildings and wash away roads and other man-made facilities.)

Secondary effects of cyclones include:
- o flooding, resulting from heavy rains;
- o mudslides, resulting from supersaturation of soils on steep or denuded hillsides.

Factors that contribute to increasing the hazard are:
- o improper siting of buildings and communities;
- o poor construction practices;
- o poor development and land-use practices contributing to flooding (see flood section below).

1.2.3
Floods

Flooding is a worldwide phenomena that threatens many metropolitan areas. Floods may result from unusually heavy rains during a short period or from sustained rainfall over a longer duration. Flooding may be increased by factors occurring in areas well upstream of the effected area (**Figure H4**).

The primary effects of floods are inundation of communities and structures. Buildings may be damaged through:
- o water damage;
- o undercutting by the streams current;
- o impact damage from floating debris.

Secondary effects of flooding include:
- o mudslides;
- o erosion of land.

The factors contributing to increasing the damage levels include:
- o poor siting of buildings or communities;
- o over development;
- o inequitable land tenure practices;
- o poor land development practices;
- o changes in the watershed such as over grazing, engineering works, etc., that could increase flooding downstream.

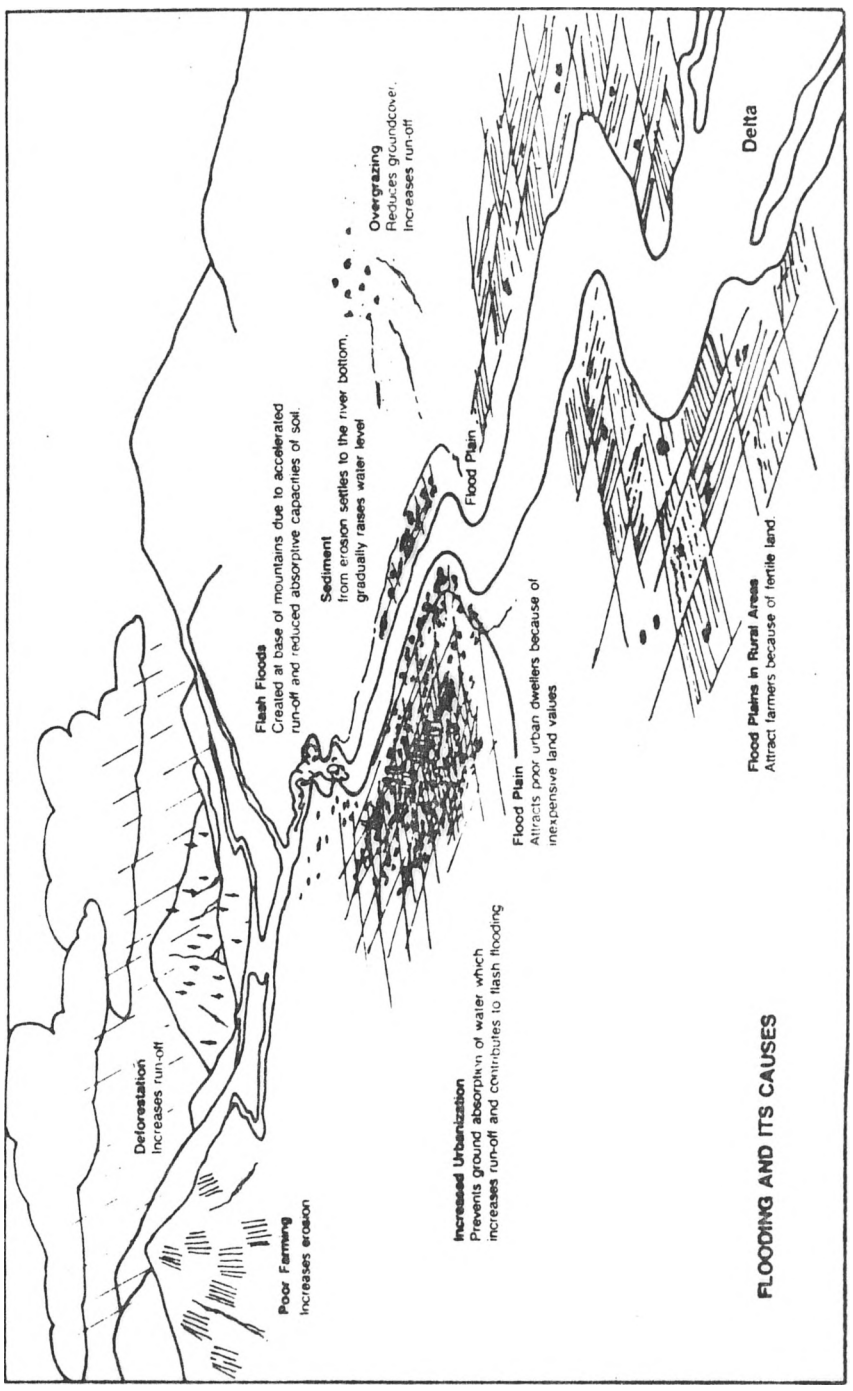
1.3
METROPOLITAN TRENDS THAT AFFECT HAZARD MANAGEMENT

Poor Urban Planning Practices - Many urban planning practices fail to consider the effect various urban designs have on lessening or increasing the effects of natural hazards. For example, settlements can be protected from high winds by placing them behind natural barriers such as hills or forests. Conversely, wind speed can be increased by funnel effect.

Inability to Control Squatter Settlements - The inability of governments to control access to sites, site development, or the structures built in squatter settlements, usually results in poor urban design and marginal structures. This in turn increases the number of people vulnerable to natural hazards.

Inequities in Land Distribution - In many countries the lack of access to good safe land and the inability of governments to provide alternative sites to marginal lands forces those seeking urban land to locate in marginal areas.

FIGURE H4: FLOODING AND ITS CAUSES



Poor Development Practices - Governments often choose to develop marginal sites for low-cost housing because the land is available and often purchase costs are less. Sites such as landfills or reclaimed land may be unsuitable for housing in areas threatened by natural hazards. For example, poorly compacted soils may experience liquefaction during earthquakes. Reclaimed coastal zones may be subject to storm surges or other types of flooding.

Inability to Control Urban Development - The inability of governments to stem urbanization results in a parallel inability to keep pace with demands for sites and housing. To a large extent this is beyond the control of metropolitan planners and it must be recognized that to improve the situation, increased development efforts must take place in the rural areas. Nonetheless, unchecked urban expansion lessens the ability of metropolitan planners to control events and results in the proliferation of unplanned settlements and poor quality structures.

The Failure of Housing Codes and Zoning - The traditional means of controlling urban development are housing codes and zoning. In developing countries where the municipal governments are greatly overextended and where urban expansion outpaces the ability of the municipality to provide serviced sites, these control measures have not proved suitable. Alternative methods and controls as well as numerous incentives programs need to be considered as alternatives for controlling and improving the quality of urban development.

1.4
THE MANAGEMENT OPTIONS

1.4.1
Planning and Design Options

There are several options or combinations of options available to metropolitan planning authorities for managing and minimizing the risk from natural hazards. These include:

- o Improving the structural performance of buildings and other facilities. This can be done by:
  - improving designs;
  - improving construction techniques;
  - incorporating disaster resistant construction methods into new buildings;
  - retrofitting existing buildings with hazard resistant features.
- o Engineering measures such as construction of dikes or dams to reduce flooding potential;

- Improving the siting of buildings and communities.
- Improving comprehensive planning procedures and expanding the planning parameters to include regional considerations where necessary. For example, flood control often depends on proper watershed management and in many cases the watershed may include areas outside the flooded zone (**Figure H5**). In order to reduce flooding, coordination between metropolitan and regional authorities may be necessary.
- Introducing urban design concepts that reduce risk. Certain urban designs can substantially reduce risk to buildings and communities in general. The orientation and clustering of buildings for example, can reduce wind speeds and provide protection to leeward buildings. Earthquake losses can be reduced by limiting the height of buildings, increasing the separation between structures to reduce transfer of forces, and by creating safe zones for evacuation of buildings in major tremors.
- Environmental management; example, reforestation and rangeland management in watersheds.

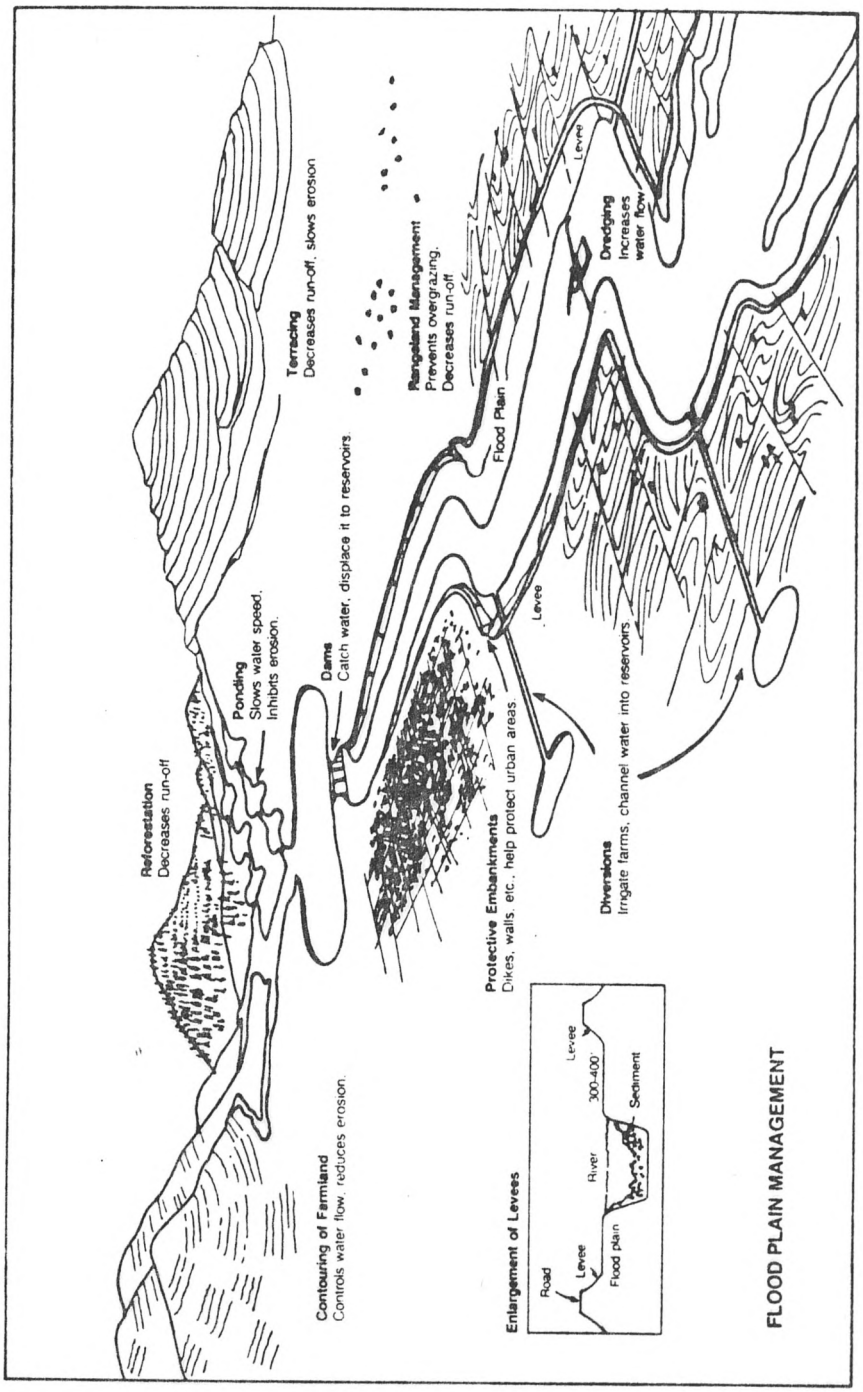
Environmental hazards can be managed and losses reduced. However, metropolitan planning authorities must take innovative measures and look for alternatives to the planning and control mechanisms now in use.

1.4.2 Administrative Options

The range of administrative mechanisms for mitigating environmental hazards are:

- zoning, building codes, performance standards, and other regulatory mechanisms;
- strategic development (or investment) of sites and services;
- housing education, i.e., the training of home builders to improve the quality and performance of housing;
- code encouragement, i.e., the establishment of flexible building standards and providing non-binding construction advice through building inspectors to encourage homeowners to utilize disaster resistant construction technique;
- financial incentives for using hazard resistant construction techniques;
- improving coordination between municipal departments. Often within municipal governments, individual departments have authority to undertake various urban development activities without consultation with other departments. This is especially a problem when autonomous agencies

FIGURE H5: FLOOD PLAIN MANAGEMENT



operate within municipal boundaries. In one country for example, the establishment of a new medical center with several hectares of buildings and parking lots created a flooding problem several kilometers away. To improve coordination, metropolitan planning authorities should be strengthened.

1.4.3
Selecting Options that Fit Local Circumstances

All of the control mechanisms listed above require a technical understanding of the threats and the possible solutions. The selection of a particular set of control mechanisms must be within the economic capacity of the metropolitan authorities as well as the administrative capacity of the municipality to implement the mechanisms chosen. For example, the adoption of a building code would be dependent upon the capacity of the municipality to carry out enforcement. In a case where rapid urbanization and small metropolitan budgets would not permit enforcement, housing education or code encouragement could be chosen as an alternative.

Hazard management controls are not different from the normal metropolitan planning and management mechanisms. Each of the control mechanisms outlined above are normally used in metropolitan planning and management, only hazard management has been added as a new dimension.

1.5
POLICY COORDINATION

1.5.1
Key Actors and Agencies

The following public and private bodies play a major part in policy coordination. From the diversity of these agencies and interests it can be seen that policy coordination is a complex problem that requires extensive attention in order to increase effectiveness.

- Municipal Agencies
  - Mayor or Town Council
  - Town Planning Agency
  - Housing Authorities
  - Public Works Agencies
  - Public Utilities
  - Financial Planning Authorities of the
- Independent Bodies Operating Within Municipality
  - School Boards
  - Medical Districts
  - Flood Control Authorities (Regional)

- Water Districts
- Port or River Authorities
- Public Universities

o Private Sector Bodies
- Major Industries
- Non-Government Organizations
- Housing Finance Organizations (Banks, Co-operatives, etc.)
- Private developers
- Engineers and architects
- Insurance agencies

1.5.2
Potential Conflicts and Policy Issues

Unawareness of risk from natural hazards lowers concern and the sense of urgency on the part of both metropolitan planners and the general populace. Thus, a low priority is assigned to managing natural hazards vis-a-vis other concerns. This in turn fosters a chain of conflicts that hinder not only hazard management but also comprehensive metropolitan planning and management. Typically the cycle goes like this - unrestricted development creates a high demand for housing and the cost of good, serviced land escalate. To meet the demands, authorities must reduce costs. This can only be done by increasing density and often by choosing land only marginally suitable for housing. Increasing density reduces the effectiveness of urban design solutions to hazard management and increases the need for costly engineering solutions. Due to the lack of awareness of the risk or concern for the risk, the engineering solutions are omitted in the final design and construction of the buildings and communities, this increasing the number of people at risk.

The significance of the conflicts can be demonstrated by the fact that the number of people living in vulnerable conditions is increasing each year, and the magnitude of disasters, i.e., the number of buildings and persons affected has tripled in the last decade. Furthermore, the disruption to national economics from the impact of widespread disasters in metropolitan areas has significantly increased.

The primary issues in policy coordination are:
- o who has authority or responsibility to develop or build;
- o what land is developed;
- o which agency controls development, i.e. who makes the trade-offs and, for metropolitan hazard management, who decides the significance of the risk;
- o the quality standards of the development;

- how conflicts are resolved and policies coordinated.

1.5.3
Options for Resolving Conflicts

The prerequisites for resolving conflicts between metropolitan hazard management and, metropolitan planning and management are:

- to improve the information gathering capacity about the risks and the potential consequences of ignoring the risks;
- to improve the general awareness of the hazards and the potential for adverse impacts.

The options for resolving conflicts are:

- to strengthen the capacity of metropolitan planning and management authorities, to collect information and prepare policy options;
- to establish or expand mechanisms for formulating and coordinating policies;
- to expand the municipalities' capacity to utilize policy implementation such as codes, financial incentives, strategic investment, education, etc.;
- to improve coordination between municipal planning bodies and private sector development interests.

One model which has been used successfully in large metropolitan areas is to establish a hazard management commission within the municipal government. The staff is formed by a small permanent staff of hazard management specialists with the remainder of the staff being obtained from the municipal agencies and departments with responsibilities relating to hazard management and/or development. These personnel are rotated on a periodic basis so that they return to their ministries with experience in hazard management and on expanded awareness of the problems. The commission reviews all development plans and comments on potential conflicts.

For smaller governments of those with financial restrictions, expertise in resolving conflicts may be found outside the government. Options include:

- use of consultants;
- use of university personnel;
- use of personnel from national hazard management agencies;
- sharing of personnel between municipal governments in the same region;
- utilization of regional hazard management authorities in an advisory capacity.

In the Dominican Republic an interesting concept has been utilized. A group of private institutions have established and organization to provide hazard management services to the government. This group is structured similarly to a planning agency and has the capability of carrying out a full range of planning and environmental management studies. Through agreements with the government, this agency provides non-binding reviews of all major development plans and draws attention to potential hazard and metropolitan planning conflicts.

Whatever mechanisms are chosen for institutionalizing hazard management, it is important that the ultimate decision-making authority be assigned to one specific agency. Failure to do so will result in an inability to resolve the conflicts.

1.6 INFORMATION MANAGEMENT

The primary tool for operationalizing hazard management is the the hazard management study. In essence these provide the data base that enables planning or hazard management authorities to determine what conflicts may arise and how best to resolve them. (An outline for a typical hazard management study follows in part 2.0.)

Information collection in management is one of the most important factors in managing environmental hazards. Without an adequate data base and the active exchange of information between agencies, metropolitan hazard management is difficult.

Steps to manage information are:

- o determine what information is needed for hazard management;
- o determine what information is needed for coordination with other environmental concerns;
- o determine the status of existing information
  - where the data is available;
  - how the data is collected and stored; and
  - how it is shared;
- o identify the information gaps and assign appropriate agencies to remedy the deficiencies.

1.6.1 Information Resources

To determine the location of hazards and the threat they pose to metropolitan environmental concerns, a wide variety of data must be collected, mapped, and then correlated with projects and other regional plans. The following is a list of essential informa-

tion needed to determine the nature of a hazard and various countermeasures.

FLOODS

Information Resources	Sources
Base Maps	Public Works Department Geological Surveys Agricultural Ministries Military Engineers River Basin Authorities Hydroelectric Companies or Agencies
Topographic Maps	National and State Geological Surveys Military Engineers
Soils Maps	Geological Surveys Ministries of Agriculture Military Engineers
Vegetation Maps	Ministries of Agriculture Geographic Surveys Departments of Forestry
Hydrologic Maps	Engineering Organizations River Basin Authorities Specialized Flood Control Agencies
Land-Use Maps	Regional Planning Authorities Metropolitan Planning Authorities Taxation Bodies Urban and Regional Planning Authorities
Aerial Photos	Commercial Resources Engineering Companies Planning Authorities Military Authorities
LANDSAT Imagery	AEROS Data Center, Sioux Falls, SD or Regional LANDSAT Data Centers
Road Maps	Public Works Departments Highway Authorities
Utilities Maps	Utility Companies
Hydrologic Data	Public Works Departments

Subdivision Development Maps	Private Developers City Planning Departments

EARTHQUAKES

Information Resources	Sources
Fault Maps Epicenter Maps Isoseismal Maps	Geophysics Institutes Universities Earthquake Engineering Societies
Seismic Zones & Micro-Zones	Geophysics Institutes Universities Earthquake Engineering Societies Insurance Companies
Bathymetric Maps	Harbor Authorities Coastal and Marine Agencies Marine Navigation Harbor and Naval Authorities
Topographic Maps	National and State Geological Surveys Military Engineers
Soils Maps and Maps Depicting Geology Substructure	Geological Surveys Ministries of Agriculture Military Engineers
Land-Use Maps	Regional Planning Authorities Metropolitan Planning Authorities Taxation Bodies Urban and Regional Planning Authorities

Maps that depict locations of critical facilities, structural conditions of housing, linear systems (such as power transmission facilities, pipelines, water and sewer lines, etc.) and transportation facilities or networks within the metropolitan area should also be acquired.

CYCLONES

Information Resources	Sources
Information about past windstorms	Meterological Office World Meterological Organization & Regional Hurricane Research Centers
Topographical Maps	National Geographic Office Geological Surveys Military Map Services
Drainage Systems	(See previous section on Floods for sources)
Land-Use Maps	Regional Planning Authorities Metropolitan Planning Authorities Taxation Bodies Urban and Regional Planning Authorities
Bathymetric Maps	Harbor Authorities Coastal and Marine Authorities Marine Navigation Port and Naval Authorities
Tide Tables	Port Authorities Marine Navigation Agencies Military Agencies Commercially Available Almanacs
Maps of Landslide Zones	Geological Surveys or Hazard Management Agencies
Flash Flood Zone Maps	Disaster Preparedness Agencies Watershed Authorities Geological Surveys
Storm Surge Run-up Zones	Disaster Preparedness Agencies Military Engineers
Subdivision Development Maps	Metropolitan Planning Authorities Private Developers

1.6.2
Analysis Techniques and Applications

Once the various information identified above has been collected metropolitan planners may utilize the following routines to determine risk and potential impact of the various natural hazards.

Flood Routines:
- o Map the high risk areas by equating rainfall, topography, soils, vegetation and hydrology.
- o Map the vulnerable zones by identifying areas where flooding is likely to occur and have a major negative impact on human settlements or structures.
- o Overlay the map of vulnerable zones with maps depicting critical facilities, population centers, urban development projects or other items of concern to the metropolitan planner.
- o Determine priority areas for action.

Earthquake Routines:
- o Determine the high risk areas by mapping the past seismic occurences, epicenters and isoseismal data.
- o Prepare hazard maps by equating the risk to human endeavors that would be susceptible to damage in an earthquake and to environmental features that could be adversely affected such as steep slopes, earthen dams, etc.
- o Overlay the vulnerability maps with population, project and critical facilities maps.
- o Identify population, building or human settlement trends that would affect future vulnerability.
- o Determine priority areas for action.

Windstorm Routines:
- o Map the high risk areas by equating topography, soils, vegetation and hydrology.
- o Map the vulnerable zones by identifying areas where high winds and flooding are likely to occur within the metropolitan area and have an impact on buildings or other man-made structures.
- o Overlay the map of vulnerable areas with maps depicting critical facilities, population centers, projects or other items of concern within the metropolitan area.
- o Determine priority areas for action.

2.0 TYPICAL LOCAL SCENARIO: TECHNICAL ISSUES AND SOLUTIONS

The following is a typical scenario demonstrating the application of the hazard management routine in a local context.

2.1 NEW HOPE - A HYPOTHETICAL TOWN

The town of New Hope is a large metropolitan area located on a coastal plain adjacent to the sea. It is a major shipping port and an international trade center. In recent years it has experienced phenomenal growth, and because the city has been unable to keep pace with development and because the cost of land is extremely high, large numbers of squatters settlements have developed. Three are of major concern. The first is located in the flood plains of the river that divides the city; the second is located on the steep slopes of the foothills that comprise the northern boundary of the city; and the third is located close to the beach on a landfill that had only recently been completed prior to its illegal occupancy by the squatters.

2.2 NEW HOPE IS THREATENED BY FLOODS

After heavy rains, residents of the squatter settlement in the flood plains inform the municipality that flood waters have inundated a small portion of the settlement. The municipality is concerned because this area has not been flooded in the past.

The Public Works Department is directed to look into the matter. They collect data and map the metropolitan watershed. Of special concern and interest are changes in land-use upstream of the squatter settlement. The department notes that rapid growth has occurred in several sectors upstream and that increases in the level of run-off have been noted in all the tributaries. PWD then contacts the Town Planning Department to obtain information on new developments in the watershed. It is noted that several new subdivisions are planned and a new university with large parking lots are under construction. It is also noted that there are plans to build an airport several kilometers north of the city.

Contact is established with the national Ministry of Agriculture to determine land-use changes occurring in the watershed to the north of the metropolitan

area. It is noted that because of fuel costs, deforestation has increased in the mountains in the upper portion of the watershed and efforts to control deforestation have been unsuccessful.

Town Planning authorizes PWD to conduct a study a hydrology in the metropolitan watershed and contracts with the Regional Watershed Authority to carry out a study of hydrology in the upper reaches of the watershed. The two studies determine that land-use changes in the watershed will increase flooding, not only in the original area of concern, but also will threaten a new government low-cost housing project being planned in an area adjacent to the flood plain.

At this point, the conflicts the municipal government must resolve are whether or not:

- o to move the airport;
- o to move the squatters;
- o to move the government housing project;
- o to stop subdivision development in the upper regions of the watershed;
- o to ask the national government to build dams or other flood control measures north of the city to control flooding;
- o to build levees within the municipality to protect the existing areas and, if so, were to locate the levees;
- o to channelize and deepen the stream in order to increase run-off capacity.

In this scenario let us assume that the deforestation upstream is beyond control and the subdivision development currently planned will only contribute minimally to the flood problem and that the university and its parking lots would contribute only to flash flooding in the squatter settlement.

Given these choices, it is probable that the metropolitan planners in New Hope would choose the following alternatives:

- o to continue work on the airport;
- o to halt construction on the new housing project for low income people;
- o to change density levels in the new subdivision to reduce the discharge into the stream;
- o to build levees in order to protect a portion of the squatter settlement;
- o to provide alternative land and economic assistance in order to relocate the portion of the squatters who would still reside within the flood plain.

2.3
A NEARBY CITY IS DAMAGED BY CYCLONES

Cyclones damages to a nearby city cause planners to evaluate the impact of a cyclone on New Hope. The Town Planning Department is ordered to do a study of the potential impact. The Department collects data and requests that the Housing Authority conduct a housing vulnerability study within the metropolitan area. At the same time, the Planning Department commissions a study of potential storm surge run-up zones along the coast.

The result of the findings are as follows:

- few owner-built homes can withstand the forces of high winds and damage to over 60% of the buildings within the metropolitan area can be expected;
- the areas most exposed are squatter settlements on the coast and in the ravines;
- the squatter settlements on the coast are also threatened by storm surge run-up;
- flooding caused by heavy rains proceding a cyclone could reduce the chances of a successful evacuation of the squatter settlements on the coast;
- new housing settlements proposed by the government in low-lying areas adjacent to the squatter settlements are threatened by both winds and storm surge;
- a proposed refinery on the coast is also threatened by storm surge and high winds.

Given these findings the metropolitan planning authorities must now decide whether or not:

- to upgrade the existing housing stock;
- to replace the existing housing stock;
- to relocate threatened communities;
- to build levees to protect communities threatened by a storm surge;
- to build levees to protect the refinery from the storm surge;
- to build evacuation shelters within the threatened squatter settlements to provide a refuge for people in the event of a cyclone.

These conflicts might be resolved as follows:

- In areas subject to wind damage, housing education programs designed to teach builders how to retrofit existing houses and improve the quality of new construction to a more wind resistant standard would be initiated.
- New development in threatened areas would be prohibited and other land uses initiated to restrict the possibility that squatters would take over and expand the existing settlements.

- The government would elect not to build shelters because safety could not be guaranteed and the presence of shelters would make evacuation to safe areas more difficult. To encourage evacuation, shelters outside the areas would be established and additional roadways and evacuation routes from the existing settlements would be constructed.
- Alternative land would be acquired and financial assistance would be extended to persons within the squatter settlement to enable them to relocate to the safer site. Squatters in the ravines would also receive high priority for relocation to other areas.
- Where feasible, engineering works such as levees and bunds would be installed to protect those remaining in the coastal settlements.
- The refinery on the coast would be prohibited.

2.4 NEW HOPE IS INFORMED ABOUT EARTHQUAKE RISK

The national government completes an assessment of earthquake risk and determines that New Hope is in a high risk area. At the urging of the national Disaster Preparedness Agency, the municipality decides to undertake an earthquake hazard analysis.

The Town Planning Department contracts with a consulting firm to complete a microzonation study of the community. When that is completed, other consultants are retained to complete a housing vulnerability analysis, a lifeline vulnerability analysis and a structural analysis of multi-story buildings in the central business district.

The findings of the various studies are:

- that 30% of the housing is vulnerable to damage from earthquakes;
- that 25% of multi-story buildings are vulnerable;
- many critical facilities are located on hazardous sites. Of major concern are:
  - a municipal reservoir and dam situated directly on a fault;
  - a power generating station situated on a site with a history of liquefaction;
  - the proposed refinery would also be situated on a site with a history of liquefaction;
- the squatter settlements located on hillsides and ravines would be vulnerable to earthquake induced landslides;
- the vast areas of the metropolitan area situated along the coast are sited on soils subject to liquefaction.

The choices facing the metropolitan planning authorities are:

- o to replace or retrofit housing to make it more earthquake resistant;
- o to retrofit or condemn high rise buildings;
- o to relocate, replace or retrofit critical facilities;
- o to relocate the squatter settlements situated on vulnerable sites;
- o to prohibit the construction of the refinery;
- o to relocate housing located below the dam.

A typical set of decisions that might be made, given these circumstances are:

- o to alter the building code to incorporate earthquake resistant designs standards;
- o to develop flexible building standards for owner-built structures;
- o to encourage residents to retrofit buildings and bring them up to an earthquake standard through housing education, code encouragement and financial incentives;
- o to improve building code enforcement for high rise structures;
- o to phase out and relocate critical facilities located on hazardous sites;
- o to acquire alternative land for the residents of the hillside squatter settlements and encourage them to relocate through economic assistance and housing projects;
- o to restrict new development below the dam and initiate programs to gradually reduce the density in that area;
- o to alter the urban design standards in the central business district and to gradually encourage the development of more open space in the area;
- o to take no action in squatter settlements in the coastal zones, but to discourage further development on the sites where liquefaction would be a problem.

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SPECIAL SECTION B

(Frederick Cuny)

ENVIRONMENTAL HAZARDS IN REGIONAL DEVELOPMENT