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Intergovernmental conference on the assessment and mitigation of earthquake risk

Paris
10-19 February 1976

Final report

Unesco

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FINAL REPORT

1. INTRODUCTION

By resolution 2.222, adopted at its eighteenth session, the General Conference of Unesco authorized the Director-General, in co-operation with appropriate organizations of the United Nations system and with the competent international non-governmental organizations, to promote the study of natural hazards of geophysical origin and of the means of protection against them, particularly by convening an Intergovernmental Conference on the Assessment and Mitigation of Earthquake Risk.

In order to lay the foundations of this Conference on a sound scientific and technical basis, the Director-General convened at Unesco Headquarters in December 1974 a Preparatory Committee of Experts whose task was defined as follows:

(i) to review developments in seismology, earthquake engineering and related subjects since the intergovernmental meeting on seismology and earthquake engineering held at Unesco Headquarters in April 1964;

(ii) to draw up a draft agenda for the Intergovernmental Conference;

(iii) to advise on what action should be taken by Unesco, in co-operation whenever appropriate with competent international non-governmental organizations, in preparation for the Conference.

The Report of this Preparatory Committee, containing its proposals regarding the agenda and organization of the Conference, was embodied in document SC-75/WS/14 and was transmitted to Member States under cover of the circular letter (CL/2405) by which the Director-General invited them to participate in the Conference.

Prior to the Conference, the Unesco Secretariat invited leading specialists to prepare discussion papers on each item of the proposed agenda. These were circulated to Member States and to invited international organizations in advance, and were submitted to the Conference itself as documents SC-76/SEISM/3-19. The Unesco Secretariat submitted to the Conference a note entitled "Mechanisms of International Co-operation" (document SC-76/SEISM/20).

The Conference took place at Unesco Headquarters in Paris from 10 to 19 February 1976.

2. PARTICIPATION

The following 45 Member States of the Organization were represented by delegates: Algeria, Austria, Bulgaria, Canada, Chile, China, Congo, Denmark, Ecuador, France, German Democratic Republic, Federal Republic of Germany, Ghana, Greece, Guatemala, Hungary, Iceland, India, Indonesia, Iran, Iraq, Italy, Jamaica, Japan, Jordan, Libyan Arab Republic, Mexico, Monaco, Nepal, Netherlands, New Zealand, Norway, Peru, Portugal, Romania, Spain, Sweden, Switzerland, Trinidad and Tobago, Tunisia, Turkey, Union of Soviet Socialist Republics, United Kingdom, United States of America, Yugoslavia.

The following Member States were represented by observers: Bolivia, Brazil, Colombia, Egypt, Haiti, Pakistan, Panama.

The Holy See was represented by an observer.

Representatives of the Office of the United Nations Disaster Relief Co-ordinator (UNDRO), the International Atomic Energy Agency (IAEA), the International Bank for Reconstruction and Development (IBRD) and the Inter-American Development Bank (IDB) attended the Conference, and observers from the following international organizations:

- The Arab Educational, Cultural and Scientific Organization (ALECSO)
- The Latin American Physics Centre (CLAF)
- The Regional Seismological Centre for South America (CERESIS)
- The International Council of Monuments and Sites (ICOMOS)
- The International Council of Scientific Unions (ICSU)
- The International Union of Architects (IUA)
- The International Organization for Standardization (ISO)
- The Union of International Engineering Organizations (UATI)
- The International Association for Earthquake Engineering (IAEE)
- The League of Red Cross Societies (LICROSS)
- The Pan-American Federation of Engineering Societies (UPADI)

The full list of participants is given in Annex II to this Report.

3. OPENING OF THE CONFERENCE

The Conference was opened by the representative of the Director-General of Unesco, Mr. Abdul Razzak Kaddoura, who firstly referred to the extreme intensity of damage by major earthquakes, unsurpassed by any other natural phenomena, which has caused the loss in the last 12 years of over one hundred thousand lives and thousands of millions of dollars in property. Mr. Kaddoura went on to review the action taken by Unesco in seismology and earthquake engineering since the previous intergovernmental meeting in 1964. This included the promotion of projects supported by the United Nations Development Programme, the organization of symposia, missions to investigate earthquake disasters, and the establishment of international and regional centres for data handling and for training in seismology and earthquake engineering. Mr. Kaddoura pointed out that whereas the intergovernmental meeting of 1964 had as its primary objective the advancement of scientific knowledge, the main purpose of the present Conference would be to promote the full application of scientific and technical knowledge for the benefit of mankind. The full text of his speech is given in Annex I to this Report.

4. ELECTIONS

The Conference elected its officers as follows:

Chairman:
  Professor Jai Krishna (India)
Vice-Chairmen:
  Professor Keizaburo Kubo (Japan)
  Professor Nathan M. Newmark (U.S.A.)
  Dr. Emilio Rosenblueth (Mexico)
  Professor E. F. Savarensky (USSR)
Rapporteur-General:
  Dr. John Tomblin (Trinidad and Tobago)

5. AGENDA

The Conference adopted the following agenda:

1. Election of Chairman
2. Adoption of Rules of Procedure
3. Election of Vice-Chairmen and Rapporteur
4. Adoption of agenda
5. Adoption of programme and time-table
6. Establishment of commissions
7. Establishment of working groups
8. Assessment of earthquake risk
   8.1 Seismic zoning
   8.2 Microzoning (including effects of faulting, creep, landslides, etc.)
   8.3 Earthquake prediction
   8.4 Induced seismicity
   8.5 Tsunamis
9. Engineering measures for loss reduction
   9.1 Buildings (building codes, local materials and design, etc.)
   9.2 Utilities (railways, communications, pipelines, highways, etc.)
   9.3 Urban plans
   9.4 Special structures and plants (large dams, nuclear plants, offshore oil wells, etc.)
   9.5 Strengthening of existing structures
10. Implications of earthquake risk
    10.1 Economic implications (losses and insurance, cost-benefit studies, mathematical models, etc.)
    10.2 Human implications (awareness of risk, psychological reactions, public information, etc.)
    10.3 Social implications (civil protection, legislative and regulatory measures, etc.)
11. General topics
    11.1 Earthquake parameters for engineering design
    11.2 Field studies of earthquakes
    11.3 Interdisciplinary education and training
12. Implementation
    12.1 Interdisciplinary research on the mitigation of earthquake losses
    12.2 Mechanisms of international co-operation
13. Adoption of report

6. ORGANIZATION OF WORK

In order to permit full discussion of all points on the above agenda, the Conference set up three Commissions and two Working Groups, as follows:

Commission A (Assessment of earthquake risk)

Chairman:
  Professor Stephan Mueller (Switzerland)
Vice-Chairman:
  Dr. Mansoor Niazi (Iran)
Rapporteur:
  Dr. M. J. Berry (Canada)

Commission B (Engineering measures for loss reduction):

Chairman:
  Professor Giuseppe Grandori (Italy)
Vice-Chairman:
  Dr. Sergei Bubnov (Yugoslavia)
Rapporteur:
  Dr. Luis Esteva (Mexico)

Commission C (Human, social and economic implications):

Chairman:
  Dr. Otto Glogau (New Zealand)
Vice-Chairman:
  Mr. W. Wangsadinata (Indonesia)
Rapporteur:
  Mr. K. Westgate (United Kingdom)

Working Group on interdisciplinary research:

Convenor:
  Professor N. N. Ambraseys (United Kingdom)

Working Group on mechanisms of international co-operation:

Convenor:
Dr. Ulf Ericsson (Sweden)

The Steering Committee of the Conference was composed of the Chairman, the Vice-Chairmen and the Rapporteur-General of the Plenary and the Chairmen of the three Commissions, assisted by the Secretary-General of the Conference.

7. GENERAL DISCUSSION

A complete list of the topics in the order presented during the general discussion would be long and repetitive. They have therefore been summarized under three headings: recent advances in research; current problems to which solutions were suggested or requested; and future objectives which require priority attention.

7.1 Recent advances in research

It was clear that much has been achieved through bilateral and international co-operation with help from international agencies, especially Unesco. Large numbers of students have received high-level training at the International Institute of Seismology and Earthquake Engineering in Tokyo and at the Institute of Earthquake Engineering and Engineering Seismology in Skopje. Within many individual countries, seismology has become far better organized. In China, for example, there has been remarkable progress in recent years using a comprehensive, interdisciplinary approach, and the involvement of large numbers of amateur observers to supplement studies by specialists on prediction and other aspects of applied seismology. Examples were given of the value of educating a large part of the population firstly in the observation of animal behaviour and other natural phenomena as a means of immediate prediction of major earthquakes, and secondly in the general understanding of earthquake hazards so that these can be reduced or eliminated. In Japan, close interdisciplinary co-operation has led to major developments in the technology of high-rise buildings, long-span bridges and tunnels in the ground. In the Soviet Union, interdisciplinary studies have resulted in significant improvements of the seismic zoning map and of the seismic scale in the building code. New mathematical methods of risk assessment, and of earthquake prediction, have been successfully tested. In the United States a new national effort is being made to establish seismic design provisions through a large, interdisciplinary team which includes from the earliest stage the authorities responsible for enacting the final regulations.

In the field of data collection, it was reported that valuable results have already been obtained from strong-motion accelerographs. With regard to observatory practice, it was noted that a committee of the International Association of Seismology and Physics of the Earth's Interior is in the process of producing a revised and more comprehensive edition of the existing manual. The representative of the International Commission on Large Dams (UATI) illustrated the great refinement that had taken place in recent years of methods for modelling the response of large dams and the consequent progress towards mitigation of earthquake risk.

7.2 Current problems

One of the central issues is the need for progress from theory to practice in the application of earthquake-resistant design. There exists an élite of highly-trained engineers who understand and apply anti-seismic techniques, but there is a lack of communication between them and the small builders. Several delegates emphasized the need for changes in the design of private dwelling houses, especially the avoidance of heavy roofs. There is a particular problem with adobe-type rural buildings, and research is required on suitable reinforcement techniques, using readily accessible local materials. Many delegates underlined the need for public education in seismic hazard avoidance, with material written in the simplest possible language. It is important to understand the particular needs and customs of individual populations before prescribing measures for risk mitigation, especially since the social implications vary greatly from country to country.

Among problems hindering the progress of research on risk assessment, mention was made of difficulties such as the frequent failure of governments to give adequate recognition to seismological research, shortage of research funds and lack of encouragement to students to work in the field of seismology. Some countries, on the other hand, have no shortage of funds but need foreign experts to help with training programmes.

At the administrative level, the questions were raised of how to define acceptable risk levels, and who is responsible for establishing these levels. The need for design parameters and criteria for decision-making were also noted. It was suggested that the application of standards in earthquake-resistant design might be achieved if insurance companies were to charge premiums graduated over a wider and more realistic range. The need was illustrated for measures to protect historical monuments from earthquake damage.

7.3 Future objectives

One of the most repeated themes under this heading was the call for mutual understanding and discussion of earthquake risk problems by seismologists, geologists and engineers. One delegate suggested the compilation of a glossary covering all three subjects. To improve the collection of near-field data, there is a need for simpler, accelerograph-type instruments in large numbers, to allow the quantitative assessment of ground motion. The establishment of specific parameters on ground motion, energy radiation and stress drop was identified as a future objective. The global analysis of tectonic models and energy release was also considered an important means of prediction.

With regard to the dissemination of information, delegates suggested the production of a manual of simple geophysical experiments and their interpretation, and of a handbook for small buildings in developing countries. It was considered important that mechanical and electrical engineers should be sufficiently versed in earthquake-resistant design to ensure that equipment under their control is properly designed and anchored in seismically active regions. There was a request for the wider dissemination of the Unesco earthquake mission reports, and it was suggested that such missions might provide an opportunity for field training of good research students. One delegate recommended the holding of seminars on topics which bring together experts in several related disciplines.

8. ASSESSMENT OF EARTHQUAKE RISK

8.1 Seismic zoning

The discussion was based upon document SC-76/SEISM/3. The first author, introducing the paper, reviewed the existing procedures and drew attention to the problems of definition of potential source regions, largest possible magnitudes, reference soil conditions and attenuation curves.

The collection and organization of basic geoscience data was discussed. It was emphasized that catalogues of source parameters are vital to the study of seismic risk and that the listed parameters should be accompanied by error estimates. It was recommended that Unesco and governments co-operate to compile all historical information on damaging earthquakes.

The need for more instrumental data in the near-field was stressed, since the physical processes in this region are poorly understood.

While there was general agreement that macroseismic intensity data are useful for mapping earthquake damage and can serve as indicators of seismic hazard, concern was expressed as to the feasibility of finding unique relationships linking intensity with physical ground-motion parameters.

In view of some difficulties in applying the current macroseismic intensity scales, it was recommended that they be updated to be consistent with modern construction practice and that compatible versions be developed to be applicable to regional conditions.

It was generally agreed that all geoscience data must be considered in the determination of seismic risk and that historical and instrumentally determined seismicity must be combined with all available geological and geophysical data.

There was a general discussion on some of the techniques of data processing used in compiling seismic zoning maps. It was noted that existing historical catalogues covering more than 1,000 years indicate that seismicity is sometimes not a stationary phenomenon in continental regions.

It was also recognized that the magnitude-frequency relation is only valid in the intermediate magnitude range and that deviations from this can be appreciable at higher magnitudes.

In analysing data it was considered that more sophisticated models should be explored than those presently used in order to exploit the full potential of some data bases.

It was recognized that there can be several types of seismic zoning map for a territory, each having its own use. The Commission noted with interest the detailed procedures described by some countries for compiling seismic zoning maps for their territories.

It was suggested that geologists and other geoscientists should be consulted and invited to contribute to the compilation of seismotectonic maps.

The concept of seismic risk estimation as an aid to decision-making was presented to the Commission. It was pointed out that such calculations require the joint analysis of a number of probability functions which typically include those of the seismic ground motion, the population distribution as a function of time, the distribution of buildings and other critical engineering works as a function of time, the susceptibility of these to damage and the rate of human casualties. Separate functions may be calculated for economic loss and human casualties. Usual criteria for decision-making would seek to reduce the latter to zero and the former to some acceptable level.

8.2 Seismic microzoning and related problems

The discussion was based upon the working paper SC-76/SEISM/4. The author introduced the main aspects of the problem and suggested that sometimes microzoning is taken to include the soil-structure interaction. It was agreed that microzoning should be treated as a special research topic with the aim of calculating the response of varying soil conditions to seismic motion. The results of such calculations can be presented in the form of microzoning maps covering local areas.

It was agreed that the terms microtremors and small earthquakes are open to varying interpretations and that clear definitions should be developed. There was some difference of opinion as to the applicability of microtremor and small earthquake data to the determination of strong ground motion from a large earthquake. The use of microtremors and small earthquakes are valid topics for research.

Recent observational data suggest that present analytical and numerical methods may be oversimplified and are not yet capable of predicting reliably the differences in surface motion in many practical cases. Analytical methods may however be of value in extending observational data to nearby sites with different soil conditions, particularly in the far-field region.

It was suggested that the most appropriate way to select earthquake motions for the purposes of design is to assemble a group of strong motion records obtained under comparable conditions and to extrapolate from these records by simple scaling. The local soil conditions may modify the response spectrum substantially and this must be taken into consideration. If one single parameter must be insisted upon as a criterion for different soil conditions, it appears that peak ground velocity is probably best.

Soil liquefaction and related phenomena, tsunamis and induced seismicity associated with large dams were identified as being important site-specific problems.

Concern was expressed at the paucity of relevant strong-motion accelerograms available to seismologists from the near-field region. It was unanimously agreed that many more strong-motion instruments must be deployed in earthquake-prone regions in order to increase the world-wide collection of data relevant to different soil conditions. Preferably some of these instruments should be grouped in three-dimensional arrays to study the responses of different soils.

8.3 Earthquake prediction

The Secretary-General introduced the topic, emphasized the great interest of the general public in earthquake prediction and reminded the delegates that the proceedings of the Commission would be used by both governments and Unesco as guidance to future action in both the scientific and socio-economic fields.

The author of discussion paper SC-76/SEISM/5 summarized the principal points of the paper. He stressed that earthquake prediction studies must be carried to a high degree of reliability and that this would require a great deal of expensive work and international co-operation. He also described some aspects of the prediction programme in the Union of Soviet Socialist Republics.

The Conference was then given an account of the recent successful prediction of a large earthquake in Liaoning province, China, which resulted from the application of a complex approach combining the activities of a large number of scientists and amateur workers. The principal phenomena that were monitored included changes in ground tilt and uplift, water-level variations, geomagnetic and electric field variations, time-space variations of seismicity, and anomalous animal behaviour.

There followed a review of the United States prediction programme. It was emphasized that this programme was still mainly concerned with investigating methods of prediction and that it would be some time before predictions could be made with satisfactory reliability. Prediction research still lacked an adequate theoretical basis, especially for strike-slip faulting. Attention is therefore concentrated on studies of crustal deformation rather than of variations in the velocities of seismic wave propagation.

Despite an intensive programme in Japan, there does not yet appear to be sufficient consistency among the precursory phenomena that have been monitored there to warrant reliable predictions.

Other delegates described particular laboratory and field studies aimed at earthquake prediction.

The Conference then turned to discuss the social and economic implications of earthquake prediction and the discussion was introduced by R. Kueneman (Canada).

He emphasized the dilemmas which exist for social scientists in attempting to study the problems associated with the formulation of social policy to meet the potential effects of imminent earthquake prediction. He stressed that the results of social science research on disasters are relevant to the effects of earthquake prediction. He discussed the main aspects of this research; warnings, mental health, economic behaviour, insurance and legal implications. He expressed concern that certain policy measures undertaken as a result of an earthquake prediction may lead to social and economic inequalities.

The Conference was informed of the programme in the United States on this subject. The need for public education was emphasized and the Chinese and Japanese experiences of educating and informing the public about warnings and precautionary measures were described and discussed.

8.4 Induced seismicity

The author introduced discussion paper SC-76/SEISM/6 and provided some supplementary information with particular reference to the First International Symposium on Induced Seismicity, held in September 1975 in Banff (Canada). The following topics were considered:

1. Reservoir-induced seismicity

   It was suggested that earthquakes induced by reservoirs are triggered either by the increase of pore pressure or, more rarely, incremental load stress. It was therefore emphasized that a knowledge of the state of stress in the neighbourhood of the reservoir prior to impounding is a prerequisite to an assessment of the possibility of induced seismicity.

   Present indications are that earthquakes are induced by about one reservoir in 14 among those with maximum depth greater than 100 m and water volume greater than 10^9 m^3. It was generally agreed that prudence requires careful monitoring for possible seismic activity near all new reservoirs which will exceed these limits of size, both prior to, during and immediately after impounding.

2. Seismicity induced by mining

   It was indicated that a special feature of earthquakes induced by mining operations is that they can occur in a lithostatic stress field. Another special feature is that the focal region of such earthquakes is accessible. Three-dimensional arrays of seismographs in mines therefore serve both the development of safe mining techniques and the study of the faulting process.

3. Seismicity induced by fluid injection

   The process is understood to be a triggering of failure of rocks under high regional stress by the increased fluid pressure. Several delegates reported cases of earthquakes induced by the extraction of oil from sedimentary rocks.

8.5 Tsunamis

A delegate of the USSR introduced discussion paper SC-76/SEISM/7.

It was noted that while the actual process of tsunami generation has never been observed directly, it was generally thought to be a piston-like movement of the ocean floor. It has also been suggested that large elastic displacements, oscillations of the ocean bottom, sub-aqueous slumping and turbidity currents may be tsunamogenic.

The character of tsunamis depends upon their generation, propagation and transformation at the coast. The theory of their propagation is reasonably well developed, but the details of the transformation at bays, estuaries etc. is less well understood.

The Secretary of the Intergovernmental Oceanographic Commission described the work of the International Co-ordinating Group for the tsunami warning system in the Pacific and the International Tsunami Information Centre in Honolulu.

The tsunami warning system in Japan was described as a three-part programme of forecasting, warning dissemination and evacuation.

Concern was expressed that tsunami warning systems are inadequate in some countries around the Pacific, where approximately 80% of tsunami damage occurs annually.

It was noted that in Japan, with its well-developed warning system, emphasis is now being placed on the development of major civil engineering structures to protect the shorelines and on the relocation of low-lying villages to higher and therefore safer ground.

Several delegates stressed the need to improve public information services in order to reap full benefit from the existing tsunami warning systems.

RESOLUTIONS

Seismic zoning and microzoning

RESOLUTION 8.11

The Conference recommends that the Member States make resources available to develop further the geophysical and statistical methods needed to understand the characteristics of disastrous earthquakes.

It recommends that Unesco encourage and assist in regional projects, such as the Survey of the Seismicity of the Balkan Region, in zoning and microzoning in areas where adequate resources are not available today, for instance in the Andean and Alpine-Himalayan belts.

It further recommends that Unesco and UNDRO, in co-operation with international non-governmental scientific organizations (e.g. IAEE, IUGG, IASPEI, IUGS) encourage and assist international research and co-operation in the field of seismic zoning and microzoning by convening symposia and by establishing working groups on relevant topics such as cataloguing, revision of the intensity scale, methods and legends of zoning and risk maps, strong-motion data analysis, correlation of macroseismic and instrumental parameters.

RESOLUTION 8.12

In order to improve the assessment of local and regional earthquake risk, the Conference recommends that Member States take the following action where appropriate:

1. Search for relevant historical data and systematize this information in catalogues and summaries.
2. Ensure that their seismographic networks are adequate, up to date and operational both in instrumentation and in data analysis techniques.
3. Develop engineering-geological maps and neo-tectonic maps of critical areas and make detailed geological studies of areas where damaging earthquakes have occurred, in order to compare these areas with others where similar earthquakes may occur in the future.
4. Deploy strong-motion instruments where data are needed and pay attention to their systematic maintenance. In order to obtain more comprehensive data it is desirable that strong-motion instruments be deployed in arrays with some instruments in boreholes.
5. Collect macroseismic data immediately after each earthquake has occurred and present these data in regular summaries.
6. Provide trained personnel at both the professional and technical levels.
7. Develop and perfect techniques of microzoning maps and incorporate them, as appropriate, into local building codes.

RESOLUTION 8.13

Noting the fundamental importance of accurate lists of epicentral data for the preparation of zoning maps, and that several agencies already have world lists in computer-readable form,

The Conference recommends that as many of these lists as possible be pooled with a single agency, which would undertake the task of converting them to a common format and merging them into a single list edited in co-operation with national agencies;

It is also recommended that the central list should be made widely available at all stages of editing as a basis for studies of regional or world seismicity.

Earthquake prediction

RESOLUTION 8.3

The Conference recognizes the importance of developing a reliable earthquake prediction capability. In addition, research should be conducted into the socio-economic, behavioural, and legal problems related to earthquake prediction on a regional, national and international basis.

The Conference encourages Member States to organize national bodies to deal with technical and socio-economic aspects of earthquake prediction. Furthermore, in view of the extreme usefulness of the present intergovernmental conference, this Conference encourages Unesco to organize interdisciplinary meetings at appropriate intervals to provide the medium for the exchange of the latest information concerning this subject.

Induced seismicity

RESOLUTION 8.41

In order to ensure the greatest possible protection of dams and downstream populations from risks associated with induced seismicity, the Conference recommends to Member States in which large reservoirs are planned that detailed seismic surveillance be carried out to obtain good hypocentral control and source parameters of the earthquakes in the reservoir area from two years or more prior to the beginning of construction. Furthermore, it is recommended that measurements of initial stress near the deepest points of the future reservoir be carried out by the available techniques such as hydraulic fracturing and overcoring strain rosettes, as a means of understanding the mechanism of induced seismicity after filling.

For the purpose of this resolution a "large reservoir" is one which will have a maximum depth exceeding 100 m and a maximum volume exceeding 10^9 m^3 at operational level.

RESOLUTION 8.42

Since the interpretation of induced seismicity phenomena requires a multidisciplinary approach, the Conference recommends that Unesco support Member States undertaking investigations in this field by providing advice and training aimed at a more efficient processing and evaluation of the observed data.

Tsunamis

RESOLUTION 8.5

The Conference recommends that the Member States concerned take the following action, with the assistance of Unesco and its IOC, of UNDRO and UNDP:

1. Improve and put into operation stable and precise sensors for recording tsunamis in the open sea;

2. Devise and install long-period, broad-band seismographs at seismological stations; continue and complete the automatic processing of seismic data; ensure the integration of hydrophysical and seismological methods of operative tsunami warning;

3. Improve the communication channels used in the tsunami warning system, including the use of satellites;

4. Extend considerably the network of microbarographs and land-based tide gauges;

5. Pursue and further develop the theory of tsunami generation and propagation;

6. Compile schemes of tsunami zoning of the Pacific and other coasts liable to inundation;

7. Carry out reasonable engineering protective measures in the populated localities and exchange technical information through international symposia;

8. Improve public information and awareness of the tsunami threat;

9. Extend the activities of the IUGG tsunami committee, the ITIC, UNDRO and IOC;

10. Extend or create tsunami warning systems in all countries vulnerable to tsunamis.