CHAPTER IV

LAND-USE POLICY AND MEASURES APPLICABLE TO DISASTER PREVENTION AND MITIGATION

General policy considerations

Land-use policy is only one of the adjustments to disaster risk, and all adjustment measures must be responsive to the economic and social resource balance of the country or region. All too familiar is the application of inappropriate standards and techniques to the problems of developing countries. A number of general characteristics of developing countries require particular consideration:

(i) the pressures for development are frequently so overwhelming that where an increase in disaster risk is accompanied by tangible short-term gains, little weight is likely to be given to disaster prevention within land-use policies;

(ii) traditional systems of land-use have over a long period of time adjusted to periodic disasters, but the pace of development over the last twenty years has upset the natural socio-economic modes of adjustment; this pace is not likely to slow down, at least in the forseeable future;

(iii) traditional and intermediate indigenous economic systems are highly sensitive to regulation, and the economic costs (measured by employment or employment growth losses) of uprooting, relocating, or inhibiting development can be very high in labour intensive employment sectors;

(iv) growth of population and land shortages have tended to push the poor further and further to marginal land, such as ravines, steep slopes or even riverbeds. This marginal land can be either drought-prone or prone to floods, storms, earthquakes, landslides, or other natural phenomena.

(v) the resource balance within developing countries would favour methods of adjustment using more labour, less capital and less scarce foreign exchange than in developed economies.

The first of the above points is likely to add to the difficulties of land-use policies for disaster prevention. The remainder have the effect of steering these policies in the direction of a more sensitive appreciation of the socio-economic systems and levels of development in which the land-use policies are to operate. In this context, disaster prevention or mitigation is not the only goal and may sometimes conflict with other interests such as employment and income opportunities. It is the task of policy workers and planners to reconcile such differences in a manner appropriate to local customs and resources, realising that in a developing economy initial decisions have far-reaching effects. Nevertheless, those who reap the benefits of development growth in the long term are disturbed by land-use controls and regulations in the short term.

Land-use controls in countries with large intermediate development sectors (between the modern and traditional) are less effective when they do not respond to the economic forces which they attempt to channel. In this event the cost of policing a body of administrative law far exceeds the capacity of national, provincial and local governments. Many rules and regulations can be neatly formulated, but they cannot be enforced.

At the national planning level where land-use plans become an integral part of the development process, it is easier to recognize adverse economic forces and harness those in favour of reducing disaster risks. It is more likely that where a sound macro-framework of land-use policies has been adopted, undue burden will not be placed on the particular micro-level land-use measures and regulations. These micro-level measures and regulations will then be more likely to be in tune with the economic setting, either working with it or not attempting to combat more than local government offices and inspectors can handle. A few examples will be discussed below to illustrate the process of designing appropriate land-use policies for disaster prevention or mitigation, within a broad framework of national or regional level planning.

In the formulation of land-use policies in a broad macro-framework at national and regional levels, the following issues have been found to be important in many countries exposed to natural disasters:

(i) the conflict between irrigation and flooding provides a basic dilemma for planners. Some of the gains of extra production through irrigation can be legitimately claimed in preference to the less tangible benefits of extra flood prevention and mitigation measures since reservoirs for irrigation water obviously need to be kept full, whereas for flood prevention the need is for empty reservoirs;

(ii) floods provide silt for increasing soil fertility, while both flood prevention and irrigation can either eliminate the silting or limit it to well-defined areas. Large numbers of small farmers can lose their livelihoods or have their income reduced if their interests are not taken into account in the new plans;

(iii) the relation between flash floods or flood plain management and watershed or catchment area management has still not been sufficiently clarified; however, it is generally agreed that uncontrolled deforestation and "slash-and-burn" shifting agricultural cultivation can cause soil erosion, lower water holding capability of the land and increase flood risk through silting of riverbeds and faster run-off. It would have to be established in each case whether this was due more to current practices of forestry and agriculture or had arisen as a result of population pressure on marginal agricultural lands;

(iv) as pointed out earlier in this monograph, rapid urbanization in the developing countries has produced large concentrations of urban squatters who have by and large settled on unoccupied land (both public and private) in unattractive or undesirable locations, including marshes and other low-lying land exposed to periodic or seasonal flooding, but where they are close to employment opportunities and services. One of the most serious and difficult challenges to land-use

policies is the need to provide safe and suitable urban land for all segments of the population, including the lowest income groups who can least afford the disruption brought about by having to live in areas constantly subject to disasters.

The perpetuation of squatter settlements in low lying flood-prone areas is often caused by the high cost of suitable alternative locations, and the extremely high per capita costs of new infrastructure and services, for which subsidies directed at the lowest income groups are rare because of unbalanced housing policies and the low capacity of loan repayment among the informal or marginal (squatter) segment of the population. Furthermore, as mentioned above, the lowest income groups congregate as near as possible to their sources of employment, whatever the risks. In sum, nothing short of comprehensive policies programmes can effectively cope with problems of disaster prevention in urban development.

The comprehensiveness of a policy framework is demonstrable where land-use policies are supported by corresponding social and economic policies. Thus, the reservation of new urban land for housing, especially where low income families are concerned, should be linked to transport and employment facilities, education and other social services. The modes of investment in, and development of, new urban land are complex, and vary from country to country. The most feasible approach is one that undertakes the development of infrastructure services and housing in progressive phases, employing wherever possible popular participation techniques to reduce capital costs by investing the labour and savings of the interested population itself. One may cite core-housing, sites and services, and the creation of small savings and loans societies or co-operatives as components of the total land development process.

(v) with increasing urban and industrial development replacing paddy fields, swamps and natural water catchments, the risk of flooding increases. On the one hand, alternative urban development strategies aimed at decentralization and the creation of secondary centres are frequently beyond the means of national economies, owing to the extremely high per capita costs of developing raw land. On the other hand, the cost of totally restrictive land-use measures could provoke the disturbance of intermediate level production and marketing systems, and hence reduce the growth of intermediate income and employment. The choice of the mix of rural/urban policies and of disaster prevention and mitigation measures will thus need sensitive appreciation of the issues involved.

(vi) in towns and villages vulnerable to volcanic eruptions,[5/] earthquakes,[5/] landslides, land subsidence and associated risks, the land-use planning process is confronted with many of the social and economic dilemmas

---

5/ For further information, refer to Volume I: Volcanological Aspects and Volume III: Seismological Aspects, Disaster Prevention and Mitigation, published by the Office of the United Nations Disaster Relief Co-ordinator (UNDRO), Geneva, 1976 and 1977, respectively.

that can be found in land-use planning for floods and other hazards. The most vulnerable areas are the portions with the oldest housing built of load bearing construction. The poor generally live in the older and most crowded sectors of cities. The economic and social cost of uprooting, disturbing and resettling this population may inhibit employment and income growth. Nonetheless where the earthquake or landslide risk is great, preventive measures are required, but should be closely harmonized with both land-use and housing policies designed to respond to the problem of social and economic development. Thus, the re-zoning of land in the older, poorly built or high risk portions of towns can have unfavourable income distribution effects.

Extensive urban renewal or relocation investment sometimes requires rents and returns on capital which are higher than can be afforded by the population concerned and, as a result, middle or upper income groups may displace the lower income settlements, thereby benefiting at their expense, unless higher standards of living can also be created. This is not impossible but it multiplies the difficulties. Relocation or redevelopment programmes for low-income settlements should be designed to match the economic and social (self-help) resources of the communities concerned. A number of methods have been developed to meet this objective using a gradual or step by step approach, such as sites and services, core housing, etc.

Administration of land policies for disaster prevention and mitigation

(i) Decentralized administration

Decentralization relies on co-operation between local and central government in the administration of land-use policies and efforts directed at disaster prevention. In the area of risk mapping or delineation of hazardous lands within a given geographic location, the central government may provide assistance by combining the expertise and information of different ministries or departments in the preparation of "risk maps". In a decentralized system of government, the role of the Central Government in influencing land-use practices, however, is usually limited. Nevertheless, the Central Government can and should influence land policy throughout the country by its programmes of financial aid and assistance to local and regional areas. Thus, development grants, loans and subsidies may be provided on condition that certain land-use measures be applied to reduce disaster risks.

The benefits of local autonomy are often compromised by the absence of co-ordination among local authorities. Indeed, decentralized systems of public administrations are often criticised because they contribute to unco-ordinated efforts at all levels of government. Semi-autonomous local, metropolitan and regional agencies in some cases lack an integrated approach, and are left to work with fragmented policies and plans, including the area of disaster prevention. Moreover, the failure of integration contributes to the lack of uniformity of codes and ordinances among local authorities exposed to the same risk. Thus vigilance with regard to proper zoning and other land-use measures to reduce disaster risks in one community may be compromised or negated by negligence in another.

(ii) Centralized authority

In centralized systems policies and plans may be clear and well defined. However, the system is not without its problems, for in many instances such policies may not sufficiently reflect local concerns and circumstances. Indeed, local and regional agencies should participate in all aspects of national planning for numerous reasons, as noted, among others, in the section on citizen participation. Policies aimed at regulating land-use practices at the local level should be based on highly detailed physical analyses. Risk micro-zoning maps, for instance, should be of sufficiently small areas to produce adequate detail for individual project development. This responsibility, left solely to the national government, would be extremely difficult to undertake. Local expertise can provide specific inputs in a much more effective and detailed manner.

Since each country has an administrative system reflecting its political, economic and social framework, it is impossible to prescribe a single administrative solution if, indeed, one solution exists. However, an institutional framework which, on the one hand, inherently encourages the fragmentation of responsibility or, on the other, disregards local needs, contributes to ineffective planning efforts. It is imperative that planners formulate an adequate administrative machinery, which integrates land-use control, fiscal control and planning legislation, for without such a mechanism effective disaster prevention and mitigation programmes will be difficult to implement.

Legal controls

(i) Zoning controls

Despite the obvious significance of the spatial aspects of disaster risk, it is only in recent years that substantial advances have been made in quantifying risk, particularly at the local level, through risk micro-zoning. Risk macro-zoning is a technique of somewhat longer standing and more general application, but which has been of limited use for detailed land-use planning, since it applies risk mapping to the national and regional scales only. The division of a country or regions into broad areas of risk is useful for outlining general national policies in disaster prevention and mitigation. However, micro-zoning is required for the preparation of detailed land-use measures at the local level.

The implementation of legal controls to influence land development has gained wide acceptance in many countries. Zoning and sub-division controls are two means by which governments have sought to regulate and control both land-use patterns and development in both rural and urban areas. These legal controls are used to regulate the activities of the private sector by placing locational restrictions and minimum standards on specific types of land-uses and activities. However, legal restrictions vary from country to country.

Zoning involves the delineation of continguous tracts of land which differ from one another in some respect, either in terms of existing or anticipated characteristics. In terms of the typical planning effort, zoning may be defined as the division of land into districts or land-use zones, and the prescription of regulations within those zones regarding height and bulk of buildings, floor area

ratios, the density of the population, set-back regulations, and the percentage of lot occupancy. For the most part, zoning ordinances are divided into broad land-use categories such as agricultural, residential, industrial and commercial uses. However, in many countries, these broad categories have been expanded and refined by adding such uses as open space and recreation, and sub-dividing in great detail the general category into any number of specific sub-uses.

Effective zoning requires that areas be delineated according to their land-uses and be shown on an official map for the area. Once the zoning ordinance has been enacted and becomes law, exceptions from the ordinance require a special variance approved by public officials. Theoretically, the zoning ordinance is based on a professionally conceived land-use plan for the total planning area. Thus, zoning is a highly effective land-use control device in planning efforts to prevent natural disasters.

(ii) Land-use macro-zoning

Macro-zoning is the establishment of land-use planning zones at the national and regional levels. Such zones generally establish agricultural, urban, industrial and recreational uses incorporating existing and future patterns. Specific uses are allowed in designated areas, although macro-zoning plans are revised at appropriate intervals to take into account changes and growth. Such zoning is an efficient tool to control the over-all location of various human activities. Macro-zoning has a broad function in the reduction of vulnerability, since hazardous areas can be zoned permanently for agricultural or recreational uses, minimizing as far as possible urban or semi-urban concentrations of population.

The use of macro-zoning to preserve open spaces also can produce secondary benefits tending toward the prevention of disasters. For example, consider the case of flood prone areas. Development itself, whether it be residential, industrial or commercial that occurs in flood prone areas, may, as we shall see in chapter 5 of this study, contribute to an aggravation of the existing flood hazard itself. When land is extensively built upon, changes occur in soil permeability and therefore in drainage and run-off patterns. Thus roads and other paved or impermeable areas contribute to increases in the rate and quantity of the run-off of water (rains), and the absorption capacity of the original, raw or undeveloped land has been reduced, thus substantially contributing to flood risk. The same may be said about unregulated agricultural practices including unbalanced irrigation. One method of managing run-off is to place open spaces strategically so that they may absorb such run-off. In this way, the location of open spaces for agricultural and recreational uses, may help to reduce or at least minimize the flood hazard itself.

It should be noted again that regional macro-zoning for disaster prevention should be harmonized with over-all social, economic and environmental goals. Thus, the reservation of open land for the purpose of reducing risks should not compromise economic goals. However, the definition of these goals is a question of trade-offs, inter alia, between risk, environment, custom or tradition, and income.

A number of countries have recently begun to establish a limited form of macro-zoning by designating certain areas to be protected for environmental reasons. These generally include shoreland or baylands, river basins, mountains, or other

areas of outstanding natural beauty where there is a threat of over-use due to intensive development, often for recreational purposes or second homes. The preservation of the environmental features of a region is, however, closely related to the measures needed for disaster prevention. For example, the over-intensive development and filling in of a bay may create the danger of a major flood hazard to the residents situated on low-lying inland areas, as well as polluting the bay, changing its ecological balance, and overtaxing local services.

(iii) Land-use micro-zoning

Micro-zoning is the detailed preparation of land-use maps by public authorities, particularly in urban settlements, fixing specific land-uses for each site (such as residential, educational, commercial, industrial, transport, etc.). Micro-zoning also details the density of land-uses at particular sites. Furthermore, micro-zoning establishes a detailed land-use pattern within the risk micro-zoning framework. From the point of view of disaster prevention, micro-zoning is a basic tool which relates risk assessment to land-use planning.

The experience of cities destroyed by floods, cyclones and earthquakes and volcanic eruptions shows that measures proposed for limiting future disasters include zoning for wide roads, open spaces (especially in high occupancy and residential areas), the location of fire and explosion-prone industries far from areas of human concentration, etc. Indeed, the permanent process of urban renewal and urban extension can be used to plan and zone for new land-uses in order to limit or prevent potential disasters.

Micro-zoning for disaster prevention is based on the preparation of composite maps covering all types of risks as discussed in chapters 2 and 5. For example, seismic micro-zoning is based on a detailed analysis of the likely impact of probable seismic activity upon a given area according to sub-soil conditions and previous seismic events. Seismic shocks of given intensity and origin will have different effects in different locations, according to site characteristics. 6/

Detailed vulnerability analyses for given locations, as discussed in the preceding chapter, assist in determining both land-use and building criteria. It can be said, as a general rule, that whereas risk macro-zoning maps are based on the broad geological configuration of a given region coupled to records of past hazard frequency and magnitude, risk micro-zoning is essentially a detailed study of the probability of natural hazards in a given site as determined principally by the detailed study of sub-soil conditions. Naturally, risk micro-zoning identifies not only probable intensities but also probable return periods or frequency. Micro-risk mapping allows the use planner to employ quantitative as well as qualitative criteria for establishing land-use zoning ordinances. Similarly, it enables the civil engineer to formulate more precisely than would otherwise be possible building codes for public works, housing, industry, education and health facilities and transport networks.

6/ Volume III: Seismological Aspects, Disaster Prevention and Mitigation, Office of the United Nations Disaster Relief Co-ordinator (UNDRO), Geneva, Switzerland, 1977.

(iv) Land-use zoning for disaster prevention and mitigation

All natural hazards can be located in space, and consequently lend themselves to zoning ordinances for land-use control purposes. Flood plain zoning (river and coast), the most common form of land-use zoning for disaster prevention and mitigation, is widely used throughout the world, and is covered in greater detail together with seismic zoning in chapter 5. Seismic zoning (seismic macro-zoning and seismic micro-zoning) has been predominantly oriented toward the establishment of building and other engineering codes. In recent years, however, the United Nations has recommended that seismic zoning also be applied more systematically than in the past (especially in the developing countries) to comprehensive physical planning. 7/ Some United Nations bodies, UNESCO and UNDRO in particular, have been promoting efforts in this direction, as well as several industrialized countries such as the United States of America, Japan and New Zealand, as well as Yugoslavia.

As will be discussed below, seismic risk macro-zoning is useful principally for regional policy-making and planning purposes. Seismic risk micro-zoning is likely to emerge as an important land-use planning tool for local planning and development in areas of high seismic risk. In this connexion, it should be borne in mind that there is a major difference between risk micro-zoning and land-use zoning. The latter regulates the uses of the land on the basis of the risks assessed. Risk macro- and micro-zoning techniques for land-use control purposes are equally applicable to natural hazards other than floods and earthquakes: one may mention landslides, avalanches, land subsidence, tropical cyclones (plotting probable storm tracks in relation to local topography and other natural or man-made features), and volcanic eruptions. Land-use zoning ordinances for disaster prevention may control types of development (residential, open space, commercial, industrial or other), density of development and type of construction (including building codes).

In coastal areas exposed to tropical cyclones (including storm surges) and tsunamis (tidal waves of seismic or volcanic origin) zoning ordinances would regulate minimum building height, type of land-use according to the set back from the shoreline and most vulnerable locations, and of course density occupancy buildings. The percentage of lot occupancy might be regulated so as to place residential development of various types away from the coastline reserving it for other uses not requiring permanent occupancy.

Land-use zoning for disaster prevention in earthquake-prone areas requires the designation of seismic micro-zoning districts. The characteristics of each zone provide the basis for land-use controls, zoning ordinances, building codes, and building or location permits. For example, assume an area is divided into three zones. Zone 1 might be the most hazardous where there is a high probability of

---

7/ Report and Working papers of the Intergovernmental Conference on the Assessment and Mitigation of Earthquake Risk, UNESCO, Paris, February 1976. Report of the Interregional Seminar on Low Cost Construction Resistant to Earthquakes and Hurricanes, Skopje, Yugoslavia; United Nations, New York, November 1971; Low Cost Construction Resistant to Earthquakes and Hurricanes, United Nations, New York, 1975. (Sales No. E.75.IV.7.)

major damage to buildings and structures. This zone, for instance, would encompass the trace of the last known fault or areas covered by loose, unconsolidated soils. Here, new construction would be prohibited and the prescribed use would be for either open space, parks or possibly roadways (without utilities).

Zone 2 would exclude loose ground and embrace the fault zone, but would not cross the traces of the last known rupture. New building construction in zone 2 would be limited to small, one and two storey residential and commercial buildings. The zoning ordinance would specify large lot sizes in order to limit population density as well as provide open space in the immediate vicinity of the fault zone. Zone 3 would lie outside the fault zone. Here, minor damage might be caused and the area may be susceptible to fires and other earthquake-related hazards. In this district residential, industrial and commercial structures could be erected, but subject to strict building codes.

Cluster zoning schemes may be used successfully in earthquake planning. In this case it would be permissible to reduce the minimum size of lots below normal zoning specifications, provided that the land gained is used for open spaces. Thus, the open land found in zones 1 and 2 is balanced by high density residential use located in zone 3 away from the fault zone.

The types of activities envisaged near active volcanoes should be closely regulated, as there are no building materials or engineering devices that can prevent serious damage and destruction in the event of a volcanic eruption. Areas near active volcanoes 8/ should preferably be zoned for open spaces, recreational purposes or for agricultural uses. This would limit human activities and, in the event of a volcanic eruption, facilitate evacuation and minimize loss of life and damage to permanent structures. Land-use regulation in volcanic areas should be based on risk maps established by studies of the volcano's past, present and future probable behaviour.

In the case of forest fires and grass fires, zoning ordinances may help prevent forest fires from extending to human settlements. The creation of open spaces or greenbelts around hazardous fire areas (fire breaks) may help to contain the fire hazard by limiting development and creating a natural barrier to check the spread of fire. The same concept applies for other types of fires in highly populated areas.

Lastly, a word should be said about land-use zoning in agricultural areas, with particular reference to the developing countries. In tropical regions, areas that are attractive agriculturally should benefit from stringent zoning and development controls from the very beginning, for nothing is more costly, not to say impossible, than reconstituting soils ruined by malpractice. All tropical soils are fragile. Systematic over-cultivation to exhaustion, systematic slashing and burning and other practices which were to some extent acceptable when rural populations were small, scattered and contented to exist at subsistence level, wandering from place to place in search of fresh soils, are no longer tolerable in the face of vastly increased populations and the mounting need for food. Once eroded and leached at the base, tropical soils turn to laterite and become barren.

8/ See Disaster Prevention and Mitigation, Vol. I: Volcanological Aspects, UNDRO, Geneva, 1976.

Improved agricultural practices wherever they are exercised should be supported by corresponding land-use controls which prescribe not only zoning but also the rate of development desired. Land-use zoning in agricultural areas has direct environmental consequences. Thus, it is associated with natural disasters through the "downstream" effects of soil erosion and silting, leading to floods and landslides and may even be one of the main causes of the former.

(v) Subdivision regulations

Subdivision regulations, like zoning regulations, provide public control over the development of land. The subdivision regulation is a widely used tool that seeks to insure the proper development of raw land. This is accomplished through public approval of plans where the criteria for approval establish restrictions governing the exact way land is subdivided and the provision of public facilities and infrastructure. The developer is prohibited from commencing development until the public agency approves a map of the proposed design of the subdivision.

Subdivision regulations serve a wide variety of purposes. For example, they are a means of ensuring the provision of a safe and adequate water supply and sewage disposal system in new developments. They may also be used to preserve or leave land undeveloped that is prone to natural disasters.

Subdivision regulations, as a legal control, aid the planner in co-ordinating individual private development with the extension of public utilities and have considerable influence over the location and timing of development. Further, if there is uniform implementation of subdivision regulations and the location of many subdivisions is thus co-ordinated, a major advance will be made toward providing for development in a comprehensive manner. The element of co-ordination made possible by subdivision regulations provides a means for ensuring safe development patterns on hazardous lands. For example, the planner may request that two or three subdivisions be placed in one area, where infrastructures will be extended because the area is less vulnerable to natural disasters. In contrast, subdivision of the area most vulnerable to natural hazards would be prohibited. This decision, however, would be co-ordinated with decisions regarding areas suitable for development so that development needs of the community would be satisfied. Growth based on this type of scheme gradually eliminates piecemeal and spot development which contribute greatly to increasing the vulnerability of human settlements.

One significant criticism of subdivision regulations in many countries is that often they do not guide development appropriately when confronted with unique situations. Generally, subdivision regulations are designed for standard residential development on what may be called common or relatively uncomplicated terrain. Indeed, they are aimed at guiding the development of single family detached units on a 2-10 per cent slope, for instance, and frequently these subdivision regulations are inappropriate or ineffective for other types of land development situations. However, there is no reason why subdivision regulations should not be devised to cover industrial and commercial development. Such refinements and extensions would enable governments to better guide the development and subdivision of hazardous lands.

For example, in the case of hilly terrain, subdivision regulations would prove valuable in setting standards for safe development. The developer should be required to present information on the geological conditions of the area to be

subdivided and the detailed plans for cut and fill operations. This would provide information on soil compaction necessary for determining whether or not the construction of engineering works such as retaining walls and bulkheads should be required. Further, on hilly terrain special attention would be given to drainage systems, in order to avoid underground liquid accumulations which cause slippage or landslide problems.

These illustrations represent ways in which traditional subdivision regulations could be expanded to include areas that are prone to natural hazards. Clearly, subdivision regulations can be an important land-use tool in preventing natural disasters.

(vi) Construction or location permits

Construction and location permits provide planners and public officials with an opportunity to exercise micro-controls over development. A construction permit can be used not only to regulate the type of land-use activity and the structure it occupies but also to enable the authorities to control employment opportunities, thereby influencing patterns of development. When an area is subject to frequent natural disasters, obviously it is imperative that the population density of the site be carefully controlled. Since industrial and commercial development, especially on a large scale, directly influence the size and distribution of the population by providing employment opportunities, such activities should be prohibited from locating in high risk areas. Various tax incentive schemes may be devised so as to encourage industries to locate away from such sites. The careful planning of key employment generators in conjunction with other land-uses can be a powerful tool for guiding development into safe and desired areas. The requirement of obtaining a building permit from public officials and/or various ministries allows planners the opportunity to induce development into less vulnerable areas.

Planners concerned with rural development should not overlook the significance of location permits in the implementation of agricultural policies and their relation to disaster prevention. In many developing countries, agriculture serves as the main source of income for the population. However, much of the agricultural activity that takes place is by and large unregulated, thereby often directly furthering the hazard potential. For example, upstream areas subject to heavy rainfall and run-off contribute to downstream flooding. As noted previously, unregulated agricultural practices, such as slash and burn, allow for extreme run-off thereby further increasing flood potential. In addition to these types of practices, there is an absence of adequate drainage facilities and in some cases the drainage for agricultural lands is left entirely to each individual farmer.

The point here is that land-use controls should not be limited to those areas that experience flooding, but should be expanded to include areas that may in fact contribute to the hazard potential. The requirement of obtaining a location permit provides control over the location of agricultural and other development within a zoned area. Areas that appear to be prime sites for agricultural development may require measures which regulate the types of agriculture to be developed. For example, if farmers are taught and equipped to rotate crops, instead of using devastating slash and burn techniques, this will often eliminate much of the hazard. In addition the use of mulches, manure and lime contribute to increased water

infiltration in the soil, thereby minimizing run-off and erosion. To encourage improved agricultural management, crop rotation and infiltration, the location permit may in fact require compliance with new techniques.

It is highly important to consider various means for regulating agricultural land development. Although it seems unlikely that agricultural uses will be severely limited, land development policies could concentrate on improving agricultural practices by issuing location permits to prospective farmers and including in those permits specific requirements for the reduction of disaster risks.

(vii) Open space controls

Land use policies that regulate the location of agriculture have a direct impact on the provision of open spaces in the total planning area and vice-versa. Agricultural lands, parks and other types of open spaces can play an important role in helping to mitigate the effects of natural disasters. For example, consider the case of flood-prone areas: the development, whether residential, industrial or commercial that occurs in flood-prone areas contributes to the flood hazards. This occurs because when land is not left in its natural state and is built upon, changes are introduced in the soil structure as well as in drainage and run-off patterns. Residential, commercial and industrial areas may have large impermeable surfaces, which obviously contribute to increase in the run-off. Development, in fact, modifies and hampers natural soil infiltration and drainage, thus contributing to flooding in the same way that unregulated agricultural practices often do, that is, through increased run-off.

One way of managing the total run-off is to place open space areas strategically so that they can collect and store water and thereby regulate run-off. In this way, the location of agricultural land, parks, recreational areas and other open spaces may help reduce the potential for natural disasters.

Nor only do open spaces help reduce capital losses, but equally important, they serve to limit the loss of life because of their tendency to generate minimum human activity. For example, efforts are currently made in Tokyo to open up greenbelts in highly populated areas where the risk of fires in the immediate aftermath of an earthquake is particularly high. However, it should be noted that open space does not imply the total non-use of land. Clearly, such areas may be used to satisfy a wide variety of social and economic needs. Thus, open spaces may serve to prevent or mitigate disasters while providing some economic return.

As will be seen below, the acquisition of land through the transfer of full or partial development rights is frequently used as a means by which all levels of government, local, regional or national may preserve open space. Such transfers may be achieved by expropriation, purchase or donation. In the latter case, land is frequently donated by developers in the form of easements (or set-backs) within a total project or planning scheme.

Other techniques include leasebacks and salebacks. In the case of leasebacks a public agency acquires land and then leases it to third parties, on condition that certain open space requirements be respected. The technique of salebacks operates in the same way, except that the land acquired by the government is sold to private developers with restrictions attached to ensure that open space uses

will be maintained. Both leasebacks and salebacks provide a means for public control of land development which can be used to provide open spaces necessary for disaster prevention efforts. Moreover, these techniques permit the productive use of land for agricultural or recreational purposes while simultaneously providing sources of income to the community through taxes, rents and the proceeds of the sales. Other means for creating open spaces include tax exemption on undeveloped land as well as such regulatory tools as zoning and subdivision controls.

(viii) Building codes 9/

Any discussion of disaster prevention and mitigation must consider not only where but how a particular development is built, and this leads to the regulatory instrument of building codes. Building codes in the present context establish minimum standards of design, construction and materials in order to avoid structural collapse under conditions of severe physical stress caused by extreme natural phenomena.

Although building codes are extremely important for mitigating the effects of natural phenomena, they should not be divorced or considered as separate from land-use controls, especially zoning. The co-ordination of land-use controls and building codes is one of the most effective local level devices for disaster prevention and mitigation. For example, the delineation of the three zones in earthquake-prone areas mentioned previously provides only a partial solution to the risk of disaster damage. These controls should be supplemented by careful controls over building design, construction and materials with specific requirements according to the zone considered. Standards for the structural resistance of buildings are directly correlated with the level of risks identified by the risk microzoning maps and associated land-use maps and measures. In this connexion, it should be recognized that in many cases damage risks are composite. For example, earthquakes may provoke secondary effects such as landslides, floods and of course, in built up areas, fires. Thus building codes should incorporate the composite risk factor to minimize the probability of disaster as comprehensively as possible. From this observation, it can be seen how very important the method of vulnerability analysis is to the entire planning and building process.

Since building codes are not retroactive, the use of performance standards for the repair or rehabilitation of older structures could serve as a supplementary means of improving the safety of existing structures. For example, buildings and structures that withstand minor damage would have to be repaired according to prescribed performance standards. Performance codes are easy to keep current and facilitate the introduction of new methods and technology, provided they are cost effective and not beyond the reach of low income groups.

(ix) Public works and engineering

The construction of engineering works should be viewed in concert with both local building codes and land-use ordinances. For example, the installation of retaining walls and bulkheads in probable landslide paths may alter the potential

---

9/ See also Guidelines for Disaster Prevention, Volume II, Building measures for minimizing the impact of disasters, UNDRO, Geneva, 1976.