CHAPTER I

INTRODUCTION

This publication examines the spatial aspects of disaster prevention and mitigation in terms of physical planning and, more particularly, land-use planning. The major regions of the world exposed to violent natural phenomena (especially earthquakes, tsunamis and tropical cyclones) stretch across the tropical and sub-tropical portions of Africa, Asia and Latin America. These areas coincide with areas of rapid population growth and urbanization and are extremely disaster-prone. In addition, virtually no country is entirely safe from floods.

Indeed, the rapid growth and spread of population in hazardous areas is a matter of increasing concern which is rapidly contributing to mounting costs of disasters in terms of lives lost and damage to property and investments. Most developing countries are doubling their population every 20 to 25 years (assuming national population growth rates of 2 per cent to 3 per cent), while the urban population in these countries is doubling every 12 to 15 years (assuming urban growth rates of 4 to 7 per cent). Equally significant and of critical importance in areas subject to natural phenomena likely to cause disasters, the rate of growth of low-income slum and squatter settlements around major urban agglomerations is even greater than for the urban areas as a whole.

Slum and squatter populations grow at about twice the average urban rate. In settlements such as these there is a doubling of population every 5 to 7 years, and the density of slum and squatter populations is usually very high. In many cases, entire families may occupy a single room. Urban population densities per square kilometre, as measured in slums and squatter settlements, are even more revealing. In squatter areas, densities may be as high as 100,000 persons per km^2 (Morocco) and rise to 148,000 (India). Even the average densities for urban areas as a whole are high enough to cause concern in areas exposed to earthquakes, floods or landslides. The older sections of some cities may contain as many as 20,000 to 60,000 persons per km^2, although the average densities for such cities may be less than 10,000 persons per km^2. 1/ Densities such as these are all the more critical in hazardous areas.

The problem of exposure to disaster risk among rural populations, however, should not be underestimated. Although the population growth rate in rural areas is usually lower than the national average due to rural-urban migration, the scarcity of arable or developed land in many developing countries, combined with the fact that on the average more than 70 per cent of total national populations are still rural, can create significant risks in areas exposed to natural phenomena. Rural population densities can surpass 1,000 persons per km^2 in areas where rainfall and tropical soil conditions limit the amount of arable land. Wherever rural populations are sedentary (as opposed to being nomadic and pastoral) and engaged in agriculture on hazardous land, the risk of substantial disaster cannot be ignored.

1/ World Housing Survey, 1974, (ST/ESA/30), United Nations, New York 1976. Sales No. E.75.IV.8.

Dramatic increases in population size, distribution and density increase disaster risk: natural hazards such as floods, earthquakes or tropical cyclones do not in themselves constitute disasters until they strike at human lives and property.

The earthquake in Guatemala of February 1976 serves to illustrate how global and unselective disasters can be, 2/ affecting rural and urban populations with equal intensity. More than 3.4 million people out of a total of 5 million (64 per cent) were affected by the earthquake. More than 1 million persons were left homeless, and more than 222,000 dwelling units were partially or totally destroyed. Of the 1.2 million people left homeless, 350,000 were in the country's largest urban area, Guatemala City. The remainder were largely rural populations living in small towns or villages scattered throughout the earthquake zone. The single largest damage impact was on housing. The loss to the private sector (and particularly to low-income housing) was more than $2\frac{1}{2}$ times that incurred by the public sector.

Natural disasters in an increasing number of disaster-prone developing countries have become a formidable obstacle to national development; in a number of countries, the cost of disaster damage has amounted in recent years to more than 3 per cent of GNP per year. If in addition one takes into consideration that the rate of population growth in these countries often averages around 4 per cent per annum, it appears that a rate of growth of the economy as a whole of more than 6 per cent per annum is needed just to maintain the country at the same level of relative development. Since disaster-prone developing countries rarely achieve economic growth rates surpassing 6 per cent, the conclusion is that natural disasters constitute not only a humanitarian problem, but also a problem of development containing the seeds of economic and social dislocation unless appropriate disaster preventive measures are included in the national economic and social planning process.

There are two fundamental alternatives to disaster prevention and mitigation: the first aims at steering development away from hazardous areas toward safer locations; the second comprises structural measures aimed at resisting or deflecting the impact of natural phenomena. The present study is principally concerned with investigating the nature of the first of these alternatives, that is how physical planning and more particularly land-use control, can contribute to reducing both disaster risk and the vulnerability of human settlements.

Comprehensive land-use planning is a discipline which began early in the twentieth century in industrialized countries with scarce land resources, such as the Netherlands, Denmark and Great Britain. It is a physical planning tool which has since gained widespread acceptance in most industrialized countries. The more centralized the system of government, the more effectively can land-use be controlled, usually because private ownership of land is limited or strictly regulated. In free market economies, land-use controls are more complex and policies more difficult to implement due to the high rate of private land ownership and the resultant tensions between public and private interests.

2/ Damage Caused by the Earthquake in Guatemala and its Repercussions on the Country's Economic and Social Development (CEPAL/MEX/76/Guat.1) February 1976.

In disaster-prone developing countries, land-use planning and control for disaster prevention and mitigation may act as a spur to comprehensive land-use planning, especially where natural disasters have become a permanent development problem owing to their intensity and frequency.

Land-use planning and control are key factors for the orderly and safe growth of human settlements. Although there is no immediate shortage of raw (undeveloped) land for urban expansion in most developing countries, land is ultimately a finite resource and is extremely costly to develop. In developing countries, urban infrastructure costs are extremely high, the per capita costs far exceeding the per capita capacity to amortize such costs. The price of serviced land has risen out of all proportion to the costs of other resources and services, and especially in relation to wages.

Alternative methods have been explored, seeking to expand urban infrastructure and housing in planned and progressive stages with heavy reliance on purely locally available resources, including self-help. In disaster-prone areas orderly urban expansion becomes prohibitive unless investments in infrastructure, housing and other services are protected from damage at all stages of their development. Land-use control measures establish not only static norms such as function, density, and location, but also dynamic norms such as the rate of development and urban growth.

The major elements of land-use may be summarized as follows:

(a) Land-use policies and plans setting out the social, economic and environmental goals of comprehensive land development and their stages of development;

(b) land ownership and land tenure patterns, identifying the legal, social and economic basis of ownership and tenure;

(c) land values and prices, reflecting the forces of supply and demand for land with respect to free market economies;

(d) land-use controls which may be subdivided into three broad categories: legal, fiscal and directive (by direct government intervention).

Land-use planning and control for disaster prevention purposes should logically be based on knowledge of the natural hazards present and the disaster risks which may ensue. This monograph begins, therefore, with a brief survey of the principles and aims of comprehensive risk analysis, which UNDRO has termed "vulnerability analysis". The study then proceeds with a review, firstly, of land development and how it relates to the problem of disasters and, secondly, of the land-use policies and measures which are most relevant to disaster prevention and mitigation. A special chapter has been included on land-use policies and measures for the prevention and mitigation of flood and earthquake disasters. Although land-use control has been most successful with respect to floods, rapid scientific progress is currently being made in the field of earthquake risk assessment and seismic zoning and micro-zoning. Finally, a brief chapter provides some conclusions and recommendations on land-use and disaster prevention and identifies some of the gaps which require both national and international action.

CHAPTER II

VULNERABILITY ANALYSIS

A general definition

It is apparent that population and development pressures in disaster-prone areas have created severe land resource and therefore land-use problems. At the same time, since most disaster-prone developing countries are still at the early stages of urbanization and industrialization, they still have the possibility of making basic choices regarding the location of future human activities and settlements, choices which often are no longer possible in developed countries. Land-use planning for disaster prevention and mitigation should, by definition, be based on criteria establishing the nature and degree of the risks present and their potential impact. This method of risk identification and evaluation is referred to as "vulnerability analysis" in this study. Through vulnerability analysis it is possible to make rational decisions on how best the effects of potentially disastrous natural events can be mitigated through a system of permanent controls on land development.

Vulnerability analysis in disaster-prone areas is not only fundamental to the formulation of building codes, as is widely accepted, but is even more important for the general process of physical planning, and to land-use planning in particular, especially with regard to locational decisions for new development. In areas exposed to violent and sudden natural phenomena, such as earthquakes, floods, tropical storms and storm surges, rational land-use planning and control cannot proceed in the absence of a systematic analysis of the risks involved. Whereas purely economic criteria may favour certain types of land-uses in a given location, the risk of flood or earthquake, for example, may fundamentally alter the type of land-use choice which will ultimately be made in that area.

Both the probable intensity and frequency of natural hazards, and the susceptibility (or probability) to damage of human activities in the face of such hazards are integral components of disaster risk assessment. Therefore, the probability of disaster (vulnerability) may be expressed as the product of natural hazard risk and damage probability: vulnerability (disaster risk) = natural hazard risk x damage probability.

The implication of this simplified expression is that measures to reduce the risk of disaster should be aimed either at reducing the natural hazard itself, or at reducing the probability of damage which may result from such a hazard. It is generally true to say that while the reduction of the intensity or frequency of natural phenomena is in most cases beyond our present means or capabilities, the reduction of damage probability is well within our reach.

Land-use planning and control are principally aimed at reducing the risk of disaster by reducing damage probability through the application of measures to steer development away from areas exposed to severe natural phenomena. Moreover, in so doing, these same measures may indirectly contribute to the mitigation of the hazard itself, by avoiding man-made aggravation of the hazard. For example, whereas

a balanced system of land-use may conserve soil permeability in flood-prone areas and thereby minimize or at least stabilize the normal flood risk, intensive and uncontrolled land-use patterns in the same area may decrease soil permeability and increase surface water run-off into the flood way thus raising the flood level and consequently increasing damage and loss of life (see chapter V).

Natural hazard assessment

The basic quantitative input to vulnerability analysis is the asessment of the intensity, frequency and location of the natural hazard or hazards concerned. The methods of risk (hazard) assessment depend on the historical records available, data on regional and local physical characteristics, and scientific judgement. Estimates are developed for probable intensity and frequency of future events, including those of potential danger. Generally speaking, for the layout of natural hazards, intensity is much easier to predict than frequency. Hence the importance of locational criteria in preventing disasters: in the absence of knowing when, one can at least determine where disasters are likely to occur. Nevertheless, if a significant amount of data are available over an adequate period of time, standard methods of frequency calculation are available from which peak intensity in a given area can be determined. This frequency is often expressed as a "return period", which represents the average interval of time between events of a given magnitude. Because of the uncertainty of data in many areas, particularly for events of extremely long return period, it is necessary to state the result of vulnerability analysis in probabilistic rather than deterministic terms. Hazard assessment provides the basis for preparing risk maps which indicate zones of uniform risk resulting from one or more types of natural hazards.

Risk mapping

(i) General

Essential to adequate land-use planning and regulation is the development of base maps at appropriate scales indicating hazard distribution by type, intensity and frequency. Once the level or risk is established, social valuations and political decisions must be made on the acceptable levels of risk for various human activities. The relation of risk to exposure involves cultural, economic, and political judgement which may vary from one society to another.

Once maps and criteria for land-use regulation are available, they provide the necessary tools for evaluation of future settlement sites. This is a factor of primary importance in the developing countries where future natural disasters may be considerably reduced with a minimum of added development cost. Aside from directing the siting of future development, land-use regulatory instruments also offer guidance in identifying hazardous areas of existing settlements which should be given priority in renewal planning and in disaster preparedness planning.

Risk mapping should ideally be carried out at scales appropriate for the size of the planning area.

1. National scale, appropriate for long-range development planning (1:250,000 - 1:1,000,000) (Risk macro-zoning);

2. Regional scale, appropriate for regional development planning (1:62,500 - 1:125,000) (Risk macro-zoning);

3. Detail scale for appropriate urban settlement planning and vulnerability analysis (1:12,000 - 1:24,000) (Risk micro-zoning);

4. Project scale mapping for detailed land-use and construction regulation purposes (1:1,200 - 1:12,000) (Risk micro-zoning).

These maps may indicate, among other things, the location of zones of earthquake risk, (shaking, ground failure, fault lines etc.) wind exposure, flood plains, coastal areas subject to storm surge and tsunamis, the location of active volcanoes, slope instability, avalanche risk, etc.

Such maps are valuable for many applications beyond the prevention or mitigation of natural disasters. This mapping can contribute to any effort at coherent national development planning or, in the case of the larger scale maps, to urban planning. Though the cost of mapping is fairly high, natural disaster mitigation and prevention needs should contribute to its priority and motivate increased support. It has been estimated that less than 20 per cent of the land area of the earth is adequately covered by current maps at the scale of between 1:100,000 and 1:25,000.

(ii) Comprehensive risk mapping

In order to provide a useful input to the process of land-use regulation for disaster risk reduction, ideally there should be an expression of composite risk at a given site. A comprehensive hazard analysis should allow for comparison of total hazard risk from all significant sources, in order to be of value in land-use planning. Single-minded approaches to hazard mitigation may in fact increase disaster risk; for example, in the case of a flood control dam which permits settlement of a downstream flood plain, but heightens the risk of catastrophic flooding if dam overflow or failure should occur.

Risk zoning can be approached in two ways: Static Risk Zoning, which treats the hazard in an area as a function of the cumulative severity of damage irrespective of the frequency of occurrence; and Probability Risk Zoning, which takes into account frequency of event occurrence. The latter system allows infrequent, but highly consequential events to be given proper weight in comparison with more frequent events of lesser consequences. For this purpose, recurrence curves which rank the frequency and size of hazard events per 100 years, for example, (a typical consideration of probable building life) per unit area are constructed. Often in the developing countries and recently-settled areas, historical information is not available for anything better than very rough estimates of the recurrence curves.

The danger in using overly-conservative risk estimates is that significant economic resources may be diverted from more urgent social needs in order to resist inconsequential threats. The concept of comprehensive risk mapping is still in the development stage. The execution of comprehensive risk maps in the

developing countries will continue to present considerable difficulties as long as data resources remain sparse and incomplete. In many countries the preparation of risk maps, especially micro-risk maps, will be based on common sense judgement on approximation and on the knowledge and experience of local people, and increasingly on the progressive accumulation of geological, hydrological and atmospheric data. It must be emphasized that the accumulation of regional and local physical data can serve a variety of planning and development needs in addition to disaster prevention.

Damage probability assessment

This task is carried out by comparing risk maps to land-use and environmental maps or plans. Since vulnerability is a relative concept which depends on the type of mitigation measures to be decided upon, two kinds of analyses can be undertaken from which feedback procedures can be defined for integrating feasible preventive measures in land-use and land development plans:

(a) vulnerability analyses for alternative development schemes, which will include the identification of critical areas in relation to the existing and proposed land-use; cost-benefit or cost effectiveness 3/ analyses of the type and level of investments envisaged in relation to the risks posed; and an environmental impact statement.

(b) feasibility studies of typical mitigation actions such as greenbelt protection against sandstorms, flood control structural works, and antiseismic regulations for building codes and public works.

The introduction of vulnerability analysis into the development planning process

Disaster risks and reassessment of their probable impact on development should be considered as one input factor among others in formulating national, regional and local development plans. Because other priorities are usually considered first and may even be afforded greater importance in the comprehensive planning process than disaster risks, one often discovers that various economic, social and even political goals actually "compete" with the need to prevent or mitigate disasters. Thus, vulnerability analysis may act as a constraint which may appear to "hinder" certain established land-use policies in specific areas; however, since the risk factor may radically modify other variables (for instance, if a project is destroyed by a disaster,

---

3/ Cost benefit analysis tests whether or not the potential benefits of a given adjustment to risk (disaster prevention measure) or a projected investment are likely to exceed its cost.

Cost-effectiveness studies may be used in decision-making in circumstances where it is difficult to obtain information about potential benefits. Cost effectiveness has two basic approaches. The first specifies a goal and then examines the costs of alternative ways of attaining it; the second specifies the maximum amount of capital or resources a government or other body is willing to allocate for a given purpose, and then determines which alternatives can best attain that purpose within the given resource constraint.

say, five years after its completion, the initial cost-benefit calculations turn out to be completely erroneous), vulnerability analysis must be introduced at the earliest possible stage of planning. The findings of such an analysis may be integrated in the planning process at several stages: when elaborating alternative development schemes using risk maps; when selecting alternatives through multi-criteria analyses, including potential damage analyses, in line with basic planning objectives which may lead to conflicting solutions. Such a method can lead to balanced solutions which fairly meet all the objectives pursued.

In summary, while risk analysis, hazard assessment and similar concepts describing the "vulnerability" of human activities to disaster, are not unfamiliar to the engineering profession, the idea that comprehensive risk analysis should be applied to national and sub-national planning is still in its formative stages. The problems that may be faced in carrying out vulnerability analyses in the developing countries cannot be ignored or underestimated. The absence of complete historical records on past natural disasters and the present lack of sufficient scientific data pose a considerable challenge to planners in developing countries, particularly with regard to the prediction of future disasters.

Nevertheless, the governments of countries subjected to frequent natural disasters urgently need to include the risk factor in their planning efforts. The best and most pragmatic approach may be to concentrate on scientific data collection in order to build up maps identifying the location and intensity of risk in probabilistic terms and, on this basis, to calculate the costs and benefits of projected development in alternate locations, given the level of risk which the economy and the people are able to accept. The main thrust of vulnerability analysis should bear on the location of new development, but adjustments to existing patterns of settlement and land-use should not be ignored.

CHAPTER III

COMPREHENSIVE LAND DEVELOPMENT AND DISASTER PREVENTION

General

Having examined the concept of vulnerability analysis in the preceding chapter, this chapter broaches the question of land-use planning from the point of view of the broadest issues of national and regional land development policies. It should be borne in mind that all references in this and succeeding chapters to decision-making on land-use policies, plans and measures are made with the understanding that vulnerability analysis underlies all such decisions. Wherever the risk of disaster is present, it should automatically be analysed and taken into account for all prospective development purposes.

In order to understand the alternative ways in which natural disasters may be mitigated or prevented using the tools of land policies and land-use controls, it is necessary that this element be viewed as a component of the entire policy-making and planning process. In this regard, disaster prevention and mitigation policies should be included in all development policies and plans, and at all levels of government. Although the closest expression and manifestation of the importance of disasters may occur in controls over a specific parcel of land, these controls would have their roots in the general policies guiding over-all national, regional, and local development. This chapter describes briefly the concept of comprehensive land development and land-use planning.

National policies

National policies attempt to consider the needs of the country as a whole and seek to co-ordinate and integrate land policies with social and economic policies, and to co-ordinate the planning process at all levels of government. Although the issue of disaster prevention and mitigation has not commonly been a factor in the preparation of these plans, the increasing frequency of natural disasters in some countries has brought about a change in this respect. The major concerns of national policy formulation deal with economic and social goals. Lately however, the environmental implications of such policies have increased in importance, especially in developing countries where resources are limited, and where the growth of large urban centres is generating substantial environmental problems.

It is only a short step from these concerns to those of disaster prevention and mitigation. For example, the rapid urbanization of a large metropolis such as Manila not only creates a need to regulate urban growth from the standpoint of national welfare, but when the situation is coupled with severe urban flooding year after year, it becomes clear that disaster prevention policies would directly serve the national interest. Hence, more and more national land policies are attempting to plan and regulate patterns of urbanization in order to produce over-all national benefits. But such regulation requires the harmonization of many different and often conflicting factors, especially since national development is planned to achieve clearly-stated goals over some specified period of time. Disaster prevention policies should be formulated as part of national policies, especially where national policies are instrumental in

guiding the location and spatial distribution of new settlements: the question of the location of development in disaster-prone areas is of crucial concern to disaster prevention policies and strategies.

Regional policies

Regional policies emphasize spatial considerations and physical planning to a greater extent than do national policies, and hence are particularly relevant for disaster prevention. The two major concerns of regional policy are (a) the relationship between urban areas within the region; and (b) the relationship between urban and rural areas. Regional policies may include objectives such as a balance between various regions in the country by directing economic development into less-advantaged regions, or the encouragement of urban development to allow for social mobility and the progress necessary to produce an industrial society. Major components of regional policies include the selection of areas designated for transport networks, industry, agriculture, and urban growth. The relationship between urban and rural areas should normally be defined, and may include policies governing open space, and the location of utilities and services in agricultural zones, which may have an effect on the control of urban growth and on the distribution of rural communities. The spatial aspects of regional planning are a vital link to national planning efforts and constitute a basic means of implementing disaster prevention policies. Thus, controlling the location of activities within a region may not only serve social, economic and environmental goals but may also serve as a means of reducing or eliminating disaster risks on a very large scale leading to very significant national benefits in the medium to long-term.

Rural policies

Rural policies attempt to expand agricultural development and distribute to the rural population the benefits of economic and social development of the country as a whole. But rural areas (especially in developing countries) are subject no less than cities to natural hazards. Farming practices can lessen or intensify the effects of natural phenomena locally and even regionally. For example, floods 4/ may be caused or aggravated by deforestation or other practices which deprive the ground of its natural cover and increase run-off and the silting of riverbeds. Rural policies have also been designed to act as a brake on migration to the cities, which are themselves frequently subject to severe natural hazards.

It must be recognized however, that the excessively high rates of urbanization experienced in the developing countries have hardly been checked, even by the most determined rural policies. Urbanization is both a symptom and a cause of economic development and changing national aspirations. It is doubtful, therefore, whether rural policies can be used specifically to decrease rural to urban migration in the hope of reducing, directly or indirectly, urban

---

4/ For further information on this subject, the reader may refer to Disaster Prevention and Mitigation, Vol.II, Hydrological Aspects, published by the Office of the United Nations Disaster Relief Co-ordinator (UNDRO), Geneva, Switzerland, 1976.

disaster risks caused by the heavy concentration of population in vulnerable areas. A more pragmatic approach would be to incorporate disaster prevention and mitigation measures within both urban and rural policies and programmes, respectively, until such time as urbanization in the developing countries stabilizes at controllable rates.

Urban and local policies

Policies for urban and metropolitan centres are unique to each city and its special characteristics. Local level policies as well as implementation strategies are highly specific and finely detailed, and deal with population and economic growth, housing and density patterns, employment and transportation.

Local policies are of extreme importance to the total planning process, for these guide the specific spatial distribution of human activities. It is here that investments are made and that the construction of human settlements takes place, and it is here that specific disaster mitigation programmes are really implemented. The wide range of functions performed by human settlements demands that planning policies, at the local level, range from one to twenty years or longer. If one is concerned with disaster mitigation, this time frame should extend still further into the future. Planning policies must seek to integrate the structural, man-made environment so as to avoid the negative effects of unplanned growth.

Frequently, effective local control over development is limited by the lack of or weakness of the local government as well as meagre resources. Various schemes have been proposed to provide local government with the powers and financial resources needed for planning and implementation. Autonomous metropolitan and regional authorities constitute a decentralized and responsive system for local planning. This system may operate irrespective of traditional political boundaries and encompasses many communities making up the total metropolitan area or region.

Since urban migrants frequently occupy the poorest and most vulnerable urban land (most often as 'squatters' in flood plains, on unstable hillsides and elsewhere), they suffer the greatest exposure to disaster risks and the heaviest consequences. Natural disasters do not respect political boundaries nor can they be managed by the limited resources of one governmental unit. Hence, planning for disaster prevention and mitigation calls for the harmonization of the plans and programmes of a number of local governments.

The administrative schemes just described are general; variations can be found. The important elements, however, are that the local authorities be vested with adequate powers and financial resources to carry out disaster prevention plans and programmes in furtherance of national policy objectives. Programme formulation at the local level is tantamount to rational development as it responds to the needs of the community and integrates those needs with the conditions of the natural and physical environment.

Comprehensive planning

Comprehensive planning is the means by which planners can deal with the dynamic and increasingly complex environment. The general goal of comprehensive development planning is aimed at co-ordinating and integrating the many elements of human activity, including the relationship of one element to another or how a change in one element may affect an entire system. The comprehensive planning process integrates social, economic and environmental policies with specific programmes such as housing, education, industry and recreation. It also integrates factors of time, spatial distribution of development and physical conditions.

Comprehensive planning calls for three basic steps: (1) an appraisal of the economic, social, physical and administrative conditions within the bounds of the planning area; (2) the formulation of goals and objectives for the planning area as well as the alternatives associated with these goals; and (3) the determination of the means to achieve goals and mobilizing available resources, whether natural, financial or human (manpower, technology). The comprehensive planning process prescribes a systematic and realistic effort toward designing the future. Goals and objectives become realistic when integrated with present conditions associated with the planning areas. This is especially important with respect to pre-disaster planning, since it is necessary to look at the physical area before development begins. Furthermore, the comprehensive planning process can help achieve the rational use of land resources by integrating the physical risk factors with the social and economic aspects of development.

The comprehensive planning process serves disaster prevention in two ways. First, the process relies on an appraisal of the physical conditions, e.g. topography, water resources, critical or hazardous areas, and it subsequently determines the goals for the community based on the physical aspects and risks noted. While this may appear to be either common sense or simplistic planning, in many instances development planners ignore physical, and especially spatial considerations. Second, the implementation of specific facets of comprehensive plans may then include disaster prevention measures which are not in conflict with planning goals. Disaster prevention, as in the case of most control measures, can be achieved either by direct government actions or indirectly by influencing individual behaviour.

Governments may directly control development by public acquisition of land, by public land development schemes or by structural measures which physically alter land. In the case of indirect controls, governments may utilize legal measures such as zoning and sub-division or else taxation policies. These are particularly relevant to disaster prevention and mitigation as they can guide, limit or regulate the uses of the land for public safety. In addition to these advantages, comprehensive planning can help co-ordinate decisions made at different levels of government. For example, the provision of housing may be the responsibility of local government, while the issue of water resources and flood control may be entrusted to the regional or central governmental authority.

Citizen participation in the comprehensive planning process has special significance for pre-disaster planning and prevention. The reasons are twofold: first, the concept of pre-disaster planning implies limitations on the use of land. In many parts of the world the right to use one's own land as one desires is virtually sacrosanct. Government intervention in this area, though legal, requires

strong justification. Citizen participation in the planning process would make such justification and understanding easier. If citizens are made aware of the importance of the need for disaster prevention and the need to regulate land-use, this may stimulate the co-operation necessary to the successful planning of vulnerable areas. Secondly, a related aspect of citizen participation is the need for public co-operation in the implementation of disaster prevention measures.

Co-operation is not only important in a legal sense, but also in a voluntary or social, i.e. practical sense. For example, as mentioned earlier, in areas subject to floods standard agricultural practices may in fact contribute to flooding by increasing run-off. The successful management of crops and the provision of drainage facilities do not necessarily require legal contracts. However, voluntary compliance on the part of farmers to take action to reduce flood risks is required. Voluntary compliance can become part of the plan implementation strategy.

The integration of land-use planning in the comprehensive planning process

Land-use planning operates within the purview of comprehensive planning in order to distribute spatial resources to achieve social and economic planning goals. This type of planning occurs mainly at the regional or local levels owing to the fact that land-use policies are highly specific in nature. The function of land-use planning is to determine the types and amount of land-use needs and the relationship among various land-uses, thereby determining a total land-use pattern for urban and rural development.

Land-use planning operates to prevent the land market from developing at cross purposes with the goals of comprehensive planning. This becomes a crucial issue for disaster prevention, and it is particularly important that land-uses be regulated in disaster-prone areas. Poor or non-existent land-use control in disaster-prone areas not only maintains risks at unnecessarily high levels but has a cumulative effect, compounding and magnifying disaster risks over time, especially where natural hazard risk and economic interest coincide in the same zone. The private market is sometimes unaware of the existence of specific risks in given locations and may develop land against its own and the public's interest. Land-use planning helps in taking locational decisions, determines the proper uses of land and promotes the co-ordination of investments made by both the government and the private market in disaster-prone areas.