The management of natural disasters and the physical environment for long-term sound and safe urban planning

Sustainable development projects must incorporate sound and safe environmental management. They must be designed to:

- improve quality of life and safety;
- protect and restore environmental quality at the same time;
- ensure that natural resources and patrimony will not be degraded;
- ensure that the threat of natural hazards will not be exacerbated.

In the perspective of the IDNDR, the concept of a sustainable development requires an overall approach of the problems, taking account of all elements that can influence the environment for urban planning with the objective of public safety and health:

- the environmental assessment of projects and the protection of the environment;
- continuous monitoring of the environment and environmental management;
- study and management of risks, including plans for their prevention and the crises preparedness;
- the design and use of spatial models of the environment.

In this context, the sound and safe management of the physical environment and natural hazards is a fundamental factor for urban planning; it is neither a privileged, nor a dominant factor, but it should never be neglected. It is a task of paramount importance to develop within the framework of the IDNDR suitable methods for the assessment and management of the physical instability of megacities, particularly in developing countries.

Conceptual approach of preventive urban planning

The conceptual approach for the management of physical instability in urban development and planning might be organized into a logical framework as follows:

- *Analysis of the megacity environment (the urban biotope: a new medium):*

  i) *The "natural" environment.* Geology, geochemical and geotechnical conditions, surface and ground waters, climatology, etc.;
  ii) *The "man-made" environment.* Spatial organization, land use, types of construction, the urban fabric, main phases of urban expansion, pollution sources (human effluents, waste disposal, industries, etc.);
  iii) *The community organization for managing risks and the physical environment in urban planning.*

- *Process of physical instability and their relation with urban development conditions*

  i) *Impact of urban development on the geological environment (human interaction).* Lowering or rising of the water table; subsidence; loss in bearing capacity of soil foundations; instability of slopes and underground excavations, contamination of soil waters; exhaustion of natural resources; etc.
  ii) *The assessment of natural hazards for urban planning.* The natural hazards taken into account are: earthquakes, storms, cyclones, floods, mudflows, landslides, rockfalls, snow avalanches,

volcanic eruptions, swelling and subsidence of soils, coastal problems, tsunamis, etc. The assessment will be along deterministic/probabilistic lines (using frequency/intensity laws when possible) and should lead to zoning and microzoning of the direct and induced effects of the hazards.

iii) *The interaction between natural hazards and urban impact on the environment.* Determination of physical instability process and of the geo-ecological vulnerability of the urban environment, leading to induced "natural" hazards.

• *Evaluation of the socio-economic impact of physical instability on urban development. Risk analysis*

Evaluation of vulnerability (counted in living creatures, potential diseases, material property production systems, critical utilities, municipal and other organizations); risk assessment (the product of hazard and potential damage), within the framework of representative scenarios.

• *The management of risks and the environment*

i) *The means for mitigation and prevention of risks due to physical instabilities.* Scientific and engineering actions.
ii) *Actions for protecting and rehabilitating the urban environment.*

Monitoring and control, data management, prediction, warning, preparation for crises and disaster management, building codes, land use, environmental management, strengthening and rehabilitation of the environment, health and safety assistance, action for planning and regulation, life-line networks strengthening, education and training, information, and awareness.

• *Contribution to decision-making for the environmental management of megacities*

i) *Evaluation of the geo-ecological capacity of urban sites (resources and fragility) and environmental bases for a spatial restructuring.*
ii) *Cost-benefit analysis of the preventive actions for natural disasters and/or for environmental protection.*
iii) *Data management systems or methods, for making the information accessible to the end-user.*

• *Institutional systems (framework and organization): finances, integrated development planning, operation control, warning, rescue services*

• *Communication plan: information and awareness of decision makers and population*

R & D programmes for action

In view of the variety of the problems, their multi-disciplinary character, the manifold possible persons intervening, it seems desirable to select some priority projects to be developed within the 90's Decade.

- Economic evaluation of the direct and indirect damage caused by natural disasters in megacities; cost-effect and prospective analyses of the prevention programmes.
- Definition of the concept of geo-ecological capacity of the urban sites (resources and fragility) in order to ensure a sustainable development.

- System analysis models for physical instability of megacities.
- Preparation of a Geo-Ecological Information System (GEIS) to help in the decision-making process for the preventive planning of megacities.
- Adaptation of construction codes to different socio-economic and technological levels.

These projects should be discussed more fully among the various scientific and technical organizations involved in the IDNDR activities at an international level.

It is obvious that the models of control, cost-benefit analysis, prevention and rehabilitation have to be developed on application sites, preferably in megacities of developing countries.

The use of new methods and tools, such as remote sensing, geographic information systems, computerized databases, decisional map-making and system analyses, will help in such complex ventures.

The objectives of transferring suitable methods and technology adapted to the local conditions, be they social, technical, geographical or institutional, require the periodic organization of regional technical seminars, scientific meetings, and workshop discussions organised by scientists (natural and human sciences) and engineers with decision-makers and particularly with the mayors.

3. Conclusions

The volume of building and complementary infrastructure to be created in the urban areas, over the next twenty years, will be equivalent to that built during the past few millennia that constitute Man's history; this implies that all new policy of urban preventive work be quickly amortised.

The main objective of the proposed initiative is to impose on the politicians and other decision-makers a long-term development basis, by providing an indispensable complement to the more traditional approaches of urban planning, whether they are socio-economic or concern the spatial and architectural organization. In addition, the proposed preventive urban planning approach present multiple interest, which include:

— Increased awareness and information for politicians and other decision-makers, and for economists, sociologists, engineers, architects, rescue services and the population in general, by means of the development of a dialogue between specialists and users.
— Increased ability of society to cope with natural hazards (preparedness and prevention or reduction of natural disasters), leading to greater security for the citizens and a sustained development that are independent of politics.
— Increased capabilities to control urban growth, the types of land-use construction standards, through the judicious use of structuring factors, like infrastructure elements, and the necessary works for the protection and/or rehabilitation of the physical environment.
— Increased education and integration of the population into the feeling of social justice, because of the increased security and respect of the surroundings ("cadre de vie") that will be accessible to all, particularly in the suburbs.
— Increased employment because of the creation of new activities, through the development of programmes of physical rehabilitation, protection and prevention in the megacities.

Coordination and Integration of International Projects on Risk Assessment in Megacities

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1. Introduction

To achieve social and economic sustainable growth and to ensure a comfortable and safe life by reducing the damage of natural disasters is a common concern shared by all people throughout the world. At the 42nd United Nations General Assembly in 1987, all countries adopted unanimously a resolution designating the 1990s as the "International Decade for Natural Disaster Reduction (IDNDR)." The resolution states that the purpose of the IDNDR is to reduce the loss of human lives and property damages caused by natural disasters throughout the world, particularly in developing countries, through concerted international action. The resolution calls on all countries to make every possible effort to prepare for natural disasters and to reduce the subsequent damages through international collaboration and cooperation. Nevertheless, natural disasters, such as earthquakes, floods, and volcanic eruptions have continued unabated, causing serious damage to metropolitan areas in particular.

The IDNDR marked its first step in 1990. Since then, various international projects on risk assessment in megacities have been proposed and are now under implementation. Although each of these projects is considered individually significant, they are rather irrelevant when taken as a whole. This suggests that risk assessment has not necessarily been approached globally. To develop international cooperation in natural disaster reduction throughout the world during the latter half of the IDNDR and beyond, an integrated approach is critical to properly assess and compare natural disaster risks in different regions and to exchange data.

On this premise, further development of these human networks and inter-institutional friendship will promote an integrated approach to such risk assessment. Within the limited time period left in the IDNDR, we propose identifying major megacities in high earthquake hazard areas in developing countries, and establishing earthquake risk assessment through international cooperation.

2. Urban Disaster Vulnerability

Many people have been attracted to urban areas for economic reasons in recent years, and disaster preparedness has not kept up with the subsequent rapid urbanization. As a result, increasing numbers of people are living in areas susceptible to disasters. Particularly in developing countries, disorderly development is accelerating expansion of slum districts, which in turn increases disaster vulnerability. Almost every year, developing countries suffer huge losses of human life from natural disasters.

Urban areas are sites of dense convergence of economic infrastructure and population. However, the damage caused by disasters is not limited to urban areas alone but often spreads over the entire nation or even beyond national boundaries. It is therefore all the more important to decrease the disaster hazards to major cities. In developing countries the social and economic damage caused by disasters is much greater than that experienced by developed countries. Among the major political issues, disaster prevention should be given higher priority in the interests of sustainable social and

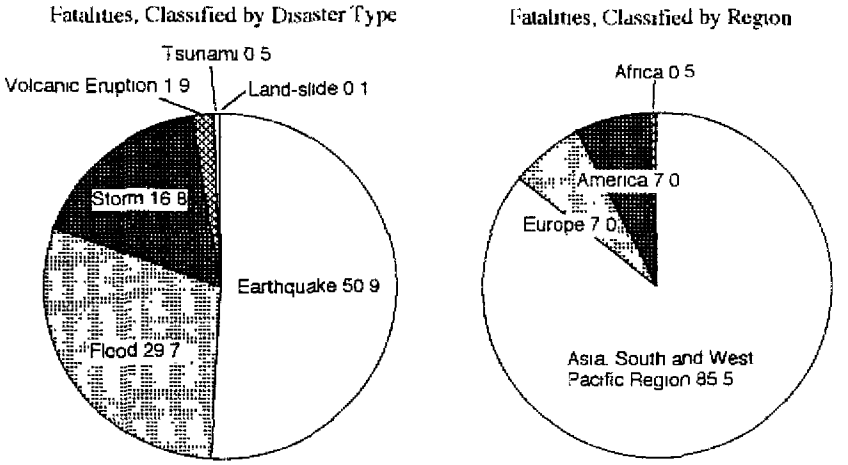

Figure 1. Classification of Natural Disasters (total from 1900–1987, 4 million)

economic development.

There are certain aspects of urbanization that makes it possible to reduce the damage caused by natural disasters. For example, urban areas, as opposed to small local areas, are equipped with many services such as hospitals, ambulances, electricity, water works, and educational institutions, through which they are able to educate the populace about disaster prevention. This gives urban areas more advantage over small local areas. However, although some effort is being made in the developing countries to prevent damages from disaster, sufficient countermeasures are usually hampered by over-concentration of population, an increasing number of dangerous buildings, and environmental disruption such as the removal of vegetation. These obstacles compound the effects of natural disasters. A significant issue for the IDNDR is to mitigate urban disaster vulnerability in developing countries by applying the experience learned by developed countries.

3. Recent Earthquake Damage

Figure 1 shows the classification of the over 4 million fatalities due to natural disasters during the 20th century reported by the Secretary General at the 43rd UNESCO (United Nations Educational, Scientific and Cultural Organization) General Assembly. As can be seen in this figure, fatalities due to earthquakes compose more than 50% of the total disaster fatalities, and for the Asian and Pacific ocean region this number reaches 85%. Once an earthquake occurs, not only does it cause great loss of human life, it also seriously affects the economy of the country in its aftermath. Therefore, it is critical that all earthquake-prone countries try to mitigate earthquake disaster. Unfortunately, such mitigation in most of these countries has recently taken on a political nature.

Table 1 shows the major earthquakes that have caused serious damage during the latter half of the 20th century. From this table we can see that since the Fukui Earthquake in 1948, there has not been any earthquake in Japan where fatalities exceeded 1,000. On the other hand, in other earthquake-prone countries in the world, there have been 12 earthquakes where the fatalities exceeded 10,000. In China alone, there were 240,000 fatalities during the Tang-shan Earthquake in 1976. As seen in Table 1, many of the megacities in the developing countries are located in earthquake hazard areas. If a major earthquake strikes these megacities in the future, both life and property damage would be immeasurable.

Table 1. Major earthquake damage during the latter half of the 20th century.

Year	Earthquake name, Magnitude		Fatalities*	Year	Earthquake Name or Epicenter Region, Magnitude		Fatalities*
* 1948	Fukui	7.3	3,769				
1952	Tokachi	8.1	33				
				1960	Agadir(Morocco)	5.8	10,000-15,000△
				1962	Qazvin(Iran)	6.3	12,000△
				○1963	Skopje(Yugoslavia)	6.0	12,000△
1964	Niigata	7.3	26	* 1964	Alaska(USA)	8.4	131
				* 1967	Caracas(Venezuela)	6.5	300
1968	Tokachi-oki	7.9	52	1968	Dasht-i Biyaz(Iran)	7.1	12,000-15,000△
				○1970	Peru	7.6	40,000-50,000△
				* ○1971	Los Angeles(USA)	6.5	58-65
				○1972	Qhir(Iran)	6.9	500-17,000△
				* ○1972	Managua(Nicaragua)	6.0	500-10,000△
				1974	China	6.8	100-20,000△
				1976	Guatemala	7.5	22,500△
				1976	Tangshan(China)	7.8	242,000△
				* ○1977	Bucharest(Romania)	7.2	15,000-15,000△
1978	Izu-Oshima Kinkai	7.0	25	1978	Tabas(Iran)	7.2	15,000-20,000△
* 1978	Miyagiken-oki	7.4	27				
				○1980	El Asnam(Algeria)	7.1	2,900-5,000△
				○1980	Campania(Italy)	6.9	2,350
1983	Nihonkai-Chubu	7.7	104				
1984		6.8	29				
				* ○1985	Michoacan(Mexico)	7.9	10,000△
				* ○1988	Leninakan(Armenia)	7.0	30,000△
				* ○1989	USA(Loma Prieta)	7.1	62
				1990	Iran(Manjil)	7.7	40,000△
				1991	Philippines(Luzon)	7.8	2,430
				1991	India(Uttarkashi)	7.1	2,000
				1992	Turkey(Erzincan)	6.9	552
				1992	India(Latur)	6.4	30,000△
1993	Kushiro-oki	7.8	2				
1993	Hokkaido South West-oki	7.6	230				
				* ○1994	USA(Northridge)	6.6	57

* : Including Missing Persons
* : Medium High-rise Buildings Damaged in the City
○ : Figures Supplied by the Japanese Government Mission for Investigation of Earthquake Damages
△ : Approximate Figures

4. Training Programmes Through International Cooperation

Since 1962 the International Institute of Seismology and Earthquake Engineering (IISEE), which is organized within the Building Research Institute under the Ministry of Construction in Japan, has implemented an annual international training program in seismology and earthquake engineering for researchers and technical experts from developing countries. This training program began as a collaborative project of the Japanese government and the UNESO, and then became an independent training program promoted only by the government of Japan.

Through this training program, the IISEE has played an indispensable role in the mitigation and prevention of earthquake disasters throughout the world, and at the same time, has been contributing to international friendship and goodwill and to the peaceful cooperation among different people. As of July 1993, the total number of participants in the training program has reached over 800 persons, representing almost 60 countries (see Fig. 2). These participants are all now playing important roles in their own countries, contributing to the development of seismology and earthquake engineering to mitigate earthquake disasters. These training programs has been targeted for researchers and engineers from earthquake hazard prone metropolitan areas and has developed world-wide human networks. At the 21st General Assembly of International Association of Seismology and Physics of the Earth's Interior (IASPEI) held in Turkey from August to September 1989, the demand for an expansion of IISEE was put forward. Thus the necessity of IISEE is widely recognized in the international arena.

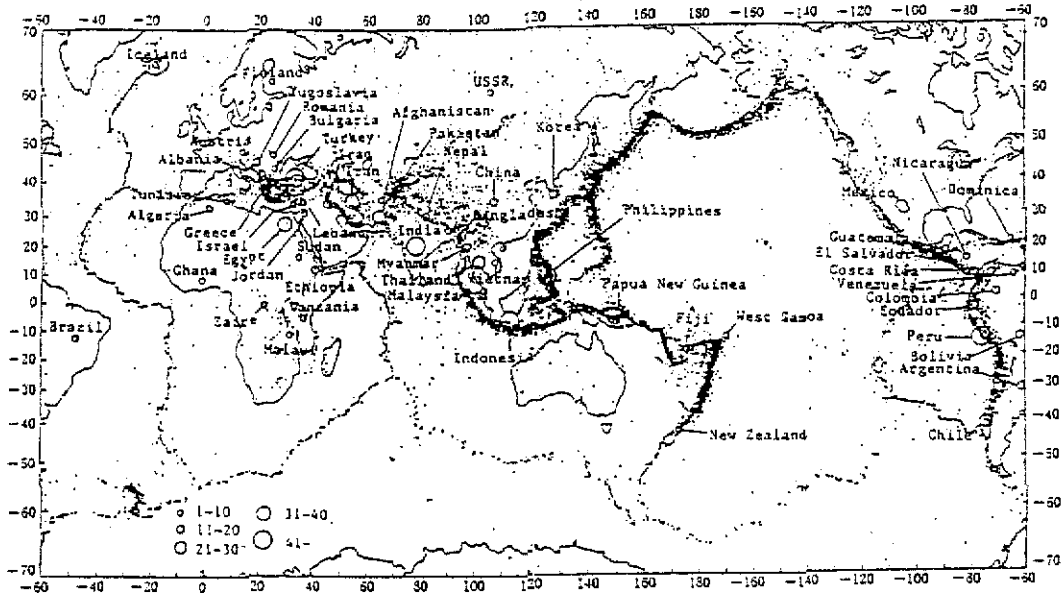

Figure 2. Number of ex-participants overlaid onto a seismic map of the world (as of July 1993).

In December 1992, an IDNDR International Symposium on earthquake disaster reduction technology in commemoration of the 30th anniversary of IISEE was held in Tsukuba, Japan. The purpose of the Symposium were threefold: (1) to set specific objectives to be achieved within the next 10 years; (2) to define the problems involved in transferring earthquake disaster mitigation technology to developing countries; and (3) to study proper means to facilitate this transfer process. Over 200 researchers and experts from almost 30 countries participated in this Symposium. At the symposium, along with two keynote lectures, 31 papers were presented during the three sessions, which were titled "The Present State of Earthquake Disaster Reduction Technology," "The Dissemination of Earthquake Disaster Prevention Technology," and "New Developments in Earthquake Disaster Prevention Technology." The three panel discussions also presented during the sessions were all up-to-date and brilliant.

Supporting strongly the spirit of the objectives and goals of the IDNDR, the Symposium adopted the following three resolutions, appealing for support from the international community of researchers, engineers, and decision-makers engaged in earthquake prevention and mitigation.

Resolution 1

A regularly scheduled international forum should be set up in order to ensure ongoing discussion of the development and dissemination of earthquake disaster reduction technology.

Resolution 2

Technology and experience transfer should be further strengthened between developed and developing countries in the fields of seismology and earthquake engineering and disaster management. Training of expert personnel, as has been carried out by IISEE for the past 30 years, should

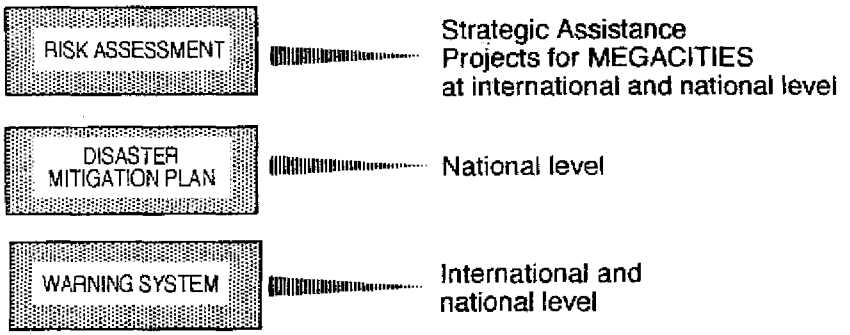

Figure 3. Target of the IDNDR showing the implementation level.

be emphasized.

Resolution 3

In order to implement Resolutions 1 and 2, a global kernel institution should be established for technology transfer in the fields of earthquake science and earthquake disaster reduction technology. The necessary financial and human resources should come from contributions by national, regional, and international bodies responsible for natural disaster prevention and mitigation.

In the future, IISEE should be expanded to become a center for seismology and earthquake engineering where researchers and engineers throughout the world can get together in order to investigate and conduct research and training, focusing on prevention and mitigation of earthquake disasters. This global institution might be realized through cooperation of both developed and developing countries that are engaged in research on seismology and earthquake engineering.

5. Proposal of Strategic Assistance Project for Natural Disaster Prevention

A target adopted by the United Nations General Assembly for the IDNDR is that all countries should incorporate the following three programs, as shown in figure 3, into their plans to achieve sustainable social and economic development by the year 2000.

(1) *Risk Assessment*. This involves the determination of a comprehensive assessment of risk from natural hazards in the international and national levels. The results of these risk assessments should then be considered in development planning.
(2) *Disaster Mitigation Planning*. This means the determination of disaster mitigation plans, which includes community awareness and long-term disaster prevention planning for such events as tsunamis, volcanic eruptions and earthquakes, at the national level.
(3) *Warning Systems*. This pertains to the accessibility of international, national, and local-level warning systems such as the news media, and the broad dissemination of warnings and other information to the populace.

Of the three programs enumerated above, a strategic assistance project for risk assessment in Megacities may be of great importance.

Since the inception of the IDNDR in 1990, various international projects on risk assessment

in megacities have been proposed and now under implementation. A simple method for hazard and vulnerability risk assessment has been used utilizing available data from the viewpoint of developing guidelines for risk assessment in terms of earthquakes, tsunamis, volcanic eruptions, landslides, floods, and tropical cyclones. For the second half of the IDNDR, national and local organizations should cooperate with international agencies to implement this risk assessment, and should include data collection, hazard analysis, diagnosis of infrastructures, housing and other facilities, and mapping and reporting.

Within the limited time period left in the IDNDR, we now promote identifying major megacities (namely, those cities in which the population will exceed five million in the year 2000) in developing countries under high risk of natural disasters. Under earthquake and tsunamis risk, such megacities include Beijing, Cairo, Caracas, Casablanca, Istanbul, Jakarta, Lima, Mexico City, Santiago, and Teheran; under volcanic eruption risk, Kinsha-sa and Manila; under landslide risk, Baghdad, Bogota, Buenos Aires, and Rio De Janeiro; under typhoon risk, Calcutta, Rangoon, and Seoul; and under flood risk, Bangkok, Dakha, and Hanoi.

To avoid the immeasurable life and property damage should a major earthquake strike a megacity, risk assessment should be developed through international cooperation with human networks, as has been developed by the IISEE and its inter-institutional friendship. It is important to enhance assistance of donor countries and international organizations to disaster prevention mitigation activities and to establish a network comprising national government, international organization, universities, and other establishments to exchange information and data for use in the assessment and planning of disaster reduction.

6. Concluding Remarks

At present the Scientific and Technical Committee for the IDNDR, with the cooperation of several international agencies, is promoting numerous international projects including so-called "megacity projects" and "risk assessment projects." These projects, however, will not be able to cover all of the representative disaster-prone megacities in the world, and in some cases, there might be duplication in objective cities between projects. Towards the second half of the IDNDR, it is absolutely necessary to coordinate and integrate these projects so that natural disaster risks in megacities in developing nations are systematically assessed and the results of the assessment including risk-maps are prepared in a coordinated and integrated manner. To modify existing international projects and to fill the gaps among these projects, the STC or the IDNDR Secretariat will be faced with the necessity of finding special funding sources. Special consideration of donor countries in this matter is strongly requested.

I would like to close my presentation by expressing that my organization, IISEE, will try to do its best in contributing to this globally coordinated project with its multiple experiences in earthquake risk assessment

7. References

1) J. P. Bruce, "IDNDR : Its Importance for Metropolitan Areas," Proceedings of IDNDR Aichi / Nagoya International Conference 1993 JAPAN.