I A E G
International Association
of Engineering Geology

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THE PHYSICAL INSTABILITY OF MEGACITIES

(on the management of natural disasters and the physical environment in urban planning)

Second version

A proposal submitted to the

International Council of Scientific Unions

and to the Scientific and Technical Committee for IDNDR

as part of the

International Decade for Natural Disaster Reduction

September 23th, 1991

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FOREWORD

The objective fixed for the IDNDR is to reduce, by means of concerted international action and in particular in developing countries, the loss of human life, the physical damage, and the social and economic disturbance caused by natural disasters.

The proposal submitted in September 1989 by the International Association of Engineering Geology (IAEG), designated to provide the lead function on behalf of the International Union of Geological Sciences (IUGS), is centred in the geo-engineering domain. Emphasis is put on the physical environment and on the management of natural hazards within urban-planning actions for a sound, safe and sustainable development.

The accelerating growth of megacities throughout the world has produced impacts on the physical environment that, even in well-established cities, are self destructive. In addition, the demand for ground space in rapidly growing cities, has led to the use of land that is fraught with natural hazards when developed. These two tendencies increase the number of victims of natural disasters.

The IAEG proposal is for an integrated approach to the problems and their reduction. Its main objectives are:

- to show the efficiency of the preventive means deployed in certain megacities, applying available knowledge, methods and techniques;
- to favor the adaptation of such means to the various geographical, socio-economic, institutional and technical conditions that are especially prevalent in Third World countries;
- to design specific research programmes for filling the major gaps in our knowledge, for improving and adapting disaster-mitigation techniques, and for developing integrated methodologies to manage both risks and the environment in urban planning and institutional systems.

To this purpose, the IAEG recognized the need to involve other associations and unions, such as the geophysicists' (IUGG), geographers' (IGU) and engineers' (WFEO/UATI) unions. Furthermore, the "METROPOLIS" association, which combines more than 50 major cities in the world with a view to favour the exchange of information and to put at the disposal of decision-makers the necessary instruments for the solution of problems concerning megacities, is very interested in this project and will facilitate the contact with the municipal authorities involved.

After a long procedure, involving almost 100 projects submitted by scientific and technical associations and unions, three "Spearhead" and four "Second-Wave" projects were selected by the Special Committee of ICSU for the IDNDR. This committee regarded the IAEG proposal entitled "The

Geological Instability of Megacities" as a most promising enterprise, worthy of recognition as a "Second-Wave" project.

The first meeting of the Scientific and Technical Committee (STC) of the IDNDR, held in Bonn in early March 1991, also showed a strong interest for this project, which is considered as particularly important, not only because of its integrated and multi-disciplinary approach, but also because of the North-South cooperation it proposes. Like the ICSU, the STC particularly recommended accurately to define its scientific and technical objectives, its planning, its organization (management and operation) and the corresponding financial requirements.

In order to finalize the contents of the project and to take up further contacts with potential funding organizations, a meeting financed by the ICSU took place on 23 and 24 May 1991 in Orléans and in Paris (France). The participants of this workshop were members of IAEG (Michael Langer, Philippe Masure, Victor Osipov, Louis Primel), of WFEO/UATI (Michael Leonard, Adelin Villevieille) and the METROPOLIS Association of Megacities (Alain Le Saux). Other invited specialists were prevented from attending this meeting: IGU (Herman Verstappen and Denise Pumain) and STC (IDNDR).

The draft report of the more advanced version of the project prepared by Philippe Masure (IAEG) was given to the members of the ICSU Special Committee for IDNDR during its meeting held in Vienne (Austria) on August 16th, 1991. In the light of the discussion, the Special Committee recommended that the project be renamed "The vulnerability of Megacities" and that the next conference on the "Megacities project", planned by the end of the year in Moscow (Planning conference), give consideration to a massive cooperative effort by scientists, engineers, geographers, planners and members of other concerned professions on programmes for reducing the vulnerability of Megacities.

IAEG fully agrees with this recommendation for a broad and interdisciplinary cooperation, which was planned since the first version of its project (September 1989). The comments of the Scientific and Technical Committee for IDNDR during its second meeting in Guatemaly City (16-20 September) are asked for by the ICSU Special Committee, for possible consideration of this programme as a new Demonstration Project.

The first phase of the project could start immediately after the Moscow meeting during which the organizational and operational conditions of the case history developments will be defined:

- Moscow: Academical Institute for Environment and Engineering Geology
- La Paz: BRGM from France
- Los Angeles (and/or San Francisco): US IDNDR National Committee
- Tokyo: Japanese IDNDR National Committee.

During this planning conference, coordinated programmes proposed by the engineering organizations WFEO/UATI and the participation of IGU will be considered. R&D actions will be examined and multidisciplinary scientific and engineering teams will be organized for its execution.

1 - BACKGROUND

1.1. Urban concentration: a planetary tendency

It is expected that by the year 2000 about 50% of the World's population, or 6.5 billion people, will live in an urban environment, and thus will be concentrated on less than 0.7% of the land surface. Most of these urban sites have been in use for centuries and in some cases for millennia, and their selection usually took no account of the potential dangers presented by geodynamical phenomena, nor of the ecological fragility of the environment. In fact, until the beginning of the 20th Century, most towns saw but little growth and it was not until the middle of this century that growth became intense. In 1900, less than ten cities had more than a million inhabitants, but by the end of this same century it is expected that this number will have risen to 430 or 450. In 1960, three cities had more than 10 million inhabitants and all were located in industrialized countries. In 1980 there were 10 cities of this size, and it is expected that by the end of the century there will be 25, 18 being in developing countries.

1.2. The growth of megacities increases the vulnerability of human society

The accelerated and uncontrolled present growth of such "megacities" in exposed areas has led to their sudden bursting out of their historical confines. This has made them increasingly vulnerable to hazards that have all but disappeared from the collective memory of the citizens, who have lost the ability to perceive dangerous natural phenomena. To this must be added the hazards caused by the impact of Man's activities and structures on an already fragile physical environment, whose degradation further increases the type, number and intensity of "natural" hazards that threaten Man. Rural depopulation which comes together with the migration toward cities also induces new phenomena of physical instabilities. These latter are linked to the decay of drainage and other civil works which where previously maintained by the country people. The hyper-concentration of people, goods, services, infrastructure and production means in the megacities, today renders Mankind particularly vulnerable, the more so as construction quality and the technology used often leave many things to be desired. The multiplication of natural hazards and the increased vulnerability are graphically shown by the worrying statistics since 1960: the number of persons affected by catastrophes increases regularly each year by 6%, which is three times the World's population growth; of these, more than 90% are the victims of natural disasters.

1.3. Poverty increases vulnerability to disasters and vice versa

Poverty increases vulnerability to disasters. The loss of GNP from natural disasters is about 20 times greater in developing than in developed countries, and the number of victims is 150 times greater. The urban explosion in the Third World is no longer related to industrialization, as is still the case in developed countries, but to poor development policies on the national scale.

The megacities in developing countries double in size every 12 to 15 years, but the poorer parts of such cities double in size every 7 years! The poor quality of constructions and of the technology used, the absence of basic infrastructure elements and of understanding the effective capacity of the natural environment to support urban growth, all render such spontaneous urbanization in the more informal parts of megacities particularly vulnerable.

In many cases, the economic and environmental disturbance, and the social and institutional disorganization that usually result from disasters in megacities, form a true brake on the development of Third World countries (the direct damages of the Managua's earthquake, 1972, represented 209% of the GNP of Nicaragua).

1.4. The means for prevention exist, but are particularly neglected in developing countries. Megacities can no longer tolerate this situation

Though most natural hazards may be inevitable, their effects can be prevented or mitigated. The physical instability of megacities can be avoided. Reliable mechanisms for prediction and warning, carefully planned emergency response, judicious land-use policies, disaster-resistant designs, as well as enforceable and enforced codes specific actions have led to notable successes in the developed countries. However, until now, mitigation measures have not been widely implemented because of economic, social and political barriers. Mitigation is commonly perceived as restrictive in nature, costly, and incompatible with the goals of economic development. Furthermore, where economic resources are already inadequate to meet basic human needs, risk reduction may appear to be very low on the list of national priorities, the more so as it is always long-term and difficult to measure, which gives the politicians very little to show for the measures they advocate.

In fact, disasters undermine development efforts and waste development resources. When disaster-proneness or environmental fragility are well-known, failure to include them into planning represents a serious mismanagement of resources. In addition, even if it were "cheaper" to let disasters happen than to prevent them, it is generally agreed that widespread human suffering should be prevented when possible. Megacities form geographic units where the respecting of such rules is fundamental. Faced with a growing international awareness, the authorities of megacities are increasingly forced to manage this new reality.

1.5. The preventive management of risks and the environment: a common commitment to ensure an environmentally sound, safe and sustainable development

Certain megacities that experience an explosive growth can no longer control their expansion, in particular in their suburbs. For most large cities, their development strategy is based on a project-by-project approach (sectorial investment projects). If environmental constraints are not taken into account for such projects, new natural hazards may be

caused, or existing ones may increase in frequency or severity. The cumulative effect of multiple independent decisions can thus lead to serious environmental crises. The project-by-project approach is an ineffective means of promoting social well-being. Integrated development strategies are very much preferable, but they also require an effective control over growth. A development policy must be based on a double socio-economic and environmental approach. The Brundtland Report of 1987 declared that, even though Man for some time has been aware of the effects of economic growth on the environment, the time has now come to question in how far environmental agressions may affect our economic perspectives; in fact, causes and effects are inextricably interwoven. In a more general sense, the reduction or the prevention of risks must go hand in hand with the protection or improvement of the environment, in the same perspective of environmentally sound, safe and sustainable development.

From this it is obvious that the control of the increasing problems of physical instability in megacities must form one of the priorities of the International Decade for Natural Disaster Reduction (IDNDR) decreed by the United Nations Organization (UNO) for the 1990s.

2 - AIM AND OBJECTIVES OF THE IAEG PROPOSAL

2.1. The megacities should be integrated in an "organic" fashion into their natural site

Today, many megacities seem to be creations that are divorced from nature, which they exploit at their convenience, imposing on it their own equilibria and dynamics, and degrading its physico-chemical and biological characteristics. They behave like autonomous entities, devouring natural space, difficult to control, and whose entropy in a physical, social and cultural sense can end up by compromising the medium- and long-term development projects.

The accelerating growth of megacities throughout the world has produced situations which, even in well-established cities, are self-destructive. In addition, the demand for ground space in fast-growing cities has led to the use of land which, earlier avoided, is fraught with hazards when developed.

Hazards associated with man's occupation of the terrain include:

i) subsidence (due to groundwater extraction), settlements and collapse (due to underground cavity collapse);

ii) the rise of piezometric levels and the resulting flooding of space below the ground surface (i.e., basements, underground space, parking, garages, etc.);

iii) the contamination of soil and water from solid and liquid wastes, accidental spills, leakage and poorly designed landfill sites;

iv) the loss in bearing capacity of soil foundations (due to saturation, concentrated loads, internal erosion, etc.);

v) the loss of natural resources (construction materials, water, etc.).

Natural hazards, with or without the influence of man, include:

a) floods, mudflows, erosion and sedimentation (particularly that resulting from deforestation);

b) landslides, natural as well as man-induced (i.e., the cutting or overloading of slopes, groundwater-flow changes);

c) earthquakes, volcanic eruptions;

d) coastal erosion and sedimentation;

e) swelling or contraction (desiccation) of soils.

In urban and regional planning, man acts on his environment by drawing up a plan of spatial organization. However, he cannot create such a space without taking account of the properties, limits and threats of the natural environment. The time has come to wake up the megacities to the reality that they, like all other cities in the past, must integrate themselves into their natural site in an organic fashion. From this viewpoint, engineering geology has a pivotal role to play. The physical environment (structure and dynamics) that surround and support human life, represents the conceptual framework for environmental-planning action.

2.2. 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 or 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. The IAEG considers it as 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 the Third World.

2.3. Objectives and advantages of the project

The main objectives of the project on management of the physical instability of megacities are:

. to show the effectiveness of the preventive means deployed in certain megacities, applying available knowledge, methods and techniques;

. to favour the tailoring of such means to the various geographical, socio-economic, institutional and technical conditions that can be found especially in Third World countries;

. to design specific research programmes for filling the major gaps in our knowledge, for improving and adapting disaster-mitigation techniques (resistant constructions, protection and improvement of the environment), and for developing integrated methodologies to manage both risks and the environment in urban planning.

The main aim of the project is thus 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 programme present multiple interests, which include:

- Increased awareness and information for politicians and other decision-makers, and for economists, sociologists, engineers, architects 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 capability to control urban growth, the types of land-use and 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 a 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 new suburbs.

- Increased employment because of the creation of new activities, through the development of programmes of physical rehabilitation, protection and prevention in the megacities.

- The necessary rehabilitation work on the degraded environment to increase the protection against natural hazards in existing urban areas can be expensive because of having neglected the characteristics of the physical environment in the past. On the contrary, the extra cost of the preventive plans will be minimal when it is integrated into the planning of new suburbs or of the renovation of older parts of town. Eventually, over the next twenty years the volume of buildings and complementary infrastructure to be created in the urban areas 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 will be very quickly amortized.

2.4. Difficulties and requirements of the project

The scientific fields involved in the project are numerous: engineering geology, soil and rock mechanics, hydrogeology, hydrology, geochemistry, climatology, pedology, Quaternary geology, civil engineering, seismic engineering, geophysics, neotectonics, geomorphology, volcanology, geography, ecology, ecotoxicology, medicine, mathematics, architecture, urban planning, economics, sociology, as well as law, administration and institutional specialists.

It requires a generalized and integrated approach, but, in order to remain on a manageable and realistic footing, and to avoid dispersion, this approach should remain centred on the management of the physical instability of megacities.

Multi-disciplinary teams should be created and coordinated, with a view to the acquisition of highly complex data that must be processed and managed in a dynamic manner, and that must be translated into easily understandable recommendations and instructions for the users (decision-makers and persons charged with educating the population).

All this requires from the scientists and engineers, and from the politicians and other economic and social decision-makers as well as from the population in general, that a permanent dialogue is created and maintained between all, which should be further enriched by adapting sectorial experiences from other fields. That this is possible has already been proven (e.g., La Paz). The use of new methods and tools, such as remote sensing, geographic information systems, computerized data-bases, decisional mapmaking and systems analyses, will all help in such complex ventures.

3 - STRUCTURING AND TECHNICAL CONTENT OF THE PROJECT

To overcome and control their own particular geo-instability problems, several large cities throughout the world have established extensive data banks, management systems and specific organizations.

- Part 1 of the proposal will be to review the procedures established in three or four of such megacities, determine the common elements and, using a uniform set of criteria, establish a basic methodology for the management of natural disasters and the physical environment in megacities. This phase involves case history studies.

- Part 2, based on the review of the major gaps in our knowledge and on the lessons from Phase 1, will establish theoretical and practical tools and models for the monitoring, prediction, control and mitigation of geo-unstable situations. This part consists of R&D programmes.

- Part 3 will take the basic methodology and the theoretical and practical models, and apply them to three or four megacities where the monitoring, prediction and control of instabilities are non-existent or at a minimum level. This constitutes the phase of application to megacities.

- Part 4 will be a summary review of the attempts made to establish the model in these application cities and the preparation of a final report.

. Part 5, informative, will be developed during the overall programme to make all persons concerned aware of the project by means of seminars, scientific meetings, workshops, etc. This constitutes the seminars and informative actions.

3.1. Case-history studies

During the meeting at Orléans, four cities were selected as case-history subjects (Phase 1), in view of the efficiently described experience and basic data that are available for them in the field of managing geo-instability in urban development. They are Los Angeles (and/or San Francisco) in the USA, La Paz (Bolivia), Moscow (USSR) and Tokyo (Japan). The teams to implement these case-history studies were identified for La Paz and Moscow; for the former it will be BRGM in France, which in 1976-1977 drew up the integrated urban-development plan of La Paz within a framework of natural-disaster prevention, and for the latter it will be the Academical Institute for Engineering Geology and the Environment of the USSR, which disposes over Soviet State funds to carry out the evaluation of the physical environment of Moscow.

The METROPOLIS association will facilitate the contacts with the municipal authorities of Los Angeles and Tokyo. The organizations that could compile the data on these two megacities, which are both very much exposed to natural disasters, have not yet been identified. The national IDNDR committees for the USA and Japan might facilitate this selection.

For each case history, the conceptual approach to the problems of physical instability of megacities might be organized into a logical framework as follows:

CASE HISTORY: ASSESSMENT AND MANAGEMENT OF THE PHYSICAL INSTABILITY OF MEGACITIES

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

A.1 - The "natural" environment
Geology, geochemical and geotechnical conditions, surface and ground waters, climatology, etc.

A.2 - 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.), etc.

A.3 - The community organization for managing risks and the physical environment in urban planning

B - Processes of physical instability and their relation with urban development conditions

B.1 - 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 and waters; exhaustion of natural resources; etc.

B.2 - 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.

B.3 - The interaction between natural hazards and urban impact on the environment
Determination of physical instability processes and of the eco-geological vulnerability of the urban environment, leading to induced "natural" hazards.

C - Evaluation of the socio-economic consequences 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.

D - The management of risks and the environment

D.1 - The means for mitigation and prevention of risks due to physical instabilities. Scientific and engineering actions

D.2 - 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.

E - Contribution to decision-making for the environmental management of megacities

E.1 - Evaluation of the geo-ecological capacity of urban sites (resources and fragility) and environmental bases for a spatial structuring

E.2 - Cost-benefit analysis of the preventive actions for natural disasters and/or for environmental protection

E.3 - Data management systems or methods, for making the information accessible to the end-user

F - Institutional system (framework and organisation) : finances, integrated development planning, operation control, warning, rescue services.

F - Communication plan: information and awareness of decision makers and population

3.2. R&D programmes

In view of the variety of the problems, their multi-disciplinary character, the manifold possible persons intervening, and the uncertainty concerning the means of financing, it seems desirable to subdivide the project into several complementary modules.

The few R&D subjects mentioned hereafter are only given as examples, as they should be discussed more fully among the various scientific and technical organizations involved during a next meeting, which will probably be held in Moscow in late 1991 or early 1992 (see later):

- Economic evaluation of the direct and indirect damage caused by natural disasters in megacities; cost-effect 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.
- Systems analysis models for physical instability of megacities.
- Preparation of a Geo-Ecological Information System (GEIS) to help in the decision-making process for the urban planning of megacities.
- Adaptation of construction codes to different socio-economic and technological levels.
- etc.

3.3. Application phase to megacities

It is obvious that as soon as the models of management, control, cost-benefit analysis, prevention and rehabilitation are available, they will be used in two or three application sites. In this case, Mexico City, Lisbon, Tashkent, Alma Ata, Calcutta, Seoul, Beijing, Bangkok, Sao Paulo, Rio de Janeiro or Algiers spring to mind. However, it would be premature to arrive at a choice at this stage, but contacts should be made, either directly, or through the METROPOLIS Association or the national IDNDR committees, in order to prepare the application projects.

3.4. Seminars and informative actions

The objectives of making all persons concerned aware of the project, and 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 with the decision-makers and particularly with the mayors. Such meetings can be specific or can be integrated in other sessions, organized by UN organizations, scientific and technical associations, or international associations of megacities.

4 - PRACTICAL ASPECTS

4.1. Management plan

The proposal submitted here represents an extensive, ambitious, complex, multinational activity, which is anticipated to have a very significant effect on large urban centres in the 21st Century. The management and operation of the project is no less formidable and calls for an organizational plan that will accommodate a myriad of institutional and national aspirations.

The IAEG, designated to provide the lead function on behalf of the IUGS, recognized the need to involve other associations and unions at both the executive and operational level. We believe that the operational plan outlined here will achieve this objective and the contacts developed with IUCG, IGU, WFEO/UATI (and perhaps IIASA and Health organizations in the future) are very promising.

The general direction of the project would be provided by a Directorate working closely with an advisory board formed of representatives of related international unions and associations. The Directorate would report to the IAEG Co-ordinating Committee, which would ensure that the Megacities project does not duplicate nor is duplicated by other multinational or inter-union activities.

The Directorate (supported by a full-time Executive Secretary) would be in direct contact with and be responsible for monitoring the national groups designated to undertake specific national projects in Phases 1 and 3, and would be responsible for persons or organizations preparing reports in Phases 2 and 4.

National groups in charge of the implementation of specific national projects would, in turn, be composed of representatives of IAEG Work Commissions at national level, scientific specialists and local representatives of other international unions and associations, similar to those represented on the Advisory Board (e.g., IUGG, IGU, WFEO/UATI, IAH, ICL, etc.).

A provisional Organization Chart is presented in Figure 1.

Comments on the Organization Chart

i) Composition of Directorate

Directors should originate from organizations that are committed to at least some elements of the Megacities project. Suggestions include:

BRGM	:	France
BGR	:	Germany
Academy of Sciences	:	USSR
IGUSP	:	Brazil

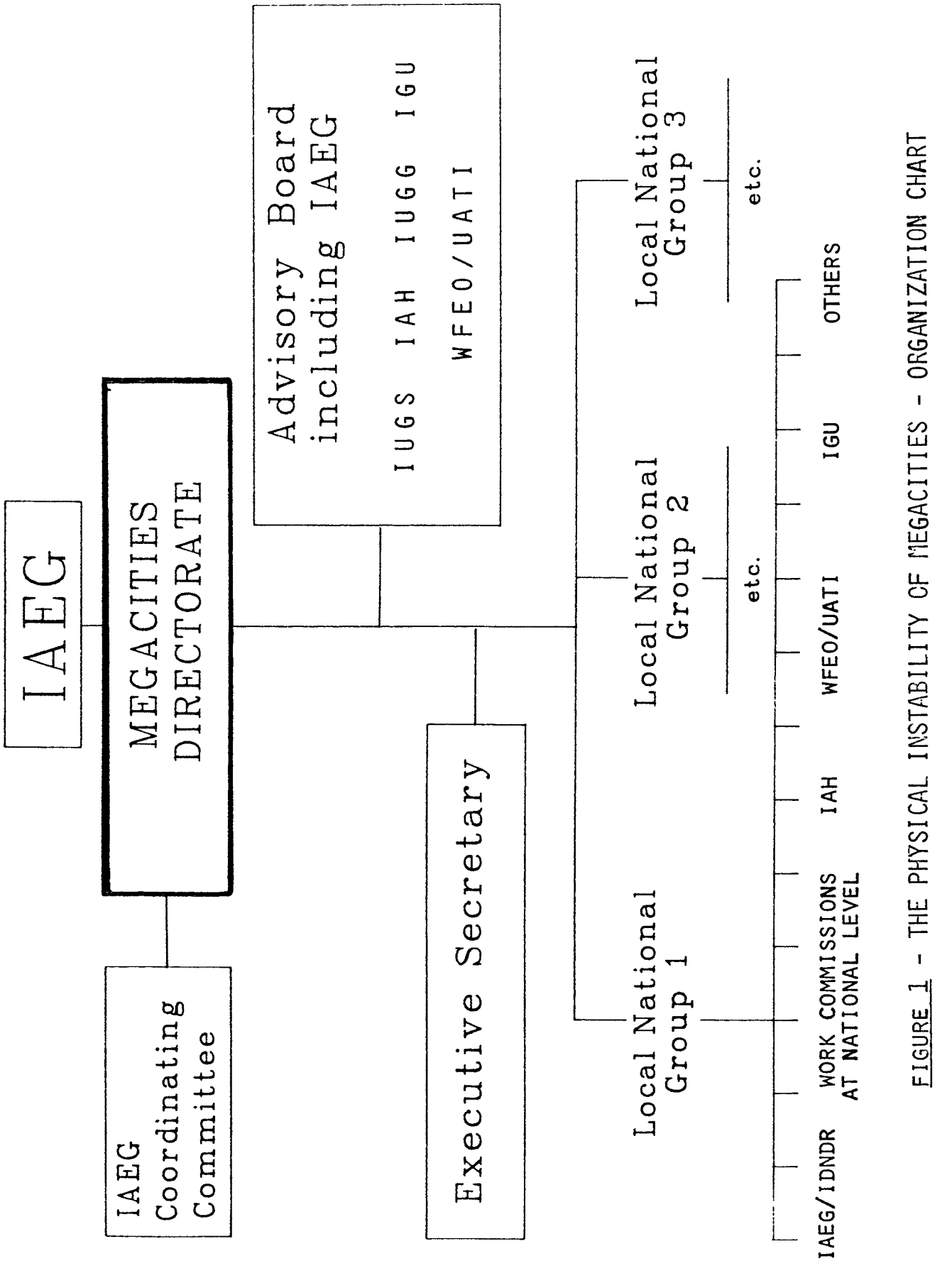


FIGURE 1 - THE PHYSICAL INSTABILITY OF MEGACITIES - ORGANIZATION CHART

The Chairmanship of the Directorate should change every twelve months, where practical to do so.

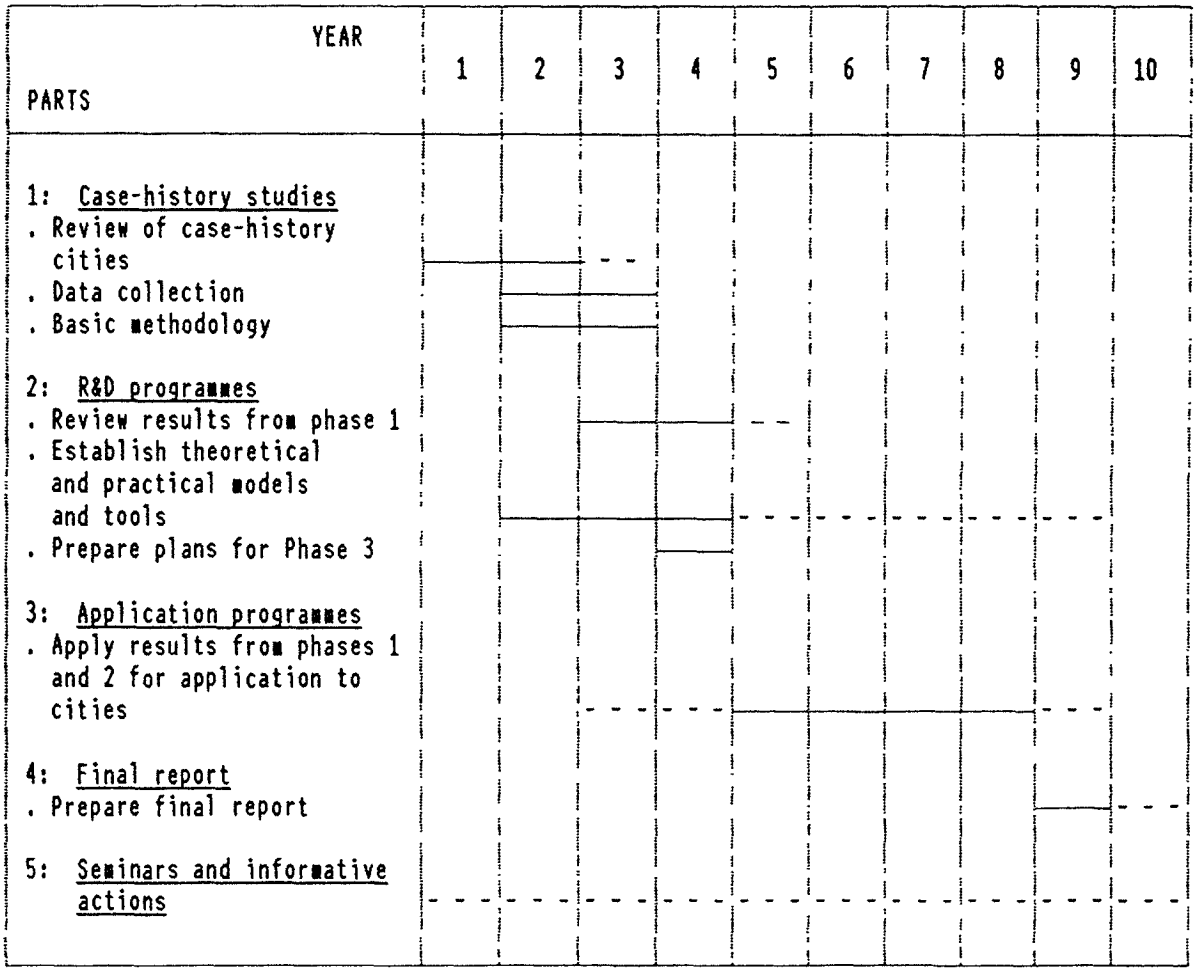
ii) Executive Secretary

A full-time, paid position, with location probably best in Western Europe and in proximity to at least one of the Directors of the Directorate.

iii) Meetings

The Directorate should meet collectively with the chairmen of local national groups (i.e. a Steering Committee), say twice a year, and with the Advisory Board once a year when the project is underway. An additional meeting or two may be necessary in the early stages.

4.2. Schedule



4.3. Funding requirements

All figures are expressed in US $ (1991 dollars).

i. Directorate

Estimated annual costs:

. Secretariat	$ 80,000 to 100,000	(Full time employment of Executive Secretary and operation of the Secretariat).
. Travel Assistance	$ 30,000 to 50,000	(For technical and directorate meetings).
. Special Actions	$ 70,000 to 90,000	(For contracted studies, not readily covered by local groups or covering international aspects).

Such funds would be required on a per-annum basis for 10 years, i.e. to an estimated total of $ 1,800,000 to 2,400,000. External funding is requested for this amount.

ii. R&D programmes

The establishment of the methodological system developed in Phase 1 and of the theoretical or practical models for the monitoring, prediction and control of geo-unstable situations, need specific research done by specialized organizations or laboratories. The other R&D programmes also require specific funding. The estimated total cost for a three-year program is $ 500,000 to 1,000,000. External funding is partly requested for this amount.

iii. Megacities programmes

Costs associated with the various studies planned in Phases 1 and 3 would, in general, be incurred at the specific locations and could be expected to be financed by local sources. Nevertheless, costs associated with Case-History Cities may need some seed funding and costs associated with Application Cities may need some external support. With these variations in mind, the following estimates of costs are given.

(a) Case-History Cities

Costs associated with Case-History Cities in Phase 1 would be expected to be raised within the city or nation involved. Project activities would largely relate to gathering and reviewing data previously obtained. Little new data gathering is

expected but electronic data processing may have to be extensive to present data in a uniform format.

As Case-History Cities may see the impact of the whole project having a limited direct effect on themselves, some external funding may have to be sought and found.

Estimated cost = $ 100,000 per city per year.

For these cities and the project extending over three years in each city, costs are estimated at $ 900,000 plus $ 100,000 for contingencies.
Total estimated cost= $ 1,000,000.

(b) Application Cities

Costs associated with applying the methodological model to the Application Cities would certainly need to cover the acquisition of new data. Thus costs could be quite variable from year to year and from place to place. As half of the Application Cities could be in developing countries, even the modest cost approximated here may be overwhelming for the site concerned. Thus external funds may have to be sought.

Considering known factors and circumstances, the costs for Phase 3 are estimated at $ 200,000 to 300,000 per city per year. This gives a total cost for four cities for four years at $ 3,200,000 to 4,800,000 plus $ 300,000 to 500,000 for contingencies = $ 3,500,000 to 5,300,000. Much of this funding could be expected to be raised within national boundaries of each selected site, with some external funding required for developing countries.

iv. Summary of Costs

For a ten-year programme:

a)	Directorate costs:	$ 1,800,000 to 2,400,000 external funding required
b)	R&D programmes:	$ 500,000 to 1,000,000 external funding required
c)	Megacities programmes:	$ 4,500,000 to 6,300,000 mostly raised at local level with some external funding possible.

The total cost for a ten-year programme stands at about US$ 10,000,000.

v. Funding sources

Part of the financial resources for developing the Megacities Project should come from the IDNDR trust fund, provided the project is

selected by the Scientific and Technical Committee. However, other funds may come from other UN organizations (e.g., as a Demonstration Project UNDP) or from international development-aid banks, such as the World Bank, the IBD or the ADB, as well as from the CEC or from bilateral cooperation funds.

4.4. Future meetings

The next Workshop, during which the representatives from the IAEG, IGU, WFEO/UATI and IUGG can deliberate and design the definitive organization of the Project, once it will have obtained the final approval from the ICSU and the STC of the IDNDR during their meeting of September 1991 at Guatemala City, will be held at Moscow; Professor OSIPOV, director of the Academical Institute for Engineering Geology and the Environment of the USSR, has invited the representatives to meet in late 1991 or early 1992.

In 1992, the Second Latin-American Symposium on Urban Geologic Risks, to be held at Pereira (Colombia) and the International Geological Congress, to be held at Kyoto (Japan), will provide the venues for special meetings on the Megacities Project and its state of advance. The UNCED conference of Rio (June) could receive a specific message on the physical instability of megacities.

A major meeting on the Vulnerability of Megacities could be scheduled for 1993 or 1994, in order to present the results of Phase 1 of the Project, and to prepare the Application and Training/Information projects.

All these points will be discussed in more detail, once the necessary financial means have been secured for the Project.