Guidelines for disaster prevention

Volume 3
Management of settlements
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OFFICE OF THE UNITED NATIONS DISASTER RELIEF CO-ORDINATOR

GUIDELINES FOR DISASTER PREVENTION

Volume III

MANAGEMENT OF SETTLEMENTS

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JAMES LEWIS
APPENDIX

BUILDING CODES

Building Codes have been treated for public administrators separately under each type of disaster. The following are some additional general considerations:

1. Except for very specialized types of construction, complex laws and regulations are not likely to be implemented very effectively.

2. Laws and regulations should be "proportional" to the experience and number of technical and professional persons available.

3. The number of such people will change. The prevention techniques will also change. This may lead to constant changes in codes, which in itself may be confusing. To strike an acceptable rate of change in the codes will be left to the insight of the public administrator.

4. Laws and regulations should be consistent with the dominant administrative practices of a given period. Administrative or cultural change is more easily obtained on its own grounds, but seldom through specialized legal measures. These can only encourage change.

5. Laws and regulations should be instituted along with the necessary fiscal measures and research funds.
Location may be prescribed for disaster prevention, but only in advance of the construction of the settlement. Relocation is rarely practicable but may, however, be a good solution in the aftermath of a disaster.

The administration may prefer to set aside the safer areas for self-built housing, and develop the less safe areas under public land ownership, because in such cases it may be assumed that safe construction measures will be strictly applied.

All locational decisions will have to be taken in terms of proper economic locations and in conjunction with productive investments, in preference to projects aimed solely at housing.

FOREWORD

The Office of the United Nations Disaster Relief Co-ordinator (UNDRO) presents the first three volumes of the series entitled "Guidelines for Disaster Prevention". These volumes set forth the most basic problems in the field of disaster prevention related to physical planning, building and the management of human settlements. They are primarily concerned with the problems of new and rapidly expanding settlements in developing countries.

These publications represent the first steps at the international level to produce a clear statement of general principles and a basic set of guidelines in the field of disaster prevention in developing countries. The guidelines constitute the initial phase of a long-range programme of expansion and improvement. The reader should be aware of the limitations of their scope and terms of reference. They are not final or definitive, nor do they claim to answer the specific needs of individual countries.

The types of disasters considered are those resulting from sudden and violent natural phenomena such as floods, tropical cyclones, tsunamis and earthquakes. "Creeping" disasters, such as drought and epidemics, were excluded. However, certain man-made disasters which may result from natural catastrophes or which call for equivalent preventive measures (such as fires or explosions) were included in the present publication.

It was not within the purview of these guidelines to consider the most destructive of all man-made disasters: war. In this area, UNDRO can justifiably make recommendations and provide guidance under the heading of "post-disaster planning and reconstruction", a subject for the next set of guidelines to be published by UNDRO.
These volumes are addressed to a broad spectrum of potential users, such as policy-makers, administrators, technicians and community leaders in urban and rural areas at the national, regional or local levels. They are especially intended for government officials who have responsibility for initiating or approving development projects in high risk areas and who require an immediate and simple method of determining whether vulnerability factors and criteria and disaster risks in general have been taken into account.

Certain terms of reference were established in order to simplify and facilitate publication of the guidelines at the present stage of development. They are clearly contained within the framework of prevention. The emphasis has been on a pragmatic approach, based on the collective experience in disaster situations of those preparing these publications. Preparedness, relief and post-disaster planning and reconstruction have been intentionally omitted, since these subjects are presently being examined in several complementary studies by UNDRO.

The Office of the United Nations Disaster Relief Co-ordinator invites the users of this publication to provide the United Nations with their comments and suggestions on a continuing basis. The establishment of such a feedback and exchange of information will assist in building a comprehensive and detailed library of guidelines on disaster prevention for national and international use.

The structure of the present volumes has been adapted to the stages in the life of a settlement: the planning stage, the building stage, and the stage during which the settlements are in use, maintained, expanded or renewed. For this reason a certain overlap among the three sets of guidelines has been allowed to it is, however, essential to determine the allowable variation of quality for each material on a legal basis.

11.1.7 The results of research should be translated into building codes. Considering the practical difficulties of building code enforcement, policy-makers should instruct everyone on the great advantages of training builders and of convincing owners of prevention measures.

11.1.8 The above considerations are important for all types of construction, but they assume primary importance when they concern small builders and builder-owners.

11.1.9 In many countries, self-built housing is increasing and now dominates urban politics. This housing is often pushed to more disaster-prone areas, and the construction may not withstand specific stresses.

11.1.10 The introduction of disaster prevention measures should never necessitate expenditure beyond the economic resources of the occupants. When new techniques are introduced into construction practices the new goals should be clearly known by the administration. It is also important to remember that the lifestyle of the community will remain unchanged at least for some time. New construction practices which do not accord with this lifestyle are likely to be improperly utilized or underutilized.

11.1.11 At this point in time the problem of damage resistance in self-built housing remains, but a partial solution may be reached through the choice of location:
11. SELF-BUILT HOUSING

11.1.1 While not ignoring any other measures for disaster prevention, the quality and resistance of buildings is the central issue in most disasters.

11.1.2 It should be made very clear that any attempt in the future to pay attention to the architectural style of buildings is definitely not a measure of disaster prevention. There is a danger that this may be interpreted as such, and that this will divert attention from the essential prevention measures.

11.1.3 If the above misinterpretation is made, it may cause immediate large increases in building costs, and perhaps still not provide the resistance measures proper to a given locality. It may also redistribute the funds for prevention.

11.1.4 Measures which pertain to the quality and treatment of building materials and to principles of resistance are much more to the point.

11.1.5 The quality of building materials does not necessarily change solely from one material to another; it may change more within a single material. In many cases building failure has resulted from poor quality cement or concrete or from poor brick or mortar.

11.1.6 Standardization of building materials becomes one of the most important measures for disaster prevention. This should not be interpreted as the establishment of similarity nor the restriction to a few types only, but remain, since there are indeed areas of common concern among the different phases of planning, building and management. It is hoped that the cross-referencing between volumes will assist the reader. A bibliography has been included for the more specialized reader desiring to examine certain issues in greater detail.

The present three volumes were made possible with the financial support and co-operation of the United Nations Environment Programme (UNEP). They were prepared for UNDRR by Mr. Sergei Rubnov, Secretary-General of the European Committee for Earthquake Engineering; Professor Adolf Ciborowski, Faculty of Architecture, Technical University of Warsaw, in co-operation with Urszula Ciborowski, Architect and Town Planner; and Mr. Aydin Gormen, Professor, Department of City and Regional Planning, Middle East Technical University, Ankara. The volumes were completed in consultation with the League of Red Cross Societies, the United Nations Centre for Housing Building and Planning, the United Nations Environment Programme, the World Meteorological Organization, and the following panel of experts:

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The Office of the United Nations Disaster Relief Co-ordinator wishes to express appreciation to all those who have contributed to these volumes for the protection of human settlements against disasters.
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10.4.5 Building Inspectors:
   - to read design drawings
   - to check the quality of building materials
   - to check particular items at all stages of construction

10.4.6 Architects:
   - to understand the basic principles of damage resistance
   - to concentrate on items to be checked on site during
     construction

10.4.7 Engineers:
   - engineering seismology
   - development of survey methods necessary for disasters

10.4.8 Town planners
- Earthquakes
  - Geotectonics
  - Historical seismicity
  - Instrument measurements
  - Locational probability
  - Strong ground motion studies
  - Study of post-earthquake damage

- Construction measures
  - Research in Performance Criteria (see section 4.2)

10.4 Training and education

The following principles are the main considerations applicable to the education of various groups:

10.4.1 The general public:
  - to convince them that preventive measures are to their advantage, and are not expensive
  - to eradicate superstitions
  - to convince them that disaster warnings are serious

10.4.2 Public administrators

10.4.3 Small builders, construction supervisors and foremen:
  - to train in the important, simple principles of design, materials and techniques

10.4.4 Construction workers:
  - to eliminate poor workmanship

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boring
- soil mechanics investigations
- files on existing buildings

The priorities in a national microzoning programme should be given to settlements as follows:
- in earthquake-active districts
- in areas estimated to be less safe
- in areas which are rapidly expanding
- in areas which are attracting large industrial investment
- study of the sea bottom near the shoreline (for possible tsunami defence measures, and protection against storm surges).

10.3 Scientific research

Scientific research should be conducted in the following areas of interest:
- Cyclones
  - statistical distribution and locational probabilities
  - causes
  - warning systems
- Floods
  - basin hydrology
  - correlation of headwater precipitation with lower basin flood levels
  - soil conditions for each locality and season
statistical studies of the causes and forecasting are best dealt with on an international scale.

At present it is not possible to generalize about specific measures. It is only when countries undertake specific studies on the best combination of preventive measures that they will be able to benefit themselves, provide information for other countries, and by the same token, profit from studies performed in other countries. In other words, an international publication cannot provide integrated disaster prevention goals for each country until the necessary research for each country proceeds. Thus, while check-lists are helpful for directing and supervising prevention efforts, it is essential that strong leadership is exerted in the field of research by public administrators.

10.2 Locational research

Some specific areas may be investigated concerning locational research, including:

- Economic and cultural surveys of localities (with priority to areas of high economic significance, with a low share of the national product/income/consumption, or with high disaster risk)
- Flood probabilities
- Seismic zoning maps (for appraisal of regional planning projects)
- Microzone maps (for consideration of urban expansion, and the appraisal of building projects)

If difficulties arise in the preparation or financing of microzone maps in densely settled areas, data may be used from:

INTRODUCTION

The Office of the United Nations Disaster Relief Co-ordinator (UNDRO) has placed the highest priority on planning and prevention because of the dual phenomena of rapid urbanization and the high rates of population growth, particularly in the developing countries. According to United Nations estimates, more than 50% of the world's population will be living in urban areas by the year 2,000. Between the present time and the end of this century, mankind will probably have to provide as much shelter and related facilities as during the whole of past recorded history. Whereas most countries in the developing world double their national populations every 25 to 30 years, the same countries double their urban populations every 12 to 15 years and, in the case of the urban poor living in slums and squatter settlements, there is often a doubling of population every 7 years or less. The sheer magnitude of the human problem in disaster-prone areas, especially the rapid expansion of these settlements and the concentration of population in them, indicates that relief measures and post-disaster action are by themselves not sufficient.

The essential aim of the guidelines is to assist the international community to take the first co-ordinated steps to prevent or at least to mitigate disasters. During the last two decades, the world public has become increasingly alarmed by disasters, which have tended to become more and more destructive as they affect ever larger concentrations of population. The response of the international community has been focussed primarily on relief actions; however, it is now realised that the actual and potential consequences of disasters are so serious and increasingly global in scale, that much greater emphasis will henceforth have to be given to planning and prevention.

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UNDRRO's objective in the broad field of pre-disaster planning is to promote the prevention, control and prediction of natural disasters. All its activities are based on three findings:
(a) that disasters constitute a major development problem for most disaster-prone countries; (b) that most disasters can be prevented; and (c) that the most basic preventive measures are also the least expensive.

Although detailed statistical data on disaster damage are still very scarce, it is known that the damage caused by disasters greatly exceeds the total amount of assistance - both bilateral and multilateral - which disaster-prone developing countries receive from abroad. In terms of percentage of their gross national product, the losses caused by disasters in many of these countries more than cancel out any real economic growth. To cite one example, the Office of the United Nations Economic Commission for Latin America (ECLA), in Mexico, estimated that in the five countries of the Central American Common Market, disaster damage has averaged 2.3% of the gross domestic product in the fifteen year period 1960-1974. This figure does not take into consideration a number of indirect effects, such as higher incidence of certain diseases, or many small events such as limited floods which, taken on aggregate, may have disastrous effects. Since the countries concerned also have a population growth rate of about 3% a year, to avoid an actual decline in the rate of economic growth or remain at a static level of development, they must achieve an economic growth rate of at least 5.3%. Very few of these countries actually achieve this rate and, partly because of disasters, many are actually losing ground in relative terms. This fact clearly indicates that disasters should be viewed as a problem of economic development and that, as with all such problems, they should be resolved in a systematic manner by concerted action beginning at the level of national planning. It is this simple observation that has prompted UNDRRO to

10. RESEARCH AND EDUCATION

Two important matters should be highlighted, independently from the main sections of the volume, namely, research and education.
- Research, because a disaster prevention programme can only be accomplished by local, regional, national and international research.
- Education is a fundamental means of persuading the public that disaster prevention is essential.

The majority of the population in many countries lives in small buildings, and self-built housing at present dominates the scene in many of the less industrialized countries.

10.1 Research

10.1.1 It may not be possible to apply the principles and techniques concerning areas which are relatively safe against earthquakes from one country to another. There is a need for research on the local level.

10.1.2 Building techniques often have a regional character; hence their adaptability to disaster-resistant measures must be studied (need for research on a regional scale).

10.1.3 Laws, standards, training, education and finance are usually handled at national level. Furthermore, the characteristics of transport or communication systems of a country will affect its disaster prevention programmes to a great extent (need for research on the national level).

10.1.4 The best methods of prevention, regional differences in the types of disaster, physical characteristics of phenomena,
This type of very general principle may be modified from one region or locality to another, depending on the local balance of taxes. For example, if real estate taxes approach the limits bearable by the local economy, the above principle may be applied with necessary change in emphasis, perhaps resulting in a smaller increase in such taxes.

9.1.10 In urbanized areas the lack of compatibility between the limits of the settlement and the administrative boundaries is increasing in all countries. This often results in an imbalance of taxation with respect to the sharing of community expenditures. In some of the richer countries, the suburban areas contribute less than their share.

If in the less industrial countries it is the central cities or urbanized areas in general which are the beneficiaries of economic development, proportionately higher taxes levied upon these areas may help to redress the balance. The bases and effects of such a policy will have to be studied in detail.

9.1.11 Emergency funds for post-disaster purposes are increasingly coming into use. In the post-disaster period there will be delays in finding these funds, and the national budgetary balance may be upset. In terms of public psychology and for purposes of tax collection, these funds should preferably be included in the general budget and should be set aside in advance of disasters. The proportion of these funds in the national budget may depend on the frequency of disasters; portions of the funds should be increasingly diverted to the prevention programmes.

Many disasters – considered as distinct from the natural phenomena which cause them – can be avoided. Virtually all natural phenomena liable to cause disasters share one common feature: although it may not be possible at the present stage of scientific knowledge to forecast when they are going to happen, (except for a few hours beforehand in some cases), it is often possible to predict with a reasonably high degree of accuracy where they are most likely to occur, for example, in flood plains, seismic areas or avalanche corridors. Even in the case of such ‘erratic’ phenomena as tropical storms (hurricanes, cyclones and typhoons), it is known that some 90% of the human losses and damage are attributable to the action of water and not to the effects of wind.

This conclusion has obvious implications for the location of human activities of any kind. There is nearly always a choice that can be made between a dangerous site and a less dangerous one. Such a choice can be encouraged or even imposed by measures whose cost is negligible if taken in time. Examples would be the adoption and application of town and country planning laws and zoning regulations based on vulnerability studies. The key to ensuring that the best choice is made is to include in the appropriate development projects a vulnerability analysis of the region affected. Whereas expenditure on such a study is negligible in comparison with the total cost of a major development project, the ‘multiplier effect’ of such a preventive measure is enormous, both in terms of human lives saved and damage avoided, and from the point of view of the savings in aid which might otherwise have gone into relief and reconstruction. This is a particularly justifiable strategy at a time when the most disaster-prone developing countries are undergoing rapid demographic expansion and urbanization. Errors committed now will be all the more costly to
correct later. The massive investments needed to develop the infrastructure of human settlements can be safeguarded by planning and prevention based on vulnerability analyses.

Although it has been demonstrated that much can and should be done in disaster prevention, some countries are afflicted with a sense of fatalism about natural disasters, which acts as a brake to development as a whole. Such a sense of fatalism has often arisen because of the enormity of the problem and the accumulated burden of successive disasters, compounded by the lack of resources to plan for timely assistance in emergency situations. Nevertheless, Governments bear the basic responsibility for action with respect to disasters, not only in post-disaster situations but also at pre-disaster stages. They should initiate appropriate measures and promote a national consciousness of and active interest in disaster prevention. Governments in many countries should also adopt measures designed to improve the disaster relief machinery.

Mention should also be made of the role of dissemination of information, training, warning for disaster prevention, and community preparedness. The education of the public can begin at the primary school level and should be extended to many skilled and unskilled professional categories, including construction workers and others. The application of preventive policies, plans and measures could be considerably facilitated through legislation. Governments should assume greater initiative in such legislation in the field of prevention, particularly regarding land use and other locational aspects of physical planning and building.

UNDO is currently undertaking a comprehensive study on the state of existing knowledge in disaster prevention and mitigation, which will identify firstly, the existing expertise which may be applied directly in developing countries and, secondly, the gaps in expertise which need to be filled. The availability of insurance may also promote a localization of investment which unduly favours high disaster-risk regions.

9.1.5 However, if experience shows that some of the preventive measures become a burden for local governments or individuals, the central government may prefer to provide new institutions through which prevention investments could be conveyed.

9.1.6 If certain regions are comparatively poor or constantly ruined by disasters, the central government may prefer to provide all the required funds. In other cases, however, it may not be desirable for national funds to be diverted to a few regions.

9.1.7 Depending on national or local conditions, certain taxes may be increased for the purpose of disaster prevention programmes. In such cases it may be assumed that this increase in taxation will lead in time to reducing the losses normally suffered from disasters, up to an amount at least equal to the increase in taxes.

9.1.8 It is understandable that areas and individuals benefiting from disaster prevention should contribute to its finance. On the other hand, those regions under constant threat may be assisted from national funds, particularly in order to break any vicious circle.

9.1.9 If it is income or production which is being protected from disasters, slight increases in income or corporation taxes may be appropriate. If it is property which is protected, then real estate taxes may be increased.
9. FINANCE AND TAXATION

9.1 General

9.1.1 Depending on the measure and local conditions, disaster prevention should either be financed by local or national government, or as a regional scheme.

9.1.2 The levels of government which initiate, plan or supervise the prevention programmes do not have to be the levels which provide the financing. In spite of the administrative advantages of unifying implementation and financing by one body, the financing of preventive measures can only be carried out at various levels including individuals and private or semi-public organizations.

9.1.3 Building codes, which are an essential part of the measures against almost all disasters, will naturally require financing by individuals and private organizations, if they involve any additional costs at all.

9.1.4 Insurance is the method of alleviating the financial burden on individuals. However, insurance for disasters is not widely institutionalized and, furthermore, is not a true preventive measure. The essential financial consideration particularly in less industrialized countries, is to prevent physical losses to the economy. Although such losses may be compensated through insurance in the aftermath of a disaster, much of the economic resources will already have been lost; therefore, the best alternative to insurance is a stricter enforcement of preventive principles.

which require concerted action by the international community. This study, which includes varied subjects such as seismology, vulcanology, meteorology, hydrology, land use, building and civil engineering, health, public information, and the economic sociological and legal aspects of disasters, will provide the qualitative data necessary for the formulation of the international disaster prevention strategy mentioned above. Another study now in progress is a world-wide survey of the damage, both direct and indirect, caused by disasters. The objectives are to provide the quantitative data necessary for the formulation of the strategy and to enable disaster-prone developing countries to formulate their own long-term prevention policies and to carry out cost-benefit analyses of various alternative preventive measures.

There are many additional areas where planning, prevention and preparedness measures can be taken. A particularly important area is the field of education in disaster preparedness and prevention and the establishment of prediction and warning systems. However, the first and most basic problems in the field of disaster prevention are those related to planning, construction and the management of human settlements.
1. TYPES OF MAJOR DISASTERS

Major disasters are the results of the following natural phenomena:

- Earthquakes
- Floods (river floods and storm surges)
- High winds (Tropical Cyclones, Typhoons, Hurricanes, Tornadoes)

These disasters cause more loss of life and disrupt economic activities more than any other types. They affect whole regions, usually in a short period. An essential fact about them is that very little can be done at present to interfere with the phenomena themselves, although their effects can be prevented or minimized.

Some disasters included with the first group have more limited effects, namely:

- Landslides
- Avalanches
- Volcanic Eruptions
- Tsunamis

Disasters may not only result from natural phenomena, but also from human activities or errors. Among these are:

- Fires
- Explosions
- Dam Failure

There are many other disaster phenomena with different

land may be cheaper and potential users may be attracted by the lower value.

In such cases the official land-use plan may be less effective than expected or desired.

8.7.3 It is most important to know the above tendencies for each locality. This information may help to determine where to emphasize land-use plans and where to undertake public land acquisition.
8.7 Controlled settlement expansion

8.7.1 In 8.6.2, attention was drawn to the advantages of public land acquisition in advance of immediate requirements. It is worth repeating that this would not only benefit disaster relocation programmes, but would also assist the control of the settlement's expansion. This control may be exercised for other purposes relating to the welfare of the community, but it is particularly important in the prevention of disasters resulting from floods, earthquakes and other phenomena.

Such a control may well be supported by the public function of the design of transport networks, since the location of transport routes is extremely effective in determining the direction of expansion.

Control may also be attempted without expropriation, but through town master plans, land-use plans, building codes, and subdivision regulations.

8.7.2 It would be a considerable economic advantage to national disaster prevention programmes if the expansion and extension of settlements could be effectively controlled by planning and legal measures. However, there may be the difficulties listed below:

- The location requirements of disaster prevention measures may not coincide with the locational tendencies of the economic activities of the settlement and of the real estate market.
- If disaster risks for particular areas are known such

characteristics, but these are outside the scope of this manual.

1.1 Disasters and prevention

1.1.1 The majority of the most destructive disasters are caused by natural forces, although it is not the forces themselves which are disasters but the effects they have on human settlements. Whether any natural event reaches disaster proportions does not solely depend on the magnitude or violence of the natural force. Other factors are involved and it is the degree of control we may exert on these other factors which provides an opportunity to prevent the disasters.

1.1.2 As emphasized throughout this volume, disasters may reinforce or cause each other.

1.1.3 It is in the fields of construction and physical planning that many of the preventive measures should be taken. Poor construction, neglect, ignorance and bad siting may be eliminated. Protection may be obtained through engineering measures and special design methods which are being developed.

1.1.4 In order to reinforce the above measures, the following should be considered:

- The public should be educated on disasters.
- Various professions should be trained in prevention techniques.

(See Volume 1 'Pre-disaster Physical Planning of Human Settlements' and Volume 2, 'Building Measures for
Minimizing the Impact of Disasters"

- The public should be informed about all the precautions taken and the results of research.

1.1.5 These informative measures not only reinforce the others but are preventative principles in their own right.

1.1.6 Warnings of impending or approaching natural phenomena likely to cause disasters play a major part in some types of event (cyclones, tsunamis, floods, etc.). In the case of cyclones and floods the precautions to be taken at warning time are intimately linked with the previous application of proper construction techniques, implementation of building codes and training of the public.

1.1.7 The same may be said for fires. In fire warning, people should actually know the precise steps and precautions they need to take. After earthquakes, immediate attention should be given to the prevention of the next possible disaster which is fire. Fire damage can easily and often does surpass the damage of the earthquake, mainly because people are often too shocked to pay attention to fire hazards.

1.2 The framework of the management manual

The management manual for disaster prevention is intended for use by public administrators in their capacity as policy makers. In such a capacity they will make the choice between alternatives, allocate resources and supervise the implementation of their decisions. They will also act in an over-all administrative capacity.

8.6.4 In case land is privately owned and has a high market value at the same time, the owners will try to use it for high density construction. This often results in congestion, but sometimes the pressure of high land value results in a more careful consideration of the best way for its use.

Public ownership of land may remove this pressure from the planners and designers. Consequently, it may become the responsibility of management to ensure that land is carefully used, that vast unused spaces are avoided and, conversely, that such an approach will not necessarily imply congestion or high density.

8.6.5 It is of the utmost importance that the expropriation system be geared to the exact values assigned to real estate by the open market, as long as such a market is in full operation.

Reference has been made to practices by which land prices may be pushed up artificially. In such cases it is probable that a few individuals would stand to gain very much at the expense of the public treasury.

Conversely, and especially in the case of public projects which would otherwise be very costly, pressure is on public management to acquire land as cheaply as possible. If, in such cases, compensation for expropriation is below the market price, then small groups or levels of the community would be carrying the financial burden of the whole community.
Furthermore, the principle that the increase in the value of real estate should preferably accrue to the public is accepted in many countries of different degrees of industrialization or with various political systems.

8.6.2 Land acquisition should be programmed according to long-range town and regional plans, and the expansion and extension of the settlement should be guided according to very clear goals and criteria. These goals and criteria may be clear in the case of many of the disaster types, i.e. floods, earthquakes, sea surges, etc.

The above principles are equally applicable to relocation projects or site selection.

Long-range programmes will make it possible to acquire the necessary land while its commercial value is low.

If attention is not paid to this timing, public land acquisition programmes are not likely to be effective at all.

8.6.3 Urban land-use plans should not restrict the areas of land to be made available for various usages precisely to that amount determined by the projections. Such restrictions would create monopoly values for most land uses, and in this way it would not only be more difficult for individuals to buy land, but public land acquisition programmes would also cost more. It is therefore advisable that urban land-use plans allow more space and choice for each type of use than is deemed necessary.

This manual stresses disaster prevention in preference to post-disaster measures and adheres to a checklist form.

There are limits to generalizations which may be applied to all less industrialized countries; therefore, specific suggestions on legal or administrative mechanisms have been avoided. However, administrative goals and criteria have been suggested in the appropriate sections which should be expanded in the context of any given country.

The central part of this volume is organized in terms of individual types of disasters, and the differences in the major measures have been emphasized.

To some extent, certain subjects could be considered common to all disasters. Thus relocation, public land acquisition and disaster phases (other than prevention) have been treated separately. These are public functions which have a framework wider than disaster prevention; hence these sections do not deal comprehensively with the principles of these areas, but only list the main points requiring attention in disaster prevention.
2. THE ADMINISTRATION OF DISASTER PREVENTION

2.1 Administrative principles

2.1.1 Preventive measures should be concentrated in areas where risk is greatest. If the systematic collection of information relating to the distribution of disaster risk is not obtained quickly enough through the normal operation of public management, a group of specialists may be appointed to collect this necessary information.

Costlier measures of prevention should be distributed within disaster-prone regions in accordance with the degree of risk, density of population, and the amount and concentration of investment. Otherwise, a costly nation-wide programme might interfere with other goals in the development plan. This may also misallocate the resources of the prevention programme. A vulnerability analysis of the given site and, subsequently, a cost/benefit analysis of prevention measures are basic methods to be used. Social and psychological factors also must be considered in such decision making processes.

In the vertical division of management, it is preferable that there be a single authority, either national or regional, which has been given jurisdiction over all preventive measures, even when separate items will be controlled or enforced by several agencies.

Experience suggests that only comprehensive measures will be effective. However, this should never become an obstacle to action. Disaster prevention planning is to be addressed

8.6 Public land acquisition by compulsory purchase

8.6.1 As far as disaster prevention programmes are concerned, the public purchase of land on the open market may progress too slowly. Furthermore, it may not be possible to acquire all the needed land through this method. It may therefore be necessary to acquire land through existing expropriation legislation, or to develop new legal systems for compulsory purchase.

Expropriation projects require extreme care. It is likely that in any country, private individuals will have occasion to seek redress in the courts against the valuation made on their property by government assessors. Courts will then seek exemplary or comparable cases of sales on the open market. If expropriation is known widely and in advance, inequitable sales may take place. It is therefore necessary that expropriation projects be handled with discretion and good timing.

There are a variety of legal bases according to which public management may acquire land compulsorily. It is essential that expropriated land be used for those purposes listed in the original legal document.

It is also probable that the national legal structure will specify that expropriated land should not be given over to profit-making uses. This should be generally the case for private persons or organizations, but the principle may sometimes include public or semi-public agencies. This principle, however, may be waived in the case of public housing programmes, whatever the financial returns of these programmes, or in the case of urgent disaster relocation projects.
greater size, thus making the provision of some social services economically feasible.
- The need to come closer to an existing or planned transport route.

8.5 General

8.5.1 In all scales of relocation, there may be better and less costly measures of disaster prevention, depending on individual situations. This applies to almost all types of disasters.

The leading exceptions are villages subject either to certain types of landslide or located on top of a potential earthquake fault, in which cases relocation may be the best possible measure.

8.5.2 For all types of disaster and on any scale, the greatest risk is that relocation may cause temporary setbacks in productivity. Sometimes the setback may be more permanent; consequently, new residential settlements may not be occupied or may be abandoned, because of their improper location with respect to resources and productivity.

New residential settlements may be useless or abandoned also when they have assumed an immediate change in the social habits associated with such dwellings or, similarly, when they have been designed by urban people for rural people. These and other social aspects must be studied in depth.

to the most pressing problems and to the establishment of priorities. In many cases a correct diagnosis of the main needs or difficulties in a region, or with respect to one type of disaster, even when the analysis is only partial, will be more fruitful in disaster prevention than a formal administrative attempt at comprehensive measures, which will often require more time and extensive experience.

2.1.2 The national programmes for prevention should clearly assign responsibility to either national, regional or local management. It may be more effective to establish these preferences not according to formal lines, but according to examples of effective and non-effective agencies from previous experience.

2.1.3 It is more convenient to have one general set of building and planning legislation applicable to the whole country, and a supplementary disaster set applying only to the appropriate disaster regions.

This legislation should be unambiguous, easy to understand, and no more than is necessary for each case; otherwise, straightforward, simple principles may become harmful in their general application.

Financial mechanisms, on the one hand, and building control, number of available trained individuals, volume of work to be performed, extent of engineering measures and land acquisition programmes, should be parallel and proportional to each other. There should be no legislation adopted which cannot be enforced.

2.1.4 A substantial portion of disaster prevention measures
concerns damage resistance in buildings. Under certain conditions, building techniques may be preferred which will react to natural forces in such a way as to reduce loss of life only, and not emphasize the resistance to collapse of the building itself. (See 'Building Measures for Minimizing Impact of Disasters')

Since resistance in buildings is of such great importance, the design of buildings becomes a major subject in disaster prevention. It is extremely important that preventive measures should not be concerned as much with the architectural style of buildings, as with their resistance to damage and their capacity to protect human life.

Building designs adopted in one country as a result of their advantages in resistance to damage may well be inappropriate or inadequate in another country, not only with respect to local building traditions, climate, etc, but even technically. In judging the desirability of particular designs for buildings not only should their resistance be considered, but cultural traditions, sources and amount of income and the climate should be borne in mind. It will not always be necessary to resort to more expensive building materials in order to secure resistance against various types of potential disasters, nor will it always be necessary to resort to the building practices of industrialized countries.

At present, many techniques of disaster prevention have been studied for industrialized countries, in particular, but their applicability to all countries has not yet been ascertained. It is essential, therefore, that local research into prevention techniques should be given.

expansion is even more important and less costly than relocation of existing districts.

Either type of relocation should be attempted only when the diversified risks associated with earthquakes, floods and other disasters are clearly less in the new location, or when these considerations combine satisfactorily with the economic advantages of the new location.

8.4 Village relocation

8.4.1 Whole villages may be relocated as a preventive measure against some types of disasters.

8.4.2 It is obvious that relocation on this scale is a less formidable proposition than on other scales.

8.4.3 A national programme and a legal system for the relocation of villages may be instituted for the purpose of disaster prevention.

8.4.4 On this scale, opportunities for relocation may give rise to a demand for relocation with purposes other than disaster prevention, including:

- Land or resource litigation with neighbouring villages.
- The limit reached in land resources compared to population density.
- The limit reached in water and other resources.
- The need to switch from one economic activity to a more productive kind.
- An amalgamation with other villages in order to reach
If disasters hit particular regions regularly and prevention seems to be costly or very difficult to supervise a redistribution of the population within the country may appear to be the best solution for purposes of disaster mitigation alone. Even under these circumstances, perhaps the most that can be accomplished is only to direct elsewhere the population increase likely to take place within the affected regions, while the density already existing may only be decreased to a limited extent.

8.2.2 Such a programme would require an intimate knowledge of the economic activities in the disaster-prone region. The country should also be zoned into belts or areas according to the varying degrees of disaster-risk for each type of disaster, and the size of the population involved should be accurately known.

8.2.3 If regional relocation is decided upon after a disaster, many relocation decisions may have to be made quickly, and consequently all the necessary information should exist in advance of the disaster.

In post-disaster situations, a further complication is that emigration or immigration decisions may be taken by a number of individuals.

8.3 Urban scale relocation

8.3.1 On an urban scale, often partial rather than total relocation may be the matter to be decided upon.

In practice, and conforming to the spirit of preventive measures, a control of the geographic direction of urban

priority consideration in the programme.

2.1.5 The enforcement of building codes is so complicated and difficult a process in many countries that a national construction inspection service has sometimes been proposed. Since enforcement of disaster prevention legislation is a more serious matter than that of normal building codes, such a national or regional inspection service may be recommended.

The institution of such an inspection service in the field of construction should operate under the framework of legislation concerning labour or work safety and should include inspection of working conditions on construction sites.

The more serious offences should be judged by courts of law, and the administration of justice should be speedy; otherwise, the rate of construction may decrease and, in turn, cause psychological resistance to the disaster prevention programme.

This inspection agency could operate by a system of multiple site visits and multiple checks, and the personnel may be rotated. These measures may help to secure strict implementation.

2.1.6 The nature and timing of prevention measures will be different from one disaster to another. Although this point is important, it should not be taken to mean that these measures are finalized and exclusive for each disaster. The techniques will change in time and according to country and region. The suggestions in this manual call
attention to the main measures and to the necessity of developing local measures on a continuous basis. They also try to emphasize the advantages of acting differently according to each disaster and according to the circumstances. Mutual reinforcement among the measures for different disasters is possible and is also treated.

The specific recommendations made for various disasters should be considered in terms of "selective concentration of preventive measures"; however, many of them are applicable to several disasters.

- Cash compensations may be made for the real estate in the old settlement, and new property provided to settlers in the relocation area against cash or instalment payments. The difficulties of this approach are similar to those of the previous method, especially in post-disaster situations.

In the pre-disaster case, however, particularly when some settlers wish to leave the community entirely, this method may appear practical. This approach is likely to demand from the government financial measures much beyond its capacity, because both the costs of compensation and the costs of building the new settlement will have to be borne during the same period.

There may also be insuperable difficulties in collecting the instalment payments regularly. This may first lead to great inequalities among individuals and then lead to a write-off on the part of government in an outright grant or compensation. This would keep national disaster funds and resources in the relief-rescue-compensation phase, and thereby diminish the resources available for prevention.

8.1.6 Relocation will be practicable only under a few circumstances and may be attempted on national, regional, and urban or rural scales.

8.2 Population distribution policies, national or regional

8.2.1 It is an extremely drastic and costly step to change the existing pattern of population density within a country or a region, and thereby virtually impossible.
financial and other resources, and the severity of disasters in the areas concerned:

- Property values in the abandoned disaster-prone section may be written off, and compensating properties given to title-holders or residents of the old settlement in the new location.

Such an approach may be preferred for practical reasons in regions where disaster damage is severe and disaster prevention most urgent. However, since the implementation of such programmes is likely to be rigid, this method may cause as many or more injustices towards individuals than other methods.

In this type of scheme, real estate values in the new settlement can only be estimated outside the operation of a market system, since at the time of assignment of new titles or deeds there will be no market in operation.

- Market values in the old settlement may be determined and compensated by assumed market values in the new settlement. However, in pre-disaster situations it may be difficult to carry out a full-scale market survey without upsetting the actual bid values.

In post-disaster situations, it may be impossible to determine pre-disaster values, or to try artificially to set them after the disaster, because the disaster itself will have resulted in entirely different values. The market values to be assumed for the new settlement, on the other hand, may be computed in terms of the locations and amenities provided to the settlers.

2.2 Levels of administration

2.2.1 Introduction

Prevention programmes will be handled by all levels of government. Different aspects of disaster prevention may be more effectively administered or better coordinated at one particular level than others. The most effective level will differ from one country to another and there can be no general preferences for any of the levels. Some general remarks may be made:

- In a few industrialised countries the traditions of local administration are rather strong, which may be equally true for some of the less industrialized countries. It is clear, on the other hand, that there are many countries of both types who prefer centralized administration.

- There are many advantages to local administration; for example, the central government will not be overloaded and local needs may be more clearly expressed. However, in disaster prevention there is a need for clear lines of responsibility and jurisdiction between various levels of administration, and the initiation of a prevention programme may necessitate strong direction from a single source. These considerations normally accord priority to national and regional levels.

- It may be stated that in disaster prevention the importance of regional administration and its relationship to the national level are dictated by the fact that most disasters are regional.
Regional management will have had occasion to concentrate on particular aspects of the region, whereas national government would have centralized most of the expertise, communications, administration of funds, establishment of comparative standards, and the programme of research.

2.2.2 National Level

- A permanent emergency organization should be instituted. This organization needs to be at a high level and may be one of the major functions of a particular Ministry. However, as functions associated with disaster emergency or prevention cut across the classical vertical divisions of government, the jurisdiction of one specific ministry over all matters concerning disasters should be made very clear. If this arrangement does not provide sufficient authority for the disaster organization, an office may be created attached to the Prime Ministry to secure interest and authority at that level.

- Legislation must be produced concerning disasters, building, or planning, in accordance with the needs of various regions.

- Post-disaster damage surveys (especially important in earthquakes, cyclones, etc) will be helpful in discovering past mistakes in construction, management and preventive measures. Only a national team may be able to accumulate and extend the experience necessary for this task.

probable that the total area of land needed will not be available for sale.

8.1.3 In those cases where land is already subdivided into small plots or partially built-up, property lines may need to be cancelled, land consolidated and new subdivisions created subsequently.

This process will require detailed information concerning real estate values and the complications of ownership may be difficult to sort out. In post-disaster cases this process may need cadastral (public register) surveys which may take a considerable time.

8.1.4 As the population is relocated, the area left behind may be dealt with in a number of ways:

- abandoned, without formal value, to lower density uses.
- indemnity or other compensations paid to the owners, to the extent of the value of the economic activity abandoned.
- rights to property in the old settlement, compensated by property in the new settlement.
- expropriated.

Expropriation of the old site may be unnecessary; it may be necessary however, to limit indemnities to losses suffered in productive activities.

8.1.5 Some relationships between real estate values in the old settlement and those in the new may be evaluated in the following ways, depending upon the legal systems,
8. RELOCATION OF EXISTING SETTLEMENTS AND PUBLIC LAND ACQUISITION

8.1 Introduction

Relocation, partial or total, must be considered among the alternative measures of disaster prevention. In those cases where almost total reconstruction is going to be undertaken, or when new regions are to be opened up, new towns built, or entirely new geographic directions given to the growth of a city, relocation of existing settlements is a measure which could work satisfactorily along with disaster prevention goals.

Relocation for disaster prevention purposes is an expensive solution to a (potential) problem and in many cases may not be correctly planned. In order to assist with this planning, the following general principles should be observed.

8.1.1 Relocation should never be attempted, either before or after disasters, without due consideration to the existing economic activities of a community and where possible should not interfere with these activities.

Disaster prevention measures or relocation should not deter ongoing economic activities in any way before the alternative activities have begun to function.

8.1.2 Planned relocation of any kind is likely to necessitate public expropriation of land. In some cases development land may also be bought on the open market but it is

- A national team for the evaluation of damage and for the purposes of reconstruction is most likely to have sufficient experience, sufficient numbers of people, and the advantage of being outsiders to the region in which the disaster occurred.

It is necessary to keep a national register of people who are experienced in various phases of disasters. The national register should be prepared for the purpose of identifying the types of experience needed in emergencies and in long-range planning. Even though disasters occur repeatedly, they are treated as discontinuous events. Therefore, due consideration is not often given to continuity in administration, resulting in the appointment of inexperienced individuals to new posts in the emergency phases of disasters; at the same time, experienced people may have moved to jobs outside the field. This process becomes an obstacle to the accumulation of experience.

- The rapid post-disaster social survey is most likely to be organized on a regional scale; however, experience necessary for the method of the survey and its interpretation may not be available in the regions. It may be more fruitful to accumulate experience at national level.

- The training of laboratory technicians for regional building material testing laboratories and research centres in general requires the establishment of a national building materials quality testing laboratory.

- Inclusion of disaster prevention techniques is needed in the education of engineers, architects and in other professions, such as town and country planning.
- Short courses should be organized on prevention techniques for construction supervisors, foremen, small-scale building entrepreneurs and construction workers.

- Constant education of the public on disaster hazards, disaster warning and disaster prevention is essential.

- A study of the degree of effectiveness of the town plans will show how effective they can be in disaster prevention and ways in which they can be made more effective.

2.2.3 Regional Level

The following tasks may best be carried out at a regional level:

- The administration and coordination of regional disaster prevention schemes.

- Supervision of local administration in those cases where local level implementation is preferred.

- The integration of preparedness measures in different localities, to the extent to which these would affect the prevention programme.

- The maintenance of regional engineering and soil, geological and construction records.

- Rapid social surveys after disasters.

disaster prevention will also be more equitably distributed, this distribution taking place before disasters rather than after.

7.3.22 It is possible to harmonize reconstruction investment with a wider programme concerning the total needs of a whole region. Timing and priorities may be arranged to give precedence to investment in productive fields of activity; such an approach will necessarily divert funds from reconstruction measures as such, therefore slowing down these measures. On the other hand, the priorities for productive investments will create a stronger economic base for the future of the disaster preventive programme.

7.3.23 The creation of new employment is likely to be more important than the creation of new buildings.

7.3.24 It may be that striking a balance between productive investment, on the one hand, and reconstruction as such, on the other, may become critical, especially in the post-disaster phase. In contrast, management has better opportunities and more alternatives to achieve this balance in the prevention programmes prepared in the pre-disaster phases. During such phases it will also be easier to integrate the measures with regional schemes.
is, the less pressure there will be to keep it. The more easily transportable it is, there will be less danger of it remaining in one area to become a shanty-town. This is, however, a problem which cannot be dealt with in a more generalized manner for all circumstances, climates and building materials.

7.3.19 There may be emigration from a settlement after a disaster. In addition, in larger settlements much of the population may have to be evacuated to other areas for long periods, thus changing the social and economic structure of the settlement.

7.3.20 Regional disaster prevention programmes need to take such changes into consideration, as well as the situation in which there may be an influx of outsiders to the settlement. This results from the manpower required or jobs created during the rebuilding phase, or even during the emergency period.

This is one reason why response to disaster should be thought of as a matter of economic and social structuring, as well as prevention, and not simply as a problem of post-disaster relief or compensation.

7.3.21 In the sense that local resources should also be used to the greatest extent possible, national resources should not be diverted disproportionately to a region or town unless it happens to be in great need. The region's own resources should be the main basis of reconstruction and it is therefore essential that more attention be paid to strengthening the region's economic basis than to reconstruction alone. In this way, national funds for

2.2.4 Local Level

- In various parts of this volume it is assumed that the local level may be able to contribute substantially to prevention measures, depending upon the type of disaster and the type of measure. (See volumes on Pre-disaster Physical Planning and Building Measures for Minimizing the Impact of Disasters)

2.2.5 International Level

At the international level more experience is available on the variations which manifest themselves in each type of disaster. Research on prevention and the consequent exchange of information is also likely to bring results which cannot be obtained on a national or local level.

Aspects of disasters which are best dealt with at the international level include:

- Individuals with international experience could or should take part in the continuous study of the occurrence of disasters, their effects and their prevention.

- Many countries take part in the international warning systems for tsunamis, cyclones and floods.

- Experts from other countries may be called in for consultations concerning the design of specialized or important buildings and structures. This may be particularly important for measures affecting resistance to earthquakes.
Foreign experts are likely to be extremely useful in the determination of past mistakes during the damage evaluation survey.

International expertise may be utilized for consultation on disaster and prevention legislation. In this instance, it is more important for outside experts and advisers to learn about particular local aspects of disasters and about the country itself, than for them to make proposals based solely on their past experience.

7.3.14 The location of temporary shelter after a disaster is likely to greatly influence programmes of planning and disaster prevention, as well as those of reconstruction and rehabilitation.

7.3.15 It is frequently advised that they should be totally eliminated. This however may not always be possible or necessary.

7.3.16 In practice, the nature and standard of temporary shelter will vary considerably. First, there is shelter which is supplied immediately after the disaster. Then, depending on local circumstances, there is temporary housing which may in fact serve for a number of years.

7.3.17 There have been cases where permanent housing rather than temporary has been attempted. This has been started within two or three months after a disaster and completed shortly afterwards, thus by-passing many complicated phases. Such an approach is to be recommended.

However, unless very detailed town plans, social and economic studies and construction norms and designs have existed prior to the disaster, this approach is neither likely to provide permanent housing of acceptable quality nor be suitable for the continuous functioning of the local economy and to social habits and needs.

Under these circumstances this approach may have negative effects on long-run disaster prevention programmes.

7.3.18 The location and future use of temporary shelter will depend on its cost, and transportability. The cheaper it
3. FLOODS

Floods are the most disastrous natural phenomena. Floods may be caused by sea surges, tsunamis, dam failures and by atmospheric processes in general. They may occur in connection with other disasters, such as earthquakes, either at the same time or in close sequence, and they may cause landslides, dam failures, and the destruction of bridges and roads.

Floods are most destructive in flood plains and other areas of low-lying land, and require the most extensive prevention systems of all disasters. Measures of prevention are local as far as zoning and building codes are concerned, but engineering works require planning over entire river basins. Zoning and building codes also have to be coordinated over the whole basin.

3.1 General

3.1.1 Flood damage may be prevented or reduced in a number of ways including river basin management, afforestation and the introduction of other plant cover. The two most important methods of prevention are engineering measures and land use regulations. (See manual on "Pre-Disaster Physical Planning" and "Building Measures for Minimizing the Impact of Disasters").

3.1.2 Engineering measures will usually involve expenditure of large sums of public money. Furthermore, it is often not possible to design strictly local measures of protection. Since the flow of water is reduced or increased as a result of these measures, and due to other possible complications, the risk of flood may be passed on to upstream or downstream localities.

7.3.9 In the case of planning, it is important to consider the future functions and layout of the settlement, hence decisions that are urgently needed during the emergency period should not, where possible, be harmful to this planning.

7.3.10 Since in the aftermath of a disaster it is most important that economic functions continue, that possibly new economic functions be created, that the settlement be rebuilt, and that preventive measures be taken against future disasters, compensation should not take precedence over these goals.

In most disasters, experience has shown that compensation has not been used in the way intended by government during the emergency period.

7.3.11 The extent of damage and its geographical distribution within a settlement raises not only the question of compensation but also that of land expropriation. While compensation is oriented toward replacement through money distribution, expropriation emphasises physical replacement.

7.3.12 A combination of both measures may be used depending on the district or locality but this may cause serious problems in administration, law, finance and politics.

7.3.13 In case it is the only alternative, land expropriation will considerably aid the effectiveness of town planning, and other measures of disaster prevention. (See Pre-Disaster Physical Planning of Human Settlements, Volume I).
3.1.3 Land use regulations, through zoning maps and laws, will involve much less expenditure of public money. In this approach, the main goal of management is to control undesirable trends in the location of community activities. There may be economic or psychological reasons for some settlements to be located in flood-risk areas; however, especially in areas where floods are of regular occurrence, public opinion will readily support reasonable zoning controls.

3.1.4 It is preferable to prevent as much flood damage as possible through zoning measures. However, these should be considered together with engineering measures or other possible alternatives.

3.1.5 Land use regulations and the planning of engineering works are both part of larger schemes of public management.

3.1.6 Flood-control engineering is sometimes part of multi-purpose river basin planning, and also forest and pasture management. Consequently, in such cases it should be evaluated as an alternative to zoning measures, not only in isolation but as part of over-all basin planning.

3.1.7 Zoning regulations should be part of the master plan of a settlement when such a plan exists or is being prepared. Flood plain zoning should be part of over-all land-use zoning, but it may be preferable to institute flood plain zoning by itself in cases where the adoption of a master plan will take too much time.

earthquake, flood or other phenomenon occurring again. This classification will also clarify the nature of compensation to be made, if any.

The classification is also as important as the above studies (or even more so) in that it will help to determine the future location of the settlement, thus influencing the preventive measures associated with town and regional planning.

7.3.4 Since the emergency period evaluation provides only temporary figures, it is important to repeat the damage evaluation a few weeks later. The results are likely to differ significantly from those made during the emergency period.

7.3.5 Government and management must accept the fact that damage evaluation cannot be precise, and that the technical experts are only able to make estimates to the best of their ability and knowledge.

7.3.6 The above is certainly the case during the emergency period, and is also true to some degree in the repeat survey.

7.3.7 It may be considered advantageous by the government for the damage survey team to include local people to instruct others on the peculiarities of the area, but the decision-makers should not be people from the settlement or region.

7.3.8 The damage survey should not constitute the central document for decisions, neither for town and country planning nor for compensation.
7.2.6 Maintaining the security of water supply and other public services may be considered as preparedness for one disaster but prevention for another (such as fires, epidemics, etc.)

7.2.7 The crucial point in distinguishing prevention from preparedness is the desire to forestall all catastrophes when this is possible. In most disasters, it is neither the causes nor the underlying factors that can be eliminated, but it is their effects which can be controlled. Emphasis on prevention is to underline the pointlessness of passive acceptance and, in addition, directing attempts at futile and costly effort after the disaster has occurred.

Although, in consequence, prevention should always have priority over preparedness measures, the above examples indicate that preparedness, as long as it does not duplicate prevention, can work in support of prevention.

7.3 Post-disaster

7.3.1 The study of damage after disasters and its classification within a legal framework is extremely important. This is not only for the purposes of emergency and rehabilitation, but for the prevention of future disasters.

7.3.2 The study of damage will provide one of the best guides to mistakes made in the past, and therefore will provide instruction on the preventive measures to be taken or developed in the future.

7.3.3 A legal classification of the degree of damage, particularly in the case of residential buildings, will indicate which buildings are unsafe in the event of another flood.

3.1.8 Although land use regulations and engineering measures may be considered as exclusive alternatives to each other, often a combination of both measures should be used. In such a case instead of an alternative we have a matter of the relative emphasis on one aspect or the other.

3.1.9 The choice between the alternatives or the emphasis will depend on the density of population or on economic activities in a given settlement. As a general rule, in places where density is high engineering works may be more justifiable in economic terms, and control of land use may be more difficult.

3.1.10 Floods may combine with different types of sea surges with disastrous consequences. Floods and dam bursts may be coincident with earthquakes. This makes the control of land-use of utmost importance in the prevention of flood damage, since the other two types of disaster also involve such control.²

3.2 Flood plain zoning, land use regulations and legal measures

3.2.1 Legal principles and preventive regulations in flood protection deal with rights to property and to the use of natural resources. In all societies, laws and traditions

² For general measures affecting flood damage prevention see sections on Public Land Acquisition, Relocation, Finance and Taxation, and Other Phases Connected with Disasters.
3.2.2 The legal trend is towards zoning and land use regulation.

3.2.3 Land use regulations may be included in the general codes which govern zoning, building construction and subdivision of land.

In addition, for the purposes of regulating the flood itself, principles may be established with respect to the use of the stream channel and its immediate vicinity (encroachment statutes).

It is better to have all four types of codes and regulations in both written and map form. The maps should be very precise on the application of regulations to different zones and sub-areas.

3.2.4 Preventive measures against floods may be separately inserted into these four types of legal instrument if the needs and legal traditions of a country so require. However, these legal measures could also be drafted in a unified form. It is best to include all in a single system of land use planning.

3.2.5 Flood plain regulations should not over-restrict economic activities. Since residences, factories and service installations may be forbidden in areas of flood risk, alternative economic activities should be allowed in such places, and in certain cases enumerated. Alternative

7.2.2 The authorities should request the industrial plants, offices and institutions within any type of administration or ownership to prepare shut down plans in advance. Electrical installations, gas systems and other fire hazards can be as dangerous as the initial disaster disrupting them; hence, prevention for certain disasters may result from preparedness for others.

7.2.3 Particularly in the costlier installations of a settlement, guards and watchmen, protective illumination and emergency lighting equipment, fencing and similar measures are initially preparedness items, but may take on aspects of prevention at some phases after the onset of the disaster.

7.2.4 Sites for temporary emergency shelter should be decided in advance as a measure of preparedness and their comparative service costs should be known in advance. Evacuation routes will also have to be established.

As decisions will be taken during the emergency phase of a particular disaster, the sites will be preempted and will therefore influence any prevention programme for the future.

7.2.5 The provision of rescue equipment (fire fighting, earth-moving, transport) and its location in the safer areas of buildings and cities at the onset of a disaster, is also a preparedness measure. However, after the onset this may constitute a prevention measure for secondary disasters.
7. PREPAREDNESS AND POST-DISASTER ACTIVITIES

7.1 Introduction

7.1.1 Phases and measures connected with disaster preparedness, emergency operations, rehabilitation and reconstruction, as well as warning, rescue and relief, will often be affected by prevention measures, or conversely will have effects on prevention programmes.

7.1.2 Some of the preventive measures will either coincide with, or constitute alternatives to both preparedness and post-disaster activities.

7.1.3 The organizational scheme of management should include principles which will preserve the continuity of emergency and preparedness administration with the over-all prevention programme.

7.1.4 Many measures related to preparedness will protect investments in prevention and, similarly, preventive measures will protect investments in preparedness.

7.2 Preparedness

7.2.1 Safeguards for preserving mass movement in buildings, in cities and their exit routes are preparedness measures. However, since they are connected with building design and town planning, and to the extent that they reduce damage, these safeguards merge with prevention.

land uses should be of a type which will incur comparatively little damage in the event of a flood. (See sections 3.2.13 and 3.2.14)

3.2.6 In a flood plain, restrictions on the use of land should be codified in terms of degree of hazard, namely, land subject to more frequent floods will be subject to more severe restrictions.

3.2.7 In the case where the regulation of the flood plain is not based on systematic information, especially with respect to hydrology and topography, unnecessary economic hardship may result and sections of the population may not receive equal treatment. Therefore, whatever the timing of public works, systematic information should be collected at the earliest possible time and priority given to higher-risk areas.

3.2.8 Land use zoning will be effectively supported by subdivision regulations, which should be drafted mainly with that purpose in mind.

3.2.9 Subdivision regulations themselves may contain use restrictions if necessary, but their main purpose will be to limit further land subdivisions and consequent sales of land in flood-risk areas.

3.2.10 The public should be widely informed about zones subject to subdivision regulations of various kinds, especially those concerning disaster-risk areas.

3.2.11 The management of subdivision and zoning controls for floods as a matter of public administration is similar in
nature to that in other types of disasters; therefore,
in areas prone to several types of disaster these should
be operated as a single system.

3.2.12 Flood plain regulations will not only restrict rights to
the use of land but will also control flood protection
measures in individual lots. Uncordinated landfill,
reclamation, and drainage projects may deprive a stream
of its natural detention basin and cause damage elsewhere.
This legal and regulatory side of flood risk minimization
should be coordinated with those engineering measures
adopted by the public administration.

3.2.13 In establishing the types of land use to be allowed by the
zoning ordinance in flood-risk areas, the following should
be considered:

- The value of installations subject to damage should be
  minimal.

- It should be possible to evacuate people in good time
  which in turn is dependent upon the efficiency of the
  warning system

- Parking and storage areas and volumes should also be
  of such a nature that quick evacuation can be performed
  in case of warning.

- Refuse and garbage disposal should be safe from flood
  waters.

3.2.14 The following uses may be reasonably permitted in flood-
risk areas:

6.7. Local government activities

The measures of specialized agencies may come under the
supervision or jurisdiction of general urban management in
the following ways:

6.7.1 The control and supervision of the degree of effectiveness
of the equipment and plans of the fire department.

6.7.2 Urban and metropolitan sewerage systems should be flood-
proof.

6.7.3 The same sewerage systems should not discharge untreated
wastewaters above the purifying capacity of seas and rivers.

6.7.4 Location control for explosion risks is a continuous
system, and it must be considered that urban growth is
very likely to move towards and envelop land with
explosion risks which were originally located safely in
outlying areas.
6.4.2 Various levels of government will normally ensure that human settlements are not located above underground mining operations, and vice versa.

6.4.3 In open-cut mining, operations should be conducted so as not to create disaster hazards for human settlements.

6.5 Design and maintenance of public works

6.5.1 The design of dams must take into consideration detailed geological investigations and earthquake forces.

6.5.2 Bridges and roads must be located with regard to flood risks and be designed with reference to earthquake hazards.

6.6 Design and maintenance of industrial and similar installations

6.6.1 The risks of explosions and fires must be carefully controlled by the industry concerned.

6.6.2 It is important that industries have paid sufficient attention to problems of location within human settlements, in addition to the prescribed town plan, the regional plan, and the zoning ordinances.

6.6.3 National regulations should be adopted and published with respect to prevention of explosions and fires, and reference made to different branches of industry if need be.

- Parks, open spaces, play areas
- Uses normally dependent on the river and its shores, if proper precautions are taken
- Environmental protection areas and reserves
- Agricultural production and marketing
- Parking of motor vehicles, and other uses requiring large spaces but offering speedy evacuation
- Other uses essential to the country's culture, but having considerations similar to the above uses.

3.2.15 Zoning ordinances will usually exclude residential construction and assembly places from the flood-risk areas. In cases where non-residential construction does not increase the risk of flood in either the locality, or upstream and downstream, and where necessity and economic advantage is clear, such construction may be allowed in the flood plain if it is able to provide all necessary safeguards for its own protection.

3.2.16 Zoning ordinances and building codes may specify the following conditions for buildings to be erected in the floodway fringe:

- Floors of structures should be above certain stated flood levels
- Structures should be designed to withstand inundations and specified water velocities, and otherwise be
flood-proofed.

- Sewage, refuse disposal and similar systems must be safe from floods.

3.2.17 Building codes should specify additional requirements:

- Adequate anchoring

- Construction materials used should not be subject to damage either from water itself or from stream flow and flood.

3.2.18 The building code may specify that buildings in areas subject to flood risk will not be permitted unless such risk is eliminated. This risk may be eliminated by filling, drainage, protective walls and other means. Such protective measures, however, are very local in nature and are likely to increase flood hazards in unprotected neighbouring areas.

3.2.19 In all cases, legal measures should be addressed to prevent building in flood-risk areas, rather than to regulate the safety of any construction to be allowed in such places. All types of excavation or filling, and the operation of gravel pits and similar activities should be subject to public control.

3.2.20 Enroachment statutes will be prepared with two main purposes:

- No construction should cause hardship and loss in other places

be given to neighborhood - scale measures (see 6.1.4).

- In dense areas with narrow streets, inspection of control measures inside buildings should be made very strictly and in areas of high fire risk, fire drills should become routine.

(See also sections on Earthquakes, Cyclones, Forest Fires and Preparedness and Post Disaster Activities).

6.2 Forest fires

6.2.1 Forestry organizations will usually take preventive measures themselves.

6.2.2 The administration (national or regional government) will have to consider the expenses involved in prevention within the overall budget.

6.2.3 Local or regional governments will supervise the efficient provision of these preventive measures in the vicinity of human settlements.

6.3 Forest, range and pasture management

6.3.1 Governments will normally ensure that such management is coordinated with the flood prevention programme.

6.4 Mining operations

6.4.1 Safety measures are usually taken by the mining management.
- Immediate extinguishing by occupants of the buildings.

On a neighbourhood scale, the risk can be reduced by:
- Control of land uses with potential fire risk.
- Regulations concerning distances between buildings.
- Immediate local extinguishing.

On a settlement scale, the risk can be minimized by:
- Fire-fighting services.
- Circulation systems which will still be effective after earthquakes or explosions.

On a sub-regional scale, one fire-fighting service and its equipment could be made available to several villages within short distances of one another, especially in those areas with high fire risk. Volunteer fire-fighting service should be encouraged.

6.1.5 The above situation not only provides successive and cumulative measures for preventing, fighting or minimizing fire and risks, but makes it possible to emphasize some measures at the expense of others, or to substitute one measure for another, according to varying circumstances.

- In those cases where sufficient distance between buildings and groups cannot be provided for practical, climatic, cultural or economic reasons, emphasis should be given to a fire-fighting service.

- If the circulation system of a settlement is likely to be blocked as a result of an earthquake or explosion, at the stage of prevention planning, emphasis could

- The most dangerous parts of the flood plain should not be occupied.

3.2.2 The legal provisions should be precise and universally applicable so that litigation will not result in selective application, nor will it delay the application of public policy.

3.3 Tsunamis

These sea waves are caused by earthquakes. When the focus happens to be under the sea, the resulting waves are extremely destructive.

3.3.1 Settlements along the shoreline may be relocated; however, the cost of such a measure may be prohibitive. It may also disturb a country’s network of economic activities and, furthermore, relocation decisions need to be taken without a proven degree of risk for any particular settlement.

3.3.2 Warnings are effective in saving lives and equipment if the warning arrives in time and if the population is actively convinced of the danger. However, there may not be sufficient time for a warning in those cases where the focus is too close to a particular shore.

An international warning system is in operation in the most hazardous tsunami regions of the world.

3.3.3 If the sea-bed, its depth along the shore, and other factors are properly studied, some engineering measures may be taken to prevent damage.
3.3.4 Contour maps of coastal lands may make it possible to plan for evacuation in case of warnings.

3.4 Combination of normal river floods and sea surges

3.4.1 This combination is potentially the most serious among disasters and the situation is far more complicated than in the case of plain floods. For engineering measures and legal regulations, however, zones may again be established, based on the frequency of the event.

3.4.2 The levelling of sand dunes and other natural barriers along the sea shore should be prohibited; neither should forest cover and trees be destroyed in low-lying coastland.

3.4.3 Regulation in densely populated regions will be difficult, but only light structures should be allowed in specific zones. If the currents observed in sub-areas are not too strong, pile foundations may be more appropriate prevention measures in sea shore regions than they are in flood plains.

3.4.4 In the case of areas reclaimed from the sea (Dutch Polders for example), special engineering and legal measures may need to be adopted.

3.4.5 The above are the few additional minor factors to be considered in such a combination. The important point to remember is that this catastrophic combination is possible, although the particular situations will be different in various parts of the world. If this combination recurs in a given region, especially if it

6. MISCELLANEOUS DISASTERS

In some fields preventive measures are usually taken by specialized agencies and are not the direct responsibility of urban management, which will only coordinate or indirectly supervise certain aspects.

6.1 Fires

6.1.1 Fire is not only a considerable hazard itself, but it may be initiated by other phenomena such as explosions, cyclones, and volcanic eruptions. In many earthquakes, loss through fire has been greater than through the earthquake itself and, furthermore, fires may lead to explosions.

6.1.2 Town planning can contribute to prevention by controlling distances between buildings and groups of buildings, and by land use regulations, which control the location of buildings with fire or explosion risk.

6.1.3 There is not only an extensive and intricate relationship with other hazards, but in contrast to almost all other disasters, a fire can start almost anywhere, on the most minute scale. It needs the most pervasive and relentless type of preventive controls, but on the other hand, there are many stages and levels at which a fire can be prevented or fought, providing successive alternatives in prevention.

6.1.4 At the smallest scale, fire risk can be prevented by:
- Regulation of goods and equipment which may cause fire.
- Regulation of building materials to make them more fire resistant
- Design of proper and sufficient fire exits.
- Availability of fire fighting equipment within buildings.
5.2.6 The public should be clearly instructed on those measures to take during different stages of warning.

happens to be densely populated, large programmes of relocation and engineering protection will be necessary. The methods will have to be developed for each region.

3.5 Other measures of prevention in flood plains

3.5.1 Engineering works may constitute the leading prevention means in many cases. (Measures related to engineering works are listed in the Building and Planning Manuals.)

The main points concerning engineering measures are:

- They are not designed for total protection, since if they had such a purpose the cost could exceed the total cost of damage over long periods.

- Comprehensive protection throughout a river basin can generally only be completed over decades.

- Engineering works are not likely to be built if calculations show that their costs exceed benefits.

3.5.2 Conservation programmes, including forest and pasture management, may prove to be the most effective and cheapest measures in many circumstances.

Permanent evacuation of the population and land expropriation are other measures that can be used. (See Relocation and Public Land Acquisition.)

Flood damage insurance is not a preventive measure, is generally not institutionalized, and is likely to favour areas more frequently flooded. (See section of Finance
3.5.3 Flood warning has a very important role in the prevention programme.

3.5.4 The elevations of roads and bridges should be above anticipated flood levels. Among engineering measures, levees, fills and other techniques should not unduly restrict floodway capacity. Levees designed for certain flood levels will be toppled by higher floods and in such cases the levees will retain the water for considerable periods in those areas they were designed to protect. Compensating measures should be sought to overcome this problem.

3.5.5 After a flood disaster, drying and repair of existing buildings are of great importance. These factors will influence the performance of buildings in a possible future flood.

Sometimes the buildings may withstand a flood but the top-soil may not. For example, certain types of clay soils may cause heaving after a flood. The most effective management measure against topsoil problems is the control of the location of settlements, namely zoning and planning.

3.6 Cost/benefit analysis

3.6.1 Cost/benefit analysis is likely to be used more often in flood control than in the case of other prevention programmes.

5.2.2 The probable path of a typhoon, hurricane or cyclone becomes clearer as it progresses; hence, during a given period, all settlements within a particular area are under threat, but later it should become clearer when these settlements are no longer under further threat. This makes it possible to concentrate warning and precautionary efforts in the relevant places.

5.2.3 Much depends on an efficient tracking system, probably international, and an equally efficient and authoritative warning arrangement.

Tracking and warning systems necessitate close cooperation among meteorological agencies, public authorities, telecommunications (especially radio), and the disaster prevention administration which is concerned with the continuous education of the public.

5.2.4 In many cultures, especially in industrialized countries, fewer people pay attention to warnings than would be expected. Warning should be complemented by an inspection by public officials in the settlements concerned. If a warning accomplishes its purpose, not only will loss of life be minimized, but the amount of any compensation paid from national funds should be considerably less.

5.2.5 Coordination among these various agencies depends on links simple enough to be put into operation with speed during an approaching cyclone. Final decisions regarding the declaration or withdrawal of a state of alarm should lie specifically with public authorities.
5. HIGH WINDS AND HEAVY RAINFALL

5.1 Effects and locations

5.1.1 These atmospheric processes cause large loss of life and, together with associated effects (such as fires and floods), result in considerable damage. The range of preventive measures that may be taken against them is less extensive than in some other disasters.

5.1.2 Although these processes occur usually only in specific regions of the world, choice of location in the case of individual settlements is not relevant where cyclones are concerned. Hence, town planning measures should be addressed to possible secondary, or associated, disastrous effects. Management and town planning measures for the prevention of fires, explosions and floods will minimize the disastrous effects of cyclones and typhoons. It is in the case of floods that the choice of location becomes important, since the greatest damage during cyclones is most likely to be caused by heavy rainfall, and some areas at a given site will be safer than others.

5.2 Warnings

5.2.1 The most important preventive measures against cyclones are building practices and warning systems. Compared to other disasters, there is ample time for warning in the case of cyclones, as in the case of certain floods. In this case, therefore, warning becomes a preventive measure.

3.6.2 It is essential to remember, with regard to this very widely-used technique, that it is not an extremely precise method. In many cases it is difficult enough to judge costs, especially if they are to be spread over a long time span, but the estimation of benefits is even more complicated, and is likely to differ from one experienced professional to another.

3.6.3 It is, however, an essential technique in river basin planning and flood control, and consequently will also determine the extent of zoning measures needed.

3.6.4 If cost/benefit analysis gives a clear-cut situation, the application of preventive measures at the earliest possible time is likely to save a greater amount on investment than would otherwise be the case.

3.7 Public administration

3.7.1 It is sometimes suggested that the enforcement of flood control at local level will be more expensive than enforcement at regional level. (See Chapter 2 on Levels of Administration.)

3.7.2 Flood control zones should never be made to follow administrative boundaries, since the purpose of flood control may be lost. The boundaries of control zones should be established according to flood probabilities.

3.7.3 Agencies responsible for flood disaster prevention should be linked with existing agencies and be given specific tasks rather than mere powers. In such a case, they are also likely to obtain a larger budget.
3.7.4 Management may prefer to expropriate land for flood protection programmes, especially if the lands under flood risk have buildings on them. In the case where land liable to flood damage has no buildings, management may find zoning measures sufficient, since the owners are not likely to suffer economically.

3.7.5 International agreements exist on the use and management of international river basins, and disaster prevention adds another dimension to these agreements. Basin management agreements, as such, may not adequately cover disaster considerations, and it is the responsibility of the government of upstream countries to reach agreements with those of downstream countries on flood disaster prevention.

4.5.4 Transport routes may be closed under dangerous conditions.

4.5.5 The risks for small settlements should be evaluated throughout the country or region.
4.5 Earth movements: avalanches

Avalanches may be triggered by landslides, rockfalls, winds, heavy snow, melting snow and other conditions in snow layers, earthquakes, other vibrations, temperature, diurnal and seasonal changes of climate, and possibly other factors.

Planning on a local and regional scale may provide effective prevention measures through the selection of less dangerous sites; however, relocation will not always be practicable. Furthermore, avalanches may have more disastrous effects on moving traffic and on established transport routes.

4.5.1 In the case of avalanches, the most effective prevention measures are the continuous surveillance of hazardous sites, the controlled, preventive triggering of avalanches in hazardous conditions, and the construction of engineering works.

4.5.2 Artificial triggering of avalanches can only be carried out in suitable areas. In such cases very stringent measures of warning must be taken, and the area cordoned off.

4.5.3 Preventive structures are "galleries", tunnels, deflection trenches and walls.

Total protection through engineering works, similar to some other disasters, is very expensive for any country; therefore, the areas with greatest damage risk will have to be identified and given priority.

4. Earthquakes and land movements

4.1 General

4.1.1 Earthquake damage may be prevented or minimized by careful and appropriate construction, and by the rigorous enforcement of building codes. The location of human settlements (i.e. site selection), town and regional planning are very effective instruments in many circumstances.

4.1.2 Some sites will be more convenient than others on both a regional and an individual scale, such as a city.

4.1.3 In contrast to those types of disaster which affect only one particular location or long strips of area in a uniform way, damage caused by a single earthquake occurs in uneven fashion throughout a region.

4.1.4 An earthquake has one focus over which the damage is likely to be greatest. The geological effects of the same earthquake normally become less as the distance from the focus increases.

4.1.5 Actual damage caused by an earthquake is affected by local geology, top soil condition, type of construction, etc. and therefore, does not necessarily decrease with distance from the focus.

4.1.6 Countries and regions subject to earthquakes are documented in terms of past records and recent trends.
Even though damaging earthquakes may occur in areas which have not had a recent experience, national efforts for the prevention of possible damage should be concentrated in those regions of known risk.

4.1.7 On a regional scale there may not be any reason to concentrate preventive measures on particular districts or to accord them any priority, since the focus of an earthquake may be anywhere within the region.

4.1.8 On a city or settlement scale however, since locational preferences should be established on the character of surface strata and under-lying rocks, and since the differences between areas are quite permanent, site selection, town planning, and a concentration of effort and priorities in some of the settlement sub-areas may be of more value and meaning.

4.1.9 In common with most other types of disaster, preventive measures against earthquake damage will have to be taken over entire regions, since the disaster may occur anywhere within that region.

4.1.10 The cost of preventive measures over an entire region may be less than the total cost of a disaster in a single settlement where no preventive measures have been taken. This is especially so in those cases where attention to simple construction techniques and their enforcement are sufficient to make buildings earthquake-proof.

4.1.11 Building codes should be prepared separately, according to the size and function of structures; the economic and social characteristics of the various localities; local

seismic zoning. On the other hand, the possible extent of the damage to be caused by a given earthquake in various districts at individual settlement level is connected with the surface structure of an area, and local differences are investigated by the technique of microzoning.

4.4.2 The character of the regional distribution of earthquake probability will differ from one part of the world to another, and there are several methods of determining this probability. Regional probabilities will help to determine the location and possibly the relocation of human settlements on a regional scale. Seismic zoning at present will not provide precise information to assist in the choice of locations for human settlements; therefore, research should be speedily undertaken in each country to advance the technique.

Seismic zoning on a regional scale may however be helpful in construction and in the choice of location in some ways. It may provide information on those areas to avoid and, as in the case of microzoning, provide information on precautions to be taken in construction and engineering works.

4.4.3 Microzoning should be carried out on the scale of individual settlements and provide information on the safer or riskier areas. This technique should be used both in areas already urbanized and in those areas where future settlement is probable.

The results obtained from microzoning should indicate the differences in construction costs between districts.
been argued in some cases that the remaining buildings were of poor quality, that the roads were very narrow in the existing settlement, and that the fire hazard was almost permanent. These and other reasons would make relocation an alternative to be seriously considered. However, in such a situation the administration should make certain that the judgment of specialists has not been hasty, that land speculation at the proposed alternative site should not be in question, that profits to be made commercially in the large-scale new construction should not be the dominant consideration, and most important, that the new site is clearly safer. If these points are not considered, substantial amounts of national disaster prevention funds and other resources would have been diverted without much effect either on disaster prevention or on the establishment of more productive regional schemes.

4.3.5 In those cases where an earthquake hazard is combined with the risks of landslide and other disasters, relocation may become a more serious alternative.

4.3.6 Relocation is a drastic and costly undertaking and should only be considered when it does not disrupt or decrease productivity, but on the contrary, when it contributes to resource development within the region.

4.4 The vulnerability of regions and locations and the application of zoning

4.4.1 The probability of the occurrence of earthquakes may be determined to some extent for given regions. The determination of belts and areas on this scale is called building traditions; the size of the construction enterprise; the abilities of builders; the income of prospective inhabitants as well as regional geotectonics. Furthermore, separate codes may be necessary for low-cost housing, on the one hand, and commercial buildings on the other.

4.1.12 In most countries, particularly in urban areas, the number of dwelling units to be built over the next two decades or so is likely to be as much as those existing at the present. Hence, this provides a good opportunity to make an increasing percentage of buildings earthquake-resistant.

4.1.13 National or regional research may indicate that the resistance of existing buildings may be improved and the risks lessened through simple measures.

4.1.14 In larger and more specialized buildings, measures used for earthquake-resistance are likely to increase costs. However, the increased cost will produce long-term benefits for the owners, and since these are buildings for special use, no incremental costs will be involved for low-income groups.

4.1.15 In both large and small buildings, enforcement of the codes may prove difficult, but enforcement of measures for disaster prevention is not in nature any different from enforcement of normal building codes. It may be made more effective by a regional or national administration supervising local enforcement, and by paying attention to fewer but more vital details.
4.2 Building codes and their implementation

4.2.1 A possible drawback to building codes and similar legislation is that they may be unnecessarily rigid under differing circumstances, and it may not be possible for them to pay sufficient attention to detail and necessary variations.

4.2.2 One way to minimize this drawback is to prepare the codes in terms of performance standards, provided that there are opportunities and advantages in doing so. These would specify what is required in or for the building, but not specify how this result should be obtained, and they may also not specify quantities.

4.2.3 This would suggest that there are advantages in specified and detailed codes over the performance-standard type of codes, but specific measures themselves complicate a code, since it would be necessary to take account of various localities, building materials, types of building and cultural traditions. Codes which do not take account of such variations will be improper under many conditions; codes which do take account of them will be difficult to prepare and to implement. Thus while the performance-standard type of regulation complicates supervision, the numerical and detailed approach will complicate the code itself.

4.2.4 The most generalized principles of earthquake resistance may contradict regional traditions or the use of available materials. For example, it may not be possible or desirable to make all buildings symmetrical, to eliminate the use of local building materials, or to avoid balconies altogether. It would then be up to the local building codes to settle the matter, provided the goal of earthquake-resistance is secured. In this respect national and regional research are essential, and international exchange of information should also prove very helpful.

4.3 Relocation

The selection of locations within a region may be a specific matter in the case of some disasters (floods and avalanches) but is less specific for earthquakes. Consequently, relocation becomes a special issue in the case of earthquakes; it may be considered before or after the disaster, and may be partial or total.

4.3.1 Alternative sites in the vicinity or in the region may not necessarily be safer, in either geological or engineering terms; hence, relocation would not be an advantage.

4.3.2 It may not be advisable or possible to change the location of economic activities; the distances involved in the agricultural or trading functions of a settlement will have a tendency to remain unchanged. This consideration also does not favour relocation.

4.3.3 In a post-disaster situation, the number or proportion of undamaged buildings may be sufficient to rule out relocation.

4.3.4 It has been suggested that after some earthquakes the clearing of debris and rubble would take a considerable amount of time and involve very high costs. It has also