ECONOMIC AND SOCIAL COMMISSION FOR ASIA AND THE PACIFIC
BANGKOK, THAILAND

NATURAL DISASTER REDUCTION IN ASIA AND THE PACIFIC: LAUNCHING THE INTERNATIONAL DECADE FOR NATURAL DISASTER REDUCTION

VOLUME I

WATER-RELATED NATURAL DISASTERS

UNITED NATIONS
December 1991

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VOLUME I

WATER-RELATED NATURAL DISASTERS

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FOREWORD

Many of the Asian and Pacific developing countries are situated in the world's hazard belts of earthquakes, windstorms, tidal waves, droughts, heavy precipitation and floods. Storm surges and earthquakes are the natural disasters which cause the most destruction of human lives and property, and in some countries affect the national economy significantly. In addition, tsunamis, landslides and volcanic eruptions are known to have affected certain areas of the region in varying degrees at different times.

Losses due to natural disasters deprive countries of resources which could otherwise be used for economic and social development, thus further impeding their development process. The toll from disasters is particularly severe and tragic in developing countries, which have often had their development goals set back years and even decades as a result of the devastating impacts of natural disasters.

In December 1987, the General Assembly, recognizing the importance of reducing the impact of natural disasters for all people, and particularly for those in developing countries, declared the 1990s as the International Decade for Natural Disaster Reduction in its resolution 42/169. During the Decade, the international community, under the auspices of the United Nations, is to pay special attention to fostering international cooperation in the field of natural disaster reduction. The objective of the Decade is to reduce, through concerted international action, especially in developing countries, the loss of life, property damage and social and economic disruption caused by natural disasters, such as earthquakes, windstorms, tsunamis, floods, landslides, volcanic eruptions, drought and other calamities of natural origin.

Global coordination of disaster mitigation and response activities has been entrusted to the Office of the United Nations Disaster Relief Coordinator (UNDRO) and of Decade-related activities to the IDNDR Secretariat, established in Geneva, Switzerland.

In its resolution proclaiming the 1990s as the International Decode for Natural Disaster Reduction, the General Assembly urged the regional commissions of the United Nations to play an active role in implementing the activities of the Decade, considering that natural disasters often transcend national boundaries. Although the Economic and Social Commission for Asia and the Pacific (ESCAP) had long been involved in efforts to mitigate the effects of natural disasters, particularly water-related ones, the Decade has provided a new impetus for concerted efforts for activities in natural disaster reduction. ESCAP, at its forty-fifth session held in 1989, adopted a resolution on fulfilling the objectives of the Decade in the region, endorsing the proposal to give increased emphasis to activities aimed at reducing natural disaster. An interdivisional task force for the Decade was subsequently established within the ESCAP secretariat to undertake multisectoral activities related to natural disaster reduction in the region, within the framework of Decade programmes.

In order to launch the International Decade for Natural Disaster Reduction officially in the region, ESCAP, in cooperation with UNDRO and the IDNDR Secretariat, and with generous financial support from the Government of Japan, organized a Regional Symposium for the International Decade for Natural Disaster Reduction in Asia and the Pacific. The Symposium was held at ESCAP headquarters at Bangkok from 11 to 15 February 1991, and was attended by 72 participants, representing 22 members and associate members of the commission as well as international and regional organizations.

Volume I of the Proceedings of the Symposium concentrates on water-related natural disasters. The report of the Symposium, including a considerable number of concrete recommendations, is included as part one of this volume. Part two comprises the technical background papers on water-related natural disasters in countries of the ESCAP region. Part three includes country reports on national efforts to reduce natural disasters, particularly water-related ones. Twenty case studies from 16 countries of the region are presented. Finally, part four presents activities of international agencies in all aspects of natural disaster reduction. Thus, parts one and four of this volume relate to several types of natural disaster including: cyclones/typhoons and floods; droughts; earthquakes and tsunamis; and volcanic hazards. Parts two and three, comprising the technical background papers, are concerned primarily with water-related natural disaster. A second volume will be published to include a number of background papers related to seismic and volcanic hazards.

The ESCAP secretariat would like to express its gratitude to the Government of Japan for making possible several specific projects related to natural disaster reduction in the region. Although most of these concentrated on flood loss prevention and other aspects of water-related natural disaster reduction, the secretariat was able to conduct some studies on seismic and volcanic disasters as well. The Government of Japan also generously provided financial support for this Symposium, at which all the background studies prepared up to that point were presented.

We are also grateful to the other United Nations agencies, which generously cooperated in this activity, as well as to regional organizations, which have supported ESCAP disaster-related programmes.

Natural Disaster Reduction in Asia and the Pacific: Launching the International Decade for Natural Disaster Reduction

Volume I

PART ONE

REPORT OF THE ESCAP/UNDRO REGIONAL SYMPOSIUM ON THE INTERNATIONAL DECADE FOR NATURAL DISASTER REDUCTION

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PART ONE

REPORT OF THE ESCAP/UNDRO REGIONAL SYMPOSIUM ON THE INTERNATIONAL DECADE FOR NATURAL DISASTER REDUCTION

I. REPORT OF THE REGIONAL SYMPOSIUM

A. Organization of the Symposium

The ESCAP/UNDRO Regional Symposium on the International Decade for Natural Disaster Reduction was held at Bangkok from 11 to 15 February 1991.

The Symposium was organized by the Economic and Social Commission for Asia the Pacific (ESCAP), in co-operation with the Office of the United Nations Disaster Relief Co-ordinator (UNDRO), with generous financial support from the Government of Japan. It marked the launching of the International Decade for Natural Disaster Reduction in the ESCAP region.

1. Attendance

The Symposium was attended by 39 participants from 22 members and associate members of ESCAP: Australia, Bangladesh, China, Fiji, Hong Kong, India, Indonesia, Iran (Islamic Republic of), Japan, Lao People's Democratic Republic, Malaysia, Myanmar, Philippines, Republic of Korea, Singapore, Solomon Islands, Sri Lanka, Thailand, Tonga, Union of Soviet Socialist Republics and Viet Nam. It was also attended by the Director of the secretariat of the Decade and by representatives of the United Nations Centre for Human Settlements (Habitat), the United Nations Centre for Regional Development (UNCRD), the United Nations Development Programme (UNDP), the United Nations Disaster Relief Co-ordinator (UNDRO), the United Nations Educational, Scientific and Cultural Organization (UNESCO), the World Health Organization (WHO) and the World Meteorological Organization (WMO). Six participants represented the Asian Development Bank (ADB), the Interim Committee for Co-ordination of Investigations of the Lower Mekong Basin (Mekong Committee) and the Asian Institute of Technology. In addition, 12 resource persons assisted the secretariat with their technical expertise in the areas of: cyclones/typhoons and floods; earthquakes and seismic hazards; volcanic hazsards; storm surges; tsunamis; and droughts. In addition to ESCAP secretariat staff, a total of 72 participants and observers attended the Symposium. The list of participants in attached as annex I.

2. Opening of the Symposium

The Executive Secretary of ESCAP, in opening the Symposium, welcomed the participants and expressed his appreciation to the Government of Japan for its generous financial support. He recalled the General Assemby resolution proclaiming the 1990s as the International Decade for Natural Disaster Reduction and noted the important role of the regional commissions in carrying out Decade activities. He stressed that many developing countries of the region were located in the world's hazard belts for natural disasters. Such calamities were frequently devastating in terms of loss of life and property. The toll resulting from natural disasters was particularly severe and tragic in developing countries, which had borne the brunt of property losses and had suffered 90 per cent of the deaths in recent years. Many of the countries which were hardest hit were those least able to mobilize funds to restore their physical infrastructure and rebuild communities. Massive outlays on emergency and recovery operations had forced several countries to set back their development goals many years. He observed that, during the Decade, long-standing international involvement in emergency relief and rehabilitation could be augmented by an increased international contribution to disaster prevention and mitigation. He emphasized the important task before the Symposium: to chart a course and recommend a plan of action for the countries of the region to participate in cooperative action to reduce natural disasters

The Director of IDNDR Secretariat, noted that, in adopting resolution 44/236, the General Assembly had challenged the human race to focus its scientific knowledge and creative skills on reducing the death, sorrow and physical hardship which were so often the result of natural disasters. Preventing and mitigating natural disasters were vital in both humanitarian and economic terms. He stressed the need to harmonize the strategies for taking care of environmental concerns with efforts to mitigate natural disasters. It was necessary to put into use and share knowledge on how to reduce natural disasters through: enhancing national capabilities, particularly in the areas of early warning, assessment and programmes for building disaster-resistant structures; and mobilizing the pool of existing scientific and technical knowledge. In addition to the important function ESCAP had to perform at the regional level, the role to be played by individual countries at the national level was of special importance. To that end, all Governments were called upon to formulate natural disaster mitigation programmes as well as economic, land-use and insurance policies for disaster prevention, and to integrate them fully into their national programmes for economic development. National committees should provide the impetus for attaining the goals of the Decade. The IDNDR Secretariat was giving priority to steps for enhancing the national capability to meet the challenges of natural disasters and was working closely with national committees to achieve the aims of the Decade.

The Deputy Permanent Representative of Japan to ESCAP, in his address, noted that frequent natural disasters in the region had caused tremendous set-backs to the socio-economic development of vulnerable countries and areas, which were sometimes beyond the capabilities of those countries to cope with. In that connection, he stressed the importance of international attention and co-operation, and expressed the willingness of the Government of Japan to share its experience and expertise in the field of disaster prevention, and to provide some assistance to the countries in need of help. He hoped that the Symposium would produce a workable framework of action for natural disaster reduction in the region through constructive and candid discussions.

3. Election of officers

Mr. Ratu Meli Bainimarama (Fiji) was elected Chairman, Mr. B. Narasimhan (India), Vice-Chairman and Captain Devendran Selvarajoo (Singapore), Rapporteur.

4. Agenda of the Symposium

The Symposium adopted the following agenda:

(a) Opening of the session.

(b) Election of officers.

(c) Adoption of the agenda.

(d) Technical session I: International Decade for Natural Disaster Reduction:

  (a) Background and aims;
  (b) Relevance to countries of the ESCAP region;
  (c) Results of the IDNDR International Conference 1990 Japan.

(e) Technical session II: General overview of disasters in the ESCAP region;

  (a) Disasters caused by cyclones/typhoons and floods;
  (b) Disasters caused by earthquakes and volcanic activity;
  (c) Disasters caused by drought.

(f) Technical session III: International disaster mitigation activities.

(g) Technical session IV: Regional disaster mitigation programmes.

(h) Technical session V: Parallel working groups: Presentation and discussion of case studies;

  Working group 1. Cyclones/typhoons and floods;
  Working group 2. Volcanic and Seismic hazards;
  Working group 3. Droughts.

(i) Technical session VI: Special session on the impact of natural disasters on the least developed, land-locked and island countries.

(j) Technical session VII: Laws and regulations required for disaster responses.

(k) Technical session VIII: Parallel working groups: Discussion of community-level responses to natural disasters

(l) Technical session IX: Parallel working groups: Formulation of policy on natural disaster reduction:

  (a) Pre-disaster assessment and prevention;
  (b) Emergency preparedness and early warning systems;
  (c) Post-disaster rehabilitation.

(m) Technical session X: Formulation of framework of action for natural disaster reduction.

(n) Adoption of the report.

B. Technical sessions

(Items 4-13 of the agenda)

The opening session was followed by 10 technical sessions, which are outlined in the programme in annex II. The first technical session covered the aims and objectives of the International Decade and its relevance to the ESCAP region. The Director of the IDNDR Secretariat reiterated that the objective of the Decade was to reduce the effects of natural disasters through the application of science and technology. It could be demonstrated that in several developed countries, including Japan, the decrease in loss of life from natural disasters had been dramatic following the adoption of policies and legislation on disaster mitigation. He noted that the role of the IDNDR Secretariat was that of a catalyst, facilitator and co-ordinator, thus orchestrating the entire process at both the national and international levels. He outlined the mechanisms for achieving the objectives of the Decade, including the establishment of the Special High-level Council to provide policy guidance, and the convening of the Scienlific and Technical Committee, to advise on a detailed action plan and specific projects to be supported under the Decade. Contributions to a fund for assisting the Decade activities had been sought from individual countries. He invited suggestions as to the adequacy of the mechanism envisaged for "energizing" national committees and other actors.

The representative of the Office of the United Nations Disaster Relief Co-ordinator (UNDRO), presented a statement on behalf of the Co-ordinator. He noted that UNDRO was a joint sponsor of the Symposium and had, together with ESCAP, taken the initiative of holding the symposium early in the Decade. UNDRO considered that the Decade was particularly important to countries of the ESCAP region, not only because of the natural conditions in the region but also because of the economic and social circumstances which increased the vulnerability of densely populated areas to disaster. UNDRO was the only specialized organizational entity in the United Nations dealing exclusively with disasters and was the focal point for disaster management in the United Nations system. Its tasks in relation to natural disasters encompassed the complete disaster cycle — from the early warning phase preceding the actual impact or occurrence through the emergency management and response phase, to identification of sectors for reconstruction and rehabilitation and, finally, covering the issue of mitigation, that is, applied disaster reduction as part of the development process. The majority of the UNDRO activities were thus to be seen as directly related to the realization of the Decade's goals.

The Chief of the Water Resources Section of ESCAP made a presentation on the relevance of the Decade to countries of the ESCAP region. He pointed out that 85 per cent of 4 million deaths resulting from sudden natural disasters in the world in the period 1900-1990 had occurred in Asia and the South-west Pacific. In their efforts to reduce the effects of such natural disasters, various divisions of ESCAP had initiated practical programmes on natural disaster reduction, which he described briefly. He gave some examples of how death tolls due to cyclones had been reduced successfully in some countries owing to concerted action on the part of the government and the concerned United Nations agencies.

The Senior Disaster Management Planner of the United Nations Centre for Regional Development (UNCRD), presented a report on the past activities and future plans of the Centre in relation to the Decade. The Centre would contribute to the Decade through regional development activities, in particular training, human resources development and research co-operation with developing countries. The priorities for UNCRD were in the following areas:

(1) Exchanging knowledge and experience among regions suffering from similar types of disasters;

(2) Encouraging research work on the vulnerability to major disasters in metropolitan areas;

(3) Supporting studies to clarify the socio-economic effects of major disasters in various locations;

(4) Assisting the establishment/enforcement of an administrative and institutional system for disaster management.

Mr. Motosuke Tanaka, Councellor to the Disaster Prevention Bureau, National Land Agency, Government of Japan presented the results of the IDNDR International Conference 1990 Japan which had been held in Japan from 27 September to 3 October 1990. At that Conference, various topics related to natural disaster reduction and international cooperation had been discussed by senior-level policy planners, administrators, researchers and leaders of non-governmental organizations from 43 countries and representatives of 16 international organizations. The Conference had identified major tasks that should be implemented as Decade activities (see annex III).

In the discussion that followed on the aims and objectives of the Decade, it was pointed out that in addition to enhancing the scientific and physical capabilities from disaster reduction, management was very important to relief and mitigation. It was considered necessary to include the management aspect in initiatives concerning the Decade, including the rectification of improper management techniques. Identification of economic development programmes which had potential to reduce natural disasters would also assist developing countries. It was noted that industrial and other man-made disasters might also be prevented by locating an industry or community away from a disaster-prone area or constructing it in a disaster-resistant way. Some representatives questioned how resources could by mobilized for the Decade, particularly funds to strengthen existing mitigation programmes, motivate actors and coordinate the vastly different activities of many countries coping with various types of disasters.

The Director of the secretariat of the Decade replied by stating that generally investments in disaster mitigation were justified if they achieved multiple objectives–encompassing economic and social development aims and more efficient management of natural resources. The IDNDR Secretariat was aiming at actors, including non-governmental organizations, business and the media in addition to Governments and international and regional organizations, as potential sources of funds and as key actors in mitigation efforts. He welcomed the suggestion concerning the constitution of a policy-level committee to facilitate intergovernmental consultations. He explained that the IDNDR Secretariat would soon be publishing a newsletter and he welcomed inputs from representatives at the Symposium. As for coordinating activities related to different types of disaster, he explained that some measures could be applicable to more than one hazard, such as risk assessment, monitoring and early warning networks, and selection criteria used in siting industry or communi-

ties. Furthermore, multi-hazard approaches could be used in building up national capacities and training disaster managers.

The opening session and the first technical session were followed by nine other technical sessions as indicated in the programme. The list of technical papers presented is attached as annex IV. In brief, these sessions covered the following:

(a) General overview of disasters in the ESCAP region.

(b) International mitigation activities and programmes.

(c) Regional mitigation activities and programmes.

(d) Presentation and discussion of case studies, including all the major types of natural disasters experienced in the region.

(e) Presentation and discussion on the impact of natural disasters on least developed, land-locked and island countries.

(f) Presentation and discussion of the laws and regulations required for disaster responses.

(g) Parallel working group discussions on community-level responses to natural disasters;

(h) Parallel working group discussions and specific recommendations on water-related natural disaster reduction, droughts, earthquakes and tsunamis, and volcanic eruptions.

(i) Discussion and formulation of an action plan for natural disaster reduction and recommendations applicable to the mitigation of all the natural disasters considered during the sessions.

The Symposium split into four working groups, covering the following: typhoon/cyclones and floods; earthquakes; volcanoes; and droughts. The groups formulated a series of recommendations, some of which were generally applicable to all hazards, and some applied specifically to reducing the effects of one type of hazard. The recommendations are included in the next section. Throughout the plan of action and recommendations, the term "developing countries" was meant to cover least developed countries, land-locked and island developing countries, as well as other developing countries prone to natural disasters in the region.

In the course of the Symposium, issues related to global warming were not considered during the discussion. It was decided to leave that subject to other forums.

Adoption of the report

The report was adopted on 15 February 1991.

II. PLAN OF ACTION AND RECOMMENDATIONS FORMULATED BY THE REGIONAL SYMPOSIUM

1. The group proposed that, in addition to the Scientific and Technical Committee appointed to oversee the work on natural disaster reduction, a policy-level committee, comprising persons actually engaged in practical disaster-reduction activities in various disaster-prone countries, and persons from donor countries/agencies, could assist the Decade machinery in the formulation of disaster-reduction programmes and selection of projects to be implemented under the Decade.

2. The role assigned to the secretariat of the Decade by the General Assembly was supported, and it was expected that it would achieve its role in the coordination and monitoring of activities on natural disaster reduction. It was essential to avoid duplication of work by various United Nations and other international agencies. Since disaster reduction efforts required multidisciplinary approaches, the need for concerted action by the concerned organizations was emphasized.

3. Member countries should consider establishing national committees for natural disaster reduction, where required.

4. National action plans should aim at generating technical capabilities, strengthening the observational network and improving research and development activities, so that better services could be provided. In order to promote local capabilities, preference could be given to local consultants in natural disaster reduction activities.

5. Member countries were urged to establish their priorities, to assess the gaps in their knowledge, and to determine the resources required for an effective disaster reduction programme. Accordingly, projects could be formulated for assistance, and compiled by the Decade secretariat to solicit funding. Projects of a regional or subregional nature, covering several countries, could then be implemented by ESCAP and/or other United Nations and international agencies.

6. Member countries should undertake research and studies on various aspects of natural disasters and their reduction, with international assistance if required. ESCAP and other United Nations agencies, donor countries and organizations could be called upon to provide such assistance.

7. Decade programmes should be responsive to national priorities and perceptions as well as to regional and global trends. In that context, meeting the requirements and filling the gaps in knowledge or technology transfer should be emphasized.

8. Considering that the implementation of disaster reduction measures would call for a significant amount of resources, and that many developing countries prone to disaster would not be in a position to mobilize them, the United Nations was called upon to make all the necessary efforts to attract funds from donor countries and agencies to support Decade programmes.

9. International financing institutions were urged to accord high priority to projects aimed at disaster reduction. Their procedures could be streamlined to provide a quick response to requests for the financing of such projects. Interim funding pending appraisal of projects, and earmarking of funds for financing such projects, could also be considered.

10. Many development programmes could lead to disaster reduction. Such projects should be accorded the highest priority for funding by financial institutions.

11. It was recommended that success and failure criteria for evaluation of the impact of the natural disaster reduction activities should be established and distributed to member countries. An expert group meeting, or a workshop of specialists, could be convened by concerned United Nations agencies to draw up such criteria.

12. It was also recommended that a regional workshop should be organized on land-use planning in relation to natural disasters.

13. A conference or meeting of the concerned countries should be organized in 1995 in order to review achievements up to the middle of the Decade and provide information for review by the General Assembly that year.

14. Training programmes for disaster management personnel should be organized at national, regional and local levels. Training programmes, seminars and symposia should be organized by national and international organizations to upgrade the skills of technical personnel. Developed countries should devote a percentage of their training efforts to assisting least developed and developing countries, with emphasis on in-country training.

A. Recommendations for the reduction of all hazards

General recommendations of the Symposium applicable to the reduction of all the natural disasters considered during the sessions were as follows:

1. Formulation of policy

1. Countries must immediately establish national committees or disaster prevention councils, as envisaged under the Decade. Such committees might be entrusted with the formulation and implementation of disaster management policies.

2. National committees for the Decade should be sufficiently high-powered to ensure efficient and effective interdepartmental cooperation and coordination.

3. There was an urgent need for the countries to formulate national policies on disaster relief and disaster reduction strategies and disseminate them very widely. The obligations of the community and the responsibilities of government should be clearly spelled out through appropriate legislation or executive orders.

4. In order to overcome resource constraints in undertaking relief programmes and disaster reduction projects, such efforts should form an integral part of development programmes. The national committee for the Decade must monitor the development programmes to ensure that the disaster reduction content was given due recognition, building up infrastructure and increasing the country's resilience to disaster in the long term.

5. Countries should formulate contingency action plans, at national and subnational levels, identifying the authorities responsible for taking relief management measures, the triggering mechanisms and procedures for inter-agency interaction.

6. Focal points for the direction and control of disaster management should be established at the appropriate levels. Crisis management groups, with representation from all concerned agencies, should be set up at appropriate levels, to monitor relief operations, identify bottlenecks and initiate corrective measures. Those groups should meet periodically to review preparedness measures prior to a disaster.

2. Pre-disaster assessment

1. Hazard mapping should be undertaken to delineate causative source areas and areas which were exposed to potential risks from natural disasters. Those maps should be distributed for international, national and local use.

2. A comprehensive vulnerability analysis should be undertaken in all disaster-prone areas, incorporating past disaster events, the socio-economic conditions of the population living in that area, and inventories of major structures of public concern. That would enable quick assessment of the potential impact of a disaster and initiation of appropriate measures for reducing the impact.

3. Attention should be given to improving the risk assessment of all natural hazards. Risk assessment should include areas of influence, frequency, intensity, impact, return period, etc. Risk zoning for each natural hazard could be carried out and published.

3. Disaster prevention measures

1. Each country should develop policies establishing the Government's position on the desired mix of prevention and preparedness measures to be employed for natural disaster reduction.

2. Each country may enact legislation/regulations to ensure the effective implementation of disaster management policies and programmes by the responsible departments, authorities and the community.

3. Each country should allocate adequate funds for the implementation of preventive and preparedness measures as a means of reducing the future costs of disaster response activities. The international community should assist countries facing resource constraints.

4. Each country should implement comprehensive programmes for the collection of statistics on damage caused by natural disasters. That type of information should form a suitable basis for economic analyses.

4. Early warning systems

1. Disaster preparedness started from the observation and monitoring of the potential disasters. Therefore, every country should ensure that its observational equipment and networks monitored the disasters properly and provided quick dissemination of the hazard information.

2. Early warning systems as well as command control and awareness systems, should be developed.

3. Institutional arrangements should be established for the exchange of information among neighbouring countries/areas on all phases of the disaster on a continuous basis, preferably in a standardized format.

4. Neighbouring countries should exchange emergency information relating to any impending disaster to ensure that advance warning would reach the areas likely to be affected.

5. Emphasis should be given to collecting reliable feedback information on damage caused by natural disasters.

5. Disaster preparedness

1. All levels of government must have effective counter-disaster plans and organizations in place. Those should be coordinated vertically and laterally with established and equipped emergency operations centres. To facilitate mobilization of resources for disaster relief operations, the focal authorities at different levels should be invested with powers to reallocate resources from sectoral allocations of government departments.

2. Disaster response volunteer organizations should be formed, trained and equipped to work with professional agencies, as required.

3. Countries might identify rescue teams which could be made available for relief operations in neighbouring countries. The services of those teams must be publicized and thus utilized to promote regional co-operation. In that connection, the Symposium was pleased to note that the Government of Japan was prepared to dispatch, upon the request of disaster-stricken countries, disaster relief teams which would carry out rescue, emergency medical care and restoration/rehabilitation activities.

4. All communication links with disaster-prone areas could be examined periodically and upgraded so that they would serve without problems during a disaster.

5. Special emphasis should be given through the Decade to the improvement of communications systems throughout the region. Those systems were vital at both the national and regional levels for the transmission of basic data and warning information.

6. Community awareness programmes and school educational programmes on disaster preparedness should be developed and implemented.

7. In order to promote community involvement, committees could be established at the local level, including representatives of non-governmental organizations and the public, to monitor and guide disaster-relief operations.

8. Manuals and guidelines on different aspects of natural disaster reduction, such as risk assessments, forecasting, warning, disaster preparedness and mitigation measures, could be prepared by national and international organizations.

9. Emergency relief stockpiles should be established as warranted.

10. In case of supply of medicines to a disaster area from other countries, international terminology and descriptions of the medicines should be indicated clearly to facilitate the use of such medicines. Standardization of medical supplies and their pre-positioning should be done at strategic points.

11. Training of health personnel should be carried out at the grass-roots, managerial and policy-planning levels on a regular basis by countries to provide timely assistance to the affected people. The required international assistance could be provided by concerned international agencies such as WHO, and non-governmental organizations such as the International Red Cross/Red Crescent Societies.

6. Disaster response

1. Developed countries might offer to provide assistance when requested by approved authorities in the recipient country or area. Unsolicited disaster relief supplies or personnel, such as rescue teams, should not be dispatched to affected countries.

2. Immediate life-saving measures should always have top priority. Recipient countries should implement rapidly customs and health/quarantine arrangements for clearance of relief personnel and supplies. Donor countries should not send food which did not conform to local quarantine requirements and local culinary standards.

3. Nutritional supplements for vulnerable sections of the society must form an integral part of disaster mitigation programmes.

4. Epidemic and nutritional surveillance should be carried out immediately after natural calamities.

5. When evacuation was required, families should be evacuated as a unit, to avoid unnecessary psychological suffering.

6. Due attention should be given, internationally and nationally, to rehabilitation activities. Reconstruction of basic infrastructure, in particular, should be carried out so that communities, families and individuals could restore their former living standards and secondary disasters be prevented.

7. When resettling communities, sites should be chosen so as to allow the population access to meaningful economic occupations.

7. Community-based approaches to disaster response

1. It must be recognized that the initial and most vital response to disaster must be at the local level.

2. The community must be well informed about disaster-preparedness measures and be alert in time of disaster.

3. Agreed, co-ordinated and tested arrangements for disaster response were required.

4. All levels of government should recognize and support the above principles.

5. Governments should provide incentives for the formation of trained, equipped, disaster-response organizations of volunteers at the community level. Transport, communications, rescue, first aid and disease surveillance and control facilities should be provided.

6. Volunteer response agencies should have affiliation with full-time agencies such as the police and fire services to ensure that the volunteers were recognized as a valuable resource asset and fully utilized.

7. Governments should provide adequate resource support to non-governmental organizations.

8. Governments should provide public awareness training material.

9. The preparation phase must include: formation, equipping and training of response organizations, and regular conduct of exercises.

10. Non-government organizations should be encouraged and their capabilities integrated into community disaster plans.

11. The application of knowledge was required to catch up with research.

B. Recommendations on water-related natural disasters

The Symposium made the following recommendations on reduction of the effects of water-related natural disasters:

1. Each country or area should attempt to improve the quality of forecasts and warnings and increase the lead time of warning to enable affected areas to make advance preparations. Sufficient recognition should be given to strengthening those activities under Decade programmes. Because of the critical importance of basic data in the prediction of natural disasters, greater emphasis should be given to the expansion of observational and monitoring systems, especially in the data-scarce areas of the region.

2. Proper vulnerability analyses could be made in the high-risk zones, taking into consideration the infrastructure and other structural facilities for cyclones, floods, storm surges, etc. affecting the region.

3. The efficacy of large-scale engineering projects in the reduction of floods should be carefully analysed and evaluated in view of their impact on environmental endowment and their potential for causing land degradation. Such projects involved high investment and could be accorded lower priority in the allocation of resources as compared with non-engineering measures in a disaster reduction strategy.

4. When major engineering projects were being undertaken, meteorological services should be encouraged to provide, wherever possible, their expertise on the recurrence of extreme surge heights and high winds.

5. Dwelling units and public service buildings in cyclone and flood-prone areas should be constructed to wind and flood-resistant design. Low-cost housing programmes should incorporate disaster-resistant construction techniques. Traditional building techniques which had disaster-resistant components should be encouraged.

6. Critical facilities, such as medical and public health facilities, drinking water supplies and communications facilities, should be established on sites least likely to be affected by floods, cyclones, landslides or tsunamis.

7. Disaster-proof structures, such as shelters, raised platforms, emergency food grain and drinking water storage tanks could be built in high-risk areas. Easy access to such structures must be ensured.

8. Land use played a crucial role in the ability to contain run-off and reduce floods. Long-term disaster reduction efforts should therefore aim at evolving appropriate land use in the flood-prone areas by harmonizing land suitability with agricultural development strategies. Measures to evolve proper land use should include both legislative and economic inducements. Countries must formulate land-use policies to sustain development over the long term.

9. Management of catchments through appropriate soil and moisture conservation measures, shelter belts of trees along the banks of rivers and degradation-resistant land use should constitute important components of a disaster reduction strategy. Such measures were multidisciplinary in nature. Consequently, the disaster reduction strategy must include mechanisms for the coordination of the activities of agencies engaged in the sectoral development activities. The strategy should also include promotion of public awareness of proper land-use practices.

10. Contour maps with 0.5 m elevation intervals should be prepared for high-risk zones in order to facilitate preventive work against floods and storm surge, in those areas where such maps did not exist.

11. For facilities which required large investment, countries might consider utilizing or establishing regional facilities with international assistance.

C. Recommendations on droughts

With respect to drought assessment and mitigation, the following steps were recommended in addition to the general recommendations made for natural disaster reduction.

1. Pre-disaster assessment and mitigation

1. A complete resource analysis of the drought-prone areas was recommended, which should take into consideration land-use patterns, water resources, livestock and fodder resources, cropping patterns and drinking water facilities. Monitoring of important parameters affecting living conditions in the drought-prone region must be undertaken regularly.

2. Preventive measures for drought should be integrated with other developmental programmes to insulate areas which suffered periodic droughts.

3. Suitable cropping systems for drought-prone areas needed to be developed. Those should include drought-resistant crop varieties and also less water-dependent crops.

4. Crop cultivation practices (dry farming) that used less water needed to be developed and practised.

5. Comprehensive resource development on the basis of watershed management in the drought-prone areas should be attempted. That should include provision of irrigation facilities, groundwater development, run-off storage and recycling, and appropriate crop practices to ensure sustainable development.

6. A comprehensive crop insurance scheme should be introduced to mitigate the effects of crop failure.

7. Groundwater management appeared to be an important aspect in drought-prone areas. It should include groundwater recharge practices and, wherever possible, regulation of over-exploitation of groundwater.

8. In the drought-prone areas, secondary and tertiary sector activities needed to be encouraged so that people were less dependent upon rainfed agriculture. Such activities included the development of horticulture, agro-based and small-scale industries.

2. Emergency preparedness and early warning systems

1. Establishment of an early drought warning system based upon meteorological parameters and crop growth monitoring, similar to the ESCAP/United States National Oceanic and Atmospheric Administration (NOAA) satellite crop monitoring project, appeared to be useful.

2. Food distribution systems to provide food security for the drought-prone areas might be set up. Agricultural contingency plans should be drawn up, keeping in mind the agro-climatic endowments, and should be disseminated widely among extension networks and farmers. Proper stocking of appropriate crop seeds might be considered.

3. Projects which could be implemented during drought periods for employment generation might be prepared in advance.

4. Advance plans could be made to identify areas where fodder cultivation could be taken up and to identify sites for cattle camps.

5. In case of storage reservoirs, careful water budgeting needed to be adopted to meet the critical needs of the population, livestock and crops.

6. Provision should be made for augmenting drinking water facilities, such as procuring drilling rigs for deep well drilling and mobile pumping equipment.

7. Nutritional surveys and disease surveillance should be carried out and appropriate health measures initiated to prevent morbidity and mortality.

3. Drought management

1. With respect to agriculture, contingency crop plans prepared prior to drought needed to be implemented in time of drought. In that respect, agricultural extension activities and credit to farmers were important.

2. For water conservation, the activities of the agriculture, irrigation and water supply agencies needed to be coordinated.

3. Provision of drinking water to the affected areas should be given high priority.

4. Persons who were unable to find employment owing to drought should be given employment opportunities. The projects for employment generation should be carefully designed to suit the local situation.

5. Preservation of livestock resources could be assisted by establishing cattle camps and operating fodder banks, or by arranging cattle migration to other areas.

6. A special feeding and nutritional monitoring programme for vulnerable groups of people should be continued until the threat of famine-related disease was over.

7. Rehabilitation programmes needed to be monitored until conditions returned to normal in the area.

8. All efforts should be made to prevent migration of the people and cattle from the drought region. The objective should be "living with drought".

4. General

1. Countries such as China and India had considerable experience with droughts, and their experience could be used to improve techniques, as and when appropriate.

2. Drought periods could be used to advantage by accelerated implementation of development activities.

3. Innovative drought management practices should be documented to enable other countries or regions to adopt them, if they were suitable.

D. Recommendations on earthquakes and tsunamis

With respect to earthquakes and tsunamis, the following were recommended:

1. Pre-disaster assessment and mitigation

1. The seismicity of the region needed to be better understood. The major earthquake disasters in the region should be fully investigated and documented. There was a need for free exchange of data among countries in the region in standardized formats. Attempts should be made to utilize the available data more effectively. Further studies should be initiated in areas having inadequate data. Mechanisms of earthquake-generated tsunamis in certain parts of South-East Asia needed to be better understood.

2. Existing seismic data acquisition networks should be updated and improved. In certain areas of the region, there was a need for the installation of seismic data acquisition systems. In several parts of the region strong earthquake ground motion data acquisition should be initiated.

3. Methods for earthquake hazard assessment needed to be improved. There should be more intraregional exchange and cooperation.

4. The assessment of the vulnerability of structures, systems, human lives and the social-economic structure was a very complex and challenging subject with physical, socio-economic as well as environmental variables. Because of its "soft" variables, vulnerability assessments were site-specific. However, generalized approaches to such assessments were needed for different building systems and socio-economic groups.

5. Since urban areas could be strongly affected by earthquakes, there was a need for "micro/zonation" maps delineating the earthquake hazard. Those maps should preferably indicate the associated risks.

6. Multidisciplinary (engineering-geology-geophysics-urban-planning-economics-sociology) cooperation and communication were essential in order to ensure that the knowledge was properly applied and implemented.

7. Earthquake-resistant design codes for buildings and other civil engineering structures might need to be reviewed. For certain countries there might be a need for their preparation and enforcement.

8. Earthquake-resistant designs of important civil engineering structures, such as port and harbour structures, dams, bridges and power plants, should be based on site-specific studies. Guidelines should be updated and/or prepared for pre-earthquake strengthening of critical and essential buildings, civil engineering structures and systems.

9. For non-engineered construction, special guidelines, in easily understandable formats, should be prepared to increase their earthquake resistance.

10. Land-use planning, earthquake insurance and tax incentives, were regarded as effective long-term mitigation tools available to administrators and policy makers, together with other legal measures.

11. Education, training and awareness building should be considered as an integral part of pre-disaster assessment and mitigation activities.

2. Emergency preparedness and early warning systems

1. For tsunamis, early warning networks in the Pacific should be completed. Research in earthquake prediction should be encouraged.

2. Emergency management planning at the inter-agency level must be coordinated and integrated. The plans should be rehearsed periodically, and should be clear at each operation level.

3. Emergency management in large urban areas should be emphasized. Restoration of life lines should be given priority. Provision of immediate access to the disaster area should be considered.

4. In earthquake disasters, the use of rescue teams was important, since after 24 hours the survival rate of the victims dropped sharply. That necessitated adequate preparation of the local emergency, rescue and medical

services. The rescue operation plans should include transport and access.

5. The building of disaster awareness in the general population, starting with the individual, was essential in reducing casualties. Training in emergency management should be introduced. Regional and national disaster management training institutions should be strengthened.

3. Post-disaster rehabilitation

1. Especially in developing countries, earthquake disasters created opportunities for the mitigation of future disasters through review and revision of disaster-management regulations and earthquake-resistant new constructions.

2. The reconstruction planning should be done effectively and as soon as possible after the disaster. It should be ensured that all new construction would be earthquake-resistant.

3. For large-scale, post-earthquake development project sites, structure- and system-specific earthquake hazard and vulnerability studies should be carried out.

4. In urban areas, critical structures and schools should be relocated in less hazardous sites.

5. Resettlement of communities was a very delicate and complex issue which should be considered only for small rural villages with imminent hazards and severe logistical problems.

E. Recommendations on volcanic hazard assessment and mitigation

In addition to the general recommendations made for natural disaster reduction, the following were formulated for action on assessment and mitigation of volcanic hazards to reduce the number of casualties resulting from volcanic eruptions:

1. A methodology should be developed for assessing the significance of volcanic risk (i.e. in percentage of GNP (gross national product) or by a similar indicator).

2. A hazard booklet, including a map, should be prepared by scientists in each country in the local language for each potentially active volcano in that country.

3. A concerted effort should be made to inform and educate the general public regarding volcanic hazards, using all possible means.

4. In addition, the following other specific activities were recommended for implementation:

(a) Improved monitoring of major sources of volcanic risks not sufficiently covered so far (for example, Savo, Solomon Islands; Iraya, Philippines; Doma Peaks, Mt. Yelia, and Mt. Victory, Papua new Guinea);

(b) Preparation of an inventory of volcanic tsunami risks in the region;

(c) Age-dating of volcanoes;

(d) Promotion of national databases.

5. Recommended training and information exchange activities were:

(a) On-the spot training on "Decade" volcanoes, identified as particularly appropriate by the International Association of Volcanology and Chemistry of the Earth's Interior (IAVCEI);

(b) Arrangement of exchange visits at times of eruption;

(c) Training for medical specialists to understand the problems associated with volcanic eruptions.

6. Collaboration with meteorologists would be useful for obtaining upper wind measurements, and close cooperation with the International Civil Aviation Organization (ICAO) would help to avoid volcanic-related airline disasters.

7. Promotion of the use of satellite telemetry for volcanic monitoring was also recommended.

Annex I

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Annex II

PROGRAMME OF THE SYMPOSIUM

Monday 11 February 1991

0800-0845 Registration

0900-0930 **Opening session**

Welcome address by Mr. S.A.M.S. Kibria, Executive Secretary, ESCAP
Statement by Mr. N.S. Merani, Director, IDNDR Secretariat
Statement by Mr. K. Shimizu, Deputy Permanent Representative of Japan to ESCAP

0930-0945 Election of officers
Adoption of the agenda

1000-1200 **Session I:** International Decade for Natural Disaster Reduction: 1. Background and aims;
2. Relevance to countries of the ESCAP region;
3. Results of IDNDR International Conference 1990, Japan

IDNDR Secretariat.....N.S. Merani
UNDRO.....J. Nemec
ESCAP secretariat.....C. Ertuna
United Nations Centre for Regional Development.....I. Tsukagoshi
IDNDR Promotion office.....M. Tanaka and T. Itoh

1330-1500 **Session II:** General overview of disasters in the ESCAP region.

Disasters caused by cyclones/typhoons and floods in the ESCAP region and preparedness and prevention measures for mitigation.....G. Whitehouse

Assessment and mitigation of earthquakes:
South-East Asia (selected countries).....P. Nutalaya

Himalayan region.....M. Erdik

1530-1630 Assessment and mitigation of volcanic disasters in the Philippines and Indonesia.....J.A. Katili

Assessment and mitigation of droughts.....V.V.N. Murty

Tuesday 12 February 1991

0830-1030 **Session III:** International disaster mitigation activities

International and regional disaster mitigation.....J. Nemec (UNDRO)

Science and technology for natural disaster reduction.....M. Hashizume (UNESCO)

Meteorological and hydrological aspects of natural disaster reduction.....O.M. Melder (WHO)

Health-related risks associated with natural disasters ..... B.K. Verma (WHO)

Mitigation of the effects of earthquakes on human settlements ..... I. Armillas (UNCHS)

1100-1200 **Session IV:** Regional disaster mitigation programmes

Asian Disaster Preparedness Center ..... B. Ward (Asian Institute of Technology)

Regional study on disaster mitigation ..... M.W. Schelzig (Asian Development Bank)

Flood forecasting on the upper and lower reaches of the Mekong River ..... Le Huu Ti (Interim Mekong Committee)

1330-1600 **Session V:** Parallel working groups for presentation and discussion of case studies

Working Group 1. Cyclones/typhoons and floods

Working Group 2. Volcanic and seismic hazards

Working Group 3. Droughts

Wednesday 13 February 1991

0830-1030 **Session VI:** Special session on the impact of natural disasters on least developed, land-locked and island countries

Overview ..... S.P. Upadhyay

Case studies

South Pacific ..... J.H. Latter

Bangladesh ..... M. Azad

Vanuatu ..... M. Bergin

1100-1200 **Session VII:** Laws and regulations required for disaster responses

1330-1600 **Session VIII:** Parallel working group sessions for discussion of community-level responses to natural disasters

Working Groups 1, 2 and 3 as in Session V

Thursday 14 February 1991

0830-1200 **Session IX:** Parallel working group sessions to formulate policies on disaster reduction

(Working Groups 1, 2 and 3 will all discuss three phases of disaster reduction)

1. Pre-disaster assessment and prevention

   - Long-term structural measures to reduce disasters: Large-scale engineered projects, disaster-resistant construction techniques, etc.

   - Long-term non-structural preventive measures: hazard mapping and risk analysis, legal framework, building codes, land-use regulations, disaster insurance, tax incentives, etc.

2. Emergency preparedness and early warning systems

   - Early warning networks and forecasting
   - Community-level responses
   - Emergency measures: evacuation, mobilization of medical assistance and necessary supplies.

3. Post-disaster rehabilitation

   - Reconstruction
   - Resettlement

1330-1600 **Session X:** Formulation of framework of action for natural disaster reduction in the ESCAP region

Friday 15 February 1991

0930-1130 Adoption of the report

1130-1200 Closure of the Symposium

1230-1800 Field trip (optional)

Annex III

IDNDR INTERNATIONAL CONFERENCE 1990 JAPAN: MAJOR TASKS IDENTIFIED

1. To raise the level of awareness of the policy makers of each country of the importance of disaster countermeasures (prevention, preparedness, relief and recovery).

2. To disseminate disaster prevention knowledge and enhance awareness of disasters on a broad basis (not only among individuals but also among private enterprises and the mass media); to transmit to others the lessons learned from disaster experiences and disseminate disaster prevention ideas, and educate children about disasters and prevention; and to compile the manuals necessary for such efforts.

3. To maintain comprehensive records of natural disasters, so that the experience and knowledge gained will not be lost to future generations and other countries; to promote the exchange of information on disaster experiences among developing countries.

4. To develop human resources and organizations for disaster mitigation activities; to introduce training courses and organized strategic centres for this purpose.

5. To organize volunteers to carry out disaster mitigation activities, and to formulate guidelines for the effective utilization of all volunteers who may offer their services at the time of an emergency.

6. To collect and edit information and statistics on disasters; to compile and issue white papers on disaster mitigation activities in each and every country.

7. To improve the means of communicating disaster information (both hardware and software), and to train personnel to understand such information accurately and respond appropriately.

8. To strengthen the international network for collecting information on disaster prevention and promote mutual exchange of information (for example, meteorological information) among the countries concerned.

9. To provide technical guidance and prepare manuals on the dissemination of disaster prevention technology (for example, earthquake-resistant building design codes).

10. To prepare hazard maps and formulate land-use plans which incorporate the disaster prevention component.

11. To take necessary disaster prevention measures in response to the potential danger of disasters caused by the concentration of population and urban functions in metropolitan areas.

12. To assess the possibility of damage to communication systems in a highly industrialized society, and to take necessary preventive measures.

13. To send advisory missions, when requested by disaster-prone countries, to recommend comprehensive disaster prevention/preparedness plans for disaster mitigation.

14. To provide orderly emergency relief assistance that will meet the actual needs of a disaster-stricken country.

15. To promote not only emergency relief assistance but also assistance for the recovery of basic infrastructure and other facilities, recognizing the crucial need for assistance in restoration and rehabilitation after disasters.

Annex IV

LIST OF DOCUMENTS

Title	*Author*
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PART TWO

TECHNICAL BACKGROUND PAPERS ON WATER-RELATED NATURAL DISASTERS IN COUNTRIES OF THE ESCAP REGION

I. OVERVIEW OF NATURAL DISASTERS CAUSED BY CYCLONES/TYPHOONS AND FLOODS IN COUNTRIES OF THE ESCAP REGION AND EXISTING PREPAREDNESS AND PREVENTION MEASURES IN THE VULNERABLE COUNTRIES

A. Introduction

Data available on the occurrence of tropical cyclones and related storm surges and floods in countries of the ESCAP region confirm that these climatic hazards occur during defined seasons and in specific zones. Damage resulting from these water-related hazards is common but when their intensity reaches extreme proportions, causing widespread destruction and loss of life beyond the capacity of the affected country to manage, they are classified as disasters. Collectively, these hazards constitute the major recurring natural disasters of the region and are responsible for the greatest loss of life, disruption of populations and destruction of property.

The available data also show that while not all the ESCAP countries are ravaged by tropical cyclones, very few of them are free from damaging floods. The data tend to indicate that although tropical cyclones and associated storm surges are liable to cause the most fatalities, floods are the most frequently occurring disaster and are liable to cause the greatest total damage. The distribution of death and damage in the countries of the region is related to a number of factors which include each country's vulnerability to cyclones and/or floods, population density and concentration, and level of economic development. Many of the occupied areas in the disaster vulnerable countries involve an element of risk and contribute to the magnitude of the disaster. For example, those areas comprise the cyclone prone low-lying coastal areas and the flood-prone alluvial flood plains. It is a matter of record that most of the greatest disasters of the region have occurred in the low-lying coastal areas as a result of tropical cyclones and floods. Growing populations and their over-concentration in the cyclone and flood vulnerable areas are increasing the risk of major disasters.

Until recently, most of the disaster-prone countries have directed their efforts towards disaster relief and post-disaster activities. However, the continual occurrence of these disasters is influencing most governments of the region to consider the implementation of comprehensive disaster prevention and preparedness to mitigate the impact of these disasters. Under this programme, all methods and tasks necessary to protect the population and to ensure its recovery form the effects of disasters caused by tropical cyclones and floods are considered and used when appropriate. By definition, disaster prevention covers the long-term policies and activities and is achieved by using permanent controls, structural and non-structural, which are implemented in advance of the disaster. On the other hand, disaster preparedness covers the short-term measures, which are essentially non-structural in nature and which are planned in advance but carried out during the emergency.

To encourage those countries to realize improved disaster planning, a number of United Nations agencies which have an involvement in the field of disaster management are providing tangible support. In particular, joint programmes sponsored by the Economic and Social Commission for Asia and the Pacific (ESCAP) and the World Meteorological Organization (WMO) have led to the formation of committees with membership drawn from countries affected by cyclones and floods. The activities of two committees, namely the Typhoon Committee and the Panel on Tropical Cyclones, have resulted in substantial progress being made in the provision of scientific and technical advice on disaster mitigation. This advice is in the form of manuals and guidelines and covers the full range of concepts and principles applying to disaster mitigation and management. In addition, the agencies and the committees maintain and implement action programmes under the five components of meteorology, hydrology, disaster prevention and preparedness, training and research. These programmes have already resulted in some significant gains in disaster preparedness activities, especially the improvement of tropical cyclone and flood forecasting systems. The timely and more reliable warnings which can now be issued are responsible for the saving of many lives and a significant reduction in damage.

To be effective, however, the disaster prevention and preparedness programmes must be supported by efficient response and rehabilitation activities should a disaster occur. As part of its function, the Office of the United Nations Disaster Relief Co-ordinator (UNDRO) provides support to those countries which suffer from a disaster by coordinating the relief activities of all potential donors. Further support is provided by non-government agencies, such as the League of Red Cross Societies, especially in the relief and rehabilitation phases of disaster management.

Achievements in implementing disaster prevention plans throughout the region have been varied. While the

lack of funding is usually the major obstacle to disaster prevention activities, there are a number of other factors which have slowed progress. The formulation of comprehensive disaster prevention plans should be based on the identification of the hazard by risk analysis. Structural solutions to mitigate the hazard will follow normally once the potential risks have been defined. The non-structural solutions which rely heavily on land-use regulations and building codes of most developing countries are limited. Such regulations cannot be enforced without the support of both the government and the local people and this will in many cases require a significant change in social attitudes and conditions.

A review of the disasters suffered by the countries of the region clearly indicates that if effective measures are taken to deal with disasters caused by tropical cyclones and floods, substantial reductions in loss of life, injuries, property and social and economic infrastructure will be achieved.

This paper provides an overview of the nature of tropical cyclones, storm surges and floods which afflict the ESCAP region and the range of possible prevention and preparedness measures which are being employed or contemplated to combat the effects of disasters. It also attempts to appraise the activities being undertaken by some countries and organizations to improve the standard of disaster management throughout the region.

B. Tropical cyclones

1. General

Typhoons and tropical cyclones are two different names which are used in the ESCAP region to describe the same meteorological phenomenon. Depressions which form over the sea in the tropics and develop into intense storms are called "typhoons" in the north-west Pacific and are known as "tropical cyclones" in the south-west Indian Ocean, in the Bay of Bengal and Arabian Sea, in parts of the South Pacific and along the northern coasts of Australia. For the purpose of this paper, the term tropical cyclone is taken to be synonymous with typhoon.

A single tropical cyclone may affect large areas and may have tremendous destructive potential. During the life of a tropical cyclone, which can last from several days to several weeks, the energy released can be extremely high and spread over a wide area. During its lifetime, a tropical cyclone may vary in intensity and destructive power as it progresses along a largely unpredictable track. It may cause loss of life and damage in a number of countries during its passage. Many tropical cyclones form but do not reach high intensity, while others travel far away from land areas, having little destructive effect.

The violent winds and torrential rainfalls which accompany well-developed tropical cyclones can result in extreme damage over land areas. When the destructive force of these depressions combines with the devastating hazard of a storm surge in low-lying coastal areas, tropical cyclones become the most deadly disturbances of the tropics. The heavy and prolonged rainfall which accompanies tropical cyclones often produces major flooding and can cause loss of life and property damage of disastrous proportions.

2. Nature and characteristics

Tropical cyclones are low-pressure systems or depressions around which the air circulates in an anti-clockwise direction in the northern hemisphere but in a clockwise direction in the southern hemisphere. Tropical cyclones form over the open sea in an area where the sea surface temperature is 25°C or higher. They are usually classified according to the surface wind strength measured near the "eye" or centre of the disturbance. The two categories for these disturbances are: wind speeds which range from 17 to 32 metres per second; and wind speeds in the range of 32 to 85 metres per second. In the more intense tropical cyclones, wind speeds greater than 32 metres per second occur and the tropical cyclone is then said to be at full hurricane force.

The areas of occurrence and the names ascribed to the disturbances under the above classification are given in table 1 below.

Table 1. Tropical cyclones: areas of occurrence and categories

REGION	*RANGE OF MAXIMUM WIND SPEEDS (METRES PER SECOND)*	
	17-32	*32-85*
Western North Pacific Ocean	Tropical cyclone	Typhoon
Bay of Bengal and Arabian Sea	Cyclone	Severe cyclone
South Indian Ocean	Tropical depression	Tropical cyclone
South Pacific Ocean	Tropical depression	Cyclone

The period of maximum frequency for tropical cyclones is broadly related to the occurrence of the summer monsoon which begins over South-east Asia by the end of May and extends to north-western India and central China by mid-July. During the southern hemisphere, the monsoon moves southward across northern Australia. The frequencies of occurrence of tropical cyclones by areas and months are given in table 2.

Table 2. Tropical cyclones: frequency of occurrence

AREA	*Jan*	*Feb*	*Mar*	*Apr*	*May*	*Jun*	*Jul*	*Aug*	*Sep*	*Oct*	*Nov*	*Dec*
Northern Hemisphere												
Western North Pacific Ocean	0.6	0.3	0.6	0.8	1.2	2.1	4.6	6.2	5.7	4.6	2.9	1.4
Bay of Bengal and Arabian Sea				0.3	0.7	0.6	0.5	0.4	0.4	1.0	1.1	0.4
Southern Hemisphere												
South Pacific Ocean	2.0	2.0	1.9	0.7	0.1	0.1					0.1	0.7
South Indian Ocean	0.5	0.5	1.8	2.7	1.7	0.4						

Some of the significant characteristics of tropical cyclones are:

(a) The magnitude of force of a tropical cyclone is a measure of its destructive power. Its damaging effect is produced by a combination of strength, gustiness and persistence, which can be indicated by wind force.

(b) Frequency describes how often a tropical cyclone of given magnitude may be expected to occur on average. For example, the greatest frequency of formation of tropical cyclones occurs in the region east of the Philippines. The average frequency of these events is greater in the northern latitudes compared to the southern latitudes of the ESCAP region.

(c) Duration refers to the length of time over which the tropical cyclone persists. It may last from a few hours to several days or longer.

(d) Areal extent refers to actual area affected by the tropical cyclone. Depending on the intensity of a tropical cyclone, its area of influence may be limited to a narrow path or its destructive power may extend over a large area.

(e) Rate of onset is the time interval between the issuance of the first forecast and arrival of maximum impact of the tropical cyclone. This time interval determines the amount of time available to implement emergency operations and disaster relief operations.

(f) Seasonability refers to the season of the year during which tropical cyclones are experienced. These disturbances usually occur during known periods of the year and reach a peak frequency over a span of several months.

3. Regional occurrence

Tropical cyclones occur more frequently in Asia than in any other part of the world. These atmospheric disturbances generally originate over the ocean south of latitude 20°N and north of latitude 20°S. In the ESCAP region, the most frequent formation of tropical cyclones occurs over the north-west Pacific Ocean just east of the Philippines. The main tropical cyclone period in the north-west Pacific extends from July to October. Tropical cyclones which are spawned in this region are relatively regular in their development and movement. Once formed, they generally track westward and may later turn north-west, affecting the Philippine Islands first and moving on to the coast of Asia, particularly early in summer, or then may recurve north-eastward towards Japan.

Those tropical cyclones which rarely continue to move westward across Indochina and Myanmar tend to lose their intensity after crossing the coastline. They may redevelop, however, over the Bay of Bengal and continue to move westward over India or recurve northward towards Bangladesh.

In the Bay of Bengal, in addition to those coming from the north-west Pacific, tropical cyclones usually develop over the southern section of the Bay and move in either a westerly or northerly direction to affect India or

Bangladesh. These tropical cyclones are more likely to occur towards the end of the monsoon season in October and November and are often accompanied by storm surges. Extremely heavy rainfall which is generated by these tropical cyclones, may result in severe flooding.

Some tropical disturbances track across India or develop over the Arabian Sea and move towards Pakistan or eastern Islamic Republic of Iran. The occurrence of damaging tropical cyclones which affect these two countries is not an annual event.

Tropical cyclones originating in the southern hemisphere within the ESCAP region, have a relatively extensive spawning area that includes the Indian Ocean, the south Pacific Ocean, the Timor Sea, the Arafura Sea, the Gulf of Carpentaria and the Coral Sea. Frequently the tropical cyclones which form to the east of Australia track west-south-westwards before either encountering the Australian continent or recurving to the south-east. Many cyclones in the zone around Australia exhibit quite erratic movement and have low travel speeds compared to the northern hemisphere depressions. The frequency of occurrence of tropical cyclones in the southern hemisphere is about half the number generated in the northern hemisphere. These disturbances usually occur during the period December to April each year.

C. Storm surges

1. General

Storm surge is the term used to describe the rise of the mean level of the ocean which occurs as a tropical cyclone approaches a coastline. Over the open sea the low atmospheric pressure at the centre of a tropical depression causes the water below it to rise above the level of the surrounding ocean. As the cyclone approaches the coast, winds may pile up the already high sea waters against the shoreline, thus causing an additional rise in the water level.

2. Nature and characteristics

While the general effect of waves and swell may extend a considerable distance from the cyclone centre, the surge itself is usually restricted to a limited section of coastline. Although a storm is a fairly rare event, it is a devastating hazard. It occurs with high winds, wave action, often intense rainfall and major flooding, and carries with it the potential for substantial loss of both life and property. Its effects are more pronounced in wide and shallow bays exposed to the tracks of tropical cyclones.

When the landfall of a tropical cyclone coincides with a high tide, the results may be particularly devastating as the rise in sea level may reach several metres or more above normal, quickly inundating the low-lying areas of the coast. Thus, in assessing the risk of storm surge, normal tidal oscillations must be included. This combined effect of surge and tide is termed "storm tide".

A particularly dangerous feature of storm surge is that it may occur several hours in advance of the landfall of a tropical cyclone and cause severe flooding at a time when the evacuation of people is still in progress. If a tropical cyclone which possesses a low central pressure and strong winds occurs in shallow coastal waters and coincides with high tide conditions, the loss of life and material damage may be extremely high.

Most of the great disasters associated with tropical cyclones have been caused by storm surges. When a tropical cyclone approaches the coast, the accompanying storm surge has a greater potential for heavy loss of life than any other meteorological phenomenon.

3. Regional experience

Areas of the ESCAP region where storm surges are most severe lie in the tropical belt where cyclones occur. However, other combinations of conditions have resulted in disastrous storm surges in extra-tropical and temperate regions.

Disastrous inundation of coastal zones as a result of storm surge have been experienced in seaboard countries and areas, including Australia, Bangladesh, China, Japan, Philippines, Hong Kong, Republic of Korea, Thailand and the Pacific island countries. The northern sector of the Bay of Bengal is reported to be most vulnerable to storm surge, where coastal geometry exacerbates the formation of these abnormal rises in sea level.

D. Floods

1. General

Damage from flooding has been increasing in most countries in the ESCAP region, and floods are the most frequently occurring and thus the most destructive of all natural hazards which affect the area. Flooding is a by-product of persistent heavy rain which is usually associated with the passage of a tropical cyclone or a monsoonal depression. It is a natural phenomenon and will occur inevitably from time to time in all rivers and natural drainage systems. However, flood disasters are increasing because of deforestation, poor land drainage, expanding agriculture and urbanization. All of these activities promote an increased rate of run-off and greater flood peaks.

As with other natural hazards, floods are beyond human control, but they only become a problem because of man's intrusion and the location of incompatible activities in the natural flood plain. Floods are a natural phenomenon and all that can be done is to find ways of mitigating the damage they cause.

2. Nature and characteristics

Flooding occurs in well-defined areas when the channels of a river or stream cannot contain run-off from the catchment. This results in overtopping of the river banks and inundation of the adjoining low-lying areas forming the floodplain. Flooding can also result from a combination of high river flow and storm surge in the lower reaches of coastal rivers and in estuaries.

In summary, natural river flooding may arise from:

(a) Heavy and prolonged rainfall in the catchment of major river systems;

(b) Intense storms of relatively short duration in the catchments of small watercourses;

(c) Coastal storm surges;

(d) Wind and tide coinciding with high discharges in the estuaries of a coastal watercourse;

(e) Snow-melt either directly or in combination with heavy rain.

Artificial flooding can be caused by obstructions on floodplains. These obstructions can be temporary due to debris build up or permanent structures such as bridges or embankments.

Some of the significant characteristics of floods are:

(a) Depth of water - the maximum depth of inundation affects the damage to buildings and crops and the cost and practicability of structural mitigation measures;

(b) Duration - the period of inundation is an important factor in the degree of damage and inconvenience caused;

(c) Rate of rise - the time taken for the flood to rise governs the practicability of such approaches as emergency evacuation and flood warnings;

(d) Velocity - high velocity floodwaters create erosive forces and hydrodynamic pressures which affect the design of levees and floodproofing measures;

(e) Frequency - a statistical expression of the average time period between floods equalling or exceeding a given magnitude. Floods that occur frequently are well remembered by people while less frequent floods tend to encourage complacency and carelessness;

(f) Silt and debris - these not only increase urban losses but can, when deposited, reduce channel capacity, degrade agricultural lands, and choke flood-passing structures, thus exacerbating flooding;

(g) Inundated area - extent of the area covered by flood water corresponding to a flood of a given frequency;

(h) Seasonability - inundation during the growing season can have a devastating effect on cropping enterprises whereas at other times flooding and the deposition of sediment may enhance production.

3. Regional flood behaviour

Most countries in the ESCAP region experience frequent and devastating floods. Because of the vast differences in topography, climate and exposure to tropical cyclones throughout the region, wide variations in the nature and effects of flooding are experienced. These variations range from flash flooding in some countries to long duration flooding in others. A number of countries experience the full range of flood behaviour.

The basic causes of most river flooding in the region is the incidence of heavy rainfall. Only a few rivers rising in the Himalayas or in countries at higher latitudes are affected by flood flows from snow-melt. Other factors, such as tidal surge or wind configuration may operate either to exacerbate an already occurring flood problem or to create a flood problem.

The most devastating flood-producing rainfall can be that associated with tropical cyclones. Those countries in the region which experience tropical cyclones usually suffer the most destructive floods. When aggravated by wind-induced surge along the coastline, flooding created by tropical cyclones can reach catastrophic proportions. If rainfall intensities are high and the area affected by the tropical cyclone is large, extreme flooding may be experienced over both small and large river basins.

The size of the basin usually governs the nature of flooding and therefore the type of meteorological event, or events, which are capable of causing extreme floods. In the large river basins of the region flooding is usually seasonal and peak discharges can be maintained for long

periods extending over days or weeks. Flash floods are usually produced on small, steep catchments and characterized by the short time of concentration between the storm occurrence and the arrival of the flood wave at the basin outlet. This type of flooding is becoming more widespread, causing an ever-increasing amount of damage, especially in areas which are suffering from growing populations and deforestation.

Rivers of the region with large drainage areas which receive more or less continuous rainfall during the wet season, such as the Yangtze, Mekong and Ganges, show a fairly uniform increase and decrease of such flow during the high water period. On the other hand, the rivers such as those of north China, Japan and the Republic of Korea which receive their flood flow from local convective storms and occasional tropical cyclones and which have smaller drainage basins, show marked fluctuations of water level during the high water period.

E. Damage assessment

Damage caused by tropical cyclones and floods continues to rise in most countries to the ESCAP region. This is because many of the human settlements in the disaster vulnerable countries are located in high-risk areas. The particularly vulnerable areas are floodplains and low-lying coastal regions where the density of population is already high and where population growth and economic development are concerntrated.

Although floods are the most commonly occurring disasters and cause the greatest total damages, tropical cyclones are reported to cause the most fatalities. The deaths or damages resulting from these two hazards are not uniformly distributed among the ESCAP countries but are related to number of factors, including location, vulnerability, population density and community wealth.

The total damages associated with these two hazards are usually referred to as tangible and intangible costs. It is customary to further divide tangible damages into direct and indirect categories. Direct damages are of a physical nature. The physical damages caused by tropical cyclones stem from the strong winds, heavy and prolonged rainfall and storm surges. Physical damages associated with flooding result from the actual contact of flood water with goods, crops and structures and involve damage from sediment, debris or other floating objects. Indirect damage covers all damages which result indirectly from the tropical cyclone or flood and may occur during the event or in the weeks or months following. These damages cover the activities which are associated with lost production, disruption to communications and the like.

Intangible damages cover those damages which might be classified more as social than economic. These losses concern items that are not normally bought or sold and for which market values do not exist, in contrast to tangible damages which can be evaluated in monetary terms. The main intangible damages are disruption of personal activities, health impairment and risk to life.

Until 1983 few countries in the ESCAP region were collecting, compiling and analysing damage data for the purpose of regional and national planning. Although some data were collected in most of the countries, these were used mainly for the evaluation of the magnitude of the disaster and for allocation of resources for relief and reconstruction. The data were not sufficient for identifying the problems on a regional basis or for planning mitigation measures. The significance of the data for the formulation of the countermeasures was not well recognized.

The need for better estimates of the nature and magnitude of damages caused by tropical cyclones and floods was promoted by the Typhoon Committee in 1981. ESCAP, WMO, UNDRO and the League of Red Cross and Red Crescent Societies (LRCS) co-operated to produce a revised format which was more detailed and specific that the previous questionnaire circulated to ESCAP countries. The revised format was adopted in 1983. In addition, a roving seminar was organized by ESCAP in 1983/84 to assist selected Typhoon Committee countries in the ESCAP region to develop methodologies for the systematic data collection programmes of damages experienced during tropical cyclones and floods. The type of information identified for collection and compilation was similar to that included in the revised TCS format and included direct damage caused to human resources, agricultural products and facilities, public utilities and private properties. The evaluation of indirect damage to economic and social activities was also recommended for inclusion in the suggested programme. The categories for damage assessment are those adopted in the ESCAP *Water Resources Journal* for the presentation of such statistics.

Data and information which relate to annual damage sustained as a result of tropical cyclones and floods in the region are compiled in June issues of the ESCAP *Water Resources Journal*. The information considered includes loss of life, injuries, population affected, damage to buildings, agricultural area affected and area of cropland damaged.

Not all countries providing information on damage caused by tropical cyclones or floods include a monetary assessment of damages. Information gleaned from other sources indicates that damage costs attributed to these two phenomena are increasing at a rate of about 4.4 per cent annually. However, as these damage costs relate only to

direct damage, they significantly underestimate the actual damage. If the value of the additional and significant indirect losses was included, the total monetary value would increase substantially.

Not all countries report on a regular basis or provide a complete set of statistics. As a result, there are gaps in the chronology of damages presented for the countries concerned. Although questions have been raised as to the reliability of these data, the information does serve as a general indicator of the disruption and damage that cyclones and floods inflict on the individual countries. An indication of severity and frequency of disasters which accompany these events may be obtained from the tabulations.

A summary of major disasters caused by tropical cyclones and floods, based on the information in the *Water Resources Journal*, is presented as table 3. The magnitude of each disaster is expressed in terms of the number of people killed and the size of population affected.

F. Risk assessment

Risk assessment or the assessment of a country's vulnerability to tropical cyclones, flooding and storm surge should be regarded as an essential element in the planning and implementation of measures which are designed to prevent or mitigate the disasters which these hazards may cause. Naturally, if a country is prone to any or all of these hazards, action of various kinds should be taken in order to save lives and reduce damage even if detailed risk-evaluation studies have not been carried out.

When a tropical cyclone approaches a country, the threats are threefold — winds, river floods and storm surges. Although strong or violent winds are a fundamental characteristic of tropical cyclones, it is often the rain-induced river floods and the storm surge which cause the heaviest loss of life and do the greatest damage. In any planning for disaster prevention and mitigation, it is recommended that the hazards likely to arise from winds, river floods and storm surges be analysed separately and also collectively. Composite analyses which take into account all risks should be carried out so that the disaster prevention measures may be comprehensive and effective. In coastal areas, in particular, it may be necessary to make a combined analysis of storm-surge and river-flood frequency.

The pattern of wind damage which accompanies tropical cyclones is usually widespread and can be extreme, culminating in the large-scale destruction of buildings. Evaluation of the hazard due to wind and the setting of design criteria to resist wind forces are based on a frequency analysis of measured wind velocities at specific locations. Buildings and other structures can be designed to resist these wind forces.

Because of the devastating effect of storm surges associated with tropical cyclones, it is necessary to ascertain the extent to which a segment of coast is vulnerable to this hazard. The assessed element of risk associated with storm surges is converted into an estimate of likely damage. This is achieved by a frequency analysis of climatological data on sea level elevation and on relevant meteorological elements. Statistical methods are used to estimate the likelihood of extreme values of surge amplitude and duration. Numerical modelling techniques are used to estimate surge frequencies in the absence of factual data. The risk assessment of storm surge also includes the consideration of astronomical tide and seeks to maximize the joint occurrence of these two factors.

It is prudent to accept that all tropical cyclones, whatever their intensity, have the potential to produce heavy rainfall capable of producing river floods. The extent of damage caused by a flood is a function of the characteristics which describe its destructive capability, such as depth, inundated area, water velocity, frequency of occurrence, etc. However, rain induced floods can occur separately as a result of tropical depressions, thunderstorms, etc.

The description and assessment of hazards should be regarded as an essential element of flood prevention and mitigation. If sufficient data of acceptable quality are available, it may be feasible to estimate risks in quantitative terms for small areas, i.e., at the local level. This procedure is called flood risk mapping. Such maps can play an essential role in economic and physical planning and in the equitable financing of insurance schemes.

G. Disaster prevention and preparedness

1. General

The key to reducing in the loss of life and material damage caused by tropical cyclones, storm surges and floods throughout the ESCAP region is the adoption of improved disaster prevention and preparedness measures. Disaster prevention may be described as measures designed to prevent natural phenomena from causing or resulting in disaster or other related emergency situations. It is concerned with the formulation and implementation of long-range policies and programmes to prevent or eliminate the occurrence of disasters on the basis of vulnerability analysis of all risks. It also includes legislation and regulatory measures principally in the fields of physical and urban planning, public works and buildings. On the

Table 3. Summary of major disasters caused by tropical cyclones or floods in selected countries of the ESCAP region. 1970-1988

Country	*Year*	*Nature of Hazard*	*Human Casualties*
Afghanistan	1976	Flood	46 dead
	1978	Flood	130 dead
			350 000 affected
Australia	1974	Tropical Cyclone	60 dead
Bangladesh	1970	Tropical Cyclone &	More than 225 000 dead
		Storm Surge	600 000 people affected
	1973	Tropical Cyclone	1 451 dead
	1974	Flood	2 000 dead
			6 million families affected
	1985	Tropical Cyclone	11 000 dead
			1.31 million people affected
	1987	Flood	2 055 dead
			25 million people affected
	1988	Flood	1 644 dead
			45 million people affected
Myanmar	1974	Flood	1.4 million people affected
China	1981	Flood	1 300 dead
			10 million people affected
	1986	Tropical Cyclone	430 dead
			4 550 injured
Fiji	1986	Tropical Cyclone	2 dead
			165 000 affected
India	1977	Tropical Cyclone	10 000 dead
			3.5 million people rendered homeless
	1983	Tropical Cyclone	2 300 dead
			53.1 million people affected
	1988	Flood	4 910 dead
			50 million people affected
Islamic Republic of Iran	1979	Flood	800 000 people affected
	1986	Flood	424 dead
			10 000 injured
Japan	1982	Flood	345 dead
			661 injured
	1987	Tropical Cyclone	200 people dead or injured
Pakistan	1973	Flood	160 killed
			5 million people affected
	1976	Flood	425 killed
			10 million houses demolished
	1988	Flood	510 dead
			3.7 million people affected

Table 3 *(continued)*

Country	*Year*	*Nature of Hazard*	*Human Casualties*
Philippines	1976	Tropical Cyclone & Floods	215 dead
			621 000 people affected
	1978	Tropical Cyclone	444 dead
			1 000 people injured or missing
	1981	Tropical Cyclone	236 people killed
			600 000 people affected
	1987	Tropical Cyclone	980 killed
			930 injured
			2.79 million people affected
Repulic of Korea	1971	Tropical Cyclone	225 dead
			132 missing
			116 000 people affected
	1977	Floods	277 dead
			455 injured
			70 000 people affected
	1987	Tropical Cyclone	343 dead
			138 injured
			25 000 people affected
	1987	Floods	381 dead
			428 injured
			151 000 people affected
Sri Lanka	1981	Tropical Cyclone	Over 1 000 dead
			1 million people affected
Thailand	1975	Flooding	314 dead
	1980	Flooding	61 dead
			832 000 people affected
	1988	Flooding	373 dead
			2 000 injured
			1.4 million people affected
Tonga	1982	Tropical Cyclone	5 dead
Viet Nam	1971	Floods	594 dead
	1978	Floods	643 dead
			5 million people affected
	1980	Floods	459 dead
			10 million people affected
	1983	Tropical Cyclones & Floods	658 dead
			508 injured
			400 000 homes destroyed
	1985	Tropical Cyclone	900 dead
			213 000 houses destroyed

other hand, disaster preparedness may be described as the actions designed to minimize loss of life and property damage and to organize and facilitate timely and effective rescue, relief and rehabilitation in the case of disaster. It is supported by necessary legislation which comes into force in disaster situations or similar emergencies which cannot be avoided. It is also concerned with forecasting and warning, the education and training of the population, and organization and management of disaster situations including the preparation of operational plans, training of relief groups, the stockpiling of supplies and provision of the necessary funds.

Prevention and preparedness measures are not isolated activities, since both can be undertaken together or one can be a continuation of the other. This is because not all disasters can be prevented, and preventative measures may fail. Thus, to limit or mitigate the effects of the disasters which cannot be prevented, certain measures have to be undertaken to return the community to normality as soon as possible after the event.

As previously stated, disaster prevention and preparedness consist of a wide range of measures, some long-term and others short-term, aimed at saving lives and limiting the amount of damage that might otherwise be caused. Prevention covers the long-term aspects and is concerned with policies and programmes to prevent or eliminate the occurrence of disasters. Preparedness covers the short-term measures which are designed to cover the action necessary during the approach of a possible disaster, during the existence of a disaster situation and in the ensuing period devoted to relief and rehabilitation. Disaster prevention and preparedness is usually accomplished using two fundamental approaches. Firstly, it may be achieved using permanent controls, structural or non-structural, designed and developed in advance of the disaster. Secondly, it may be obtained by employing temporary measures, planned in advance, but carried out during the emergency.

The destructive power of a tropical cyclone is manifested by strong winds, flooding and storm surges. Any disaster prevention and preparedness system must include warnings and protective measures against each of these effects. Winds are a fundamental property of tropical cyclones, while flooding and storm surges are consequences of tropical cyclones and various other causes.

2. Disaster prevention

The principal preventative measures employed to curb the destructive and injurious effects of tropical cyclones are building design and construction standards to resist wind and water.

Disaster prevention measures attempt to lessen the impact of flooding or storm surge on the social and economic conditions of human settlements in floodplains or low-lying coastal areas. The range of preventative controls adopted to protect development on floodplains includes both structural measures, such as channel modifications, flood storages and levees, which are designed to reduce the incidence or extent of flooding, and non-structural measures such as flood insurance, zoning restrictions, land-use management, economic incentives, public information and education, etc. Non-structural measures are intended to modify flood susceptibility and flood impact. The range of measures available to protect against the effects of flooding is much wider than that available to reduce the impact of tropical cyclones.

Preventative measures to protect low-lying coastal areas against damage from tidal inundation also include structural and non-structural measures. The principal structural measure involves the construction of embankments capable of withstanding the anticipated storm surge heights and forces. Non-structural measures employ land-use zoning and controls over occupation in high hazard areas. Building controls are also imposed to restrict building on vulnerable areas. These controls require that flood heights are set at a safe elevation above a given datum.

The selection of the best mix of measures to prevent the occurrence of future flood or storm surge disasters will be based on the consideration of all the available structural and non-structural options. The optimum mix of measures will be based on risk analysis and the economic performance of the overall scheme. Consideration of social and environmental factors in addition to the legislative and legal constrictions should be included in the planning process.

3. Disaster preparedness

Disaster preparedness is seen as that action taken when the occurrence of a tropical cyclone, flood or storm surge threatens to become a disaster. Preparedness activities are designed to reduce social disruption and losses to existing property and are an essential component of overall disaster planning. They can serve in the absence of more permanent measures to reduce the threat to loss of life and property.

The main types of disaster preparedness include:

(a) Forecasting and warning and evacuation from affected areas;

(b) Flood fighting;

(c) Relief.

Depending on the size of the drainage basin, the length of river and the time of concentration of floodwater in the main channel, flood forecasts and warnings may be issued well in advance of the arrival of the flood crest on large rivers. Flash floods originating on small catchments present special problems and usually require some form of forecasting based on rainfall estimates.

Although the forecasts for cyclones and floods may be accurate and timely, they may have little or no effects on the intended recipients if the warning system for dissemination of the forecast is inadequate. Each agency responsible for emergency operations should receive prompt forecasts and warnings of the changing circumstances so that action needed to meet the emergency can be achieved. Dissemination of forecasts requires an effective communications system based on radio broadcasts, television, newspapers, telephone and special warning systems.

The evacuation of people from a potential or actual disaster area is one of the most important elements of disaster mitigation. Careful planning is necessary for the efficient evacuation and relief of flood victims. To be effective, the plan should define hazardous areas and potential dangers. However, the difficulty in evacuating victims and property can be increased if escape routes cannot cope with the traffic volume, if evacuation services cannot be contacted, or suitable evacuation equipment such as trucks, boats, helicopters, are not available.

Flood fighting can be defined as the taking of precautionary measures against disaster at times of flood and storm-surge. These measure should aim to prevent damage or to minimize its extent, to protect life and property and, in general, to ensure the safety of the population. Successful flood fighting depends upon good organization, thorough advance planning, well-trained personnel and the effective coordination of operations at local, provincial and national levels. The planning should cover all those who will be involved from the flood-fighting corps, municipality, town or village officers and the general public to the regional and central government. It involves the construction of temporary controls to exclude floodwater from protected areas or the strengthening of existing structures to ensure protection.

The main aim of relief is to provide immediate assistance to overcome personal hardship and distress, including essential repairs to houses and the repair and replacement of essential items of furniture and personal effects. Relief should include the reception and care of evacuated victims, medical services, etc.

H. Current status of disaster prevention and preparedness in the ESCAP region

1. Disaster prevention

Many coastal areas of the seaboard countries of the region which are prone to damage by tropical cyclones and associated storm surge are experiencing rapid population growth and economic development. The more advanced countries have implemented long-term protective measures against hazards, such as land use controls, building codes to ensure the structural integrity of new buildings, improved infrastructure, such as roads and communications, and the proper design and appropriate siting of essential services.

While most other countries are contemplating these measures, there are a number of obstacles to their adoption. The principal impediment to land use controls is the cost and social disruption in the relocation of large numbers of people, especially the poor and underprivileged. It is not an easy task to enforce land use regulations in developing countries which have little experience in these matters.

Although cyclone resistant design has helped to reduce the number of casualties and to prevent serious damage to buildings, introducing appropriate building codes to control new buildings can be a difficult task if new materials and foreign building techniques are involved. However, when these codes are adopted, the structural capability of buildings to withstand the impact of wind forces will be improved dramatically. In addition, progress has been made in developing mitigation measures to improve the safety of non-engineered structures such as ordinary dwellings and simple public buildings which are built with local material in the traditional manner. As a consequence, the toll of human life and the total property damage may undergo a significant reduction. It should be noted, however, that the opportunity to adapt those measures to existing development is limited.

Almost all countries in the ESCAP region experience severe flood problems at comparatively frequent intervals. Flooding in some countries represents the greatest natural disaster and its occurrence is becoming more frequent especially in urban areas, and causing increased loss of life and destruction of property. This is the result of a number of factors, which include: increasing concentration of people on flood plains; squatter populations occupying floodways; encroachment of development into flood-prone areas; and lack of government action because of shortage of necessary funds, absence of statutory controls and insufficient technical capability.

The traditional approach to reducing flood losses relies upon the implementation of structural flood mitiga-

tion measures. The possible range of measures to protect development on flood plains includes the construction of dams, levees and channel improvements. Most earlier flood mitigation programmes adopted by individual countries have been specific to a city or a discrete agricultural area and have employed a narrow range of engineering works to provide a solution to the flooding problem. Although some projects were successful, may of the programmes have actually exacerbated flood damages for the following reasons:

(a) The adopted structural measures were inadequate and ineffective because of the adverse site conditions;

(b) The flood standard adopted for delineation of the flood hazard area was too low;

(c) Increased population was occupying the protected area.

In recent years, most countries have recognized the inadequacies of programmes based solely on structural measures. Numerous attempts have been made to employ non-structural flood loss prevention measures to assist in minimizing losses through exercising control over development in flood-prone areas. These measures usually involve a mix of structural measures and, in some circumstances, provide a comprehensive means of coping with a flood problem. In many cases, however, attempts to formulate programmes which include some of the non-structural measures, have met with limited success, especially those involving planning controls, acquisition of lands and relocation of people. Generally, application of large-scale non-structural measures is inappropriate for existing developed areas because of costs and social disruption. Only small-scale flood proofing measures such as house raising have limited application for the protection of those existing buildings which can withstand the mechanical effects of raising and where raising can be justified on economic grounds. Experience indicates that it is not an easy matter to enforce land-use regulations in most ESCAP countries.

The more advanced countries of the region have accepted that the model for comprehensive flood loss prevention should be based on the concept of the basin-wide management approach. Under this approach, the whole basin is considered and an appropriate mix of structural and non-structural measures is incorporated into the management plan. By this method, a reasonable degree of control is exerted over land use and development to ensure that the natural flood generating capacity of the basin is not exacerbated. To achieve the desired level of management, increased co-operation is required among the agencies involved in the management of land-based natural resources.

Before any significant impact in the reduction of flood losses can be made in many countries, it will be necessary for them to make significant progress on the following issues:

(a) Definition of flood-liable lands using flood risk analysis techniques;

(b) Preparation of comprehensive plans based on the "whole basin" concept, which consider the best combination of both structural and non-structural measures together with relevant social, economic and environmental factors;

(c) Formulation of suitable regulations for the control of the future use of the land and the nature of development within flood-liable areas with special provisions being exercised where these lands are substantially developed;

(d) Adoption of flood standards which minimize future flood damage and loss of life;

(e) Allocation of adequate funds which reflects a realistic rate of progress in the implementation of flood prevention plans and works.

2. Disaster Preparedness

The organizational response to disasters created by tropical cyclones and floods in most countries of the region is highly developed, and preparedness activities are seen by many as the most effective means for minimizing losses, given the current availability of funds and resources. Significant advances have been made in recent years for improving these measures.

(a) Forecasting and warning

Substantial progress has been made in meteorological forecasting and warning of tropical cyclones, especially through the regional co-operation of members of the Typhoon Committee, the Panel on Tropical Cyclones and the Tropical Cyclone Committee for the South Pacific. Improved data collection networks and forecasting techniques have been introduced in recent years and these have resulted in the enhanced prediction of tropical cyclone formation and movement. The improved techniques include: the installation and upgrading of various facilities, such as radar, telecommunications and satellite receiving systems; improved warning dissemination; upgraded data collection systems; and better prediction techniques for storm surge warning purposes. Regional co-operation in the sharing of observations and forecasts from neighbouring countries, combined

with technical assistance from WMO, has dramatically improved the accuracy of forecasts of tropical cyclones.

The improved dissemination of warnings to the public, together with advice on countermeasures to be adopted, has resulted in a better public response and substantial mitigation of the damaging effects of tropical cyclones.

In most countries, the capability to forecast floods has improved considerably, especially through the support given by ESCAP and WMO and the programmes initiated by the Typhoon Committee and the Panel on Tropical Cyclones. Computer modelling of watersheds, when linked to a network of meteorological and hydrological observation stations, has enabled the development of accurate flood forecasts and warnings. The development and use of radar for measuring rainfall has increased the capacity for rapid collection and processing of precipitation data. The improvement in the establishment of meteorological and hydrological recording and reporting networks has allowed many countries to prepare accurate and timely forecasts and warnings. However, there still exists considerable variation among ESCAP countries in the availability and reliability of telecommunications equipment needed for effective flood forecasting.

A by-product of improved forecasting has been the early dissemination of warnings. The receipt of warnings with increased lead time has allowed disaster co-ordinating bodies and the general public to undertake more effective measures to cope with the flood threat. With the receipt of more timely warnings, orderly evacuations are conducted which minimize the loss of life and movable property.

(b) Emergency activities

Most countries have upgraded their civil defense capability for the rescue of people from endangered areas through the mobilization of armed forces transport groups. Flood fighting and related activities have been upgraded. Several countries of the region have also organized local communities to respond to threats of disaster through co-operative activities which involve volunteers.

(c) Public awareness and education

Because adequate protection against flooding cannot be provided immediately to safeguard vulnerable areas, a number of countries have introduced programmes to provide information and educate the public on flood hazard situations. The development of readily accessible information which is easily interpreted has proved beneficial in reducing the flood hazard. This information includes the hydrology and hydraulics of a range of floods on areas subject to inundation. An understanding of the nature and extent of the flood threat can assist in preventing the unwise use and development of land; can lessen resistance to the application of sound planning and development controls; can reduce the extent of damage caused by floods; and can save lives in a flood emergency.

(d) Relief

In general, the recovery phase of disasters created by tropical cyclones and floods in the ESCAP region has been and continues to be well catered for. In most countries, the organizational response by governments to disaster victims' needs in the delivery of relief and rehabilitation services is highly effective and efficient. Governments of disaster-stricken countries are supported by the activities of UNDRO, which plays a central role in co-ordinating international relief efforts, so that the needs of an affected population are met in a timely and effective manner. Additional support is usually provided by non-governmental organizations (NGOs), such as the League of Red Cross Societies (LRCS), which contribute significantly to the effective mitigation of the adverse social impacts of these two natural disasters.

3. Legislative and institutional aspects

Most countries of the region have enacted a body of legislation which provides the necessary controls and responsibilities to cope with disaster situations. These laws permit the relevant authorities to govern the long-term requirements of disaster prevention and the short-term needs of disaster preparedness. They relate to such aspects as funding, planning, development, emergency relief and rehabilitation. They also specify the responsibilities of the various levels of government and the required integration of functions among them.

Although statutory controls to govern relevant aspects of community planning and development, including zonings, sub-division controls and environmental issues which pertain to disaster prevention, are available, many governments are reluctant to invoke them. On the other hand, virtually all countries of the region have well developed legislative provisions for dealing with the effects of disasters when the emergency occurs and to cater for the post-impact phase after the threat has subsided. The institutional responsibilities and emergency arrangements for implementing counter-disaster plans and measures to adequately deal with the situation are clearly spelt out. These formalized responses by governments have developed as a result of long experience with disasters created by tropical cyclones and floods.

Responsibilities for disaster management are usually divided among the various levels of government. At the national level the concern is with the broader issues, such as the disbursement of funds to the provincial and local governments for disaster prevention and disaster relief activities. Development and implementation of disaster management programmes becomes the responsibility of the relevant government agencies responding to the different levels of government. Few governments have appointed a central organization to co-ordinate the disaster mitigation activities of the different government bodies and other interested groups, so that a comprehensive approach may be adopted. It is only the more developed countries of the region which have cohesive institutional arrangements in place.

Bibliography

1. ESCAP/WMO Typhoon Committee, 1986. Annual Review 1986. Manila, Typhoon Committee Secretariat.

2. United Nations Economic and Social Commission for Asia and the Pacific (ESCAP), 1984. Proceedings of the Seminars on Flood Vulnerability Analysis and on the Principles of Flood Plain Management and Flood Loss Prevention. Water Resources Series No. 58. New York, United Nations.

3. ESCAP, 1984. Damage Information Compilation Systems in the Typhoon Committee Regional Member Countries. Bangkok, United Nations.

4. ESCAP, 1986. Proceedings of the Expert Group Meeting on the Improvement of Disaster Prevention Systems Based on Risk Analysis of Natural Disasters Related to Typhoons and Heavy Rainfall. New York, United Nations.

5. ESCAP, 1988. Proceedings of the Expert Group Meeting on Improvements of Flood Loss Prevention Systems on Risk Analysis and Mapping. New York, United Nations.

6. ESCAP, 1989. Proceeding of the Expert Group Meeting on Comprehensive Flood Loss Prevention and Management. New York, United Nations.

7. World Meteorological Organization (WMO), 1989. Some Aspects of Flood Forecasting Systems in Asia, 1984 to 1988. Report No. TCT-25, Geneva, WMO Secretariat.

8. WMO, 1987. Tropical Hydrology. Operational Hydrology Report No 25. Geneva, WMO Secretariat.

9. WMO, 1978. Present Techniques of Tropical Storm Surge Prediction. Report No. 13. Geneva, Marine Science Affairs, WMO Secretariat.

10. ESCAP, WMO and the League of Red Cross Societies, 1977. Guidelines for Disaster Prevention and Preparedness in Tropical Cyclone Areas. Geneva/Bangkok.

11. WMO, 1976. The Quantitative Evaluation of the Risk of Disaster from Tropical Cyclones. Special Environmental Report No 8. Geneva, WMO Secretariat.

12. United Nations Department of Economic and Social Affairs, 1976. Guidelines for Flood Loss Prevention and Management in Developing Countries. Natural Resources/ Water Series No 5. New York, United Nations.

13. United Nations Office of the Disaster Relief Co-ordinator, 1976. Disaster Prevention and Mitigation, Vol 2. Hydrological Aspects. New York, United Nations.

14. United States Fleet Joint Typhoon Warning Center, Guam,1989. Annual Tropical Cyclone Report. San Francisco, US Naval Oceanography Council Center.

15. ESCAP, 1970 to 1988. *Water Resources Journal* June Issues. Bangkok, United Nations.

16. Barton, I, R.W. Kates, and G.F. White, 1978. The Environment as Hazard. NewYork, Oxford University Press.

17. United Nations Centre for Regional Development, 1988. Regional Development Dialogue, Vol 9, No. 1. Nagoya, Japan.

II. CASE STUDIES ON PREPAREDNESS AND RESPONSE MEASURES RELATED TO DISASTERS CAUSED BY CYCLONES/ TYPHOONS AND FLOODS

Introduction

One of the main purposes of the current symposium is to exchange experiences on various aspects of different natural disasters. In line with this purpose, case studies on some cyclone/typhoon- and flood-related disasters were conducted.

Missions fielded to five countries collected information on disasters caused by cyclones/typhoons and floods as well as measures being taken to reduce the effects of these disasters and accordingly prepared case studies. The countries visited were:

(a) Philippines 22-26 October 1990;

(b) Samoa 12-16 November 1990;

(c) China 19-24 November 1990;

(d) Viet Nam 27 November - 2 December 1990;

(e) Pakistan 1-4 December 1990.

This paper provides summaries of these case studies, highlighting salient parts of each case study. Detailed information including tables, statistics and figures can be found in each mission report.

A. Philippines

1. Introduction

The Philippines is an archipelago comprising 7 107 islands, 11 of which constitute 94 per cent of the total area. The Philippines is a mountainous country, and with the exception of the large urbanized areas, many towns are accessible only by narrow dirt roads which can be easily washed away by floods or rendered impassable by landslides. The country lies along the path of destructive tropical cyclones, usually generated in the Pacific Ocean, east and south-east of the Philippines.

All the major urban areas are susceptible to tropical cyclones with various degrees of risk. Because of the numerous plains and valleys that make up the country's topography, these tropical cyclones usually cause serious flooding of the terrain as well. Furthermore, the total length of the combined coastlines of the islands and islets that make up the Philippines is about 17 000 km and is susceptible to storm surges as well.

2. Damage due to tropical cyclones, floods and storm surges in the Philippines

A tropical cyclone not crossing the country could still inflict considerable damage to lives and property. However, usually the typhoons which do cross leave a trail of devastation behind them. The months in which the largest number actually cross the country are October and November. In the past several typhoons followed each other within a few days during those months causing extreme damage to lives and property in the Philippines.

The disaster information available for the last 20 years (1969-1988) indicates that total loss of life due to tropical cyclones and related phenomena was as high as 2074 in the year 1984 and the total cost of damages amounted to 2.26 per cent of the GNP of the Philippines in 1970. In November 1984 only one typhoon and the associated storm surge and floods caused the death of 1 028 persons and property damages worth ₱4.1 billion (over $ US 250 million).

Tropical cyclones in addition to the very high winds also carry moisture flow, which, upon intensification at mountainous terrains, causes extensive flooding of the plains and valleys, losses of lives and extensive damage to crops. Flooding of urban areas causes considerable loss of property and nuisance to daily life and sometimes loss of lives. Such floods were experienced in a number of years in Central Luzon including the Metropolitan Manila area. The flooding of 1986 inflicted by one single typhoon covered an area of 8 670 hectares in the Metropolitan Manila area.

In the year 1980, 336 persons lost their lives due to floods and the total damage was over ₱366 million (about $US 35 million).

According to the records, storm surges as high as 3.0 m (10 feet) have been experienced in various coastal areas in the Philippines.

In some areas of the country whirlwinds, also known as tornadoes, with diameters less than a hundred metres are also observed, which cause some damage to property and rarely loss of lives.

3. Disaster prevention agencies in the Philippines

Originally the Philippine Weather Bureau, later restructured as Philippines Atmospheric, Geophysical and Astronomical Services Administration (PAGASA) was responsible for the observations of tropical cyclones in the Philippines area of responsibility (PAR) and for issuing public warnings accordingly, among its duties.

The National Civil Defense Administration (NCDA) was formed in 1945 to render services to the people for their protection and survival during war and peace time, duties of which included protection against disasters. The civil defense plan and policies were formulated but were never implemented due to inadequate budgetary support, public apathy and indifference. The Office of Civil Defense was established in 1973 under the Department of National Defense by superseding NCDA's functions including establishing and administering a comprehensive national civil defense and civil assistance programme.

In order to respond better to the destruction caused by the natural disasters, the Calamities and Disaster Preparedness Plan, first initiated in 1978, was revised, restructured and strengthened in 1988, and a National Disaster Coordinating Council (NDCC) was formed. Priority has been given to saving of lives. The NDCC, which is the highest policy determining body for major disasters, is composed of members of the cabinet under the chairmanship of the Secretary of National Defense. The NDCC, whose main function is to advise the President of the Philippines on the status of the national disaster preparedness programmes, disaster operations and rehabilitation efforts undertaken by the government and the private sector, meets at least four times before every typhoon season and utilizes the facilities and services of the Office of Civil Defense. All the members of the Council contribute their manpower facilities and expertise to effectively carry out the functions of the NDCC.

The local government, at the provincial, city, municipal and barangay levels, is responsible for organizing the respective disaster co-ordinating councils and for overseeing the status of preparedness programmes, disaster operations and rehabilitation activities by the government and the private sector in their respective area of responsibility.

For the disaster coordinating councils from the national, regional, provincial down to barangay level to carry out their functions effectively, activities are grouped within the following civil defense services working under a team leader: (a) Health Service, (b) Auxiliary Fire Service, (c) Police Service, (d) Emergency Transportation Service, (e) Communications and Warning Service, (f) Public Information Service, (g) Rescue and Engineering Service, (h) Evacuation Service, (i) Relief Service and (j) Welfare and Rehabilitation Service.

After the designation of the 1990s as the International Decade for Natural Disaster Reduction (IDNDR), NDCC created four committees to co-ordinate programmes related to the implementation of the IDNDR activities:

(a) Committee on Structural Measures;

(b) Committee on Non-structural Measures;

(c) Committee on Disaster Research;

(d) Committee on Disaster Legislation.

The main objectives of the four committees are:

(a) To improve the capability of the country to mitigate the effects of natural disasters expeditiously and effectively, paying special attention to the establishment of early warning systems;

(b) To devise appropriate guidelines and strategies for applying existing knowledge;

(c) To foster scientific and engineering endeavours aimed at closing critical gaps in knowledge in order to reduce loss of life and property;

(d) To disseminate existing and new information related to measures for the assessment, prediction, prevention and mitigation of natural disasters;

(e) To develop measures for the assessment, prediction, prevention and mitigation of natural disasters through programmes of technical assistance and technology transfer, demonstration projects and education and training, tailored to specific hazards and locations and to evaluate the effectiveness of these programmes.

4. Disaster reduction measures and practices in the Philippines

PAGASA is responsible for issuing tropical cyclone warnings. It receives information from satellite imagery and as the cyclone reaches 1 500 km east of the Philippines the first advisory warning is issued so that all the areas that the cyclone could possibly be affected could put into action disaster management plans from the Office of Civil Defense down to barangay levels. Six-hourly reports are issued until the cyclone leaves the Philippines area of responsibility. The difficulties associated with warning system are that there are many dialects in the country, live television broadcasts are only at highly urbanized cities

and a national telecommunication system linking all the populated islands would be very costly. The radio broadcasting is being used as the most common and dependable way of issuing warnings.

The Flood Forecasting Branch (FFB) of PAGASA is responsible for providing flood forecast and warning in the country. Since 1973, flood forecasting and warning systems have been established for some of the major river basins of the Philippines, and the work for extension to other basins is continuing. The FFB of PAGASA has developed comprehensive systems and has acquired extensive experience during the last decade, and coordinates operations with the Department of Public Works and Highways (DPWH) with which the flood forecasting and warning system is directly linked, and also with other agencies concerned in flood mitigation and control. Timely flood forecasts and warnings together with efficient flood control structures in some river basins have contributed significantly to reducing the damage. PAGASA has also established a flood forecasting and warning system for dam monitoring, reaching as far downstream as 25 km from major dams, with sirens, loudspeakers and patrol cars, alerting people when water would be released from the dams. Hydrological and warning systems operate by solar-charged batteries and there is an ongoing project on powering all the flood forecasting and warning systems of FFB by solar energy. In the past, due to local power cuts in many parts of the country, warning signals could not be issued to the people.

DPWH is responsible for the structural works related to disaster reduction. DPWH is involved in protective works as well as national and local infrastructure damage repairs. Provincial and municipal engineers, for example, programme flood control and drainage activities for their respective regions and the regional and district offices are in charge of implementation. The central office is mostly involved in inspection of works undertaken. Large projects are constructed by contractors and managed by Project Management Offices of DPWH. Currently P800 million are assigned annually to the National Calamity Fund to be utilized in all disaster reduction and compensation activities. This amount was said to be inadequate and covered only a fraction of the damages caused by natural disasters. Furthermore, in the Philippines property protection measures are given low priority, and the government concentrates largely on repair and rehabilitation of bridges, roads and public buildings. Out of the total annual National Calamity Fund P140 billion are released as an immediate response fund at the time of the occurrence of a disaster.

The Department of Social Welfare and Development (DSWD) is the government agency that is involved with the protection of private property and public welfare. DSWD sets up welfare and rehabilitation centres after the disasters, for providing accommodation, catering, emergency clothing, registration and inquiring, and other assistance of a personal nature to the homeless and the stricken, for rapid restoration of well-being and morale. After a particularly disastrous typhoon in 1987, DSWD initiated a "core shelter programme", and came up with a design for construction of low-cost, typhoon-resistant housing utilizing locally available materials and built by local expertise. The cost of such housing has been limited to ₱8 000 ($US320) per unit for the time being. So far, this programme has been implemented on a small-scale on selected typhoon-prone areas. Initial results indicated that they could withstand high winds of up to 170 kph with minimal damage. The core shelter was designed by the Asia Disaster Preparedness Centre of the Asian Institute of Technology. Normally, in the rural areas of the Philippines the houses are surrounded by orchards or trees which also serve as wind-breakers, but in strong winds these may fall and crash onto the houses.

Previously the Philippines National Red Cross (PNRC) provided only medicine and food to the stricken, but it recently has started distributing fishing nets to fishermen who lost their property during a disaster. Presently PNRC is starting to provide simple houses, largely made of bamboo, at a cost of ₱12 000 ($US480) to PNRC.

The Office of Civil Defense (OCD) becomes the centre of operations during disasters. OCD is involved in establishment, organization and training of Disaster Coordinating Councils. It also conducts studies on disaster management and monitors implementation of the "Calamities and Disaster Preparedness Plan".

B. Samoa

1. Introduction

Samoa comprises the two large islands of Savaii and Upolu and several smaller islands. The total land area is 2 820 km^2, with Savaii measuring 1 700 km^2 and Upolu measuring 1 100 sq.km. Both islands are built up around rugged mountains, with the highest peak on Savaii rising to 1 858 m and the highest peak on Upolu reaching 1 100 m. Both islands are characterized by a flat to gently undulating coastal plain, which passes gradually into a region of undulating to gently rolling slopes. These slopes give way to steeply inclined foothills which terminate in an upland plateau.

Tropical rainforests and dense vegetation cover most of the islands. Agriculture is the main industry and source

of income with coconuts, bananas, taro and cocoa being the principal agricultural products. Fishing and forestry resources are also exploited.

The total population approximates 170 000 people. Of this total, about 25 per cent live on the island of Savaii and most of the remainder on Upolu; the population is heavily concentrated around the capital, Apia. There are some 360 villages with an average population of 350 people distributed around the coastal locations of the islands. Many of the occupied areas are only 1 to 3 m above mean sea level.

2. Damage caused by tropical cyclones, storm surges and floods in Samoa

Tropical cyclones are the most serious weather disturbances which affect Samoa. The months between November and April are the most favourable for the formulation of tropical cyclones when warm, moist air ascends over ocean surfaces. The most favourable spawning area is between latitudes 10° to 15°S when the sea surface temperature is at least 27°C. Most cyclones which move into the Samoa area come generally from the north, but occasionally some originate from the east or west.

The nature of tropical cyclones affecting Samoa can vary greatly. The diameter of the storm can vary from a low 300 km to over 1 000 km. The duration of recorded cyclones has ranged from a few hours to over three days.

Historical records show that Samoa is frequently traversed by destructive cyclonic disturbances. In fact, a total of 79 cyclones have affected Samoa during the period 1831 to 1990.

Records indicate that many destructive cyclones struck Samoa during the last century. The first destructive cyclone was registered in 1831 when the islands of Upolu and Savaii were devastated. The worst cyclone to occur last century ravaged Samoa in 1889. Its intensity was so great that it sunk seven out of eight warships and over a dozen merchantmen in Apia Harbour. Massive damage was also recorded on land, especially in the Apia town district. The period after this event was followed by a number of violent cyclones which inflicted great damage and caused a number of deaths. Many of these disturbances were accompanied by storm surges and sea swell, which caused considerable damage in the low-lying coastal areas.

The cyclone in 1966 was one of the most destructive in recent times. Hurricane force winds resulted in massive wind damage to agriculture and buildings. Ten people were killed and the country's economy was crippled.

The most destructive natural disaster to affect Samoa in modern times occurred in February 1990 when Cyclone "Ofa" struck the islands. This cyclone produced exceptionally high storm surges which combined with high tides and storm waves to cause great destruction in low-lying coastal areas, especially to the sea-front road system. A total of ten people were killed, mostly as a result of storm-surge, and evacuation of beachfront residents was essential. Violent winds of up to 140 knots were responsible for massive damage to forests and coconut plantations.

This cyclone was unusual because it was not accompanied by heavy rainfall or flooding. Salt spray whipped up by hurricane force winds which lasted for three days was carried over 30 km inland and defoliated virtually all the vegetation contacted. The result was the almost complete destruction of all natural and agricultural vegetation within the affected zone. The damaged plantations lost their complete crop production. Distribution of food aid and other essential requirements continued for six months after the cyclone. It is estimated that "Ofa" has a return period of about 25 years.

Tropical cyclones affecting Samoa are often accompanied by storm-surge and sea swell. The effects of storm-surge can be particularly devastating in the heavily populated coastal zones.

Flooding in Samoa is not considered to be a major problem. However, with the continuing influx of people into flood-prone areas, especially in the vicinity of Apia, the potential for flood disasters has increased dramatically. Because most of the catchments are relatively small, have steep topography and experience heavy rainfalls, floodwaters concentrate rapidly, resulting in flash floods. Flooding is confined to the lower reaches of the streams adjacent to the coast. Flooding can be exacerbated by storm surge and high tide.

Because systematic collection of streamflow records did not commence until 1971 when a few hydrological stations were installed, very little factual data on flood flows are available. Most information on flooding relates to reports of damage caused to agriculture, villages and transport routes.

The worst flood problems were experienced in 1982, 1989 and 1990. The 1982 flood resulted from heavy rainfall and caused severe damage to property, roads, utilities and a bridge. Flooding which accompanied cyclone "Gina" in January 1989 caused damage to roads and bridges, disrupted water supplies, destroyed homes and resulted in widespread evacuations.

Torrential rain fell in May 1990 and caused widespread flash flooding, especially on the island of Upolu. A

massive amount of debris and silt which resulted from the damage caused by Cyclone "Ofa" was conveyed by flood-water and affected water supplies, destroyed bridges and inundated low-lying areas. Massive damage was also suffered at hydro-electric stations and buildings adjacent to flood-affected streams.

3. Disaster prevention measures in Samoa

The defence against tropical cyclones and storm surges involves reinforcement of sea protection works. Work has been progressively carried out on the upgrading of Apia Harbour breakwaters and the armouring of the coastal road system which is prone to storm surges and swell. The need to accelerate this work and to implement an inland road system safe from the ravages of the sea are considered to be high priority.

The May 1990 floods which resulted in the destruction of several bridges and damage to water supply facilities and hydro-electric plants highlighted the need for better design and construction of facilities to avoid future flood damage. The need for some form of river catchment control to overcome erosion problems and improve water quality is also considered necessary.

Samoa uses the New Zealand Standard Wind and Earthquake Loading Code for vetting the design of new European style buildings. The design wind speed adopted is the highest for the region. No controls are imposed on traditional native style buildings. Problems have arisen, however, because of inadequate enforcement of the regulations. It was found that much of the building damage sustained during Cyclone "Ofa" resulted from faulty workmanship.

The application of planning controls, acquisition of land and relocation of people have not been employed as disaster mitigation strategies. This is due largely to the nature of land ownership which is vested in the village system.

4. Disaster preparedness in Samoa

(a) Forecasting and warning

All basic forecasts are prepared in the Regional Meteorological Office at Nadi in Fiji and relayed to the Samoan Weather Observatory in Apia by satellite. Although the forecasting system is considered to be reasonable, the communication system failed completely during the early stages of Cyclone "Ofa". It become necessary to remove the satellite receiving dish to avoid damage, thus interrupting the communication system. A new installation is being planned to overcome this problem. To overcome the existing forecasting deficiencies, the Observatory needs an upgrading of technical facilities including weather radar and communication equipment.

It might be noted that the weather observatory, which is situated on the sea front, was demolished by storm-surge and swell during Cyclone "Ofa". Unfortunately, many valuable records, some extending back for 100 years, were completely destroyed. Plans are in hand to rebuild the observatory on the same site.

Storm and flood warnings are issued by the weather service via radar bulletins and through the newspapers. However, it is generally considered that the current warning system is inadequate, especially to outlying villages. During Cyclone "Ofa", all communications systems except that of the Police Department were disrupted, which caused serious problems in alerting the public to the gravity of the situation. Plans are now in hand to undertake a complete upgrading of the communications system to ensure that the future warning service is reliable, timely and accurate.

(b) Public awareness and education

There have been limited programmes for the dissemination of knowledge to aid the general public in the understanding and required response to natural disasters in Samoa. Public awareness campaigns are conducted by the National Disaster Council (NDC) as part of the National Disaster Plan. The plan requires that communities develop a degree of self-reliance which allows them to fend for themselves during the initial stages of a disaster. To achieve this goal, members of the public are provided with information on the necessary steps required to ensure their safety and survival. Village Action Teams have the ultimate responsibility to help village populations to be aware to the required response during disaster situations.

The NDC is being supported in this role by the Voluntary Organizations Disaster Relief Preparedness Committee. To this end, the committee has issued a booklet which clearly sets out the necessary actions required during the range of possible disasters. The booklet was designed and distributed to secondary school pupils.

Although the Police Department carries out regular training exercises for disaster situations, no such exercises have been carried out for cyclone or flood situations.

(c) Emergency activities

Samoa has developed a well-structured emergency plan to counter disasters created by tropical cyclones and, to a lesser extent, by floods. This plan details the responsibilities of the different levels of government, government departments and agencies and the non-government organizations.

A number of shortcomings in the plan surfaced during Cyclone "Ofa" which have prompted a revision of some aspects and further fine tuning of the plan. The principal problems involved inadequate forecasts and warnings, communication breakdowns and delayed response to emergency situations.

(d) Relief and rehabilitation

The provision of the services is organized according to the National Disaster Plan and coordinated firstly at the District level and then at the village level. Arrangements are put in place to ensure that all available supplies are distributed in an efficient and effective manner.

The non-governmental organizations (NGOs) play a prominent role in the disaster relief operations, especially in the earlier stages of the disaster. Local subscriptions of cash and clothing and the distribution of emergency supplies from accumulated stores, all provide tangible assistance during the relief phase of the disaster. Considerable assistance was given during Cyclone "Ofa" towards emergency shelter. The NGOs and especially the Red Cross Society proposes to upgrade its on-site emergency supplies storage as a safeguard against delays caused by inclement weather.

During the rehabilitation phase, considerable reliance is placed on international aid for carry on assistance from the NGOs and the international community. Following "Ofa", aid in the form of food supplies was required for six months after the event to make good the damage suffered to food crops.

The rehabilitation phase of disasters is not covered by the National Disaster Plan.

5. Institutional and legal arrangements in Samoa

The Constitution of Samoa contains emergency powers to deal with disaster situations. It includes provisions which permit the Head of State, after consultation with Cabinet, to proclaim an emergency situation to deal with natural disaster. Under the proclamation, the Head of State can make emergency orders to secure public safety and essential supplies and services, and safeguard the interests and maintain the welfare of the community.

C. China

1. Introduction

China occupies a land mass of 9.6 million km^2. Its topography is essentially mountainous and varies in elevation from sea level along the eastern seaboard to over 8 000 m in the vast mountain chains. More than half of the total area of China consists of tableland and mountainous regions and its coastline exceeds 18 000 km in length.

Within Chinese territory, there are more than 1 600 rivers with drainage areas exceeding 1 000 sq km. The total length of these rivers is approximately 226 000 km. The upper reaches of the large rivers traverse steep valleys and areas of sparse population. In the middle and lower reaches of these rivers, the extensive floodplains are extremely densely populated.

Only 11 per cent of the country is cultivated with most of the remainder being composed of waste tracts of desert, denuded wasteland and urban areas. Forests and inland water bodies amount to about 10 per cent of the total area.

China supports a population of over 1.2 billion people of which some 80 per cent are engaged in rural production. Most of China's major cities and large industrial centres are situated on the alluvial plains of the coastal strip and are vulnerable to tropical cyclones and flooding.

2. Damage caused by tropical cyclones and floods in China

China ranks high among the countries worst affected by tropical cyclones, storm surges and floods in the ESCAP region. These natural hazards cause considerable losses of life and massive damages to property almost every year. They often reach intensities which wreak devastation of such magnitude that they are classified as national disasters. In total, these three types of hazards kill more people and cause greater property damage than any of the other natural disasters which afflict the country, perhaps excepting the earthquakes.

While tropical cyclones affect the full length of the Chinese coastline and adjacent offshore islands, the eastern and southern coastal regions experience the greatest number of landfalls. Consequently these regions suffer the most damage. Although tropical cyclones often penetrate considerable distances inland, their intensity and destructive power diminishes rapidly as distance from the ocean increases. Although tropical cyclones can affect China at any time during the period from May to December, the peak intensity occurs from July to September.

The greatest damage reported in the last 40 years in China was typhoon No. 6903 which landed in Hui Lai Country, Guangdong Province. When landing at the area

on 28 July 1969, the maximum wind speed reached about 50 to 55 m/s. Occurring at a time of high astronomical tide, this typhoon caused severe damage causing the death of about 1 000 people.

Cyclones approaching the Chinese coastline are often accompanied by storm surges. Rises of up to six metres in the sea surface can be experienced in coastal areas if a strong cyclonic depression coincides with a high astronomical tide. Strong winds which accompany cyclones can generate high waves of up to 10 metres which further increase the potential destructive power of storm surges.

Heavy rainfalls associated with tropical cyclones produce frequent and high floods. The greatest floods occur in the coastal rivers during the mid to late summer period when cyclonic depressions occur close to the coast.

Although many major floods have occurred since 1949, their effects have been reported to be less damaging because of the efforts made in implementing structural flood mitigation measures. This fact is confirmed by the occurrence of the highest floods on record in the post 1949 period. However, these floods resulted in significantly less damage than that was caused by the earlier floods. It must be noted that China's efforts in the field of flood disaster reduction over the last 40 years have reduced the average annual death rate from about 140 000 in the 1930s to some 3 000 in 1990.

Up to 1990, the most severe flood of recent decades occurred in 1954 and affected the whole of eastern China. River levels in the Yellow and Yangtze during April to July were the highest recorded for over 100 years. High river levels at Nanjing and Wuhan persisted for over 100 days.

Floods in China are also caused by tropical storms and monsoonal depressions. Because of the considerably larger areas affected by floods, they are more destructive, and have claimed more lives and caused greater damage to the economy than tropical cyclones.

Concentration of population and property in flood-prone areas largely contributes to the scale of flood disasters. Over 85 per cent of the total population and most of the nation's assets are located in flood-prone areas which occupy about 30 per cent of the total land area. Most of the major cities are situated in the downstream areas of major river basins and consequently are vulnerable to flooding.

In addition to massive urban flood problems, China also experiences widespread rural flooding. It is reported that almost 8 million hectares of farmland are flooded annually causing significant losses of agricultural production. Major damages are inflicted on infrastructure, including roads, railways, bridges, water supplies. Flood damage also includes major river bank collapse and aggradation of river beds by the deposition of sediment.

3. Risk assessment in China

For a number of years China has been undertaking a programme of risk assessment related to tropical cyclones, storm surges and floods as a prelude to the planning and implementation of measures to mitigate the disasters caused by these hazards.

Since China has a vast amount of historical data describing the occurrence of past floods, it is well placed to undertake the task of flood risk mapping. The purpose of these maps is to provide guidelines for flood plain management by implementation of land-use controls. It might be noted that the level of risk adopted to describe the flood hazard shown by these maps is comparatively lower when compared to the standards adopted in other ESCAP countries.

Flood risk mapping exercises have been conducted for major rivers and have been undertaken for major dams and reservoirs to cover dam break situations. The mapping programme is currently being extended to other areas, especially urban areas which are experiencing rapid rates of development.

4. Disaster prevention measures in China

Historically the principal measure adopted to prevent flood disasters in China was the construction of dykes and river training works to protect development from flood damage. As the heavy sediment load carried by the major rivers exacerbates the flood problem, it has been necessary to include soil conservation works as an integral component of the flood protection programme.

Since 1949 multi-purpose water resources development schemes, which included a flood protection component, have been implemented on numerous rivers, particularly within the catchments of the seven major rivers.

Although these works have reduced the potential for flooding along the middle and lower reaches of rivers, the capacity of the various flood control structures to withstand flooding is still limited. In addition, the urban flood problems in major cities, including provincial centres on the small streams have increased because of insufficient conveyance capacity of waterways. There is also an increasing risk of flash floods in small catchments and densely populated areas causing damage of major proportions.

The principal non-structural measures currently adopted by the Chinese Government are: planning controls which

include land-use management and building codes, acquisition of lands and relocation, flood insurance and flood proofing. It is intended that the comprehensive approach be applied to both developing and developed areas.

China has established land-use management controls or planning controls which can be applied to address the flood hazard. These controls define the type of activity which can be undertaken within the delineated flood prone area and have been based on actual flood risk mapping. These planning controls also establish the guidelines for the safety and construction of flood storage and retardation areas, including the types of crops which can be grown in these areas.

As another element of its flood management programme, China has proclaimed and developed a number of floodway districts which involve flood detention and storage areas. These districts are situated in low-lying agricultural areas in the downstream reaches of rivers. They are used for temporary storage of floodwater diverted from a river when the magnitude of river flow threatens the safety of protected areas downstream. By this method, the more developed areas are protected on a priority basis and the overall flood damages are minimized. Population within the area is controlled to reduce the number of flood-affected inhabitants. To achieve this control, excess population is actively encouraged to migrate to safer areas and offered inducements, such as preference in employment in order to encourage them to do so.

China has in place a number of flood insurance schemes operated by insurance companies. These companies are entitled to collect premiums and pay claims for flood damage. Any shortfall in the payment of damage claims is made up by the provincial government which is empowered to collect levies from beneficiaries within the proclaimed flood area.

In order to reduce the reliance on flood relief funds provided by the central government, provincial governments are actively encouraged to implement flood insurance schemes in areas highly prone to flooding.

5. Disaster preparedness in China

During the last 20 years China has made a concerted effort to upgrade its forecasting capability in tropical cyclone and flood prediction. China has in place an extensive network of weather observation stations including satellite image receiving facilities, radar observation facilities and intensified upper air observations. Improved forecasting techniques which use the real-time observational data provided by the network of synoptic weather stations are being employed in order to increase the accuracy of the estimated rainfall distribution and tropical cyclone movement.

Extensive use is made of satellite imagery from the available weather satellites. An elaborate research programme is being pursued into satellite applications including image analysis and processing and data reception and processing. The National Meteorological Centre is being assisted in upgrading its forecasting techniques by the research effort of the Academy of Meteorological Science, especially in regard to cyclone formation and tracking.

Effective warning of tropical cyclone movement and intensity is issued 48 hours in advance of its landfall. The warning also identifies the communities and coastal areas which are being threatened.

A network of broadcasting stations issues cyclone warnings at regular intervals and the warning frequency is increased as the severity of danger increases or when major changes to previous warnings are necessary. Additional warnings are also relayed to the public via television, newspapers, and direct telephone service and by special weather bulletins to key organizations.

China has developed and operates a fairly sophisticated flood forecasting network for all the major river systems. A network of hydrological stations including some 17 000 rainfall stations, 5 000 river stage stations and about 3 500 stream discharge stations has been established. Many of the individual flood forecasting systems have been automated by the installation of telemetering stations and supported by computer systems for forecast preparation employing hydrologic models.

In some cases rainfall radar technology is used for precipitation estimates and telemetering by satellite is employed in the preparation of forecasts.

The Ministry of Water Resources through its Hydrological Forecasting and Water Control Centre (HFGC) is responsible for the overall management and operation of flood forecasting and warning services in China. Actual forecasting services are organized on individual river basins and the dissemination of warnings is undertaken at the local level. However the HFGC assumes responsibility for the formulation of forecasts and issuing of warnings regarding the major river systems. Dissemination of flood warnings is accomplished through an elaborate information transmission system. The warnings are issued at the local level through a network of 1 200 hydrological stations.

Although the flood forecasting and warning systems for the large rivers are considered to be adequate, there still exists the remaining problem of flash floods at the smaller catchments. As flash floods constitute a major problem in many parts of the country, it is recognized that special forecasting efforts and resources will need to be employed to overcome it.

China has developed a series of regulations and well-structured emergency plans to counter disasters created by tropical cyclones, storm surges and floods. This approach requires preparation of detailed emergency plans in advance. These plans include an indication of the extent of the affected area, the identification and location of the population to be evacuated, the actual evacuation route and destination and the mode of transport, the means of informing the population of impending evacuation and the time of its execution, and the provision of emergency shelters.

The provincial governments are charged with the control of emergency activities, including the safe evacuation of residents, the provision of food and shelter, the supply of medical and welfare services and maintaining public order during an emergency.

The Central Flood Control headquarters has the power to marshal both the army and civilians for flood fighting activities. Large numbers of people are mobilized to undertake emergency activities, such as the strengthening of dykes and dams which are threatened during major floods. In addition, the Headquarters carries out a number of other important functions, which include training of personnel in flood control activities and conducting public awareness campaigns.

The central government has issued orders that the public be fully advised on emergency arrangements to be implemented during disasters. In the case of flooding, for example, the provincial governments are directed to prepare guidelines for public information on the topics related to flood storage and retardation areas, including details of historical floods which have affected the area.

During the tropical cyclone season, disaster prevention headquarters are set up at localities in coastal areas. These headquarters are staffed by representatives of the Meteorological Department, the Civil Affairs Department and Red Cross Societies. The Ministry of Civil Affairs has the prime responsibility to assist disaster victims during and immediately after the event. In less hazard prone areas these headquarters are established on the basis of forecasts of an impending disaster.

6. Institutional and legal arrangements in China

In 1988 China strengthened its laws and regulations on water resources, including the control of water related disasters. The new regulations give strong powers to different levels of government for the implementation of measures for flood control and flood fighting. This law confers special powers on the State Council to control all relevant activities and undertake any emergency actions deemed necessary. It embodies the notion that comprehensive planning must be undertaken in advance and that all emergency operations be conducted according to an approved operation plan. Strong punitive action can be taken against breaches of the regulations.

D. Viet Nam

1. Introduction

Viet Nam occupies an area of some 329 600 km^2. It is bounded in the east by the South China Sea and by the Annamite Mountain Range in the west. Its topography is generally rugged with the highest elevations exceeding 3 000 m along the western borders. Its elongated shape stretches for over 1 600 km. At its widest point its western border is only 500 km from the sea.

The northern region of Viet Nam is characterized by mountainous or hilly terrain with elevations reaching 3 142 m. The major rivers which rise in the mountainous country to the west, flow through steep and hilly terrain to the sea in the east. Viet Nam possesses narrow floodplains and limited coastal plains. The Red River is the principal stream of the region. The capital city, Hanoi, is situated along is banks.

In the central region, the river system is characterized by short streams with steep slopes. The average distance from the coast to the mountain range is about 70 km.

The southern region comprises the Mekong River delta which is characterized by flat topography and numerous tributary flood channels.

Viet Nam has a monsoon tropical climate and experiences frequent tropical cyclones in the northern and central regions. However, tropical cyclones rarely track across the southern region. Rainfall is concentrated in the months of June, July and August when up to 80 per cent of the total annual rainfall is recorded. The intensity of rainfall can be extremely high and produces rapid rates of runoff and serious flooding.

The population of Viet Nam is about 65 million and it has rural population densities which are among the highest in the world.

2. Damage caused by tropical cyclones and floods in Viet Nam

Over the last 1 000 years, Viet Nam has suffered from numerous cyclones/typhoons, storm surges and floods. In

many cases, these hazards have reached disaster proportions causing catastrophic loss of life, property damage and social disruption. Its geographical position, climate and physical shape make Viet Nam particularly vulnerable to these hazards. The entire country can be exposed to the ravages of tropical cyclones, its long coastline exacerbates the storm surge problem and devastating floods can occur in all of its rivers and streams.

Viet Nam is affected by tropical cyclones which originate over the ocean to the east of the country. The principal spawning ground is the North-West Pacific Ocean to the east of the Philippines. However, cyclones can also be generated closer to the coast in the South China Sea.

The entire country can come under the direct influence of tropical cyclones because of its physical setting. Hurricane force winds can extend unabated across the full width of the country when the "eye" of the cyclone is situated close to the coastline. Consequently, cyclones are the most destructive of the meteorological hazards which affect the country.

Although Viet Nam can be affected by cyclones at any time during the period from May to December, the greatest number of landfalls is recorded in the months from July to September. On the average, three to four cyclones strike the mainland each year. The frequency of cyclone strikes decreases from north to south of the country.

Because of its extensive coastline and low topography adjacent to the seaboard, much of the country is exposed to storm surge. These storm surges, which are generated by tropical cyclones, accompanied by high winds and high sea waves, can overwhelm coastal regions along the entire length of the country.

The high rates of rainfall caused by the tropical cyclones result in widespread and devastating floods in all the river systems of Viet Nam. The occurrence of many floods is directly related to the visit of tropical cyclones.

In the northern region, devastating floods are generated on the Red River system. The majority of the basin is comprised of mountainous topography which is conducive to a rapid concentration of flood water. As most of the tributaries join the main river close to the delta where the grade flattens, high river levels and widespread inundation are experienced in the lower reaches. The severity of flooding can be exacerbated by backwater effects which retard drainage during high tides and storm surge.

Rivers in the central region have steep mountainous catchments and are characterized by short channel lengths. The concentration of runoff from these catchments is extremely rapid and results in flash floods which exit from the mountains across a very narrow coastal strip. Flood levels in the downstream reaches are increased by storm-surge and tidal effects.

The southern region comprises the Mekong River delta which is the outlet point for flood discharges from a catchment area exceeding 50 000 sq.km. A large part of the delta is regularly flooded for extended periods to depths of between two to three metres. This delta comprises about 25 per cent of the total lowland area of Viet Nam.

Viet Nam has a long history of water related disasters dating back thousands of years, and continues to experience flood disasters. An intense tropical cyclone which landed in central Viet Nam in May 1989 claimed the lives of 157 people, injured 106 and 400 others were listed as missing. During the cyclone, over 111 000 houses and other buildings were destroyed rendering some 336 000 people homeless. About 166 000 ha of crops were damaged and about 21 000 ha of paddy rice were completely destroyed. A large number of boats were sunk and marine installations suffered heavy damage.

3. Disaster prevention measures in Viet Nam

Viet Nam has been using structural measures to combat its flooding problems for over 1 000 years when the original system of dykes was constructed on major rivers. This form of flood protection has continued to be the prime flood control measure since that time.

The principal preventive measures employed to decrease the impact of water–related disasters concentrate on reducing the effects of flooding and storm surge. The measures adopted include flood control reservoirs, dyke systems, groins, channel improvements, diversion channels, retarding basins, pumping systems and drainage systems.

The construction of dyke systems had commenced over 1 000 years ago and has continued ever since. By the year 1945 the total length of dikes in the country was 3 000 km and that has been extended to over 7 700 km comprising 5 700 km of river dikes and 2 000 km of sea dikes. In general, it is considered that the programme of continued construction of river dykes involved raising, strengthening and extending the systems in the north of the country, has rendered those rivers safe against maximum flood levels.

Dykes are categorized according to their location, importance and extent of the protected area and the nature of construction. The most important dykes, which protect major areas of development, are designed to withstand overtopping by rare floods. The standard of the dyke is reduced as the protected area diminishes in importance. It is intended that the dyke systems will continue to be an

important structural measure, and it is proposed to extend the existing systems, especially for improved protection of agricultural crops against flooding and for improved defense against storm surge and salt–water intrusion in the coastal areas.

Diversion channels or by-pass floodways have been constructed to divert flood flows major rivers in order to decrease water levels below the point of diversion. The rate of diversion may be controlled by a regulator. These systems have been widely employed along the Red River and in the Mekong Delta. In many cases, the diversion channels are combined with flood storage areas to form flood retardation areas. The storage areas are used for agricultural production with the knowledge that they may be flooded if it becomes necessary to make flood diversions.

Viet Nam presently has made only limited use of non-structural measures for disaster prevention activities related to tropical cyclones, storm surge and floods.

4. Disaster preparedness in Viet Nam

Because of the long experience with natural disasters caused by tropical cyclones and floods, Viet Nam has developed efficient emergency preparedness programmes to protect life and property when these hazards occur. The emergency preparedness programme involves a range of non-structural measures, including forecasting and warning, storm surge prediction, flood fighting and evacuation, relief and rehabilitation.

The Vietnamese Government considers that forecasting and warning are among the most important measures to help mitigate the effects of tropical cyclones and floods. This measure has proved very effective in reducing the potential damage due to natural disasters by increasing the time between warning and onset of an event. The Hydrometeorological Service is responsible for the preparation of cyclone and flood forecasts and warnings and storm surge prediction.

Tropical cyclone forecasting is based on data provided by weather satellites and available radar stations in the three major cities of Hanoi, Da Nang and Haiphong. Accurate prediction of cyclone intensity and movement has been hampered because of inadequate links with the weather service of neighbouring countries, obsolete equipment and shortage of funds to upgrade the existing system.

The Hydrometeorological Service prepares short-term flood forecasts for all the major river systems. A sophisticated mathematical model is utilized in formulating these forecasts. Currently, however, the Service does not prepare detailed forecasts of flash flood conditions in the Central Region, although these floods cause massive damages.

The responsibility for preparing forecasts and the issuing of warnings for minor rivers and streams resides with the individual provinces' and districts' administration.

Data collection systems for rainfall and streamflow statistics are manual and the information is transmitted by land-line or radio. No telemetering equipment is available to help streamline the data collection network.

Dissemination of the forecasts and warnings is accomplished by television, radio and the newspapers. During emergencies, updated forecasts and warnings are issued at frequent intervals. The Central Storm and Flood Control Committee receives frequent advice to allow it to co-ordinate all flood control activities.

Tropical cyclone warnings are issued to all shipping by radio and, in special circumstances, by gun signals. Restrictions are placed on ships departing port during emergency periods to reduce loss of life.

Education of the public on disaster prevention is carried out in a number of different ways. Firstly, technical training is achieved in flood and storm control in schools and colleges by including these subjects as part of the curriculum. River engineering is taught in special courses or in engineering courses conducted by the institutes and universities. Secondly, a meeting is held every year by the dyke management authorities at the district and provincial levels to provide instruction on this topic. Thirdly, flood and storm control techniques are disseminated to the public through radio programmes and publication in newspapers.

Since 1900 the 22nd day of May has been designated as "disaster day" to promote public awareness of cyclones and floods. A regular presidential address is made to the public asserting the need for readiness to combat the effects of natural disasters. Public awareness of floods is also kept alive by displaying slogans in flood-prone villages urging the villages to be prepared for emergencies.

Emergency response, which involves flood fighting and evacuation, has been highly developed by the Vietnamese Government. It requires the preparation of systematic plans and programmes for storm and flood control prior to each storm season. These plans set out the remedial works required to ensure the stability of protective works, the priority of implementing these works and the financial assistance necessary to complete the works. The evacuation needs and priorities are also established and incorporated into the plan. The plan is vetted by the Central

Government before any new work is commissioned or military assistance with construction is provided. Each separate province prepares its own plan.

Flood fighting is highly organized and efficient and involves a high degree of community participation. It requires the organization of embankment patrols and emergency repairs for a very large number of dyke systems. For the important rivers, the Central Government has organized dyke control teams comprising hydraulic engineers, technicians and construction workers who are trained in dyke construction and maintenance. Each team is responsible for between 20 to 30 km of dykes. The total force comprises about 600 people.

The permanent control teams are supported by emergency teams who are selected by local authorities in areas protected by dykes, prior to the arrival of the cyclone and flood season. Each team is trained in dyke maintenance techniques and becomes responsible for a section of about 3 km of dyke and they are on continuous duty during floods. Each emergency team is supported by a flood fighting brigade enlisted from the local villages. The brigade, which comprises up to 100 members, supports the emergency team to undertake any emergency repairs.

Evacuation needs in the event of an emergency, including the identification of escape routes, the number of people and livestock to be evacuated and the shelter arrangements for the evacuees under different levels of flooding are set out in the emergency plan. The population is advised in advance of the actions required by them. In disaster situations, the army is mobilized to assist in cyclone and flood fighting activities. Their main task relates to rescue activities with the use of specialized equipment such as trucks, helicopters, etc.

Sea dyke protection teams are organized along the same lines as the river dyke protection teams.

Requirements are also set out in the emergency plan. These plans include the estimates for the needs for food, water, shelter, fuel and other necessities required by the affected population. All disaster victims receive government support by way of relief food aid and medical services. Some rehabilitation assistance is given to disaster victims to help build their houses and re-establish themselves. Some tax relief is also provided.

5. Institutional and legal aspects in Viet Nam

The co-ordination of water-related disaster activities in Viet Nam is the primary responsibility of the Central Committee of Storm and Flood Control (CSFCC). It operates under the guidance of the Council of Ministers of the Central Government. The full committee is comprised of 17 members drawn from relevant ministries and it is chaired by the Minister of Water Resources. Up to the present time, all regulations and rules relating to disaster mitigation have been formulated and issued by the CSFCC. These rules specify the duties and responsibilities of the various Government departments and the teams concerned with prevention and preparedness functions. Special emphasis has been placed on dyke protection, surveillance and maintenance.

E. Pakistan

1. Introduction

Pakistan is located in the western portion of the subcontinent and is bordered by India, Afghanistan and Iran.

Although Pakistan is situated entirely within the temperate zone, the climate is, in general, tropical or subtropical. The high mountain ranges of the north and north-west provide an effective barrier to cool air masses moving southward from central Asia. Average precipitation in the country is 190 mm, the highest being 760 mm and the lowest 100 mm. In the north the precipitation is mainly in the form of snow. Except for the western part, the rest of the country is under the influence of the monsoon season which is from July to September.

Pakistan was estimated to have a population of over 110 million in 1989. The annual rate of population growth has been estimated as 2.9 per cent.

Although Pakistan is traversed by several large rivers and numerous smaller streams, only the Indus River carries significant flow. The rest are smaller rivers and their floods are usually less severe.

The Indus river is an international river with a total catchment of 944 000 sq.km, out of which about 10 per cent lies in China and another 8 per cent in Afghanistan. The remaining 82 per cent lies in Pakistan and India. The Indus river has a length of over 3 000 km from the head waters in the distant highlands of Tibet to the Arabian Sea. In Pakistan, downstream of the Tarbela Dam, the river cuts through the Salt Range for a distance of more than 160 km before emerging into the plains. At this point the Indus leaves its mountaineous character and becomes an alluvial

river flowing through the Indus plain for a distance of 1 500 km before reaching the Arabian Sea. The river along its journey through the Indus plain tends to meander. At places the meander belt becomes more than 16 km. More than 20 large rivers join the Indus along its journey to the sea. The major ones are Chenab, Jhelum, Ravi and Sutlej.

In its upper reaches, the Indus river system receives discharge only by snowmelt whereas in its middle to lower reaches it is under the influence of monsoon rains.

2. Damage caused by floods in Pakistan

Large flows in the rivers are generated mainly due to excessive rainfall in the basin and excessive snow melts in the upper catchments in the Himalayan mountains as the weather warms up. These rivers, therefore, carry high discharge during summer season, which also coincides with the monsoon season.

The floods in the upper Indus are generally the result of snowmelt in mountainous catchment areas in the Himalayan and Hindu Kush ranges. These areas have limited valley storages. Large floods in the upper reaches are usually caused by excessive snowmelt and collapse of temporary natural snow/debris dams which are formed every year either by glacial movement or landslides. The floods in the lower reach of the Indus are the continuation of flood flows of the upper Indus and the flood flows of its tributaries, namely Jhelum, Chenab and Sutlej. The floods in Indus occur between July and October and the river can be in high stage for a period exceeding one month.

In the tributaries of the Indus River, snowmelt is not a significant factor contributing to high floods, but floods generally result from heavy rainfall in the catchment area during the monsoon season.

Pakistan experienced two periods of high floods in 1988. First during the period of July/August due to heavy rains in the catchment areas, floods occurred in the Indus, Chenab and Jhelum rivers. Although these rivers remained in spate in upper reaches, significant damage was caused in the lower reaches due to the cumulative effect of high discharges in Indus flowing to south where heavy rains coincided with the high flow period.

In the Western part, from 3 to 6 August 1988, various areas experienced extremely heavy rainfall resulting in flash floods. The extraordinary wet spell in August caused floods also in northern Pakistan.

The second flood occurred in September/October, which was caused by heavy rains in the catchment of the Chenab, Ravi and Sutlej in India. The duration of high floods was from 25 September to 10 October 1988. Floods caused extensive damage to the irrigation networks, roads, railways, telecommunication and power distribution lines and other infrastructure. Emergency breaching sections on the headworks and bridges in the province of the Punjab in the Upper Indus Basin, which were provided after the 1973 floods, had to be utilized for the first time during 1988 relieving pressure on these vital works.

3. Flood management measures in Pakistan

Prior to 1970 catastrophic flood events, flood management was a provincial issue with an unintegrated approach. Flood works were planned on the basis of local requirements and there were no basic criteria for planning for the whole country. After the 1970 flood, the country established a central authority, the Federal Flood Commission (FFC), to cope with multifarious problems stemming from the frequent recurrence of flood. It has since prepared two flood plans - the National Flood Plan 1978 which has since been updated in 1987. The updated Plan provides consistent and economically appropriate flood protection measures for the whole country. Since 1978, flood works have been constructed according to the national plan and better co-ordination has been established between the federal, provincial and military authorities in flood management efforts.

(a) Structural measures

The existing reservoirs at Tarbela and Chashma on the Indus River and Mangla on the Jhelum River do not have any storage capacity specially allocated for flood control. However, filling of these reservoirs can, in most cases, help in reducing the flood peaks particularly if they occur in the early part of the season. Therefore, the reservoirs are operated according to predetermined criteria to ensure, as far as possible, their filling even in the years of low inflow and at the same time keeping a significant capacity for absorption of the high flood peaks except those in the late flood season.

As a result of the predetermined filling criteria, it has been possible to regulate floods through existing reservoirs. Mangla Dam is so far playing a significant role in the attenuation of flood peaks. Tarbela Dam, though commissioned in 1974, could not play its due role for flood attenuation owing to massive repair operations on its low level outlets up to the end of the 1980s. Thereafter, no major floods were experienced at Tarbela until June 1987, and the reservoir operations were mainly aimed at attenuation of flood peaks in order to avoid their synchronization with peaks of other major rivers downstream.

There are about 5 400 km of river dykes in Pakistan. They provide the first line of defense against floods. After

these dykes the loop dykes form large reservoirs behind the first line of defense. Although there is no uniformity on the level of protection among different reaches of the river, in general the dykes provide protection of up to 25-year flood events.

(b) Non-structural measures

The flood forecasting system in Pakistan is based on measurement of discharge and computation of flood peaks, by the use of modern devices such as weather rader and computers, and then providing warning through a well coordinated system to all concerned by a modern telecommunication network.

The rainfall measurement and transmission system in Pakistan consists of about 36 tipping bucket type rain gauges installed within the catchmemts of the rivers Indus, Jhelum, Chenab and Ravi. A display board indicating up-to-date information in respect of all the stations is available at the centre. In order to augment the rainfall data the rainfall information from some of the meteorological observatories connected with the warning centre through a radio link is also made use of. For acquisition of rainfall data from the upper catchment of the Chenab, Ravi and Sutlej Rivers a quantitative precipitation measurement radar has been installed at Sialkot. The radar has a wave length of about 5.32 cm and an effective range of 230 km.

A flood warning centre was established within the office building of Director, Flood Forecasting and Warning Centre during the flood season. The Flood Warning Centre comprises the representatives from the Ministry of Information, Punjab Government, Water and Power Development Authority (WAPDA) and Army Corps of Engineers. The Centre is assisted by the Federal Flood Commission, Islamabad. The Centre operates round the clock and is responsible for dissemination of the flood warning to provincial as well as the federal authorities concerned with flood management and disaster relief operations. Dissemination of the flood warnings and the other flood related data is done using the communication system of the Punjab Police.

(c) Future flood protection plans

The strategy of the National Flood Protection Plan is primarily based upon the results achieved with the execution of the previous plans. The planning objectives are based on a comprehensive plan utilizing to the maximum the existing structural and non-structural measures and to modernize and upgrade them wherever they are needed. The plan includes a review of the existing flood forecasting and warning system in Pakistan with specific recommendations to modernize the system to comprehend the problem along with the reinforcement and activation of other compenents of the non-structural flood management system.

The flood forecasting system is being further improved both in the field of remote sensing of the precipitation data, as well as in the field of computerized mathematical modelling. The area of warning dissemination and the relief and rescue operationsl arel also being improved to the required level. Future development of the flood forecasting system envisages installing a number of QPM radars at suitable locations throughout the country in order to provide the total radar coverage to all regions.

4. Disaster management agencies in Pakistan

In view of the costs involved, Pakistan can ill-afford to maintain permanent disaster management organizations at all levels, separate from normal administrative machinery. As a result, most of the disaster management duties are performed by various Government departments on a part-time basis. Like the small full-time organization of the Emergency Relief Cell at Federal level, the Provincial Governments also have very small full-time relief departments. A Provincial Relief Department is usually headed by a senior civil servant of the province who performs these duties in addition to his main duties in his above referred capacity. Similarly, instead of having separate relief organization at district level the Government officials holding various posts in different departments automatically assume relief duties in accordance with a pre-planned scheme.

(a) Emergency Relief Cell

At the national level, the natural disasters are handled by the Emergency Relief Cell. It functions under Cabinet Division. It is a small organization, but draws highest support from the whole Government.

The Emergency Relief Cell prepared a disaster relief plan titled "National Disaster Plan" in 1974 under the guidance of the Office of the United Nations Disaster Relief Coordinator. The purpose of the plan was to establish procedures, prescribe organizational set-up, fix primary responsibilities and support functions of implementing agencies involved, and standardize procedures for the monitoring of disaster operations. The National Disaster Plan also indicates the duties and functions of the implementing agencies, i.e., Ministries and services which can be utilized in a disaster situation. The Provincial Government and District Administration have adopted the National Disaster Plan with a few minor modifications to suit their requirements.

During the flood season, the Emergency Relief Cell operates a control room on round the clock basis for

monitoring the flood situation and coordinating relief activities. The Control Room remains in touch with the Federal Flood Commission, Islamabad, Flood Forecasting and Warning Centre, Lahore, Army Flood Relief Control Centre, Rawalpindi, and Flood Control Rooms operating at District level. The information received at the control room is used to keep the Federal Government informed about the latest flood situation and to make arrangements for dispatch of relief goods to the affected areas.

While the Emergency Relief Cell is not an organization operating directly in the field, the four helicopters of the relief squadron maintained by the Cell are made available to the relief agencies busy at the scene of disaster for evacuation of marooned people and for supply of relief goods in the areas not accessible through normal means of transportation.

The Cell maintains stores of relief goods, mainly tents and blankets, for supply to relief agencies for providing temporary shelter to the calamity stricken people during emergencies. Since 1981 the Emergency Relief Cell has provided 4 565 tents, 25 970 blankets, 3 330 quilts, and a variety of other relief goods including edibles and medicines to different Provincial governments.

(b) Federal Flood Commission (FFC)

The functions of FFC include (i) Preparation of a flood protection plan for the country; (ii) Approval of flood control protection schemes prepared by provincial governments and federal agencies; (iii) Recommendations regarding principles of regulation reservoirs for flood control; (iv) Review of damage to flood protection works, and review of plans for restoration and reconstruction works; (v) Measures for improvement of flood forecasting and flood warning systems; (vi) Preparation of a research programme for flood control and protection; (vii) Standardization of designs and specifications for flood protection works; and (viii) Evaluation and monitoring of progress of implementation of the national flood protection plan.

(c) Water and Power Development Authority (WAPDA)

WAPDA's main functions, as far as flood management is concerned, are operation of reservoirs to retain floods in such a way as to reduce flood peaks. Moreover WAPDA provides real-time data to the Pakistan Meteorological Department (PMD) as an input for flood forecasting and warning.

Every year, before the onset of the flood season, Water Resource Management Directorate of WAPDA brings out a publication to delineate the role of WAPDA, in cooperation with other relevant agencies, for the overall flood management of the Indus Basin. Procedures are laid down for the judicious operation of the reservoirs for water conservation and flood attenuation and effective operation and maintenance of the telemetric and telecommunication network for transmitting the real time hydrological and climatological data to Flood Forecasting and Warning Centre at Lahore and other Federal and Provincial Agencies.

(d) Pakistan Meteorological Department (PMD)

The flood forecasting at the rim-station is now being handled by Pakistan Meteorological Department (PMD) in collaboration with WAPDA with the use of computerized models installed at the Flood Forecasting and Warning Centre established at Lahore. The resulting warnings are issued individually/severally to various concerned formations as prescribed in the 'Manual of Irrigation Practice' with subsequent modifications to enter for the progressive system additions and improvements, etc.

(e) Provincial Irrigation Department (PID)

Maintenance and operation of various flood protection works such as embankments, dykes, barrages is the responsibility of PIDs. The Provincial Irrigation Departments have flood fighting plans of their own in respect of each structure such as headworks, canals, drainage systems and embankments, containing comprehensive information about the preparedness for flood fighting, indicating flood limits and actions required to be taken in case of very high or exceptionally high floods. The breaching sections wherever required are also indicated, showing levels as to when they have to be operated.

(f) Pakistan Army

The Pakistan Army helps civil authorities in case of extreme flood situations. Its functions include: (i) To control flood relief activities; (ii) To collect information and disseminate relevant portions to the Ministry of Defence and Cabinet Division; (iii) To issue necessary warnings to lower formations regarding meteorological data and flood situations; (iv) To advise allocation of engineering equipment; and (v) To maintain up-to-date flood situation maps.

(g) Relief Departments

Evacuation and relief measures are generally handled by the Provincial Revenue Departments under the guidance of the Flood Relief Commissioner (who is a senior civil servant). In case of emergencies, help is also sought from the armed forces as well from some para-military organizations such as Rangers, Civil Defense Department etc. under the standing arrangements.

III. PRACTICAL MEASURES FOR MITIGATION OF WATER-RELATED NATURAL DISASTERS IN THE ESCAP REGION

by M. Nishihata[1]

A. Introduction

Every nation in the ESCAP region suffers directly and indirectly from the damages resulting from recurrent water-related natural disasters caused by cyclones/typhoons and floods. However, the natural disasters caused by cyclones/typhoons and floods occur under different environmental conditions and at different time intervals; therefore, the damages caused are different in each country.

Water-related natural disasters have a severe impact on a nation's normal economic and social development, especially in the developing countries. It is sometimes said that disaster prevention is a social and economic problem rather than a problem of technology in developing countries.

When considering practical countermeasures for mitigation of natural disasters, it would be very useful to learn from the past disaster experiences in one's own country and to exchange information between countries affected by similar hazards. Historical information and experiences gained are very important for disaster prevention.

It should be considered that advanced technologies and systems for disaster prevention in highly industrialized countries often cannot be transferred to developing countries immediately, because these countermeasures and systems are unsuitable to the social, economic and technological conditions that may exist in the developing countries.

It may therefore be necessary to alter disaster countermeasures to suit appropriately the conditions of the countries receiving assistance.

B. Disaster prevention

Disaster prevention measures should be designed to minimize the damages caused by natural disasters. In order to minimize damages caused by water-related natural disasters, it is necessary to establish comprehensive measures which include both hardware (structural measures) and software (non-structural measures).

Disaster prevention measures should be integrated and not be fragmented, and should have a good combination of both software and hardware.

Generally, there are three phases to mitigate the damages caused by water-related natural disasters:

(1) Prevention/preparedness

(2) Emergency countermeasures

(3) Restoration/rehabilitation

C. Prevention/preparedness

Prevention/preparedness for natural disasters is essentially the most important measure, but takes a long time and needs enormous resources.

It is necessary to promote disaster prevention/preparedness measures even if slowly, but steadily.

1. Hardware (structural measures)

Long-term structural measures adopted for mitigating damages caused by water-related natural disasters are classified into two types:

(a) Measures to discharge floods to the sea as soon as possible through waterways protected by strong embankments;

(b) Measures to store floodwater in reservoirs or retarding basins.

Such measures include: river improvement (strength ening and hightening of embankments, construction of retarding basins, etc.); urban drainage (construction of pump stations); dam construction (flood control and development of water resources); sabo works (erosion and sediment control); landslide prevention; construction of refugee shelters; construction of meteorological observation facilities; and construction of flood observation facilities.

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2. Software (non-structural measures)

Practical non-structural measures for mitigation of water-related natural disasters are selected considering various conditions, such as the social, economic and technological conditions prevailing in the country. In Japan, these measures could generally be classified as follows:

(a) Laws/regulations

- Basic law on disaster measures
- Act of National Treasury providing contribution to the post-disaster work expenses for restoration of public facilities
- Flood Fighting Act
- Regulations on land-use
- City planning

(b) Organization

- Disaster Prevention Council
- Basic, operational and local plans for disaster prevention
- Emergency disaster measures headquarters
- Communications network
- Training

(c) Observation/research/statistics

- Flood forecasting and warning systems
- Flood risk mapping
- Research and study
- Manuals and guidelines
- Observations (meteorological, hydrogical)
- Data collection and compilation
- Conducting careful inspections before the flood season
- Statistics on water-related natural disasters

Structural measures and non-structural measures are both effective but they all need large capital investment. The difficulty is to determine who will pay the costs.

These measures will take time to implement. In Japan a high continuous embankment could not be finished in a short time. It has taken a long time and is still under construction at present.

In ancient times, a small ring levee was usually built by the inhabitants of an area to protect their homes and paddy fields against floods. After that the ring levee was gradually expanded and resulted in continuous levees being built along both sides of the rivers up to the present times.

D. Emergency countermeasures

Emergency countermeasures should be taken immediately during disaster and after the disaster. All available means should be mobilized. Before the disasters strike, training exercises should be periodically undertaken.

Evacuation and relief measures during emergencies are facilitated by the transfer and distribution of correct information in a speedy manner.

1. Flood fighting

In Japan the primary responsibility for flood defence lies with the Flood Defense Administrative Body which is formed at the municipality level. The Prefectural Government and the Central Government also have their own responsibilities for efficient execution of flood defense activities, giving guidance and assistance to the municipalities.

If the floods become serious, rising beyond the specific water level, the Flood Defense Administrative Body will take appropriate action and mobilize flood fighting squads according to its own work programme. There are approximately 3 000 flood fighting squads in Japan, having more than 1 million members ready for any emergency.

Flood forecasting and warning issued by the National and Prefectural organizations are transmitted to the municipalities through public or exclusive communications systems.

The main flood fighting measures employed in Japan are: Sandbag piling which prevents water from overflowing the levee; and Placing sheets over the levee to prevent collapse due to overflow.

2. Japan Disaster Relief Team (JDR)

When a great disaster occurs in another country, the Japanese government is prepared to dispatch the Japan Disaster Relief Team (JDR) in response to the request of the striken country. It goes without saying that financial

aid and donation of relief goods (medicines, tents, blankets, food stuffs, etc.) are also carried out.

JDR consists of three teams as follows:

(a) The Rescue team, which undertakes search and rescue activities, and is composed of rescue members of the Fire Defence Agency, National Police Agency and Maritime Safety Agency.

(b) The Medical team is responsible for emergency medical care activities, including prevention of infectious diseases, and is composed of doctors, nurses, etc.

(c) The Expert team undertakes restoration/rehabilitation work for disaster activities and is composed of technicians and engineers.

Expert teams have already been dispatched several times, but they were dispatched more than one month after the occurrence of the disaster. Therefore they did the overall surveying of the damaged area and provided assistance and technical guidance for restoration.

In case of a disaster, Rescue and Medical teams are requested, and dispatched as soon as possible after the receipt of the request. They commence the emergency activities within 48 hours.

E. Restoration and rehabilitation after disaster

Restoration/rehabilitation work should be taken as soon as possible after the implementation of emergency measures, and the damaged public facilities should be restored quickly. Procedures and modalities for sharing of expenses for disaster restoration/rehabilitation must be established.

In Japan, during World War II disaster prevention did not progress much because of military expenditure. Therefore, after the War, Japan suffered from major disasters which caused enormous damages to public facilities. Consequently, a system has been established to restore damaged public facilities.

The principle of restoration is to restore damaged facilities to predisaster conditions. Substitute reconstruction is also permitted in case of difficulty or inadequacy in recreating the original state. In Japan, damaged facilities should be restored within three years and the minimum amount of the national expenditure to be allocated for such projects is two-thirds of the total cost.

1. Objectives of the system

Rivers, sea shores, erosion control works, roads and bridges, are closely related to people's lives. Destruction of these would have serious social and economic repercussions and would influence the stabilization of the people's livelihood.

A large amount of funding is required for restoring damaged public facilities, since it is far beyond the financial ability of local government, which normally manages such facilities, to bear the burden of reconstruction costs. In Japan, the national government provides special financial assistance to such local governments in order to assure public welfare.

The National Treasury Contribution Act, which determines national treasury contribution to disaster restoration expenditure, has the following purpose; "It determines government contributions to the restoration expenses of damaged public facilities to match the financial ability of the local government concerned and, thereby, assures the public welfare by the quick restoration of facilities". Naturally, public facilities which are managed directly by the government are restored at the national treasury's expense.

Japan is subjected to frequent natural disasters due to its geographical location, topographical and geological features. Every year, typhoons and torrential rains cause considerable damage throughout the country, sometimes causing deaths and destroying large amounts of property. These have serious adverse effects on people's lives and the social economy.

The total amount of damages sustained by public facilities under the jurisdiction of the Ministry of Construction (MOC) in 1990 was 908.5 billion yen, consisting of those under direct jurisdiction by MOC (223.5 billion yen) and those subsidized by MOC (685.0 billion yen). The principal causes of these damages were heavy rains of the seasonal rain front, typhoons and torrential rains. The restoration of the damaged property project is to be completed in two years (disaster affecting facilities under direct control) and in three years (disaster affecting subsidized facilities).

As for extremely heavily damaged places among subsidized facilities, improvement and restoration work is to be done under a fixed plan and additional fundamental improvement work is to be undertaken as a disaster-related project. This restoration work is to be completed in three to five years. Expenditure on disaster restoration work consists of the total of direct main work expenses, incidental work expenses, land expenses etc. (called fieldwork expenses) and office work expense. Work expenses include emergency expenses for the work undertaken before determination of the project expense.

2. Determination of disaster restoration work expense

(a) Report of disaster

When public facilities are damaged by abnormal natural phenomena, they must be reported without delay. In Japan when a damaged facility is managed and maintained by municipalities, the mayor reports it to the prefectural governor.

When the prefectural governor receives a report from the mayor of a municipality, he/she must summarize and report it to the concerned Minister in an established format without delay.

(b) Application for national treasury contribution

In Japan, the expenditure for a disaster restoration project to be paid by the national treasury is determined by the concerned Minister after reviewing the material submitted by the local government concerned and the results of the field survey. The concerned Minister makes a decision when he/she receives an application from the head of a local government. In addition to the report and the cost estimate, the related drawings, meteorological data, material on causes and current status, and disaster statistics are attached to the application form.

(c) Assessment of disaster

In Japan, after receiving an application for national treasury contribution, the concerned Minister dispatches necessary personnel to conduct a field investigation. MOC has disaster assessment officers who undertake such assessment work to determine the cost of a disaster restoration project. This type of field investigation is called "disaster assessment".

Disaster assessment is also reviewed by inspectors from the Ministry of Finance. The project cost is determined for major items of expenditure, with minor items to be considered later since the mission of the disaster relief system is quick restoration, and applications are made from a large number of places.

For those places which are accepted for reconstruction funding, as the result of disaster assessment, the amount of the agreed expenditure, field assessment/desk assessment and emergency rank are written in red on the cover of the project document. As for those incidents which cannot be accepted, the reason for rejection is written.

As for those places which need a further study or require very large amounts of expenditure (more than 200 million yen), the decision is reserved, and is made after a discussion between MOC and the Ministry of Finance.

(d) Determination and notification of the disaster restoration work expenditure

Disaster restoration work expenditure is determined by the Minister of Construction. When the Minister of Construction determines a project cost, he/she notifies the Governor concerned. As for disaster restoration project expenditure for city/town/village, the Governor concerned notifies the mayor concerned.

(e) Re-investigation

In some cases, meteorological or topographical conditions bring about various changes at damaged places. Therefore, it becomes necessary to make significant changes and the initially determined project expenses become insufficient. For this reason, a re-investigation is conducted to review the project expense in the third year of the disaster restoration work.

3. Government budgetary measures and success certification

Ordinary public facilities such as roads, bridges, dams and embankments., are constructed and improved according to a long-term plan. However, disaster restoration works are undertaken when abnormal natural phenomena such as typhoons, earthquakes and heavy snow occur and cause a disaster. Therefore, it is difficult to determine the scale of work in advance and make the necessary budgetary requests.

When a local government undertakes disaster restoration works with the central government's contribution, it must calculate the expenses exactly without delay and obtain a certification from the Minister of Construction. Such a certification means that inspection has been carried out to determine whether the results of restoration works are in line with the law and regulations concerning disaster assessment.

4. From occurrence of disaster to completion of restoration work

When a public facility managed by municipalities is damaged by a natural hazard, the mayor of the city/town/village must report it to the Prefectural Governor without delay. If a disaster occurs to a public facility which is managed by the prefecture, the Governor must report it to the concerned Minister without delay.

This report becomes the important basic material for determination of measures which are taken for each disaster by the government.

Disaster assessment is the field investigation which is conducted by assessment officers for determining the expenditure that would be required, most of which is determined, in effect, in the field.

Assessment officers then determine the expenditure for reconstruction works on the basis of the National Treasury Act mentioned earlier and of various other regulations.

Damaged public facilities are to be restored by the organization which manages and maintains them. However, adequate and quick restoration is difficult because in Japan local government finances are limited.

In view of the above, the National Treasury Act and other regulations were established for quick restoration of damaged public facilities by determining the levels of contributions from different sources according to the financial ability of local governments.

5. Procedures of disaster assessment

The procedure for disaster assessment is as follows:

(a) General description

Prior to assessment work, the following items are to be reported by the prefecture: The characteristics of the disaster; the abnormal meteorological conditions; the number of places affected; the amount of expenditure; the distribution scheme to places affected; schedule and organization.

(b) Field assessment

The damaged area under investigation is delineated with marking poles and the length of the damaged site is measured with a scale tape.

The applicant identifies the damaged area, the amount of funding applied for, the outlines of required work, etc. and describes the method of restoration work desired. The assessment officer reviews and confirms the state of damages and determines the extent of damaged areas. The assessment officer may approve or reject the application after checking the method of restoration work required and examining the design documentation for the restoration work.

(c) Desk assessment

A desk assessment is sufficient if the amount required by the application is less than two million yen or if a field assessment is difficult for an unavoidable reason. A desk assessment is made at the prefectural or municipal work office, and the state of damages is judged only by using photographs, taken correctly from various view points. When the state of damages is uncertain, a field assessment is made.

(d) Consideration required for selection of the method of work

The required work method is selected by following the procedure outlined below:

- Study the cause of the damage for preventing repetition;
- Select the method of restoration work that matches the site;
- Select an economical method;
- Select the method which will make a positive economic impact;
- Select a unified method (do not change methods drastically; use the same method for upstream and downstream, and for front, rear, left and right);
- Select the method that would utilize material that can be obtained locally.

(e) Correction in red

In accordance with the results of the disaster assessment, the method of restoration work and cost estimates can be altered, and the applicant then corrects the design documentation and the cost estimates. The assessment officer makes a final check and revises the design document and finalizes the cost estimates, and writes them down with a red pen.

The disaster assessment procedures ends here.

F. Conclusion

The Tokyo declaration on IDNDR stated that "Fatalism is no longer acceptable; it is time to bring the full force of scientific and technological advancement to reduce the human tragedy and economic loss of natural disasters".

The major principles and measures for water-related natural disasters such as cyclones/typhoons and floods are summarized as follows:

1. Meteorological and hydrogical observations, research, studies and collection of statistics of water-related natural disaster are required.

2. Comprehensive disaster mitigation plans consisting of both structural (hardware) and non-structural (software) measures should be formulated promptly.

3. Within the limits of available budget, the priority of disaster measures should be considered from both economical and social points of view.

4. Structural measures need large capital investments and therefore are hard to undertake. However, they must be undertaken, even at a slow but steady pace.

5. The investigation of damages caused by water-related natural disasters should be carried out promptly and appropriately. Due to lack of timely and accurate information, one is not able to grasp the damages sustained in detail. If coordination among the national and municipal administrations in charge of emergency measures is not adequate, appropriate measures against natural disasters cannot be carried out.

6. If restoration/rehabilitation work is not carried out for some reason, such as lack of adequate finances or technical difficulties, secondary disasters or other unfavourable events may occur because of lack of restoration work, in turn leading to a larger disaster.

7. It is necessary to encourage the people inhabiting the flood plains to participate in flood fighting activities and it is important for them to cooperate in daily activities for reduction of damages caused by water-related natural disasters.

8. As for global environmental problems, research on global climate change is needed urgently all over the world. It is recommended that international action required for reduction of natural disasters which may be caused by global climate change should be undertaken immediately.

IV. SUGGESTED POLICIES FOR REDUCTION OF DISASTERS CAUSED BY TYPHOONS, CYCLONES AND FLOODS

A. Introduction

The policies to mitigate the impact of the disasters caused by cyclones/typhoons and floods should be comprehensive and consider the following three time frames:

(1) Disaster prevention—long-term activities, which are achieved by using permanent controls and are implemented in advance of the disaster;

(2) Disaster preparedness—short-term measures, which are planned in advance but carried out during the emergency;

(3) Disaster rehabilitation—post-disaster activities.

Post-disaster activities are sometimes treated as part of disaster preparedness. However, rehabilitation can extend over months and even years after the occurrence of the disaster and cannot be considered as short-term measures. Rather they should be regarded as a preceding stage of long-term disaster prevention. Therefore, they are treated separately in this paper.

These three kinds of measures are not isolated activities since they can be undertaken together or one can be a continuation of the other. This is because not all disasters can be prevented, and preventive measures may fail. Thus, to limit or mitigate the effects of the disasters which cannot be prevented, certain measures have to be undertaken to return the community to normality as soon as possible after the event.

The policies should not be too specific to each hazard, and should be integrated into a set of overall policies relating to all kinds of natural disasters.

B. Disaster prevention

1. General

Disaster prevention may be described as application of measures designed to prevent natural phenomena from causing or resulting in disaster or other related emergency situations. It is concerned with the formulation and implementation of long-range policies and programmes to prevent or eliminate the occurrence of disasters on the basis of vulnerability analysis of all risks. It also includes legislation and regulatory measures principally in the fields of physical and urban planning, public works and buildings.

Before disaster prevention measures are taken, characteristics of hazards and resulting damages should be properly assessed.

2. Assessment of hazards

The description and assessment of hazards should be regarded as the first element of disaster prevention. Occurrence of cyclones/typhoons and floods should be scientifically and statistically evaluated. For this purpose, observation and archive systems should be established and properly maintained. Records of various forms, which would be continuously updated and improved by these systems, should be utilized to estimate the frequency, nature and extent of these hazards. Risk maps would be an excellent means for expressing severity of these hazards.

Recent advances in remote sensing techniques offer new opportunities for a more efficient and more comprehensive assessment of these hazards. The special contributions that satellite systems have made to meteorology and climatology include their global coverage of data, spatial continuity of data and ability of homogeneous investigation of selected elements.

Simulation techniques also provide useful tools for assessment of floods and storm surges. Availability of high speed microcomputers at relatively low costs made the application of various simulation models possible for practical purposes in the developing countries. These models are utilized both in planning of flood control measures and in flood forecasting and warning.

3. Assessment of damages

The assessment of a country's vulnerability to cyclones/typhoons and flooding can be divided into two phases as follows:

(a) Delineation of areas exposed to cyclones/typhoons and flooding;

(b) Assessment of losses and damages that represent and quantify the consequences of these hazards in a socio-economic context.

The first phase of the assessment is technical and provides estimates of vulnerability to these hazards. The second phase is more difficult to achieve because: (a) the losses and damages depend on the type and intensity of land uses which vary in time; (b) plans and policies are future-oriented, whereas factual data on losses relate to the past; (c) hazard events, particularly extreme ones, are rare and it is virtually impossible to collect representative sets of records from flood damage statistics even if such data are regularly collected for long periods.

Total damages include direct damages, which result from physical contact with water, and indirect damages, such as the cost of disruption to business and to living conditions. Intangible damages, such as death, sickness, stress and anxiety, are also a major part of total damages.

Damages other than direct damages are difficult to evaluate in monetary terms. Some indirect damages may be estimated as a proportion of direct damages. In Japan, for example, damages due to suspension of business are estimated by multiplying direct damages excluding those to public facilities by 0.06. Other indirect damages, such as disruption of living conditions, are not readily obtainable, because undisputed methods for determining effects of hazards on these damages have not been established. A comprehensive method for damage evaluation, including all kinds of damages should be sought for application. This might involve an extremely difficult task of expressing life, health and convenience in monetary terms.

The survey of damages should be carried out after each significant hazard event and the information should be properly compiled. Such information could be utilized in developing simulation techniques for assessing the potential damages caused by cyclones/typhoons and floods, which will combine physical hazard simulation models and hazard-damage functions such as depth-damage, wind speed-damage functions.

4. Disaster prevention measures

The principal preventive measures employed to curb the destructive and injurious effects of tropical cyclones are building design and construction standards to resist wind and water. The range of measures available to protect against the effects of flooding is much wider than that available to reduce the impact of tropical cyclones. It includes civil engineering oriented structural measures, such as channel modifications, flood storages and levees, as well as other measures, such as planning controls and flood proofing of buildings, which are referred to as non-structural measures. These measures are designed and implemented to reduce the incidence or extent of flooding and storm surges and/or the effects of them.

The selection of the best combination of measures to prevent the occurrence of future flood or storm-surge disasters should be based on the consideration of all the available structural and non-structural measures. The optimum combination of measures should be based on risk analysis and the economic performance of the overall scheme. Consideration of social and environmental factors as well as the legislative and legal constraints should also be included in the planning process.

C. Disaster preparedness

1. General

Disaster preparedness may be described as the action designed to minimize loss of life and property damage and to organize and facilitate timely and effective rescue and relief in the case of disaster. It is supported by necessary legislation which can achieve readiness to cope with disaster situations or similar emergencies which cannot be avoided. It is also concerned with forecasting and warning, the education and training of the population, and organization for and management of disaster situations including the preparation of operational plans, training of relief groups, the stockpiling of supplies and provision of the necessary funds.

These disaster preparedness measures, including those which are taken when the occurrence of a tropical cyclone, flood or storm surge imposes the threat of a disaster, should be planned well in advance.

2. Structure of disaster preparedness activities

A number of organizations of various levels are involved in the disaster preparedness activities. A co-ordinating body at each level should be established for streamlining the planning process and assuring proper implementation of the plan.

In an emergency the major tasks are apt to fall upon communities. It is at this level that evidence will be found whether the overall planning has been sufficiently comprehensive and co-ordinated to develop the necessary high degree of motivation among the responsible people as well as among the general public in carrying out the whole range of measures which the emergency demands.

The terms of reference and functions of such a body should be clearly set out and would include such matters as the following:

(a) To keep the population and its property, installations, etc. constantly prepared for an emergency arising from natural hazards;

(b) To keep under review, and to take all appropriate action on matters likely to reduce danger and devastation from natural hazards;

(c) To supervise the warning systems and the organization for dealing with emergencies;

(d) To direct and control rescue and relief work;

(e) To maintain liaison with the press, radio and television and to organize programmes for public information and education;

(f) To organize a survey of deaths, injuries and damages after each emergency and to take action based on the lessons learned.

A plan of disaster management activities of the Philippines, an extract from the Rules and Regulations Implementing the Provisions of Presidential Decree, "Strengthening the Philippine Disaster Control Capability and Establishing the National Programme on Community Disaster Preparedness", is attached as an appendix.

3. Flood fighting

Unlike other disaster preparedness activities, which can be considered as a local and self-help responsibility, it has long been realized that when a flood constitutes a threat to a number of neighbouring communities, co-ordinated flood fighting under unified control is much more effective than independent action by each community. For example, a system of levees may protect several communities and this system should be patrolled and maintained as a single unit rather than a number of isolated elements.

D. Disaster rehabilitation

1. General

Disaster rehabilitation including resettlement would fill the gap between emergency activities of disaster preparedness and long-term activities of disaster prevention. Although rehabilitation constitutes an important part of activities for reduction of suffering caused by disasters, its importance has not been recognized as much as it should be.

Emergency measures during major disasters and relief activities immediately after them attract much more attention and are covered more heavily by mass media than the rehabilitation phase. This is partly because these are directly related to death, injury or illness suffered during the disaster. Due attention, however, should be given, internationally as well as nationally, to rehabilitation activities, notwithstanding that they are less dramatic in nature compared to the short-term measures.

2. Rehabilitation

The basic purpose of rehabilitation is to provide services and facilities which will restore communities, families and individuals to their former living standards while at the same time encouraging any necessary adjustments to drastic changes caused by the disaster that has occurred. However, because disasters caused by cyclones/typhoons and floods are often recurring, the aim of a rehabilitation programme should include improving rather than merely restoring the accustomed living standard and social conditions. For example, flood control facilities which have failed should be upgraded, and houses and buildings destroyed or severely damaged by cyclones/typhoons should be rehabilitated and improved so as to become cyclone/typhoon-resistant.

Rehabilitation should be carried out in a two-pronged programme covering, on the one hand, the victims of the disaster and on the other hand the public services and amenities. For the victims, assistance may include the repair of homes, the provision of basic home needs such as furniture and kitchen utensils, the provision of food and clothing and resettlement. In this programme, morale is one of the most important factors in rehabilitation. This factor should be considered in relation to the community itself and also in relation to families and individuals. It is possible for people to emerge from a disaster in a hopeless and apathetic state of mind. If this attitude is allowed to persist, people affected will become over-dependent on welfare services and be a permanent burden on the nation. A spirit of high morale can be fostered by helping people to realize that the efforts made on their behalf are prompted by a regard for their value to the country and by the desire to promote feelings of self-reliance and a determination to participate in the work and social life of a community growing in prosperity.

The rehabilitation of public services and amenities makes a most important contribution to the recovery of a community and would include such matters as the repair of roads and bridges, the restoration of the various public utilities, assistance to industry and commerce to resume full activity and a variety of activities to assist agriculture.

Disaster rehabilitation includes the following measures:

(a) Repair and restoration of damaged public infrastructures, such as levees, roads and ports, public utilities, educational, welfare and agricultural facilities;

(b) Loans, under softer conditions than usual, to persons who suffer disaster damage;

(c) Insurance;

(d) Reduction, suspension or exemption of income and property taxes.

3. Resettlement

Resettlement may be an expensive, and probably questionable solution for large communities, particularly for certain types of natural disaster. However, in flood-prone areas, the issues are clearer than in many other disaster-prone situations, and the community as a whole may see a common benefit in moving on to higher and safer ground.

Resettlement involves not only questions of location but also such aspects as availability of employment, transportation and services. It is evident that the formulation of resettlement plans calls for close inter-ministerial and inter-departmental co-ordination at all levels of government. Ministries responsible for housing and urban development, public works, regional and physical planning, etc., are important contributors.

Relocation is often necessary as a temporary measure following the occurrence of a flood. Flood-stricken populations rendered homeless as a result of destruction of their accommodation by floodwater require emergency, and subsequently, permanent settlement. It is often the poor and underprivileged who are forced to live in flood-affected properties. Being carried out properly, relocation and resettlement immediately after disasters can improve the squatter problems. If not, these people will occupy the same areas and keep suffering from disasters.

Appendix. PHILIPPINE PROGRAMME ON COMMUNITY DISASTER PREPAREDNESS. Extract from the Rules and Regulations Implementing the Provisions of Presidential Decree, "Strengthening the Philippine Disaster Control Capability and Establishing the National Programme on Community Disaster Preparedness"

DISASTER MANAGEMENT ACTIVITIES

A. PRE-DISASTER PHASE

The pre-disaster activities to be undertaken are the following:

1. Planning for Disasters

The National Disaster Coordinating Council (NDCC), through the Office of Civil Defense, shall review and evaluate all documented plans submitted by all government entities, political subdivisions as well as private organization as to compliance with pertinent advice/instructions and/or guidelines set forth in the National Calamities and Disaster Preparedness Plan.

2. Organizing

a. The National Disaster Coordinating Council through the Office of Civil Defense, shall spearhead the organization of Disaster Coordinating Councils from the Regional down to the Barangay levels in coordination with the Ministry of Local Government which shall act as the overseer of the councils.

b. All other government ministries, agencies, offices, entities and instrumentalities, including large private institutions, shall establish their respective disaster control organizations.

3. Training

a. The Ministry of Local Government shall conduct training of members of local disaster coordinating councils in coordination with the Office of Civil Defense (OCD), the Ministry of Social Services and Development (MSSD), the Philippine National Red Cross (PNRC), and other appropriate agencies.

b. The Ministry of Social Services and Development shall undertake training on disaster preparedness of barangay tri-sectoral groups and shall assist in the training of Disaster Coordinating councils at all levels.

c. The Philippine National Red Cross shall conduct disaster leadership training courses and shall assist in the training of the Disaster Coordinating Councils.

d. The Ministry of Education and Culture (MEC) shall assist in the public education campaign through integration in the school curricula of subjects relative to the different calamities, their causes and precautionary measures.

e. The Ministry of Trade and Industry shall train disaster control groups and reaction teams in large buildings used for commercial purposes.

f. The Office of Civil Defense (OCD) shall provide guidance and assistance in the training of disaster coordinating council members and disaster control groups.

g. All other training activities shall be as enumerated and prescribed in the National Calamities and Disaster Preparedness Plan.

4. Drills

All agencies responsible for organizing Disaster Control Groups (DCGs) shall also be responsible for the conduct of periodic drills and exercises.

The Ministry of National Defence, through the Office of Civil Defense, shall assist and/or observe and provide critique in the conduct of drills and exercises.

5. Public Information Drive

a. The Office of Media Affairs (OMA), in coordination with the OCD as well as other government or private entities with facilities for disseminating information, shall conduct public information campaigns on disaster prevention, control and mitigation measures.

b. The OCD, in coordination with the OMA, shall prepare disaster control manuals, handouts and other publications as well as audio-visual materials related to disaster prevention, control and mitigation measures.

6. Stocking

a. Provisions for basic necessities such as food, clothing, shelter, medical supplies and transportation, shall be given priority in any stockpiling activity.

b. The Ministry of Social Services and Development (MSSD) and the Philippine National Red Cross (PNRC) shall pre-determine the quantity of relief goods that might be required in particular areas and preposition the same in disaster-prone areas.

c. The Ministry of Health shall stockpile medicines and medical supplies for possible deployment in disaster areas.

d. The local disaster coordinating councils, especially in disaster-prone areas, shall pre-determine the food, clothing, shelter, medical supplies and other emergency requirements of the community and shall take appropriate measures for stockpiling of such supplies and materials.

e. Disaster Coordinating Councils and other civic organizations may conduct drives for the collection of used clothing and sort, repair or mend and launder them before stockpiling for the purpose stated herein.

7. Communications and Warning Activities

a. The Office of Civil Defense (OCD) and other tasked agencies shall disseminate the warning in formation as well as precautionary measures to the public.

b. The Disaster Coordinating Councils in all levels shall be responsible for the organization of warning units.

c. The building owners through their disaster control teams shall be responsible for warning all occupants thereof of any impending disaster.

d. The warning agencies shall provide, to the fullest extent possible, information concerning impending disasters including estimated intensity, duration and scope.

B. EMERGENCY PHASE

1. Emergency Service

a. GENERAL

(1) Emergency services and intervention activities likely to be needed in the disaster area are rescue and engineering, evacuation, first-aid and medical relief, police auxiliary, fire, and transportation services.

(2) The above services shall be coordinated and orchestrated by the local disaster coordinating council of the affected locality.

b. RESCUE AND ENGINEERING

(1) The local disaster coordinating councils shall supervise rescue and engineering activities within their areas of responsibility.

(2) In case of air crashes outside the airfield, the nearest Disaster Coordinating Council (DCC) shall undertake initial response until the arrival of the Bureau of Air Transportation officials who shall then take over responsibility for the rescue operation.

(3) The Philippine Coast Guard (PCG) shall be responsible for the coordination of rescue activities at sea.

(4) The Armed Forces of the Philippines shall, whenever possible, assist the local disaster coordinating councils during emergencies.

(5) The Ministry of Public Works and Highways shall, whenever possible, lend equipment and manpower to local rescue and engineering units.

c. EVACUATION

(1) The Disaster Coordinating Councils (DCCs) shall be responsible for organizing evacuation teams for the transfer of disaster victims or potential victims to safer grounds.

(2) The regional and provincial disaster coordinating councils shall extend assistance to their lower level councils whenever the situation has deteriorated beyond the capabilities of the latter to cope with.

(3) The Armed Forces of the Philippines shall, whenever possible, assist in the evacuation activities. Authority from higher headquarters shall be sought in each case.

d. FIRST-AID AND MEDICAL SERVICES

(1) The Health Services shall consists of the Ministry of Health personnel and the PNRC first-aiders and volunteer workers who administer first-aid at the disaster areas.

(2) Patients who require further medical attention or hospitalization and/or surgical intervention shall appropriately be evacuated.

(3) Measures shall be undertaken to prevent the occurrence/outbreak of epidemics and to control them, as necessary.

e. DISASTER RELIEF SERVICES

The local disaster coordinating councils, in coordination with the Ministry of Social Services and Development and the Philippine National Red Cross shall be responsible for undertaking immediate survey of the disaster area and provide mass feeding, emergency housing, emergency clothing and missing persons tracing services, as necessary.

f. POLICE AUXILIARY SERVICES

(1) Police Auxiliary Services organized in accordance with existing laws shall augment the regular police forces in time of disaster. The PC/INP Station Commander shall be responsible for their organization and control.

(2) The Director-General, Integrated National Police, shall prescribe the duties, functions and responsibilities of the Police Auxiliary Service.

g. AUXILIARY FIRE SERVICE

(1) The existing fire department in cities and municipalities shall be the center of the Auxiliary Fire Service. The Fire Station Commander of the Integrated National Police, is also concurrently the Chief of the Auxiliary Fire Service.

(2) In case of fire, the Auxiliary Fire Service shall coordinate with the Chief of the local fire service within the locality and shall assist in the control thereof.

(3) The Director-General, Integrated National Police, shall prescribe the duties, functions, and responsibilities of the Auxiliary Fire Service.

h. EMERGENCY TRANSPORTATION SERVICES

(1) The Ministry of Transportation and Communications and other government ministries, agencies and entities, as well as the private sector, shall, whenever possible, make available for use by the disaster relief teams their organic transportation facilities.

(2) The Bureau of Air Transportation shall be responsible for coordinating with airline companies for the airlifting of victims and supplies during emergencies; and

(3) The Philippine Coast Guard shall coordinate with the Conference of Inter-Island Ship Owners for the use

of vessels, ships, motor boats or bancas to transport relief, supply, personnel, and victims during emergencies.

i. DAMAGE ASSESSMENT

The local disaster coordinating councils shall conduct immediate survey of the disaster area to determine casualties and damages to infrastructure, agriculture, aquatic resources, animal life and other properties. Results of the survey shall be reported to the operations center of the affected locality for initial assessment. It shall be sent through the next higher disaster coordinating council for transmittal to the NDCC through OCD for final evaluation and appropriate action.

C. POST EMERGENCY

1. CROSS-CHECKING OF DATA

All information gathered during an emergency shall be cross-checked with pre-emergency data obtained by local disaster coordinating councils to facilitate the location and whereabouts of persons and to assess available community resources for rehabilitation purposes.

2. REHABILITATION REQUIREMENTS

The local disaster coordinating councils within their respective levels shall determine the nature and extent of the rehabilitation effort to be undertaken and shall request assistance from appropriate government agencies, private offices/agencies or individuals, if the situation goes beyond their capability.

3. RESPONSIBILITY FOR EMERGENCY LABOUR SUPPLY

The Ministry of Labour and Employment shall coordinate and synchronize with appropriate agencies, the hiring of labour from the affected population as may be needed for the restoration, repair and construction of public buildings, roads, dams, harbours, airports and such other public infrastructure damaged by disasters or calamities.

V. ASSESSMENT AND MITIGATION OF DROUGHTS IN ASIA AND THE PACIFIC

by V.V.N. Murty*

A. Introduction

The Asian and Pacific region served by the United Nations Economic and Social Commission for Asia and the Pacific (ESCAP) extends from the Islamic Republic of Iran in the west to Japan in the north-east and the Cook Islands in the south-east; from Mongolia and China in the north to Australia and New Zealand in the south. The region covers almost half of the total surface area of the earth; approximately from 45° East longitude at the Western border of Iran to 156° West longitude at the easternmost point of the Cook Islands. It covers about 31 million square kilometres of land area.

The available information indicates that several countries in the ESCAP region are afflicted with the drought hazard intermittently. In many countries of the region, a majority of the population is dependent on agriculture and is rurally based. In case of droughts it is generally this strata of the society that is adversely affected. Considering historical information, droughts have caused negative impacts ranging from reduction in agricultural output to large scale economic devastation. As civilization progressed, many of the countries in the region became better prepared both administratively and technically to deal with the drought situations. In spite of this, droughts will continue to occur in the future and there is a need to prepare adequately for them.

The occurrence of droughts is not limited to a particular region or country in the world. However, it has been observed that their impact has been completely different in developed and developing countries because of the several socio-economic factors influencing both the behaviourial and management patterns. Even within the developing countries, the effects of droughts could vary, but the fact remains that during the drought the groups most seriously affected are the economically weaker sections of the population. Solanes (1986) drawing upon this fact outlines several legislative approaches to drought management. Quoting Theodore H. White from "In Search of History" it can be said "Drought is nature's guilt, but human suffering from drought is man made".

In this paper, the topic of drought is briefly reviewed in the context of the countries of the ESCAP region and the recent available information regarding their occurrences is presented. The countries responded to the droughts with various management measures and available information on this topic is presented. Drawing upon the experiences from the countries in the region and other available information, possible measures are suggested for drought management. It is hoped that the scientists, engineers and administrators in these countries will be aware of the issues involved and take effective measures in their spheres of activity.

B. Droughts as natural disasters

1. General

Droughts can be considered as extreme hydrologic events causing acute water shortages detrimental to human, plant and animal existence in the affected areas. Unlike other natural disasters such as earthquakes, typhoons and floods, the occurrence of droughts is not sudden but their effects are prolonged and in some situations equally detrimental as other natural disasters. In countries where a majority of the population are dependent on agriculture, the effects of prolonged drought are devastating. In such situations while the urban populations may be able to withstand drought to some extent the vast rural masses are badly affected. As a result of droughts, significant adverse economic consequences to the country are caused in terms of reduction or elimination of agricultural production, effect on energy generation, effect on livestock systems, population migration and finally resources needed for mitigation of the resulting hazards.

In spite of this, it can be stated that droughts differ from other natural disaster in several ways. First of all, their occurrence is not sudden and hence affords time to plan for their mitigation. Next, with the currently available knowledge and research information , in many situations the effects of droughts could be largely counteracted, if not completely eliminated.

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2. Identification of drought conditions

In understanding drought one may accept in general that "Drought is a condition of moisture deficit sufficient to have an adverse affect on vegetation, animals and man over a sizable area" (Warrick, 1975). Drought has to be distinguished from arid and semi-arid conditions as in such situations the human activity gets adjusted to the recurrent climatic conditions. Droughts can occur under different climatic conditions but their recurrence and effects are more pronounced in arid and semi-arid situations.

Three common categories of drought situations are:

(a) Meteorological Drought: Meteorological definitions of drought are the most prevalent and are based upon the degree of dryness and duration of dry period. Meteorological drought is referred to as " a period of abnormally dry weather, sufficiently prolonged for the lack of water to cause serious hydrologic imbalance in the affected area" (Huschbe, 1959). Rainfall is the most common parameter used in defining the meteorological drought.

(b) Agricultural Drought: In the context of agriculture, drought is referred to as a "climatic condition involving shortage of precipitation sufficient to adversely affect crop production or range production" (Rosenberg, 1979). Rainfall and the soil moisture are the two important parameters and drought conditions are said to exist when either of these are inadequate during the crop season to support healthy crop growth to maturity.

(c) Hydrologic Drought: This refers to "a period of below average water content in streams, reservoirs, ground water aquifers, lakes and soils" (Yevjevich, 1967). Meteorological drought, if prolonged, results in hydrological droughts with marked depletion of surface water and ground water resources.

Another categorization which is not commonly quoted is the socio-economic drought which refers to an acute scarcity of water resulting in the disruption of the supply and demand equation of socio-economic goods like food, fodder and water. In a given situation it is necessary to understand the important attributes and characteristics of drought which affect the human society.

3. Drought indices

Drought conditions are basically due to a deficit of water supply either in time or in space. Deficit water supply conditions may be in precipitation, runoff (stream flows), or in accumulated water in various storage capacities like soil moisture, reservoir or groundwater aquifers. In describing a drought it is necessary to understand its duration, areal extent, severity, probability of recurrence and its initiation and termination. Depending on the areal extent, the drought can be referred to as a point drought, the small area drought or the large continental drought (Yevjevich, 1967).

In order to characterize a drought situation, several indices are in vogue. Wilhite and Glantz (1985) discuss the different definitions for understanding the drought phenomenon.

Some meteorological drought indicators developed for application in various countries of the world as mentioned in Wilhite and Glantz (1985) are:

(a) less than 2.5 mm of rainfall in forty-eight hours (United States);

(b) fifteen days, none of which received as much as 0.25 mm (Britain);

(c) actual seasonal rainfall is deficient by more than twice the mean deviation (India); and

(d) a period of six days without rain (Bali).

The Palmer Drought Severity Index (PDSI), is one of the well-known meteorologic drought indicators. The PDSI relates drought severity to the accumulated weighted differences between actual precipitation and the precipitation requirement of evapotranspiration in a region. Although referred to as a drought index, PDSI is used to evaluate prolonged periods of abnormally wet or dry weather. The PDSI has been later modified by Palmer (as quoted in Wilhite and Glantz, 1985) to reflect agricultural drought conditions. The Crop Moisture Index (CMI) defined drought in terms of the magnitude of computed abnormal (Evapotranspiration) ET deficit. This deficit is the difference between actual and expected weekly ET. In the United States PDSI and CMI values are published monthly in the US Department of Agriculture's *Weekly Weather and Crop Bulletin*.

According to the Indian Meteorology Department (IMD), the definition of drought is mainly based on rainfall deficiency of a season. IMD uses two measures: the first describes rainfall conditions, while the second represents drought severity. Rainfall conditions are defined as follows (based on the average of 70-100 years):

Excess: + 20 per cent or more
Normal: + 19 per cent to -19 per cent
Deficient: -20 per cent to -50 per cent
Scanty: -60 per cent or less

The precipitation is expressed on a weekly and monthly basis. Drought is described as moderate if the seasonal rainfall deficiency (South-West Monsoon) is 26-50 per cent less than normal or severe if the deficiency is greater than 50 per cent of normal, respectively.

A drought-prone area is defined as one in which the probability for drought in a given year is greater than 20 per cent. A chronic drought-prone area is one in which probability of drought in any year is greater that 40 per cent. A drought year occurs when less than 75 per cent of the normal rainfall is received.

The National Institute of Hydrology, India (1989) analysing the 1986-87 drought proposed indices describing rainfall deficits, low flows in streams and declines in groundwater levels. In terms of runoff volumes, the following criteria were used to classify drought conditions:

Per cent departure in runoff volume	*Drought Class*
50 per cent or above	Severe
25-50 per cent	Moderate
<25 per cent	Normal

In Thailand, the Generalized Monsoon Index (GMI), developed by Achutuni and others (1982) is used to indicate the impact of rainfall conditions on crops. In the Philippines, the Philippines Atmospheric, Geographical and Astronomical Service Administration (PAGASA) monitors rainfall in the country and issues warnings on drought when, within three successive months, less than 40 per cent of normal rainfall is recorded.

4. Drought Hazards in the Region

In several member countries of ESCAP, drought continues to be a natural hazard. Its effect is mainly on agricultural production and on the population dependent on agriculture. The effects of drought as reported by the countries in the region are presented in table 4. Following this, detailed available information in respect of some countries is given.

(a) Australia

Australia is subject to a range of natural hazards including droughts. It has been reported that in recent years huge expanses of agricultural land have been flooded (an area larger than Thailand was covered in April 1990), bush fires have burned extensive agricultural and timber resources, and droughts have affected most of the eastern states at different times.

Gibbs (1981) broadly discusses drought and its effects in Australia. The 1967 drought in south-east Australia had resulted in a 36 per cent reduction in the wheat harvest, 60 per cent reduction in oats, 30 per cent reduction in barley and 15 per cent reduction in rice. The drought caused a reduction in sheep population of 5 million head and reduced wool production by 10 per cent. It was estimated that farm income was reduced by $A 500 million or 40 per cent. Moreover, as Gibbs pointed out, the drought impact was felt beyond the farm. The small businessmen from whom the farmer bought commodities were affected by the farmer's reduced purchasing power as were larger business enterprises such as manufacturers of farm machinery. The social impact can also be considerable. Particularly for the farmer with limited resources, farming is a risky enterprise and the impact of drought disasters can cause social disruption to families for more than a generation. Droughts were also reported in 1971-72 and 1977-78.

In the case of a major drought disaster, national disaster relief arrangements exist, run by the State and Commonwealth government. Each State meets its own costs up to a predetermined base—after which the Commonwealth contributes $A 3 for every $A 1 of State expenditure. Benefits include loans for feedings/restocking and subsidies for transport of livestock. A drought-bond scheme exists whereby a landholder can put aside untaxed profits, receive a reasonable interest rate on them, and withdraw them when needed in times of drought. Some landholders maintain reserves of grain or fodder for drought feedings. However, this practice is only marginally economic. Drought insurance schemes have been discussed, but not implemented. Stock in drought-affected areas may be sold, retained and hand fed, or moved to areas not affected by drought (ESCAP-UNEP, 1983).

Wilhite (1986) makes a comparative analysis of the drought policy in the United States and Australia and makes several recommendations. He observes that government actions in Australia have usually taken the form of loans and grants to individual citizens, businesses and municipalities experiencing the hardship of drought. It was also observed that most of the actions have occurred in an environment of crisis management, rather than as a result of clearly stated policy objectives. He suggests a national drought plan as an efficient mechanism through which different recommendations could be implemented. Australia also has a programme for supporting disaster mitigation in developing countries through bilateral development aid programmes (ADB, 1990).

(b) China

China is a country of vast land and water resources and climatic variations. The country has identified four regions of drought: (i) the middle and downstream basins of Songhuajiang and Liaohe in the north-east of China; (ii) the alluvial plain of Huanghe-Huaihe-Haihe river basins in the north of China (iii) the north-eastern district of Sichuan province; and (iv) the Yunnan-Guizhou plateau and Zhanjiang district in Guangdong province in southern China. In the former three regions there are about 90 drought days in a

Table 4. Estimates of damages due to droughts reported by some Asian and Pacific countries (1982-1989)

Country	*year*	*Material damage to farm lands (ha)*	*Total estimated or actual damage cost*
Australia	1982-1989	Not significant	-
China	1982-1983	-	-
	1984	6.9 million	
	1985	8.65 million	
	1986	-	
	1987	13 million	
	1988-1989	-	
Fiji	1987	As indicated in the following note.	-
India	1982	Not available	Rs 8.3 million
	1983	3.68 million	Not available
	1984	24 000	Rs 15.93 million
	1985	52 080	Rs 10.32 million
	1986	Not available	Rs 10.71 million
	1987	4.59 million	Rs 73.80 million
	1988	Not available	Rs 1.63 million
	1989	Not available	-
Indonesia	1982-1985	-	-
	1986	7 865	-
	1987	24.52	-
	1988	435	-
	1989	-	-
Japan	1982-1983	-	-
	1984	-	¥ 28 920 million
	1985	-	¥ 13 163 million
	1986	-	¥ 8 777 million
	1987	-	¥ 486 million
	1988	-	¥ 268 million
	1989	-	-
Myanmar	1986	701 074.85	-
New Zealand	1982	-	-
	1983	-	$ NZ 40 million
	1984	-	-
	1985	29 000	$ NZ 32 million
	1986-1987	-	-
	1988	-	$ NZ 400.00 million
	1989	All farm lands in affected areas	$ NZ 377.42 million
Republic of Korea	1982-1984	-	-
	1985	200	Won 361 million
	1986-1989	-	-

(Compiled from Economic and Social Commission for Asia and the Pacific (ESCAP), *Water Resources Journal*, June issues).

year on average, and the last region has about 40 drought days.

The eastern regions of China are well known for their productive areas of grains, cotton and vegetable oils. However, in those regions, due to the impact of the monsoon climate, agricultural production is often affected by drought and/or excessive rain disasters. The annual precipitation is not uniformly distributed, either over the area or throughout the year, and its yearly variation has a large amplitude. By statistic estimations from historical writings and literature concerning drought situations which occurred in the provinces of Hebei, Shandong, Henan, Shanxi, and Shenxi during the period since the sixteenth century up to the present, in nearly 400 years the number of drought years was more than one-half of the total. During the past 30 years, in spite of large-scale water conservation works carried on, the droughts still threaten agricultural production in those regions. For instance during the periods 1959-1961, 1971-1972 and 1978-1980, successive droughts caused a severe setback in agriculture production.

Moreover, in 1980 north China suffered from a very severe drought. The drought was characterized by its persistence in duration and extension over a large area. The total monthly rainfall observed in July 1980 at Beijing was reported to be only 31 mm. Many regions of China are affected by successive droughts, causing severe impacts on agricultural production. Tables 5 and 6 (from Chen Jiaqi and Shen Zhenrong, 1980) give information relating to regions of successive drought periods.

In terms of development of water resources, China has made significant progress. It has been reported that : farmland irrigation areas have been enlarged; industrial and urban water supply systems have been developed; navigation waterways have been improved; and the protection of natural environment has been emphasized. By the end of 1985, more than 80 000 reservoirs, large, medium and small, had been built with a total storage capacity of 430 billion cubic metres; the mechanical and electrical power for irrigation and drainage reached 80 million horsepower. Over 5 000 irrigation areas, which make up half of the total cultivated land, supply two-thirds of the food grain for the whole country. Three-quarters of lowlying land, two-thirds of salinized land in the north and one half of lowyielding land in the south have been improved. In 1985, the total water supply for industry and agriculture topped 480 billion m^3 (United Nations, 1987). All these measures helped in drought alleviation.

(c) Fiji

Fiji consists of a group of 332 islands spread over a vast area of the South Pacific. The agricultural sector plays an important role in the economy, contributing about 20 per cent of GDP, 50 per cent of total employment and nearly 75 per cent of total export earnings (ADB, 1989).

Fiji, particularly the Western and Northern divisions and the outer islands, was severely affected by drought during 1987. A survey was made to assess the availability of food; assess the effect of drought on the nutritional status of the people; and to ascertain the necessary rehabilitation programmes to improve the situation (*Water Resources Journal*, June 1988).

The drought of nearly a year in 1987 had drastically affected the overall situation of the Western division, though the intensity of the drought varied from place to place. In many areas, most of the green vegetables and root crops had been destroyed by the drought. Reserves of crops that were left were running low, pushing the people to rely more on rice, flour and tinned foods. In some villages and settlements which were located in the interior hills, people were totally dependent on shops to purchase food items because the land was so dry that nothing could be grown. Even fruit trees of some fruit varieties, which bore much fruit in normal times, were drying out or bearing vary little.

In the cane farming belt, cane production in 1987 had been very much affected by the drought. Most of the people claimed that their cane harvest had been reduced by half because the cane could not mature and dried up. That affected not only the cane farmers but the cane cutters (labourers) as well. Under normal circumstances, cane farmers in low-lying areas grow enough rice for themselves. But with prolonged drought, they had to consume the seed they kept for planting. Similarly with legumes, the farmers were consuming the stock they kept for planting.

With regard to livestock (chickens, goats, cows and pigs), more animals were dying as there was no pasture or feed for them. In most of the households the number of chickens and goats had decreased greatly and in some cases were completely depleted. They were sold to keep the family going. In addition, raising chickens had become expensive because the price of the chicken feed had increased three-fold.

The health status of the people on the western side had deteriorated. The key reason was that they were not receiving the regular diet they had been accustomed to before the drought. There was an increase in the number of cases of diarrhoea, common cold and cough cases reported. People were obtaining water from sources other than the usual ones. The villagers stated that the water they currently obtained from the community piped system tasted differently and most of the children looked dull, weak and sickly, and sometimes had diarrhoea. The health centre reported that there was an increase in anaemia in pregnant mothers due to lack of green vegetables.

Table 5. Successive drought periods in some regions of China

Region	*Occurrence of successive drought year periods (per cent)*		*Frequency occurrence of single drought years (per cent)*
	Drought lasted 2-3 years	*Drought lasted 4 or more years*	
1. The drought regions			
Songhua-Liao river	4	4	17
Hang-Huai-Hai rivers	15	3	7
North-east region of Sichuan province	13	2	10
Yun-Gui-Zhanjiang	9	3	13
2. The region of Huang-Hai-Huai river			
The upper and middle stream region of Huai river	10	6	9
The middle stream region of Huai river	11	4	10
The middle stream region of Huang river	9	8	8
The south river system region of Hai river	12	6	7
The north river system region of Hai river	16	5	4

Table 6. Duration of successive drought periods in some regions of China

Region	*Successive drought period (years)*		*Average return periods (years)*
	Longest	*Average*	
The drought region of Songhua-Liao river	8	4.9	31
The drought region of Huang-Huai-Hai rivers	11	6.3	27
The drought region of the north-east region of Sichuan province	7	5.4	31
The drought region of Yun-Gui-Zhanjiang	10	4.9	31
The upper and middle stream region of Huai river	11	5.8	27
The middle and downstream region of Huai river	12	6.1	27
The middle stream region of Huang river	24	7.2	35.5

Most of the areas surveyed did not have water readily available and depended on emergency water supplies. They received about two to three drums of water for two weeks, insufficient for all household needs. Some people had dug wells in the dry river beds to wash clothes and some travelled to distant places for water. Some did not receive emergency water owing to the remoteness of their dwellings and therefore borrowed water from others. Overall, the drought created extreme problems to the population and huge economic loss.

(d) India

Drought has been a recurring feature of Indian agriculture. While practically all the areas have suffered crop losses and distress on account of drought at some time or other, some clearly identifiable areas have been subjected to frequent droughts. The subsistence economy in those areas is unable to withstand particularly severe drought, and the distress assumes the characteristics of a scarcity before long. Nearly 19 per cent of the total land of the country is frequently affected by lack of rains. In other words, it is estimated that about 33 per cent of the cultivable area of the country is drought-prone. The Deccan Plateau alone constitutes 50 per cent of the drought-prone area. About 12 per cent of the total population live in the drought-prone areas. The number of small and marginal farmers and agricultural labourers in the drought-prone areas is estimated to be 7 million households, constituting the poorest segments of the rural population.

(i) Major droughts since 1875 A.D.

During the past 120 years recorded information suggests occurrence of seven severe droughts in seven years which affected large parts of the country (see table 7).

Table 7. Major drought occurrences in India

Year of drought	*Country's area affected, per cent*	*Departure of monsoon rainfall from normal, per cent*	
		Over India	*Over drought region*
1877	64	-32	-
1899	65	-28	-
1918	71	-26	-49
1965	41	-17	-36
1972	47	-25	-35
1979	45	-21	-38
1987	50	-18	-45

The following inferences (for the period 1875 to 1987) are apparent:

- Concerning the area affected, the 1987 drought was the fourth in severity following those of 1918, 1899 and 1877. It was the second worst of this century.

- As for intensity of drought, that of 1987 ranks second in this century. The same year severe floods were also experienced in Bihar and parts of West Bengal. Though this is another form of calamity, in the particular situation it compensated for some of the deficiency in rainfall of the whole country.

- In 1987, most of the affected areas (except Orissa and Karnataka) were normally drought-prone, whereas in 1972, drought occurred over the Bihar Plains, Sub-Himalayan West Bengal and those parts of Maharashatra, which are not used to such conditions.

- Based on these criteria, in terms of severity, the ranking of droughts in the twentieth century so far is : 1918 ranks first, 1972 and 1987 may be bracketed to take second place.

(ii) Frequency of Occurrence

Jaiswal and Kolte (1981) quoted in Pasrija (1990) have worked out periodicity of drought in different meteorological sub-divisions, and the results are summarized in table 8.

Table 8. Periodicity of droughts in India

Meteorological Sub-Division	*Recurrence of the period of deficient rainfall (75% of the normal or less)*
Assam	Very rare, once in 15 years
West Madhya Pradesh	Once in 5 years
Konkan	Once in 5 years
Coastal Andhra Pradesh	Once in 5 years
Maharashtra	Once in 5 years
Kerala	Once in 5 years
Bihar	Once in 5 years
Orissa	Once in 5 years
South Interior Mysore	Once in 4 years
Eastern Uttar Pradesh	Once in 4 years
Vidarbha	Once in 4 years
Gujarat	Once in 4 years
Eastern Rajasthan	Once in 4 years
Western Uttar Pradesh	Once in 4 years
Tamil Nadu	Once in 3 years
Jammu and Kashmir	Once in 3 years
Rayalaseema	Once in 2.5 years
Telangana	Once in 2.5 years
Western Rajasthan	Once in 2.5 years

(iii) Forecasting and warning

The India Meteorological Department (IMD) has a network of weather stations and offices spread out all over the country to meet the requirements of weather forecasts and reports.

(iv) Mitigation measures for drought

The Government has taken a number of long-term measures for reducing the impact of droughts, as indicated below.

(a) Irrigation: Increasing the area under irrigation. Compared to gross irrigated area of only 22.6 million ha in the country in 1950-1951, the amount has currently reached 62.8 million ha.

(b) Drought-Prone Area Programme (DPAP): The core components of this programme are soil and water conservation, water resources development, afforestation and pasture development.

(c) Desert Development Programme (DDP): The objectives of the programme include controlling the process of desertification, mitigating the effect of drought in desert areas, restoration of ecological balance in affected areas and raising the productivity of land, water, livestock and human resources in those areas. The objectives are sought to the achieved through activities such as afforestation, with special emphasis on sand-dune stabilization, shelter belt plantations, grass-land development, soil and moisture conservation and water resources development.

(d) National Watershed Development Programme for Rainfed Agriculture (NWDPRA): the NWDPRA programme addresses the unirrigated arable land in the country. The main components of the scheme are: land and moisture management practices for introduction of improved cropping systems; dryland horticulture; supply of seedlings and grass seeds; conducting adaptive trials; supply of improved tools and equipment; and preparation of scientific field manuals.

(e) Comprehensive Crop Insurance Scheme (CCIS): A comprehensive crop insurance scheme was introduced in 1985. The objectives of the scheme are to: (i) provide a measures of financial support to the farmers in the event of crop failure as a result of drought, flood etc.; (ii) restore the credit eligibility of farmers; and (iii) support and stimulate production of cereals, pulses and oil seeds.

(v) Disaster preparedness measures

The following measures were reported to have been taken:

(a) Establishment of a food distribution network;

(b) Employment generation;

(c) Extension of social security schemes to drought areas;

(d) Establishment of health care network;

(e) Establishment of dairy co-operatives and veterinary care centres;

(f) Drinking water facilities; and

(g) Provision of credit.

(vi) Administrative Arrangements

The basic responsibility for undertaking the relief and rescue operations is vested in the State Government concerned. However, the Government of India is intimately involved at every stage in providing financial, technical and material support. In the Union Government, the Department of Agriculture and Co-operation is the nodal Department. The Central Relief Commissioner maintains a close liaison in the concerned Central Departments/ agencies as well as the State Gevernments' representatives in co-ordinating the relief measures.

(a) A standing Cabinet Committee on Natural Calamities (CCNC) under the chairmanship of the Prime Minister exists, which gives direction to undertake short-term and long-term measures to mitigate the impact of natural disasters.

(b) At the national level, the National Level Crisis Management Committee (CMC) under the chairmanship of the Cabinet Secretary implements the policy directives of the CCNC.

(c) The Crisis Management Group (CMG) under the chairmanship of Central Relief Commissioner and Additional Secretary in the Ministry of Agriculture meets regularly in the wake of natural calamities to review the situation and take necessary action to assist the affected States in carrying out the relief operations promptly. CMG consists of representatives from all concerned Central Ministries besides the Resident Commissions of the affected states.

(vii) 1987 Drought

The country faced unprecedented drought in 1987 when the summer monsoon failed in most of the States. As a result the rainfall was considerably below the normal. The estimated rainfall deficiencies are given in table 9.

Table 9. Rainfall deficiencies in India during the 1987 drought (From Sinha, 1989)

Region	*Estimated rainfall deficiency*
North Karnataka	2 per cent
Eastern Madhya Pradesh	23 per cent
Kerala	31 per cent
Gujarat	42 per cent
Eastern Rajastan	50 per cent
Western U.P., Himachal Pradesh	51 per cent
Punjab	58 per cent
Haryana, Chandigarh, Delhi, Western Rajasthan	67 per cent
Saurashtra, Kutch	74 per cent

Such extensive and intense rainfall deficiencies resulted in drought conditions in the rural areas, which suffered from depleted irrigation and drinking water supplies. To overcome the crises, emphasis was laid on accelerated exploitation of ground water resources, as outlined below (From Sinha, 1989).

(a) Accelerated Rural Water Supply Programme and Minimum Needs Programme

(b) Drought Assistance for purchase of Rigs and Installation of Wells

(c) Long-term Measures for Augmentation of Ground Water Recharge

The 1987 drought focused not only on the need for providing people with access to food, but also for maintaining their quality of life. The central theme of relief today is to meet the food and nutritional needs of all sections of society in their own communities, keeping in view their normal energy requirements, supply of drinking water, providing adequate health care and fodder for the cattle. This objective emphasizes "living with droughts", and aims to reduce the necessity for migration to other areas.

(e) Philippines

The Philippines also has its share of droughts. Three major drought events were experienced in the Philippines during the past decade: in 1982-1983, 1986-1987 and most recently in 1989-1990. Descriptions of the rainfall variation in the Philippines will be presented separately for each drought event. It is stated that all these droughts are related to what is referred to as the El Niño phenomenon (Jose, 1990).

El Niño can be considered as an oceanographic/meteorological phenomenon that develops in the Pacific, mostly off Peru and is associated with extreme climatic variability characterized by devastating rains, winds, drought and other events that wreck havoc on the economy and society in the global and local scale. During a severe El Niño, sea surface temperatures are measurably higher than normal over a large expense of the equatorial Pacific which can prevail for more than a year. Theories supported by recent observations indicated that the El Niño in the central and eastern equatorial Pacific is linked to the drought occurrences in the western equatorial Pacific regions such as Indonesia, portions of Australia and the Philippines.

The 1982-1983 drought event in the Philippines was considered as the most severe in the last two decades. Below normal rainfall was observed even at the early part of 1982 in Visayas and Mindanao. This condition become more pronounced and extended over central southern Luzon during the second semester rain period. The most severely affected areas received less than 10 per cent of normal rainfall found in western Central Luzon and Southern Tagalog provinces, over northern portion of Visayas, Bohol Island and western Mindanao. Based on 40 years data (1951-1990), total rainfall for October 1982 to March 1983 over central and eastern Visayas and northeastern Mindanao was the driest for that season. In April to September 1983, there was also a failure in the performance of the rains associated with the southwest monsoon season. This had caused drought conditions in the areas which were mainly spared from the rainfall deficiencies during the preceding season.

Seasonal rainfall amounts of less than 80 per cent of normal values were experienced in western Luzon, the Bicol region, Samar, southern Visayas, western Mindanao and Davao provinces. Most severely affected areas were the Bicol region, southern Negros and Cebu Islands and western Mindanao.

Assessment of the rainfall situation during the last quarter of 1989 indicated that a large portion of the Philippines had rainfall which was below the normal. In October, when the north-east monsoon season normally starts, below average rainfall conditions were already noted over the Bicol region, western Visayas and southern Mindanao. However, the remaining greater part of the country was still near normal to above normal. It was during the succeeding month of November that a larger portion of the Philippines, particularly the western sections including northern Luzon, experienced below normal rainfall conditions. In December, the rainfall situation further deteriorated. A large portion of Luzon, Visayas and southwestern Mindanao experienced rainfall amounts which were less than 40 per cent of the average values.

Major economic losses due to drought in many parts were experienced in the agricultural sector, particularly losses to coconut and sugarcane production. It was reported by the Department of Agriculture that rice growing areas affected by drought were 181 560 hectares, of which 72 320 hectares (40 per cent) were damaged. Estimated production losses were 313 490 metric tons valued at 216.95 million pesos. For the corn crop, the area affected was estimated at 102 000 hectares, of which 58 760 hectares (57 per cent) were damaged. The estimated production loss was 185 190 metric tons valued at 235.05 million pesos. For water supply, it was reported that a 10 per cent cut-back in water production was maintained by the Metropolitan Water and Sewerage System. Hydroelectric Power generation was also affected.

(f) Sri Lanka

Floods, cyclones, droughts and landslides are some common natural disasters that affect Sir Lanka. The country has experienced droughts of varying durations and impacts. It has been observed that droughts occur almost every year in 13 administrative districts in the northern and eastern parts of the country. Sri Lanka being an agricultural country, crop failure affects the national paddy production as well as the livelihood of the people. It has also been reported that droughts caused scarcity of drinking water and consequent incidence of diseases.

The number of families affected by drought in the past has been indicated as follows.

Year	*No. of families*
1970	201 000
1977	64 000
1978	26 417
1979	75 000
1980	100 000
1981	205 000

The major drought protection scheme which the Government has envisaged is the diversion of the largest river in the country, the Mahaweli Ganga, to the dry zone to irrigate six drought-prone districts.

Tennakoon (1986) presented a detailed analysis of the drought hazard and rural development issues in Sri Lanka. He lists numerous adjustments to drought attempted by the farmers. This may be considered in four categories which need not necessarily be mutually exclusive. First, are adjustments which affect the basic causes of hazards. These include appeasing of supernatural powers by chanting religious scriptures and praying in small groups as well as individually, to wish away the natural hazards (including drought) conceptualized as agents of supernatural powers. The second category of adjustments to drought are those which modify the hazard effects, such as irrigation, water management, shifting cultivation as a form of crop insurance, and supplementing of income from irrigated farming. Third is a set of adjustments which modify the loss potential of man and his work: timely planting and sowing of a mixture of crops, some drought-resistant and others more moisture-tolerant; moisture conservation with minimum tillage; cultivation of crops of short growing periods; and the practice of cultivating part of the fields. Finally, adjustments in the form of sharing and suffering losses include the use of food rations, relief aid, borrowing, reduced consumption expenditure, casual earnings as daily paid workers, mortgage and sale of belongings, collection of bush food etc. In addition he outlines the role of the different governmental agencies in mitigating drought hazards.

(g) Vanuatu

Vanuatu suffers periodic droughts, and their effects can be expected to increase as the population grows and development puts greater pressure on existing water resources. Major droughts were experienced in 1957-1958, 1977-1978 and 1982-1983. The effects of a drought in 1986-1987 were masked by the impact of Cyclone Uma.

(h) Samoa

Samoa also has periodic droughts. The western part of Upolu Island and Savaii Island are the most vulnerable. In 1983, the worst drought on record affected Apia and north-western Samoa in general. There were widespread water shortages in the higher elevations of Apia and the west coast supply areas. Crops were damaged in 1988 because of drought.

(i) Thailand, Pakistan and Indonesia

Apart from the countries mentioned above, drought situations of varying degrees occur in several of the remaining countries in the ESCAP region. For example in Thailand, it is estimated that out of the total 17.0 million ha of arable land, 81.6 per cent or 13.8 million ha is rainfed. The north-eastern region of the country is most important to rainfed agriculture as it contains one third of total land area and one third of the population of the country. Frequent drought conditions are reported form this region. Short term droughts, mainly affecting agricultural production, are reported from other parts of the country from time to time. Pakistan has about 4.7 million ha of area under rainfed agriculture subjected to drought conditions (ADB, 1989). It has been reported that Punjab and Sind provinces in the country have experienced drought conditions affecting 31 500 sq km in Punjab and 27 800 sq km in Sind.

Government provided relief measures such as cash grants, exemption from land revenues and food supplies. In Indonesia, though severe drought has not been reported, food crop failures due to uncertain weather conditions have been reported from the Nusa Tenggara Timur region (ESCAP, 1983).

C. Forecasting droughts

1. General

Attempts to forecast droughts much in advance of their occurrence do not appear to be fully successful but need to be continued. A UNESCO-WMO publication (1985) outlines eight forecasting methods. These are based upon a combination of statistical, physical and synoptic methods and are listed as (i) analogue methods; (ii) linear regression methods; (iii) teleconnections; (iv) statistical and kinematic methods; (v) contingency tables; (vi) use of air-sea interactions; (vii) statistical time series forecasts; and (viii) extrapolation in time using cyclicities. The efficacy of these methods in advance forecasting is not fully established. However, it appears that methods which predict the occurrence of the drought at a very early stage and forecast its effect on crop production seem to be fairly successful.

2. Organizational setups in the region

From the report of the seminar on "Agro-Climatic Models for the Assessment of Drought-related Food Shortages in South and South-East Asia" (Bangkok, January 1984), the following information was furnished by some countries of the region.

In Bangladesh, since 1980 the Food Planning and Monitoring Unit (FPMU) has attempted to develop crop assessment models based on weather parameters. In India, drought is monitored every week by an Aridity Index distribution. Its intensity and spread are examined and a qualitative assessment of drought impact on yield is made. In Indonesia, an assessment of impact of climate on agriculture is produced by the Climate Impact Assessment Service. Several types of indices and maps are used. They include the Generalized Moisture Index (GMI), the Yield Moisture Index (YMI) and YMI for specific crops such as maize, soybean and groundnuts. Malaysia monitors paddy and estimates areas affected by droughts/shortage of irrigation water through its Drainage and Irrigation Department. The Nepal Meteorological Service (NMS) and the Agriculture Statistics Division (ASD) have started a joint programme to monitor the crop situation in Nepal. In Pakistan the yields of crops are determined by the Agriculture Department using both subjective and objective methods. The Philippines Atmospheric, Geophysical and Astronomical Service Administration (PAGASA) and the Bureau of Agriculture Economics (BAEcon) jointly came up with a model for monthly agro-climatic crop assessment and quarterly yield and area assessments based on forecasting models. The forecasting models make use of traditional regression techniques. In Sri Lanka, the Department of Meteorology has the capacity to utilize weather satellite information for assessing the impact of predictable drought trends on domestic food production. In Thailand the yield of paddy is estimated by a yield forecasting model which is a function of the amount of rainfall. The Office of Agricultural Economics (OAE) and the Department of Agricultural Extension (DAE) are involved.

An Early Drought Warning System identifies drought, problems, determines the areal extent and magnitude of potential drought impacts and provides an early warning alert. This enables the disaster manager to develop strategies and take actions to mitigate potential impacts such as food shortage which lead to malnutrition, starvation, population migration and other socio-economic disruptions. A National Early Warning System can reliably do the following:

(a) Continuously monitor, assess and report weather impacts on the agricultural sector, identifying potential weather-related problems.

(b) Assess significant crop production losses due to drought approximately 30-60 days before crop harvesting begins; this represents a 3-6 month early warning/prediction of severe economic losses and/or potential food shortage conditions.

(c) Provide indications at harvest of potential "bumper" crops due to favourable growing season weather; this helps determine import/export requirements.

(d) Track and report weather impacts in areas where on-going disaster relief operations are in effect.

3. UN/ESCAP Project on Agro-Climatic Assessment

The UN/ESCAP provided logistical support to an Agro-Climatic Assessment Project developed to provide reliable early warning for disaster relief, preparedness, and food security in South and Southeast Asia. The programme was conducted through the joint efforts of the National Oceanic and Atmospheric Administration (NOAA) and the Cooperation Institute of Applied Meteorology (CIAM), sponsored by the Agency for International development, Office of U.S. Foreign Disaster Assistance (AID/OFDA).

This Agro-Climatic Assessment Project, began with Phase I in 1984, has the long-term objective of establishing a crop monitoring tool to be used on a real-time basis by food security decision makers in each country. Technol-

ogy transfer during Phase I focused on the utilization of cumulative rainfall indices and statistical climate crop yield models to : monitor drought; assess the impact on crop production; and produce and disseminate an operational Crop Assessment Early Warning Bulletin within each participating country. The agencies in the programme generaly included the national Meteorological Department, the Ministry of Agriculture, and the agency responsible for national food security. Bangladesh, India, Indonesia, Malaysia, Nepal, Pakistan, the Philippines, Sri Lanka, and Thailand participated. Many of these countries established Drought Early Warning Units within their government framework which still continue to produce and disseminate Crop Assessment Bulletins. Users report that this rainfall analysis technology proved especially effective during the severe drought of 1987.

The Phase II project utilized NOAA polar orbiting satellite imagery and vegetative index analysis to enhance the Phase I analysis. Although relatively coarse in resolution, the data enable a continuous real-time analysis of the phenology of vegetation, provided that clouds can be removed by selection of the cloud free areas of a sequence of superimposed images. This low cost technology, developed and refined by the Climate Applications Branch (CAB) of NOAA and the Cooperative Institute for Applied Meteorology (CIAM) for use on personal computers, was tested extensively in the Sahelian countries of Africa. The data can be received twice daily by any country with the appropriate antennae and data reception and analysis system. Two Phase II activities have been completed. A National Workshop Mission was conducted in each country at the outset to: introduce the new technology; liaise directly with each participating agency; help clarify the inter-agency relationship; facilitate the selection of trainees; and assess computer software and hardware needs. A Regional Training Workshop for 16 trainees from four countries (Indonesia, Malaysia, the Philippines, and Thailand) was held at the Asian Institute of Technology (AIT) in Bangkok for four weeks in June and July 1989. A follow-up in-country technical training mission is currently being conducted to assure that the technology is in place and operational. Continuation of this project under Phase III is under consideration (Johnson and others, 1989).

D. Planning for mitigation of droughts

1. General

Preparation for mitigating the effects of droughts could be broadly considered under two groups, viz., (i) steps to be taken in anticipation of droughts, i.e. when droughts are not actually in progress, and (ii) steps to be taken when a drought has actually occurred. By virtue of the nature of droughts, planning and implementation of drought mitigation has to be at the initiative of national agencies. Participation of non-government organizations for some specific activities could be considered. A range of administrative and technical measures are needed in dealing with droughts either before they occur or when they are in progress. The approach adopted could change according to whether or not the drought actually occurs.

2. Measures for mitigation of drought hazards

The various aspects of the programmes related to the drought prone areas could be broadly outlined under: (i) meteorological aspects; (ii) agricultural aspects; (iii) animal husbandry; (iv) forestry aspects; (v) water resources development and management; and (iv) institutional arrangements.

(a) Meteorological aspects

The meteorological aspects consist of collection and analysis of meteorological data including long term analysis of rainfall for drought forecasting. Meteorological aspects also include developing a suitable data base for decision making on issues related to drought and also delineation of drought-prone areas. In some situations meteorological aspects could also include crop climate monitoring using satellite data and other related activities.

(b) Agricultural aspects

Agricultural aspects relating to drought include both research support as well as field implementation. In the ESCAP region as the countries affected by drought have large populations dependent on agriculture, the role of the agricultural department becomes very significant. Research aspects to be taken up through the research organizations include development of drought-resistant crop varieties, developing cropping systems suitable to the drought-prone areas etc.

Land and water management practices are vital for any drought-prone area. These practices include measures like bunding and terracing, construction of small ponds for runoff storage and recycling etc. Practices for efficient utilization of the rainfall are important. Appropriate measures for a region are to be developed and field implementation is generally through the soil conservation/land department.

Storage of food supplies and warehousing in some countries are handled by the agricultural department.

(c) Animal husbandry

In drought-prone areas livestock management is very critical. Initial selection and introduction of animal spe-

cies adaptable to drought are important. During drought, provision of fodder and drinking water to the cattle is vital. In any plan for drought management, the needs of the livestock should be considered.

(d) Forestry aspects

Forestry aspects in the drought-prone areas should be included in the national forest policy. Forestry aspects include planting of fuel and fodder trees, protection of catchments etc.

(e) Water resources development and management

Water is the key factor in any drought management programme both before and during the drought. Development of surface water resources and establishment of large irrigation systems definitely help the drought-prone areas.

Major irrigation systems such as the Indus system in Pakistan, the Ganges in India, Mahaweli in Sri Lanka etc. have been designed to convey water over long distances to traditionally drought-prone areas. They withstood the test of time with respect to drought alleviation. Establishment of such systems in future will need investigations as well as financial resources. Environmental considerations also need be taken into account.

For drought-prone areas provision of irrigation facilities from a surface water source even if it involves inter-basin water transfer needs to be seriously investigated. In very serve drought situations, the irrigation systems also could be badly affected. However, operation of the irrigation system over a long period of time helps in improving the groundwater resources of the region and improves the vegetative growth all around, thus withstanding the drought situation.

Ground water resources are undoubtedly critical during drought periods. In drought-prone areas, groundwater resources need to be developed and conserved. Only scattered attention appears to have been given to this aspect. Groundwater recharge needs to be intensified wherever possible. Recharge methods like percolation tanks, recharge shafts and water spreading need to be understood. Generally land management practices designed for soil and water conservation help in ground water recharge. Irrigation systems could also be used for groundwater recharge. The concept of "Groundwater Sanctuaries" is worth examining. Herein large areas are earmarked for grounwater recharge and conservation. In drought-prone areas it is desirable to conserve the groundwater resources. If this could be achieved in such areas, groundwater resources could be used in time of drought at least for providing some drinking water supplies.

(f) Institutional arrangements

While institutional arrangements are needed for development activities during the non-drought period, their functioning is critical during any drought. During the drought a wide variety of functional approaches have to be envisaged. These could include sale of food at fair prices, effective control of migration, protection of labour rights, providing credit, etc. International co-operation is another aspect which needs to be considered.

A range of suggested activities and institutions are given in table 10. The institutional setups however, vary from country to country in the region. The Departmental activities proposed are purely suggestive, as the framework and responsibilities allocated could differ from country to country.

E. Droughts and desertification

Desertification and its effects are broadly given by the definition of desertification: "the diminution or the destruction of the biological potential of the land, which can lead ultimately to desert-like conditions. It is an aspect of the widespread deterioration of ecosystems, and has diminished the biological potential, i.e. plant and animal production, for multiple purposes at a time when productivity is needed to support growing populations in quest of development" (UN/ESCAP, 1987).

To elaborate the definition, desertification is the result of rapid degradation of the soil due to aridity, overgrazing, overcropping, waterlogging and salinity and large-scale deforestation. In terms of the above, it can be stated that desertification in Asia and the Pacific is extensive in the rainfed crop lands, irrigated lands, rangelands, forests and woodlands.

Measures to combat the physical and biological process of desertification could be grouped under the following titles.

(1) Development and management of water resources;

(2) Rehabilitation of degraded rangelands and improvement in livestock production;

(3) Conservation of soil and water in rainfed crop lands;

(4) Combating waterlogging and salinization in irrigated lands;

(5) Restoration of the vegetation cover; and

(6) Conservation of flora and fauna.

Table 10. Suggested institutional arrangements for mitigation of droughts

Possible Department	*Suggested Activities*
1. Agriculture, Agriculture Research	i) Development of drought resistant crop varieties ii) Cropping systems iii) Land and water management practices iv) Watershed management, runoff storage and recycling v) Evaporation reduction vi) Agricultural inputs
2. Animal Husbandry	i) Selection of animal species ii) Developing suitable livestock production systems iii) Fodder development and management iv) Animal health
3. Forestry	i) Fuel and fodder tree plantations ii) Protection of catchments
4. Food Supply and Storage	i) Food security ii) Storage
5. Groundwater Division	i) Groundwater monitoring and utilization ii) Groundwater recharge
6. Legal	i) Required legislative measures ii) Declaration of drought iii) Legal support to other agencies iv) International co-operation
7. Meteorology	i) Analysis of meteorological data ii) Drought forecasting iii) Demarcation of drought-prone areas iv) Developing information for decision making
8. Public Health and Water Supply	i) Drinking water supply ii) Well drilling iii) Waste water recycling iv) Water use restrictions
9. Social Services, Health and Financial Institutions	i) Crop insurance ii) Health services iii) Credit facilities iv) Prevention of migration
10. Transport	i) Transport of drinking water ii) Transport of fodder
11. Water Resources	i) Irrigation projects ii) Interbasin water transfer iii) Water resources development

ESCAP was instrumental in establishing a Regional Network of Research and Training Centres on Desertification Control in Asia and the Pacific in 1987, with a view to pool and share national research, development and training experiencies among the countries of the region. It can be stated that prolonged drought conditions also contribute to desertification. The technical measures designed to combat desertification do also help in the mitigation of droughts in a region.

F. Conclusions and recommendations

1. Droughts considered as extreme hydrologic events causing severe water shortages, continue to be a natural hazard in many countries around the world. Their occurrence is not as sudden as some other natural hazards, but in some situations their affects can be equally devastating.

2. The ability of a region to withstand the effects of drought will depend upon the socio-economic conditions. The effects of droughts seem to be significant on populations which are largely dependent upon agriculture.

3. The occurrence of droughts does not appear to follow a set frequency in any region, and the forecasting of drought occurrences seems to be difficult. However, procedures using agroclimatic information and remote sensing data from satallites offer scope for detecting the occurrence of the droughts very early, thus enabling some corrective procedures to be initiated.

4. A range of technical and administrative measures, effectively implemented, could counteract the adverse effects of drought to a large extent. The proposed measures need to be considered in two phases, one before the drought has occurred and the second when the drought has occurred and is in progress.

5. Technical measures centre around water, in terms of water resources development and management. Development and management of groundwater resources in drought-prone areas is important. Human requirements as well as the livestock requirement seem to be equally important.

6. In planning for drought mitigation programmes, an important aspect appears to be to prevent migration of people from the drought-affected areas. Minimum supplies of food, fodder and water need to be ensured. The farming community needs to be assured that as the drought

conditions disappear, necessary inputs for the agricultural operations will be available to them.

7. The approach to reduce the unfavourable impact of droughts should form a part of the overall development plans for the region. This should include long term planning for the development of natural and human resources and provision of services.

8. In each country, it is desirable to delineate the drought-prone areas. It is also necessary to set up a monitoring mechanism to serve as an early warning system for the droughts.

9. The subject of drought is of relevance to several technical and professional groups including agriculturists, engineers, climatologists, social scientists, animal scientists, foresters and economists. Information on drought needs to be collected on a continuous basis so that a country is better prepared for future occurrences based upon previous experiences.

10. Institutional arrangements seem to be vital in any drought management programme. Co-ordination and co-operation between the agencies involved appear to be the crucial.

References

Achutuni, V.R., L.T. Steyaert and C.M. Sakamoto, 1982, Agroclimatic Assessment Methods for Drought/Food Storages in South and Southeast Asia-Test and Evaluation, Final Report to USAID/OFDA by NOAA/AISC/CIAD. Models Branch and the Atmospheric Science Department. Columbia, University of Missouri.

Asian Development Bank, 1989. Rainfed Agriculture in Asia and the Pacific. Manila.

Central Ground Water Board, Government of India, 1989. Inter-Regional Symposium on Ground Water Resources Management in Drought-Prone Area. New Delhi.

Chen Jiaqi and Shen Zhenrong, 1980. Analysis of Drought Occurrence and Long-Term Variation of Annual Stream Flow in Eastern Regions of China, (In) Proceedings of the Technical Conference of Climate–Asia and Western Pacific. Geneva, WMO No. 578, World Meteorological Organization.

ESCAP-UNDP, 1983. Problems and Prospects of Desertification Control in the ESCAP Region, Proceedings of the Region Technical Workshop to Consider Implementation of the Plan of Action to Combat Desertification, Jodhpur, India, 20-23 October 1981. Bangkok, Thailand.

Johnson, G.E., V.R. Achutani and J.B. Orsini, 1989. The Use of NOAA/AVHRR Data as a Tool for Operational Agroclimatic Assessment in Asia. Kuala Lumpur, Malaysia, Proceedings of the Tenth Asian Conference on Remote Sensing.

Jose, A.M., 1990. EL Niño Related Drought Events in the Philippines During the Past Decade. Paper presented at the 1990 Philippines Water Congress and Exhibitions held in Baguio Convention Center, Philippines.

National Institute of Hydrology, 1989. Hydrological Aspects of Drought in 1986-1987, Final Report. Roorkee, India.

Pasrija, V.I., 1990. Country Paper on Natural Disasters Management in India. Paper presented at Regional Seminar on Disaster Mitigation. Bangkok, Asian Institute of Technology.

Sinha, B.P.C., 1989. Ground Water in Drought : Review of Indian Scene. (In) Proceedings of Inter Regional Symposium on Ground Water Resources Management in Drought-Prone Areas. New Delhi, Central Ground Water Board.

Solanes, M.R., 1986. Legislative Approaches to Drought Management. *Natural Resources Forum*, United Nations, New York.

Tennakoon, M.U.A., 1986. Drought Hazard and Rural Development. Colombo, Central Bank of Sri Lanka.

UNESCO-WMO, 1985. Hydrological Aspects of Droughts: Studies and Reports in Hydrology, No. 39.

United Nations. ESCAP, 1983-1990. *Water Resources Journal*, June Issues. Bangkok, United Nations.

United Nations., 1987. Water Resources Development in Asia and the Pacific, Some issues and concerns. Water Resources Series No. 62. Bangkok, Economic and Social Commission for Asia and the Pacific.

United Nations. ESCAP, 1987. Desertification in Asia and the Pacific. A Regional Review and Assessment.

Wilhite, D.A. and M.H. Glantz, 1985. Understanding the Drought Phenomenon: The role of definitions. *Water International*, 10:111-120.

Wilhite, D.A., 1986. Drought policy in the U.S. and Australia : A Comparative Analysis, *Water Resources Bulletin*, 22:3:425–437

Yevjevich, V., 1967. An objective Approach to Definitions and Investigations of Continental Hydrologic Droughts, Hydrology Paper No. 23, Colorado State University.

VI. CHARACTERISTICS OF STORM SURGES, WITH FOCUS ON JAPAN

by Tatsuo Konishi[1]

A. Introduction

1. Definition of storm surge

Storm surge is a temporary rise of the sea level at the coast in excess of the predicted astronomical tide level caused by barometric pressure differential and strong winds. Storm surge must be distinguished from waves. Some scientists use the term "positive" surge for the above definition and the term "negative" surge for recession of the sea induced by winds blowing from land to sea (WMO, 1978).

Figure I illustrates the storm surge and astronomical tide components of the tides observed at the Tokyo port during 30 June to 31 July 1991.

Devastating surges are generally associated with intense meteorological disturbances due to tropical cyclones, but some can be caused by extratropical cyclones.

2. Historical records of storm surges

Large storm surges often occur along the coasts facing vast shallow seas. In particular, the coast of the Bay of Bengal, the east coast of the United States, the coast of the Gulf of Mexico, the coast of east Asia and the north-east coast of Australia have suffered severely from storm surges in the past. Characteristics of major storm surges observed up to 1990 in those areas are presented in table 11. The maximum height of the storm surge experienced in the United States was 7.4 m which was observed near Pass Christian, on the coast of the Gulf of Mexico, associated with Hurricane Camile in August, 1969.

East Asia, as well as Bangladesh, has suffered extremely severe damage due to storm surges. In India and Vietnam, large numbers of people have been reported to be killed by storm surges. A typhoon caused storm surge on 2 September 1937 and killed 11 000 people in Hong Kong.

A famous example of storm surge due to extratropical cyclones was experienced in 1953 along the North Sea coast. In the Netherlands, the plans for storm surge reduction works in the south-west part of the country were formulated based on the damage caused by this storm surge.

B. Storm surges in Japan

1. Geographical characteristics of storm surges in Japan

Storm surge occurrences exceeding one metre in height at various ports in Japan are shown in map 1. The map indicates that metropolitan port cities located in bays such as Tokyo, Nagoya and Osaka are highly vulnerable to storm surges, due to the fact that the physical conditions for storm surges exist in those areas. Namely, the bays have vast shallow sea area and long fetch lengths for strong southerly winds to generate storm surges.

2. Historical characteristics of storm surges in Japan

Figure II is a chronological table of significant storm surges including death tolls experienced in Japan from 1945 to 1989. Such surges were observed 35 times during the last 45-year period and two metres were exceeded on eight occasions. This means that return periods of surge exceeded 1 and 2 m in height are roughly 1.3 and 5.6 years, respectively. Among these events storm surges generated by a typhoon in 1959 caused heavy death toll at Ise Bay area. Since 1972, no storm surge exceeding 2.0 m has been recorded.

3. The Ise Bay disaster due to storm surges in Japan

One of the most severe storm surges in the modern history of Japan occurred in 1959 along the coast of Ise Bay associated with the typhoon 5915 at which time a storm surge of 3.5 m was observed at Nagoya and many coastal levees were broken during the passage of the typhoon. Inundated area was about 300 km^2 and more than 5 000 lives were lost. Eighty per cent of the death toll was due to the storm surge. The coast of the Ise Bay had experienced land subsidence before the typhoon hit due to overpumping of groundwater and in many places the ground level was below the mean sea level. Consequently, inundation in some area lasted over one month.

The knowledge gathered on this event was used to prepare inundation hazard maps in some other places. Major paths of storm surge invasion were delineated after post-inspection of Ise Bay as 1) water routes, 2) creeks and rivers, 3) past rivers, 4) low land between levees and 5)

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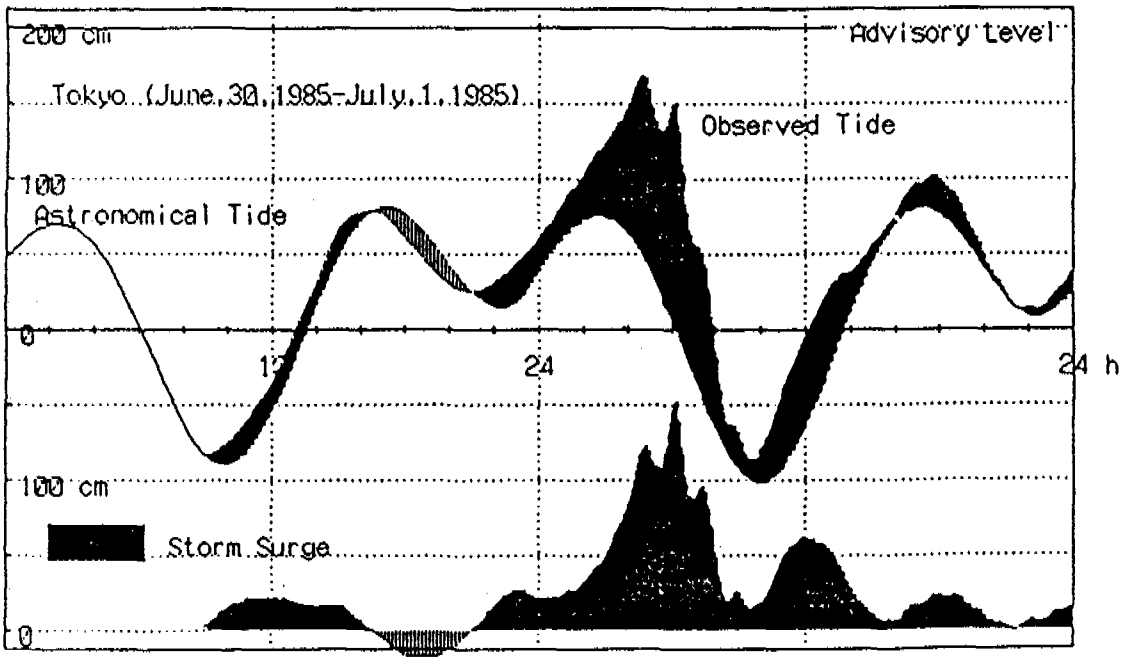


Figure I. Observed tide, astronomical tide and storm surges during typhoon 8506 at Tokyo port (June 30-July 31, 1985)

Table 11. Major Storm Surges due to Tropical Cyclones

Country	*Station*	*Date*	*Strom Surges (m)*	*Estimated Deaths*
USA	Galveston	8 Sept. 1900	>6.5	6 000
Bangladesh	Chittagong	13 Nov. 1970	4.2-7.2	200 000
Japan	Nagoya	26 Sept. 1959	3.5	5 100
Australia	Townsville	23 Dec. 1976	3.0	-
USA	Pass Christian	August 1969	7.4	-

streets. There was much damage to houses located perpendicular to the direction of storm surge invasion. On the other hand, a few houses located parallel to the direction of the storm surge at seaside were damaged.

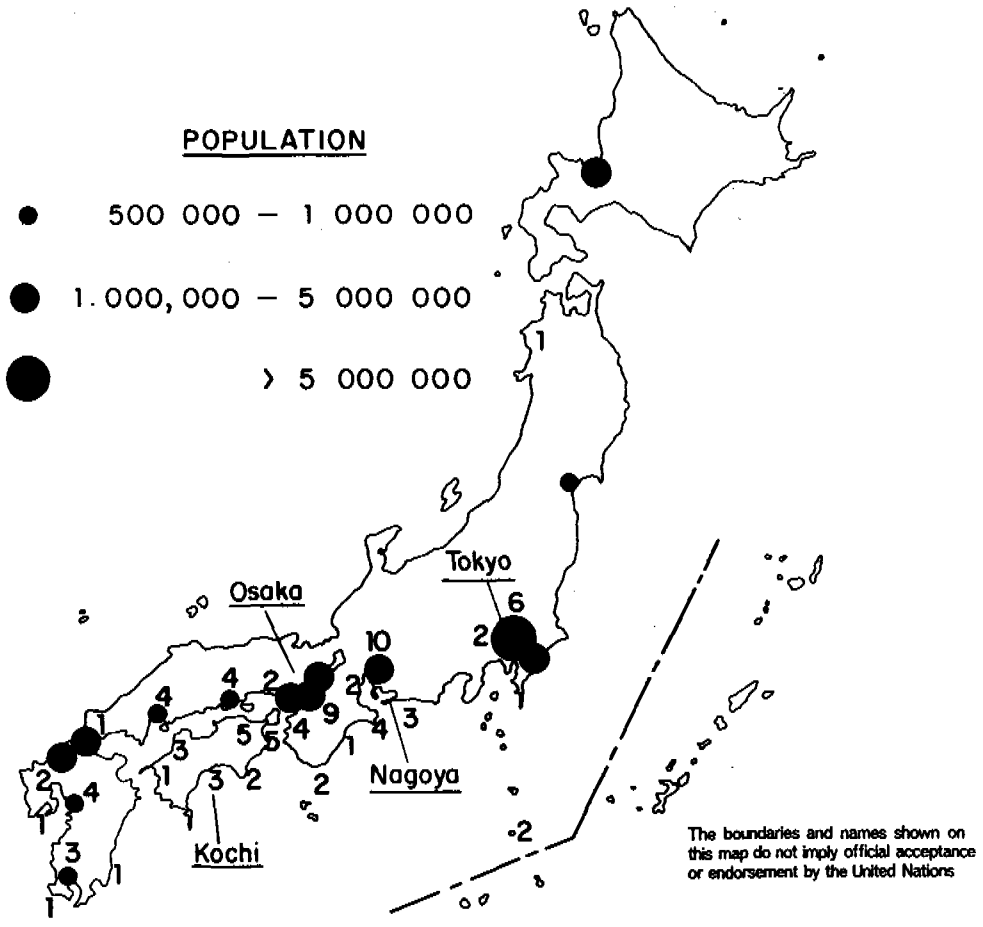
C. Dynamic characteristics of storm surges

Main causes of storm surges are the effects of barometric depression and wind stress caused by winds blowing towards the coast from the sea.

A fall in atmospheric pressure of 1 millibar leads to a rise in the sea level of approximately 1 cm with the condition of stationary storm and without the effect of topography.

Sea level rise due to the effect of wind stress is expressed by the formula, $h=CFW^2/D$, where F, W, D and C are fetch length, wind speed, water depth and a numerical constant, respectively. This equation indicates that high storm surges are expected in a shallow bay, which has a long fetch along wind direction.

In addition, bathymetry of the sea bottom, waves, astronomical tide, river floods and earth's rotation also influence the height of storm surges.



Map 1. Frequencies of storm surges exceeding 1 m along the Japanese coast since 1945. Circles indicate the position of the city whose population is over 500 000.

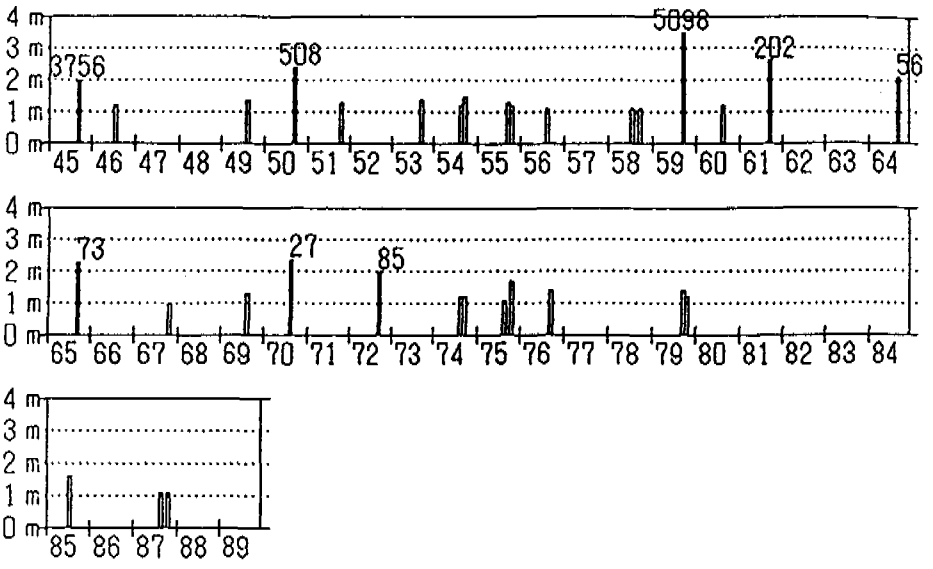


Figure II. Chronology of storm surges exceeding 1 m in Japan since 1945. Numerals attached to the bars indicate the death toll due to the typhoon. They are shown only for the storm surge exceeding 2 m.

D. Forecasting methods for storm surges

1. Empirical or statistical method

In employing an empirical or statistical method, a simple formula is applied to forecast maximum storm surge using the predicted meteorological components, such as maximum pressure drop and maximum wind. In Japan, the following relation is introduced for predicting the maximum surge (h),

$$(1)\quad h = a(1010-P_0) + bW^2 \cos(\theta)+c$$

Where P_0 stands for the lowest pressure of the typhoon, W is the maximum wind speed and θ represents the angle between the wind vector and the direction in which the wind set-up is most effective. Coefficients a, b and c are the numerical constants determined based on many observations. The formula has a physical basis and the estimation of peak surge with this formula is generally accurate for constants derived from a large amount of data on storm surges caused by the typhoons with various tracks.

This method cannot be used to estimate storm surges at a port which does not have historical data on storm surges and it does not predict spatial distribution nor temporal variation of storm surges. Due to these defects, the dynamic method appears to be preferable to the empirical method.

In case of extratropical cyclones, a statistical method, for example, a time series or a regression model, was often used.

2. Dynamic numerical method

This method is based on application of the fluid dynamics equations to describe the motion of sea water under atmospheric pressure and wind. In Japan, after the terrible disaster caused by a typhoon at the Ise Bay, simulations of past storm surge events were extensively conducted for major bays and applicability of the method was well demonstrated.

In the past, the application of the method had been limited to estimation of design tide levels to construct facilities for disaster prevention, such as coastal levees and tide gates. Recently, Japan Meteorological Agency (JMA) has developed the numerical forecast method on a real time basis. The method has six parameters that need to be estimated: initial typhoon position (longitude and latitude of the position), the direction and the speed of typhoon, the minimum pressure and the radius of maximum wind, in addition to information on bathymetry and topography. The results obtained by employing this method with the observations made during typhoon 8506 in Tokyo Bay generally indicated a good agreement. But there still remain some problems to be solved and efforts are continued to improve the method.

E. Special storm surge-related problems in Japan

There are two types of storm surges in Japan, mechanisms of which are not yet clarified.

1. Storm surges at ports facing the open sea

As mentioned previously, main surge is generally caused by the wind stress due to winds blowing towards coasts and the effect is inversely proportional to the depth of the sea outlying the coast. High storm surges are not usually experienced at ports facing deep ocean. In 1970, the typhoon 7010 hit Tosa Bay in Japan and the peak surge of 2.1 m was observed at Kochi Port. A comparison between observed storm surges and calculated ones using the formula employing historical records of the Kochi Port indicated abnormally high storm surges related to typhoon 7010. The survey revealed that the abnormality extended to the whole of Tosa Bay.

Considerable efforts have been made to explain the mechanism, including use of numerical simulation, but in vain up to the present. Similar abnormally high storm surges have been observed in some other ports as well. Recently some investigations showed that the wave set-up effect plays an important role in development of the storm surge at open sea but quantitative conclusions have not yet been reached.

2. Abnormal tides

After the passage of the typhoon, it sometimes so happens that the sea level rises about several tens of cm. in excess of the astronomical tide. If it occurs at the period of spring tide, it causes inundation in the low-lying areas. There have been many such cases that no clear intense meteorological phenomena were accompanied with the high sea level. This situation induces anxiety among people. It is thought qualitatively that the causes of such abnormal tides may be the Ekman transport effect due to the long duration of the wind parallel to the coast and the resultant wave which transmits a surge along the coast.

The phenomenon cannot yet be forecast, and its mechanism has not been explained. On a real time basis, specialists are trying to detect the phenomenon in its early stage in order to inform people of its occurrence as soon as possible.

F. Operational monitoring and forecasting system for storm surges

1. Monitoring system

As mentioned above, there are unforeseeable tidal phenomena, and tides need to be monitored continuously

since it is desirable to detect the abnormal tides automatically. JMA has a tidal network composed of 72 tide gauge stations. The data from the stations are transmitted to nearby meteorological offices. The apparatus for monitoring tides has two automatic warning modes. One mode is to watch the height of the actual sea level. When the sea level reaches a predetermined height assigned for each port, a buzzer vibrates and the warning light is emitted to attract the notice of the meteorological staff. Another mode is to watch the tidal residual. It the tidal residual is bigger than an assigned magnitude during an assigned period, a similar warning to the mode for watching the actual sea level is released.

This system makes it possible to detect tidal abnormality in its early stage. The information from this system is disseminated to people from the meteorological office.

2. Forecasting system

Today, JMA uses the empirical method for operational storm surge prediction. Each meteorological office issues an advisory or warning on storm surges to the public. The local centre of the meteorological agency forecasts the storm surges and the sea levels on a personal computer. The same computer also has two other functions of monitoring and collecting the tidal data.

G. Storm surge disaster prevention measures– – Tokyo Bay case

There are generally four kinds of structural measures for storm surge prevention. They are levee banks, floodgates, locks over the land and drainage pumps. Levee banks prevent the sea water from invading the low-lying areas. Floodgates are usually opened and ships are allowed to pass through canals and rivers. The flood gates are closed when the sea level reaches a predetermined height. Locks over the land have the same function as the floodgates, and normally they allow transportation over land, for example loading/unloading of ships. Pump stations are installed for pumped drainage of inner basins to the sea. These facilities are operated by a single authority, the staff members of Tokyo Metropolitan Government, because improper communication between bodies causes great damages to the area behind the levee bank. Figure III shows an example of the operation of the disaster prevention facilities during the passage of the typhoon 7920.

Furthermore, there are three kinds of countermeasures to be undertaken during the storm period. They are the measures for: the safe evacuation of ships; floodproofing of buildings and other facilities; and protecting life and property of inhabitants in the coastal areas from storm surges. Concerning the first measure, the Maritime

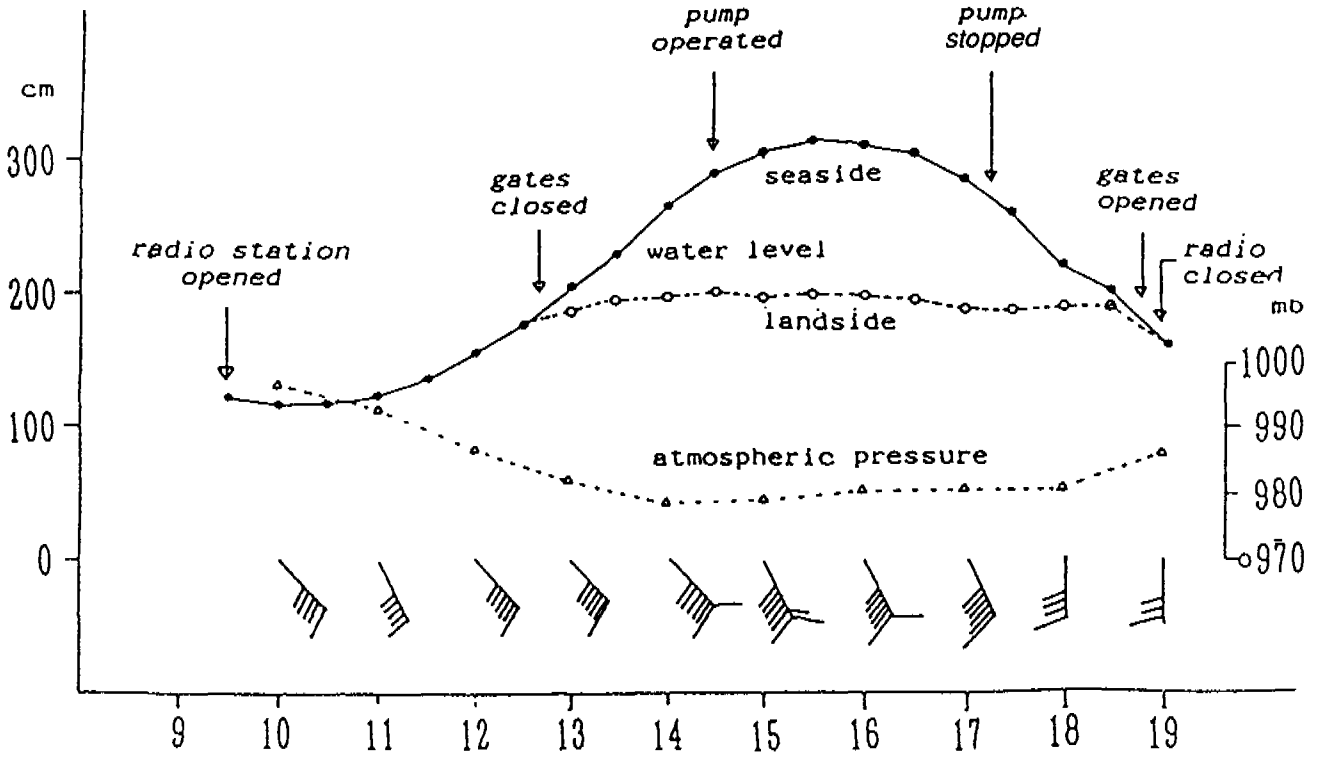


Figure III. Time table of operation of facilities and observed water levels and meteorological elements during the passage of typhoon 7920 at Tatsumi-Gate of Tokyo Metropolitan Government.

Safety Agency organizes a committee composed of related authorities and groups to coordinate the measures against the typhoon. In accordance with the decisions of the committee, the chairman declares the stoppage of loading/unloading and recommends the evacuation of ships. The second type of countermeasures for the buildings are performed by the management body of each building, individually. Countermeasures for inhabitants near the coast of Tokyo port are undertaken by the port management body, Tokyo Metropolitan Government.

References

Japan Meteorological Agency, 1973, Abnormally high storm surges in Tosa bay. Oceanogr. Magazine, 25: 37-58.

Konishi, T, 1989. Numerical forecast of storm surges on real time basis. Oceanogr. Magazine, 39: 21-42.

Murty, T.S., 1984. Storm surges - Meteorological Ocean Tides. Canadian Bulletin of Fisheries and Aquatic Sciences, 808-835.

Oya, M., 1984. Multifunctional uses of geomorphological survey maps in identifying flood-stricken areas and land types. Seminar text for "Technology for disaster prevention" of Japan International Cooperation Agency.

World Meteorological Organization, 1978. Present techniques of tropical storm surge prediction. WMO, Reports on Marine Science Affairs, No. 500.

VII. FLOOD DISASTER REDUCTION IN THE LOWER MEKONG BASIN

by Thaipuck Thammongkol[1] and Le Huu Ti[2]

A. Background

The Mekong is the longest river in South-east Asia and one of the largest rivers in the world. In terms of drainage area (795 000 sq km), it ranks as twelfth, but in terms of runoff (475 000 x $10^6 m^3$) it ranks as eighth. Originating from the Tibetan plateau at an elevation of 5 000 m, the Mekong flows more or less in a southerly direction through or along the border of six countries: the People's Republic of China, Union of Myanmar, the Lao People's Democratic Republic, Kingdom of Thailand, Cambodia and Socialist Republic of Viet Nam.

The Mekong drains an area of 795 000 sq. km, of which 606 000 sq. km. are in the lower Mekong basin, comprising almost the whole of the Lao PDR and Cambodia, one third of Thailand and one fifth of Viet Nam.

Each year about 475 000 million m^3 of water empty into the sea. At Pakse, where the drainage area accounts for 79 per cent of the total area, the maximum discharge (57 800 m^3/sec) is more than 50 times the minimum discharge (1 060 m^3/sec). The general information on the hydrology of the Mekong is shown in table 12.

B. Natural disasters in the lower Mekong basin

Although the lower Mekong basin is located in the world's hazard belt of windstorms, storm surges, floods, drought and earthquakes, the major threats are floods and drought and, to a lesser extent, windstorms.

Out of the average 31 cyclonic storms which occur over the western North Pacific and the South China Sea, from three to four storms or about 10 per cent enter or affect the lower Mekong basin. There will be floods if more than six storms, and drought if less than three storms, enter the basin. However, flooding usually occurs when two or more of these storms occur in rapid succession or when the equatorial trough zone, which is the forward edge of the south-west monsoon, has passed in one of its active stages, and a tropical storm follows shortly thereafter.

1. Flood damage

The Mekong, as many other major rivers, carries an enormous volume of excess water during the wet season, resulting in severe flooding and substantial damage almost every year in the fertile flood plain along the mainstream, major tributaries, as well as the vast flood plain of the delta. One of the largest floods in the history of the Mekong occurred in 1966. This inflicted a total damage in infrastructure and crops of US$ 66 million at the 1966 price level (or approximately US$ 220 million at the present value). The average prospective annual damage was estimated at US$ 36 million at the 1975 price level (or approximately US$ 55 million at the present value).

Associated with annual floods is erosion of river banks. Bank erosion can cause loss of lives and property for many towns located along the river banks.

2. Drought problems

Drought occurs annually in the basin. Even during the rainy season, drought can take place due to long dry spells. This type of drought causes heavy loss to the economy of the member countries of the Mekong Committee. Its severity is aggravated by other problems related to the soil, such as salinity and acidity.

During the dry season, serious reduction in flow often lead to drought in many areas, causing shortage of water for domestic use and agricultural development. The most seriously affected area during the dry season is the coastal plain of the Mekong delta, where the low flow not only creates a shortage of water for human consumption and agricultural development, but also results in severe salt water intrusion into the delta. An indication of the prospective damage can be estimated from the extent of area affected by the intrusion of salt water of some 1.2 million ha.

3. Windstorms

Windstorms usually come with typhoons and heavy rainfalls which normally occur from June through Novem-

Note: The views expressed in this document are those of the authors and do not necessarily reflect the policy of the Mekong Secretariat.

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[2] Senior Adviser, Basin Planning Division

Table 12. General hydrology of the Mekong River up to 1989

Station	*Drainage area*	*Discharge (m^3/sec)*						*Average annual*	
	(km^2)	*Maximum*		*Minimum*		*Average (year)*		*Runoff 10^9 m^3*	*Sediment 10^6 ton*
Chiang Saen	189 000	23 500	(1966)	543	(1969)	2 710	(1929)	85	
Luang Prabang	268 000	25 200	(1966)	652	(1956)	3 820	(1940)	120	
Vientiane	299 000	26 000	(1966)	701	(1956, 58)	4 560	(1977)	144	160
Nakhon Phanom	373 000	32 900	(1948)	915	(1969)	7 420	(1966)	234	
Mukdahan	391 000	36 500	(1978)	958	(1933)	8 020	(1966)	253	
Pakse	545 000	57 800	(1978)	1 060	(1932, 33)	10 100	(1966)	319	
Stung Treng	635 000	65 700	(1939)	934	(1937)	13 800	(1946)	435	
Kratie	646 000	66 700 *	(1939)	1 250	(1960)	14 000	(1945)	441	
Phnom Penh	663 000	49 700 *	(1961)	1 250	(1960)	13 100 **	(1914)	413	

Notes: * Backwater effect
** Tidal effect

ber. However, during April to May, localized windstorms can occur over the basin, particularly in the Lao PDR and Thailand. For the delta, windstorms at various degrees can cause damage by the magnitude of wind and those associated with water level rise. During the dry season, although the wind velocity is relatively small, the slight increase in the water level can push the saline water further inland. The most severe damage usually takes place when a windstorm occurred at the same time as the highest spring tides during the dry season. On these occasions, highly saline water is spread over large areas of farm lands, causing damage to the second crops and making the soil less suitable for cultivation in the next cropping season.

C. Flood forecasting and warning for the Lower Mekong Basin

There are two types of measures which can be used to deal with the flooding of the Mekong: (a) dam construction; and (b) non-structural measures. Dam construction helps to control the excess volume of water during the flood season by storing it in reservoirs. However, dam construction requires large investment and is really a long-term solution.

In the short and medium-term, non-structural measures, such as hydrological forecasting, are cheaper and more practical. Hydrological forecasting is the predicted behaviour of the river relating to the magnitude and the time of occurrence of flooding. Although flood warnings cannot prevent flooding, damage to property and loss of life can be minimized through timely and accurate forecasts. If the forecast is given well in advance, protective measures, such as the strengthening or heightening of flood protection dikes, can be carried out.

Flood forecasting, if based upon reliable hydrological analysis and if accompanied by carefully prepared plans for emergency evacuation and rescheduling, can cut the loss of livestock, machinery, and household goods. However, a forecasting system alone cannot be very beneficial unless it is tied to a system for spreading and disseminating the forecasts. A comprehensive flood forecasting system, including plans for using the forecasts, might be one of the most cost-effective measures in dealing with flood losses.

1. Flood affected areas

Differences in the magnitude and extent of flooding in flood-prone areas depend on local conditions and the distribution of rainfall. In the upper reaches from Chiang Saen (Thailand) to Thakhek (Lao PDR)/Nakhon Phanom (Thailand), every key station recorded the maximum discharge during the 1966 flood; in the middle reaches in Savannakhet (Lao PDR)/Mukdahan (Thailand) and Pakse, (Lao PDR), the maximum discharge recorded was during the 1978 flood; at Kratie (Cambodia), the highest recorded flood was in 1939; and, at Chau Doc in the Mekong delta (Viet Nam), the maximum water level was recorded in 1961.

In the upper reaches some areas are subject to direct flooding from the Mekong river on both banks of the mainstream. The Vientiane/Nong Khai plain in the Lao PDR/Thailand is the worst affected area. In 1966, a flood of estimated 80-year frequency caused damage there amounting to US$ 22 million. Two thirds of the city of Vientiane and the whole town of Nong Khai were inundated for almost a month. In the middle reaches the flood-prone areas are along both banks of the river from Thakhek/Nakhon Phanom to Pakse. The worst flood in this area occurred in 1978. At Pakse the water level was 2.5 m above the flood stage and almost the whole town was flooded.

In the lower reaches in Cambodia, where the land is low and flat, a larger area is usually inundated. Flooding is not only attributable to the Mekong, but also partly to the backwater effect from the Great Lake. The frequency of flooding is also more than that observed upstream. In Viet Nam a large part of the Mekong delta is often flooded for extended periods. During the 1966 flood, the damage in the lower reaches in the Mekong delta was estimated at US$ 34 million.

2. Development of flood forecasting in the lower Mekong basin

The severe flood of 1966 led to a call for a flood warning system. To help alleviate the adverse effects of flooding in the member countries, the Mekong Committee requested UNDP's assistance in establishing a basin-wide flood forecasting system for the lower Mekong basin in January 1968.

With the assistance of India and the United States, an expert group was formed to carry out the required study. A report entitled "Proposed implementation of a basin-wide flood forecasting system for the lower Mekong basin" was prepared in December 1969 and was approved by the Mekong Committee in 1970.

The expert group recommended the training of three staff members from the Mekong Secretariat in river forecasting and the application of satellite imagery in weather forecasting at the United States Corps of Engineers, North Pacific Division, and the Portland River Forecast Centre, US National River Service, Portland, Oregon. The forecasting programme started on a trial basis during the 1970 Mekong flood season to demonstrate the feasibility of a centralized forecasting system using advanced computer techniques and mathematical models. Since then, the operation has

been carried out annually during the flood season from July to October.

The basin-wide flood forecasting operation has been carried out jointly with the member countries and real-time data have been provided.

3. Simulation of flooding

Based on the flood characteristics discussed above, flooding in the lower Mekong basin is simulated by three computer models in the flood forecasting operation:

- SSARR (Streamflow Synthesis and Reservoir Regulation) for the upper and middle reaches
- DELTA for the lower reaches of the delta without tidal effects
- TIDAL for the main channels of the Mekong estuaries system with tidal effects.

(a) SSARR Model

This is a river system model. Drainage basins are sub-divided into homogeneous hydrologic units, and the outflow from each of the sub-basins or watershed model is derived from rainfall. The watershed model estimates runoff excess based on soil moisture index values which are computed from rainfall and evaporation relationships. The runoff excess is further divided into baseflow and direct runoff, using an empirically estimated baseflow infiltration index. The direct runoff is further separated into surface and sub-surface flows using an empirical surface-sub-surface separation curve. These three components of runoff are then routed through their respective conceptual storages, each with a different number of storages and time of storage. The routed components are combined to become the sub-basin outflow which is then added to the mainstream flow, routed through the channel to a downstream point and combined with the outflow from the next sub-basin.

(b) Delta Model

The DELTA model covers an area of about 50 000 sq. km. in Cambodia and Viet Nam. This area was schematized into 293 meshes. The schematization was based on topographic condition and flow regime between one mesh and another. The flow regime in the DELTA model is expressed by the system of Saint Venant equations integrated with respect to the vertical direction and averaged over the lateral direction. The finite difference method in an implicit scheme is used in programming. Included in this model, besides the effects from rainfall and main river discharge from the upper area, are the effects of overbank flow in flood plains and flow regulation by the natural reservoir of the Great Lake. The Great Lake with its maximum capacity of about 72 000 million m^3, significantly reduces the flood peak upstream by absorbing a large volume of flood water during the rising period and prolongs the inundation period by releasing water during the recession period.

The main inputs to the DELTA model are the mainstream discharge at Kratie, water level at river mouths, rainfall and flow from the Great Lake sub-basin.

(c) TIDAL Model

The TIDAL model was originally used to study the distribution of low flow under tidal effects during the dry season. The model was subsequently modified to estimate the effects of tides on the flood water level in the main channels. The finite difference scheme adopted in this model is the node and branch approach using the third implicit scheme of Dronkers. The main inputs to this model are the water level at Phnom Penh and tidal fluctuations at the sea.

(d) Relations among SSARR, DELTA and TIDAL models in flood forecasting operations

The SSARR model is used to estimate the discharge and flood stage of the upper and middle reaches. The discharge obtained from simulation by SSARR is then used as an input to the DELTA model. The water level at Phnom Penh estimated by the DELTA model is used as a forecast input to the TIDAL model. The forecast water levels are updated using first-hand data.

4. Operational details

(a) Basin-wide flood forecasting operations

An operation starts in May each year to establish the correct initial conditions of all parameters so that the actual forecasts can be made from July through November.

The accuracy of the results produced by the sophisticated models depends mainly on the quality of the inputs. Rainfall data are the most important.

These inputs consist of information provided by a network of 41 rainfall reporting stations and 26 water level stations equipped with radio-transceivers and APT pictures from weather satellites including NOAA and GMS.

During the whole period of the flood forecasting operation, data on water levels and rainfall from reporting stations of the Mekong radio network are sent to the Mekong Secretariat at 0730 hours each working day. Additional information on rainfall from another 15 stations is

received by telephone, and satellite pictures are obtained through the telefax system from the Meteorological Department of Thailand. All data are analyzed and used as inputs to run the forecast models on the computer. The flood forecasting operation is carried out each working day and on holidays during the critical period of high flow.

All daily information, including rainfall with the time of distribution and gauge height reading of the water level of the Mekong as well as its tributaries, is received through the radio-transceiver network (30 reporting stations) from 0730 to 0800 hours. Received data are analyzed on a routine basis as follows:

(1) Interpretation of all available rainfall data, including the distribution of rainfall.

(2) Analysis of a synoptic chart, together with satellite pictures, is made from the quantitative rainfall for the preceding period as well as the forecast period, and forecasts are made for each sub-basin.

(3) Conversion of water levels to discharge by applying the appropriate rating curves.

(4) Computation of local or sub-basin flow as the difference between the station's inflow and the next upstream routed flow.

(5) Preparation of data for each of the above items to be used as inputs to the SSARR model.

(6) Computer run at 1000 hours.

(7) Computer outputs are examined and checked.

(8) Forecasts and local flows are plotted for all stations.

(9) Adjustment of forecasts, if necessary.

(10) Forecasts are disseminated to all authorities concerned in the member countries around 1130 hours.

Forecasts of water levels are made for 14 key locations: they are made from one to five days in advance for five locations in the Lao PDR, namely, Luang Prabang, Vientiane, Thakhek, Savannakhet and Pakse; five locations in Thailand, namely, Chiang Saen, Chiang Khan, Nong Khai, Nakhon Phanom and Mukdahan; and one to 15 days in advance for four locations in Viet Nam, namely, Tan Chau, Chau Doc, My Thuan and Can Tho.

The location of the forecast stations and reporting stations is shown in map 2.

(b) Flood forecasting for a major tributary

Flood forecasting for the lower Nam Ngum is carried out during the flood season between July and October with the application of the SSARR model and information received from the Mekong reporting stations. Forecasts are made from one to five days in advance for one location on the Nam Ngum. The programme will be extended to cover other major tributaries.

(c) Forecasts of flow into the existing reservoir

The experimental forecast of flow into the Nam Ngum reservoir is expected to be carried out in 1991. The forecast will be useful for flood control and better reservoir regulation. In preparation for this, flood models are being calibrated with the available data.

(d) Long-term river forecasting

Long-term river forecasts (monthly or seasonal) serve to provide information on the volume of runoff for flood control, irrigation, power generation, water supply and long-range navigation planning. The Mekong Committee is planning for this kind of forecasting in the near future.

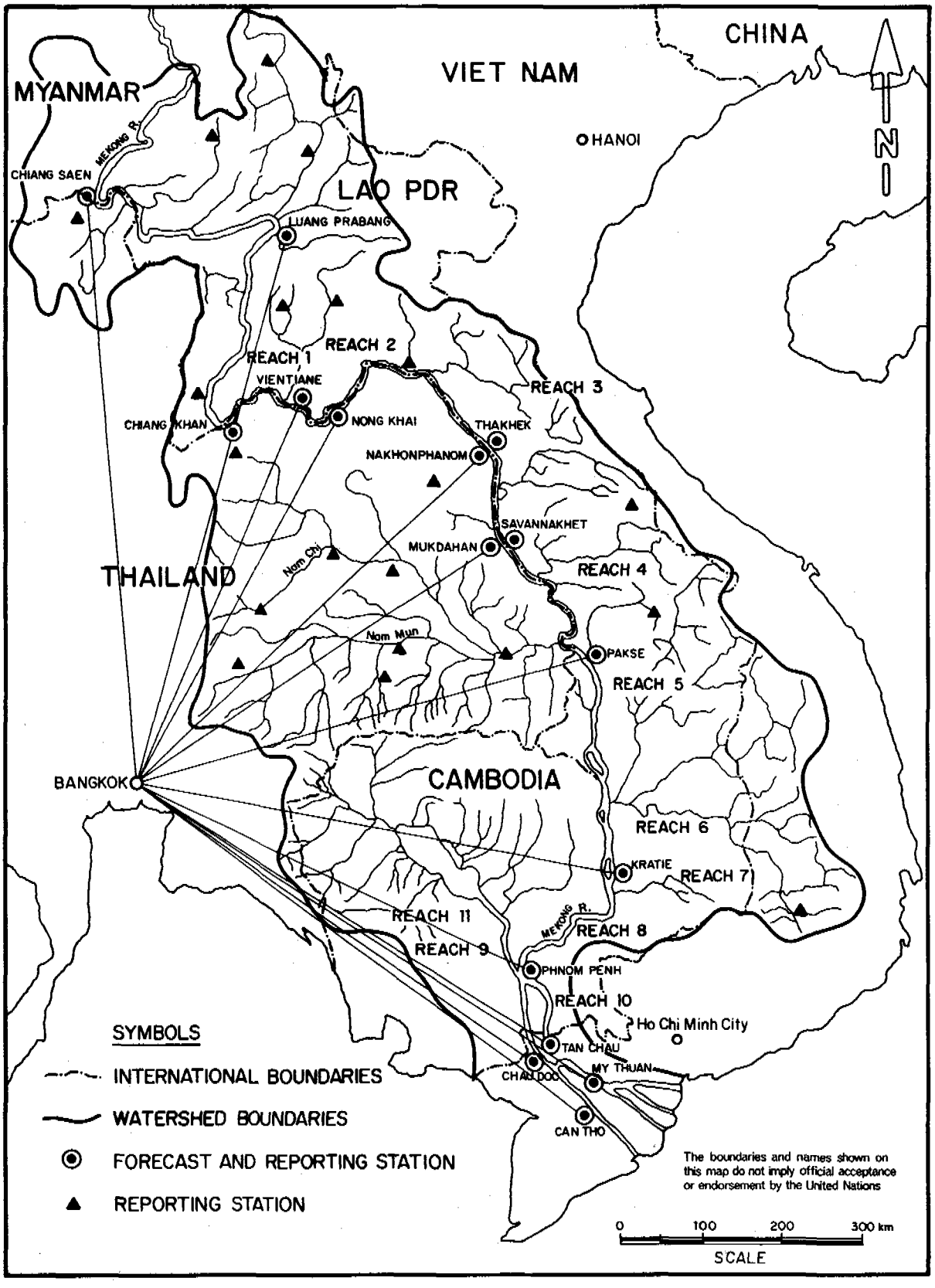
5. Dissemination and utilization of forecasts

Forecasts are disseminated daily to the National Mekong Committees in the member countries which also serve as communication centres in providing the real-time data as shown in figure IV.

Information is transmitted to the following:

- National Mekong Committee of the Lao PDR, by radio at 1130 hours;
- National Mekong Committee of Thailand (National Energy Administration) by hand at 1400 hours and the Meteorological Department by telephone at 1130 hours; and
- National Mekong Committee, Viet Nam, in Hanoi and the Flood Forecasting Centre, in Ho Chi Minh City, by radio at 1330 hours.

The National Mekong Committees relay forecasts to Flood Forecasting Centres in each country. Forecasts are then transmitted to provincial centres by radio or telephone and/or to radio broadcasting stations for further action as one of the flood warning measures, and to the Disaster Prevention Centre for appropriate action for flood relief and flood fighting. An example of the flood loss prevention measures being carried out in Viet Nam is shown in Figure V.



Map 2. Flood forecasting operation in the Mekong delta

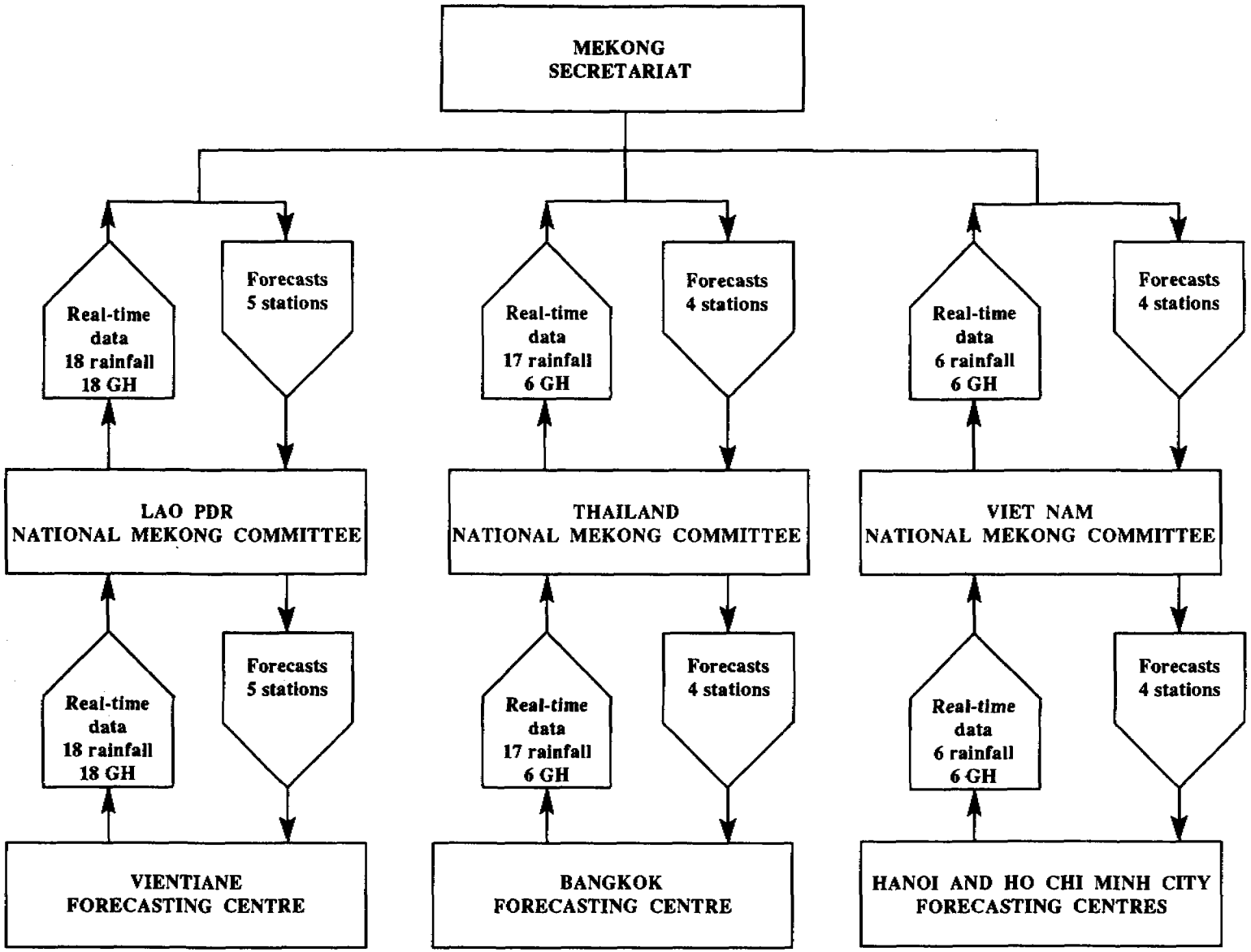


Figure IV. Dissemination of forecasts in the Mekong Basin

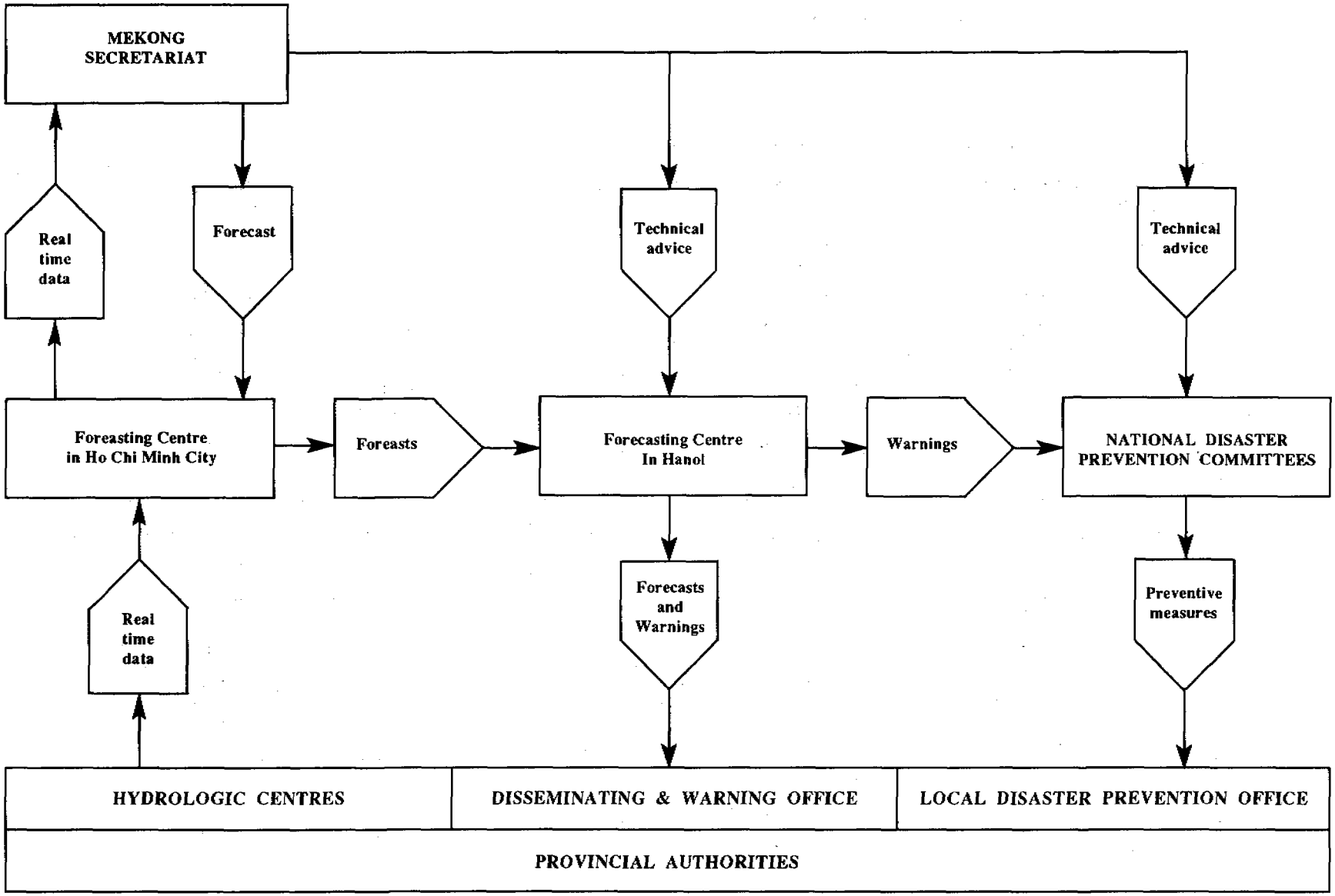


Figure V. Communication of forecasts between the Mekong Secretariat and Vietnamese authorities

As mentioned earlier, flood forecasting cannot prevent the occurrence of a flood, but advance warnings can help to reduce damage caused by flooding.

The economic value of forecasting depends on its accuracy and the period of time covered. The greater the accuracy and the longer the period covered, the greater the economic value in planning for the utilization of water resources. Apart from protection measures mentioned earlier, flood warnings are of considerable value in organizing the evacuation of people and removal of property and equipment from affected areas. The experience gained by the Mekong Secretariat staff over a relatively long period of forecasting operations has indicated that application of mathematical models for flood forecasting purposes is technically feasible and effective. Reference can be made to the important flood of 1971 in the Vientiane-Nong Khai area where forecasts were a major contributory factor which helped to save movable assets in the flood plain and gave the authorities concerned in both cities time to strengthen the flood protection dikes. Reference can also be made to the flood of 1978 in the Mekong delta, when two-week warnings of the flood peaks helped to reduced damage; crops were harvested before the arrival of the flood. The authorities concerned had enough time to prepare for flood monitoring in the delta and were able to raise the height of the dikes in densely populated areas.

D. Other disaster reduction activities of the Mekong Committee

1. Other river forecasting activities

Besides the annual flood forecasting operation, the Committee also carries out its annual low flow and salinity intrusion forecasting operation during the dry season, starting in January until June. Currently, these forecasting activities are limited to the Mekong delta to provide forecasts to facilitate the operation of water control structures, irrigation and water management. Attempts have also been made to provide forecasts on the effects of windstorms to reduce damage associated with a rise in water level at the river mouth. Since the forecasts of low flow are also important to navigation, low flow forecasting operations are expected to be extended to the upstream part of the Mekong in the near future.

2. Activities related to river bank erosion

In view of the damage caused by river bank erosion to the many densely populated settlements along the Mekong, a pilot basin-wide bank protection project was formulated with three major objectives:

(a) To construct bank protection works at pilot areas of critical reaches with emphasis on low cost and the use of local materials;

(b) To study the detailed process of river morphology at selected reaches to provide more precise data for bank protection design and to provide information for a warning operation; and

(c) To prepare guidelines on bank protection works and the use of river channels to prevent severe bank erosion.

Phase II of this pilot basin-wide project has practically been completed, except that due to a shortage of external financial assistance, only one of the four pilot sites of bank protection was constructed. Regular monitoring of changes in the river bed is conducted.

E. Cooperation with international bodies

After its inception in 1957 under the aegis of the United Nations, the Mekong Committee cooperated closely with the Economic Commission for Asia and the Far East (ECAFE); particularly with the Bureau of Flood Control, and later with ESCAP. Since the establishment of the Typhoon Committee in 1968, the Mekong Committee has cooperated with this Committee. Lately it has cooperated with ESCAP in the Expert Group Meetings on comprehensive Flood Loss Prevention and Management.

From June to August 1990, ESCAP provided the services of a technical Adviser to the Mekong Secretariat to field a mission to the Lao PDR, Thailand and Viet Nam to assess the present flood forecasting facilities and to propose improvements.

In order to mitigate the severe effects of flooding, the Committee initiated its flood forecasting programme for the four member countries in 1970. Since then, this operation has been carried out annually.

To signify the International Decade for National Disaster Reduction, the Mekong Committee formulated in 1990 a project entitled "Flood Forecasting and Damage Reduction Study". The main objectives are:

1. To provide advance information on flood conditions to the people living in flood-prone areas to enable them to undertake necessary actions that may eliminate/minimize the human suffering and/or property losses;

2. To establish a programme of emergency action for the issuance and dissemination of forecasts; and

3. To increase the capability of technical personnel of the Secretariat and the national agencies concerned in the preparation and dissemination of forecasts.

PART THREE

NATIONAL DISASTER MITIGATION EFFORTS IN COUNTRIES OF THE ESCAP REGION, WITH EMPHASIS ON WATER-RELATED NATURAL DISASTERS

I. MAJOR NATURAL DISASTERS WHICH AFFECT AUSTRALIA

by Raymond K. Ellis[1]

A. Introduction

Australia is an island continent extending from approximately 10 degrees to 45 degrees south latitude and is subject to harsh extremes of climate. It has an area of 7.7 million square kilometres and a population of 17 million. Much of the land is desert or semi desert and the remainder varies from tropical rain forest to extensive winter snowfields.

Natural disasters affecting Australia include cyclones, severe storms, earthquakes, floods, bushfires, droughts, soil degradation and locust plagues. Introduction of exotic animal diseases to which local stock has no immunity is a constant threat which is viewed very seriously.

This paper will address Australian perceptions of major natural disasters affecting this continent. However, before doing this it is necessary to explain counter disaster principles and arrangements applicable to the Australian scene.

Australia has a federal system of government with one Commonwealth and eight state governments. Additionally there are 880 local government authorities.

B. Ntural disasters in Australia and counter measures

1. Bushfires

These are a severe summer hazard in the east/south-east, including the island of Tasmania and the south-west of the continent. Good rains in 1990 have produced high fuel loads in forests and farmlands and early summer conditions have been hot and dry with strong winds. Although several months of summer remain, bushfires have already caused hundreds of millions of dollars in damages. The state of New South Wales alone had some 500 separate fires burning at one severe period over Christmas 1990.

Although damage from cyclones, storms and hail, easily exceeds that from bushfires in an average year, the potential destruction from large fires is enormous. For example 1983 Ash Wednesday fires in Victoria and South Australia caused the following damage:

	TOTAL
People killed	75
Cattle killed	16 690
Sheep killed	264 000
Houses destroyed	2 031
Commercial properties destroyed	84
Farms destroyed/damaged	2 234
Area of land affected (ha)	243 700
Fencing destroyed (kms)	14 400
Estimated costs (1983 prices)	A$ 600 m

Australian bushfires fall into two main categories:

- Grass fires
- Forest fires

The former occur on grazing and farming land. They are mainly fought by well organised and trained volunteer fire fighters with vehicle mounted equipment. Observation is often provided by light aircraft and helicopters. Crop dusting aircraft using water or retardants are often effective in saving farm houses and facilities. Helicopters with buckets lift water from dams or swimming pools and provide a similar service. They are effective in stopping spot fires ignited by windborn firebrands, sometimes kilometres ahead of the main fire front. This greatly assists and contributes to the safety of fire fighting crews. Larger aircraft are rarely used because of cost, long turn around times, limited water supplies and questionable effectiveness. Bulldozers and graders are used to create firebreaks ahead of fire fronts and back burning in conjunction with firebreaks is frequently effective.

Vegetation varies from grasslands through transitional stages to dense forest, often in inaccessable country. Under adverse weather conditions, fires in Australian sclerophyll forests cannot be stopped. Huge amounts of flammable eucalyptus vapour, transpired from leaves, create fireballs which often engulf the upper storey ahead of the main fire front. Clouds of dense smoke can mask the fire front from both ground and aerial observation. During the Ash Wednesday fires aerial-mounted infra-red heat-sensing equipment was needed to locate and plot some fires.

[1] Executive officer, Australian IDNDR, Coordination Committee

The South–east of Australia is probably the greatest fire hazard in the world. Fires are driven south by strong hot north winds and long fire flanks frequently become fire fronts when wind changes move in from the Great Australian Bight. Timely and accurate meteorological information is vital for fire fighting teams. This is later amplified under counter measures. Many forest fires burn until stopped by nature. This may be many weeks after ignition. Forest fires are fought by professional firefighters and trained volunteers.

An important countermeasure for all fires is accurate meteorological forecasts. Routine estimates of fire danger are prepared several times daily and passed to fire authorities. Special forecasts are issued during fires. Meteorological information is routinely gathered from sources which include free floating ocean transmitter stations to the south of Australia. Arrangements commencing January 1991 now provide during periods of high fire danger for aerial reconnaissance to intercept wind changes before they make landfall. This will enable better predictions. Other countermeasures include: heavy fines for careless campers or smokers; partial or total fire bans; trained and equipped volunteer and professional fire fighters; controlled burning to reduce fuel loads; firebreaks; clearing vegetation from buildings; clearing debris from roof gutters; public awareness campaigns and spark eliminators for agricultural vehicle exhaust pipes.

2. Cyclones

Approximately 10 000 kilometres of Australian coastline is subject to cyclone threat. Although the city of Darwin in the Northern Territory was reduced to rubble on 25 December 1974, the greatest cyclone threat is to the Queensland coast which has numerous substantial cities and towns along its length.

Cyclone Tracy destroyed Darwin and was Australia's most extensive natural disaster. Only 400 out of 10 000 buildings survived. Power, water, sanitation and communications were lost. Some 45 000 people were homeless. Sixty-five died. The airport anemometer recorded 217 km/h before failing.

Although Darwin had experienced prior cyclones and ample warnings of Tracy were broadcast, many of the population disregarded warnings and proceeded with their Christmas festivities. Many lives would have been saved and some of the $A1 000 million damage reduced had people heeded warnings.

Substantial damage has been caused by cyclones crossing the Queensland and West Australian coasts but fortunately most have struck areas of sparse population.

Each year the Bureau of Meteorology conducts workshops on the latest techniques for forecasting the behaviour of tropical cyclones. Meteorologists from Papua New Guinea and the South-west Pacific are invited whenever possible. Australia also provides lecturers for World Meteorological Organization (WMO) sponsored Pacific workshops on tropical cyclone forecasting. A comprehensive Australian tropical cyclone warning system computer package which will operate on personal computers, was introduced in November 1990 to tropical cyclone warning centres situated in Perth, Darwin and Brisbane. It can be made available to interested meteorological services. Cyclones are now rated on a category from 1 to 5, with 5 being the most destructive.

Other cyclone countermeasures include: cyclone emergency warning sounds to precede electronic media warnings; and revised building construction codes for cyclone areas. A cyclone structural testing station has been functioning since 1977 at the James Cook University at Townsville in Queensland. This specializes in testing house designs. Although not restricted to any specific natural disaster, one of the main lessons learned from Cyclone Tracy was that much needless stress is caused by evacuation of women and children first. In most cases families should be evacuated as a unit.

3. Floods

Generally forested mountainous ranges, parallel and close to the east coast of Australia, result in short easterly flowing rivers which usually flood violently for a period of days or a few weeks. Massive inland river systems are frequently waterless but flood vast areas for periods of weeks to many months.

During the first few days of 1991, Tropical Cyclone Joy degenerated into a vast depression dumping some 2310 millimetres (91 inches) of rain in an area from Townsville to Rockhampton in Queensland, over a period of 8 days. One town recorded 1040 millimetres in 12 hours. The Dawson and Mackenzie Rivers feeding into the already flood swollen Fitzroy River produced severe flooding at Rockhampton. Severe stock and property losses occurred and a state of emergency was declared over one third of the state. Many properties and homes were evacuated and Australian Defence Force assistance was provided. Army Blackhawk helicopters were used for evacuation and fodder dropping to isolated stock. Several days warning of impending flood levels assisted to reduce losses. However there was need for essential resupply by air for isolated communities and towns.

Towards the end of January about 500 000 square kilometres of Queensland were flood affected by monsoonal rains.

When inland river systems flood as occurred in mid 1990, huge tracts of relatively flat country become covered with slow moving sheets of water which flow into normally dry inland lakes or to the ocean, thousands of kilometres away. These waters appear months later and hundreds of kilometres away from where it rained. The pattern is fairly predictable and losses are minimized by moving stock away from threatened areas and prepositioning supplies. Towns in such areas are generally small and protected by levee banks.

Disasters however do occur. The 1990 floods were huge, covering more than 1 000 000 square kilometres of Queensland and New South Wales. The interaction of numerous flooded river systems made flood height prediction difficult. Residents of the Western New South Wales Town Nyngan, strengthened levee banks in expectation of a flood height which was eventually exceeded. The whole town of some 2000 people was evacuated under emergency conditions as all services were lost. Considerable cost and hardship occurred because the town did not have a disaster plan to cope with levee bank failure.

Countermeasures for floods include preparation of flood plain maps and control of development on flood prone areas. Federal-State flood warning consultative committees (FWCC) have been established in all states. Membership includes: the Bureau of Meteorology; Water Resources Commission; State Emergency Services and Local Government Association. Many hundreds of thousands of sandbags are prepositioned in flood prone areas.

The December 1990 issue of the Natural Disasters Organisation Newsletter 'The Macedon Digest', available on request, contains three articles on recent Australian floods.

4. Storms

Violent storms including hail cause considerable damage to buildings and crops. During 1990 one hail storm alone caused several hundred million dollars loss in Sydney. A large component of this was damage to many thousands of motor vehicles both on the road and in dealers' yards. Australia also experiences numerous tornados mainly in the sparsely inhabited interior where, usually, little damage is caused. However in January 1991 both Melbourne and Sydney, large cities, experienced violent storms believed to be tornados. In the space of minutes, hundreds of millions of dollars damage resulted.

Volunteer State Emergency Services (SES) provide the main storm countermeasures, repairing roofs and removing fallen trees. Considerable stocks of plastic sheeting, small and large tarpaulins and ropes are maintained in stores servicing approximately 1000 SES units throughout the country. A significantly upgraded thunderstorm warning service based largely on radar observations and supported by automatic weather stations was introduced for mainland capital cities in February 1990. It will be extended to other major population centres as resources become available.

5. Earthquakes

Australian earthquakes are intraplate. Adelaide and Perth, state capitals, are in known earthquake risk areas. Meckering and Cadoux, wheatbelt towns in Western Australia, have both been damaged by earthquakes in the past two decades and the small mining town of Tennant Creek in the Northern Territory has experienced three earthquakes since 1988. These have registered 6.3, 6.4 and 6.8 on the Richter Scale. However, the only major Australian city to suffer severe earthquake damage is the mining and industrial New South Wales coastal city of Newcastle. On 28 December 1989 an earthquake measuring 5.6 on the Richter Scale caused 12 deaths and total damage of approximately $1.5 billion inclusive of infrastructure costs. Considerable research has been done to determine why a small earthquake caused so much damage. Causes include: underlying alluvium which significantly magnified ground motion; a major club building had faulty roof trusses; outer wall ties in buildings had corroded with age and cantilevered shop awnings could not withstand the shock.

Countermeasures for earthquakes are currently under assessment, but multiple seismic monitoring stations linked to central computers have already been established at Newcastle.

6. Drought and soil degradation

Drought has always been a part of Australian life and communities affected by drought have received Government financial assistance in the past. There is however a growing realisation that much grazing and farming country is so marginal that it should never have been developed in the first place and the wisdom of continuous use of national funds in support of such development is being questioned. This and the subject of soil degradation, which is being hastened by questionable farming and grazing practices as well as the depredations of imported pests such as rabbits and goats, is under continuous review by the Commonwealth and State Governments.

Countermeasures include: restrictions on further land clearing; reforestation programmes; vermin control programmes; and a wide range of incentive programmes to encourage sound land management. These measures are too numerous to be covered here except in the broadest sense.

7. Exotic animal diseases and locust plague

The Australian Quarantine and Inspection Service maintains a constant guard to prevent introduction of exotic animal diseases. Australia is free of foot and mouth disease and long expensive campaigns have been undertaken to eliminate tuberculosis and brucellosis from cattle herds, ensuring that meat and by-products qualify for entry to the most demanding markets.

Although exotic animal diseases are not considered a natural disaster by most Governments, the economic impact on Australia following any loss of overseas markets would exceed that of natural disasters.

Countermeasures include strict quarantine regulations, and aerial and maritime coastal surveillance coupled with regular inspection of herds and animal products.

Locust plagues pose a serious threat to Australian primary producers and if left unchecked would prove disastrous. Departments of Agriculture maintain close watch on known and reported breeding areas and control by aerial spraying before locusts swarm.

C. Disaster management system

Australia's counter disaster system reflects the fact that states have constitutional responsibility for protection of the lives and property of their citizens. State governments exercise control over most of the functions which are essential for effective disaster prevention, preparedness, response and recovery - through the legislative and regulatory arrangements within which the community and the various agencies operate; through the provision of police, fire, ambulance, medical, hospital and emergency services; and through the government and statutory agencies which provide services to the community. Local government plays a major role, as do the communities they serve. The role of the Commonwealth is to provide guidance and support to states in developing their capacity for dealing with disaster. This is done in part by the Natural Disasters Organisation and its training arm, the Australian Counter Disaster College. Should a State experience a disaster with which if cannot cope, the Commonwealth will provide physical assistance and may also provide finance for recovery.

The national system for combating disaster thus relies on a partnership between all levels of government and the community.

Australian national system has three main elements:

- the Commonwealth/states agreement for financial relief under the Natural Disaster Relief Arrangements (NDRA);
- the state counterdisaster organisations; and
- The Natural Disasters Organisation.

The first element is a Commonwealth/state agreement for financial relief under the Natural Disaster Relief Arrangements (NDRA), established by the Commonwealth, to assist states to meet the unpredictable and sometimes large costs of providing natural disaster relief and recovery. Under NDRA the Commonwealth reimburses at least 50 per cent of state expenditure on eligible measures for short-term relief of personal hardship and distress. It also provides financial assistance for other eligible longer-term relief and restoration measures.

The second element is the state counter disaster organisations. They are generally built around state counter disaster committees or councils. Their functions differ in detail, but they are mainly responsible to ensure that proper plans and arrangements for dealing with disasters are in place.

Members come from the various emergency services, state authorities, and volunteer organisations likely to be needed. Below State level, that is at regional and local levels, there are similar committees, which are usually chaired by senior police officers.

At the operational end of the system there are emergency operations centres at each level to co-ordinate the activities of the many participating organisations including the police, fire and ambulance services, State Emergency Services, plus numerous supporting organisations.

The Australian concept is simple. In the first instance, the problem of dealing with an emergency or disaster is the responsibility of individuals who are directly involved. When it becomes apparent that they cannot reasonably cope, they seek help–normally from local government. Thus, responsibility for response, containment and restoration starts at the lowest level of government and passes up through the region or district to state level as capabilities or capacities are exceeded.

This disaster management philosophy has developed from the fact that the closest relationship between people and government is at local government level. It relies on the fact that early application of locally available resources will provide the most effective response, in the form of first aid or life-saving remedial measures.

It also acknowledges that if help from a nearby municipality or from the state is called for, there will be a delay before it arrives. This means that self-help, especially at local government level, is central to the Australian philosophy for development of an effective capability.

Indeed, experience has shown that development of such a capability depends primarily upon having a prepared community–that is, a community which:

- is alert, informed and active;
- has an active and involved local Government; and
- has agreed, co-ordinated and proven arrangements for disaster response.

The third element of the national system is the Natural Disasters Organisation (NDO).

Its function is:

"To promote and support an effective national counter disaster and core civil defence capability. To co-ordinate Commonwealth Government physical assistance within Australia in time of disaster and act as operational agent for the Australian International Development Assistance Bureau within the South West Pacific and Papua New Guinea.

To meet that function NDO is organised in two parts: A Headquarters responsible for operations, policy and support, and the Australian Counter Disaster College responsible for training. Total staff is 68.

It is important to note that Australian counter disaster arrangements apply equally to natural and man-made disasters. We apply the same set of management arrangements to all types of disasters and to civil defence. This is generally known as the 'All Hazards Approach'. We also believe it is essential to address four basic elements of disaster management. These are prevention, preparedness, response and recovery. It is called the 'Comprehensive Approach'. These and other basic considerations are amplified in a publication 'Commonwealth Counter Disaster Concepts and Principles' which together with its companion document 'Australian Counter Disaster Arrangements' is available on request, free of charge. Study of these publications will provide an understanding of Australian counter disaster arrangements which are simple, effective, and have withstood the test of time. Arrangements rely heavily on volunteer effort, and the extent of this effort may be better appreciated from the fact that Australia's population base of about 17 million provides 250 000 volunteer fire fighters, 60 000 volunteer members of State Emergency Services plus many thousands of volunteers in organisations such as the Red Cross, Salvation Army and the St John Ambulance Brigade.

This national system has evolved from over 30 years of practical experience and is serviced by, and in turn serves an informed society backed by a sound national infrastructure.

Australia also provides substantial assistance to overseas countries with emphasis on Papua New Guinea and nations of the South West Pacific.

The Australian International Development Assistance Bureau (AIDAB), an arm of the Department of Foreign Affairs and Trade, manages all Government overseas aid. To assist in this task the Natural Disasters Organisation acts as agent for AIDAB in co-ordinating government physical response to overseas disasters. The Australian Overseas Disaster Response Organisation (AODRO) is a NGO substantially funded by AIDAB to co-ordinate Australian non-government organisations response to overseas disasters.

There are several important lessons common to all disasters. These are:

- you have never learnt all the lessons;
- lessons learnt must be recorded for future use;
- lessons recorded for future use will rarely be read; therefore
- regular exercises must teach lessons learned.

D. International Decade for Natural Disaster Reduction and Australia

Although geographically large, Australia has only modest financial and population resources. Consequently it must be selective in its IDNDR contributions and these will be mainly channelled into the South West Pacific area. Nevertheless, Australia is producing a series of emergency operations and training manuals as a general contribution.

Experts from each Australian Emergency and Response Agency, funded by the Natural Disasters Organisation, are jointly preparing manuals of wide application. Already two have been published. These are, 'Disaster Rescue', and 'Land Search Operations'. Copies have been sent by request to a number of overseas countries. Manuals now being printed include 'Flood Rescue Boat Operation', and 'Storm Damage Operations'. Manuals under development include: 'Four Wheel Drive Vehicle Operation', 'Communications', 'Training and Instructional Techniques', 'Chain Saw Operation', 'Vertical Rescue'; 'Road Accident Rescue' and 'Emergency Management Planning'. These manuals may be reproduced free of copyright fees, subject to suitable acknowledgement. For developing countries copies will be provided in English, free of charge. Copies of the two printed manuals and other public awareness material covering cyclones, severe storms, earthquakes and floods are available on request.

Enquiries should be directed to:

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Australian IDNDR Co-ordination Committee
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Australia

E. Conclusion

Australian counter disaster arrangements have stood the test of time and work well. Changes are continuously made as a result of lessons learned, but these are generally of a 'fine tuning nature' and major changes are unlikely.

Although systems and procedures which work under political and geographic circumstances applicable in Australia, may not be ideal for other countries, it is possible that some or all will be of interest.

In accordance with the international spirit of the IDNDR, enquiries for additional information will be welcomed.

II. IMPACT OF NATURAL DISASTERS ON BANGLADESH

by Mohiuddin Azad[1]

A. Introduction

Bangladesh is an small country, covering an area of 144 000 sq. km. The country has four administrative divisions with 64 districts and 460 sub-districts. Over 110 million people are squeezed in this small area, of whom 85 per cent are engaged in agriculture. The country is a deltaic plain through which three mighty river systems flow into the Bay of Bengal in the south—the Ganges, the Brahmaputra and the Meghna.

B. Natural disasters in Bangladesh

Bangladesh is a disaster-prone country. Floods, cyclones, and droughts are the three most destructive natural disasters that have been affecting the life of the people of Bangladesh. Droughts, however, are not very frequent and may happen once in ten years, the last in 1979. On the other hand, floods and cyclones are annual phenomena and take a huge toll of lives and properties. Hence, floods and cyclones have tremendous effects on the economy of the country.

1. Floods

Of all disasters, cyclones and floods are the most devastating in magnitude and intensity. In normal years when rainfall within and in the catchment areas of the river systems is not excessive or when the peak flood times of the river systems do not coincide, nearly 20 per cent of the country is engulfed by flood while in the years of severe flood, 55-60 per cent of the country goes under water.

The major causes of flood in Bangladesh have been as follows:

(a) Excess rainfall within and in the catchment areas of the river systems;

(b) Flat topography and low elevation of the country;

(c) Spill from the main river systems and from smaller rivers, including tributaries of the main river systems;

(d) Drainage congestion due to flat topography, flood plain developments and tidal influence;

(e) Severe flood when the peaks of the major rivers coincide.

Each year flood affects Bangladesh. The magnitude of flood, however, varies. In some years severe flood engulfs one-third to two-thirds of the country with devastating effect. Crops are damaged, homesteads, roads, bridges and culverts along with other development infrastructure are washed away. Loss of lives can be quite sizable. In the post-flood period millions starve because of food shortages and loss of means of livelihood. Consequences of the great floods of 1987 and 1988 are given below:

Table 13. Consequences of 1987 and 1988 floods in Bangladesh

	1987	*1988*
1. No. of districts affected	50	53
2. No. of Upazila affected	347	346
3. No. of people affected	24 823 376	35 732 336
4. Crops damaged (acres)	4 856 522	5 545 496
5. No. of houses damaged	1 940 676	3 296 345
6. No. of human lives lost	1 470	1 517
7. No. of livestock lost	34 162	297 986
8. No. of poultry lost	335 595	410 000
9. No. of educational institutes damaged	3 738	9 099
10. Roads Damaged (Miles)	24 158	96 531
11. No. of bridge/culvert damaged	3 429	2 397
12. Embankments damaged (Miles)	1 272	2 657

[1] Joint Secretary, Ministry of Relief, Government of Bangladesh, Dhaka.

2. Cyclones and storm surge

The Bay of Bengal is in the south of Bangladesh. Depressions form in the Bay during pre-monsoon, monsoon and post-monsoon periods. leading to cyclones. These cyclones are associated with heavy rainfall, gusty wind and sometimes with storm surges. Severe cyclones cause heavy damage to life and property of the affected people. Storm surges have been responsible for terrible loss of lives in the past. Bangladesh is hit by cyclones each year. In some years severe cyclones affect the country. The consequences of cyclones of some years are given below:

Table 14. Consequences of three major cyclones in Bangladesh, 1970-1989

	1970	*1985*	*1989*
1. No. of districts affected	5	9	33
2. No. of Upazila affected	99	30	71
3. No. of population affected	600 000	167 500	346 087
4. Area affected (in sq. miles)	9 056	720	N.A.
5. Crops damaged (in acres)	1 100 000	126 090	77 341
6. No. of houses damaged	3 350 000	17 230	32 181
7. No. of human lives lost	250 000	10 000	573
8. No. of livestock lost	470 000	602	45
9. No. of poultry lost	N.A.	1 428	2 020
10. No. of educational institutes damaged	N.A.	N.A.	N.A.

C. Forecasting and warning

An organization has been built up to collect on a day-to-day basis, from April to October, data on water level in the rivers and its impact on the basins. The flood forecasting office has 35 field centres to collect data and is equipped with computers. It is being further strengthened with foreign assistance.

Elaborate and co-ordinated arrangements to predict intensity and course of a cyclone have been developed since 1970. The Meteorological offices have been strengthened, scope for gathering data from neighbouring countries has been created and, above all, a space research centre has been put to use to collect satellite imagery on the cyclone and its movement. Electronic media are widely and extensively used to disseminate warning well in time.

D. Disaster prevention and preparedness

Bangladesh, being a flat country with very low elevation from the mean sea-level, has very limited alternative measures for flood control. It has been established through decades of experience that the best and the most suitable measure for flood control in Bangladesh would be construction of embankments along river banks and maintenance of the drainage capability of the rives and their tributaries. Dredging of the rivers is also useful, though this would be very expensive. Re-excavation of rivers/canals by manual labour is more economic since the country has cheap labour.

The planners over the decades have sought to reduce the impact of floods by providing protection to populated areas through protection measures such as afforestation, changed land use patterns or attempted reduction of susceptibility to damage by flood forecasting, flood warning, evacuation, and construction of roads and highways above the flood level. They have also worked to reduce the human distress through emergency relief and rehabilitation.

Over the decades millions of taka have been invested to construct over 6 000 km of embankments, improving the carrying capacity of 4 300 km of drainage channels. Some areas have thus been protected against flood.

The Government plays a key role in disaster mitigation in Bangladesh. All the key ministries are involved.

As such the Government has issued "Standing Orders for Flood" detailing the functions and responsibilities of different ministries, field offices and local Government institutions. The instructions cover the functions and responsibilities for emergency relief as well as rehabilitation.

As in the case of flood disaster management, most of the key ministries as well as field offices, local Government institutions in the affected areas are involved in mitigating disaster. The Government has issued "Emergency Standing Orders for Cyclone" detailing the responsibilities of the concerned functionaries and offices. The emphasis is obviously on reducing loss of life and property by issuing timely warnings and by evacuation if need be, and taking preventive measures against disease and famine.

In collaboration with the International Red Cross and Red Crescent Societies, the Government of Bangladesh has been running a Cyclone Preparedness Programme since 1972. The programme has installed wireless communications in 24 sub-districts of 12 districts which have been identified to be more prone to cyclone disaster and has raised a volunteer corps of over 20 000 volunteers to ensure dissemination of warnings, to arrange for evacuation, provide basis food and medicine, and also assist in post-disaster survey of loss and damages

Immediately after the disaster, arrangements are required to provide food and employment to the affected people. The Ministry of Relief as well as NGOs take up the following: relief operations in the area; food for distressed women; wheat/rice as food for work to get rural roads repaired.

According to estimates, over 7 million people live in the cyclone belt. Over 98 per cent of the people of the belt live in thatched houses which can hardly withstand cyclones of severe intensity. Moreover, everything including the homestead may be washed away by the storm surge. For safety of the evacuated people, therefore, a large number of shelters were built for them and their cattle. With foreign assistance, about 300 shelters and two thousand "killers" - earth mounds - have been constructed for over 30 000 people. Although inadequate, they are still useful. More such shelters will contribute to saving more lives.

Severe cyclones lash the coastal belt. Storm surge, too, hits the area often. It is thought that a forest belt along the coast could contribute to minimizing loss of life and property. Hence the mangrove afforestation project has been taken up. Implementation of the project has been continuing. To protect the coastal belt from storm surge, the Water Development Board, with foreign assistance, has also constructed embankments along the coast. This has so far resisted incoming storm surge to a great extent and thus saved lives and property inland.

Regular drills to increase the effectiveness of the voluntary corps have not been taking place. Besides, owing to the short time gap between warning and dissemination, evacuation of people and their cattle becomes difficult, if not impossible. The number of shelters with accommodation for a limited few cannot really provide safety for millions. The need for an emergency relief and rehabilitation fund is hardly ever met adequately. The vulnerable groups remain vulnerable and get much less assistance then they deserve.

E. Disaster relief

Measures include relief and rehabilitation of the distressed people. To formulate mitigation measures involving relief and rehabilitation, a National Disaster Council has been set up with the President as its chairman. The objective of setting up the Council is to assess the overall situation regarding disasters and initiate short, medium and long-term measures to mitigate suffering and manage any disaster crisis. In addition, there is a National Co-ordination Committee for Flood Emergency headed by the Minister of Relief with other key ministries represented on the Committee. The Council and the Committee are assisted by the flood control and monitoring cell set up in the Public Division of the President's Secretariat and the Ministry of Relief. Besides, in the UNDP office in Dhaka, the United Nations Inter-Agency Working Group on Disasters was formed to keep the participants informed of disaster situations and assess the need for external assistance and request for the same.

The colossal loss of life and property in the flood of 1988 once again necessitated international efforts to contain floods in Bangladesh. The World Bank has come up with a Flood Action Plan composed of 26 programmes involving studies on community-based flood preparedness, flood fighting, etc. and some pilot projects. It is expected that the programmed activities will be completed by 1995. The success of the programme will further strengthen the mechanisms for coping with flood disaster in the country.

F. Community response to disasters

In Bangladesh, rural communities are not, generally speaking, well organized, although attempts are now being made to organize them institutionally. Clubs are springing up in rural villages, co-operatives of landless or land-owning farmers are being formed, and, above all, authority is being given to village councils to ensure people's par-

ticipation in development and mitigation efforts. In past years, involvement of the large rural community in mitigation efforts has obviously been sporadic and isolated. Community participation has been mostly marked during disaster, to a limited extent in the post flood/cyclone rehabilitation, but significantly not much or at all during the pre-disaster preparatory stage.

During the severe flood of 1988 the wealthy came to the assistance of the affected people with food, clothing and medicines in the camps established either by the local communities themselves or by the administration. Well-to-do families made significant contributions to mitigate hunger in many camps, sometimes on a sustained basis for days.

Political parties organized their workers to collect and distribute relief goods to the affected people all over the country even in remote areas. They also helped in improving the sanitary situation in the camps, in distributing water-purification tablets or medicines to counter water-borne diseases.

The students and industrial workers, mainly in the affected urban or semi-urban areas, have, like the political workers, got involved in mitigation efforts. They raised the consciousness of the nation and raised funds for relief work in the distressed areas.

At several places where breaches in the embankments threatened the properties and lives of the people, the entire community, young and old, including women and children, did their best to plug the breaches and save the community.

The rural population have very limited access to institutional credit. In the post-disaster period with their means of subsistence partially damaged or totally destroyed, the rural communities' need for credit is mostly met by friends, relatives, neighbours or village leaders. The have-nots do pay a price for such credit. But where survival is at stake, no price can be considered high.

It is true that public participation in disaster mitigation is the most important coping mechanism, if this can be effectively deployed. The areas where the rural community could be fruitfully utilized are: (i) creation of awareness about flood and cyclone or any other disaster; (ii) formation and training of groups for disaster management; (iii) mobilization of local flood-fighting groups; (iv) evacuation; (v) co-ordination of relief and rehabilitation. To ensure people's participation in these areas, it is necessary to localize disaster management and develop an institutional framework.

In Bangladesh, as already stated, emphasis is being given to decentralize mitigation functions to the local level, so as to enable the community at the grassroots level to take care of any disaster,with the central authority providing guidance, training and resources. The sub-district councils along with union and local organizations can play a vital role in Bangladesh. These local Government units should locally plan and coordinate, procure resources to build up stocks of relief goods and an emergency relief fund. They will install their own local warning systems (for flood or cyclone), arrange for dissemination of warnings, mobilize volunteers for flood fighting, evacuation and distribution of emergency relief, and finally rehabilitation. There is a programme to recruit 25 000 volunteers for management of flood disasters to take care of the affected people from pre-disaster preparation to post-disaster rehabilitation.

III. ATMOSPHERIC DISASTERS IN CHINA AND COUNTERMEASURES

by Wang Ang-Sheng, Fan Zhen and Xin Miao-Xin[1]

A. Introduction

China is one of the countries which frequently suffers from natural disasters. High economic losses caused by natural disasters every year seriously hinder economic development. Of all the natural disasters, atmospheric disasters are the most serious. They occur frequently, affect large areas and cause enormous losses. Therefore, it is a very urgent task to learn more about atmospheric disasters and undertake further studies on how to forecast and prevent them effectively. In this paper, research work on some major atmospheric disasters is presented and some countermeasures on how to forecast, prevent and reduce them are also mentioned.

B. Natural disasters and prevention measures

1. Heavy rainfall and floods

The heavy rain and ensuing flooding and waterlogging are major natural hazards experienced in China. The maximum 24-hour precipitation exceeds 400 mm, both in plain and hilly lands. The extremely heavy rainfalls reaching or exceeding 1 000 mm have occurred not only in the coastal areas but also in the inland, even in the desert region of China. Therefore China is a country where heavy rain and extremely heavy rain are experienced frequently. There were many great disasters due to flooding and waterlogging caused by heavy rains in the history of China.

According to the statistics from 1951 to 1980, South China, the Hunan and Hubei Basin, the east coastal area, the Huaihe valley and Haihe valley were areas in which flooding and waterlogging appeared once or twice in two or three years on the average. The other districts frequently affected by flooding and waterlogging were in the Liaobe River, Yellow River and Hanshui River areas. The most famous and heavy disasters of flooding and waterlogging in the history of China were experienced in those areas.

At least 147 larger floods and waterlogging events occurred during the last 2188 years in the Yellow River valley and 187 events during the last 1889 years in the Changjiang River valley.

The extremely heavy rainfall, flooding and waterlogging causing disaster in Henan Province were caused by typhoon No. 7503 in August 1975. Its hourly and other duration rainfalls; even three-day precipitation, were the highest in the meteorological record of the interior of China. The amount of rainfall that fell in 3 days was above 1 600 mm, causing two large type and ten middle or small type reservoirs to burst at the same time. The death toll may have reached over 100 000. It was the second largest disaster, causing the highest number of deaths, after the Tangshan earthquake.

The extremely heavy rainfall next in magnitude to that of August 1975, occurred at the foot of Taihang Mountain in the first 10 days of August 1963. It caused extremely widespread flooding in Haihe River valley where 3.8 million ha of cultivated land were waterlogged, causing heavy losses to crops and to the economy (Tian Sheng-Chun and others, 1990).

2. Prevention measures for heavy rain and flood loss

The accurate forecast of heavy rain is a basis for disaster reduction. Accurate forecasts minimize heavy losses. For example, at the beginning of the last 10 days of July 1983 the Department of Meteorology made a middle-range forecast that there would be a middle to heavy rain, and heavy rain at Ankang area from the 27th to 29th. Again on 26th they made a forecast that the heavy rainfall would appear at southern Shanxi Province and northern Sichuan Province with local extremely heavy rain. On the 31st, based upon both meteorological and hydrological forecasts, the executive branch of Shanxi government made a resolute decision that the citizens in Ankang City were to be evacuated quickly. Most of 10 000 people in the city were evacuated to a safe place, avoiding unnecessary injuries and large loss of lives, and minimizing economic losses.

The above case confirms that forecasting for heavy rain can play an important part in protection from resulting flood disaster. For reduction of and protection from flooding, some suggestions are as follows:

[1] All of the Research Committee of Natural Disaster, Academia Sinica, Beijing, China.

The studies for ascertaining the regularity of flood and waterlogging for each main river must be intensified; basic studies must be undertaken on the development and occurrence of heavy rain; advanced technologies such as satellite and radar in observing the occurrence and development of clouds that result in heavy rainfall and flooding must be adopted; advanced technologies in communication should be utilized to guarantee each department can get any necessary information on heavy rainfall and flooding correctly and quickly as early as possible.

C. Typhoons and loss prevention measures

1. Typhoon disasters in China

The north-western Pacific, that is the area east of China, is the sea area where the largest number of typhoons occur. Every year, typhoons occurring in this area make up about one-third of the total number of typhoons all around the world. China is affected most heavily and has the largest number of landing typhoons in the world.

Typhoons, the weather systems that cause very serious disasters, also produce the most severe rain. The world records of precipitation of duration from 12 hours to 7 days, as well as the highest records in China, were all caused by typhoons/tropical cyclones. Table 15 shows the world records and the highest records of rainfall in 17 coastal or inland provinces and cities in China in 24 hours and 3 days and the weather systems causing them (Cai Ze-Yi, 1990).

In addition to causing the heaviest rains in many cities and provinces, typhoon-based rainfall also makes up a great part of the total rainfall received in China in summer months. The ratio of the precipitation caused by typhoons in July, August and September is always over 50 per cent of the total annual rainfall in coastal areas such as south Zhejiang, Fujian and Guangdong provinces. The highest value recorded was 76 per cent in east Guangdong and the percentage decreases with the distance inland from the sea. The average monthly rainfall in China generally shows one maximum in a year such as in Beijing. Moreover, there are always two maximums in southern and south-eastern coastal areas, such as Hangzhou, Guangzhou, Fuzhou, the other high monthly rainfall usually appearing in August or September and, caused by typhoons (Cai Ze-Yi, 1990).

2. *Preventive measures to reduce typhoon effects*

The measures to prevent and reduce the effects of disasters caused by typhoons must be based on accurate weather prediction which means to predict the position and strength of the typhoon accurately 24-27 hours ahead. This will offer opportunities for the government to select appropriate defensive measures. Correct prediction can being great benefits. For example, typhoon No. 8607 landed at the east part of Guangdong Province on 11 July 1986. About 72 hours before its landing, an accurate prediction had been made by meteorological observatories of Fujian Province and Guangdong Province. The governments issued orders in time to take necessary measures for reducing the effects of the disaster. It was estimated that the reduction in economic loss was over one billion yuan, in Guangdong Province alone.

Two measures can be adopted in order to increase the accuracy of the prediction. One is to improve the observation to give the right position and intensity of the typhoon. These are very important for accurate prediction. Another is to develop scientific research on typhoons, especially on those with abnormal character. The research should be mainly concentrated on their moving direction and speed, intensity and mechanism of rapid weather change. Based on the research, effective methods of prediction are to be found to reduce effects of disasters caused by typhoons.

D. Hail

1. Disasters due to hail in China

China is a country which suffers frequently from disasters due to hail. Hail disasters have caused economic losses ranging from several hundred million to more than a billion yuan (RMB) on the average per year. In 1987 more than 2 000 counties in China were hit by hailstorms which damaged a total area of over 5 million ha, and destroyed houses with a total of 1.08 million rooms, and injured more than 10 000, killing about 400 persons, and causing a direct economic loss of over 1.1 billion yuan (RMB) (Wang Ang-sheng, 1990b; Huang Mei-Yuan and Wang Ang-sheng, 1980).

In China hailstones fall more on mountain areas than on plains, inland and coastal areas. There are as many as 33.7 days with hail every year in Heihe, Tibet, and about 25.3 days in Zhaduo, Qinghai Province. Though they fall frequently, these hailstones do not bring about much damage because of their small size and sparse population in those vast territories.

There are more hail falls, averaging a few days yearly, on Yinshan, Taihangshan, Tianshan, and Changbaishan mountain areas as well as Yungui Plateau, where hailstorms are more frequent and disastrous.

People have already discovered some ways to reduce hail hazards in the long-time struggle against hailstones.

Table 15. The maximum recorded rainfall in 17 provinces and cities in eastern and central China

No.	*Province*	*Site*	*Date*	*Rain (mm)*		*Weather System*
				24-hr	*3 days*	
1a	Taiwan	Xinliao	17 October 1967	1672	2749	Typhoon Carla (6718)
1b	Taiwan	Paishin	11 September 1963	1248	1684	Typhoon Gloria (6312)
2	Henan	Linzhuang	7 August 1965	1060	1605	Typhoon Nina (7503)
3	Hebei	Zhangmo	4 August 1963	950	1458	SW vortex
4	Guangdong	Shantou	30 May 1977	884	1461 **	Low-trough
5	Hainan	Ledong	13 June 1974	783 *	912 *	Typhoon Dinah (7406)
6	Fujian	Gaoshan	21 June 1974	733	765	Vortex
7	Hubei	Duzhenwan	8 August 1975	685	685	Typhoon Mina (7503)
8	Hiangsu	Dafengzha	21 August 1965	673	917	Typhoon Mary (6513)
9	Guangxi	Laohutan	11 July 1960	658	1036	Vortex
10	Liaoning	Heigou	7 August 1921	657	794	Typhoon Opal (6208)
11	Shanghai	Tangqiao	21 August 1977	591	592	Typhoon Amy (7707)
12	Zhejiang	Shilin	1 August 1956	564	688	Typhoon Wanda (5612)
13	Anhui	Zilaiqiao	17 August 1975	593	809	Typhoon Ora (7504)
14	Shandong	Shifuzi	12 August 1975	499	572	Tphoon Lucy (7412)
15	Jiangxi	Dongxiang	17 August 1953	499	553	Typhoon Nina (5310)
16	Beijing	Zaoshulin	27 July 1921	479	518	Typhoon Rita (7203)
17	Hunan	Meicheng	26 August 1955	423	553	Typhoon Iris (5519)
La Reunion Island-Highest (South Indian Ocean)			15 March 1952	1870	3240	Tropical cyclone

* Rainfall of one day

** Rainfall of five days

In China hailclouds are usually identified by radar and lightning characteristics. On the basis of considerable research undertaken on the subject, 85-90 per cent accuracy has been gained using radar in distinguishing hailclouds by size, strength and characteristics of echo waves as well as correlation between echo waves and temperature. Scientists in China have also made good efforts in distinguishing hailclouds by using lightning information and by using acoustical principles.

Having worked for a long time scientists finally discovered a scientific method called artificial hail suppression, which aims at reducing the size of hailstones or changing hail embryos to raindrops by altering the hail growing process, in order to prevent hail damage. In a period of more than 20 years significant achievements have been made in artificial hail suppression under the leadership of authorities at all levels and with the direct leadership and participation of scientists in the Institute of Atmospheric Physics, Academia Sinica and the Lanzhou Institute of Plateau Atmospheric Physics. The artificial hail suppression system, characteristic of China, has been gradually set up and it has been helpful in contributing to hail disaster reduction, which has been very welcome by the people in hail hazard prone areas. In some areas about 50 per cent of the hail hazard has been reduced by artificial hail suppression (Huang Mei-Yuan and Wang Ang-Sheng, 1980).

In addition to the above, thunderstorms, blizzard winds, strong wind storms and tornado storms are also very dangerous natural disasters, usually causing terrible results (Wang Ang-Sheng, 1990a).

E. Conclusion

Regulations and distribution features of some major atmospheric disasters in China, and loss prevention measures taken respectively were described. Although it may not be possible to control or prevent some disasters from taking place because of limited scientific and technological knowledge at present, the losses caused by them can be reduced as long as policies, mechanisms and regulations are well prepared and accurate forecasts of time and intensity are made. Every precautionary measure for fighting against disasters and rescue work will be required.

References

Cai Ze-Yi, 1990. Calamities caused by Tropical Storms in China. *In Natural Disasters in China*. Beijing, Academic Book and Periodical Press.

Huang Mei-Yuan and Wang Ang-Sheng, 1980. The Introduction of Hail Suppression. Beijing, Scientific Press.

Tian Sheng-Chun and others, 1990. The heavy rainfall and disaster of flooding and waterlogging in China. In *Natural Disasters in China*. Beijing, Academic Book and Periodical Press.

Wang Ang-Sheng, 1990a. Atmospheric Storm and its Disasters in China. *In Natural Disasters in China*. Beijing, Academic Book and Periodical Press.

Wang Ang-Sheng, 1990b. Hail Damage in China. In *Natural Disasters in China*. Beijing, Academic Book and Periodical Press.

IV. TYPHOON DISASTERS AND PREVENTIVE MEASURES IN CHINA

by Fan YongXiang[1]

Typhoons and tropical cyclones are among the most severe natural disasters in China. The characteristics and causes of typhoon disasters are analyzed below and a summary assessment is given of the country's capability in typhoon monitoring, forecasting, and warning dissemination. Finally, preventive measures against typhoon disasters are proposed.

A. Introduction

The large territory of China lies over three climatic zones: tropical, extratropical and cold from south to north. East China faces the Pacific Ocean, and the Qinghai-Tibet Plateau — known as "the roof of the world" — is location in west China. Monsoon and strong continental climates are distinctive features of China with complicated geography, variable climate and changeable weather. Various natural disasters have frequently been experienced in China. Relatively weak economic strength, multitudinous population, inadequate storage of materials, low transport capability, economic activities dependent on natural factors and low capability in disaster prevention and disaster support, place China among countries suffering most from natural disasters in the world. Many different types of natural disasters, such as meteorological, oceanic, flood, geologic, seismic, plant diseases and pests and forest fires are all experienced in China.

Meteorological disasters are the most severe of natural disasters. Among the 10 major types of natural disasters listed by the United Nations (table 16), about eight types are of a meteorological nature, having caused up to 62.9 per cent of the total number of deaths brought about by natural disasters. Typhoons caused the highest death toll, 199 000 people, 41.1 per cent of the total deaths. Figure VI shows the frequency distribution of natural disasters in selected Asian countries over the period 1964-1986. The highest percentage, over 62 per cent, was due to meteorological disasters, typhoons causing 32 per cent of total deaths.

In China, the meteorological disasters were caused mainly by typhoons/tropical cyclones, heavy rain resulting in floods and waterlogging, drought, heat waves and dry-hot wind, cold and freezing, severe convection (such as thunderstorms, hail and tornado), continuous rain and thick fog (table 17). Meteorological disasters have always brought great destruction of lives and property and socio-economic problems in China. During the period 1951 to 1988 on average 25 major meteorological disasters were experienced annually in China (table 18). In general, every year about 40-47 million hectares of fields have been affected and about 20 million hectares of crops were damaged (causing a reduction of more than 30 per cent of total crop production) and 20 billion kg of grains were lost. About 3 million houses were destroyed. These two categories of damages alone caused about 10 billion yuan of direct economic loss every year. More than 200 million people were affected and 5 000-10 000 people were killed each year. The amount of total damages would become much more severe, if all the losses to stock raising, fishing, forest, industry, communication, transport and navigation, caused by meteorological disasters, were counted.

Table 16. Ten major types of natural disaster and lives lost from 1947 to 1980

No.	*Natural Disaster*	*Persons Dead (million)*
1	Tropical cyclone (Typhoon, Hurricane)	49.9
2	Earthquake	45.0
3	Flood	19.4
4	Thunderstorm, Tornado	2.9
5	Snowstorm	1.0
6	Volcanic eruption	0.9
7	Heat wave	0.7
8	Snowslide	0.5
9	Landslide	0.5
10	Storm surge, tide tsunami	0.5

[1] State Meteorological Administration, People's Republic of China.

Table 17. Meteorological disasters

1.	Typhoon Tropical cyclone	→	rainstorm strong gale	→	flood storm surge storm tide	landslide debris flow avalanche
2.	Rainstorm Heavy rain	→	floods waterlogging	→	landslide debris flow avalanche	→
3.	Drought Heat wave Dry-hot wind	→	disease pest desertification forest fire	→		
4.	Cold Freezing	→	chilling damage frost bite freezing rain snow storm cool summer damage cool-wind injury strong wind	→		
5.	Storm squall Thunderstorm Tornado	→	local strong wind local heavy rain hail storm		local flood landslide debris flow avalanche	→
6.	Continuous rain	→	disease pest	→	agriculture transport	
7.	Thick fog	→	fog lightning pollution	→	industry navigation	

SOCIO-ECONOMIC DISASTER

- Agriculture
- Industry
- Transport
- Navigation
- Water-conservancy
- Persons Dead and Injured

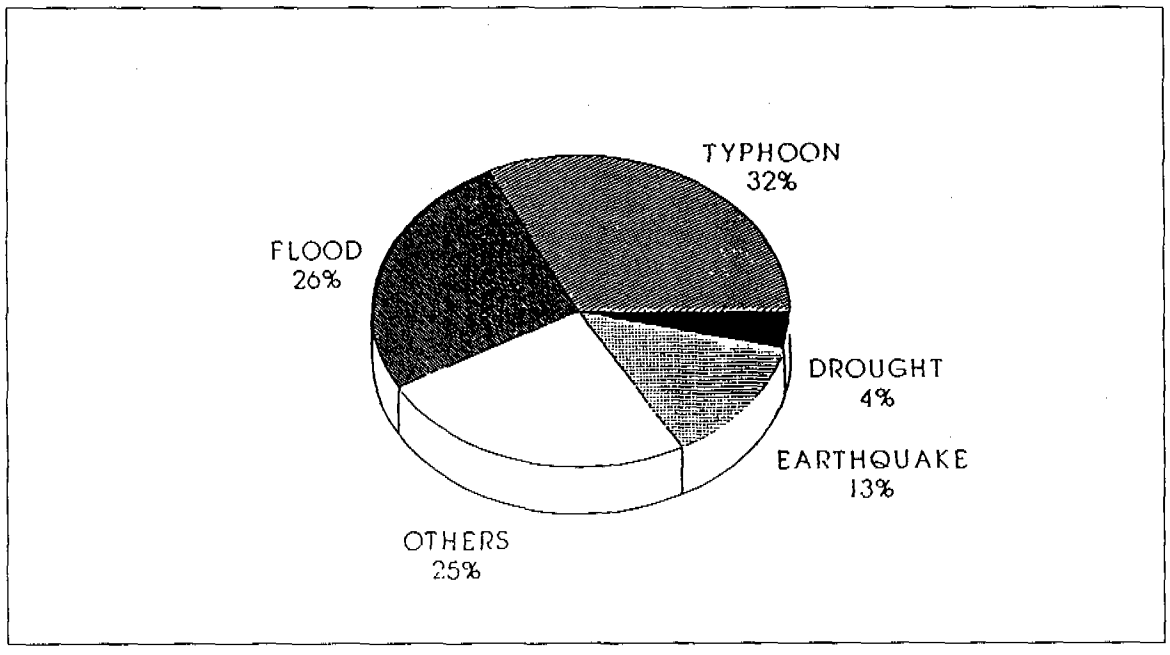


Figure VI. Fequency distribution of natural disasters in selected Asian countries over the period 1964-1986

Table 18. Occurrence of major meteorological disasters experienced in China by type (average per year 1951 to 1988)

	Landfall typhoon	*Rainstorm flood*	*Drought*	*Dry-hot wind*	*Freezing*
1951	3	3	9	2	lack
1952	9	5	4	2	lack
1953	7	3	8	2	2
1954	5	5	3	0	2
1955	4	3	8	2	2
1956	7	8	5	1	2
1957	5	3	7	1	2
1958	7	5	6	1	3
1959	6	4	6	1	3
1960	8	9	7	3	2
1961	11	6	4	3	2
1962	7	6	10	3	2
1963	7	10	10	0	3
1964	7	9	5	1	2
1965	8	7	7	3	3
1966	8	6	10	1	2
1967	11	4	8	3	3
1968	5	5	6	3	2
1969	5	5	6	1	3
1970	5	6	8	1	2
1971	12	10	9	3	2
1972	6	5	10	2	7
1973	9	8	7	1	2
1974	11	5	9	3	7
1975	7	7	11	3	3
1976	5	7	9	1	2
1977	5	4	11	1	6
1978	6	5	10	2	3
1979	5	6	9	2	3
1980	9	6	9	1	2
1981	8	6	6	1	3
1982	4	7	3	1	5
1983	5	4	6	1	2
1984	8	5	5	0	3
1985	9	5	7	1	2
1986	6	5	10	1	3
1987	5	7	8	1	6
1988	6	8	9	0	3
Total	106	222	285	59	106
Average annual	2.8	5.8	7.5	1.6	2.8

The disasters brought upon by typhoons not only play a prominent role among meteorological disasters in China, but also cause the greatest number of deaths among the world's natural disasters. Table 19 presents an estimate of typhoon disasters sustained by some members of the Typhoon Committee recently. Every year typhoons bring about severe economic damage and losses of lives on the continent and the adjacent sea area of China.

The characteristics and causes of typhoon disaster will be analyzed in this paper. A summary introduction and assessment of monitoring measures, forecasting techniques and typhoon warning dissemination are presented. Finally, preventive measures for typhoon disaster reduction are proposed.

B. Characteristics and causes of typhoon disasters

Typhoons form in warm seas and have a vortex with the lowest atmospheric pressure at the centre. The rotation of a typhoon or cyclone is anticlockwise in the northern hemisphere, and clockwise in the southern hemisphere. The maximum sustained wind near the typhoon's centre is an indication of its intensity. The intensity of the tropical cyclone is classified as follows in accordance with WMO Guide to Marine Meteorological Services (WMO - No. 471) and WMO Manual on Marine Meteorological Services (WMO - No. 558):

(1) Tropical depression: maximum wind speed is up to 17.2 m/s and less than 8 wind force (Beaufort Scale);

(2) Tropical storm: maximum wind speed is 17.2-24.4 m/s and 8-9 wind force (Beaufort Scale);

(3) Severe tropical storm: maximum wind speed is 24.5-32.6 m/s and 10-11 wind force (Beaufort Scale);

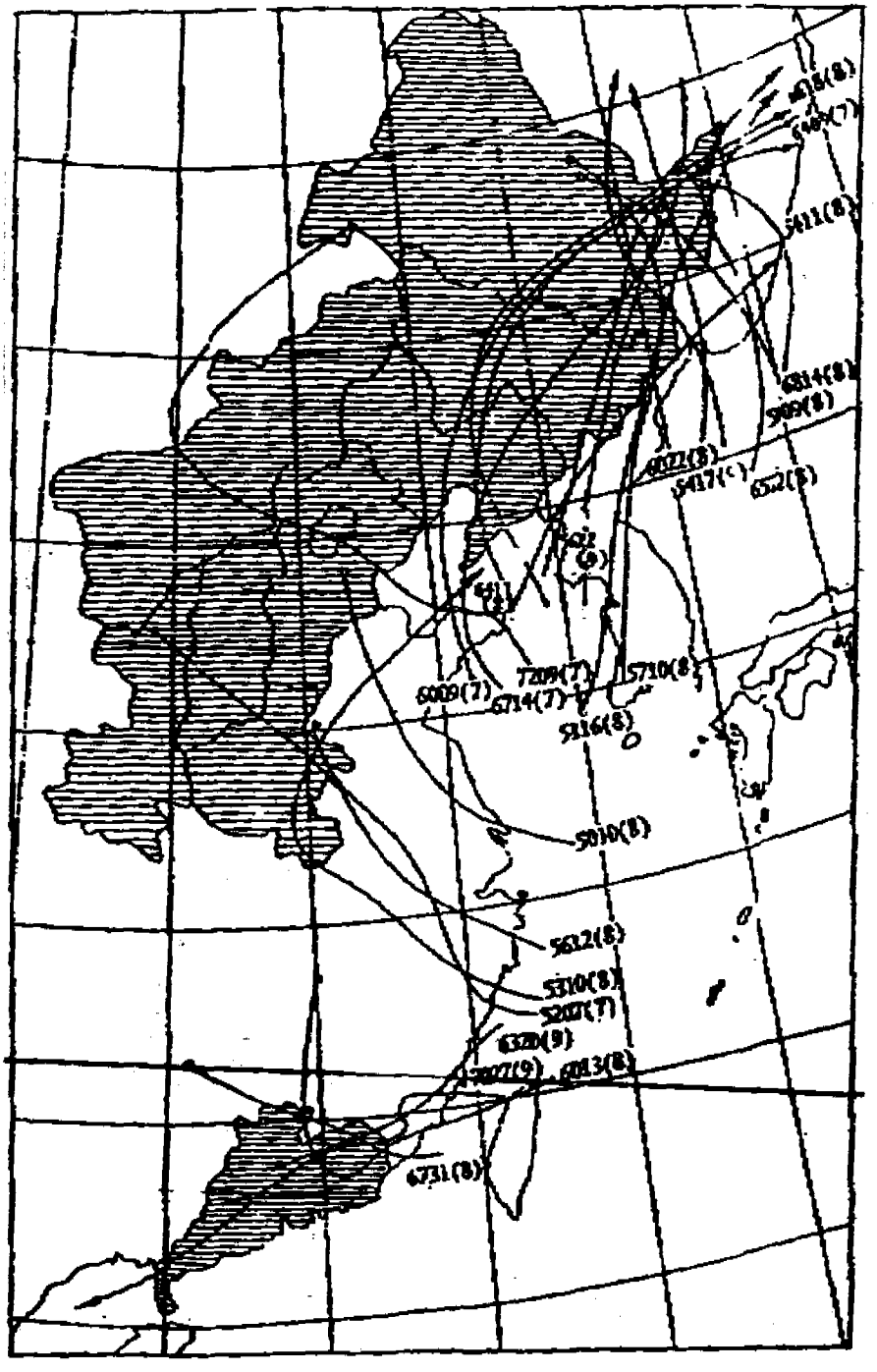
(4) Typhoon: maximum wind speed is 32.7 m/s or more; and 12 wind force (Beaufort Scale).

All of the above are generally called "Tropical Cyclones". In China the international terminology and classifications of tropical cyclones were adopted with effect from 1 January 1989, but "Tropical Cyclone" is traditionally called "Typhoon" in China.

There were 28.3 tropical cyclones with maximum sustained wind speeds of more than 17.1 m/s on an annual average from 1949 to 1985 over the western North Pacific. Some of the strongest typhoons, with wind speeds of up to 110 m/s and with the largest size (the areal extent of winds above gale force or 17 m/s), occurred over the western North Pacific.

Table 19. Typhoon disasters sustained by some members of the Typhoon Committee (1985-1988)

	Typhoon number	*Dead*	*Persons missing*	*Injured*	*Economic loss (in million $US)*
China	22	1 942	52	13 896	1 837.68
Hong Kong	9	9	2	103	2.04
Japan	16	116		666	208.80
Malaysia	4				
Philippines	20	2 028	258	2 111	743.57
Thailand	4	14			5.07
Republic of Korea	11	583	10	303	386.70
Viet Nam	8	1 432	145	2 704	31.00
Total		6 124	467	19 783	3 214.86



Map 3. Inland typhoon tracks affecting North China

Although the highest wind speed of 200-250 m/s appears in the tornado, its size is less than 1 km. The extent of wind force 12 Beaufort Scale near a typhoon centre has a diameter of 160 km on average and the extent of wind force 7 Beaufort Scale has a diameter of 650 km. Some super-size typhoons have a diameter of 1 600 km. The lifespan of a tornado is usually less than an hour, whereas the lifespan of a typhoon or tropical storm is 5-9 days. The forward speed of a typhoon is about 20 km/hr, and distance travelled reaches about 4 000 km or longer affecting large areas. Some characteristics of typhoon disasters, due to special geographic and circulation conditions in China, are as follows:

1. High frequency

About 7 tropical cyclones with maximum winds of over 17.2 m/s in China each year, and annually about 20 tropical cyclones on the average, appear on the adjacent sea areas. China is one of the countries most seriously affected by tropical storms in the world.

2. Period of effect

The typhoons occur in China during the period from May to December, and the period of typhoons affecting the adjacent sea areas is almost from January to December. Possibly China is the country which is under typhoon effect for the longest period annually in the world.

3. Areas affected

The data of 32 years (1949-1980) show that typhoons may occur anywhere along China's coastline and the adjacent sea areas. In general, a tropical storm rapidly dissipates after landing. Some typhoons often maintain their circulation for 2-3 days, and do not dissipate quickly when they move inland. China's inland area, with the exception of the north-west portion, is also within the effective range of tropical storms. Most areas of China are exposed to typhoon hazards (map 3).

4. Burstability

The burstability of typhoons along China's coastal areas shows mainly three aspects, namely: violent winds, rainstorm and storm surge. Maximum wind speeds may reach up to 50-60 m/s, which can capsize large ships, destroy houses and uproot trees in a short time. The data for 27 years (1953-1979) show that the rainstorms (over 400 mm per day) caused by typhoons are mainly experienced in the coastal areas (map 4). These heavy rainfalls may result in flash floods, destruction to reservoirs, waterlogging, landslides, debris-flow and avalanches within 48 hours. The storm surge also often causes catastrophes within 24 hours.

In addition, the burstability of typhoon disaster over China's inland areas mainly shows the abrupt increase of rainfall amount. Increasing precipitation is generally over 100 mm in 24 hours. Sometimes it even reaches 500-800 mm or more per day. More severe hazards often occur in the region of severe rainstorm and flash floods caused by typhoons inland. For example, Typhoon Nina landed on the coast of Fujian province on 4 August 1975, moved inland for two days, weakened to a tropical depression and became nearly stationary on 7 August. Typhoon Nina brought about 1 062 mm precipitation in 24 hours, 685 mm in six hours and 189.5 mm in one hour. The maximum total three days cumulative rainfall for 5-8 August amounted to 1 605 mm at Linzhuang, Henan province. The severity of this rainfall resulted in the ruin of two big reservoirs and several small reservoirs and caused a devastating flood, destroying 102 km of the Beijing-Guangzhou railway.

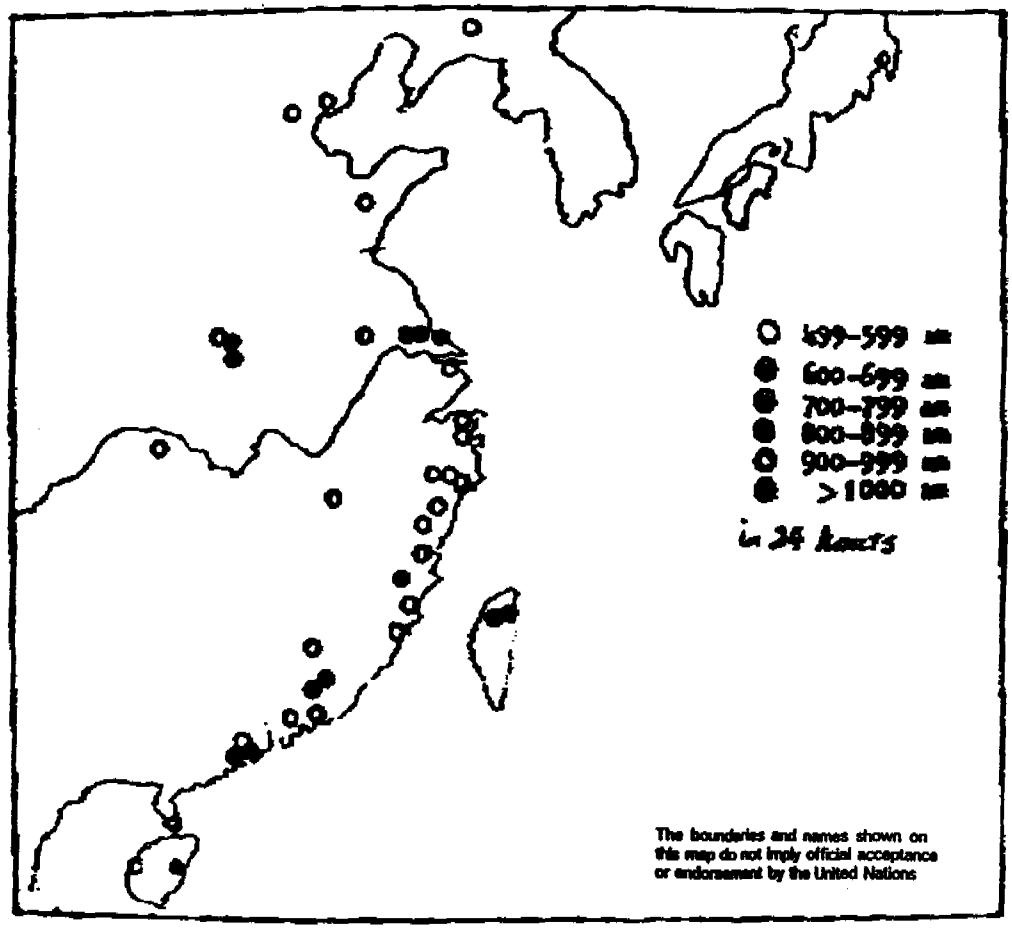
5. Swarmability

Typhoons not only bring severe winds, but also cause a variety of other natural disasters, such as rainstorm, storm surge, high waves, floods, waterlogging, landslides, debris flow, environmental pollution and epidemic disease.

The swarmability of typhoons is that several typhoons may strike the same region during a short period. For example, three tropical storms continuously struck most parts of north-east China from 2 to 21 August 1985, causing severe flooding and waterlogging. Hainan province suffered seriously from four consecutive typhoons in October 1989. Three typhoons continuously attacked over Zhangjiang province during a period of 10 days from 30 August to 8 September 1990, caused serious rainstorms and resulted in severe floods and waterlogging. About 867 000 hectares were destroyed or damaged, 264 people were killed and 1 182 people were injured. About 90 000 houses were destroyed. One thousand four hundred million kg of grains were damaged. The total damage was estimated to be $US 748.56 million. Two typhoons landed over Fujian province during a period of six days from 24 to 29 June 1990, and three typhoons attacked the region again for 20 days from 20 August to 8 September 1990. Losses totalled about $US 767.5 million.

6. Severity

Heavy financial losses have been sustained by the ESCAP/WMO Typhoon Committee Members every year. There were 59 tropical cyclones, which affected Members from 1985 to 1988, of which 52 caused severe damages. The highest percentage of damages was experienced in



Map 4. The distribution of severe rainstorm caused by typhoons in China (1953-1979)

China (see table 19) with an estimated economic loss of about $US 1 837 million over this period. A death toll of 1 942 people in China was second only to the Philippines. Incomplete statistical data for eight years (1982-1989) show that about 420 people per year on average lost their lives due to typhoons in China and the annual average (over five years) economic loss reached RMB 3.2 billion yuan (see table 20). In 1990, tropical cyclones caused a death toll of over 570 people, exceeding the average number, and the total economic loss was over RMB 7 billion yuan, three times as much as the average losses for earlier years.

C. Typhoon monitoring and warning

The effects of typhoon disasters may be mitigated, if the capability of the monitoring and warning are enhanced and other measures are taken. For example, a correct warning of three days before landfall over eastern Guangdong province was issued, and proper and timely preventive measures were adopted by the local government. Thousands of fishing ships operating in the South China Sea returned in time to the seaports and avoided the strong winds and high waves without a single one lost.

There are three important links in typhoon warning, i.e., the capability of typhoon monitoring, forecasting and warning dissemination.

1. Typhoon monitoring

The routine observational network, the radar network in coastal area and satellite data received are the main measures of typhoon monitoring in China. The first Chinese polar orbiting meteorological satellite FY-1A was launched on 7 September 1988. It did not fulfill the expected lifetime, and the system design and equipment performance were re-examined. After two years of study and improvement, the second polar orbiting satellite FY-

Table 20. Some statistics on disasters sustained by China from 1982-1989

Year	*Persons*			*Ships*		*Houses*		*Economic Loss (Million Yuan)*
	Dead	*Missing*	*Injured*	*Capsized*	*Damage*	*Destroyed*	*Damaged*	
1982	59	N.A.	518	926	30	335 330	1 062	N.A.
1983	228	81	1 601	103	N.A.	66 159	36 273	N.A.
1984	76	N.A.	424	31	50	93 346	77 002	N.A.
1985	1 030	354	14 075	4 236	744	834 472	2 056 065	4 234
1986	843	46	9 375	4 102	N.A.	386 347	741 011	2 782
1987	343	8	627	390	290	153 699	375 038	153
1988	229	37	1 895	1 244	970	106 809	796 616	1 389
1989	552	407	5 467	13	2 620	304 979	753 251	5 763
Total	3 360	933	33 983	11 045	5 704	2 281 141	5 897 677	15 700
Average	420	117	4 248	1 381	713	285 143	737 210	3 140

1B was launched on 3 September 1990. Up to now (February 1991) FY-1B was still operating normally. The cloud images from FY-1B are of high resolution useful in analyzing and monitoring the weather systems and tropical cyclone activities as well. The main objective of typhoon monitoring is to establish the centre position, intensity and structure of the tropical cyclone. Tropical cyclone monitoring capability of China is expected to further increase during the coming Five-Year Plan period.

2. Forecasting and warning

The operation forecast level of China is up to the "official forecast" level of most countries of the world. The mean forecast errors are about 200 km/24 hr and 400 km/48 hr. Beginning in 1975, various objective methods such as dynamic, statistical-dynamic, and statistical methods have been put into operation forecasts of tropical cyclone tracks. The "official forecast" is made by experienced forecasters synthesizing all methods. Although all methods are effective for regular tracks, objective methods are not available when unusual movements appear. At present, it is a serious problem that all the techniques and methods make predictions unreliable for three kinds of unusual typhoon activities as follows:

(a) Abrupt change of typhoon track

Abrupt change of typhoon track involves two aspects of the direction and speed of unusual movement. A typhoon recurves westward suddenly when it moves northward over the East China Sea. The abrupt northward recurving and landfall take place when a typhoon is following a westward track in the South China Sea. A typhoon may suddenly accelerate and decelerate (or loop) when it is moving normally. Some typhoons with a smooth trajectory suddenly make a large departure from normal motion, which is difficult to predict. There are about 10 patterns of unusual tracks in the western North Pacific, but they have a low probability of occurrence.

(b) Abrupt strengthening along adjacent sea areas

Sometimes a tropical cyclone suddenly strengthens to a typhoon intensity along the adjacent sea area and rapidly lands over in China. It is difficult to predict this phenomenon due to short period of validity.

(c) Abrupt rainstorm

Heavy precipitation of 150 mm per day is generally caused by a typhoon landing. Sometimes typhoons move inland and make a long stay there, bringing great rainstorms of up to 1000 mm in 24 hours. It has been very difficult to predict such rainstorms.

3. Warning dissemination

The warning should be disseminated immediately to the state council and other departments of the government via facsimile, telephone or special report. At the same time, the warning must be transmitted as soon as possible to the public and persons on oil drilling platforms and ships in the adjacent sea areas via TV/radio broadcasts and newspapers.

The telecommunication of warning dissemination plays an important role in disaster reduction. Telecommunications are often cut off in disaster areas due to typhoon landing, making disaster reduction activities very difficult. The telecommunications capability of China will be expanded during the coming Five-Year Plan period.

D. Preventive measures for typhoons

The operations for natural disaster reduction have been under the special care of the Communist Party and the Government of China since 1949. State leaders showed special concern for the development and the modernization of the Chinese meteorological service. In 1954 an order was issued to strengthen the prediction, warning and prevention operations for meteorological disasters, and in 1955 preventive measures for typhoons were issued. Starting in 1956, weather forecasts were openly broadcast. The National Meteorological Centre (NMC) was established in 1973, with the aim that meteorology should serve the people. The meteorological departments at the various levels have provided quite accurate and timely weather forecasts and were highly regarded in the provinces for their combat against natural disasters and in the service to industrial and agricultural production.

In order to further enhance the operational capability of typhoon monitoring and prediction, the Typhoon Joint Prevention System (TJPS) was established in 1961 to enable data exchange, identification of best tracks, assessment of prediction and service, determination of operational objective methods, discussion of scientific problems, intensive observation and telecommunication etc. The TJPS has been playing an important role in typhoon disaster reduction.

The Chinese Government also actively responded to the International Decade for Natural Disaster Reduction (IDNDR). China's National Committee for IDNDR was established on 12 April 1989. The activities of natural disaster reduction have developed extensively in China.

Recommendations for further preventive measures in China against typhoon disasters are as follows:

(1) Establishment of united prevention guidance centre: Such a centre could improve coordination of the operations for disaster reduction and would strengthen leadership and management in handling disaster reduction activities.

(2) Formulation of preventive measures: A good preventive measures policy should be formulated on the basis of various categories of natural disasters, and on various classifications and the accuracy of disaster forecasts. Preventive measures for large rivers and reservoirs have been adopted by the central flood control department, and others have been adopted by local governments for typhoon, rainstorm and flood disasters. Moreover, the Government has mobilized and organized the masses to strengthen and repair the banks and dams and to open the spillway to avoid the collapse of the dam if the water storage is over the dangerous level. These preventive measures are still insufficient and incomplete, however. The disasters caused by typhoons often are not avoided.

(3) Improvement of the capability of monitoring, forecasting, and warning dissemination: Typhoons have the property of burstability and the track and intensity of tropical cyclones may abruptly change character. Therefore, close monitoring is very important for the unusual movement of cyclones. If such abrupt changes can be predicted early enough, track forecasting and disaster mitigation will be easier. Further development of the potential of mass media such as TV and radio broadcasts, will enhance the capability of warning dissemination.

(4) Enhancement of the consciousness and knowledge of disaster prevention among the people: Still a lot of people have fatalistic attitudes regarding disasters. Therefore, various publicity media should be employed to propagate the science and technology of disaster occurrence and prevention. A great number of people have been killed by disasters due to lack of preventive knowledge. To enhance the consciousness and knowledge of the people on disaster prevention is necessary.

(5) Improvement of legislation: Legislation plays a crucial role especially in combatting, prevention and relief against natural disasters. Existing legislation requires continuous improvement.

(6) Establishment of a disaster data collection and processing system: Confusion and incomplete disaster data may result in the lack of a united approach and inadequate scientific management, greatly affecting disaster research. Data on disasters must be collected as early as possible, and the data collection should be reviewed and reorganized, according to a strict programme of collection and processing. It is very important to establish a disaster data bank as soon as possible.

(7) Development of international cooperation: The active typhoon region in the western North Pacific and the South China Sea has no national boundaries. Typhoon disaster reduction is a common objective of all the members in the ESCAP/WMO Typhoon Committee; the Committee has developed a number of effective activities on typhoon disaster reduction during the past decade. In particular, two main activities of typhoon experiments which have received extensive and successful international cooperation, were:

From 1981 to 1983, the Typhoon Operational Experiment (TOPEX) had been developed successfully in the western North Pacific. This activity had been proposed by China and was supported by all the members of the Typhoon Committee. It contained a series of operational cooperation activities, such as intensive observation, information exchange, warning dissemination and assessment, research on the movement, intensity and structure of typhoons. It was a good starting point for international cooperation on typhoon prevention in the western North Pacific and the South China Sea.

Other extensive international cooperation on the typhoon experiment was undertaken in the western North Pacific in August-September 1990. There were three independent and cooperative typhoon experiment plans with a view to monitor the physical features of the unusual movements of typhoons and to investigate the causes of such unusual movement as well as to improve operational tropical cyclone forecasting.

The ESCAP/WMO Typhoon Committee has recently organized the experiment known as the Special Experiment Concerning Typhoon Recurvature and Unusual Movement (SPECTRUM). An experiment undertaken by the United States known as the Tropical Cyclone Motion Experiment (TCM-90) also took place in the western North Pacific around the same time as SPECTRUM. An experiment with similar objectives (TYPHOON-90) was undertaken in the region by the USSR. A total of six intensive observation periods for seven typhoons, amounting to a duration of 15.5 days, was undertaken successfully. Intensive observation data involved all the data of upper-air stations, surface SYNOP stations, marine platforms, meteorological satellite, radar, voluntary observing ships, wind profilers, weather buoys and airplane reconnaissance, which will all be exchanged and utilized jointly.

Human beings have an intensely common wish to mitigate disasters. International cooperation on typhoon disaster reduction is hoped to receive a wide perspective and better basis.

V. CHINA'S STRATEGY TO REDUCE SERIOUS NATURAL DISASTERS

by Wang Ang-Sheng[1]

The natural disasters occurring worldwide have caused economic losses of several hundred billion dollars and death of several million people in the last decade, and natural disaster reduction has been a common task lying before the peoples of the whole world.

How to establish the strategy for natural disaster reduction is one of the crucial steps for undertaking the task.

A. General strategy

Human history is a history full of struggle against natural disasters, as they have always been a main factor threatening human life and hindering the development of society. Mankind has just started making progress in fighting against natural disasters.

Currently, the rapid development of productive forces and the great progress of science and technology enable the society to overcome natural disasters much more effectively. There is still a long way to go however, to transfer the advanced methods and science and technology into effective weapons to combat natural disasters in China as well as in the world. Without such strategic transformation, it would be difficult to make significant progress in natural disaster reduction.

Today, although people cannot directly prevent serious natural hazards from occurring, it is possible to gather a series of indications before the onset of certain natural disasters.

To minimize the losses resulting from natural disasters full use of advanced science and technology must be made to gather those indications. It is necessary to organize people with a systematic programme and employ existing engineering knowledge for disaster reduction and to bring their ability and intelligence into full play under the leadership of the Government, so that a quick response can be made to the predictions, and countermeasures can be taken to reduced the adverse consequences of natural hazards.

However, it is very difficult to carry out this general strategy, because there exists a large gap in this aspect in different countries, especially in the developing countries. Therefore, the general strategy must be improved to make progress during the International Decade for Natural Disaster Reduction (IDNDR) in combating natural disasters.

The 42nd General Assembly of the United Nations decided that the 1990s should be designated as the International Decade for Natural Disaster Reduction, and many countries immediately responded to this call and began to take the necessary actions. This strong motivation will provide favourable conditions for realizing the general strategy of disaster reduction.

B. Disaster situation strategy

China is one of the few countries affected with frequent natural disasters and suffering serious losses. The direct economic loss is about 50-60 billion yuan per year due to natural disasters and was 52.5 billion yuan in 1989.

The natural disasters in China may be divided into the following three types:

1. Water/atmosphere disasters: including rainstorm, flood drought, typhoons, storm, thunderstorm, hail, gale, forest fire and forest etc.

2. Geologic disasters: including earthquakes, volcanic, eruptions, landslides, mud-rock flow, soil erosion and land desertification, etc.

3. Biologic disasters: including pests and diseases of crops, farmland rat disaster, malignant weeds, red tide, etc.

On average, the above natural disasters cause economic losses of 40, 10 and less than 10 billion yuan, respectively per year. It is clear that water/atmosphere disasters cause the most serious damage in China.

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The aim of disaster situation strategy is to pay great attention to the severe natural disasters which not only cause heavy economic losses and loss of lives but also bring significant social and political problems. For instance, the Changjiang River flood in 1954, the Henan torrential rain in 1975 and the Tangshan earthquake in 1976 each caused a total economic loss of more than 10 billion yuan and tens of thousands of deaths.

From the above, it can be seen that the damage resulting from severe natural disasters is extremely grave. How to minimize such disasters should be regarded as the main problem in the work on natural disaster reduction.

C. Information strategy

Appropriate action to reduce natural disasters can be taken if forecasting can be made as early as possible using advanced technology. Responses can then be undertaken rapidly, and strategic decisions will be made in time. The collection of indications and forecasts, transmission of decisions and feedback of various information are of great importance in the reduction of disasters. Unfortunately, up to the present, there still is an important gap in this field in China as compared with other countries. Therefore an information strategy must be given due consideration promptly.

The reason why natural disasters have caused serious losses in Chinese history is that there was no information available before the disaster struck, and a lack of information after the disaster occurred. For example, during the Henan torrential rain in 1975, although it had been raining for as long as 60 hours, the Central Government did not receive any report until floods had run rampant and it was too late to fight the disaster and to evacuate the people from flood-stricken areas. Again, in 1976, after the earthquake in Tangshan, some survivors drove from Tangshan to Beijing to report the disaster situation to the State Council. At present, information can be transmitted everywhere all over the world in several seconds, but the information about the terrible Tangshan earthquake in 1976 was transmitted so slowly the everybody was astonished, which shows that it is very important to establish and carry out an information strategy in China.

Implementating an information strategy includes: establishing a State System of Disaster Communication (SSDC); a Central Network of Disaster Information (CNDI); and a Satellite Network of Disaster Monitoring. SSDC is needed to strengthen the existing telephone network in provinces, cities, districts, counties and villages; to improve satellite communication and wireless communication; and to form a disaster network between State Centre for Disaster Reduction (SCDR) and country-wide. The Central Network for Disaster Reduction (CNDR), on the basis of strengthening the existing communication system in ministries and commissions, departments, bureaus and stations, aims to form serious disaster situation network between SCDR and the ministries and commissions. It is to set up direct communication channels between SCDR and the State Council, so that the State Council can understand the occurrence, course and tendency of disaster promptly and make decisions as early as possible. In addition, various satellites for meteorology, oceanography and resources as well as disaster cruise planes will form a special monitoring system for disasters.

The information strategy plans to adopt advanced methods, to set up multichannel, all-weather and comprehensive information systems to make good use of existing disaster networks, to collect the disaster's indications as early as possible and to make sure the system transmits information properly.

D. Organization strategy

The reduction of natural disasters is a systematic activity relating to many departments and districts, which is an important factor affecting politics and the economy. Therefore, an efficient organizational system and good command are the keys to success or failure in natural disaster reduction.

Since 1949, the organizational system of the Communist Party, Government and army has been an important force, and is the first favourable condition. In addition, a lot of manpower and material resources have been used to set up a large-scale system for natural disaster reduction which includes individual ministries, commissions or bureaus of water conservancy, meteorology, oceanography, agriculture, forestry and geology and minerals. This is the second favourable condition. Although many natural disasters have been successfully mitigated under the above two conditions, the serious disasters mentioned above shook the whole world after all. They indicated that some links still needed to be improved in China's organization strategy.

As a large country with frequent disasters, China does not have enough close administrative structures and longitudinal organizations available for natural disaster reduction. From a practical point of view, the first step is to set up State Centre of Disaster Reduction as the leading organization in China. Second, regional or provincial centres of disaster reduction should be established step by step. Thus, the central structure based on longitudinal and cross regional linkages at provincial level can be realized. With such a good organization, the information strategy can be applied adequately and the goal of natural disaster reduction can be fulfilled realistically.

The work of SCDR should include three main aspects: prevention, reduction and relief of disaster with high working efficiency. In addition, SCDR must understand a disaster situation in a timely way and propose countermeasures for the State Council's reference. In order to fulfill the above tasks better, SCDR must posses the ability to monitor comprehensively and give warning of disasters and establish relations with the ministries and commissions under the State Council as well as to make full use of various materials and data.

The calculation of disaster situation in advance, evaluation and decision system are the most important jobs in the centre, which must be studied and prepared so that SCDR, on the basis of understanding disaster situation, can put forward countermeasures for the State Council's reference.

According to the above analysis and research, the author believes that setting up the SCDR is the core and key of realizing Chinese disaster strategy.

References

United Nations General Assembly 1987. Resolution 42/169. Collection of documents and materials for China International Decade for Natural Disaster Reduction.

Sun Guangzhong, Wang Ang-sheng and Zhang Peiyuan, 1990. Natural Disasters in China. Academic Book and Periodical Press.

Cui Naifu, 2 February 1990. Speech on the reception for international cooperation on Chinese disaster reduction.

VI. IDNDR ACTIVITIES IN CHINA AND PROSPECTS FOR COOPERATION IN REDUCING NATURAL DISASTERS IN ASIA AND THE PACIFIC

by Chen Hong[1]

In the following paragraphs a brief account of the state of natural disasters in China, the Chinese activities in carrying out the International Decade for Natural Disaster Reduction and some ideas on strengthening international cooperation in reducing natural disasters are presented.

A. Natural disasters in China

China is one of those countries in the world, where natural disasters occur frequently and losses are heavy.

The losses caused by water/atmosphere related disasters account for about 70 per cent of the entire losses from the natural hazards suffered by the whole country. The losses caused by geologic disasters are about 15 per cent of the total. The rest are caused by biologic disasters. During an average ordinary year, 40 to 47 million hectares of crops fail, 3 million houses collapse, and about 5,000 to 10,000 people die of disasters. The direct economic losses from these disasters are around RMB 50 billion yuan (about $US 10 billion).

Among the natural disasters affecting China, flood and waterlogging, drought, earthquake and typhoons are the most harmful. During the past 40 years, flooding took place on average 5.8 times annually in the whole country; regional droughts, 7.5 times; earthquakes over magnitude 6 on the Richter scale took place about 5 to 6 times; and typhoon, 6 to 7 times.

The Government of the People's Republic of China has always paid great attention to natural disasters and played an active role in controlling and harnessing them. During the last 40 years, professional institutions specializing in natural disaster monitoring and forecasting, disaster control, harnessing and relief work were set up and enlarged; scientific research organizations were established; a series of projects for disaster control were set up; great masses of people were organized to struggle against droughts, floods, waterlogging, earthquakes and other natural disasters. Results acclaimed by the world have been achieved and rich experiences were accumulated in disaster reduction. Facts show that by strengthening the organizational leadership, mobilizing the whole people to work together, paying full attention to advanced science and technology, and their application, the reduction of the losses caused by natural disasters could fully be achieved.

B. Brief account of the activities for the International Decade for Natural Disaster Reduction (IDNDR) in China

Responding to the suggestion made in the resolution No. 42/169 of the United Nations in December 1987, the Chinese Government established the China National Committee for the International Decade for Natural Disaster Reduction. The Committee comprises 32 Departments and Units. Its working office was set in the Ministry of Civil Affairs.

The guiding principles of the China National Committee are: to consider prevention of natural disasters as its main work; and to combine controlling and fighting disasters with resistance and relief work. It stresses the construction of disaster control installations and taking preventive measures. The Committee requires concerned organizations to step up scientific and technological research on natural disasters in their activities, push forward and apply energetically the scientific and technological results already achieved, continuously do research and discover courses and rules of development of various natural disasters, and propose countermeasures.

Under the leadership of the State Council, the China National Committee has carried out a series of practical and effective activities, which could be divided into three aspects. Firstly, extensive publicity activities were carried out to raise awareness of disaster reduction among the whole population. Secondly, organizations were set up, and plans were formulated. Thirdly, extensive international cooperation and exchanges were carried out. Since

[1] Office of China National Committee for the International Decade for Natural Disaster Reduction.

the establishment of the China National Committee, the Chairman has asked governmental organizations to intensify their sense of disaster reduction and has established the guiding principles of undertaking economic construction and disaster reduction work together. Organizations are also to bring the task of reducing natural disasters into line with the national economic development plan when they map out their long-term and annual economic development plans, so that the funds for disaster reduction work could be guaranteed.

The majority of departments and units of the China National Committee have done lots of work in accordance with their terms of reference. These include the Ministries of Agriculture, Water Resources, Forestry, Metallurgical Industry, and Construction; National Meteorological Bureau, National Bureau of Oceanography, State Seismological Bureau, State Science and Technology Commission, Chinese Academy of Sciences and Chinese Association of Sciences and Technology. Some have set up their own disaster reduction organizations and formulated their plans of work; some have determined their targets in reducing disasters and adopted concrete measures; some have convened meetings to study the laws of the natural disasters and countermeasures against them, and have actively put forward proposals to the central government. The governments of all provinces, autonomous regions and cities have also taken an active part in this work. Committees for Disaster Reduction were set up one after another in the provinces of Gansu, Hainan, Tibet, Hebei and in the city of Chengdu. Their disaster reduction plans were mapped out. Some of the provinces have appropriated special funds to help carry out disaster reduction projects and scientific research.

The Chinese People's Liberation Army has always been an important factor in dealing with emergencies and disasters. The troops in the disaster-prone areas have enlisted the work dealing with emergencies and disasters as subjects in their military training. The organizations engaging in public relations, news work and publications have also played an active role in the work. They have driven home the importance and significance of disaster reduction to the masses by means of newspapers, films and television programmes. Country-wide activities for the IDNDR involving the whole population are emerging in China.

During the last two years, talks were held with the United Nations Development Programme, Relief and Rehabilitation Administration, World Food Programme, the Secretariat of the International Decade for Disaster Reduction, World Bank and organizations concerned in some bilateral donor countries on cooperation in disaster reduction, and tentative cooperation intentions have emerged for some programmes. The international cooperation and exchange for disaster reduction are a powerful impetus to disaster reduction activities in China.

Concerned people in China are clearly aware that the work to reduce natural disasters is complicated and requires cooperation among different regions, departments and trades. Therefore, it is necessary to build up a disaster reduction system which is suitable to China's conditions and to possess sophisticated and effective technology. Apart from further improving the present systems of disaster prevention and fighting, and relief work of all professional departments, it is also necessary to establish a "national centre for natural disaster reduction" so that it is possible to use modern and advanced means in monitoring, computing and communication. In this way, the laws of development and evolution of the natural disasters can be mastered, scientifically and fully, and countermeasures can be put forward as the basis for decision-making of the State Council.

No efforts will be spared to carry on the activities of the International Decade for Natural Disaster Reduction so as to bring benefit to future generations and to make due contribution to the peoples of the Asian and Pacific region and the world over.

C. Prospects for cooperation in reducing natural disasters in the Asian and Pacific Region

Natural disasters are a common threat and challenge to all mankind. China is ready to strengthen cooperation with all countries of the world, especially countries of the Asian and Pacific region, and to carry out international exchanges and cooperation to push forward the activities of the International Decade for Natural Disaster Reduction still further.

Since the founding of the People's Republic of China, the government at all levels has done a large amount of work to relieve the losses from natural disasters. Great efforts have been made to harness the Yellow River, Hai River, Huai River and other big rivers, and to construct a large number of flood control and irrigation projects. These effects have controlled and relieved the damages caused by heavy drought, floods and waterlogging. Tree planting has reduced the disastrous effects of soil erosion and sandstorms. The application of the results of scientific research have provided modern systems of observation, monitoring and forecasting in meteorology, oceanography and hydrology as a means to alleviate the damages caused by typhoons, storm surges, heavy rains, floods and waterlogging. The strengthening of buildings to resist earthquakes combined with research in earthquake fore-

casts, have played an active part in reducing damages due to earthquakes. Finally, the damages due to plant diseases, pests and mice have been controlled and harnessed, thus reducing the losses of grain and cotton crops. Together with the great masses of the people, the People's Liberation Army speeded up the work on fighting natural disasters and the relief work. This series of projects and measures have helped China achieve tremendous results in reducing natural di- sasters. The Yellow River, which used to be called "China's Sorrow" has thoroughly changed from the past miserable state. It used to have dike breaches twice in three years. Such dike breaches have not been experienced during the summer and autumn flood seasons for 40 years. The Chinese people have gained quite a lot of useful experiences and lessons in disaster control, fighting and relief work.

In the past 40 years, the Chinese Government has trained tens of thousand of experts in disaster reduction science and technology. They are now working in numerous research institutes of the Chinese Academy of Sciences, the research institutions of the ministries and bureaus of the state and the universities and colleges. They are carrying on comprehensive specialized, applied and fundamental research to lessen the damages from natural disasters.

China and some countries in the Asian and Pacific region have similar natural geological conditions, and have some common natural disasters, such as drought, heavy rain, flood, waterlogging, typhoons, storm surge and earthquake. All the countries have undertaken considerable work to relieve the damages caused by these natural disasters and have made efforts for exchange of information and cooperation.

China and a large number of Asian and Pacific countries are developing countries. On disaster reduction, they face common problems in fund raising, strengthening government leadership and applying advanced science and technology. Therefore, mutual support and assistance and learning from each other will be important aspects of cooperation. Countries of the region with abundant resources and advanced technology should play a more important role in the course of international disaster reduction.

The Chinese Government has always paid great attention to international exchange and cooperation for disaster reduction. Especially in the recent years, it has established exchange and cooperation managements for disaster reduction with the United Nations organizations concerned and many countries.

The Chinese people cherish the assistance of the international community in the relief work. They have made the international assistance most effective by strengthening the organizational leadership, increasing the working efficiency in reducing disasters and putting in additional funds. From 16 to 22 October 1990, China invited 22 envoys and diplomats from the European Community, from United Nations organizations in China, and from the countries which had given aid to China's disaster-hit areas in recent years, to make a one-week on-the-spot inspection of the relief work in areas of Zhejiang and Fujian provinces hit by typhoons, floods and water- logging. In the new villages, built up after the disasters, the envoys and diplomats saw for themselves the extraordinary difference between the new dwellings which are well-planned and solid, and the ruins left over after the disasters. Having visited the homes and talked with the victims of the natural disasters, the diplomats got a clear picture of their present life and the measures taken by the government at all levels after the disasters. The foreign guests were especially pleased to learn the fact that the relief work which had been promptly and effectively realized was a result of additional funds put into the relief work by the government at all levels. There are broad areas for cooperation on disaster reduction in the Asian and Pacific region. China is ready to step up cooperation with all countries in the Asian and Pacific region and with all international organizations for disaster reduction through bilateral, multilateral or regional channels.

VII. NATURAL DISASTERS : FIJI EXPERIENCE

A. Introduction

Fiji lies between latitudes 15 degrees and 22 degrees south of the equator and longitudes 176 degrees and 178 degrees E. Because of its geographical position, Fiji is affected by hurricanes and floods and, to a lesser extent, earthquakes, storm surges, droughts and landslides. The islands are occasionally traversed by tropical cyclones during the hurricane season (November-April) with attendent violent winds, heavy rainfall, landslides, flooding and storm surge with greatest frequency around January and February. Fiji is hit on average by one cyclone annually and a very strong cyclone causing severe damages every four to five years. Fiji is within the "Pacific Rim of Fire," the zone of earthquakes and volcanoes which surrounds the Pacific Ocean. However there are no volcanoes in Fiji and the number of earthquakes is somewhat less than for the most active areas around the Pacific. Earthquakes and tidal waves are relatively infrequent but, like hurricanes, may cause major disasters. Hurricane Bebe in 1972 was the most destructive hurricane in Fiji's recent history, resulting in 20 deaths, 3 000 homeless, 50 000 on the Government's relief distribution scheme and causing damage estimated at $20 m. Natural disasters have had a significant impact on the economy, causing major setbacks to the development process. The Government's Emergency Services and Relief and Rehabilitation Committees serviced by the Ministry of Fijian Affairs and Rural Development are responsible for the coordination and implementation of emergency, relief and rehabilitation work in times of national emergency resulting from natural disasters.

B. Tropical cyclones

1. Disastrous cyclones experienced in Fiji

Tropical cyclones are the most destructive of all natural disasters affecting the country and indeed have had a significant impact on the social and economic development of the country. A feature of cyclones and hurricanes which have struck Fiji since independence in 1970 has been the regularity of their visits. From 1980 to 1990, 15 tropical cyclones struck the country with different intensities ranging from moderate to hurricane-force winds. Tracks of tropical cyclones affecting Fiji during this period are shown in map 5.

The most destructive cyclone of recent times was Cyclone Bebe in 1972, which devastated the whole country. Relief, rehabilitation and reconstruction work went on for years, which led to the establishment of a full-time Relief and Rehabilitation Committee. The disaster was a major setback to the national development programme and it took years to restore the economy to pre-1972 levels.

Current efforts by the Government towards mitigating the effects of tropical cyclones on life and property, such as the recent drawing up of a Building Code and its enforcement to ensure buildings are cyclone resistant, adoption of appropriate farming methods, systems and practices and improving public state of readiness, underline the importance Government attaches to the impact of this type of disaster on the country.

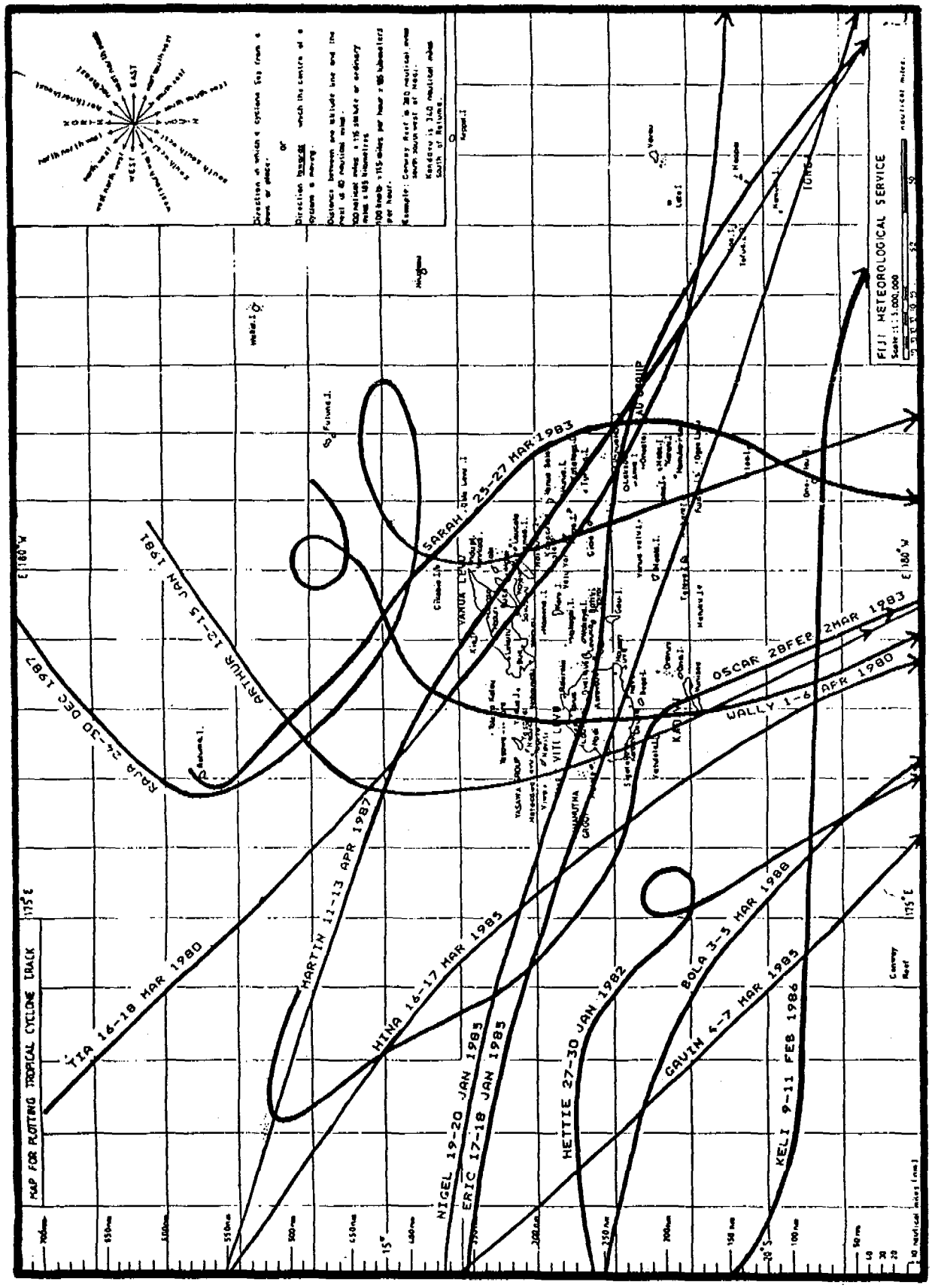
2. Cyclone forecasting and warning

The Regional Tropical Cyclone Warning Centre at Nadi serviced by the Fiji Meteorological service is responsible for the detection and prediction of tropical cyclones for the area between the equator and 25 degrees South latitude, and from 160 degrees East to 12 degrees West longitude. It provides regular forecasts, warning, and advisory services for 13 countries/areas of the region namely Fiji, Tonga, Niue, Northern and Southern Cook Islands, Samoa, Tokelau, Tuvalu, Kiribati, Wallis, Futuna, Vanuatu and Solomon Islands.

To meet this role, the Centre operates on a 24-hour basis receiving, exchanging and processing vast amounts of meteorological data from both within and outside the region. Surface and upper air observations, reports from ships, drifting buoys and aircraft, and data from meteorological satellites and radars are analysed every three to six hours and provide input towards preparation and update of warnings and forecasts for marine, aviation and general public use.

The Aeronautical Fixed Telecommunication Network (AFTN) of the International Civil Aviation Organization (ICAO), telex and telefax are used to disseminate most of the products and provide essential channels of communication.

The Centre requires data mainly from the Japanese Geostationary Satellite, GMS, and the American Geostationary



Map 5. Tropical cyclones affecting Fiji (Jan. 1980 - Jan. 1989)

Observational and Environmental Satellite, GOES-W, to carry out its work. Unfortunately, the GOES-W satellite, is no longer capable of providing such service due to its malfunction some time ago.

Prior to 1986, the Centre could receive only low resolution imagery at three-hourly intervals from the GMS satellite. However, towards the middle of 1986 a South Pacific Severe Storm Detection and Warning System project was implemented with assistance from the United States Agency for International Development (USAID) and the National Aeronautic and Space Administration (NASA) at Nadi, which provided the Centre with appropriate hardware and software to receive and process high resolution satellite data from the same satellite.

Towards the middle of 1988 an enhancement project was implemented which has enabled the Centre to receive Stretched VISSR data at hourly or more frequent intervals from the GMS satellite. This basically means that the Centre has now access to very high quality satellite data, available at more frequent intervals than in the past, to utilize for the location and prediction of tropical cyclones and other weather systems. Consequently its cyclone detection and warning system has improved significantly.

Hopefully, with the launch of a new GOES satellite within in 1992 or 1993, the Nadi Centre will have access to such high quality data for the entire area of its responsibility.

The Centre has only one 10 cm wavelength, both windfinding and surveillance, radar. The range for useful surveillance is about 200 nautical miles (nm) which means that the radar can be used for monitoring systems which are only within that range. Though the radar is very old and unreliable, it gave excellent performance during the passage of a recent tropical cyclone over Fiji.

There exists a two-step system of advisories on cyclones, namely, Alert phase and Warning phase. Special weather bulletins are issued for Tropical Cyclone Alerts and Warnings to: alert the community to the developing threat of a tropical cyclone; give progress reports on its development; and provide warnings of tropical cyclones or other disturbances.

All special weather bulletins are kept under constant review and owing to the periodic nature of satellite and synoptic data, substantial review is only possible at three-hourly intervals.

The most effective and quick means of advising the public of a tropical cyclone threat is through radio broadcasts. The desirability of early advices to enable people to take appropriate measures is vital even at the risk of a false alarm.

C. Floods

Fiji experiences some 15 cyclones per decade. Associated with these cyclones are exceptionally intense rainfall that causes destructive floods. Steep slopes, and short streams are characteristic of the otherwise mountainous islands of volcanic origin. Flood forecasting is therefore difficult, given the short time lapse between the rainfall and the rise in the rivers. Flood forecasts may be ineffective, unless a system or methodology is developed to use rainfall for forecasting floods. The traditional use of the river levels at upstream locations for forecasting floods in the lower reaches may not be effective for a majority of river systems. Very heavy rainfall further complicates the severity of flash floods caused by cyclonic storms. Concentration of development along river banks and coastal flats adds to the vunerability to flood damage. Fiji does not have the capability to forecast quantitative rainfall, the only radar for severe weather forecasting centre in Nadi being over 24 years old.

1. Flood forecasting and warning

The only flood forecasting system available is along the Rewa River, Fiji's largest catchment, which makes use of river levels in the upper catchment areas to estimate/forecast the anticipated levels down at the delta. It comprises six river level stations linked by radio to a computer located in the Hydrology Office.

The system uses a black box model to forecast floods in the delta using the river levels upstream. A lead time of some six hours is available to allow for preparedness measures such as driving livestock to higher ground and moving property to safety, it also gives time for evacuation if necessary. In the process the public is continually warned over the air of its progress and appropriate measures to take. This system, purchased from New Zealand, has been satisfactory but may not be applicable to other catchments which are smaller, and where there is a very short time difference between the rise in river levels in upstream locations and the rise in the levels in the more densely inhabited lower reaches. A system that uses a real time rainfall, and a microprocessor to simulate floods is necessary but unfortunately not available in Fiji.

2. Flood disaster countermeasures

Flood disaster countermeasures are limited to dredging and the government has expended considerable resources to maintain waterways that are capable of conveying floods.

Fiji's experience of floods, which normally accompany tropical cyclones highlighted the need for flood protection works to safeguard the rapid surburban growth of the

coastal towns located along the major rivers, and the much more intensive, more capitalized and technically more advanced agricultural development on river flats.

Although in the short term floods could be mitigated by dredging and river bank diking to ensure that adequate channel area is maintained, in the longer term these engineering works should be accompanied by appropriate watershed rehabilitation and management works which, among other things, would minimize the amount of sediment transported downstream.

River models are being studied and the Government has sought assistance from relevant international organizations to facilitate watershed management studies. Recommendations from such studies are being gradually implemented in the hope that the impact of flood disasters can be minimized.

In the lower delta areas a programme of raising village levels as protection against flood is already underway.

D. Earthquakes

1. Major earthquakes in Fiji

Fiji is located on the geologically active Pacific rim and is subject to a moderately high level of earthquake risk. In 100 years a damaging earthquakes has occurred approximately once every 10 years in Fiji. However, with its rapid development and growing urban population, Fiji is increasingly vulnerable to the effects of strong earthquakes. The earliest recorded report of earthquake activity in Fiji goes back to around 1850 when an earthquake near the island of Kadavu was "so tremendous that it took a heavy toll on life and property".

The Suva earthquake of 1953 killed eight people, five by drowning from a tsunami, and caused damage estimated at about $50,000 to Government structures alone (Suva city had a population of 35,000 at the time). A similar earthquake near Suva today would cause widespread destruction and casualties, and would incur substantial costs to the Government.

History shows that Fiji is subject to earthquake activity but it is not clear at what level and to what extent protection should be provided. The 1953 Suva earthquake damaged roads, bridges and wharf facilities. In present day Suva, high rise buildings and major port facilities are also at risk, in addition to residences.

2. Preparedness measures against earthquakes

Buildings and infrastructure can be designed and built to withstand strong ground shaking from earthquakes but at a cost. In the past, with limited knowledge of the level of hazard in Fiji, there was probably some neglect in designing buildings to resist earthquakes. Certainly there was no uniformity in design standards. However, adequate design by itself is not enough. In addition, there is also a need to ensure that construction takes place according to set standards. To this end a Building Code had been drawn up to ensure buildings are cyclone resistant that would greatly minimize the effects of a cyclone on buildings. The Code includes an earthquake hazard map of Fiji.

Efforts have been made to reach every child of school age in Fiji with educational material on earthquake hazards. The Mineral Resources Department (MRD) is coordinating this project. MRD operates the Fiji national seismographic network and monitors earthquake activity in Fiji.

The Emergency Services Committee assumes responsibility for disaster safety measures related to an earthquake or tsunami. The Police and MRD are involved in earthquake and tsunami warning.

At the moment it is impossible to predict an earthquake reliably but nonetheless statistical estimates can be made of the probability of an earthquake occurring, based on the earthquake history. MRD has begun projects to determine the level of hazard in Fiji. A study currently underway is analyzing the earthquake hazard in Fiji in greater detail, and a hazard map has been prepared.

E. Tsunamis

Tsunamis are rare in Fiji, but were reported after two earthquakes, in 1881 and after the 1953 'Suva' earthquake. The one in 1881 was reportedly about 1.8 m in height and did not cause concern. However in 1953 the tsunami was from 1.8 to 4.5 m above low tide level, causing minimal damage along water frontages.

The public is always warned to take appropriate measures in the event of an earthquake which is likely to generate tsunamis which are considered as a potential threat to lowlying islands.

F. Droughts

Drought normally occurs during the dry period of the year, that is, from May to October. In addition to its effects on human lives, droughts have had adverse effects on agriculture and livestock and the economy generally. The severe drought following cyclone Oscar in 1983 caused heavy damage to the sugar cane crop. More than 14,000 cane farmers lost most of their crop and export losses for Fiji were estimated at over US$70 million. In addition, more than 30,000 persons had to be provided with food

rations. The implications of such a event to the national economy are clearly very serious. The most recent extensive drought was in 1987 and was associated with the El Niño Southern Oscillation (ENSO) phenomenon. It almost reached the level which would have warranted the declaration of a national emergency.

Overall, a total population of about 84 500 was supplied with emergency water during the drought period at a total cost of nearly $1 million. The lack of adequate rural water supply facilities further exacerbated the severe drought conditions, though Government has steadily assisted rural communities in their water supply schemes. For the Northern Division alone a total population of 6 906 was issued with food rations at a cost of $47 000.

Cane and other crops have been badly affected by drought. In livestock farms a number of stock mortalities have resulted from lack of feed and/or water and grazing toxic plants due to shortage of grass.

The Government's agricultural drought assistance programme is geared towards assisting livestock and crop farmers through the provision of supplementary feeds, planting material, manure, etc.

Because of the need to maintain adequate water supply especially in remote areas, studies are currently underway to determine alternative sources of water supply, namely, boreholes and also the provision of adequate water tanks.

G. Landslides

Landslides are often occasioned by continuous heavy rainfall over a prolonged period. The most recent major landslide in Suva in 1986 claimed four lives. Apart from causing damages to crops, buildings and loss of human lives, roads and bridges have also sustained heavy damages where substantial sums of money were required to restore normal services.

Landslides have also been associated with poor land-use management. Deforestation and indiscriminate grazing of livestock are major contributing factors.

In addition to economic considerations, the government's reafforestation programme forms an important element of the national soil conservation programme.

H. Natural disaster risk study/mapping

Fiji does not have hazard or risk maps on natural disasters which are considered a potential threat to the country to provide guidance and direction to developmental activities. Developers and investors, however, take into consideration the vulnerability of locations from local knowledge before any development takes place. However efforts are underway to secure the assistance of relevant international organizations and agencies to carry out risk study and risk mapping on natural disasters affecting the country.

The Department of Mineral Resources is currently undertaking a study on landslide hazard which hopefully will lead to the production of risk mapping on this hazard. It is difficult to predict or forewarn people of an impending landslide; however, the risk mapping exercise should provide useful guidance and direction to developers and people alike of areas which are considered vulnerable to landslide hazards.

VIII. MAJOR NATURAL DISASTERS IN INDIA: INCIDENCE AND MANAGEMENT APPROACH

by B. Narasimhan[1]

A. Introduction

India is geographically situated between latitudes 8°4'N and 37°6'N and longitudes 68°7'E and 97°25'E. The Tropic of Cancer passes through the middle of the country. The snow-covered Himalayas constitute the northern border and the peninsular region is bounded by the Arabian Sea on the west and Bay of Bengal on the east.

The country is a Union of 25 States and seven Union Territories. The Union Territories are subject to the direct rule-making powers of the national parliament and the administrative control of the Union Government. The States have elected legislatures and governments, which are fully autonomous in relation to the sphere of activities entrusted to them under the constitution. The States are further divided into administrative units called districts.

Major parts of the country are subject to tropical and sub-tropical climate, though some areas experience extreme heat and cold. The country has an annual average rainfall of 1 170 mm, nearly 73 per cent of which is contributed by the south-west monsoon during June to September. The annual rainfall shows great variability in terms of time and space. There are areas of very low precipitation; erratic distribution of rainfall during the monsoon is quite common. The percentage distribution of rainfall during the year is as follows:

Period		*Percentage*
Pre-monsoon	(March-May)	10.4
South-west Monsoon	(June-September)	73.7
North-east Monsoon	(October-December)	13.3
Winter rains	(January-February)	2.6

B. Natural disasters in India

Of all the natural disasters experienced in India the most important are droughts, floods, cyclones and earthquakes, to which the country is frequently exposed and which cause extensive damage to life and property. Areas vulnerable to these disasters extend over 84 per cent of the geographical area of the country, as illustrated in map 6. The information on these disasters can be summarized as follows:

1. Droughts

India has a geographical area of 329.3 million hectares, of which the arable area constitutes about 140 million hectares. The percentage distribution of the cultivated areas under various ranges of rainfall is as follows:

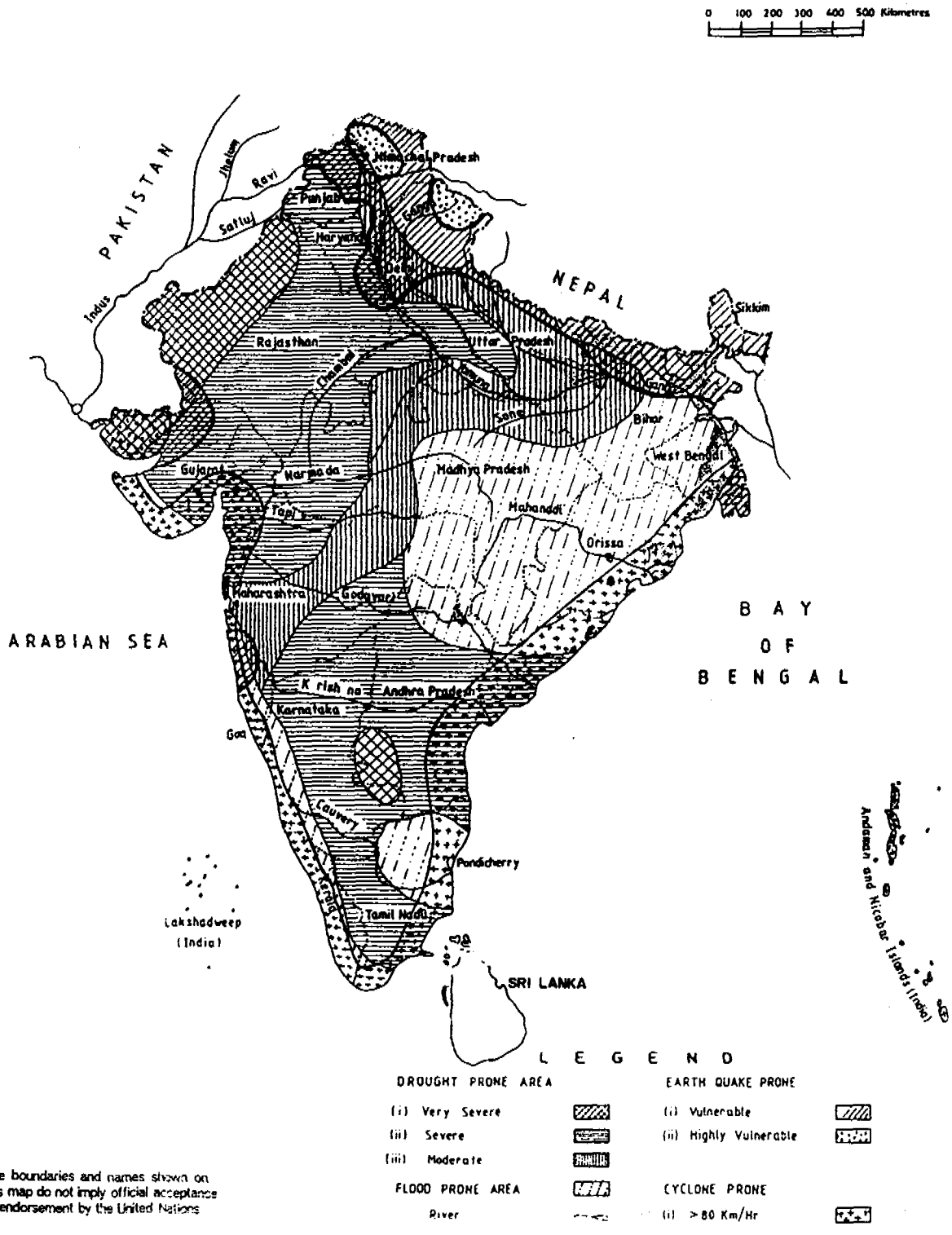
Percentage of total	*Region*	*Annual rainfall, mm*
33	Low Rainfall	750
35	Medium Rainfall	750-1125
24	High Rainfall	1125-2000
8	Very High Rainfall	2000 and above

Because of the erratic behaviour of the rainfall, even the medium rainfall region is vulnerable to drought conditions. Consequently, 68 per cent of the cultivated area is drought-prone.

2. Floods

Floods in India occur during the monsoon season. A combination of heavy spells of intense precipitation during the monsoon, tropical storms and depressions result in flooding over 40 million hectares in the country. Deforestation in the catchments, inappropriate land use and degraded lands, inadequate capacity of drainage channels to carry the peak flows and extensive human occupation of the flood-prone plains aggregate the damages caused by floods.

[1] Additional Relief Commissioner and Joint Secretary to the Government of India, Ministry of Agriculture, New Delhi.



Source S.R. & SWC DIVISION DEPTT OF AGRI & COOPN GOVT. OF INDIA, NEW DELHI

Map 6. India: Incidence of natural disasters

3. Cyclones

India has a long coastline of 5 700 km, which is exposed to tropical cyclone hazards arising in the Bay of Bengal and the Arabian Sea. On average, two or three out of six tropical cyclones generated in this region hit India. Cyclones are characterized by very high winds, torrential rains and associated flooding and high storm surges, which cause extensive damages in the coastal areas.

4. Earthquakes

India has about 56.6 per cent of its total area vulnerable to seismic hazards of varying intensity. The vulnerable areas are located essentially in the Himalayan regions of the country, and the Union Territory of Andaman and Nicobar Islands.

5. Landslides

Landslides are frequent and recurrent in various regions of India. They are triggered by natural causes such as heavy rainfall, and sudden cloud bursts and by land and soil degradation caused by human interference. The Himalayan region has a very high incidence of landslides.

6. Avalanches

About 25 000 ha of the country, mostly in the Himalayas, fall in the Alpine region. The snow avalanches of the Himalayan region are massive and have great destructive potential. An area of northern India is exposed to avalanche hazards. Most of these are direct action types, occurring during periods of heavy snowfall or immediately thereafter; wet-snow avalanches in spring are also very frequent.

C. Organizational structure for natural disaster management

India has an integrated administrative machinery for natural disaster management. Disaster preparedness, relief and disaster mitigation should underlie development programmes in order to achieve cost effectiveness. The functional expertise of line departments and the quick response system through designation of nodal and focal points are the cornerstones of the administrative arrangements for responding to natural disasters.

The basic responsibility for undertaking rescue, relief and rehabilitation measures in the event of natural disasters is that of the State Governments concerned. The role of the national Government is supportive, in terms of supplementing physical and financial resources and complementary measures in sectors such as transport, warning, and interstate movement of foodgrains. The Union Department of Agriculture and Cooperation (DAC) is the nodal department. An Additional Secretary in the DAC is designated as the Central Relief Commissioner. He provides the focal point for interaction with the State Governments, and the Departments and agencies of the Union Government and for the implementation of the decisions of the Union Government.

The standing arrangements provide for the activation of a Cabinet Committee on Natural Calamities (CCNC) for providing direction and guidance in the execution of the relief operations and also to monitor the execution of short-term and long-term measures for disaster mitigation.

At the executive level, the Cabinet Secretary presides over the National Crisis Management Committee (NCMC) which closely monitors the relief effort and takes steps for the implementation of the policy directions of the CCNC.

A Crisis Management Group (CMG) under the Chairmanship of the Central Relief Commissioner meets regularly, daily during the crisis period and weekly or fortnightly in the post-crisis period, to review the situation and take steps to assist the affected States in the relief efforts. CMG consists of representatives of all concerned central ministries and senior (Commissioner level) representatives of the affected States, resident in New Delhi.

The Central Relief Commissioner is assisted by an Additional Relief Commissioner, who has under his charge an Emergency Operations Centre (EOC), which closely interacts with various agencies to collect information relating to disaster and relief operations; EOC communicates with the nodal authorities to respond to requests for assistance for relief operations. EOC functions round the clock during the crisis period.

A national Contingency Action Plan (CAP) facilitates the launching of relief operations without delay. This is updated every year; CAP identifies the initiatives required to be taken by various central ministries and departments in the wake of natural calamities, sets down the procedure and determines the focal points in the administrative machinery.

At the State level, the State Relief Commissioner (or Secretary, Department of Revenue) directs and controls the relief operations through Collectors or Deputy Commissioners, who are the responsible for relief operations, such as coordination, direction and control, at the district level.

The State Governments are autonomous in organizing relief operations in the event of natural disasters and in initiating long-term measures. The Union Government

supplements the State relief effort by initiating supportive action in complementary sectors falling within its purview.

Each State has a Calamity Relief Fund (CRF), administered by a State-level Committee, headed by the Chief Secretary to the State Government. The size of the fund is determined by the vulnerability of the State to different natural calamities and the magnitude of expenditure normally incurred by the State on relief operations. The fund is built by annual contributions of the Union Government and the State Governments concerned in the ratio of 3:1. At present, the aggregate annual increment to the States' Calamities Relief Funds amounts to Rs 8.3 billion. The State Governments are free to draw upon this fund for providing relief in the event of any natural calamity. In the event of a major disaster, warranting intervention at the national level, a provision exists for the Union Government to supplement the financial resources needed for relief operations.

D. Management of natural disasters in India

1. Droughts

(a) Forecasting and warning

Meteorological forecasts play a crucial role in regulating agricultural activities and helping an area to meet drought conditions; for this purpose, the country has been divided into 35 meteorological subdivisions. The India Meteorological Department (IMD) has a large nation-wide network of weather stations to make daily weather forecasts and give notice of heavy precipitation or dryspells and cyclones. Satellite imagery and remote sensing techniques are used in making these forecasts.

Rainfall data is collected regularly by IMD through its network of about 4,000 raingauges and by State Governments through an extensive network of raingauges located at sub-district level. State Governments have also a system of collecting daily status reports about rainfall, reservoir storage and crop conditions from the field; this information is compiled at the district and state level on day-to-day basis.

The agricultural extension machinery and the field officers of the Revenue Department undertake visits to villages and furnish reports about crop conditions. Steps under the Contingency Agriculture Plan are also initiated depending on the progress of the monsoon. Visual crop forecasts are also made at suitable intervals. These provide advance notice of drought incidence.

(b) Preparedness

The drought management strategy comprises measures to mitigate disaster impact and provide relief. Water budgeting helps in providing life-saving critical irrigation to drought-affected crops and reduces the fall in agriculture output and also ensures adequate drinking water for human and livestock population. The main objectives of the relief programme are to provide:

(i) Food security to the affected population through a network distribution system;

(ii) Income distribution through a massive employment generation programme;

(iii) Nutritional supplements to vulnerable sections of society; and

(iv) Effective health coverage to human and animal population through a widespread network of primary health centres, mobile teams and rural veterinary dispensaries.

The public distribution system, primary health centres and veterinary dispensaries constitute the permanent organization, which is strengthened and expended during the drought period. To meet the escalating demands from drought-affected States, special allocations of foodgrains are made from the national buffer stocks held by the Food Corporation of India. In the face of the impending drought, the District Collector makes an assessment of the areas likely to face drinking water shortages and draws up a plan for provision of drinking water during the anticipated periods of crisis either by development of new water sources or transportation of water. The provision of fodder either by transportation to the deficit areas or by crash cultivation of fodder and care of the vulnerable cattle population in camps are also important components of the drought relief programme.

A comprehensive Crop Insurance Scheme provides a measure of financial support to the farmers in the event of crop failure. Supply of subsidized agricultural inputs and provision of agriculture credit under relaxed criteria are measures designed to sustain the agricultural activities in the succeeding monsoon.

(c) Prevention and reduction

A watershed approach to dryland agriculture has been promoted through a National Watershed Development Programme for rainfed agriculture. Moreover, exploitation of major irrigation and groundwater potential and construction of water harvesting structures for providing critical irrigation have reduced vulnerability to drought.

Environmental development programmes, including the drought-prone area programme and the desert development programme, promote appropriate land use, rehabilitate degraded lands and develop subsidiary occupations. All of these programmes are being implemented as measures to reduce vulnerability in drought-prone areas.

2. Cyclones and floods

India has four major flood-prone regions identified by river systems, namely:

- The Brahamputra region: essentially in the north-eastern region consisting of Brahamputra and Barak rivers and their tributaries;

- The Ganga region: in north-eastern India comprising river Ganga and its tributaries;

- The north-western region: comprising rivers Indus and its tributaries; and

- The Central India and Deccan region: consisting of westward-flowing rivers such as Narmada and Tapti and eastward flowing rivers Mahanadi, Krishna and Kaveri.

Tropical cyclones affect the coastal areas along the eastern and western coasts of India. The cyclonic disturbances occurring in the Bay of Bengal in the east are more frequent and cause more extensive damages. From 1891 to 1990, the Bay of Bengal produced 442 cyclones, while 117 cyclones originated in the Arabian Sea. They occurred mainly in the months of April/May and October/November.

(a) Forecasting and warning

The IMD gives forecasts of heavy precipitation and impending cyclones and associated destructive weather 72 hours, 48 hours and 24 hours in advance. The State Governments obtain, on a regular basis, details about the reservoir status in relation to storage, inflow and outflow at major dams. The Central Water Commission has a network of 151 forecasting stations on major interstate rivers in the country. Flood forecasts are issued to various State authorities, almost on a daily basis during the monsoon and at suitable periodical intervals at other times.

A two-stage cyclone warning system is available in the country to trigger off advance precautionary measures in the face of cyclonic threat. The first stage cyclonic alert is issued by cyclone warning centres to State Governments and District Collectors 36 to 48 hours before the expected onset of the adverse weather. Broadcasts over radio and television also warn people. A satellite-based disaster warning system is used to communicate warnings to the affected population directly. A second stage cyclonic warning is issued by IMD 24 hours before the expected land-fall of the threatening cyclone.

(b) Preparedness

A Contingency Action Plan exists for meeting the threat of floods and cyclones at the State and district levels. The preparedness activity consists in reviewing the status of various measures to be initiated in advance and to sensitize the administrative machinery.

Typical preparation consists of:

- identification and establishment of temporary shelters;

- advance stocking of material required for rescue and immediate relief operations;

- inspection of river embankments and undertaking of repairs, where necessary;

- keeping the warning system, the communication and navigation equipment in a good state of repair;

- stocking or essential medicines, drugs and first-aid kits; and

- conduct of drills to keep the administrative machinery on the alert.

(c) Prevention and reduction

The strategy for ensuring protection to flood-prone areas comprises:

- training of rivers and protection of embankments;

- canals to divert the surplus flow in the river;

- balancing of reservoir storages;

- activities to decongest drainage lines;

- treatment of the catchments of flood-prone rivers through soil; and

- disseminating information to dissuade human settlement in flood plains.

(d) Relief measures

The post-disaster relief effort consists in the supply of housing material, restoration of communication links,

provision of financial help for resumption of normal activities, provision of physical and financial resources for restoration of affected agricultural lands for agricultural purposes and supply of subsidized agricultural inputs for resumption of agricultural activities.

3. Earthquakes

(a) Monitoring

IMD is the nodal agency in India for monitoring earthquakes. Fifty-six (56) seismic stations and 32 seismic observatories in different parts of the country are engaged in the task of monitoring seismic activities. Arrangements also exist for monitoring seismic disturbances in some particular reservoirs/dam sites.

(b) Preparedness

Guidelines for suitably strengthening buildings against seismic activity of various magnitudes have been evolved after extensive research by the Department of Earthquake Engineering, University of Roorkee. Roorkee stock-rolling facility for testing resistance of structures to earthquake impact has also been developed. The National Building Organization (NBO) has brought out design and construction standards for construction of earthquake-resistant buildings. The Indian Standards Institution has issued codes incorporating guidelines for design and construction of earthquake resistant buildings.

(c) Prevention and preparedness

Disaster reduction efforts consist essentially in promoting earthquake resistant structures in the highly seismic regions. NBO has put up specially designed houses under its experimental housing scheme in the seismic regions. Special measures are undertaken by NBO through its 15 regional Housing Development Centres to transfer technology in the field of rural housing to building organizations and others.

(d) Relief

A contingency action plan exists for initiating relief measures immediately after the earthquake. Periodic drills are carried out by administrative machinery for disaster management. Training in civil defence is important to key disaster relief personnel in the country in the National Civil Defence College.

Relief measures, on similar lines for flood measures are undertaken for relief, reconstruction and rehabilitation purposes.

E. Involvement of non-governmental organizations in disaster relief

The association of non-governmental organizations (NGOs) in the provision of relief in the wake of natural disasters is a significant aspect of disaster management in India. During drought, NGOs are entrusted, on a selective basis, with the task of providing drinking water, supply of fodder, management of fodder depots and maintenance of cattle camps. During floods, cyclones and earthquakes, they are very actively involved in the task of evacuation, provision of temporary shelters, distribution of food and essential commodities and reconstruction and rehabilitation programmes. Supplementary financial resources needed for relief operations of NGOs are extended by the Government. Inter-NGO coordination and their effective interaction with State agencies is ensured under the direction and control of district Collectors and State Relief Commissioners.

F. International Decade for Natural Disaster Reduction (IDNDR) in India

As a part of the IDNDR observance, India has envisaged launching of special training programmes and evaluation studies to help in improving the resilience of disaster-prone areas and to integrate development activities to reduce the vulnerability of different areas to particular disasters. A core group comprising senior officers of different Departments of Union Government and State Governments has been set up in DAC to formulate specific action plans.

IX. NATURAL DISASTERS AND METEOROLOGICAL WARNING SYSTEMS IN INDIA

by G.S. Mandal[1]

A. Introduction

Loss of life and property owing to natural disasters such as tropical cyclones, floods, droughts, tornadoes, earthquakes and volcanic eruptions is very large. Fortunately, for some of the greatest natural disasters such as tropical cyclones, warning services are available today and by proper long and short term mitigation measures, loss of lives and properties can be reduced. It is the endeavour of national meteorological services of the world to provide warnings to the public for some of the weather related natural disasters by detecting, tracking and predicting them.

It is not possible to forecast a long period in advance precisely when and where a dangerous natural phenomenon will take place. Nevertheless, it is feasible to make an assessment of the vulnerability of different localities to these natural disasters by considering the historical records. Risk assessment of this nature falls under long-term disaster measures. On the other hand, warning systems for them fall under short-term disaster mitigation measures.

Some of the natural disasters affecting India and the role of the India Meteorological Department (IMD) in mitigating these disasters will be discussed in this paper. More emphasis will be given to tropical cyclone warning systems in India, as tropical cyclones constitute the major natural hazard affecting the country.

B. Tropical cyclones, floods and tornadoes

Tropical cyclones, at times, bring nature's worst disasters in the tropics. Slightly away from the equator within the belt of tropics (between 30°N and 30°S) the tropical cyclones form at ocean areas where the ocean water is warm. However, their frequency, intensity and impact varies from place to place. The frequency of tropical cyclone is the least in the north Indian Ocean (the Bay of Bengal and the Arabian Sea) and they are the deadliest when they cross the coast bordering the areas of north Bay of Bengal (coastal areas of north Orissa, West Bengal and Bangladesh). This is due to the serious storm surge created by cyclones in the area. Records indicate that a large majority of noteworthy tropical cyclone disasters (human loss>10 000) took place over the coastal areas in the north Bay of Bengal during the last couple of centuries. The above facts bring the special nature of the problem in our area, the importance of cyclone warning system in this part of the world and their long-and short-term preventive measures.

1. Features of a tropical cyclone

Tropical cyclones are the intense low pressure areas in the atmosphere around which fierce wind blows. Horizontally, it extends from 500 to 1 000 km and vertically from surface to about 12 to 14 km.

The intensity and classification of cyclonic disturbances (low pressure areas) are made by the strength of the associated winds. The classification used in India is given in table 21.

Table 21. Intensity and classification of cyclonic disturbances

Disturbance	*Wind speed in knots*
1. Depression	17-27 (32-50 km/hr)
2. Deep depression	28-33 (51-61 km/hr)
3. Cyclonic storm	34-47 (62-68 km/hr)
4. Severe cyclonic storm	48-63 (89-117 km/hr)
5. Severe cyclonic storm with a core of hurricane winds	Exceeding 63 (117 km/hr)

A mature tropical cyclone consists of a central region of light winds known as its 'eye'. The 'eye' has an average radius of about 20 to 30 km, but it can be 40 to 50 km in large mature storms. The pressure is the lowest and temperature the highest in this region with either clear or partly cloudy skies. The 'eye' is surrounded by a ring of very strong winds extending on an average up to 30 to 50

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km beyond the centre. This area is called "wall cloud" zone. Surrounding this region, winds spiralling in a anticlockwise manner in the northern hemisphere, extend outwards to large distances, with speeds gradually decreasing further away from the centre. The rate of decrease of winds may be rapid or gradual. Vertically wind rotates in a anticlockwise manner up to about 7-8 km followed by clockwise winds up to 12-14 km in the northern hemisphere.

The 'eye' (central portion) of the tropical cyclone is almost cloud free, surrounded by walls of clouds arranged in the form of a hollow cylinder. This wall cloud zone coincides with the zone of maximum wind. Thus, this zone, though very narrow, constitutes the most hazardous zone of a tropical cyclone, as wind here is extremely strong and rainfall is very heavy and vertical velocity is very large. Clouds outside the wall cloud appear in bands and finally these bands merge with the wall clouds or the central portion of the tropical cyclone. Because of this special nature of the clouds associated with the tropical cyclone they are easily detectable in satellite and radar cloud photographs.

2. Climatology of tropical cyclones

On average, about five to six tropical cyclones form in the Bay of Bengal and the Arabian Sea every year, out of which two or three may be severe. More cyclones originate in the Bay of Bengal than in the Arabian Sea, and the ratio of their frequencies is about 4:1. May, June, October and November are the stormiest months of the year. Compared to the pre-monsoon season, particularly the months of October and November are known for severe storms. The frequency of cyclones and severe cyclones in the Bay of Bengal and the Arabian sea during the 98 year period from 1891 to 1988 is shown in table 22.

Although the cyclonic storms have occurred in the monsoon season, really severe ones are rare. Storms during the monsoon are more marked by rainfall, which often leads to floods in different parts of the country.

3. Destructive effects of tropical cyclones

Severe tropical cyclones are responsible for large casualties and considerable damage to property and agri-

Table 22. Frequency of tropical cyclones near India, 1891-1988

	Bay of Bengal		*Arabian Sea*	
Months	*Cyclonic storm*	*Severe cyclonic storm*	*Cyclonic storm*	*Severe cyclonic storm*
January	4	2	2	0
February	0	1	0	0
March	2	2	0	0
April	11	10	2	4
May	15	33	4	15
June	33	5	6	12
July	33	7	3	0
August	27	3	2	0
September	24	15	5	3
October	44	34	14	11
November	40	52	6	21
December	23	18	5	2
Total	256	182	49	68

cultural crops. The destruction is normally confined to the coastal districts and the maximum destruction takes place within 100 km from the centre of the cyclones and on the right side of the storm track. Principal dangers from a cyclone are: gales and strong winds; torrential rain; and high storm surges. Most of the casualties are caused by coastal inundation by storm surges. Maximum penetration of severe storm surges varies from 10 to 20 km inland from the coast. Heavy rainfall and floods come next in order of devastation. They are often responsible for much loss of life and damage to property. Death and destruction purely due to winds are relatively small. The collapse of buildings, falling trees, flying debris, electrocution, rain and aircraft accidents, and disease from contaminated food and water in the post-cyclone period also contribute to loss of life and destruction of property.

The most destructive element associated with intense tropical cyclones is the storm surge. The enormity of devastation may be fathomed from the fact that the storm surge of about 6 m associated with the single cyclone in 1970 caused death of about 300,000 people in Bangladesh.

The storm surge is the sudden rise in the sea level due to topical cyclone and is greatly amplified where the coastal water is shallow, and where the shape of the coast is like a funnel. The coastal areas of north Bay of Bengal meet all these criteria and therefore storm surge gets enormously amplified there. Due to several suitable conditions in these areas the world's highest storm surge (11 m) was reported from this area in association with a storm of moderate intensity in 1876 (near Bakerganj).

The rise in sea level due to astronomical tide may be as high as 4.5 m above the mean sea level at some parts of the Indian coasts. The worst devastation takes place when and where peak storm surge occurs at the time of high astronomical tide.

Devastation due to coastal inundation by the combined effects of storm surge and astronomical tide can be reduced by evacuation of people in time if there is an efficient and reliable system of prediction of the sea level elevation. Prediction of tide is available in astronomical tide tables. It is then necessary to evolve a system to predict the storm surge due to an ensuing tropical cyclone.

Fortunately, the India Meteorological Department is in a position to evolve a method after continuous research to estimate the storm surge in association with the tropical cyclones by solving complicated hydrodynamical equations using computer.

4. Cyclone warning systems in India

The cyclone warning service of the India Meteorological Department is now over 100 years old and is one of the most important functions of the Department.

(a) Present cyclone warning organization

At present the cyclone warnings are provided through the Area Cyclone Warning Centres (ACWCs) located at Calcutta, Madras and Bombay and Cyclone Warning Centres (CWCs) at Bhubaneshwar, Visakhapatnam and Ahmedabad. The zone of responsibility of each office is clearly demarcated. Cyclone warning bulletins for All India Radio, and cyclone advisories for the north Indian Ocean to Bangladesh, Myanmar, India, Maldives, Pakistan, Sri Lanka and Thailand are being issued from the Meteorological Office at New Delhi. This office in New Delhi also issues tropical cyclone advisories for the tropical cyclones in the southwest Indian Ocean to Mauritius.

(b) Cyclone tracking

In India, tropical cyclones are tracked with the help of: regular observations from weather network of surface and upper air observing stations; ships' reports; cyclone detection radars; satellites; and reports from commercial aircraft.

In addition to the large number of surface and upper air observatories, about 280 ships of the Indian Merchant Fleet are equipped with meteorological instruments for taking observations out at sea. Ships of other countries passing through India's oceanic areas are also expected to provide frequent meteorological observations to the nearest meteorological office through the Post and Telegraph Department's Coastal Radio Stations.

A network of 10 cyclone detection radars has been set up along the Indian coast. Six of them are located at Calcutta, Paradip, Visakhapatnam, Madras, Machilipatnam and Karaikal on the east coast, while four are located at Goa, Cochin, Bombay and Bhuj on the west coast. The range of these radars is 400 km.

Satellites are one of the most dependable tools for tracking the weather systems such as cyclones. When the cyclone is beyond the range of coastal radars, its intensity and movement is monitored with the help of weather satellites. Today, the Meteorological Department of India has the capability to monitor cloud pictures from the Polar Orbiting Satellites launched by the United States and the USSR and from India's Geostationary Satellite INSAT-1B.

Aircraft reconnaissance is another important tool for tracking the tropical cyclone and measuring some important meteorological parameters from the storm field. This facility is not yet available in India.

With the availability of the cyclone warning radar network along India's coastline and modern facilities to monitor cloud pictures from satellites, today, cyclones in the Indian seas are not likely to go undetected.

(c) Main users of cyclone warnings

The main users served by the Department are: commercial shipping and the Indian Navy; port authorities; officials of the State and Central Governments; fishermen and fisheries officials of the State Governments; "special warnees", who are registered with the Department; commercial aviation; and the general public.

(d) Preparation of forecasts

The important components of cyclone warnings are the forecast of future path, intensity and the associated destructive weather systems. For the preparation of forecast of path and storm surges, the modern methods which utilize computers are used in addition to conventional methods. For the intensity forecast satellite techniques are used.

(e) Dissemination of cyclone warnings

Warnings to the State Governments and special warnees are issued in two stages. In the first stage a 'Cyclone Alert' is issued normally 48 hours before the commencement of adverse weather along the coast. A cyclone warning is issued about 24 hours before the cyclone strikes the coast. Ports and fisheries warnings start much earlier. These warnings are disseminated through: landline telegrams on special high priority; repeated broadcasts through All India Radio in different local languages; bulletins to the press; the Post and Telegraph Department's Coastal Radio Stations (broadcast in code for the benefit of ships plying in the high seas); telephones, telexes and teleprinters wherever available; and wireless network of the police.

However, the Postal Department's telegraph channels are still the main mode of dissemination of cyclone warnings in India, and these are normally vulnerable to adverse weather.

Recently, to overcome these difficulties, the India Meteorological Department has developed a system known as Disaster Warning System (DWS) to transmit cyclone warning bulletins through INSAT-DWS to the recipients. There are four elements of INSAT-DWS. These are: the cyclone warning centre for originating the area code of the districts and disaster warning message; the earth station located near the cyclone warning centre with uplink facility in C-band and suitable communication links with the cyclone warning centres; the C/S band transponder on board INSAT; and the INSAT-DWS receivers located in cyclone-prone areas.

(f) Cyclone Distress Mitigation Committee (CDMC)

To recommend ways and means to improve cyclone warning services and short and long term mitigation measures, the Cyclone Distress Mitigation Committee (CDMC) was constituted for Andhra Pradesh, Orissa and West Bengal. The committee made comprehensive recommendations for the above purposes. Later a Cyclone Review Committee was also constituted by the Department of Science and Technology. This committee also made comprehensive recommendations for the improvement of cyclone warning services and the long-and short-term measures to mitigate cyclone distress, taking into account the recommendations of the earlier committee.

As a result of implementation of the CDMC and CRC recommendations, not only have the cyclone warning services improved, but also the mitigation measures taken by all the States have been strengthened. These include construction of shelters, afforestation schemes, construction of embankments and dykes and improvement of communication systems. Coordination between cyclone warning centres and the affected State Governments has also improved considerably, with the result that loss of lives due to tropical cyclones has been reduced.

5. Heavy rainfall and flood warnings

The heavy rainfall warnings constitute an important factor in many hydrometeorological problems, such as flood forecasting. The flood forecasters are interested in the precise information on the average rainfall in the catchment areas during the previous 24 hours (quantitative precipitation estimates), and the rainfall expected to occur in the catchment areas during the next 24 hours (quantitative precipitation forecast).

There are several methods for the estimation of precipitation. These are: conventional method using raingauge network; with the help of radar; and with the help of satellite data.

One of the oldest, but still very useful methods of observing precipitation continues to be the use of raingauges installed at selected locations. In India the present number of raingauge stations available over the country is quite large. Data from about 2 500 key raingauge stations

throughout the country, are regularly used for analysing and estimating rainfall in various meteorological centres in the country. Such rainfall analysis forms the basis of rainfall estimation.

Radar is useful in estimating precipitation for a large area from a central location in real time. However, its range is limited to about 150 km. The accuracy of precipitation estimates by radar is of the order of 75 to 80 per cent, but these are not widely used in the Indian sub-continent.

Satellite imagery is another tool for estimating rainfall over a vast area from the vantage point of outer space. Today, the coverage of a geostationary satellite is such that it can provide data on an almost global scale every 20 to 30 minutes. With the visible and infra-red sensors, global coverage is possible, for the entire day and night. Land and sea regions are observed with equal spatial and temporal resolution and data are available in real time.

Heavy rainfall warnings are currently issued by the India Meteorological Department from its various meteorological offices. These heavy rainfall warnings are mainly for short-range, and are communicated to recipients through different links including telegraph channels. Heavy rainfall warnings are also broadcast through the All India Radio from different stations and in different Indian languages.

India is providing flood warnings through Central Flood Forecasting Divisions (CFFD) of the Central Water Commission (CWC) covering the major rivers such as the Ganges, Brahmaputra, Mahanadi, Krishna, Godavari and their major tributaries and other flood-prone rivers in the country. The India Meteorological Department provides support to these flood forecasting centres by providing heavy rainfall warnings through the Flood Meteorological Offices (FMOs) now functioning at 10 centres.

6. Severe local storms and tornadoes

Severe thunderstorms, known in India as severe local storms, are natural phenomena which cause considerable damage to life and property every year in India. The destructive effects of local severe storms are high winds, hail storms, lightening, heavy rains. Most violent of all are the tornadoes. However, frequency of tornadoes in India is very low (one or two per year).

Severe thunderstorms are observed in the hot weather season, i.e., from the middle of March to the middle of June. The main regions of high thunderstorm activity in India during the premonsoon season are: north-east India, north-west India, central parts of the country, and the south-west peninsula. Thunderstorms over north-east India are normally very severe and are known as "Nor' westers", as their modal direction is from northwest. In north-west India, associated with convective clouds, duststorms occur. Significant duststorm activity begins in April and reaches maximum in June.

Basic parameters leading to the development of a thunderstorm are observed through conventional synoptic surface and upper air meteorological observations. Hourly observations are taken in some selected areas and are utilized in forecasting severe thunderstorms. The most reliable tracking of severe storms is through radar surveillance. As soon as the thunderstorm cells or squall lines are observed on the radar screen, their speed and direction of movements can be measured by marking their progress over the radar screen. On the radar screen indications are also available regarding its severity and its potential for producing rain and hail. Such information is utilized in forecasting the local severe storms. Cloud observations from geostationary satellites and polar orbiting satellites are useful in demarcating broadly the area's potential for the convective development where severe storms may occur.

At present, a procedure exists for issuing warnings based on certain known factors for high wind, hail and heavy rain associated with the thunderstorms, generally 24 hours in advance to the warnees listed with the different meteorological offices in India. In addition, such warnings are issued from different meteorological offices in India to the public through All India Radio and all other news media. Considering the random occurrence of tornadoes, their short life period and very low frequency in India, the warning services for tornadoes have not been developed as yet.

C. Droughts

Drought is one of the worst natural calamities that affects India frequently. The most important cause of the drought is the deficiency of rainfall. India's agriculture depends on the south-west monsoon (June to September) rainfall. During this period, the country receives about 75 per cent of its annual rainfall. A large deficiency of monsoon rainfall in sizeable parts of the country, therefore, brings disasters. The monsoon rainfall shows considerable year to year variability over the country as a whole and also over the regions such as north-west India and peninsular India. One way of indexing a drought is by considering the rainfall departure from the normal, although there are various ways of defining drought. According to rainfall records, from 1875 to 1987 there were 19 occasions of drought in India and a whole. In north-west India and Peninsular India, the monsoon failed on 43 and 25 occasions, respectively, during the same period. The record

does not indicate a trend or periodicity for the occurrence of drought. However, during the period 1920 to 1960 the incidence of drought was much less than prior to and after that period.

Drought prediction still remains an unsolved problem. India Meteorological Department is, however, a pioneer in issuing long range forecasts of monsoon rainfall for more than 100 years.

The long range forecasts in India are being issued using statistical correlation and linear regression equations. Initially, the factors used were essentially the surface observations in and around India and later, with the availability of upper air observations, upper air data were also included. By continuous research, from time to time the techniques are modified and new techniques are added. In 1987, a parametric model was developed which utilizes 15 parameters. Some of these are global and some are regional in nature. The parameters are physically linked with the monsoon circulation. It has been observed that in a year when 60 per cent or more of the parameters are unfavourable, the monsoon has invariably failed. On the other hand, when 60 per cent or more of the parameters are favourable, the monsoon was either normal or above normal. This model indicates a very encouraging means of drought prediction.

D. Earthquakes

Earthquakes are another class of natural phenomena which bring frightening disasters to mankind. However, at present, there is no warning system for the occurrence of earthquakes. Only by analysing the past data can the risk areas be demarcated. Earthquake disaster can be reduced only by avoiding human activities in high seismic zones.

The role of the India Meteorological Department in earthquake mitigation is to observe earthquakes and to analyse the past data for risk assessment. India Meteorological Department has already demarcated the country into different seismic zones by analysing the past data.

X. INDONESIA: DISASTER PREPAREDNESS AND MANAGEMENT

by Jusuf Talib[1]

A. Introduction

The geologic and geographic setting of the Indonesian archipelago and the uneven distribution of population are continuing to expose Indonesia to a variety of hazards which adversely affect the environment, the infrastructure, buildings and constructions, and the settlements. Natural disasters can cause suffering of the people and damage to property, resulting in high economic losses amounting to billions of rupiahs. The Government of Indonesia has become very concerned with natural disasters as they have tended to become more destructive by affecting an increasingly larger numer of populated areas, and has issued several regulations to prevent and mitigate the impact.

The recently established disaster management system has achieved significant progress, especially with the application of science and technology in research and studies on assessment of disastrous phenomena and their management, successfully minimizing or reducing the damages, losses and suffering of the people.

B. Natural disasters in Indonesia

The Indonesian archipelago consists of five main islands and about 30 smaller groups totalling 13 677 islands and islets of which about 6 000 are inhabited and located in the tropical zone between the Pacific and the Indian Oceans, and bridges the two continents, mainland Asia and Australia. Indonesia's social, cultural, economical and political as well as security patterns have always been affected by its geographic position.

The territory of the Republic of Indonesia stretches from 6°8' North latitude to 11°15' South latitude and from 94°45' to 141°65' East longitude, with an estimated area of about 5 193 250 sq.km, which consists of a land territory of 202 787 km^2, and a sea territory of 3 166 163 km. Java, with a surface area of 132 187 sq.km, is the most fertile and densely populated island; Kalimantan, covering two-thirds of Borneo island, has an area of 539 460 sq.km; and Sulawesi 189 216 sq. km and Irian Jaya 421 981 sq.km. The other islands are smaller in size.

The three seismic belts which divide the Indonesian archipelago into three parts, are: (a) the Alpine Java or Tethys mountain systems, stretching from continental Asia southward, west of Sumatra and subsequently turning east, south of Java, towards the Moluccan islands; (b) the Circum-Pacific System, constituting a part of the east Asiatic systems, stretching from the islands of Japan all the way down south through the Philippines, the northern part of Sulawesi and the Moluccan islands; and (c) the Circum-Australia Belt, constituting a part of the East Asiatic System, stretching from New Zealand through Australia, the province of Irian Jaya and the Moluccan islands.

Indonesia's land area is generally covered by thick tropical rain forest, where fertile soils are continuously replenished by volcanic eruptions such as those on the island of Java, since the ejected lava has a high degree of soil fertility. The island of Java has 35 volcanic activity centres of which 16 are categorized as type A volcanoes. There are in total 128 active and 75 type A volcanoes in Indonesia.

The climate and weather are characterized by the monsoon system and there are two rainy seasons a year.

The population of Indonesia numbered over 179 million, indicating a decrease in the growth rate from 2.15 to 1.97 per cent per year since 1980 (National Census of 1990). The largest number of people, approximately 61 per cent, live in Java which constitutes only 7 per cent of the total land area of the country, with 31 per cent of the population living in urban areas on Java. This uneven distribution of population makes matters more complicated in Indonesia.

Indonesia is subjected to an extremely high degree of seismic activity with an annual average of 350 earthquakes, where between four to ten earthquakes are of high scale magnitudes. Approximately half to two-thirds of the total number of South-east Asian earthquakes have occurred in Indonesia.

Due to the 128 existing active volcanoes, Indonesia is also subjected to a high rate of earthquake incidence of volcanic nature. Active crustal movements occur along

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the Indonesian islands. The regions extending from Sumatra passing through Java and Lesser Sunda islands to the north following the western part of Sulawesi, are categorized as areas prone to earthquakes and volcanic eruptions.

The humid tropical climate of most regions in the country is characterized by very high annual precipitation, which causes high incidence of landslides and floods. According to historical records, most of this type of disasters have struck at regular intervals due to recurrent nature of rainfall. Studies have been undertaken to measure the destructive impacts of such disasters, and to improve the prediction and mitigation capabilities.

C. Disaster preparedness and management

Disaster awareness is an important issue in making the people and the concerned officials prepared to face all types of hazards. This needs education and training, and appropriate logistic facilities, of which transportation and telecommunication facilities are the most constrained in Indonesia.

In Indonesia urbanization has been rapid in recent years owing to socio-cultural and socio-economic changes, which seriously affect disaster preparedness measures.

Humanitarian issues tend to dominate the rescue and relief activities and overwhelm disaster preparedness in the country. Continuous recurrence of disasters and other economic constraints tend to reduce the level at which mitigation procedures should be practised. The Government has taken the lead in achieving the right balance between disaster relief and mitigation at the national level, and has encouraged the same at all levels of authority.

Natural and man-made disasters threatening Indonesia are comprehensive and severe. Major risks arise from earthquakes, volcanic eruptions, floods, landslides, strong winds, high tides, fires, droughts, agricultural pests and diseases, water/air/soil pollution, deforestation and other environmental degradations. Natural disasters have repeatedly caused significant economic losses, loss of human lives and suffering, and damage to and loss of personal and public properties. In addition some major air and maritime calamities and traffic accidents have been experienced frequently, while industrial accidents have occurred occasionally, due to natural disasters.

Within the period 1984-1989, about 18 591 major disasters were recorded with an annual average of 3 702 events. As can be seen in table 23, these resulted in a total of 4 129 deaths, almost 9.3 million people severely affected, 153 788 houses collapsed and 441 493 damaged, and a total estimated loss of Rp. 562 billion (approximately U$$ 315 million). This amount does not include damages to the infrastructural buildings and constructions and environmental losses, which would amount to more than twice or triple as much.

Within this context the Government of Indonesia is pursuing a policy of "disaster management" with emphasis on preparedness and mitigation programmes, covering procedures and responses related to both the pre- and post-disaster phases aimed at reducing the negative impact of disasters on population living in disaster-prone and high-risk areas.

Disaster preparedness and mitigation activities at pre-disaster phase include collection and analysis of relevant data, and formulation of countermeasures as well as undertaking education and training programmes to enhance the awareness and preparedness of the people.

Intervention of the Government of Indonesia in disaster management often follows a cyclical pattern where a disaster occurs, and the weaknesses in the response activities come into the open and protective measures fail. Greater efforts in rehabilitation, reconstruction, improvement of preparedness measures and better mitigation planning are then made in preparation for the next unpredictable disaster event.

Due to the complexity of the impacts of disasters the preparedness measures are undertaken in a multi-functional and multi-disciplinary manner.

To facilitate implementation of the Fifth Five-Year National Development Plan, the Guidelines of the State Policy designated in 1988 by the National People's Assembly, describe *inter alia* three main objectives for disaster management: civil protection; conservation of the environment; and national development of security and defence.

The disaster management strategy of the Government reflects those guidelines, that is to strengthen the community's awareness and preparedness to cope with possible disaster occurrences in vulnerable areas, and to achieve environmental management, including all socio-economic and cultural components of development decision making.

In this context the foremost implication is that "sustainable development" or "environmentally sound development" is directly related to all the disaster management efforts. All experiences gained in disaster management since the establishment of the National Coordinating Board for Disaster Management (BAKORNAS PB) are preserved and developed, and improvements are made accordingly.

The disaster preparedness strategy aims, in the long-term, at having risk assessment and evaluation techniques

Table 23. Disaster records in Indonesia, 1984/1985 to 1988/1989 (Fourth National Development Plan Period)

No.	Fiscal year	Frequency	Suffering (thousand)	Death	Houses		Estimated Losses (1,000 million Rupiahs)
					Collapsed	Damaged	
1	1984/1985	4 311	1 999	1 026	42 974	203 599	131.9
2	1985/1986	4 576	1 999	942	59 190	119 506	80.7
3	1986/1987	4 680	2 163	992	24 058	58 364	105.1
4	1987/1988	2 423	1 106	725	12 293	25 059	130.5
5	1988/1989	2 601	1 994	444	15 273	34 965	113.8
TOTAL :		18 591	9 261	4 129	153 788	441 493	562.1 *
Annual average :		3 702	1 852	826	30 757	88 298	112.4
1974/75 to 1984/85 Annual average		4 881	5 272	794	31 817	70 269	98.0

Source: Department of Social Affairs, 1989

Note : Not including environmental and infrastructural losses
* Equivalent $US 335 million

employed by the provincial level planners and authorities in all of the 27 provinces, and in having one up-to-date national disaster plan for each province. Training courses which have been conducted for disaster managers, government officials and non-governmental volunteer agencies, will be continued.

Continuous monitoring and control of all potential hazards that can be caused by changes due to nature or by human interventions, are considered to be the pre-requisite for both planned operational response and mitigation activities. A risk monitoring system is being developed into a centralized information and data processing system covering all disaster-prone provinces and areas.

Owing to the widespread scope of hazard-prone areas, the main disaster response activities are focused on the district or municipality level to give the District Head or Municipality Mayor the full authority to take the necessary steps on disaster preparedness, mitigation and response in time of emergency. The Governor of the Province has the responsibility to coordinate all departmental offices and non-governmental organizations at the provincial level and to provide general assistance to the District or Municipal Operational units. The Governor at the provincial level takes responsibility for further steps to be taken, such as provision of medicine, social and technical help, and other appropriate assistance.

D. Regional and international cooperation in natural disaster reduction

Development efforts need to be enhanced through cooperative activities with other countries since disaster occurrences are not limited by administrative boundaries of a country. Therefore regional as well as international cooperation in disaster management would be vitally important to provide mutual assistance between interested countries to help each other in strengthening the national capability to cope with disasters.

In this context Indonesia's adoption of the sustainable development concept has led to development of measures for disaster prevention and mitigation linked with reliable regional communication and information systems network. Through this network, warnings of impending disasters and emergencies can be relayed from country to country, and continuous cooperation can be maintained.

As a response to the International Decade for Natural Disaster Reduction (IDNDR), the Government of Indonesia has decided to establish the National Coordination Board

for Disaster Management as the Committee responsible to establish national work programmes on natural disaster reduction.

Sectoral and bilateral projects with technical assistance from other countries, directly or indirectly related to disaster management objectives, have been coordinated and integrated to support the establishment of one comprehensive national disaster management system.

Some examples of on-going projects conducted by several departments or institutions are:

(1) The Department of Public Works with the Japanese International Cooperation Agency (JICA) on Volcanic Debris and Flood Control which will be developed with River Disaster Engineering Project.

(2) The Department of Mines and Energy with the United States Geological Survey (USGS), JICA and France on geological hazards engineering.

(3) The Department of Communication (the Agency for Meteorology and Geophysics) with France, WMO, and UNESCO on setting up a monitoring and observation network on meteorological and seismic activities.

(4) The Department of Health with WMO on disaster medicine.

(5) The Indonesia Institute for Sciences with Australia and UNESCO on ocean dynamics.

(6) The National Coordinating Board for Disaster Management with the Association of South-East Asian Nations (ASEAN) countries, Australia, New Zealand, United Kingdom, Japan, the United States, UNDP, UNDRO, UNESCO, UNICEF, ILO, Asian Disaster Preparedness Centre of the Asian Institute of Technology (ADPC/AIT) and other countries/institutions on disaster preparedness and disaster management projects.

(7) The Department of Home Affairs with Japan on fire prevention and fire fighting.

(8) The Department of Forestry and the Ministry of Population and Environment with the United States Forestry Service, Canada, and UNEP on forest protection and environment conservation.

The implementation of these projects has brought in new concepts and methodologies in disaster management which have improved the national capability in preparedness to cope with disaster and emergency situations. Indonesia would appreciate receiving technical assistances from other more experienced and better prepared countries, and solicits ESCAP to initiate a coordinating effort for cooperative projects within the Asian and Pacific region.

XI. DAMAGE FROM FLOODS AND MITIGATION MEASURES IN MALAYSIA

by Ferng Meow Chong[1]

A. Introduction

Malaysia has no other major natural disaster than floods.

Excessive precipitation is beyond human control. Man can only attempt to reduce the adverse effects of excessive precipitation after its occurrence. The objective of flood mitigation is therefore to prevent flooding of areas where it can cause damages and to prevent river waters from overflowing their natural banks after heavy rainfall. Flood mitigation methods would therefore vary from place to place and it would be difficult to state that a method which has been successful on one river will be the best solution for another river in the country.

Flood plains of rivers attract man to live on them, where water is readily available, the soil is usually fertile and access is easy. The historical development of settlements in Malaysia has involved the occupation of the fertile flood plains and tidal flats near estuaries in the early days. Many of the urban areas today are thus situated wholly or partly in flood plains and coastal lands which are subject to flooding from rivers.

B. Floods in Malaysia

1. Flood damages

In the past, major floods had caused loss of lives and extensive damage to crops and property. The more recent floods which resulted in country-wide damage and distress were those of 1967 and 1971. In the 1967 flood, the worst affected state was Kelantan. About 6 000 sq.km. of land was inundated and an estimated 360 000 people were affected by the flood. Fifty-five lives were lost. Damage in monetary terms was about $US78 million. In the 1971 flood, the worst affected state was Pahang. Damage to property and crops amounted to$ 38 million. Over 150 000 people were affected by the flood and 24 people lost their lives. In the same flood, the capital city of Kuala Lumpur was also badly ravaged, with the damage estimated at $US 35 million. At many riverine areas, settlements and towns, flood risk still constituties a major obstacle to agricultural and socio-economic development.

2. Flood control measures

As early as 1972, the Government, recognizing the significance and importance of flood control measures in national development, established a Permanent Flood Control Commission with the primary function of formulating measures and long term plans for flood mitigation and relief in the country.

In general, available measures for flood mitigation can be listed under two categories, namely structural and non-structural measures.

The optimum flood mitigation plan for any particular locality usually involves several elements of structural and/or non-structural measures. Detailed investigation and studies are necessary for the formulation of such flood mitigation plans.

(a) Structural measures

Structural measures are those involving engineering works for the control of floods, such as flood detention dams, river improvement works, river diversions and construction of river embankments.

The implementation of such flood mitigation projects employing structural measures would require large commitment of government funds. The government has formulated a definite long-term plan of flood mitigation works for the various flood-prone areas of the country. The programme will benefit some 3 600 sq.km. where flood damages and losses have generally been high. This will also provide a relatively flood-free environment for continued socio-economic development in both the rural and urban areas.

(b) Non-structural measures

Non-structural measures include flood forecasting and warning, land-use control and zoning and other legislative control and management measures for reducing the severity and consequences of floods.

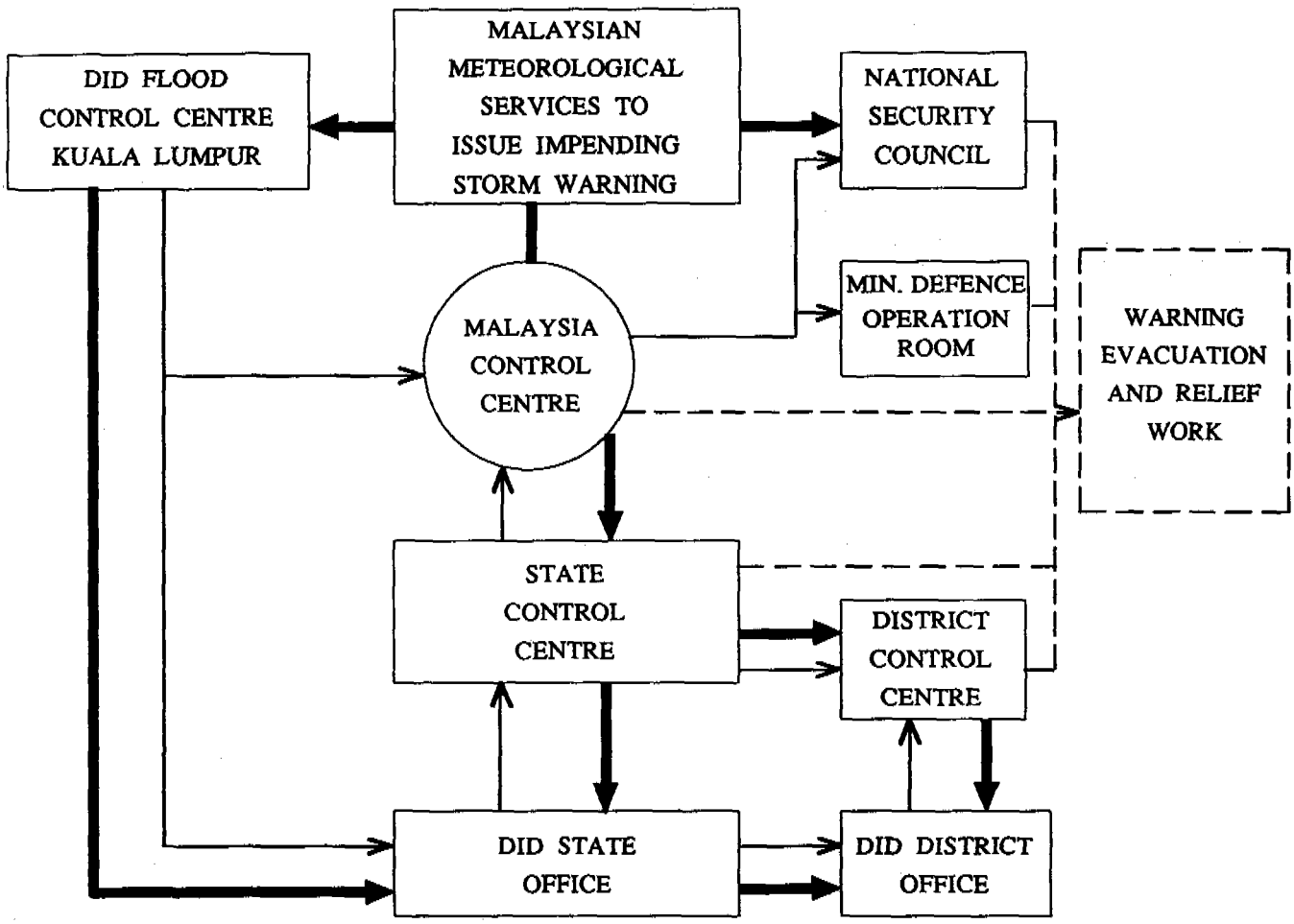
Flood forecasting and advance warning of impending floods can considerably reduce flood loss and damage and above all loss of human lives.

[1] Director of Hydrology, Department of Irrigation and Drainage, Kuala Lumpur.

Prior to 1971, only rudimentary forms of flood forecasting systems were used in a few river basins. These were mainly based on the stage-correlation method whereby the rising river stage at an upstream point is manually observed and then used to predict the river stage downstream where the populated area is prone to flooding. Warning was issued when the predicted stage exceeded the critical level.

After the 1971 major flood, the need to mitigate the effects of floods through improved flood forecasting and warning systems became evident. Since then, flood forecasting techniques and facilities were developed and established progressively for systematic real time flood forecasting in a number of river basins frequently affected by floods. Figure VII shows the flood forecasting and warning practice employed in Malaysia together with the government offices involved.

At present there are eight telemetric flood forecasting networks established in major river basins prone to severe flooding. The networks provide for automatic transmission of rainfall and river stage data to the Department of Irrigation and Drainage state offices. There are also 119 staff gauge stations, 60 flood warning boards and 35 sirens situated at strategic locations to collect data and also to give forecasting and warning to people who will be affected by flood.



Source: DID Department of Irrigation and Drainage

ACTIVATION OF SYSTEM.
FLOOD FORECASTING.
FLOOD WARNING, EVACUATION AND RELIEF WORK.

Figure VII. Flood forecasting and warning practice in Malaysia

XII. HAZARDS REVIEW, DISASTER PREVENTION AND PREPAREDNESS PROGRAMMES IN MYANMAR

by Ohn Maung[1] and San Thein[2]

A. Introduction

Myanmar is a country located in South-east Asia, covering an area of 676 578 sq.km. It is part of the peninsula that protrudes into the Indian Ocean having a long coast line on the Bay of Bengal. There are three well-marked geographical divisions, the Western hills, the Central Belt, and the Shan plateau to the east, with southward continuation of the highland in Tanintharyi Strip. Generally, high grounds are in the north and the topography gets lower towards the south of the country.

Myanmar has three marked seasons, namely: the hot season (February to May); the south-west monsoon season (June to September); and the cold season (October to January).

The types of disasters that are experienced in Myanmar are: tropical storms and cyclones; floods; fires (man-made); earthquakes; and landslides.

B. Tropical cyclones/storms and floods

In Myanmar, tropical storm is a natural disaster brought on by geographical and weather conditions, causing severe economic losses as well as loss of lives, also lowering the morale of the people in disaster-prone areas.

Myanmar, having a long coastal line bordering on the Bay of Bengal, is occasionally hit by tropical cyclones causing widespread damages to life and property especially when such storms are accompanied by storm surges. Cyclones occur mostly during the period from June to November, but severe tropical storms are also experienced during April, May, October, November and December. The storms during the monsoon period are of moderate intensity and rarely reach hurricane force. Cyclonic storms of dangerous severity occur most frequently during the transition periods of pre-and post-monsoon months. Many storms originating in the South China Sea and the West Pacific enter Bay of Bengal through the Gulf to Thailand and the Malaysian Peninsula.

From the tropical storm records covering 108 years since 1877, the average number of storms in the Bay of Bengal is 12 per year. Once in every two years a storm and once in three or four years a severe storm may cross the coast of Myanmar. From the records, 90 per cent of these storms have crossed the Rakhine coast, 70 per cent the Deltaic coast and 3 per cent the Mon State. The losses of property and life due to severe cyclones are presented in table 24.

Myanmar is a country with heavy rainfall and consequently floods of various intensities are common. Floods occur generally during the South-west monsoon season (June-September) and the most frequently flooded areas are lower Ayeyarwady Division and Delta Regions. Upper Chindwin areas and Sagaing Division are occasionally flooded due to heavy rainfall. Floods cause damages to the paddy fields, crops, disruption of communication and hindering of economic development activities.

The occurrence of earthquakes, landslides and famine due to droughts are negligible in Myanmar when compared with the disasters mentioned above.

C. Tropical cyclone warning, dissemination and use

A tropical cyclone warning and dissemination system has been developed in the Department of Meteorology and Hydrology, and as soon as conditions warrant, each step in system is strictly followed.

The following types of warnings are being issued by the Department of Meteorology and Hydrology as and when necessary.

(1) Cyclonic storm warnings;

(2) Squall warnings and storm surge warnings in association with cyclones;

(3) Strong winds outside the storm season;

(4) Untimely rainfall warnings;

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[1] Director General, Department of Meteorology and Hydrology, Yangon.

[2] Director General, Department of Relief and Resettlement, Yangon.

Table 24. Damages due to cyclones in Myanmar

	State/Division	*Towns/Townships*	*Occurrence Date*	*Houses*	*Households*	*No. of Victims*	*Deaths*		*Cost of Losses (million Kyat)*
							Humans	*Animals*	
1.	Rakhine state	Sittwe	14-5-1884	-	-	-	100	-	-
2.	Rakhine state	Kyaukphyu	26-4-1936	-	-	-	1991	700	2.8
3.	Rakhine state	Sittwe	8-10-1968	-	-	-	1	-	10.0
4.	Rakhine state	Sittwe	24-10-1952	-	-	-	4	-	-
5.	Rakhine state	Kyaukphyu	5-5-1967	-	-	-	-	-	20.0
6.	Rakhine state	Sittwe	5-10-1967	-	-	-	2	-	10.0
7.	Sagaing Division	Yinmarbin	5-10-1967	-	-	-	20	2 700	5.0
8.	Rakhine state	Sittwe	10-5-1968	-	-	-	1 037	17 022	20.0
9.	Ayeyarwady Division	26 Townships	7-5-1975	132 927	243 937	-	303	9 578	-
10.	Rakhine state	Gwa	4-5-1982	7 051	7 360	31 018	5	-	34.1
11.	Ayeyarwady Division	Kyonpyaw	4-5-1982	48 976	49 157	242 490	15	-	33.4
12.	Bago Division	4 Townships	4-5-1982	18 832	18 876	101 331	7	-	7.3
13.	Mon state	Bilin	4-5-1982	7 045	7 045	35 294	-	-	7.6

(5) Flood warnings (river floods and flash floods); and

(6) Storm surge warning.

The cyclone warning dissemination and usage, prepared by the Department, is as follows:

Warnings are issued by the Central Forecasting Officer in Yangon. Warning for (5) is issued by the Hydrological Forecasting Office in Yangon. Regional Office at Mandalay also issues flood warnings for Upper Myanmar.

All the Warnings shown in (1) to (5) are regularly broadcast in the Weather News from the Voice of Myanmar and also published in daily Myanmar and English newspapers. These warnings are also announced on Yangon television together with the weather maps at 20:00 hours Myanmar Standard Time (MST).

The most effective method of dissemination of weather warnings is by the radio broadcast of Voice of Myanmar. This Department is authorized to interrupt at any time during transmission period when a storm is threatening any Myanmar Port or when a serious flood is threatening certain areas along a river. All news broadcasts include weather news as a routine.

Post and Telecommunications Enterprise of Myanmar has recently completed its modernization plan and now it is possible to use dial system telephones to nine major cities in Myanmar including the coastal cities of Sittwe and Pathein and Mandalay in Upper Myanmar.

Since 1975, 28-SSB transceivers have been installed at meteorological station in Myanmar including coastal stations at Sittwe, Kyaukpyu, Gwa, Thandwe, Dawei, Beik and Victoria Point. With the Kyaukpyu radar already installed in 1979 and the new APT now in use for receiving cloud pictures from meteorological satellites, this department is in a better position to issue storm warnings for the general public, especially in the coastal regions. This department issued timely warnings for Gwa cyclone of May 1982 and also for the cyclones of October and November 1983.

In the case of cyclones threatening coastal cities, all traffic including sea vessels, trains, cars and planes are instructed to stop, through the State/Divisional Law and Order Restoration Councils.

D. Prevention and preparedness measures

Under the Ministry of Social Welfare, the Government has set up the Relief and Resettlement Department (RRD) to cope with disasters. The role of RRD is not only undertaking post-disaster relief works but also dealing with disaster planning and preparedness.

Myanmar has its system for disaster administration, based on its own social, cultural, political and administrative practices.

The principal aims of prevention measures against natural disasters in Myanmar are:

(1) To prevent or reduce loss of human lives;

(2) To prevent or mitigate losses to dwellings and other properties of the people; and

(3) To minimize damage to public properties.

The major task of RRD is to give relief assistance intended only to meet the immediate requirements and to minimize the suffering of the affected people. This Department has also been carrying out activities related to prevention and preparedness for natural disasters in cooperation with other respective departments such as the Meteorology and Hydrology Department, Irrigation Department, Fire Services Department, Health Department, People's Police Force, Myanmar Construction Enterprises, Social Welfare Department and Myanmar Red Cross Society.

Cyclones always bring high storm surges, causing salt water intrusion into drinking water and cleaning water. The victims who had merely survived the cyclone are then deprived of potable water as well as water for bathing. Drinking water tanks and usable water ponds help prevent such situations. Pauktaw, Myebon, Minbya in the Rakhine State, where such cyclone disasters frequently occur, have eight such refuge shelters and water tanks. High mounds at Pauk taw township can service seven villages, where nearly 3 000 persons can take shelter in case of emergencies.

During the cyclonic event people take refuge around the water tanks, shelters, for protection against storm surges as well as strong winds that come with cyclonic storms.

RRD has been conducting short-term training courses in major towns of states and divisions on natural disaster prevention measures. These are organized for the training of trainers who in turn have to organize and conduct training in their own regions under the supervision of the regional authorities concerned, so that the people may become familiar with and understand the natural disaster prevention measures. These training courses have been successful and well-accepted by the people. To date 44 training courses have been completed and there is a plan to continue this type of training course in the future.

As for disaster relief measures, emergency stockpiling centres (warehouses) have been established in major towns of states and divisions for the speedy dispatch of relief goods to disaster affected areas. There are 16 emergency stockpiling centres in the states and divisions storing relief goods such as household items, clothing, tarpaulin tents, fresh water tanks, and generators to be on hand for emergency use in case of disaster. Necessary procurement and replenishment are made monthly, quarterly and annually at these centres under the supervision and direction of RRD.

E. International assistance and cooperation in natural disaster reduction

RRD has been accepting international relief assistance when other countries and international organizations such as UNDP, UNICEF, UNDRO etc. offer to donate relief goods to disaster victims. RRD accepts international assistance offered and then transports the goods to disaster-prone areas immediately and distributes them to the victims under cooperation and supervision of regional authorities concerned.

Myanmar, being a member of United Nations, and RRD, under the Ministry of Social Welfare, have contributed to the annual funds of UNDRO, UNHCR and also donated funds and relief materials such as rice, salt and plywood for the disaster victims of neighbouring countries and other nations.

Myanmar is fully aware of the importance of international cooperation in the field of research, training and exchanges of experiences. Myanmar always avails itself of the opportunity to send its officials to training seminars, symposia and disaster management courses, such as at the Asian Institute of Technology (AIT) in Bangkok, and other opportunities provided by such organizations as UNICEF, UNDP and JICA.

F. Conclusions and recommendations

The disaster preparedness situation in Myanmar is not yet satisfactory. Measures for community preparedness for disasters are taken in the form of providing education and information to the general public through the mass media. Training work is carried out and flood control embankments have been constructed in some places but more is needed to be done. Measures to reduce vulnerability such as more intensive river training, town planning and training of personnel for rescue and evacuation work, are still required. Therefore, it is necessary to organize, educate and motivate the people to cooperate in the field of disaster preparedness, prevention and relief.

XIII. DISASTER PREPAREDNESS AND MANAGEMENT IN PAKISTAN

by Sh. Zia Ud Din Ahmed[1]

A. Introduction

Pakistan lies between 23°N to 37°N latitude and 61°E to 67°E longitude, having a total area of 888 000 sq.km. with a population of approximately 120 million. The temperature in the country varies from a minimum of 6°C in January to a maximum of 49°C in June. The climate is monsoonal, and the average rainfall recorded during the monsoon season is 200 mm. Pakistan has a varied geographic pattern having the second highest peak in the world with major mountainous ranges of the Himalayas, Karakuram and Hindukush in the north and a vast waterless desert in the south. The areas constituting Pakistan are prone to a variety of disasters such as floods, droughts, earthquakes and landslides. While devastating earthquakes are a rare phenomenon, floods occur quite frequently and cause widespread damage. Droughts in the desert region also cause considerable concern. Disaster management has, therefore, remained an important discipline in Pakistan. The country has a federal structure. Prevention of disasters and post-disaster relief and rehabilitation measures are essentially the responsibility of provincial governments conducted under supervisory guidelines issued by the federal government.

B. Floods in Pakistan

Floods rank as the number one disaster in Pakistan. Severe floods have occasionally swept across the plains of the country, resulting in heavy loss of life and property. The main river system in the country is the Indus. The Indus Basin contains five major rivers which flow in a generally southerly direction from the Himalayan mountain ranges and join together to form one river approximately half way between the mountains and the Arabian Sea. These rivers are prone to massive flooding from monsoon rains and snow melt while some extremely destructive floods have been caused by landslides and collapse of glacier dams blocking tributaries creating temporary barriers. Floods in recent history have become more frequent, partly due to reduced flow passage caused by irrigation and power projects leading to increased alluvial deposition and at some places raising of the river beds higher than the adjacent flood plains. Table 25 presents the statistical information on damages caused by floods in Pakistan from 1973 to 1989.

Despite all the protective measures and flood forecasting and warning systems, floods do occur quite frequently. The floods of 1988 were the latest in a series which have had very few parallels in the history of Pakistan. The floods occurred in two phases spread over a period of 80 days, causing the damages presented in table 25.

The first phase of the floods was quite expected in view of the forecasts of 25 to 30 per cent more rainfall than normal. The Provincial Governments had therefore taken necessary precautionary measures and they were ready to evacuate the affected people. In most of the areas, people were evacuated before the floods actually hit. In other areas where the people were affected by floods and rain water, they were evacuated by boats with the assistance of the army. The only unexpected flood situating during the first phase occurred in the southern part of the country where a 100 metre wide breach in a protective embankment on the left bank of the Indus River occurred on 17 August 1988. Subsequently the width of the breach increased to 600 metres and the water escaping through it inundated a vast area (approximately 162 000 ha). Fifty relief camps had to be established to provide temporary shelter and necessary relief assistance to about 90 000 people out of more than 150 000 evacuated from those areas. Through the joint efforts of civil authorities and the army the breach was repaired completely after 12 days of heroic effort. The overall situation during first phase was quite alarming in view of the vast area affected and the resultant dislocation of population and damages caused to life and property.

The second phase of the floods commenced on 25 September 1988 as a result of heavy and continuous rainfall in the catchment areas. The devastation caused during the second phase was mainly caused by the return of people who had been evacuated to their homes. While they were recovering from the shocks of the first phase, they were caught almost unaware. The element of surprise in the second phase could be attributed to many factors.

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[1] Director General, Emergency Relief Cell, Pakistan.

Table 25. Damages caused by floods in Pakistan, 1973-1989

LOSSES/DAMAGES	*1973*	*1975*	*1976*	*1988*	*1989*
Villages affected	9 719	8 628	18 390	21 019	25 188
People affected (million)	4.80	2.25	9.79	4.73	1.33
Total area affected (million ha)	4.2	3.5	8.3	4.2	1.0
Cropped area affected (million ha)	1.6	0.7	1.8	1.6	0.7
Houses damaged (million)	0.39	3.32	1.00	0.74	0.09
Persons dead	474	126	425	570	136
Cattle lost (head)	53 961	17 924	29 242	33 341	5 924

Timely detailed information on rainfall and discharges was not available from across the border and therefore no warning was issued to the public. The radar at Sialkot (in Pakistan) could not measure exactly the rainfall in the catchment areas due to its range limitations. The telemetric gauges installed at rim stations at Marala on river Chenab and at Jassar on river Ravi had been overrun by floods and were no longer in working condition. There were a few communication lapses also due to defective equipment. Most of the damages during the second phase however occurred upstream in Punjab; the downstream areas had sufficient advance notice to handle the situation.

Besides evacuating the flood affected people, the provincial governments, responsible for providing temporary shelter and relief to these people, set up a total of 745 relief camps during the two phases where the affected people were provided with medical facilities and basic necessities of life. The cattle accompanying the affected people were also provided with fodder. In the case of Baluchistan, where a large number of people were stranded in one area, relief assistance was airdropped. Funds provided from the federal resources and from provincial sources were 55 million rupees and 470 million rupees, respectively. The governments of Punjab and Sind also declared the flood affected areas as calamity stricken and remitted funds from taxes, causing considerable loss of revenue to the government. Other cash grants from various sources and interest-free loans to stricken farmers were also provided.

C. Droughts in Pakistan

While the northern and western areas of Pakistan receive plenty of rainfall with abundant water resources, the southern region is spread over a vast desert. The area is comprised of shifting sand dunes with very little fresh groundwater resources and scanty irregular rainfall. The area is the least developed in the country, having very little communication infrastructure. The inhabitants of this area largely depend on rainfall for their crops and cattle and in case of failure of the rains they sometimes have to abandon their homes in search of food and water. The desert areas in the Punjab and Sind experienced a long rainless period spread over three consecutive years from 1985 to 1987, which caused considerable loss of life as well as damage to the economy.

In the Punjab, the average annual rainfalls were, 223.5 mm, 85.1 mm, and 96.0 mm during 1984-85, 1985-86 and 1986-87, respectively. In the Sind, average annual rainfall varied between 125 mm to 200 mm during that period, affecting an area of 27 737 sq. km. and a population of 8 million. In Punjab 31 500 sq. km. and 71 000 people were affected. Subsequently, Arid Zone Development Authorities were created in Punjab and Sind to develop the areas towards meeting their basic essential requirements.

D. Earthquakes

Though earthquakes occur rarely in Pakistan they take a heavy toll in terms of loss of life and property. In

1935, before the creation of Pakistan, an earthquake of severe intensity (magnitude 7.5) struck Quetta city, killing 35 000 people. The region is still an active seismic zone. Since its creation in 1947 Pakistan has faced five major earthquakes. The severest of these (magnitude 6.00) hit northern areas of Pakistan in the Karakuram range on 28 December 1974. The shock of the earthquake was felt over an area of 300 000 sq km. The earthquake killed about 1 000 people and permanently disabled 1 845 people while 17 677 houses were completely demolished and 2 313 houses were partly damaged in addition to the loss of 63 393 head of cattle. The Karakuram Highway alongside the Indus was severely damaged due to rockfalls, landslides or subsidence at many places. Improvised irrigation channels were destroyed and most of the springs went dry.

A survey of the damages caused by this earthquake indicated that the main factors responsible for damage to property were inferior construction, use of mud mortar instead of lime or cement, closely and haphazardly built houses. This was in fact the state of construction in most of rural areas in Pakistan.

While it may not be possible to forecast earthquakes exactly, efforts can be made to mitigate their effects by getting information as much in advance as possible. Pakistan has therefore set up a chain of six seismological stations with headquarters at Quetta. The network is controlled by the Pakistan Meteorological Department. A seismic observatory also functions at Tarbela. There is however, a large gap in the earthquake monitoring system as the seismically active belts of Chitral, Gilgit, Makran and Chaghi are without any observatory. Therefore, in order to further strengthen the network, a seismic array system is being set up at Islamabad with the help of WMO. For quick analysis of data and prompt dissemination of earthquake information, strong motion seismographs and accelerographs would be required.

As already stated, in Pakistan earthquakes have mostly affected the less developed mountainous areas almost inaccessible through ordinary means of communication even under normal circumstances, owing to the extremely difficult terrain and severely cold weather during winter. The use of heavy machinery in removal of debris is therefore rendered impossible, adversely affecting the relief and rescue operations. The conduct of relief operations in unaccessible mountainous areas would be a good study for an international group during the IDNDR.

E. Disaster prevention and preparedness

Disasters usually occur without warning. Every calamity big or small leaves behind a trail of misery seriously affecting the social, cultural and economic order. Unless the managing body is well organized and alert , it may cause widespread panic and misery. How promptly the order is restored is the test of the working machinery. It, therefore, becomes imperative that the emergency management services are well organized having essential infrastructure on the ground, adequately equipped and trained to handle emergency situations effectively.

1. At federal level

At federal level, the "Emergency Relief Cell" functions under the Cabinet Division for handling and coordinating disaster efforts. The Cell is headed by a full-time Director General who also acts as the focal point at national and international levels. The Emergency Relief Cell is responsible for coordinating disaster preparedness measures, relief and rehabilitation activities and inter-provincial and inter-ministerial work related to the national disasters, in accordance with the national disaster plan, established in 1974. The plan has provisions to establish procedures, prescribe organizational set-up, fix primary responsibilities and support functions of concerned implementing agencies and standardize the procedures for the monitoring of disaster operations. The major functions of the Emergency Relief Cell are:

- To maintain an inventory of essential relief goods including medicines, tents, blankets, and emergency rations for immediate despatch. Two warehouses at Islamabad and Karachi are available at present with adequate storage of relief items.
- To make available a squadron of four relief helicopters for emergency duty towards airdropping/supply of relief goods, evacuation of marooned personnel and other casualties.
- To maintain Prime Minister's Disaster Relief Fund for providing immediate relief to disaster-stricken people anywhere in Pakistan.
- To coordinate relief operations with provincial governments and provide additional financial as well as other assistance out of federal funds.
- To coordinate efforts and dispatch relief goods abroad based on the decision of the Government.
- To act as a focal point for international relief and coordination of efforts with foreign donor agencies when foreign assistance is required.

Since its creation in 1970, the Emergency Relief Cell has handled the following major disasters involving widespread loss of life and property, besides a number of small-scale disasters which continue to hit different parts of the

country every year: floods (1973, 1975, 1976, 1988, 1989); droughts (1974, 1984/85-1986/87); and earthquakes (1974, 1982).

The national disaster plan mentioned above embraces all disaster situations and envisages the use of all available resources, governmental, semi-governmental and non-governmental. Being action oriented, functional and flexible, the plan is capable of meeting disaster situations of various intensity as well as multiple contingencies.

Disaster management is organized at national, provincial, district and sub-divisional levels by designating specific officials as coordinators/managers.

2. At provincial and district levels

The provincial and district disaster plans are almost a replica of the National Disaster Plan, which has been adopted at these levels with a few minor modifications. In fact the Emergency Relief Cell prepared a model District Disaster Plan and furnished it to provincial governments for adoption. These plans contain background material regarding the disaster most frequently faced by the respective provinces and district. While the national disaster plan aims at meeting all disaster situations, the provincial and district disaster plans have been prepared essentially to meet flood disasters, but cover other disaster situations also. Like the National Disaster Plan, the provincial and district disaster plans also indicate the primary responsibilities and principal actions of the federal as well as provincial departments.

F. Operational measures in flood management

Flood management planning in Pakistan includes both structural and non-structural measures. Structural measures pertain to construction of dams, protective bunds, diversions, channelizing and taming of rivers, while non-structural measures mainly rest upon providing an accurate and timely flood forecasting and warning system. Floods in Pakistan are essentially caused by heavy monsoon rains over the upper catchment of the rivers generally across the border. The agencies at federal and provincial level which get involved in this operation are:

- At the Federal level: Federal Flood Commission, Ministry of Water and Power; Emergency Relief Cell, Cabinet Division; Engineer-in-Chief Directorate, General Headquarters; Pakistan Meteorological Department; Ministry of Food and Agriculture (Deputy Inspector General, Forests); Water and Power Development Authority (WAPDA); Pakistan Commissioner for Indus Waters, Lahore; National Engineering Services Pakistan (Pvt) Limited (NESPAK); and Army when required.
- At the Provincial level: Irrigation Department – Chief Engineer, Drainage and Water; Revenue Department – Relief Commissioner; Communications and Works Department – Chief Engineer; Divisional District and Sub-Divisional Administration; Meteorological Department; and Police Department.

In order to mitigate the damaging effects of floods, the Federal Flood Commission and Provincial governments adopt all possible preventive measures within the available resources. Dredging of river beds is the best way of taming rivers and containing flood water within regular channels. However, in view of heavy costs involved, coupled with paucity of resources, the protective schemes generally envisage erection of protective embankments and spurs at selected places. Pakistan has been seeking assistance from donor countries and multilateral donor agencies towards improving structural and non-structural facilities.

The extent of damages can be reduced by obtaining advance information through the latest data collecting system. Data collected through this system are applied by the Pakistan Meteorological Department into two computerized Rainfall-Runoff and Flood-Routing models and the resultant flood forecasts are provided to the flood fighting and relief agencies. The World Meteorological Organization and United Nations Development Programme have assisted the Pakistan Meteorological Department in setting up a quantitative precipitation measurement radar of 5.6 cm at Sialkot for gauging rainfall in the catchment areas. While the radar at Sialkot can cover the catchment areas of three western rivers only i.e. Indus, Chenab and Jhelum, it cannot satisfactorily cover the catchment areas of three eastern rivers i.e. Ravi, Sutlej and Bias. It is, therefore, now planned to install, with the assistance of Asian Development Bank, another radar of 10 cm at Lahore which will improve forecasting capability of the country. Recently, the Japanese Government has also agreed to assist Pakistan Meteorological Department in the installation of two radars of 5 cm at Islamabad and Karachi. These radars shall be able to monitor precipitation and approaching weather within a radius of 360 kilometres.

The weather reports and forecasts broadcast by the Soviet Government from Tashkent Radio are also a tremendous help to Pakistan Meteorological Department in forecasting approaching weather in winters. The Pakistan Meteorological Department also uses the surface and upper area meterological charts and cloud pictures obtained from United States Weather Satellites to forecast quantitative precipitation. The Government of India also provides information over telephone regarding rainfall and river

discharges on hourly to six hourly basis depending on the flood situation, in addition to information provided through postal telegrams and radio broadcasts. The Pakistani and Indian Commissioners for Indus Water also hold frequent meetings with each other for exchange of such information in accordance with the Indus Basin Treaty.

G. Relief

In view of the costs involved, Pakistan can ill-afford to maintain vast relief organizations at all levels, separate from normal administrative machinery. As a result, most of the relief duties are performed by various Government departments on a part-time basis. Like the small full-time organization of the Emergency Relief Cell, the provincial governments also have a limited set-up. A Provincial Relief Department is usually headed by the Senior Member Board of Revenue of the province who performs these duties in addition to his main functions in his above referred capacity. Like the Emergency Relief Cell at the federal level, the Provincial Relief Departments are responsible for coordinating pre-disaster preparedness measures and post-disaster relief and rehabilitation operations. It is at the level of district administration and below that disaster situations have to be met and fought physically. Instead of having separate relief organizations at these levels, the Government officials holding various posts in different departments automatically assume relief duties in accordance with a pre-planned scheme. At the district and sub-division level, the Deputy Commissioner and Assistant Commissioner respectively act as the focal point and coordinate the activities of the officials of the concerned implementing agencies e.g. Irrigation Department, Health Department, Animal Husbandry, Pakistan Meteorological Department, Water and Power Development Authority, Buildings and Roads Department, Pakistan Railways, Food Department, Directorate of Social Welfare, Information Department, Education Department, oil and gas companies, Public Health Engineering Department, Post Office Department, Police, Civil Defence, and Army. Various officials perform primary duties and take principal actions as outlined and assigned to them in disaster plans pertaining to each district.

The shortage of disaster managers is to a large extent met by calling the Army in aid to civil administration. The Engineering Directorate of the Pakistan Army has elaborate disaster plans of its own in respect of different areas of the country. As the flood season approaches every year, the Engineer Directorate operates a flood relief control centre in the General Headquarters for monitoring the flood situation and coordinating relief and rescue operations involving Army units. The Directorate also holds flood relief coordination conferences before and after the floods every year. The units earmarked for flood duty remain in touch with the Flood Forecasting and Warning Centre, and with flood control rooms operating at provincial and district level. The disaster managers at provincial, district and sub-divisional levels can seek assistance from these units for the purpose of rescue and evacuation wherever required. Breaching of protective bunds at the places decided by the civil authorities is also carried out by the Army using explosives. While restoration of infrastructural damage after the floods is the responsibility of the concerned civil departments, the Army helps those departments in emergency repair of the communication and transport network during the floods.

H. Conclusions and recommendations

In the light of the lessons learned from flood experiences in the past, Pakistan has considerably improved its flood warning and flood fighting systems. Defective telemetric gauges have been repaired, and protective embankments are being looked after properly in order to ensure that these do not collapse during floods. Foreign expertise and financial assistance will help in achieving Pakistan's objectives speedily and in reducing the miseries of the population.

When more than one country is involved, close cooperation among them is necessary to exchange information well in time. Pakistan's direct links with India for receipt of information regarding rainfall and river discharge are an example of such cooperation.

Use of modern technology with trained and responsible manpower is essential for operating any warning system. Pakistan is installing additional radars to meet this objective.

Timely warning to the potential victims of disasters such as floods can reduce damages to a great extent. The warning should contain full information so that no panic is created.

Civil works, embankments etc. should be kept in a proper state of repair and maintenance even if no floods occur for many years. The protective embankment on Indus River gave in due to its poor maintenance. The rat holes helped the flood water to penetrate into the embankment and wash it away. It may be difficult to act on this suggestion because of resource constraints but it appears useful to consider that provision for pre-disaster preparedness arrangements for floods be based on the benchmark of the biggest past flood.

Consciousness about disaster prevention and control should be part of the thinking of planners responsible for construction, remodelling and repair of infrastructure. Rail tracks, roads and bridges in low lying areas need to be reconstructed on raised ground.

XIV. THE GREAT FLOOD IN THE HAN RIVER BASIN, REPUBLIC OF KOREA, IN SEPTEMBER 1990

by Kyung-Sup Shin[1]

A. *Introduction*

The Han River flows through the capital city of the Republic of Korea, Seoul. Korea experienced a great flood at the Han River basin, in the middle of the Korean Peninsula, from 10 to 11 September 1990. The two-day rainfall was about 400 mm throughout the basin with a maximum of 584 mm at the mountainous area, in the upper catchment of the river basin. This two day's rainfall amounted to about 30-40 per cent of the annual average rainfall in the region. Although it was not the maximum rainfall recorded within two days in Korea, it caused the most disastrous flood, because the rainfall was concentrated on a single basin, and the resulting flood hit the metropolitan area, and the river banks were breached near a highly populated area.

During this period, the Korea Meteorological Service (KMS, now Korea Meteorological Administration) issued early heavy rainfall warnings, and the Han River Flood Forecasting Centre under the Ministry of Construction issued flood warnings along the Han river Basin. Nevertheless, the flood claimed 157 lives, rendered 187 193 homeless, and caused about $US 570 million property damages. The river level measured at Seoul was the second highest on record since measurements started in 1900. (The highest record was in 1925.) Hydrologists estimated that the 1990 flood might have had a 200-year frequency though this may not be totally clear because of operation of seven dams along the Han River upstream of Seoul.

The purpose of this report is to discuss the meteorological environment that brought the heavy rainfall, the warnings issued and the disaster prevention and preparedness (DPP) activities undertaken, and present some recommendations, and share this experience with others for future planning to mitigate disasters related to floods.

B. Meteorological conditions during the flood event of 1990

The summary of meteorological conditions experienced during this major rainfall event were as follows:

- The heavy rainfall was caused by Typhoon Dot, which landed at central China in the course of weakening and transformed into an extra-tropical cyclone.
- Strong convergence band was formed in the central Korean Peninsula between the south-east wind driven by the Typhoon Dot and the north-west wind driven by the continental high pressure zone.
- The two systems were almost stationary during the two heavy rainfall days.

C. Warning and DPP activities

1. DPP structure in Korea

The Anti-Calamity Headquarters (ACHQ) under the Ministry of Construction is responsible for all decisions for DPP activity. The KMS and Flood Forecasting Centres are responsible for warning of heavy rainfall and flood, respectively. The Water Resources Corporation (WRC) is responsible for routine dam operations but with the permission of ACHQ in case of flood.

2. Heavy rain warning

Table 26 summarizes the regular and special weather forecasts and warnings issued by the KMS for the period, 10-11 September 1990. The KMS had forecasted rainfall five days earlier and expected heavy rainfall one day in advance. The KMS issued a special public guidance at 4: 30, 10 September, before the rainfall started, on expecting heavy rain. This was followed by a heavy rain watch (10:00) and warning (18:00). Figure VIII shows the accumulated rainfall amount during the period with one hour interval at Seoul and the warnings issued to the public.

The Numerical Weather Prediction (NWP) outputs, produced by employing the models used by KMS and the

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Table 26. Summary of weather forecasts and warnings for the heavy rain period, 10-11 September 1990.

Forecast	*10 September*	*11 September*	*Remarks*
120 h	cloudy and rain		
96 h	cloudy and rain	cloudy and rain	
72 h	cloudy and rain	cloudy	
48 h	cloudy and frequent rain	cloudy and frequent rain	heavy rain possibility
24 h	cloudy and rain	cloudy and rain	80-120 mm

Time	*Type of warning*	*Content*
10 Sept./04:30	Special public guidance	expecting heavy rain, prepare
10 Sept./10:00	Heavy rain watch	80-150 mm for next 24 h
10 Sept./18:00	Heavy rain warning	150-250 mm for next 24 h
	Lots of special public guidance during the flood	

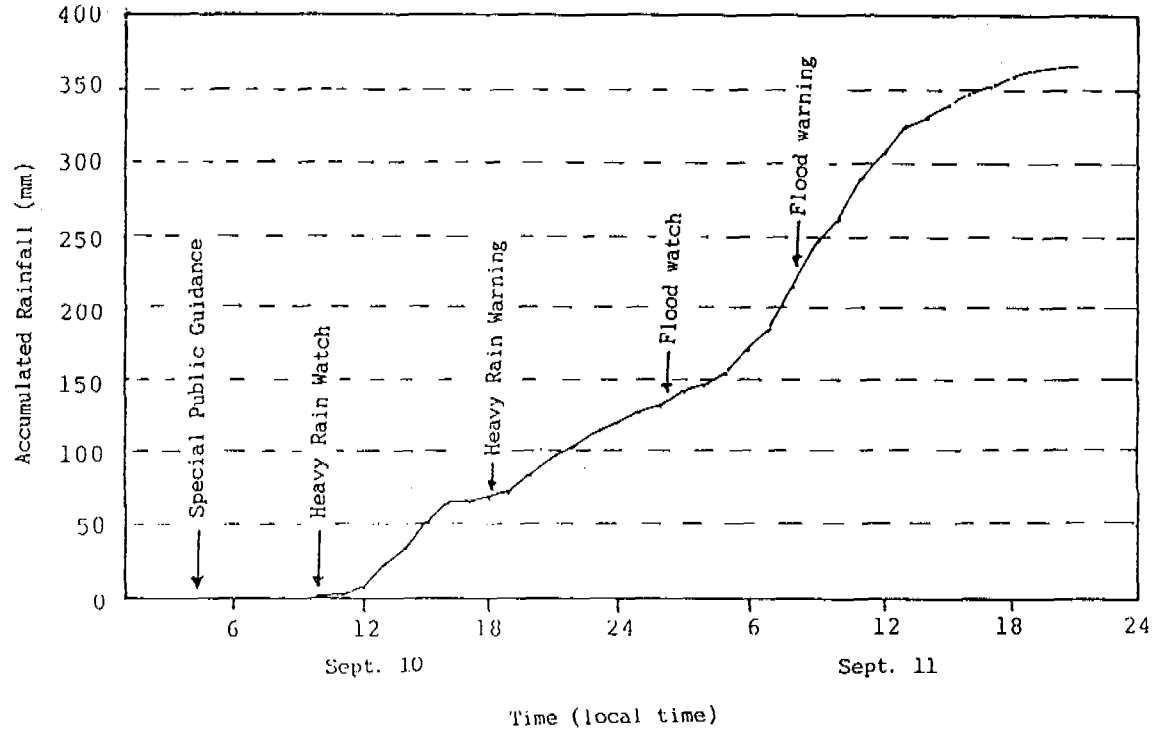

Figure VIII. Accumulated rainfall in Seoul during 10-11 September 1990 and the warnings issued to the public

Japan Meteorological Agency, predicted rainfall area and rain pattern fairly well; however, they underestimated the rainfall intensity. The KMS model generally predicted about 60 per cent of the total rainfall amount, and the JMA model predicted about 75 per cent of the total. However, the NWP outputs helped forecasters greatly to give early warnings of the heavy rainfall.

3. Flood warning

The Flood Forecasting Centre (FFC) issued flood watch and warning with the information on water levels at each dam and KMS forecasts. The flood watch was issued at 02:00 LST 11 September along the Han River, and it was upgraded to flood warning at 07:00 LST 11 September 1990.

4. Dam operation

There are seven dams along the Han River upstream of Seoul. Three of them are multi-purpose type flood control dams which have large reservoir capacities, and the other four are for hydropower. During the rainy season from 1 May to 20 September, there is a regulation that the water level at each dam should be maintained below a certain level to provide for flood storage. However, two of three large dams apparently did not maintain this level. The water level at the largest dam was 1.3 m above, and at the third largest one was 2.2 m above the limit for the season. This was as a preparation for the dry season which normally starts in September (officially 20 September), but eventually reduced the flood storage capacities of the two dams during this flood.

5. Pumping of flood waters

In the metropolitan Seoul area, at certain times during this flood the water level in the Han River was higher than the elevation of some low areas. The Government operates a number of pumping stations at these low areas. However in many places, pumping was not enough to prevent flooding due to the backwater effect from the river during the flood. Apparently some pumps also malfunctioned.

6. Bank loss

The worst event of the flood was the breach of a bank of the Han River, which occurred at dawn on 12 September 1990 when the rainfall had ceased but the river water was at its highest level. The location was the farm lands in a suburb of Seoul. Although this area was not as densely populated as at the metropolitan area, it was still dense enough to sustain considerable damage. Fortunately, the watching teams discovered the first piping at the river bank before total failure, thus saving the lives of the people living nearby.

In the metropolitan area, banks were recently constructed and well designed. But the bank that was breached had been built with clay 60 years ago. It has been suggested that there may be lots of 'rat holes' existing inside the bank, which may have been the cause of piping.

D. Conclusions

This flood event may have been the potentially most disastrous one in this century in Korea. However, it is believed that although not totally satisfactory the early warning and the DPP activities reduced the damage considerably. It is also believed that more efforts to develop techniques and improve systems in meterology and DPP could further reduce flood damages. Dams and reservoirs should also be operated more prudently.

XV. SOLOMON ISLANDS INFORMATION PAPER

A. Introduction

The Solomon Islands are located in the south-west Pacific, which places the country within two hazardous regions of the world, namely the tropical cyclone belt of the southern hemisphere and the so-called Pacific ring of fire (seismic activity belt). The country has, therefore, been exposed not only to tropical cyclones and cyclone-generated hazards but also to earthquake-generated hazards as well. The tropical cyclone season runs from November to April the following year.

The Solomon Islands are somewhat fortunate, owing to the fact that most tropical cyclones in the area form in the country's territorial waters, before moving south-east towards Vanuatu, north-east towards Fiji or south-west towards the Queensland coast of Australia.

The country at various times experienced the effects of natural disasters such as tropical cyclones. In fact tropical cyclones have been the most regular type of disaster. In the recorded history of the country, tropical cyclone Namu was by far the biggest single natural disaster experienced in the Solomon Islands. Cyclone Namu left the Solomon Islands with 103 people dead or missing, 90 000 people homeless and $A 100 million worth of damages. The long-term economic effects resulting from damage to cash crops and industries by the disaster are still felt in the country at the present time.

B. Forecasting and warning

The Solomon Islands do not currently have the know how, technology, and the resources necessary to carry out effectively forecasting of disasters. The country is still dependent on foreign countries for its requirements in this area. The Solomon Islands have plans to develop their own tropical cyclone forecasting unit in the period 1991-1992, depending on availability of foreign assistance.

The country to date receives its tropical cyclone warnings from Fiji, for the area east of latitude 160°E, and from Brisbane and Darwin in Australia for the area west of 160°E. The warnings are received by the Ministry of Aviation and Tourism, Meteorological Service. The Meteorological Service informs the National Disaster Council and warnings are broadcasted nationwide by the Solomon Islands Broadcasting Cooperation.

The National Disaster Council can activate the National Operations Centre, and directs/controls all operations.

The communities at risk are informed by National Broadcasting Cooperation, while disaster officials of National and Provincial Disaster Committees as well as non-government organizations are informed by facsimile, telephone or through the Royal Solomon Islands Police radio network.

Risk assessment is an area where the country still needs foreign assistance. A limited amount of work was done on part of the Province of Guadalcanal, for landslides, and flood affected areas of the province after Cyclone Namu. A great deal of work is yet to be done before disaster management planning can be advanced. This is certainly another area where the country needs expert advice and manpower.

C. Disaster prevention and preparedness

Disaster preparedness is the responsibility of the National Disaster Council under the National Disaster Act, in liaison with government ministries, provincial governments, semi-governmental and non-governmental organizations. The National Disaster Management Office is responsible for overseeing plans, organization and other preparedness matters.

Officials both from the Council and Government from time to time attend regional seminars, workshops and other disaster-related activities. In recent years a number of internal disaster preparedness workshops were held for disaster officials. In-country training is planned for implementation throughout the seven provinces in 1991.

The subject of disaster preparedness and prevention in general is being addressed in a weekly radio programme called Public Awareness on Disasters, which is broadcast nationwide.

Disaster prevention in building construction/civil works in urban areas is controlled by the Government through regulations. The building constructions in rural communities are very much controlled by traditional standards or a mixture of both western and traditional methods. This leaves the rural communities very much vulnerable to tropical cyclones, floods and other hazards.

1. National Disaster Plan 1987

This National Disaster Plan was developed after Cyclone Namu, which struck the country in May 1986 and was the most destructive disaster in the recorded history of the country.

Although the National Disaster Plan 1982 existed before cyclone Namu, it was found that the Plan did not work because the magnitude of destruction during Namu was so extensive.

The NDP 1987, is the current plan of the Solomon Islands, and although a major disaster of the magnitude of Namu has not again struck the country, this plan has been the major plan since 1987 and implementation of its requirements is still being carried out.

In accordance with the requirements of the NDP 1987, the seven provincial governments of the Solomons have been encouraged to revise or develop their own provincial disaster plans. The development of provincial disaster plans is being addressed in 1991.

In the Solomon Islands the National Disaster Council is the central decision-making and coordinating body in time of disaster, and the Council exercises the control/coordination of preparedness, operations and recovery as outlined in the functional diagram of organizations presented in figure IX.

2. National Disaster Act 1989

The National Disaster Act 1989, was formulated following the experiences during the cyclone Namu disaster in 1986. The Act established the National Disaster Council, a body which is given powers to assure complete control of all emergency operations during a major disaster, after a State of Disaster Order is declared by the Minister under the Act.

The National Disaster Council in turn is given legal powers to establish Provincial Disaster Committees in each provincial government. The Provincial Disaster Committees are answerable directly to the National Disaster Council in all matters pertaining to disasters.

The Act also aims to give legal effect to the National Disaster Plans.

The functions assigned to the National Disaster Council under the Act are:

- to provide and render advice to the Minister on all matters relating to disasters;
- to approve and co-ordinate all activities necessary in regard to preparedness, response and recovery;
- to assume full and complete control in operations connected with disaster;
- to provide and render financial assistance to Provincial Disaster Committees.

The Act also empowers the Minister to establish a National Disaster Management Office. This office has been established and staffed, in order to administer the provisions of the Act, the National Disaster Plan and policies set by the National Disaster Council.

The functions assigned to the National Disaster Management Officer, under the Act are:

- to be responsible to the Council in the administration of the Act, the national disaster plan and other plans which relate to national disaster;
- to ensure that the national disaster plan and other plans referred to in the above paragraph are periodically reviewed and updated;
- to keep and maintain proper accounts and such registers as the Council directs;
- to prepare the annual reports and other reports or bulletins as the Council may direct;
- to ensure that the provinces are in a state of preparedness to execute the provincial disaster plans, if the need arises; and
- to perform any other functions that may be assigned to it by the Council.

D. Recommendations

To address the problems as to be able to implement the plans properly, the following are set down as priorities:

(1) Training should be undertaken both in-country and overseas;

(2) Public awareness and preparedness must be a continuous programme;

(3) Mitigation/prevention must be integrated into the National Development Planning of the Government;

(4) Public awareness and preparedness at the provincial level must be upgraded;

(5) Assistance must be sought from overseas funding organizations or governments for medium- and long-term programmes;

(6) Periodic review of functions and the disaster plan need to be implemented;

(7) Non-governmental organizations should be involved in these programmes.

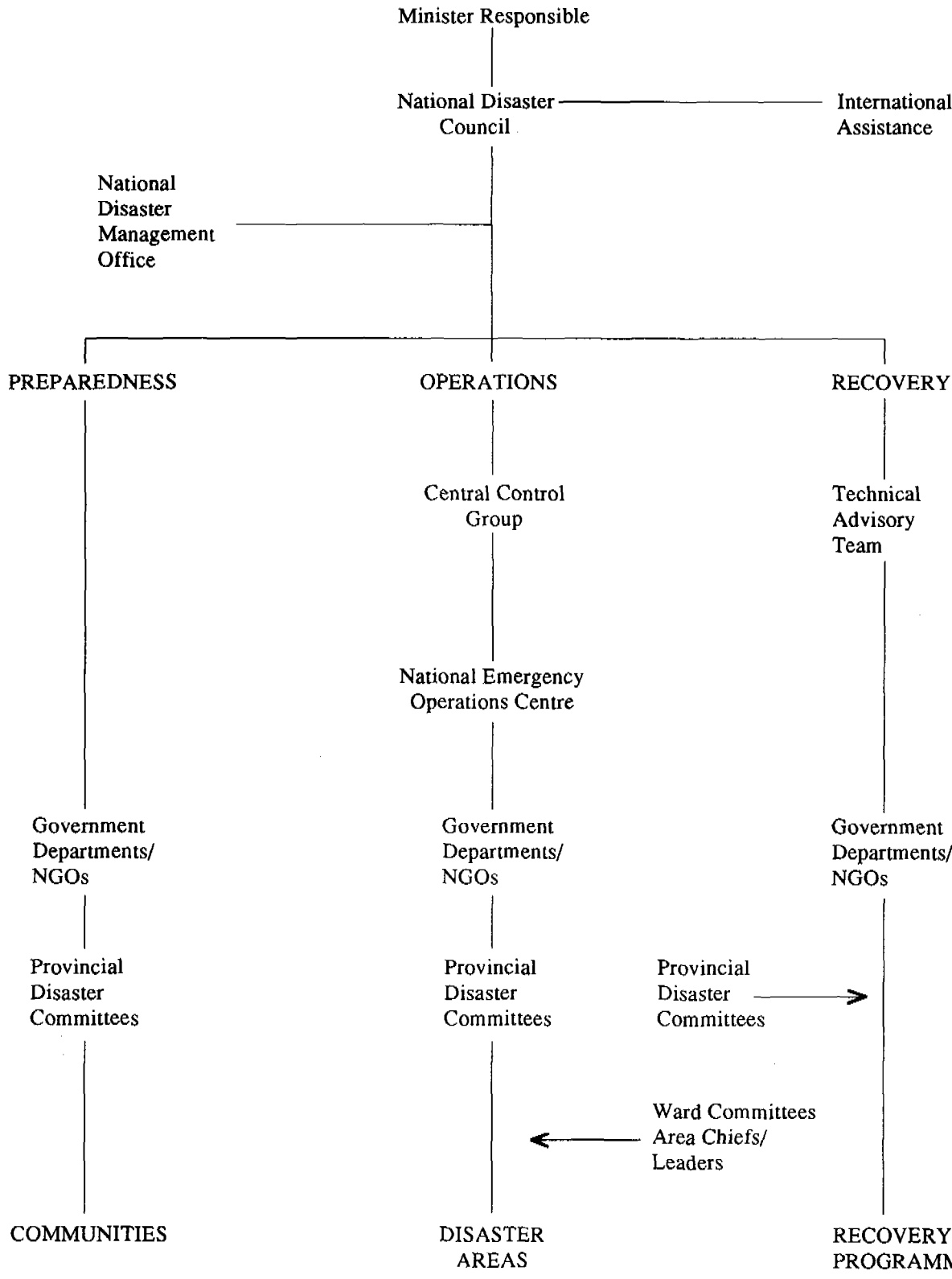

Figure IX. Functional diagram of organization for disaster prevention and preparedness in the Solomon Islands

XVI. NATURAL DISASTERS IN THAILAND

A. Major natural disasters in Thailand

Natural disasters in Thailand are mainly caused by tropical cyclones and floods, droughts and earthquakes. Some other natural disasters which occasionally occurred within the country are landslides and forest fires. The major landslide episode in southern Thailand during November 1988 was due to the effect of deforestation and a very heavy rainfall event.

The details of the natural disasters caused by those three sources are described below.

1. Tropical cyclones and floods

On the average, Thailand is annually struck by four tropical cyclones which can be both beneficial and harmful to the country. Generally, the cyclones are scaled down to tropical depressions when they enter Thailand. Tropical cyclones, particularly tropical depressions, provide beneficial rains for agriculture and occasionally bring relief to dry spells. However, tropical storms, especially typhoons, produce copious rainfall, and consequently, cause high potential for flooding. Therefore, they can have a disastrous impact on both public safety and agriculture.

Table 27 shows the frequency of the tropical cyclones entering Thailand over a 40-year period (1951-1990), which reached a total of 143. Tropical cyclones occur with highest frequency in October (44 out of 143) and lowest frequency in April (1 out of 143). January through March is a period that the country is free from cyclones. During the period 1981 to 1990, the maximum number of five tropical cyclones was experienced in 1983, while only one tropical cyclone entered the country in 1981, 1987 and 1988.

From the analysis of the 13-year (1975-1987) track data of tropical cyclones experienced in the region, it was observed that most of the cyclones originated in the Pacific Ocean and/or the South China Sea and moved westward toward Viet Nam, Laos, Cambodia and Thailand. During June-August, the mean track of the cyclones would lie across the north-eastern and northern parts of Thailand. The mean track during September-October moved southward across the central and eastern parts, upper portion of southern Thailand and lower portion of the north-east. During the end of the year, November-December, the track moved further south from Chumphon. Prior to the onset of the south-west monsoon season, April-May, most of the cyclones developed in the Indian Ocean and/or the Andaman Sea and moved through the Bay of Bengal towards Myanmar and Thailand. The mean track of the cyclones during these months would lie across the western part of the country, in the vicinity of Ratchaburi, Kanchanaburi, Tak (Mae Sot) and Mae Hong Son. The cyclones entering Myanmar would have great impact on the central part of Thailand, especially in the vicinity of Bangkok Metropolis. Heavy rainfall and resulting flooding would occur, as in May 1986, in the capital city.

Most of the 143 tropical cyclones entering Thailand since 1951 were tropical depression. Only seven full-sized tropical storms and one typhoon have been recorded during this 40-year period. Extensive damage to crops and property was caused over those areas that were hit by the eight tropical cyclones.

The severity of damages caused by cyclones scaled up from tropical storms to typhoons vary according to their intensity and wind speed. Typhoon Gay of 1989, with wind speed of 120 km/hr at its centre, was the first and the only typhoon that Thailand has experienced in the last 40 years.

The cyclone of 1989 first originated in the lower portion of the Gulf of Thailand, 270 km east of Songkhla, on 1 November. At 13:00 on 2 November, the depression had upgraded its strength to be classified as tropical storm and at 16:00 on 3 November, was finally classified as typhoon. The typhoon, named 'Gay', moved west-northwestward towards the upper portion of Southern Thailand, at the border of Chumphon and Prachuap Kiri Khan. The typhoon landed and hit two districts of Chumphon at around 22:30 on 4 November. The details and the estimates of the loss caused by typhoon 'Gay' are shown in table 28. Severe damages to property (private and public) and loss of human life and livestock were extensively recorded in those provinces in southern Thailand and some provinces in the eastern part.

2. Dry spells and drought

Dry spells usually occur shortly before the beginning of the rainy season (around May) or during the rainy season. If a dry spell lasts longer than usual, a drought will occur. The severity of the drought depends upon the length of the dry spell. Upper Thailand is susceptible to drought, which is more frequent in the northern and north-eastern parts. Both regions are prone to the drought problem due to their geographic locations.

Table 27. Frequency of tropical cyclones entering Thailand from 1951 to 1990

		Apr	*May*	*Jun*	*Jul*	*Aug*	*Sep*	*Oct*	*Nov*	*Dec*	*Freq*
1951-1960	(average)	0	0	0.1	0.2	0.2	0.6	0.9	0.2	0	2.2
	(total)			1	2	2	6	9	2	0	22
1961-1970	(average)	0.1	0.2	0.2	0.3	0.8	1.4	1.7	1.1	0.3	6.1
	(total)	1	2	2	3	8	14	17	11	3	61
1971-1980	(average)	0	0.2	0.1	0.4	0.4	1.1	0.5	0.6	0.2	3.5
	(total)	0	2	1	4	4	11	5	6	2	35
1981								1			1
1982			1				1				2
1983				1				3	1		5
1984				1				1	1		3
1985							1	2			3
1986							1	1			2
1987						1					1
1988								1			1
1989			1					2	1		4
1990						1		2			3
Freq.		1	6	6	9	16	34	44	22	5	143
Average		*0.03*	*0.15*	*0.15*	*0.23*	*0.40*	*0.85*	*1.10*	*0.55*	*0.12*	*3.58*

3. Earthquakes

Thailand is affected by the impact of earthquakes with epicentres located in Thailand and from those with epicentre located outside Thailand.

The greatest magnitude of 5.9 on the Richter scale was measured in Thailand on 22 April 1983 at Srinagarind Dam, Kanchanaburi province, approximately 200 km from Bangkok. The impact could be felt all over the country.

The impact of earthquakes outside the country such as those occurring in the south of China, Thai-Myanmar border, Lao People's Democratic Republic and Andaman Sea, may be felt throughout the country even when the epicentre is far from Thailand. For example, on 6 November 1988, an earthquake occurred in south of China with a magnitude of 7.3 on the Richter scale. Although it was thousands of kilometres from Bangkok, it could be felt, especially by those in high-rise buildings.

At present, the Thai Meteorological Department has a nine-station network which includes the Seismic Research Observatory (SRO) station, World-wide Standard Seismograph (WWSS) network and Short Period Vertical Seismograph (SPZ) stations.

The two earthquakes with their epicentres located in Thailand and felt in Bangkok have caused panic and posed potential threat for high rises and large-scale construction projects. There has been a move within the government agencies involving protection and mitigation of earthquake disaster. The National Earthquake Committee was established to draft a Ministerial Regulation for controlling building construction. The regulation will control large-scale structures to withstand potential destruction by earthquake. The draft has been submitted to the Ministry of Interior for consideration. Another function of the Committee is that it has to inform and educate the public by providing seismic information.

B. Conclusion

The increase in the recurrences of natural disasters and the extensive damage caused to property have indicated that further improvements in weather forecasting and warning services are urgently needed to minimize the damage from such natural disasters in the future. Thai Meteorological Department has played an important role to reduce heavy damage by providing weather forecast and warnings to the public.

Table 28. Damages caused by typhoon "Gay", 4 November 1989

Region and Province	*Humans affected*				*Houses Damaged (No.)*	*Ship-wreck (No.)*	*Public work facilities*							*Agriculture*		*Total estimated damage (Thousand baht)*
	Dis-tricts	*Fami-lies*	*Dead*	*Lost*			*Roads (No.)*	*Bridges (No.)*	*Weirs (No.)*	*Official premises (No.)*	*Schools (No.)*	*Temples (No.)*	*Mosques (No.)*	*Flooded (ha)*	*Livestock lost (head)*	
SOUTHERN PART																
Phetchaburi	5	–	–	–	–	2	4	1	–	–	–	–	–	842	–	22
Prachuap Kiri Khan	75	3 252	19	84	3 258	99	367	39	10	8	38	24	–	24 217	3 490	200 000
Chumphon	290	36 649	446	–	41 208	391	579	131	49	92	168	93	6	890 015	83 490	11 257 265
Ranong	19	2 780	23	–	2 106	4	24	20	–	37	9	2	–	23 498	1 369	90 880
Surat Thani	20	78	66	–	70	36	29	2	1	2	1	–	–	2 280	200	71 123
Pattani	–	–	2	–	–	58	–	–	–	–	–	–	–	–	–	–
EASTERN PART																
Rayong	7	188	3	50	188	26	12	–	1	–	–	–	–	–	–	34 791
Trat	6	–	1	–	128	–	1	1	4	3	–	–	–	–	–	1 613
GULF OF THAILAND	–	–	44	–	–	23	–	–	–	–	–	–	–	–	–	31 000
TOTAL	422	42 947	604	134	46 958	639	1 016	194	65	142	216	119	6	940 852	88 549	11 686 695

Source: The Civil Defense Division of the Local Administration Department, Ministry of Interior, Thailand.

Note: Updated on 15 January 1990

XVII. TONGA'S EFFORTS TO REDUCE THE IMPACTS OF TROPICAL CYCLONES

A. Introduction

The Kingdom of Tonga is located in the South Pacific Ocean between latitudes 15°S to 23.5°S and longitudes 17.3°W to 17.7°W. There are 270 islands in the group with a total land area of 699 sq. km. Of these islands, only 36 are inhabited.

Tonga is a relatively flat country with only a few islands to the north reaching recognizable heights ranging from 150-300 metres in the Vava'u Group to 1 030 metres in Kao Islands (Ha'apai Group). Because of its location, Tonga is dominated by east or south-easterly trade winds.

The most common natural disasters in Tonga are tropicals cyclones and storm surge flooding that often accompany cyclones.

B. Disaster prevention and preparedness

The formation of the National Office for Disaster Relief and Reconstruction (NODRR) in March 1981 was the first real effort made by the Government of Tonga to counter the disastrous impact of natural disasters after realizing from past records that Tonga experiences a cyclone once every 1.5 years on the average.

Although this unit was developed on a two-year experimental basis, the incentive for making it permanent was provided by tropical cyclone Isaac which swept over the whole Island Kingdom during the first week of March 1982, causing a lot of damage to properties, unparalleled since 1961. The estimated cost of the damages was around SNZ 23 million.

The major objective of the NODRR, as originally planned was, "to cultivate disaster preparedness and coordinate activities for emergency relief, rehabilitation and reconstruction". Theoretically, this unit was set up as a vanguard in preparing the country to a stage of readiness against natural disasters and to plan a course of action in terms of relief, rehabilitation and reconstruction.

Beside conducting a public awareness programme, and other related activities, the NODRR launched a very comprehensive low-cost housing scheme. This project was initiated with a dual purpose in mind: as a recovery and rehabilitation measure; and as a countermeasure against future cyclones.

Although limited by financial constraints, this scheme was successful to a great extent. In subsequent tropical cyclones that visited Tonga after the inception of this scheme, none of the cyclone-resistant houses were among those affected.

About 2 000 houses were built after cyclone Isaac struck Tonga. This scheme was mainly funded by overseas donors such as the Australian Disaster Unit, as well as other regional and international organizations. Unfortunately, as soon as this outside source dried up, the whole scheme came to a standstill. The Tongan Government nevertheless has learned from this experience and is well aware of the advantages of a low cost housing scheme.

Cyclone Isaac also caused considerable damages by means of storm surge flooding. Most of the northern coastal areas of the main island were flooded up to 500 metres inland. Countermeasures against this destructive aspect included foreshore construction and launching of a public awareness campaign against the risk and vulnerability of the area involved. Again this programme was impeded by financial constraints. As of now, only the coastal area of the capital has been protected and this project was funded first by the German Government and later by the Japanese Government. As such, communities in rural areas have remained vulnerable to storm surge flooding.

1. Warning system

Tonga relies completely on the regional Meteorological Station in Nadi, Fiji and the one in Wellington, New Zealand for its weather forecast bulletins. The Tonga Meteorological Service is informed by either of these two stations, which in turn warns the people of Tonga of the impending natural disaster.

2. Public awareness programme

The most recent campaign against the disastrous nature of tropical cyclones is the formation of regional natural disaster committees. The primary idea of this programme is to get the public involved in minimizing the devastating impact of the tropical cyclones in Tonga and to provide a closer link between the National Disaster Committee and the people.

At this point in time, public awareness regarding the nature of natural disasters and the precautionary measures that should be taken during such events is very limited. Apart from the experiences of the past natural disasters, there is lack of education and training of the people regarding proper steps to take when facing a natural disaster.

The normal channel of communication between the Government and the people at large is through the National Broadcasting Station. And in the event of a breakdown in this channel the people, particularly those living in the outer islands, are completely left isolated to weather the storm on their own.

District committees were therefore created to ensure that this channel of communication was open. They were to act as advisors and as supervisors, on a much more communal level, in emergency activities and to provide on the spot feedback to the National Disaster Committee.

This project is still at an experimental stage; hence, analysis and assessment of its effectiveness have not been undertaken. Nevertheless, it is believed that with these committees, the country will be in a better position to minimize the impact of natural disasters through public education and training, and recover much more quickly in terms of executing a relief and rehabilitation programme.

3. The role of non-governmental organizations (NGOs)

Besides groups which are affiliated to the international organizations such as the Tonga Red Cross, the Lions and Rotary Clubs, the main non-governmental organization which makes significant contributions to the natural disaster relief and reconstruction programme is the Tonga National Council of Churches (TNCC). Although recently formed, the TNCC played an important role in the emergency response and immediate relief phases. The execution of its role, however, required close cooperation from the Government and, as normally is the case, the Government welcomed initiatives from the TNCC. Thus, the two can be said to play a partnership role in this respect. On many occasions the Government lends a helping hand to this NGO, mainly in the form of financial assistance. Without it, some of its relief activities would have been hard to implement. Thus involvement of this NGO in disaster prevention is rather limited.

XVIII. NATURAL DISASTERS IN VANUATU; THE THREAT AND THE RESPONSE

by W.M. Longworth and M.A. Bergin[1]

A. Introduction

The Republic of Vanuatu is an archipelago of 80 islands located between 13° and 22° south of the equator. The chain of islands runs almost north/south along the 167°E meridian. The chain stretches for 800 km from the Torres Islands in the north to Hunter Island in the south. Nearly 90 per cent of the total land mass is taken up by the 10 major islands, the largest of which is Santo with an area of 2 947 sq. km. The capital, Port Vila, is situated on the island of Efate at a latitude of 17.8° south. Most of the islands are volcanic in origin, and feature rugged mountains in the interior and rolling hills leading down to narrow coastal terraces. Three of the islands have active volcanoes, the most famous of which is located on the island of Tanna in the south. Vanuatu is subject to a number of disaster risks, the most important of which are described below.

B. Natural disasters in Vanuatu

1. Tropical cyclones, storm surges and floods

Vanuatu lies in one of the most tropical cyclone prone areas of the South-west Pacific. The normal cyclone season is in the southern hemisphere summer months of November to April. On average the Republic can expect two to three cyclones each season (Vanuatu Meteorological Service, 1990a).

In recent years, tropical cyclones have been the cause of much serious damage and extensive economic loss, but there have been few casualties on land. Loss of life at sea has been more serious. However, this has not always been the case – the first (unnamed) cyclone of the 1951/52 season caused 99 deaths on Epi and Ambrym alone. Although no comprehensive records appear to have been kept, the estimated cost to the Vanuatu economy since 1985 due to cyclones (Eric/Nigel 1985, Uma 1987, Anne/Bola 1988 and Ivy 1989) has probably exceeded $ US 7 million and had a serious affect on the economy.

Storm surges are normally associated with tropical cyclones and are caused by a combination of extreme low pressures over the sea and waves induced by the associated strong winds. Because of the volcanic nature of the islands, and the resulting steeply sloped ocean floor, storm surges are not a problem in most parts of the country although surges have been reported as penetrating up to 200 m inland in Big Bay, Santo.

In normal times Vanuatu's rivers do not carry large volumes of water. However after periods of heavy rain – typically during cyclonic activity or summer depressions – they can rise rapidly to block, or wash away, roads and bridges. Again because of the volcanic nature of the islands, drainage is generally good and floods subside rapidly except in swampy areas or reclaimed land.

2. Droughts

Vanuatu suffers periodic droughts and their impact can be expected to increase as the population increases and development puts greater pressure on existing water resources. Major droughts were experienced in 1957/58, 1977/78 and 1982/83. Many of the droughts are associated with major "El Niño" events.

3. Volcanic hazards and earthquakes

Vanuatu lies along a line of volcanic activity at the boundary of the Pacific and Indo-Australian tectonic plates. Volcanoes on a number of islands, and under the sea, pose actual and potential threats to neighbouring communities. In recent years acid rain formed by the mixing of volcanic gas emissions and rain have caused considerable damage to vegetation and crops on Tanna.

As a result of Vanuatu's position close to the tectonic plate boundary, seismic events are an almost daily occurrence in and around the country. Fortunately local intensity is generally fairly low. Damaging events have however been recorded, notably in 1927 (Efate), 1935, 1965 and 1990 (Santo). Estimates have been given by the

[1] Both of Vanuatu Meteorological Service.

Institute Français de la Recherche Scientific pour le Developpement en Coopération (ORSTOM) that such events up to Intensity VIII on the modified Mercalli Scale may be expected every 60 years in Santo and Malekula, and every 100 years elsewhere in the Republic.

4. Landslips

The steeper slopes of lightly packed earth or volcanic ash hills in Vanuatu are vulnerable to landslips. These may be triggered by earthquakes or by heavy rain. Historically landslips have caused a number of casualties on Tanna (1878), Epi (1951), North Santo (1971 and 1974) and Mere Lava (1980).

5. Tsunamis

Tsunami (or seismic sea waves) are generally caused by earthquakes but may also occur after volcanic eruptions or major coastal/undersea landslips. They are generally local in effect but some travel great distances over the open ocean to affect nations far from the point of origin. They can produce floods above high tide level. Although uncommon in Vanuatu, tsunamis have been experienced after both local and distant events.

C. Forecasting and warning

1. Forecasting and warnings of tropical cyclones

Of all the natural disasters which affect Vanuatu, only some of the meteorologically related events can be forecast with any degree of accuracy and in sufficient time to enable warnings to be issued to the public. Of these events, tropical cyclones are potentially the most devastating and Vanuatu wants to concentrate on the warning of the onset of these particular disasters.

The Vanuatu Meteorological Service (VMS) staffs seven observation stations throughout the country and operates a Forecasting Service which includes a Tropical Cyclone Warning System.

The VMS is a Member of the World Meteorological Organization (WMO) Regional Tropical Cyclone Committee (TCC) for the South-west Pacific. The Members of this Committee operate a "Tropical Cyclone Operational Plan" (WMO, 1989), whose objective is "to provide for effective co-ordination and co-operative efforts among Members in the South Pacific to improve the warning systems for the protection of lives and the reduction of human suffering and property damage caused by tropical cyclones and other related hazardous weather phenomena".

Briefly the Plan seeks to provide a Tropical Cyclone Warning System to all those nations within the Pacific subject to threat from cyclones. At the foundation of the Plan is the establishment of the forecast office at Nadi, Fiji as the Regional "Tropical Cyclone Warning Centre" (TCWC). The Nadi TCWC provides Tropical Cyclone Advisory Messages to those nations, such as Vanuatu, who have their own independent forecasting abilities and Tropical Cyclone Warning Messages to those nations, such as the Cook Islands and Western Samoa, who only have observing staff.

Vanuatu (in common with other nations with forecasting staff) issue their own Tropical Cyclone Warnings, based on the TCWC Advisories, to their local communities. The warnings for Vanuatu are distributed directly by the VMS through Radio Vanuatu (in three languages, Bislama, English and French). Other warnings are issued to interested bodies (Civil Aviation, Ports and Marine, hotels, etc.) either by telex or facsimile. The VMS would expect to give advance notice of at least 48 hours of tropical cyclone landfall. Details for the issue of Warnings are given in the VMS's Tropical Cyclone Directive (Australian Red Cross Society, 1989), which is updated annually.

The cyclone warning system has basically two stages:

Advisory Messages: gale force winds are not expected to affect land areas within the next 24 hours,

Warning Messages: gale force winds (or greater) are expected on land areas within the next 24 hours.

Commencing with the 1990/1991 cyclone season, the VMS has been issuing a third category of message: a Tropical Cyclone Information Message, for broadcast on Radio Vanuatu. These messages are issued when:

- tropical cyclones, or developing depressions, are well away from Vanuatu. They are intended to heighten awareness, in the general public, of cyclonic activity in the area;
- in between the six-hourly cyclone warnings to reassure the community that the original warnings are still valid.
- As a result of a decision made at the Third Session of the Tropical Cyclone Committee at Wellington in August/September 1990, the VMS will issue all future warnings to the short-wave services of Radio Australia and Radio New Zealand International. This will ensure a more effective and wider distribution of the warnings throughout Vanuatu and the immediate Pacific region.

The VMS cyclone warnings contain information regarding not only the onset of tropical cyclones but also associated storm surges. The VMS now has the capacity to calculate storm surge quantitatively although only qualitative warnings of storm surge are issued to the public.

2. Forecasting and warning of other disasters

Flood forecasting in Vanuatu (as in many other small Pacific countries) is only in a formative stage. It is almost impossible to predict local flash flooding events and the few major rivers in the country which have flood plains do not have stream gauges which would enable the monitoring and prediction of floods. With the potential development of hydroelectric schemes, improvements may be achieved in this service in the future.

Droughts are not normally forecastable. However, the Vanuatu Meteorological Service can give some advance indication of likelihood of less than average rainfall if there is a significant "El Niño" event. This forecast technique has not been refined, but there does appear to be a very strong correlation between major El Niño events and large rainfall deficiencies in Vanuatu, particularly in the winter season.

Virtually no data of significance on geologic disasters are available in Vanuatu. There are some plans to place automatic seismic equipment in the most crucial areas. However, it will take a considerable amount of time for these to be procured, installed and sufficient information collected for any useful predictions to even be considered.

Forecasting of landslip events in Vanuatu is virtually impossible, being dependent on earthquake activity, rainfall intensity (practically only possible with a network of weather radars – far beyond the financial resources of Vanuatu) and detailed topographic knowledge of the whole of Vanuatu. However, advice on the possibility of landslips is also included in cyclone warnings.

No formal tsunami warning system operates in Vanuatu. The Tsunami Warning Centre in Hawaii issues warning to nations who are members of the International Oceanographic Commission (IOC). At this time Vanuatu is not a member. Tsunami warnings are issued via the World Meteorological Organization's 'Global Telecommunications Network' (GTS) to which the VMS is connected. There is however no formal tsunami warning system operating within Vanuatu.

D. Disaster prevention and preparedness

1. Organizational structure

The disaster management structure created in the 1985 National Disaster Plan (Vanuatu Government, 1985), is shown in figure X. It is based on a National Disaster Co-ordinating Committee (NDCC) of Ministry representatives, chaired by a representative of the Ministry of Home Affairs. The NDCC is responsible for co-ordinating, on behalf of the Minister of Home Affairs, all disaster-related measures which are concerned with: planning; organization; preparedness; operations; response and rehabilitation; training and public awareness; and other appropriate aspects.

Although some activities have been carried out following volcanic acid rain damage (Mount Yasur, Tanna) and minor earthquake activity (Mere Lava), the NDCC has mainly involved itself with response to specific tropical cyclones that have affected Vanuatu.

To assist the NDCC during emergency operations a Central Control Group (CCG)of directors of key operational departments was established to co-ordinate the allocation of resources according to correct priorities.

The Disaster Plan established a National Disaster Management Office (NDMO) as its full-time disaster management and preparedness agency. This forms part of the Ministry of Home Affairs and works as directed by the Minister of Home Affairs and/or the NDCC. The staffing level of the NDMO is currently two persons.

Within the past 12 months a National Emergency Operations Centre (NEOC) has been created within the Central Police Headquarters in Port Vila. This comes under the jurisdiction of the Commissioner of Police. The actual operation of the NEOC is still being formalized but it is planned that its role (as stated in the 1985 Disaster Plan) will be to:

- gather, collate, assess and circulate information (partially a role also allocated to the NDMO);
- coordinate operational activities including deployment of personnel and the distribution of equipment (a role of the CCG);
- issue decisions made by the Minister for Home Affairs and the NDCC.

Thus the NEOC will become the coordination centre for any type of disaster (tropical cyclone, storm surge, floods or droughts, volcanic eruption, earthquake, landslip, tsunami) or other national emergency. It is envisaged that a representative of a relevant department will take on the role of coordinator of the NEOC and utilize its facilities during an emergency. In the case of tropical cyclones, the body would be the NDCC, for aircraft accidents the Director of Civil Aviation, for shipping mishaps the Director of Ports and Marine etc.

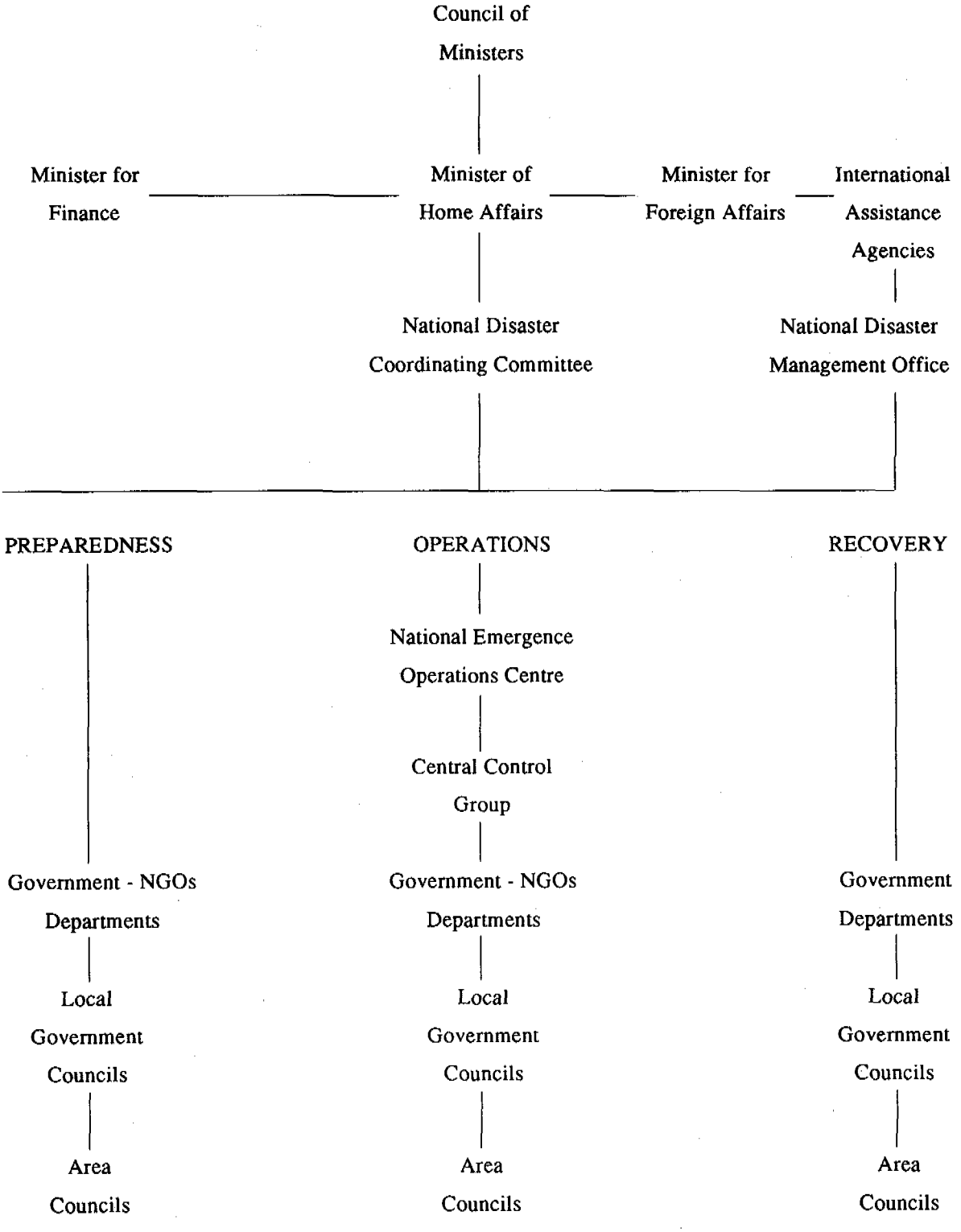

Figure X. Organizational structure for disaster management in Vanuatu

There is a non-governmental organization (NGO) counterpart to the National Disaster Co-ordinating Committee – the NGO Disaster Co-ordinating Council – comprising mainly of church and charity organizations. The Chairman of this Committee is an ex-officio member of the NDCC and thus forms the link between the two organizations.

Local Government and Area Councils have established committees to deal with disaster matters at the regional level. Coordination and training of these committees is carried out by staff of the NDMO.

2. Training and public education

Members of both the NDMO and VMS have undergone disaster training at various levels, notably at the Asian Disaster Preparedness Centre (ADPC), Bangkok. More training is planned for 1991 under the ADPC regional training programme funded by the European Economic Community.

Both the National Disaster Management Office and Vanuatu Meteorological Service contribute to disaster preparedness in Vanuatu. The NDMO issues literature to the local paper, Vanuatu Weekly, and gives interviews for Radio Vanuatu. Regular visits are also made to local government and area councils to maintain disaster awareness. Whenever possible contact is made with local government secretaries during their annual visit to Port Vila. This provides an ideal opportunity for both the NDMO and VMS to discover how people living in the rural areas view the tropical cyclone warning system. These contacts have proved beneficial in the past and have identified some problems of which the disaster management organizations were unaware. These have subsequently been rectified.

The VMS have had a further 30 000 copies of their Tropical Cyclone Plotting Maps and 10 000 copies of Precaution Leaflets (see table 29 for the English version) printed for distribution throughout Vanuatu. Funds for the printing of these maps and information sheets were obtained from Service Clubs and several insurance companies within Vanuatu. Additional funds for the printing of Bislama and French versions of the Precaution Leaflets have been requested through normal aid sources. An article giving details of some recent efforts to develop disaster awareness has been published in UNDRO News (Longworth, 1990).

3. Recent developments

Throughout 1989 it became apparent that the disaster management organization in Vanuatu was not as effective as it should be. To address the deficiencies and motivated by the declaration of the IDNDR, the National Disaster Coordinating Committee asked the Australian Government to provide a consultant to "review disaster preparedness in Vanuatu and prepare a comprehensive disaster preparedness improvement programme".

The consultant, from the Australian International Development Assistance Bureau (AIDAB), visited Vanuatu from September to November, 1989. His report was received by the Vanuatu Government in December 1990. It contains some 49 recommendations including one for a major alteration to the existing disaster management organization in Vanuatu. Much of the material in this paper was obtained from that consultant report (Barr, 1990).

A sub-group of the NDCC is currently assessing the Report. It will submit suggestions to the Minister for Home Affairs, through the NDCC, as to what action the Vanuatu Government should take on the Report.

Until the sub-group's report has been presented to the Minister for Home Affairs, it is too early to state exactly what the future Vanuatu Disaster Preparedness Organization will look like. It is expected that 1991 will be a year of 'transition', either trying to introduce a new organizational structure or at least undertaking a major overhaul of the present system.

References

Australian Red Cross Society/Australian Overseas Disaster Response Organisation, 1989. Report on the Second Disaster Preparedness Workshop for Non-Governmental Organisations. AODRO, NSW.

Barr, J.P., 1990. Preparedness in Vanuatu – A Review. AIDAB, Canberra.

Longworth, W.M., 1990. Developing Disaster Awareness in the South West Pacific. UNDRO News, March/April 1990. Geneva.

Vanuatu Government, 1985. National Disaster Plan. National Disaster Office, Ministry of Home Affairs. Port Vila.

Vanuatu Meteorological Service, 1990a. Tropical Cyclones in Vanuatu, 1939-1990. Climatological Publication No 1. Port Vila.

Vanuatu Meteorological Service, 1990b, Tropical Cyclone Directive. Port Vila.

World Meteorological Organization, 1989. Tropical Cyclone Operational Plan for the South Pacific and South-East Indian Ocean. WMO/TD – No. 292. Geneva.

Table 29. Tropical cyclone precautions

At the Beginning of the Season:

Clear gardens and surrounds of all rubbish (particularly iron, timber etc) that could be blown about in high winds and cause injury and damage. If you want to keep things, put them in tidy piles and weigh them down so they will not blow away.

Cut off any rotten tree branches which could cause damage to you and your house if they got blown off.

When planting crops, think about how they can be planted to shelter each other from wind (some taro under trees, yam vines protecting and protected by other plants).

Check that the roof and walls of your house, and all other buildings are sound and well secured.

Clear out drains and ditches to help heavy rainfall to drain away.

Set up a small reserve of:

- kerosene,
- hurricane lamp and/or torch for emergency lighting;
- batteries for the radio and torch;
- plastic bags and sheeting to protect valuable articles;
- string or rope to tie things down;
- containers for water and food;
- tape for windows.

Prepare and store some custom emergency food (smoked breadfruit, buried yams and taro etc).

Make up a small first aid kit with bandages, band aids, antiseptic and any medicines you need.

Make sure everyone in the house young and old alike - knows the safest place to go for shelter-

— within the house,

— within the village.

If you live close to the beach, or a river, know the quickest way to higher ground in case the tide, waves or river start to flood your home.

If you have shutters - check that they are sound and still fit your windows.

If you have gutters - clear them of rubbish.

If you have a radio or torch - make sure that they work. Know the frequencies that Radio Vanuatu broadcasts on, particularly the short wave frequencies.

Finally make a point of listening regularly to at least one Radio Vanuatu News Broadcast each day. All information about Tropical Cyclones likely to affect Vanuatu will be broadcast immediately. Don't miss it ! ! !

When a Cyclone is Approaching

Listen to Warnings on Radio Vanuatu.

Save enough drinking water to last a few days in clean containers and keep in secure place.

Harvest some food from your garden to eat in the days after the Cyclone has passed.

Cut the tops off manioc plants, so that they will not be broken.

Cut excess leaves from banana plants so they will be less likely to fall.

Check again for loose objects that could blow about in high winds and cause injury and damage.

Save some fuel (dry wood, kerosene, matches etc) for cooking and warmth after the Cyclone.

Remember that the mains electricity supply is likely to be cut off as a Cyclone approaches. Have emergency lighting ready.

Do final check of house roof and walls. You may be able to weigh down the roof with ropes over the top, tied down with logs or rocks. DON'T put loose rocks on roof-they might blow or roll off and fall on somebody.

Stretch sticky tape over glass windows to hold pieces together should they break.

Have hammer, wood and nails handy to be able to do emergency repairs in a hurry.

If you have shutters, close or fit them.

If you have goods that are not water proof (electrical equipment, books etc try to cover them in plastic bags etc. The radio will still work inside a plastic bag. You will need it afterwards.

Store as many items as you can inside cupboards, preferably above floor level - to avoid being blown about and getting wet.

Make sure that children, old people and pets are safe.

If you live close to the sea, listen to warnings about high tides and waves. Be ready to move to high ground on short notice.

See if your neighbours are safe.

During the Cyclone

Shelter in a safe place. **DO NOT GO OUT.**

Beware of the eye of the Cyclone- this is the centre where the wind may weaken to almost a calm for a time but it will come back again, just as strongly, from the opposite direction. You may have time to do some minon repairs whilst the winds are weak **BUT BE READY TO SHELTER AGAIN AS SOON AS THE WIND INCREASES AGAIN.**

Table 29. ***(continued)***

If you live in a western-style house and have windows, open some on the leeward side (the side away from the wind). If the wind changes direction, close these windows and open others on the sheltered side of the house.

If you live by a stream, river or by the sea, be ready to move to higher ground if the water invades your house.

DO NOT GO TO SEA at any time a Cyclone is in your area. Sea conditions will be very rough and all but very large boats are in serious danger.

After the Cyclone

Check to see everyone is safe and well.

Treat any injuries.

Check your house and make quick repairs.

Collect any fallen fruit and any crops that can be salvaged.

If possible, dry out any sensitive items that have got wet (it may however still be raining even though the winds have died down).

See if your neighbours need any help.

Listen to Radio Vanuatu for the latest news and messages.

If you are short of water, get some clean containers and collect rain-water.

Restore any communications facilities that may have been damaged (i.e., re-erect any radio aerials that have blown down).

DO NOT attempt to cross streams or rivers by foot or by boat until the flood waters have gone down.

Sea conditions will still be danagerous for at least 2 to 3 days. DO NOT GO TO SEA in any boat until the sea has calmed down.

Cyclone Information

The Cyclone Season in Vanuatu lasts from **November** to **April** - BUT CYCLONES CAN, AND DO OCCUR OUTSIDE THIS PERIOD.

On **average 2 or 3 Cyclones occur each Season** - somewhere in the Vanuatu Area of responsibility. This includes all the sea areas of Vanuatu.

Types of Cyclones. Cyclones are categorized into 3 types according to their associated wind intensities. Those with:

1) **GALE FORCE WINDS** — mean wind speeds between 34 and 47 knots (63 to 87 kph; or 8 or 9 on the Beaufort Scale);

2) **STORM FORCE WINDS** — mean wind speeds between 48 and 63 knots (88 to 117 kph; 10 or 11 on the Beaufort Scale);

3) **HURRICANE FORCE WINDS** — mean winds speeds of 64 knots (118 kph; Beaufort Scale 12) or greater.

Tropical Cyclones have the following characteristics;

1) Heavy continuous rain;

2) falling pressure;

3) Increasing strong winds with powerful gusts;

4) Extensive cloudiness and heavy thunderstorms;

5) Storms surges, abnormal rises of sea level;

6) Exceptionally high waves and dangerous sea conditions;

7) Flooded rivers — which may overflow their banks.

All Tropical Cyclone Warnings can be heard on Radio Vanuatu - and will contain the following information:

- Where the Cyclone is **now**
- Where it is **going**
- What **wind speeds** can be expected (Gale, Storm or Hurricane Winds)
- When the **next warning** will be issued.

Radio Vanuatu broadcasts on the following frequencies:

5.45 am — 10.15 pm
98.0 MHz (FM) - Port Vila
98.5 MHz (FM) - Santo
1125 KHz (Medium Wave)

5.45 am — 10.00 pm
3945 KHz (Short Wave)

9.00 am — 6.00 pm
7260 KHz (Short Wave)

5.00 pm — 10.15 pm
3945 KHz (Short Wave)

Warning Lights on the Government Building or Meteo Tower, Nambatu will indicate the following winds likely to affect Efate (and nearby islands):-
RED — GALE FORCE WINDS.
DOUBLE RED — STORM FORCE WINDS.
TRIPLE RED — HURRICANE FORCE WINDS.

Produced by
VANUATU METEOROGICAL SERVICE
with the kind assitance of

XIX. MEASURES TO REDUCE DAMAGE FROM WATER-RELATED NATURAL DISASTERS IN VIET NAM

by Nguyen Ngoc Dong[1]

A. Introduction

Natural disasters cause heavy losses in Viet Nam every year. Cyclonic storms and floods are the two main natural disasters in the country. Viet Nam is generally divided into three parts, namely the northern, central and southern. The Red and the Thai Binh Rivers are the river systems in the north. The rivers in the central part are short, running from the Truong Son mountain range to the sea. The largest river system in the south is the Mekong river. Viet Nam is a long and relatively narrow country. Flood regimes of its rivers are different, and floods take place every year.

From 1979 to 1989, 75 cyclonic storms and tropical depressions landed in or directly influenced Viet Nam. During this period 30 major floods were experienced. Loss figures were: 4 703 died; 7 000 injured; 551 missing; 940 403 houses destroyed; 3 332 221 houses damaged; 40 347 classrooms collapsed and 64 671 classrooms damaged, thousands of hospitals and medical stations collapsed or damaged; more than a million hectares flooded, 130 752 ships and boats sunk; and thousands of water conservancy and transportation projects destroyed (see table 30). The total costs of the economic losses have not yet been established due to changes in prices and exchange rates.

In 1990, there were five cyclonic storms and three tropical depressions affecting Viet Nam directly. In June and July 1990 flash floods caused heavy damage to the provinces in the mountainous area in the north (Lai Chau, Son La, Hoang Lien Son) and in the central highlands (Dac Lac). Losses and damage caused by floods and storms in 1990 amounted to 354 people killed or missing, 932 injured; 14 521 houses collapsed and 154 134 houses damaged; 1 931 classrooms collapsed and 5 709 damaged, 244 hospitals and medical stations collapsed and 420 damaged; 45 543 hectares of rice plants were washed away, and 153 750 hectares of rice damaged; the paddy output was therefore reduced by nearly 200 000 tons; 588 ships and boats were sunk and 954 damaged. These are the preliminary figures.

B. Forecasting and warning

The Vietnamese Government considers that forecasting and warning are one of the most important measures to help mitigate the effects of tropical cyclones and floods. This measure has proved very effective in reducing the potential damage of natural disasters by lengthening the time between warning and onset of an event. The Hydrometeorological Service is responsible for the preparation of cyclone and flood forecasts and warnings and storm surge prediction.

Tropical cyclone forecasting is based on data provided by weather satellites and available radar stations in the three major cities of Hanoi, Da Nang and Haiphong. Accurate prediction of cyclone intensity and movement has been hampered because of inadequate links with the weather service of neighbouring countries, obsolete equipment and shortage of funds to upgrade the existing system.

The Service prepares short-term flood forecasts for all the major river systems. A sophisticated mathematical model is utilized in formulating these forecasts. Currently, however, the Service does not prepare detailed forecasts of flash flood conditions in the Central Region, despite the fact that these floods cause massive damages.

The responsibility for preparing forecasts and the issuing of warnings for minor rivers and streams resides with the individual provinces' and districts' administration.

Data collection systems for rainfall and streamflow statistics are manual with the information being transmitted by land-line or radio. No telemetering equipment is available to help streamline the data collection network.

Dissemination of the forecasts and warnings is accomplished by television, radio and the newspapers. During emergencies, updated forecasts and warnings are issued at frequent intervals. The Central Storm and Flood Control Committee receives frequent advice to allow it to co-ordinate all flood control activities.

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[1] Chief, flood and Storm Control Section, Ministry of Water Resources, Socialist Republic of Viet Nam.

Table 30. Human losses and material damages caused by storms and floods in Viet Nam from 1979 to 1989

Items	*Unit*	*1979*	*1980*	*1981*	*1982*	*1983*	*1984*	*1985*	*1986*	*1987*	*1988*	*1989*	*TOTAL*
I. Human losses	Persons	42	455	258	97	817	452	1 032	826	140	163	421	4 703
Death													
Injured			391	35	571	551	531	323	2 794	391	65	2 004	7 656
Missing				8	150		157		35		129	72	551
II. Houses	Number												
Houses collapsed		1 627	132 704	25 961	38 469	147 621	34 967	179 406	86 185	27 874	28 422	237 167	940 403
Houses inundated		32 332	103 948	123 220	136 724	483 477	220 036	167 935	647 924	213 991	140 611	1 052 023	3 322 221
III. Schools	Rooms												
Schools collapsed		940	8 294	25	9 035	2 291	2 569	2 049	2 049	2 938	1 693	10 513	40 347
Schools roof blown away			86	230	585	1 907	423	7 326	14 790	3 947	1 755	33 622	64 671
IV. Hospital – clinics	Number												
Hospitals collapsed		40	645			891		190	2 279	25		1 763	5 833
Hospital roof blown away					3 669	1 907	360	1 961	9 367	215	212	3 542	21 233
V. Losses in agricultural production													
Rice fields completely lost	Ha	72 961	188 705	48 210	70 105	79 796	246 440	219 025	32 152	34 408	63 195	175 528	1 230 525
Rice fields inundated	Ha	124 094	49 129	148 639	52 697	175 966	415 645	630 364	408 053	107 085	79 863	663 031	2 846 566
Vegetables sweet potato completely lost	Ha	24 230	30 259	26 039	12 895	19 600	59 780	55 752	80 199	27 852	58 820	39 213	434 639
Rice completely lost	Tonne	2 156	2 719	3 465	25 962	2 941	3 660	10 987	3 025	5 844	15 931	54 062	130 752
Boats sunk	Number	103	1 984	185	463	2 503	380	1 793	548	579	401	1 988	10 927
Bridges collapsed	Number	62		57	44		152	224	321	480	369	2 636	4 345

Tropical cyclone warnings are issued to all shipping by radio and, in special circumstances, by gun signals. Embargoes are placed on ships departing port during emergency periods to reduce loss of life.

C. Disaster prevention and preparedness

The Government of Viet Nam undertakes both structural and non-structural measures in reduction and prevention of natural disasters.

1. Structural measures

The Government of Viet Nam has been implementing various kinds of structural measures. Flood control reservoirs were constructed in the upstream areas of rivers which may also serve as multi-purpose reservoirs. Dike systems are very important in Viet Nam, where the original dikes were constructed in the 11th century. Before 1945, a total of 87 million m^3 of earth had been used in construction of dikes and during the last 45 years (1946-1990) more than 260 millions m^3 of earth were used in construction of dikes. In 1945 the total length of river dikes was 3 000 km and at present, Viet Nam has 5 000 km of river dikes and 2 000 km of sea dikes.

In many rivers, about 600 units of groins and cover stones have been installed during the last 45 years using more than 4 million m^3 of stone for these groins. River channels have been improved by removing obstacles from the rivers, including sunken ships and collapsed bridges, and by providing diversion canals.

Some low areas are utilized for retaining some portion of flood waters whenever the flood levels are predicted to exceed critical levels. The polder embankment systems have been installed in some areas in order to protect rice fields from flooding. Pumping stations have been installed to pump the flood water from areas inside the dikes and polders to the rivers. Many drainage systems have been constructed.

2. Non-structural measures

A variety of non-structural measures for flood prevention are undertaken in Viet Nam.

Reforestation activities are considered to be important in Viet Nam, and in view of the positive contribution of reforestation to flood control, from 1981 to 1990 several millions of trees were planted throughout the country. The Government also has a flood and storm control plan, flood fighting plan, and an evacuation plan. Households in the flood prone zones are transferred to safe zones. Since 1969 tens of thousands of households have thus been evacuated.

As for preparedness, there are teams of dike management. Each team covers 20 to 30 km of dikes. Engineers and workers are trained in techniques on dike management. There is also a watch-post every 3 km of dike consisting of a chief, deputy chief and members. They are rewarded not with money but rice provided by the concerned farm cooperative. Before the flood season, teams are trained in villages and are organized into dike protection brigades consisting of 50 to 100 members, who are trained in dike protection. In the forest regions there are forest protection brigades, which are in charge of management of the forest.

Every year a meeting of district and province authorities on dike management is held. Flood and storm control techniques are introduced to the public through radio programmes and publications in newspapers.

In colleges and schools, the historic floods and control measures as well as climate and geography of the regions are studied. River engineering including techniques on dike protection is taught in colleges and institutes. Some training courses for river engineers and technicians on flood and storm control and dike management are organized.

D. Viet Nam's response to International Decade for Natural Disaster Reduction (IDNDR)

In December 1988, with funds provided by the Save Children's Fund of the United Kingdom and with Asian Disaster Preparedness Center of Asian Institute of Technology (ADPC/AIT) assistance, the Central Storm and Flood Control Committee opened a training course on storm prevention and control for 36 persons. Up to the present with the funds provided by Save the Children, seven training courses have been organized where more than 200 persons have been trained. Further courses will be held in the future. These training courses are of practical significance since they provide the participants with the basic knowledge which can be immediately applied.

The Government of Viet Nam decided to dedicate 22 May as the Day for Natural Disaster Preparedness, and further refined the organization of the Central Storm and Flood Control Committee in Viet Nam. This Committee together with the State Committee of Science and Technology has initiated a state level research programme on the prevention and mitigation of floods and storms in Viet Nam.

On 7 January 1991 Chairman of the Council of Ministers of Viet Nam decided to establish the National Committee on the "International Decade of Natural Disaster Reduction in Viet Nam" and appointed the Minister of Water Resources as its Chairman. Other members of the

Committee include Vice Ministers or Deputy Directors of a number of ministries and general departments, and Deputy Chief of staff of the people's army of Viet Nam.

The tasks of the Committee are laid down as follows:

- To collaborate with the concerned government agencies and the mass organizations, social organizations, scientific and technological research institutes, to make plans, programmes and take measures to prevent natural disasters and/or mitigate their consequences.
- To direct the implementation of programmes on prevention and mitigation of natural disasters in Viet Nam.
- To establish relations with international organizations (including non-governmental organizations) and foster cooperation in prevention and mitigation of natural disasters.

Disaster prevention and mitigation projects are very necessary for Viet Nam since it is a country that suffers greatly from natural disasters. It is hoped that Viet Nam can continue to receive international assistance in preventing and reducing natural disasters. Funds, equipment and technical assistance for projects on natural disaster preparedness are much needed in Viet Nam.

XX. NATURAL DISASTERS IN THE UNION OF SOVIET SOCIALIST REPUBLICS IN 1990

A. Introduction

In 1990 more than 150 severe hydrometeorological phenomena were experienced in the USSR. The most catastrophic ones both from the point of view of the damage caused and the experience gained in their mitigation were floods in Bashkiria and Zabaikalye, numerous forest and tundra fires in Siberia, severe snowstorms in Komi republic and prolonged storms in the Far East.

At the beginning of February 1990, strong and prolonged snowstorms accompanied by very low air temperatures (down to -35°C) raged in a coal mining region, situated at the north-eastern part of the European territory of the USSR (the city of Vorkuta) as a result of cyclone impact. During two to three days all traffic on highways and railroads was paralyzed, airports closed, radio and telecommunications interrupted. Seven persons died and more than 100 persons were frostbitten.

The total damage was about 10 million rubles.

At the end of April and the first 10 days of May due to intensive melting of snow accompanied by severe rains, a catastrophic flood struck the rivers of Bashkiria.

The maximum water levels of previous years were exceeded in some places by more than 1 metre. The flood affected a territory with over 100 human settlements, some of which had a population of 200 000 to 500 000 and a number of chemical plants. Unfortunately, loss of human lives could not be prevented.

As a result, the need to amend and improve existing techniques of hydrological forecasting for this region in emergency situations became evident. Special attention should be paid to protection of chemical plants in order to avoid the situation when natural and ecological disasters happen simultaneously.

In the middle of May a long period of dry weather resulted in a great increase of forest and steppe fires in the south of eastern Siberia. Stormy winds of about 130 kph also contributed to the spreading of these fires. During only one day on 16 May more than 46 000 hectares of forests were destroyed by the fire. In affected human settlements about 1000 houses were burned down, 24 people died.

Although the information about the increasing danger of fires was being communicated by the Forecasting Division of the USSR State Committee on Hydrometeorology to local authorities and other responsible organizations since the end of April, the total damage amounted to 150 million rubles, mainly because of a limited number of fire brigades engaged in the mitigation of this devastating disaster.

A similar situation was observed in July-August in the tundra region and on peat bogs of Western Siberia. The spreading of fire to oil and gas production sites and pipelines created additional dangers. This disaster severely damaged the ecosystems of tundra, so that their restoration will take years. About 100 000 hectares of tundra were estimated to have been severely damaged.

In the first two weeks of July there was almost twice the usual precipitation in the Tchita region. Several waves of high precipitation floods formed on the rivers. Flood plains were inundated to the depth of 2.5 m, in some places – for the first time in about 100 years. As a result of this disaster several people died, 70 bridges were destroyed, about 500 buildings were damaged and 1 million hectares of agricultural land inundated. After the warning about high floods the local emergency commission evacuated about 2 000 people from the endangered areas, strengthened bridges and dams. The experience gained in mitigating the disaster showed the need to strengthen and improve hydrological network significantly for a more precise and timely forecast of floods, and for development of integrated protection schemes for Tchita city and other human settlements in this area.

From 5 to 11 November on Sakhalin, Kamchatka, and in Magadane region as well as in the Japan and Okhotskoye seas severe storms, extensive precipitation and waves were observed.

On Sakhalin wind velocity sometimes reached 40-45 m/sec., the precipitation level exceeded one to two monthly norms. As a result communications were destroyed, some human settlements were left without electricity, several ships were thrown onto the shore, and a very large landslide occurred.

The damage could have been much greater but for the timely warning of the approaching disaster. It allowed

fishing boats and ships to return safely to their ports. Emergency commissions for disaster mitigation were formed with a significant number of repair and restoration teams at their disposal. These repair teams were able to undo quickly the damage done.

On 14 June 1990 an earthquake with an intensity of 7 to 8 and a magnitude of 7.1 occurred in Eastern Khazakhstan (Zaisan). The earthquake's epicentre was located about 40 km deep, therefore the surface effect was not very strong: the deformations were mainly of a secondary order (outbursts of mud, sand, water). Nevertheless, about 400 buildings (mainly of native "saman" type construction) were destroyed and about 1 000 people were left homeless.

This earthquake was the most catastrophic on the territory of the USSR in 1990. Mention can also be made of the earthquake of 16 December in the Dgevakhetskoye highland, Georgia, with an intensity of 6 to 7 and that of 28 December in the area of Issyk-Koul, Kirgizia, of 5 to 6. It showed that present maps of the hazardous seismic zones need to be reviewed, because the region of Zaisan for example, was marked on these maps as a non-hazardous zone.

In addition to these natural disasters spread over vast areas, some local events were also observed (avalanches, mudflows etc.) In a number of cases failure to follow recommendations on protective and preventive measures, lack of knowledge and awareness of the rules of conduct in avalanche– and mudflow-prone zones caused loss of human lives and considerable damage.

B. Forecasting and warning

The main aim of the USSR State Committee on Hydrolmeteorology and its bodies is timely forecasting and detection of natural hydrometeorological events and provision of timely warnings about these events to Government bodies, organizations concerned and the general public

Forecasting is based on synoptic, physico-statistical, hydrodynamic methods and mathematical modelling that has been recently introduced.

The existing methods of forecasting provide for warning about 80-95 per cent of hydrometeorological events. These warnings may be given as early as 1 to 2 hours before local events and 2 to 3 days before large-scale ones. Notwithstanding existing positive results, further improvement in prediction methods aimed at better accuracy in determining the intensity, starting time and the location of a natural disaster is needed. All the more so since a number of disasters such as whirlwinds, mudflows, avalanches etc. so far are difficult to forecast with required details in time and space by using existing methods.

Warnings on hazardous hydrometeorological events are immediately communicated to local, and, as necessary, to regional and Government authorities, to civil defense structures and enterprises under the system of hydrometeorological services.

C. Disaster prevention and mitigation

The damage from natural disasters can be substantially reduced with proper organization of population warning systems, search and rescue operations and restoration works. In this connection the State Commission of the Council of Ministers on emergency situations was established by the decision of the Council of Ministers. With the establishment of this Commission the tasks of the subsidiary bodies of the State Committee on Hydrometeorology have considerably changed.

The operational emergency groups, created in republican and regional bodies of the State Committee on Hydrometeorology provide hydrometeorological logistics for search and rescue operations and restoration work in emergency areas, and constantly cooperate with local emergency commissions. At the level of the central Government this function belongs to the Standing Emergency Commission of the State Committee on Hydrometeorology, which provides the State Commission of the Council of Ministers on Emergency Situations with timely information on possible critical hydrometeorological and heliogeophysical events on Soviet territory that can lead to emergency situations; on large-scale climatic anomalies (droughts, severe winters), and on the impact of existing and expected hydrometeorological events on the aftermaths of accidents and disasters.

The framework of a unified state system of warning and emergency action situations which is being created, envisages large-scale studies on the scientific and technical programmes for the safety of population and economic facilities, with due account given to the risk of occurrence of natural and technogenic disasters. The main guidelines in the programme will be as follows:

- improving the effectiveness of population protection against the consequences of natural disasters;

- improving the methods and technical means of search and rescue operations and other emergency measures;

- improving population life support system;

- mapping the areas of hazardous impact risk;

- setting up the system of legal criteria and economic tools integrating safety;

- working out with UN assistance the general international norms and requirements of population safety, as well as consistent systems of national and international monitoring of the evolution of natural disasters (accidents).

The programme covers the period of 1991-1995.

At the same time the State Committee on Hydrometeorology is creating:

- automatic system for detecting heavy rain zones and assessing rain floods of typhoon-prone regions in the Far East;

- versatile computerized disaster detection and warning systems in large cities;

- facilities for detecting local events, such as hails thunderstorms, whirlwinds and storms;

- facilities for assessing and preventing avalanches and mudflows.

After testing these systems in specific regions, it is envisaged to expand the areas covered by such facilities with a view to establish a unified state system of early detection and warning on natural hydrometeorological events.

Maps (data bases) of the frequency and intensity of tsunamis in the Soviet Far Eastern regions and maps of mudflows and avalanche risks will be made, regulations on construction engineering, containing the parameters of natural hydrometeorological events and some other measures will be developed. Such a system will provide an accurate picture of natural events and will permit taking of emergency measures to mitigate them, and to substantially reduce physical damage and avoid loss of human lives.

PART FOUR

ACTIVITIES OF INTERNATIONAL AGENCIES IN NATURAL DISASTER REDUCTION

I. METEOROLOGICAL AND HYDROLOGICAL ASPECTS OF NATURAL DISASTERS

by O.M. Melder[1]

A. Introduction

Mankind has suffered from natural disasters since the beginning of history. Many of these events were of a meteorological or hydrological origin. A recent ranking, by number of lives lost, for the major types of disasters shows that tropical cyclones and floods are two of the three most serious causes of death from natural disasters. Earthquakes are the only other form of hazard with a comparable death toll. In the immediate past, 1989 will go down in history as one of the worst years in terms of tropical cyclone causualties and damage in the ESCAP region. No less than 34 tropical cyclones occurred in the western North Pacific and the South China Sea, resulting in death of more than 1500 people. Tens of thousands were made homeless and the financial loss exceeded US$ 2 billion.

The consequences of natural disasters, indeed of any type of disaster, can endure for a considerable time after the event. For instance the injuries and illness sustained by the survivors of a landslide can be with them for the remainder of their lives, while in a few hours intense rains and floodwaters can erode fertile soil and ruin the agriculture for centuries.

But these and like effects are usually not accounted for in attempts to weigh up the impact of these hazards. So it is highly probable that the social and economic costs of natural disasters are much greater than is generally recognized. Indeed, where studies have been made, they demonstrate that the damage caused to the economy of a country can represent a significant percentage of the gross national product, usually involving a large loss of export earnings.

With the increase in population that is taking place in many countries, there will be a far larger target for natural disasters in these countries in the future. The pressure of population on land resources will demand that many more people must live and work where the risks of disasters are highest, for instance in river valleys and on coastal plains. Most of the poorest people will be forced to settle in the areas of greatest risk, such as in the shanty towns built on steep slopes around the expanding fringes of mega-cities. But now there is the additional problem of changing climate and the sea level rise that is expected to accompany it. A rising sea level will aggravate the risk for the coastal populations, while shifts in the major climate belts may expose some communities to new hazards. Then there is concern that climate change may bring about more severe storms and other extreme events where they may have not been prevalent previously. Concern is also growing that while some natural disasters are being amplified inadvertently by man's activities, such as the deforestation of mountainous areas intensifying floods, others may trigger environmental emergencies, for example a volcanic eruption resulting in the release of gases and particulate matter. In these circumstances, the arguments for improving the capabilities of countries to combat natural disasters are compelling. No nation can afford to ignore the increasing threat; no community can expect to be free of risk.

B. Natural disasters

Most natural disasters can be classified into one of the three main groups; those of the solid earth, those of the fluid earth and those disasters associated with the biosphere. However, some disasters cut across such boundaries, while others spawn secondary effects which may fall into another group.

1. Solid earth disasters

An earthquake, a sudden motion of the earth caused by an abrupt release of slowly accumulating stress, is an example of a solid earth-type of disaster, a volcanic eruption is another. Volcanic activity is confined spatially to well-defined geological zones that are related to the unstable margins of the world's crustal plates, and this is where the majority of the more severe earthquakes occur. Both earthquakes and volcanic eruptions can trigger other events; landslides, tsunamis and floods. For example, the 1847 Zenkouji earthquake in Japan is remembered most for the blocking of the Sai river and the secondary disaster caused

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when the natural dams collapsed. The earthquake accounted for the death of more than 10 000 people and the loss of 20-30 000 homes. More than 40 000 slope failures were recorded. The largest occurred in the slope of the Kokuzou inundation and in the huge volume of sediments accumulated in the Sai river. The volume was estimated at about 700 m along its river course with a height of 100 m. The huge dammed reservoir that occurred had a length of more than 40 km. Nearly all the river flow was dammed for two weeks after the earthquake and about 30 villages along the Sai river were flooded. Three weeks after the earthquake, the dammed reservoir was overtopped by runoff from the severe storms which followed the earthquake. The stored water flowed into the Sai river and floods killed a large number of people.

Landslides are much more widespread than either earthquakes or volcanoes, but they have a variety of causes that puts them on the boundary between the first two of the main groups of disaster. Heavy rain, melting snow and ice and associated floods together with earthquakes, volcanic eruptions and building and construction works are amongst the main reasons for landslides. Landslides occurring on the ocean bottom along with earthquakes or volcanic eruptions can cause tsunamis, large ocean waves which become destructive as they approach the shallow waters along coast lines.

2. Fluid earth disasters

The disasters of the fluid earth – the atmosphere and the hydrosphere – know no boundaries. They can occur anywhere. The most destructive of weather systems, the tropical cyclones, which form over the oceans between latitudes 5° and 25° where temperature of the water is at least 27° C, bring winds exceeding 120 kph, rainfalls of over 1 000 mm in the space of a few days and storm surges of up to 8 metres or more resulting from sea level rise due to low barometric pressure and associated winds. In 1989, for example, typhoon Gay developed in the Gulf of Thailand on 31 October and subsequently crossed the coast of Chumphon on 4 November. It was the worst typhoon to hit Thailand for 60 years. At least 600 people where killed, more than 46 000 houses either partly or totally destroyed and 639 fishing boats sunk. The total storm damage was estimated at US$ 455 million.

Floods seem to be one of the most widespread and savage of natural disasters. They can be produced by the heavy rain from tropical and extratropical cyclones and their frontal systems, from rapid snowmelt, from a dam failure, from ice jams and in several other ways. On a large river system a flood may take several weeks or a month or more to subside, but in headwater regions and in small rivers a flood may last for only a few hours. These are flash floods which are common in mountainous areas. The combination of storm surge and river floods is particularly hazardous for low lying countries, such as Bangladesh. Coastal areas are also vulnerable from flooding from tidal waves. In November 1970 some 200 000 people were drowned in Bangladesh due to this phenomenon, which can also occur in more enclosed seas. Because of deforestation in headwater regions and the greater and more rapid runoff that ensues, the flood hazard has grown and will continue to grow in many areas. Likewise the spread of urbanization increases the volume and rate of runoff, increasing further the flood hazard.

Droughts are different from other natural disasters: in particular because they are caused by a non-event rather than some rapidly occurring phenomenon. A drought is usually extensive in space and time and, neither its start nor its termination can be readily identified. In addition, while droughts normally cause no deaths directly, indirectly through famine they can kill and adversely affect the lives of millions. Unlike other natural disasters, droughts are difficult to define because their impact on society and economy is felt in so many different ways: the many different definitions that are available even in meteorology and hydrology are supplemented by more from agriculture, domestic water supply and other sectors. Nevertheless, these difficulties do not detract from the fact that drought is a natural disaster of immense consequence being disruptive of the economy, society and the environment.

Droughts provide the best conditions for bush and forest fires to start and spread. Such wildfires, often started by thunderstorms, can engulf vast areas, endangering lives, also lessening scenic values. Removal of the vegetation induces more rapid runoff from the burned areas, soil erosion and landslides. Australia is frequently hit by bushfires, the 1988-89 and 1989-90 "seasons" being particularly bad. The largest recorded wildfire occurred in China in May 1987, covering 10 000 sq. km, killing nearly 200 people, destroying 12 000 homes and displacing 56 000 inhabitants.

China also provides one of the prime examples of a country suffering from both floods and droughts, on some occasions within a calendar year. The torrential rain in eastern Sichuan, 300-500 mm in five days from 7 to 11 July 1989, caused widespread and serious damage in 24 cities and counties, Daily totals exceeded 100 mm, and reached 298 mm. More than 800 people were killed and over 1 000 were reported injured. Floods destroyed 700 000 houses and inundated 600 000 ha of farmland. Losses were valued at more than US$ 350 million. By constrast, there was a severe drought during August in north-eastern and northern China. Rainfall was only 10 to 50 per cent of normal, and high temperatures with rapid evaporation accentuated

the effects of the lack of rain. From Beijing to Inner Mongolia, monthly totals were only 10-60 mm compared with the more usual 110-165 mm. Certain places, such as Harbin with 7 mm, had their lowest August total in the past 70 to 100 years. Over 48 million hectares of farmland were badly affected in what was the severest drought in the past 40 years.

C. Disaster prevention

There are considerable possibilities for reducing the impact of natural disasters and in some cases for avoiding them completely. Such reductions are based upon the scientific understanding of the phenomena involved and the application of this knowledge in skillfully organized systems for forecasting and warning. Nations which have invested in these systems and the preparedness and public awareness measures that go with them, have been sucessful in reducing deaths and, to a lesser extent, damage. Japan and Hong Kong are among those which operate these integrated disaster management systems.

It is important to recognize the essential elements of these disaster management systems, elements which together form links in the chain of reduction and alleviation. Weakness in one link usually means that the system fails to function effectively in its entirety, often resulting in loss of life and/or damage to property. These elements, which build successively on those coming before, are:

(1) Networks of instruments distributed spatially to measure meteorological, hydrological, seismological and related events on a regular basis, including radars and satellites. Transmission of these observations to computer archives for data processing and storage;

(2) Design systems which employ the information collected and collated in (1) to assess risk for design of structures of various types (e.g. buildings, dams and their spillways, bridges and fire breaks, land use etc.);

(3) Forecasting systems which employ the information collected and collated by (1) and which have been devised and calibrated for use with real-time data in day-to-day and disaster situations for forecasts of extreme events;

(4) Warning systems which employ the forecasts produced in (3) to disseminate disaster information to public and civil defence bodies and through them to the general public;

(5) Preparedness and prevention systems which employ the information obtained from the previous elements (1 to 4 above) in designing preparedness measures and plan the action to be taken in disaster situations, establishing or identifying the responsible bodies and ensuring they work smoothly together;

(6) Public awareness systems which utilize the previous elements for the education and preparation of the public for the onset of natural disasters and the action to be taken during disasters;

(7) Rescue and rehabilitation systems which provide: immediate care for the injured and sick, food, material and fuel together with clothing and shelter, transport and other life support essentials;

(8) Reconstruction systems with a longer term aim to return the material and non-material components of society to normal following the occurrence of a disaster and to make them less vulnerable to future occurrences;

(9) Research and education to improve and upgrade the elements of the overall disaster system listed as (1) to (8).

In countries with highly proficient integrated disaster management systems, such systems have resulted from considerable and continuing investment of capital and expertise. It is worth noting however that this investment is far smaller than the costs of damages caused by disasters; cost-benefit ratios of 1 to 10 or 1 to 15 being common. It is also worth noting that while governments in the developing world normally lack the funds to plan, develop, organize and maintain systems for coping with disasters, many governments in the developed world have been reducing their spending on their systems. In both cases the outcome must be an increased loss of life and greater property damage costs.

To take Japan as an example of a country suffering from disasters: in the great earthquake of 1923 more than 140 000 died and the damage to property was immense. From 1966 onwards, following the implementation of the Disaster Countermeasures Basic Act of 1961, a distinct change occurred in disaster statistics resulting from the measures taken. When in 1987, a magnitude 6.6 earthquake occurred with its epicentre near Tokyo, only two people died, 10 were injured and the damage was negligible. For Hong Kong, the close approach of Typhoon Gordon in July 1989 provided a good opportunity for the government to test its overall response plan. It confirmed that advance notification about major changes in warning status given to the public was highly successful.

Occupying a prime position in these disaster management systems are the computer models devised by meteorologists to simulate and predict the behaviour of the atmosphere, and which are used to produce weather forecasts. Computer models are also constructed by hydrolo-

gists and other geophysicists for their particular forecasting and prediction purposes. Hydrological models of river basins, for example, are utilized to provide flow forecasts, including forecasts of floods and droughts.

To model the weather on a global scale, current atmospheric models employ as a conceptual basis a series of concentric layers of the atmosphere, like an onion, extending from the surface of the earth into the stratosphere. The layers nearer the surface are the shallower, to better represent the important processes that take place there. Within these layers, a three-dimensional grid of points girdles the globe, containing half a million or more points, depending on the number of layers in the model and the spacing of the points. The global model in use at the World Meteorological Centre in Washington has a horizontal spacing of 140 km and a vertical separation of 200 m at the bottom of the atmosphere. Initial values of temperature, pressure, windspeed and humidity are ascribed to each point from the measurements gathered from the ground and from space. The model then mathematically transforms these values to create weather patterns which move forward in time as each atmospheric cell around every grid point interacts with its neighbours. As these cells interact, the values are recalculated again and again at given time intervals, and the forecast slowly builds up. In the Washington model each forecast takes about 22 minutes of computer time and a complete 10-day forecast is run once a day. Regional forecast models describing medium-scale weather patterns operate on a smaller horizontal grid than global models, with typical grids of 50-85 km. Such models better simulate local weather events, for example precipitation, and are highly valued as inputs to hydrological models.

Hydrological models of river basins mostly operate on a much smaller scale than meteorological models. The typical basin might be 10 000 km^2 but forecasts are required for basins as small as 100 km^2 in some countries. Although they may operate on many fewer grid points, and while some use only two dimensions, the ideal hydrological model would have to represent a greater number and variety of processes than atmospheric models in simulating the movement of water from its entry into a basin as rain or snow, to the point where the forecast is required. Such hydrological models would also need to represent the topography and land use of the basin and the nature of the river channels, so that they can become much more complex than meteorological models. For these and other reasons, the use of physically meaningful hydrological models for day-to-day operational purposes is not so far advanced as in meteorology. Hydrological models in daily use tend to be much simpler. Nevertheless, the hydrological community is advancing rapidly in its modelling capability as has been shown by several WMO intercomparison projects for hydrological forecast models.

D. Activities of the World Meteorological Organization

The World Meteorological Organization (WMO) has responsibility within the United Nations system for activities relating to meteorology, climatology and operational hydrology. Within the context of the IDNDR, the Organization takes a leading role concerning mitigation of disasters caused by: Tropical cyclones; floods; droughts; tornadoes and severe thunderstorms; other severe weather phenomena such as storm surges and major snowstorms and extremely high or low temperatures; and landslides and avalanches.

WMO contributes to the mitigation of other types of disasters through its involvement in the meteorological and hydrological aspects of insect plagues and forest fires and in the dissemination over its Global Telecommunication System of tsunami warnings and certain seismological data.

Response to natural disasters is at heart a national responsibility but certain types of disasters, most notably tropical cyclones and droughts, are rarely confined within national borders. Even when the disaster itself affects only one country, there is much that that country can gain from cooperating with its neighbours in assessing the risks and forecasting the occurrence of extreme events. Such co-operation is vital to weather forecasting the world over. It is also important, for example, in studying and forecasting floods on the many major rivers which cross international borders.

It is on this desire for international co-operation that the various international organizations have been founded. The World Weather Watch (WWW) system of WMO was derived from this; the Organization also sponsors a series of regional tropical cyclone bodies and works closely with a network of river-basin, regional and global international organizations to ensure that its aims are met and that resources at its disposal are used for greatest efficiency. Examples of these organizations are the Economic and Social Commission for Asia and the Pacific (ESCAP), the office of the United Nations Disaster Relief Coordinator (UNDRO) and the League of Red Cross and Red Crescent Societies.

While the detailed approach to each particular disaster and region of concern is different, there are certain principal elements in common which can be expressed as a series of aims and needs.

Aim A: To be able to assess the magnitude of the risk of each type of disaster – expressed in terms of the likely frequency of such events.

Requirements A:
(a) Adequate data to suitably characterize occurrence of past disasters;
(b) Techniques for analysis of these data to obtain estimates of risk;
(c) Hardware, software and personnel to apply these techniques.

Aim B: To be able to forecast, with sufficient accuracy, the variables needed for the provision of timely advance warning of the actual occurrence of a disaster such as windspeed, water level and extreme temperatures.

Requirements B:
(a) Networks of observing platforms and communication links for the collection of data in real-time needed to detect and monitor phenomena, where applicable, and to prepare foreçasts;
(b) Mathematical models and other analytical tools for the preparation of the forecasts;
(c) Hardware, software and personnel to apply these tools.

Aim C: To reduce to a minimum the impact of any disaster on the population.

Requirements C:
(a) Adoption and implementation of zoning, building and other regulations to reduce the potential impact;
(b) Construction of works designed to reduce the impact;
(c) Disaster preparedness organization at the national and community levels, with appropriate legislation;
(d) Trained personnel and an informed and sensitized public able and ready to respond in times of impending disaster or emergency.

Aim D: To assess the degree of success of disaster reduction methods and plans and to implement improvements.

Requirements D:
(a) Periodic evaluation of risk assessments in the light of more recent events;
(b) Monitoring of the performance of forecasting systems;
(c) Monitoring of effectiveness of structural measures;
(d) Periodic emergency exercises to test procedures;
(e) Revision with, where needed, upgrading of all components of the programme in the light of (a) to (d).

1. General approach

An adequate scientific basis and a variety of tried and tested methodologies, technologies and equipment are now available to fulfil most of the needs listed. Further scientific advances and new or improved techniques would be extremely valuable and further studies, particularly research in meteorology, should be promoted. The real, immediate and most important problem to be addressed by WMO, as far as the IDNDR is concerned, with its ten-year span and emphasis on developing countries, however, lies in applying the existing proven technologies and procedures. Consequently, the main WMO thrust is on:

(a) Filling the gaps in the implementation of the observing networks, telecommunications and data-processing facilities, as defined in the World Weather Watch Plan and which are required for establishing or upgrading warning systems;

(b) Promoting, initiating or accelerating action on improved response to warnings to ensure that they are effectively used;

(c) Risk assessment, particularly as needed for disaster prevention measures;

(d) Public information, education and awareness.

In many developing countries the two great impediments to such improvements at national level in the near term are:

- A lack of knowledge and expertise in the technology concerned;
- Lack of funds to install, operate and maintain systems using existing technology and procedures.

The basic requirements to overcome these impediments are technical co-operation activities with the emphasis on technology transfer and/or institution building, provision of equipment and facilities and human resources development.

2. Programmes involved

All the major programmes of WMO contribute to the aims of the IDNDR to a greater or lesser degree, namely:

- World Weather Watch Programme
- Hydrology and Water Resources Programme
- Applications of Meteorology Programme
- Research and Development Programme
- World Climate Programme
- Education and Training Programme
- Technical Cooperation Programme

While these Programmes are regularly adapted to match prevailing conditions and demands, they are long-term in nature: they have a considerable history and are expected to continue well into the future. It is very obvious, however, that many of WMO's activities have the same aims as those of the IDNDR. One of WMO's major objectives has always been the reduction of loss of life and economic damage from natural disasters and its activities will continue throughout and beyond the Dacade. Several of these activities, however, are being intensified and accelerated during the IDNDR to emphasize WMO's role with the aim of saving yet more lives and reducing the level of damage still further.

The outcome of such activities will be an improvement in the accuracy and timeliness of the forecasts and warnings, in the response to these warnings and in the extent and effectiveness of disaster prevention and preparedness activities. While it is not at this time possible to predict the benefits to be derived in quantitative terms, or indeed to measure them precisely, even after the event, they should result in a substantial reduction in the loss of life, human suffering, set-backs to national economies and destruction of property caused by natural disasters of meteorological or hydrological origin.

E. WMO plans for the IDNOR

Previous sections have presented the importance of meteorological and hydrological disasters, and have shown how meteorological and hydrological services can act to support disaster prevention and mitigation. Indeed, many of the day-to-day activities of these services are directly relevant to disaster prevention. It is thus natural that the World Meteorological Organization should take a major role in the IDNDR.

In June last year, the WMO Executive Council adopted a plan of action to guide the organization's activities during the Decade. The plan recognizes four aims and makes provision for achieving them. The aims are:

(1) To be able to assess the magnitude of the risk of each type of disaster;

(2) To be able to forecast, with sufficient accuracy, the parameters as needed for the provision of timely advance warning of the actual occurrence of a disaster;

(3) To reduce to the minimum the impact of any disaster on the population;

(4) To assess the degree of success of disaster reduction methods and plans and to implement improvements.

While noting that many of the organization's activities meet these aims, the plan of action also proposes three special projects for the IDNDR.

1. Project I – System for Technology Exchange for Natural Disasters (STEND)

The aim of the project is to provide information on the technology which is available for application to reduce natural disasters and to facilitate the transfer of this technology from the countries that developed it, to the countries that need it. Technology relevant to all the types of natural disasters encompassed within the IDNDR is to be included. This technology will include instrumentation and other equipment, technical manuals and other guidance material and computer software.

A system (STEND) will be developed for collecting information on relevant operational technology and advising potential users on the purpose, nature and conditions for acquisition of the technology concerned. STEND will be modelled on the highly successful Hydrological Operational Multipurpose Subprogramme (HOMS) of WMO and there will be close coordination between the two so as to take advantage of areas of common interest and to avoid duplication.

STEND will rely on inputs provided by national institutions with expertise and experience in the specific topics of disaster reduction technology and on national focal points whose role it will be to channel information into STEND and distribute information from STEND at

the national level. In view of this, the system will operate with a small international staff and it can be expected to be very cost-effective.

The system will be flexible so as to concentrate on the technology identified as being of highest priority and in general to respond to the needs of its users. Detailed plans for its implementation will be drawn up on the basis of advice from a steering group composed of representatives of national agencies active in each field of expertise and of international agencies having responsibilities in the fields concerned.

2. Project II – Tropical Cyclone Warning System for the South-west Indian Ocean Region

The objective of the project is to upgrade substantially the tropical cyclone warning system in the South-west Indian Ocean region through the application of meteorological satellite and micro-computer technology and the transfer of scientific knowledge. This will be accomplished by strengthening the capabilities of the national meteorological services to meet their responsibilities for the provision of tropical cyclone warning services in their respective countries.

3. Project III – Comprehensive Risk Assessment

The aim of this project is to demonstrate the power of applying modern technology in making a comprehensive assessment of certain types of risk within a given region. It would focus on the risk of flooding, of violent storms and of earthquakes. The modern technology involved will include geographic information systems and remote sensing.

An international team of experts will be formed to undertake the project. The experts will be drawn from developed countries, and the demonstration project will be located in a developing country. The region chosen will be subject to the full range of hazards to be studied.

The project would see the preparation of a comprehensive report on the causes, current risk and possible future probability of these hazards. The combined risks will be discussed and analyzed. The various items of technology used in the project will be generalized and presented in forms appropriate for inclusion in STEND (see Project I above). The project will be used as a basis for training local experts and those from other developing countries in the use of the technologies involved.

The project is expected to be implemented over a period of five years. It is anticipated that the services of the experts who are members of the team, together with all their associated expenses, will be provided by their governments as part of their countries' contributions to IDNDR. Equipment would be given or lent on a similar basis. The project would be overseen by a steering group composed of representatives from the donor countries and the host country for the project.

F. Conclusion

While we cannot prevent weather-related hazards, the loss of life and damage they cause can be minimized by using adequate forecasts and warnings to take appropriate actions. In addition, climatological and hydrological analysis of extreme events, their frequency and intensity in various locations, can lead to the design of safer buildings and other structures and minimize economic losses. Such risk assessments can also save lives over the long term.

Meteorological and hydrological services obviously have a major role to play here, especially in the context of the International Decade for Natural Disaster Reduction. They must be key elements in national and regional programmes to cope with disasters.

Much of the technology and expertise required to combat the threat of natural disasters is available. Given the will and the resources, the technology and the expertise can be used now to minimize the loss of life and reduce the destruction caused by such events. WMO has a major role to play in this vital work and the organization's many decades of experiences are being placed at the service of the International Decade for Natural Disaster Reduction.

II. UNDRO'S ROLE AND PROJECTED ACTIVITIES IN THE FIRST PHASE OF THE INTERNATIONAL DECADE FOR NATURAL DISASTER REDUCTION (IDNDR)

by J. Nemec[1]

UNDRO's tasks in relation to natural disasters encompass the complete disaster cycle, from the early warning phase preceding the actual impact or occurrence through the emergency management and response phase to identification of sectors for reconstruction and rehabilitation and, finally, covering the issue of mitigation, i.e, applied disaster reduction as part of the development process. As such, it is obvious that the majority of UNDRO's activities are to be seen as directly related to the realization of the Decade's goals.

UNDRO recognizes clearly, however, that it cannot restrict its efforts simply to putting renewed emphasis on its historical approach to disaster management through an increased number of activities. The Decade has been launched as a visionary 10-year effort to break the deadlock of insufficient recognition at all levels of the detrimental impacts of natural disasters and the potential to combat these negative impacts effectively through the concrete application of existing technological and scientific means within national development policies. In order to achieve the required awareness, UNDRO considers it necessary, particularly in the Decade's initial phase, to present a number of projects to the international community that represent bold steps forward in the fields of risk analysis and reduction and that, by successfully meeting national or regional requirements, act as a catalyst for a global effort for improvement.

Consequently both branches of UNDRO responsible, respectively, for relief and for disaster mitigation, will continuously evaluate their potential for additional activities that will in themselves represent as many specific goals of the IDNDR as possible. The Relief Coordination Branch will continue to evaluate disaster response and coordination efforts after the actual event at the national and international levels in order to provide indicators of remaining gaps in those fields and to initiate adequate development, be it by streamlining the institutional or legal framework for emergency response or by upgrading the technical tools to enable higher efficiency. The Disaster Mitigation Branch will increase its coordination and exchange of information with all partners in disaster mitigation, particularly the specialized agencies of the United Nations, the Decade's National Committees, governments, regional institutions, the technical community and, of course, the Decade's institutions, with the IDNDR Secretariat foremost. Through continuous historical analysis of disasters themselves, previous mitigation efforts of countries at risk and current disaster mitigation capabilities at the national, regional and international levels, it will strive to lay a basis for increased awareness of the disaster issue, identification of remaining gaps and needs and acceptance at the political decision-making level of the need to apply mitigation efforts in the context and as part of economic development. It will assist these countries to develop specific mitigation projects in close cooperation with other relevant UN agencies, promote technical or financial cooperation by the donor community and provide information and assistance to the recipient countries for the actual implementation process.

In the first phase of the Decade, UNDRO has initiated a number of global and regional projects. These projects are grouped in three major areas, the first being sectoral approaches to specific developments in disaster management such as, for example, information management, search and rescue, disaster terminology and communications. The other two areas comprise education, public awareness and training, on the one hand, and coordinated regional approaches to disaster mitigation, on the other hand. All these projects are intended to promote and fulfill the objective of the IDNDR and are considered as high priority activities. The global projects are, of course, of importance to this region and are presented below.

During 1990, UNDRO carried out a major study on its development requirements in the field of information management, not only with regard to an internal office support system but primarily with a view to improved international information exchange. As a result of this study, and as a contribution to the IDNDR, UNDRO is beginning to implement an information systems enhance-

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ment project that aims at the creation of a global interactive system for information exchange for disaster-related data. It is intended to support relief co-ordination and disaster mitigation alike. Some of the basic tools are already in place, in particular UNIENET, the United Nations International Emergency Network. They need to be further developed in a partnership between UNDRO and other United Nations agencies and programmes, governments, scientific and technical institutions, non-governmental organizations and institutional disaster managers. The project will place particular emphasis on the issue of diasaster-related databases, be it an inventory to provide knowledge about existing databases, the provision of technical access to such databases, so it can offer windows on UNIENET to particularly interested organizations, or the creation and maintenance of disaster-related core-databases, such as disaster statistics, disaster history, resource registers, bibliographical inventories, etc. In the context of this information systems enhancement project, the following individual components are particularly relevant: (a) Database network development; (b) Disaster statistics; and (c) Historical database.

To develop an appropriate strategy not only for disaster relief but also for disaster preparedness and prevention, it is important to understand the risk and vulnerability of societies prone to natural disasters and to learn lessons from past disasters. Since policy-makers are now more aware that, from the cost-benefit point of view, the practical application of preparedness and prevention measures is extremely effective in the development process, they are looking forward to a collection of the disaster histories of each country. Furthermore, the International *ad hoc* Group of Experts for IDNDR drew attention to the need for accurate historical records of hazards and disasters for enhanced risk assessment. In this context, UNDRO has decided to establish a historical disaster database containing information on hazards and disasters, rehabilitation and reconstruction processes, lessons learned from disasters, contact points for obtaining details, etc. Although similar projects are being implemented separately by several institutes and universities, this project will provide the opportunity of unifying and possibly linking existing databases as well as standardizing records to make data available in any computer network.

For some time, UNDRO has been collecting information for the development of a Disaster History Database as part of its computerized multi-database Disaster Management Information System. Some months ago, for example, the Office acquired the "Disaster Events" database of the Centre for Research in the Epidemiology of Disasters (CRED), of the Catholic University of Louvain, Belgium, to which UNDRO contributed in the original design and provided source data. This database will be incorporated in the above-mentioned UNDRO Disaster History Database. UNDRO has also been encouraging disaster-prone countries to develop similar databases at the country level, in connection with their disaster mitigation projects, and has provided expert technical assistance in their design and implementation. This assistance has also included an investigation into the possibility of connecting local computers to UNIENET, in order to make these in–country disaster history databases available to the worldwide disaster management community. The most recent example of this is in Nepal where in November/December 1990 an UNDRO computer and communications specialist worked with the Government to develop such a database and to examine the facilities available there to connect the local computers to UNIENET. It is expected that both the implementation of the database and the connection to UNIENET will have been completed by mid-1991.

Another specific example of a regional approach towards a disaster database is the SEISMED Information System (SMIS). SEISMED is a cooperative regional project concerning those Mediterranean countries that have signed the Barcelona Convention. Its objectives are the development, transfer and adoption of common methods and technologies for the reduction of seismic risk. There is no doubt that the SEISMED initiative can find its application in other natural regions and sub-regions and UNDRO will be pleased to assist ESCAP and countries in this region in the necessary transfer of methodology and technology.

A second global initiative of UNDRO is the recently started initiative towards improved international cooperation in the area of search and rescue (SAR). In several emergencies, search and rescue (SAR) teams represent the first living sign of international solidarity. Experience shows that while the value of their services is high, much can still be done to strengthen coordination among governments giving assistance and governments receiving assistance, as well as between the teams themselves.

At the Third Meeting of Officials in Charge of National Emergency Relief Services (NERS III), which was held in Geneva from 19 to 20 October 1989, UNDRO was requested to hold a workshop for heads of search and rescue teams. In this connection, UNDRO is convening, in co-operation with the Austrian Government, the "International Search and Rescue Workshop 1991", which will take place at Wattener Lizum (near Innsbruck), Austria, from 8 to 12 April 1991. The immediate objective of this workshop is to strengthen coordination of international relief within the field of search and rescue. Several governments are now preparing for the workshop, drafting four Search and Rescue Protocols which will form a platform for future work.

Participants in the workshop, in addition to UNDRO, will be mainly heads of search and rescue teams with international experience or from selected developing countries, as well as governmental officials in charge of emergency relief services. Representatives from concerned United Nations agencies are also invited.

In the same context, UNDRO is developing a directory of qualified SAR teams.

In a longer perspective, these two initiatives should be seen as the first steps towards a common understanding of operational disaster management following sudden onset disasters which, if agreed upon, should be expanded and lead the way to all areas of international, with emphasis on regional, emergency cooperation. This work is, therefore, in line with several major aspects of the IDNDR's main objectives, such as the exchange of technology and know-how in disaster management, reduction of cost and loss of life through higher efficiency in disaster response, and further sensitization for the necessity of a coordinated international approach to disaster management.

Another major sectoral initiative will be undertaken in the field of disaster terminology. UNDRO will execute a project with the objective of enhancing existing efforts for interdisciplinary and field/office communication in disaster-related activities, including training, by preparing a widely-accepted and coordinated glossary of terms in cooperation with, and on the basis of, existing partial terminological efforts of all concerned national institutions and international governmental and non-governmental organizations.

The preparatory activities for the IDNDR, as supported by UNDRO, have clearly identified one important and urgent need in the enhancement of UNDRO and other governmental and non-governmental organizations' efforts within the IDNDR. This need is to facilitate communication in the analysis, planning and operation of disaster-related projects by establishing clear definitions of terms used at the office and field levels. Such a need is particularly felt in the projects of the United Nations family, such as the UNDP/UNDRO Training Project mentioned below. In addition, this clarification of terminology is most important for interdisciplinary understanding in the integration of prevention, mitigation and relief aspects of all projects to be undertaken within the IDNDR.

UNDRO is in a very good position to develop and rapidly implement this terminology project since it has already prepared several partial glossaries of disaster-related terms, which may be used as basic material, together with other sources. The output of the project is to be divided into two parts: (a) establishment of a common framework of basic terms in a multilingual glossary; and (b) agreement on methodologies to amend or prepare specialized glossaries in those disaster-related disciplines that consider such glossaries as needed.

As another major endeavour, this time in the field of education, public awareness and training, UNDRO and UNDP have begun jointly to implement within the IDNDR framework a global disaster management training strategy. This project aims primarily at training UNDRO and UNDP staff in this field. In line with the concept of the Decade, especially with regard to the creation of an overall awareness of the issue of natural disaster reduction at all levels, the project, however, goes further. It intends to improve the overall United Nations system's capabilities in disaster management through constant coordinated professional development and the sensitization of Headquarters' staff and the United Nations field system towards this issue. In addition, it wants to link United Nations efforts with national development and enable planners at the national level to assess their country's status in disaster management, define the gaps and develop strategies for improvement. Therefore, national counterparts will be invited to participate strongly in the training activities.

Among other UNDRO activities being undertaken in cooperation with other United Nations agencies of major interest to this Symposium, and as implementation of the recommendations of the Interagency Task Force on Disaster Management (1988), UNDRO and UNDP have developed a joint disaster management manual that is to serve principally as a guide for UNDP field staff, including the Resident Representatives in their capacity as representatives of UNDRO. At the same time, the manual will be used as a principal tool in the UNDRO/UNDP Disaster Management Training Strategy and, as such, be available to the United Nations field system as a whole. Furthermore, an UNDRO manual entitled "Mitigating Natural Disasters" has been completed, and will be published within the framework of the IDNDR. The Manual, which is both a methodological and a practical guide in project information gathering and management, has been developed as a training tool for disaster managers regionally and locally at the technical, planning and policy-making levels. This manual complements the UNDRO/UNDP Disaster Management Training Project. An equivalent manual is being developed for the area of relief coordination to serve primarily as a guide for UNDRO staff; however, it will also be a basis of information for other interested entities.

As for UNDRO participation in the initiatives in this region, in cooperation with UNDP and the IDNDR Secretariat UNDRO opened a South Pacific Project Office (UNDRO/SPPO) in Fiji at the end of 1990. The UNDRO/SPPO has been set up at the request of the governments in the South Pacific region and has four immediate objectives:

(a) To identify, with the respective governments, subjects which merit closer attention in pre- and post-disaster management;

(b) To assist in the formulation of project documents with emphasis on training and demonstration programmes;

(c) To help identify suitable organizations and individuals in the region to assist in project implementation;

(d) To assist, in cooperation with the IDNDR Secretariat, UNDP and Forum Secretariat in identifying financial resources.

Four mitigation needs assessment missions were carried out in 1990 by UNDRO staff and consultants in six countries in the region: Fiji, Papua New Guinea, Samoa, Solomon Islands, Tonga and Vanuatu. First follow-up activities have already started in Fiji, Samoa and Vanuatu, and UNDRO is ready to extend such cooperation to other South Pacific island countries. High priority will be given to risk assessment and disaster preparedness and prevention activities in the form of demonstration projects and related training programmes.

A regional seminar on Strengthening Disaster Management in the South Pacific, organized jointly by UNDRO/SPPO and Forum Secretariat, is planned for March 1991. The objectives of the seminar are to exchange views on national and regional aspects of integrating pre- and post-disaster management; to set priorities and to outline a framework for action and sharpen the focus of UNDRO's potential role and fields of activities in the region.

III. MITIGATING THE EFFECTS OF NATURAL DISASTERS ON HUMAN SETTLEMENTS

by Ignacio Armillas[1]

A. Introduction

The Asia and Pacific region covers a vast area of the planet, in fact, for all practical purposes it is a hemisphere in itself. It is therefore not surprising that every type of natural disaster known can and does occur at least somewhere in this region. Some countries in the region are exposed to one or only a few types of natural disasters, while others are exposed to all or practically all known natural disasters. The regularity and frequency of reoccurrence also varies from country to country and according to the type of natural disaster. However, all countries of Asia and the Pacific are subject to natural disasters.

It would be tedious to list even the major disasters that have occurred in Asia and the Pacific in modern times. To make the point it is sufficient to mention that in the course of the first year of the International Decade for Natural Disaster Reduction (IDNDR) several major natural disasters occurred in the region. These disasters added up to considerable loss of life and significantly affected the economies of several countries. The three most prominent disasters of 1990 were the Manjil earthquake of 21 June in the Islamic Republic of Iran, the Luzon earthquake of 16 July in the Philippines, and the cyclone that hit the Indian state of Andhra Pradesh in May of 1990. Of course, there were other disasters such as the typhoon that hit the central Philippine islands in November, the earthquake in the south-western area of Iran, also in November, as well as floods, landslides and other disasters.

1. Earthquakes

As a result of the earthquake of 21 June 1990 in Iran, which centred in the provinces of Gilan and Zanjan, 100 000 houses were destroyed and the nation mourned an estimated 40 000 dead. The affected area was large and varied, covering the plains on the shores of the Caspian sea and the mountainous areas to the south. The settlement pattern was characterized by the concentration of population in over 1 600 small villages dispersed in remote valleys and small cities on the plains. The area affected covered some 30 000 km^2.

All told, half a million people were left homeless and in need of shelter. The earthquake also destroyed 216 medical buildings, two hospitals, 1 329 schools, as well as many shops and other commercial buildings. Extensive damage was caused to industrial plants, agricultural production, water supplies and transportation networks. These damages toinfrastructure were analysed and fully reported in the UNDRO Technical Report on this earthquake prepared in August 1990.

It is clear that the economic, social and physical development of a large region in Iran has been crippled by this natural disaster, with serious repercussions on national accounts. Not since the Tangshan earthquake in China in 1976, has the world seen an industrializing and agriculturally important region so widely and comprehensively laid waste.

Not four weeks had passed since the destructive Manjil earthquake that another major tremor struck in Asia. This time the disaster occurred across the continent in the Philippines. The 16 July earthquake struck north-central Luzon, severing road and telecommunications links, and making rubble of homes, commercial establishments, factories and agricultural installations. According to the National Disaster Coordinating Council, more than 1 200 people died, while more than 2 700 were injured, and an estimated 120 000 people were left homeless. Property losses exceeded US$500 million. Physical damage was generally confined to localized pockets, except in highland areas of Benguet and Nueva Vizcaya where it was extensive. The nation's capital, Manila, although badly shaken, suffered only modest damage.

Although the immediate physical damage was limited to north-central Luzon, the earthquake placed a heavy new burden on a nation already struggling with major economic problems. The destruction caused by the earthquake has had serious repercussions on the lives and economic activities of not only the people directly affected, but of Filipinos in general. The problem of broken road links illustrates the point. It choked the flow of goods and supplies for farmers and manufacturers. The disaster

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has caused people who barely noticed the seismic event to feel their standard of living decline in its aftermath. The earthquake has increased food prices, unemployment, and pressure on the national balance of payments.

The affected physical environment, cities, towns, villages, and transport and other networks, will have to be rehabilitated for the economic and social systems to return to "normalcy". The estimated cost of reconstruction and associated development will be more than $US 1.5 billion.

2. Cyclones and typhoons

Earthquakes were not the only source of major loss of life and property to the forces of nature. Asia and the Pacific were also affected by cyclones and typhoons. The major storm to hit mainland Asia in 1990 lashed coastal Andhra Pradesh State in India. This cyclone was the worst of the century to hit the country as far as intensity was concerned. However, pre-disaster planning, based primarily on the lessons of the cyclone of 1977 which killed an estimated 10 000 people, kept the death toll to under 1 000. Nevertheless, the 1990 storm wreaked destruction in excess of that caused by the 1977 cyclone. Villages were inundated, houses collapsed or had their roofs blown away, other structures such as bridges and towers, failed, crops and stored grains were lost. Transportation and communication networks also suffered major physical damage. The environment also suffered, there was loss to the fertility of land due to inundation of sea water over vast coastal areas.

In economic terms, the Andhra Pradesh Cyclone caused total losses to private and public property well in excess of $1.0 billion. The total cropped agricultural area affected was over 300 000 hectares and 460 000 head of livestock perished. The cyclone also caused extensive breaches to railway track and damage to bridges. Other surface transport networks also suffered damage as did telecommunications and energy generating installations. Over 250 000 houses were damaged in villages and towns in the affected area.

B. Impact on human settlements

From the examples that have been briefly described, one thing is evident: natural events such as seismic activity or windstorms become natural disasters when they result in loss of life and affect the man-built environment. Moreover, the destructive effects of natural events concentrate, on the most part, in human settlement systems. This is to say the concentrations of human activity (cities, towns and villages), and the communication, transportation and distribution networks that link them. It is here that the greatest risk to human life and property exist, simply as a function of density. It is also because of the concentration of social and economic activities in cities, that when they are impacted by a disaster, the overall social and economic fabric of the country as a whole suffers negative consequences. Thus, if we are to consider reducing the effects of natural disasters on the social and economic well being of a country, we must focus on reducing the levels of risk in human settlement systems.

Ironically, it is after a natural disaster that interest in mitigation is most intense. Having just witnessed the effects of the forces of nature, people are more inclined to think about the benefits of mitigation. Therefore, that is the best time to reach the professionals, influence the decision makers and convince the private sector. The opportunity must not be lost. Moreover, it is during the reconstruction and rehabilitation phase that major investments will be made. Such investments could be several times higher than those that would otherwise have been made in the normal course of events. These investments will result in building and construction that will be in place for many decades to come. This infusion of investment and the physical heritage that it will create represent both an opportunity to regenerate the economic and social fabric of the region and the quality of the built environment we will leave to future generations.

During the foreseeable future, there will be a rapid growth of industrial development in the Asia and Pacific region accompanied by urban expansion and increased population. Experience has already demonstrated that natural disasters have tended to become increasingly destructive since they affect concentrations of population, which are growing year after year. Depending on the site, such instantaneous disasters may very well lead to increased economic, political and social instability, the adverse effects of which will further erode the capacity of the region stricken, or even the entire country, to cope with the consequences of natural and, as a chain effect, man-made disasters.

1. Protection of human settlements

Specialized or comprehensive assessment of natural (and technological) hazards, including a rigorous scientific, technological and intellectual approach will be required to solve this truly global problem. The problem is basically one of protecting human life and orderly economic and social development: a process centred in human settlements.

Even though each disaster is quite unique, the problems created are basically of the same nature, thus, quite foreseeable. Knowledge of the profile of related disasters enables planning of pre-disaster measures and activities for effective risk management through experience and technology transfer, performance of pre-disaster demon-

stration projects, elaboration of programmes for technical assistance, education and training, as well as the evaluation of the effectiveness and organization of pre-disaster measures and activities.

Efforts to mitigate the effects of natural disasters must be interdisciplinary since they must cover social, economic, environmental and physical aspects. However, the major responsibility for reducing risk to natural disasters, from a technical point of view, rests on engineers, architects and urban and regional planners, for these are the professionals that shape the physical environment. Engineering has provided methods and techniques for reducing the vulnerability of buildings, infrastructure and other civil works. These methods have been assimilated, to a large extent, into the work of engineers and architects. In urban and regional planning, the picture is far less positive. While planners have learned to integrate economic, social and, more recently, environmental factors into the planning process, they have yet to do the same regarding vulnerability and risk reduction. The reason for this deficiency is partly the lack of methodologies which can be applied to this purpose. Clearly, there is a need to develop risk mitigation techniques and methodologies, that can be integrated into the work of the development planner.

2. Planning for disaster mitigation

Some efforts at developing techniques and methodologies for integrating natural disaster mitigation concepts into physical planning and development are being made. For example, the work of engineers finds its way, more and more, into building codes and regulations. Concepts such as risk zonation are becoming better understood by urban and regional planners. But overall, risk and vulnerability reduction concepts are at best paid only lip service in the planning jargon. If we add to this the difficult political realities and expediencies of the private sector we come to realize that we are a long way from effective vulnerability awareness in so far as planning and development are concerned.

3. Preparedness tools

Quantitative risk and vulnerability assessment tools are needed for the planning of new developments and appropriate post-disaster reconstruction and rehabilitation purposes. More advanced methods, procedures and models for assessment of risk and vulnerability should be developed in order to provide the data and knowledge base in the following areas:

(a) Assessment of the accuracy of existing methods for evaluating hazard, risk zoning and microzoning and their practical application in engineering, land-use planning, development planning and public information and training, as well as performance of the sensitivity analysis of the final results on factors controlling most influentially the aforestated outputs;

(b) Reviewing of various approaches for risk mitigation under different socio-economic conditions, with an emphasis on the post-disaster period of revitalization and reconstruction;

(c) Estimation of vulnerable regions, areas and points, processes and/or activities and planning of disaster preparedness and prevention of many primary and secondary phenomena accompanying the major natural disaster. The greater preparedness for the expected event is, the more effective and timely organized relief operation, reconstruction and revitalization will be;

(d) Development of improved survey sampling methods for estimating physical, functional and economic losses and damages due to large-scale natural disasters;

(e) Improvement of data collection systems to increase their utility in estimating the size of physical, functional and economic losses for the expected natural events;

(f) Fostering of scientific and engineering endeavors aimed at bridging critical gaps in knowledge that exist on the way of reducing the natural disaster induced losses; and,

(g) Development of rigorous organizational research on the factors that facilitate or hinder the effectiveness of the pre-disaster preparedness and/or emergency response as well as disaster relief efforts in post-disaster conditions.

4. Mitigation strategies

Given an improved knowledge base it would then be possible to:

(a) Devise new mechanisms and strategies for continuous application and updating of existing knowledge, taking into account the cultural, social and economic diversities within the region;

(b) Guide industrial and residential development in regions expected to be, or already prone to disasters, in order to reduce both human and property losses;

(c) Control certain kinds of hazardous activities in industrial plants carried out in regions of expected risk; to manage and develop environmentally sound strategies for countering the threat of increased susceptibility to secondary effects caused by a natural disaster;

(d) Plan the most rational and effective access to the region stricken by a natural disaster, to provide access for emergency, disaster relief and other technical and expert services, and to plan the location of the disaster relief and emergency service facilities; and

(e) Disseminate the existing and new information related to the measures for assessment, prediction and mitigation of hazard and risk.

5. Loss prediction and evaluation

One area of research which has advanced in recent years is quantitative loss prediction methods. Two decades ago, there existed almost no predictive estimates of damage that might result from natural disasters. The development of various procedures for estimation of losses has been prompted by the increased loss potential due to rapid development and concentration of material property in disaster-prone regions. However, the development of a single damage prediction methodology is presently not feasible because of the complexity of the problem and the strong lack of a uniform data base.

Loss evaluation is carried out at present with varying degrees of rigor. However, all models (theoretically or empirically based) proposed for predicting losses share the common necessity of performing a series of complex procedures requiring extensive computations and proper data acquisition and handling. A systematic approach should include the following five basic elements:

(a) Inventory and classification of the existing elements at risk with their zonation within each zone of the considered area.

(b) Prediction of the site-dependent hazard with evaluation and presentation of hazard parameters for each zone including the effects of local conditions in modifying the characteristics of the events in the considered zones.

(c) Assessment of vulnerability and development of vulnerability functions based on experimental and theoretical studies, and empirical data banks from the past events.

(d) Loss prediction with cumulative presentation of losses for all elements at risk including density distribution with mapping for each zone and considered hazard levels.

(e) Risk analysis and optimization with consideration of the existing and improved scenarios of land use and urbanization. Through the functional improvement of the existing conditions in the development plans, physical improvements will be incorporated for each element at risk and presented for each zone and urban area/region for the considered levels of hazard, representing alternatives of improved scenarios. Risk analysis for the improved scenarios and comparative analysis in respect to the existing conditions will lead to an optimized land use scenario causing minimum losses for a given level of hazard. The optimized land use scenarios could be presented with the optimized level of physical losses as a percentage of the floor area for all elements at risk, or further elaborated into optimized level of economic losses considering the current market value for all the elements at risk cumulatively.

On this basis, a loss prediction and risk optimization assessment can be made. This assessment is essential in order to develop technically feasible and economically justifiable measures for effective pre-disaster risk management, or planning for post-disaster reconstruction and revitalization of a stricken region.

C. Conclusions

Human settlement planning is unfortunately a long range activity highly vulnerable to conflicting priorities and demands, especially if these are of an economic or political nature. Human settlements and their spatial distribution develop in response to a combination of social, economic, environmental and political forces. Risk to natural events is by-and-large a minor consideration, if at all, in this process. Ultimately, each society should accept a compromise between exposure to risk and long-term economic and social necessities. In any case, the decision should be made through balancing the pre-disaster capital inputs required for achievement of the accepted level of risk and safety, and the estimated value of expected losses.

This brief overview began with some illustrations of major natural disasters that affected the Asia and Pacific region in 1990 and presented some general strategies that could be applied to reducing those losses. Let me put forth one suqgestion that could contribute to the reduction of loss of life and property due to natural disasters in the Asia and Pacific Region.

There is clearly a need to learn more about the effects of natural disasters on human environment, and more specifically on human settlements, since it is here that social, economic and cultural activity is concentrated. There is also clearly a need to develop the tools and methodologies for mitigating the effects of natural disasters on human settlements; and, finally, there is a need to disseminate this knowledge.

To this end, a region-wide applied research institution which would carry out the functions outlined above would be desirable. Such an institution could be created either through the strengthening of an existing body, or

through the formation of a new institution. Either way, this initiative would represent a valuable contribution towards the attainment of the objectives of the IDNDR.

The following list provides examples of natural disaster-related projects in Asia and the Pacific executed by the United Nations Centre for Human Settlements (Habitat):

(1) Reconstruction of rural housing in flood-affected areas of Bangladesh (BGD/90/006).

(2) Assistance in the implementation of a post-earthquake rehabilitation programme, Gilan and Zanjan provinces of Iran (IRA/90/004).

(3) Earthquake emergency reconstruction and rehabilitation programme, central and eastern Nepal (NEP/88/053).

(4) Rehabilitation and reconstruction of flood-damaged areas in Kashur Tehsil, Pakistan (PAK/90/002).

(5) Landslide hazard mapping, two districts in Sri Lanka (SRL/89/001).

(6) Disaster preparedness and rehabilitation, subproject No. 3: Disaster-resistant building techniques, Binh Tri Thien province, Viet Nam (VIE/85/019).

(7) Rehabilitation activities following Typhoon Irving, Thanh Hoa Province, Viet Nam (VIE/89/035).

IV. THE ASIAN DEVELOPMENT BANK: DISASTER MITIGATION ACTIVITIES

by Werner M. Schelzig[1]

The Asian and Pacific region in which the Asian Development Bank operates is prone to all types of natural disasters. They entail destruction of assets, loss of life and severe economic setbacks. In short, disasters disrupt development.

Disaster mitigation is possible, desirable and warranted. The Bank considers disaster mitigation as part of a three pronged approach to development, focussing on achieving sustainable economic growth, poverty alleviation and environmental protection.

Traditionally, the Bank's approach to dealing with disasters has been reactive, and essentially limited to financing rehabilitation activities after disasters had occurred. For instance, during 1988-1990 the Bank committed some $0.4 billion for emergency rehabilitation projects in six developing member countries (DMCs). Rehabilitation lending at times took substantial parts of the annual lending programme of individual DMCs, such as Bangladesh in 1988 (35 per cent) and 1989 (24 per cent), and the Philippines (15 per cent) and Samoa (100 per cent) in 1990. The Bank has formulated a set of rehabilitation policies governing its lending responses in emergency situations.[2] These policies by now have become well established. Looking ahead, the Bank will, of course, continue to respond to the needs of its developing member countries for rehabilitation after disasters.

However, the Bank has become increasingly aware of the need for proactive mitigation measures before disasters strike. It is the Bank's policy to include vulnerability analysis and risk assessment in all of its future projects and incorporate disaster mitigation measures into the design of projects in DMCs prone to natural disasters.

In addition to its project financing for these purposes, the Bank utilizes its technical assistance facility for providing advisory and project preparatory technical assistance to its DMCs. Such technical assistance is also available for the formulation of disaster mitigation plans, devising mitigation strategies and designing measures to carry them out. This type of assistance is available at the regional level, at the country level and at the project level. An example of such assistance is the regional study on disaster mitigation which has been financed under a regional technical assistance grant by the Bank.[3]

The regional study aimed at:

(a) Enhancing the awareness of DMCs of the need for an active developmental effort to mitigate natural disasters;

(b) Producing documentation on disaster management in selected DMCs;

(c) Improving the understanding of the techniques of disaster mitigation through structural and non-structural mitigation measures; and

(d) Promoting cooperation in designing and implementing national strategies for mitigating the impact of natural disasters on economic development and the formulation of national and regional strategies.

Three major activities were financed by this technical assistance. First, a regional seminar was held for representatives of DMCs dealing with the formulation of country-specific disaster management responses. Second, to facilitate discussions, five papers were provided. A technical paper was prepared covering disaster incidence, risk assessment and vulnerability analysis and analyzing structural and non-structural measures that may be implemented with a view to mitigate natural disasters. In addition, four country case studies were produced (on Bangladesh, Nepal, Philippines and the South Pacific countries as a group) summarizing the lessons of experience and current disaster management practices in the DMCs concerned, with a view to designing general response mechanisms for closing identified gaps in existing disaster mitigation practices with and without outside assistance.[4]

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[1] Development Policy Office, Asian Development Bank, Manila, Philippines.

[2] See Doc. R74-87, Rehabilitation Assistance to Small DMCs Affected by Natural Disasters, dated 17 June 1987; and Doc. R191-88, Revision 1, Final, Rehabilitation Assistance After Disasters, dated 2 February 1989.

[3] See TAR:STU 23145, Technical Assistance for A Regional Study on Disaster Mitigation, dated October 1989.

[4] Drafts of the regional study have been provided to the participants of the ESCAP/UNDRO Symposium for ready reference.

A third activity under the Bank's technical assistance is the production of a Disaster Manager's Handbook. The Handbook is currently in its final drafting stages. It is intended eventually to serve as a reference guide for those actively involved in dealing with natural disaster management in DMCs. The handbook will be a practical reference manual dealing with specific topics in disaster management and providing specific guidelines on how to deal with them in a disaster situation. The focus is on addressing disaster managers' individual local requirements with regard to planning, policy, and institution building both ex-post and ex-ante.

It is envisaged that the Bank's regional study will eventually be followed by country-specific disaster mitigation activities as initiated by the national authorities, which may be supported by the Bank or other bilateral and multilateral agencies at the request of individual DMCs.

Such activities may follow perhaps the example of the envisaged mitigation activities under the flood action plan the Bank is now supporting in Bangladesh in close cooperation with the international community under the chairmanship of the World Bank. Assistance may also be extended to developing regional cooperation among DMCs in disaster mitigation and preparedness, building on the varied experience some of the developing member countries possess. For instance, the experience with the Philippine typhoon resistant core shelter project or the Fiji building extension service, Indonesia's efforts in mapping earthquake risks and volcano hazards, the experience gained in the People's Republic of China with hazard mapping and research for developing appropriate mitigation technology all are worth being disseminated throughout the countries of the region prone to natural hazards. These experiences are not uniformly well known throughout the region. The stress should be on sharing knowledge, drawing the lessons of experience and implementing proven approaches of some DMCs in others as well.

The International Decade for Natural Disaster Reduction provides a framework for concerted action during the 1990s. The Asian Development Bank welcomes the efforts being undertaken and closely associates itself with the concerns of the Decade. The Bank's seminal study of disaster mitigation has already resulted in raising the awareness of all concerned and in follow-up action by ESCAP and UNDRO for the region and the South Pacific, respectively. The Bank will continue to be actively involved in promoting the goals of IDNDR as they concern its developing member countries.

International cooperation is vital, if there is any hope of coming to grips with the objectives of IDNDR and implementing them in developing Asia and the Pacific. The problems ahead are formidable and can only be tackled if on the donors' side there is division of labour, burden sharing, and pooling of expertise and coordination in allocating financial resources. The Bank is interested in evolving a coordinated approach and in cofinancing rehabilitation and mitigation operations, providing technical assistance and sharing of expertise in a cooperative environment in the emerging field of disaster management.

The Asian and Pacific region is fortunate to have a focal point for disaster related activities in the Asian Disaster Preparedness Centre at the Asian Institute of Technology. The Centre may assist in formulating disaster mitigation approaches and providing training in the emerging field to officials in the developing member countries. To meet the challenging requirements of the region during IDNDR, the ADPC needs further strengthening, for instance through establishing in-house economic expertise and widening its consulting capabilities for damage assessment, formulating proposals for rehabilitation projects and advising on disaster mitigation measures of the structural and non-structural types.

Important preconditions for successful disaster mitigation already exist in the Asian and Pacific region. The IDNDR provides an excellent framework for concerted action in the years ahead. The Bank intends to continue to play an active role in implementing the goals of the Decade in close coordination with the international community and to the benefit of its DMCs. The Bank is confident that with its forthcoming Regional Study on Disaster Mitigation and the "Disaster Manager's Handbook" important new ground has been broken in the emerging field of disaster mitigation in the Asian and Pacific region. The Bank is concerned that the findings and conclusions of the regional technical assistance operation will be reflected in regional and country specific disaster mitigation activities.

How to fund disaster mitigation activities is a major challenge. There are no ready solutions. Innovative approaches by DMCs and the international community, perhaps coordinated by IDNDR bodies, need to be explored. One thing is clear, an increased commitment of resources to mitigation today, means fewer catastrophic disasters tomorrow.

This is a worthwhile goal. The Bank will continue to contribute towards achieving this goal.

V. IDNDR RELATED ACTIVITIES AT UNITED NATIONS CENTRE FOR REGIONAL DEVELOPMENT (UNCRD)

by Hidehiko Sazanami[1] and Isao Tsukagoshi[2]

A. Introduction

On behalf of the United Nations Department of Technical Cooperation for Development (UNDTCD), a report is presented on UNCRD's past activities and future plans in relation to the IDNDR as an example of IDNDR projects by a United Nations agency.

It is not necessary to repeat the significance of the IDNDR. It is only needed to consider how practical action can be undertaken to achieve a less hazardous world. The basic orientation of the IDNDR has been provided in the Guidelines for Implementation of the Secretary General's report at the 44th United Nations General Assembly. It emphasizes the coordination between national programmes and international efforts and recommends, as the basis of a national programme, hazard prediction, risk assessment, disaster preparedness and disaster management. It also refers to the importance of the application, exchange and dissemination of knowledge and information, and to the necessity of technical assistance and technology transfer.

UNCRD, as a member of the United Nations community, recognizes its role in the IDNDR as contributing to those programmes and activities from the aspect of regional development, in particular through the training of human resources and research cooperation with developing countries.

UNCRD has been active in its efforts towards preparing for and launching the IDNDR for the past five years by mainly organizing and implementing seminars, workshops and symposia. Now, as the second year of the decade begins, there is a need for a clearer perspective for future activities.

B. Towards the IDNDR

Disaster prevention has long been considered as a field of significant importance in the regional development programme of UNCRD. Since 1984, when the basic concept of the IDNDR was proposed at the Eighth World Symposium of Earthquake Engineering, UNCRD has endeavoured to make its contribution by organizing symposia, workshops, and seminars. Major examples of those activities are presented below.

1. International Seminar on Regional Development Planning for Disaster Prevention

This seminar, held in September 1986 at Nagoya, Shizuoka, and Tokyo, had three main themes: drawing up a set of guidelines on policy implementation in disaster prevention; improvement of technology for disaster prediction, forecasting, emergency relief, post-disaster recovery and reconstruction; and reports and analyses of specific cases of disasters.

2. First International Research and Training Seminar on Regional Development Planning for Disaster Prevention

This seminar, held in October 1987 at Tokyo and Nagoya, had the following main objectives: To investigate ways to strengthen the resiliency of communities in developing countries through the integration of pre-, mid-, and post-disaster measures in regional development planning; and to set guidelines for completing curricula and teaching materials for use in organizing training courses.

3. Second International Research and Training Seminar on Regional Development Planning for Disaster Prevention

This seminar, held in July 1988 at Nagoya and Shimizu, was cosponsored by the Institute of Social Safety Science (Japan) and the Earthquake Engineering Research Institute (United States). The following themes were discussed: policy problems of earthquake prediction; public and private awareness; estimation of earthquake vulnerability/damage; fire after an earthquake, and hazardous materials; short-term emergency responses; and long-term recovery/reconstruction.

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[2] Senior Disaster Management Planner, UNCRD.

4. International Symposium on Challenges of the IDNDR

The symposium, had in April 1989 at Yokohama, was jointly organized with the United Nations Department of Technical Cooperation for Development (UN/DTCD), with the collaboration of the national and local governments of Japan. Members of the International Ad-Hoc Group of Experts for the IDNDR and experts from Japan attended the symposium to share their basic ideas pertaining to the report of the Fourth Meeting of the Group of Experts and also to exchange views and information.

5. Third International Research and Training Seminar on Regional Development Planning for Disaster Prevention, September 1989, Nagoya

The following themes were discussed: flood disaster prevention and mitigation strategies from the viewpoint of information systems; and institutional arrangements for integrating measures against flood disasters into the regional development planning process such as land-use regulations, evaluation of safety in development, regional conservation, and infrastructural equipment.

C. Launching the IDNDR

In 1990, recognized as the first year of the Decade, UNCRD planned and undertook three major projects, namely:

1. UNCRD-CIRDAP Workshop on Integrated Approach to Disaster Management and Regional Development Planning with People's Participation

The main aim of the workshop, held in January-February 1990 at Dhaka, Bangladesh, was to emphasize the inclusion of disaster management and community participation in development planning and to assist the developing countries of Asia and the Pacific region in human resource development through research and training in order to achieve that goal.

2. IDNDR International Conference 1990 Japan, September-October 1990, Yokohama and Kagoshima

With UNCRD serving as a co-organizer together with the central and local governments of Japan, eminent experts on disaster prevention/regional development were invited from all over the world. Those experts contributed greatly to the conference through nine presentation sessions and two summarizing and concluding sessions. Numerous presentations and active discussions took place regarding disaster management and regional development. For example, at the session on "Regional Development for the Creation of a Hazard Resilient Society," two important issues were pointed out; one was the improvement of technology for the development of accurate hazard maps and the formulation of land-use planning based on such maps; another was how to make legislation regarding these hazard maps and how and what organization should implement them. Following these excellent presentations and meaningful discussions, the conference adopted fifteen tasks in its recommendations.

3. Fourth International Research and Training Seminar on Regional Development Planning for Disaster Prevention, October 1990, Nagoya

A debate among international experts and an Open-Forum were scheduled during this seminar. In the first part of the programme, eight papers were presented and discussed under the theme of "Socio-economic Impacts of Disasters. " UNCRD was particularly interested in clarifying the structure of damage development in order to assess disaster risk appropriately including the accurate prediction of indirect damage, and to minimize effects of direct damage and prevent economic repercussions and social unrest in the aftermath of a major disaster. To this end, four experts from the United States reported on their studies related to the Loma Prieta earthquake from the aspects of post-disaster living conditions, transportation network, economic impact on small business and the insurance industry's response, and four experts from Latin America and Japan presented their experiences and studies on disaster effects in the reconstruction process.

D. Contribution to the IDNDR

A detailed plan of the priorities for IDNDR action is expected to be presented by the Scientific and Technical Committee (STC) which is scheduled to be held in 1991. Consequently, UNCRD may have to rearrange its future programme in accordance with the direction of the STC. In the present situation, however, it is believed that the following proposed projects will be able to contribute to the IDNDR:

1. Series of workshops and seminars for training modules on disaster management in rural areas.

During 20-24 January 1991, a seminar titled "UNCRD-CIRDAP Country Seminar on Development of Modules for Training on Integrated Approach to Rural Development and Disaster Management in Bangladesh," was held in Dhaka. Experts from Bangladesh and overseas, together with participants from local areas, were involved in the presentations and discussions on: rural development planning approach; integrated rural development and disaster management; people's participation in disaster management

and rural development; and training on an integrated approach to rural development and disaster management.

This seminar, focused on issues related to Bangladesh, was organized as a case study follow up of the 1990 workshop where international experiences were presented and discussed. For the next step of this project, workshops for collecting information from the entire region of Asia and the Pacific and training seminars on specific issues will be combined into one integrated programme, and implemented in November 1991 and November 1992. Following this programme, in 1993 an expert group meeting will be held to finalize training modules on rural development and disaster management.

2. Training programme on the development of light-weight construction technology for housing in disaster-prone areas, 1991, Japan

To reduce the damage from earthquakes in developing countries, it is essential to improve conventional housing construction methods. In particular, in North Africa, most of Latin America, and the climatically dry zones of Asia, heavy materials such as stone, brick or dried mud block are popular for constructing traditional houses in masonry, adobe or similar construction. The effectiveness of light-weight construction in reduction of damages caused by earthquakes was obvious when a comparison of the June 1990 earthquake in Iran and the July 1990 earthquake in the Philippines was made. In the former case, more than 20 000 people died because of destruction caused by heavy weight structures, while in the latter case less than 2 000 deaths were sustained due to the popularity of wooden construction. In this connection, UNCRD has decided to assist researchers in development of an adequate light-weight construction methodology suitable to given economic, climatic and seismic environments. Through the above training programme, they will have the chance to have discussions on this subject with Japanese experts in the academic, practical and administrative fields.

3. Workshops and seminars in the Latin American Region on disaster prevention and regional development, 1991-93, Peru

Most of the countries in the Latin American region are vulnerable to major earthquakes, and their economic difficulties prevent them from applying advanced technology for reduction of damages. Accordingly, the major objective of this project is to establish a way for incorporating disaster reduction with advanced technology and regional development. This project will be organized in collaboration with the Peru-Japan Centre for Seismic Investigation and Disaster Mitigation (CISMID) established in Lima with the assistance of the Japan International Cooperation Agency (JICA).

4. Fifth International Research and Training Seminar on Regional Development Planning for Disaster Prevention, 1991, Nagoya

This is an annual programme organized by the Disaster Prevention Unit of UNCRD. The main topic of the seminar has not yet been decided on, but one proposal is for recent major earthquakes to be compared with the Nohbi earthquake which occurred in the Nagoya region of Japan 100 years ago. This seminar will be included in the commemoration programme of the twentieth anniversary of UNCRD which is planned for November 1991.

5. Training Programme on Earthquake Engineering and Disaster Management for Establishing Building Administration System in the Philippines, 1991-92, Japan, Philippines

This is a strategic assistance programme proposed in response to the earthquake which struck Luzon island of the Philippines in July 1990. The Philippines' current administration system for building regulations, inspection and related standards, needs to be revised and improved in order to prevent a repetition of the great catastrophe. To respond to this necessity and introduce advanced building technologies into the reconstruction process in the Philippines, UNCRD is planning to organize a training programme consisting of two courses: an eight-week course in Japan and a one-week course in the Philippines which will be organized for broader dissemination of knowledge on the subject. The trainees of the first course will be senior-level engineers, in principle, and they will act as the trainers in the second course, planned mainly for administrators.

E. Conclusions

1. Priorities of UNCRD's Activity for Disaster Reduction

Upon examination of the above-mentioned past experiences and future plans, it may be clearly stated that the activities of UNCRD have been and will be based on the priorities of:

(a) Exchanging knowledge and experiences among regions suffering from similar types of disasters:

- Water-related disasters are a common subject to be discussed among most countries of the world, particularly in Asia with its dense population in flood-prone areas.

- A number of areas in the world need to share their local experiences with each other regarding major earthquakes; information exchange within a region is also significantly important, such as in the Latin American region.

(b) Encouraging undertaking of research work on the vulnerability of metropolitan areas to major disasters:

- Risk of earthquake damage in so-called "megacities" should be highlighted.
- Special attention should be given to the relation between urban area expansion and increase in vulnerability;

(c) Supporting studies to clarify the socio-economic effects of major disasters in various types of regions:

- A relevant model of socio-economic impacts that can be used in assessing how a disaster might hamper economic development to provide the required information on ranking of disaster-prone areas;
- Knowledge about the structure of damage development will facilitate finding a way for damage control, and prevent a domino effect, whereby damage leads to even further damage indirectly.

(d) Assisting the establishment/enforcement of an administrative and institutional system for disaster management:

- A disaster-prone country/municipality shall have specific law/standards to assure the effective response of administrative organizations to a sudden disaster:
- Appropriate criteria for structural design and disaster preparedness shall be provided according to seismic maps indicating macro/micro zonation;
- Existing building/structural codes shall be reviewed and revised on the basis of disaster experiences in the entire world.

2. International Cooperation in the Decade

The objective of the IDNDR, recognized as achieving a less hazardous world, requires international cooperation in various ways. Among them, the following are of great importance:

(a) To ensure an international network for disaster information by establishing research organizations and increasing research functions in developing countries, and encouraging the international exchange of human resources and experiences;

(b) To establish a disaster observation and early warning system at the international level, in particular for cyclones and typhoons;

(c) To realize an international management system for major rivers flowing through two or more countries in order to mitigate flood disaster and promote the development of the areas concerned.

(d) To formulate an international standard for identifying areas vulnerable to earthquakes and a universal code and criteria for structural design in those areas.

In recognition of these needs, through an integrated approach towards disaster management and regional development, UNCRD wishes to contribute to the IDNDR by providing opportunities for information exchange at the national, regional, and international levels, assisting in related research work for less developed countries, and formulating training programmes for key persons in the related activities of those countries.

VI. IDNDR PROMOTION IN JAPAN AND THE RESULTS OF INTERNATIONAL CONFERENCE 1990 JAPAN

by Motasuke Tanaka[1] and Tadashi Itoh[2]

A. History of natural disaster reduction in Japan

Japan has been hit by various disasters in the past, typhoons, heavy rainfall, snowfall, earthquakes, volcanic eruptions and tsunamis, and has lost numerous lives and sustained great losses to property. As a result of those bitter experiences, Japan has developed its disaster prevention measures. In the last 30 years, Japan has exerted much effort in disaster reduction, and in recent years the total number of deaths and missing persons due to disasters has been less than 100 per year. Japan has achieved great success compared to the past decades (figure XI).

It is through these experiences and successes in disaster prevention and reduction that Japan came to believe that natural disaster prevention or reduction can be achieved by taking appropriate preventive measures and also recognized the importance of international cooperation for natural disaster reduction. So when the idea of the IDNDR was first proposed, Japan firmly supported it.

B. IDNDR promotion system in Japan

When the idea of IDNDR was first proposed in Japan, the scientists engaged in natural disaster research strongly supported it, and the Japanese Government also recognized its significance, and in 1987 the National Land Agency became the centre of promotion of the idea in the Government.

In May 1989, the Government headquarters for the IDNDR was formed in the National Land Agency by Cabinet decision, with the Prime Minister as its President. The purpose of setting up the headquarters was to ensure close coordination between the related governmental organizations regarding the IDNDR, and also for comprehensive and effective promotion of the Decade. The headquarters would formulate, coordinate and implement the programme of governmental activities to be undertaken within the framework of the Decade. A new organization, the IDNDR Promotion Office, was established in the Disaster Prevention Bureau to function as the secretariat for the headquarters. That office is in charge of planning and coordinating the promotion activities and also acts as the information centre for local governments and the private sector.

In November 1989, the headquarters declared "The Basic Promotion Policy for the IDNDR" (see appendix). According to this Basic Policy, the promotion activities were divided into three major fields, namely: international cooperation and exchanges; promotion of disaster prevention measures in Japan; and promotion, popularization and public relations activities. Based on this policy, various projects for the IDNDR in the national Government were initiated. Local governments and other public organizations were also called upon to participate in the Government activities.

On the other hand, in August 1990 the members of the Japan Science Council called on the academic and industrial sectors, the Japan Red Cross Society and the mass media to join in the promotion of the Decade, and the Japan National Committee for the IDNDR was formed. The Government headquarters and the National Committee are now working together to promote various projects.

C. IDNDR promotion activities in Japan

The publicity for the Decade had already started in 1989. Using the mass media such as television, radio, newspapers and magazines and also by publishing pamphlets and posters, the public was informed about the IDNDR and was made aware of the importance of international cooperation for disaster reduction. Also efforts have been made to raise public awareness towards natural disaster reduction and the public disaster preparedness. The Prime Minister called the attention of the public to the Decade in his New Year's Messages of January 1990 and January 1991. Promotion slogan contests for the IDNDR have been organized, and IDNDR commemorative postage stamps were issued. An IDNDR commemoration ceremony was held on 27 September 1990.

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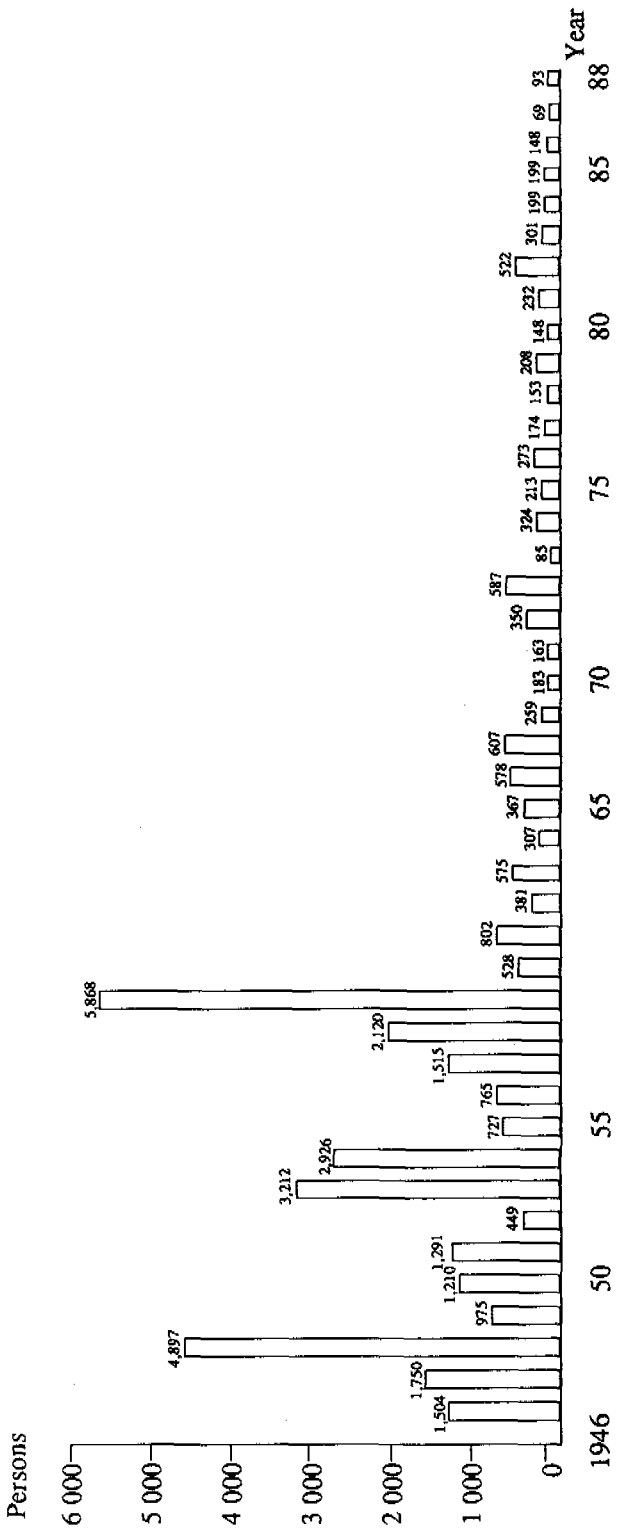

Figure XI. Chronology of death toll, and missing persons caused by natural disasters in Japan

For promotion of disaster prevention measures in Japan, previous prevention, preparedness and emergency relief measures are being reinforced. Also some new tasks are being identified as disaster prevention measures in Japan. The involvement of private companies in disaster prevention activities and the active involvement of volunteers in disaster preparedness and relief activities are some examples.

As for international cooperation and exchange, new programmes are being initiated. It is thought that it is important to transfer Japan's organizational and technical know-how experiences to those countries facing difficulties coping with natural disasters. Seminars have been organized in order to introduce the organizational arrangements and other technical know-how to the developing countries and to assist in training of experts in these countries. A Seminar on Administration for Disaster Prevention was recently organized by the National Land Agency and JICA for this purpose. Also video-films, display panels and other teaching aids for disaster prevention education in Japan and in developing countries are being prepared. This material will be available by mid-1991. Also important are exchange of experiences and knowledge among the different countries and raising awareness among policy makers of the necessity of disaster prevention. Holding international conferences and symposiums are some of the effective measures for this purpose.

D. Results of "IDNDR International Conference 1990 Japan"

From 27 September to 3 October 1990, the "IDNDR International Conference 1990 Japan" was jointly organized by the Japanese Government Headquarters, the Japan National Committee for the IDNDR, the City of Yokohama, Kagoshima Prefecture and the United Nations Centre for Regional Development (UNCRD).

Senior level policy planners, administrators and researchers, leaders of non-governmental organizations from 43 countries who are engaged in disaster prevention and management and regional development planning, and also representatives of 16 international organizations, including United Nations agencies who are engaged in disaster prevention and management, participated in that conference.

Various topics on natural disaster reduction and international cooperation were discussed. And through these discussions some common basic viewpoints to promote the Decade were identified and 15 major tasks that should be tackled in the Decade activities were outlined.

E. Future plans for the promotion of the Decade

Japan is now making plans for the next fiscal year, and is planning for future promotion activities as well. The common basic viewpoints and the 15 major tasks identified will be the basis for the action programmes.

It is very important to recognize that there are many differences regarding the occurrence of natural disasters and the social aspects of disaster among vulnerable countries. Therefore in the coming fiscal year, it is planned to undertake a basic field survey to determine which part of Japan's disaster prevention and preparedness programme can be easily applicable to some disaster-prone countries. Japan is also ready to send experts upon request. It is planned to hold an international symposium on earthquake disaster prevention and preparedness.

The Japanese Government, with the assistance of relevant organizations, and with an understanding of regional differences, will attempt to transfer the technology and administrative knowledge on natural disaster reduction to disaster-prone countries through international cooperation and thus contribute to natural disaster reduction in the world.

Appendix. The Basic Policy for promoting activities for the International Decade for Natural Disaster Reduction in Japan

IDNDR Government Headquarters Decision, Government of Japan

Paying due respect to the United Nations General Assembly Resolution on the International Decade for Natural Disaster Reduction (IDNDR), and bearing in mind the various circumstances existing in Japan, the activities for the IDNDR shall be promoted in accordance with the following basic policy:

A. Basic viewpoints with regard to the promotion of the IDNDR

The United Nations, at its 42nd General Assembly, adopted the resolution on the IDNDR to be launched in 1990, with a view to reducing through concerted international actions the adverse effects of natural disasters, such as loss of life, property damage, and social and economic disruption, worldwide, especially in developing countries.

With regard to this objective of the Decade and taking into account the present conditions of Japan's disaster countermeasures as well as international cooperation for disaster prevention, various activities for the IDNDR shall be promoted in accordance with the following basic viewpoints:

(a) Natural disasters are seriously affecting the world, especially in developing countries. On the other hand scientific and technological progress is enabling us to prevent or mitigate adverse effects of natural disasters. These are the recognized in the background of the United Nations resolution. Therefore, Japan's IDNDR Government Headquarters shall further promote international cooperation for the reduction of damage caused by natural disasters throughout the world, especially in developing countries, and raise awareness and deepen understanding of our people towards these issues, and thus consolidate the basis for the support of the promotion of international cooperation in the future.

(b) Japan is situated in a land condition vulnerable to natural disasters, meteorologically, topographically and geologically, and numerous lives and properties have been lost every year by natural disasters. In recent years, the number of people lost and missing by natural disasters has been gradually decreasing, but on the other hand, the effects of disasters are becoming more complex and diversified due to changes in economic and social circumstances, such as urbanization and improved communications. Various disaster countermeasures shall be promoted in order to conserve the national land and protect the lives and properties of the people from such disasters.

B. Promotion activities for the IDNDR

Based on the above-mentioned basic viewpoints, the following measures shall be vigorously carried out:

1. *Promotion of international cooperation* and exchanges

The IDNDR Government Headquarters shall positively participate in and cooperate with various projects planned by the United Nations system and other organizations regarding the IDNDR. At the same time, the IDNDR Government headquarters shall, with a view to contributing to reduction of damage caused by natural disasters, especially in developing countries, engage in the promotion of international cooperation and exchange activities concerning disaster reduction, under long term prospects, mainly in following areas:

(a) Assistance for the improvement and diffusion of science and technology related to natural disaster reduction, training of personnel, and improvement of the counter-disaster systems, through technical cooperation in such areas as training activities, joint research, dispatch of experts, and supply of equipment;

(b) Assistance to projects conducive to the reduction of natural disasters;

(c) Promotion of the transfer of Japan's experience and knowledge, and mutual exchanges of experiences and knowledge of each country holding international conferences, etc.

(d) Enhancement of international emergency relief assistance.

2. Promotion of disaster countermeasures in Japan

In order to ensure that all the people will be able to live safely, disaster countermeasures shall be promoted mainly in the following fields of activities:

(a) Promotion of scientific and technological research in disaster prevention;

(b) Enlargement and reinforcement of disaster prevention systems, and development and improvement of disaster prevention facilities and equipment;

(c) Promotion of various projects for national land conservation;

(d) Proper guidance of land use for a safe environment, and promotion of various measures towards realization of multipolar decentralized national land structure; and

(e) Strengthening of disaster emergency and recovery measures.

3. Promotion of popularization and public relations activities

In addition to the activities stated above, in accordance with the objectives of the IDNDR to disseminate the knowledge on disaster prevention and to raise the public awareness towards disaster prevention, various public relations activities such as exhibitions and lectures shall be implemented, commemoration ceremonies and issuance of commemorative stamps shall be promoted.

C. Methods to promote activities for the IDNDR

Comprehensive and effective promotion of the above-mentioned activities shall be achieved through a close collaboration among all relevant administrative organs. In order to widely acquaint the public with the purpose of this movement, as well as to raise nation-wide interest, it is necessary to promote activities with close collaboration between governmental organs, local governments and private organizations. It is expected that those organs and organizations will vigorously implement activities in accordance with the objectives of the IDNDR.

VII. THE ROLE OF ESCAP IN NATURAL DISASTER REDUCTION IN ASIA AND THE PACIFIC

A. Introduction

The Economic and Social Commission for Asia and the Pacific (originally the Economic Commission for Asia and the Far East) was founded in 1947 as the regional arm of the United Nations Economic and Social Council covering Asia and the Pacific. The membership currently is more than 40 countries and territories in an area stretching from the Islamic Republic of Iran in the west to the Cook Islands in the Pacific Ocean in the east. The population of the region is about 3 billion, with 45 million more being added every year.

Many of the Asian and Pacific developing countries are situated in the world's hazard belts of earthquakes, windstorms, tidal waves, floods and drought.

The climate, topography, geology and demography within the Asian and Pacific region vary considerable, as do the different problems, including natural disasters, faced in various parts of the region. The major natural disasters faced periodically by the peoples of the ESCAP region are largely due to climatic and seismic factors. Heavy precipitation and resulting floods, storm surges and earthquakes are the natural disasters which cause the most destruction of human lives and property, and in some countries affect the national economy significantly. In addition, tsunamis, landslides and volcanic eruptions are known to have affected certain areas of the region in varying degrees at different times. By some estimates, 85 per cent of the more than 4 million deaths from sudden natural disasters in the world in the period 1900-1990 occurred in Asia and the south-west Pacific. For the same period, windstorms and floods worldwide accounted for almost 50 per cent of the nearly $US100 billion total damage.

The frequency and intensity of adverse natural phenomena and the extensiveness and severity of the damage they cause seem to be increasing over time. Disastrous natural events struck the region again in 1988, 1989 and 1990 even before the full consequences of the adverse weather effects on the economies of the region in 1987 could be fully overcome. In that year, floods and drought had affected the agricultural production of virtually the whole developing ESCAP region. Similar events occurred in 1988, in 1989 and in 1990. In addition there were severe cyclones and storm surges and strong earthquakes in a number of countries, causing a significant loss of lives and damage to property.

Losses due to natural disasters deprive developing countries of resources with could otherwise be used for economic and social development, thus further impeding their development process.

In recognition of the importance of this universal issue, the United Nations General Assembly, in its resolution 42/169 of 11 December 1987, designated the 1990s as the International Decade on Natural Disaster Reduction, during which the international community, under the auspices of the United Nations, would pay special attention to fostering international cooperation in the field of natural disaster reduction. The resolution, moreover, called on the regional commissions to play an active role in implementation of Decade activities. Therefore the Economic and Social Commission for Asia and the Pacific at its forty-fifth session, adopted resolution 45/5 on fulfilling the objectives of the Decade, and consequently ESCAP has formed a multidivisional multisectoral task force for the Decade to promote and support cooperative efforts for attaining the objectives of the Decade. The task force has held several sessions since its formation and has reviewed and coordinated the work of the secretariat on natural disaster reduction.

B. Recent Activities of ESCAP on Natural Disaster Reduction

1. Reduction of water-related disasters

The Commission, since its ECAFE days, through its Bureau of Flood Control and Water Resources Development of the time, which was subsequently incorporated into the Natural Resources Division as the Water Resources Section, continues to be involved in promoting and enhancing cooperative efforts in the Asia and Pacific region to mitigate damage from typhoons/cyclones, floods and droughts. In addition, support has consistently been provided to the ESCAP/WMO Typhoon Committee and the WMO/ESCAP Panel on Tropical Cyclones, two regional intergovernmental bodies, since their inception.

The past Medium-Term Plan of work of the Water Resources Section of ESCAP (1984-1989) included a programme element on "Mitigation of damage from cyclones, floods and drought" which has continued during the current Medium Term Plan period.

Aiming at reduction of flooding and rational development and utilization of land and water resources, a manual and guidelines for flood risk analysis and mapping was prepared and finalized in an expert group meeting in 1988. The manual and guidelines have been published and widely distributed.

ESCAP has recently prepared a study on problems caused by natural disasters in selected least developed countries and developing island countries of the region, and long-term effective measures to mitigate the effects of disasters was published as part of the Water Resources Series. Work on phase I of the urban flood loss prevention project was completed by fielding missions to eight major cities in the region and holding a workshop. The proceedings of the project are being published as part of the Water Resources Series.

A manual and guidelines for comprehensive flood loss prevention, also closely related to development and utilization of natural resources, has been finalized and is currently under publication. Advisory missions and seminars are being organized in concerned member countries in order to disseminate the techniques presented in the manual and guidelines.

A project entitled "Promotion of measures for reduction of water-related disasters in Asia and the Pacific through research, training and advisory services-Phase I" was included in the programme of work related to water resources for the biennium 1990-1991. In addition to the present Symposium, another project on "Assessment of current preparedness programmes, forecasting systems and operational methods for water-related natural disaster reduction in the ESCAP region" is scheduled to be held in Bangkok from 29 April to 3 May 1991. Advisory missions will be sent to countries wishing to introduce or enhance the preparedness programmes, based on the recommendations of the workshop.

Future activities in water-related natural disaster reduction include a proposed workshop to develop guidelines for the application of cyclonic storm hydrology in natural disaster reduction in the region.

In the draft Work Programme of the Water Resources Section for the 1992-1993 biennium, the subject of natural disaster reduction was assigned the highest priority. Starting in 1992, it is proposed that two new projects be introduced. The first involves integrated river system development and management, with reference to comprehensive flood loss prevention and management. The second relates to storm surge risk mapping and analysis.

The future activities of ESCAP, within the context of the International Decade for Natural Disaster Reduction, are planned to include provision of assistance to member States in various aspects of reduction of water-related natural disasters.

2. Reduction of drought impacts

Since 1984 the Agriculture and Rural Development Division of ESCAP has been executing the agro-climatic assessment programme in eight developing ESCAP member countries. The project was designed to develop national capabilities to predict crop failures/food shortages caused by the impact of drought. Later, in 1989 remote sensing technology had been incorporated into the crop assessment systems. This new phase of the programme, the satellite crop monitoring project, has been implemented initially in Indonesia, Malaysia, the Philippines and Thailand on a pilot basis.

A Regional Evaluation Seminar on Satellite Crop Monitoring was held at Bangkok in November 1990 to assess the usefulness and efficacy of the satellite crop monitoring project. The Seminar recommended that the project should be continued in the future and the upcoming phase, if funding could be obtained (estimated US$1.45 million), would include Bangladesh, China, Nepal, Sri Lanka and Viet Nam which have expressed an interest in joining the project.

3. Reduction of geologic disasters

The ESCAP Mineral Resources Section has been involved in various disaster reduction activities through the programme entitled "Geology for Urban Development", since 1985. Studies were carried out in a number of cities affected by seismic risk, subsidence, groundwater contamination, highly compressive soils and karst collapse. There meetings were organized within the urban geology programme: (a) Expert Working Group meeting cum Workshop on the Urban Geology of Coastal Areas (Shanghai, October 1987); (b) Seminar on Geological Mapping in the Urban Environment (Bangkok, October 1986); and (c) Meeting on Quaternary Geosciences and Human Survival (Bangkok, November 1988, in cooperation with UNESCO).

ESCAP activities have included a systematic survey of the urban geology of more than 77 areas in 20 countries over the period 1987 to 1990. These studies have been published in an Atlas of Urban Geology series, the most recent volume of which was on Geology for Land-Use Planning in Asia issued in late 1990. These studies noted that large cities in Asia have spread into areas in which geologic conditions are unsuitable for various land uses. As a result of the ESCAP programme, planners and geologists have worked together to develop a series of thematic

maps that would be useful for land-use planning. These maps show areas affected by both man-made and natural hazards.

Other activities included the provision of in-house training in urban geology and the mapping of large cities in a number of countries. More recently, these studies have focused on mitigation of seismic risk in Indonesia, subsidence in Hanoi, Viet Nam, and assessment of earthquake damage resulting from the 16 July 1990 earthquake in the Philippines. A series of meetings have also reviewed the impact of man on Quaternary environments and were especially concerned with the mapping and correlation of Quaternary stratigraphy in the region. These latter activities are jointly orgainzed by ESCAP and UNESCO as part of International Geological Correlation Programme Project 296, Quaternary geology of the Asia/Pacific region. ESCAP arranged a Seminar on Geology and Land-Use Planning, in Kuching, Malaysia and two workshops on Quaternary Geology of the Asia-Pacific region in Malaysia and Thailand in 1989 and 1990 respectively. A Course on Assessment and Evaluation of Construction Materials for Urban Development was orgainzed in Kuala Lumpur, Malaysia in 1990.

ESCAP continues to provide assistance to the Member States on mitigation of earthquakes, volcanic eruptions, landslides as well as various other types of natural disasters.

The ESCAP Human Settlement Unit undertook research on disaster mitigation policy measures and published a "Study on human settlement planning in disaster-prone areas with focus on management of marginal settlements" in 1987. The study reviewed current policies and practices for disaster mitigation by member countries, in particular, through land-use planning, building design and codes and training programmes.

In future, the Unit will organize seminar/workshops to exchange the experiences and knowledge on disaster mitigation measures.

4. Natural disaster monitoring and warning

The ESCAP/UNDP Regional Remote Sensing Programme, in order to promote operational uses of remote sensing and Global Information Systems (GIS) in natural disaster reduction, for better development and utilization of land and water resources, organized a workshop on the application of remote sensing to flood plain mapping and monitoring in Dhaka, Bangladesh in December 1989.

A pilot project on flood mapping and flood monitoring using remote sensing and GIS technologies has been completed jointly by Bangladesh and Chinese experts through the TCDC arrangements under the co-ordination of the ESCAP/UNDP RRSP. A methodology for flood plain mapping and monitoring using integrated remote sensing and GIS technologies has been developed and will be tested in Bangladesh in 1991.

In cooperation with the Outer Space Affairs Division of the United Nations and the Government of China, the Regional Remote Sensing Programme is also organizing a workshop on application of space techniques to combat natural disasters, to be held in September 1991. The seminar will emphasize operational methodology for disaster monitoring and forecasting through remote sensing and GIS technologies.

In its next phase from 1992 to 1996, the Regional Remote Sensing Programme will lay special emphasis on promotion of the member countries's capabilities in using the GIS technology as well as microwave technology, such as synthetic aperture side-looking radar and high resolution satellite data for disaster monitoring and assessment. Priority will be given to the least developed countries to transfer low-cost, microcomputer-based image processing and GIS technologies for operational uses in disaster management.

The Environment Section of ESCAP organized a Ministerial-Level Conference on Environment and Development in Asia and the Pacific from 10 to 16 October 1990 at Bangkok. Regional co-operation in the disaster warning measures and in the field of coastal area resources development and management was on the agenda of the Conference, which identified the directions of technology transfer and recommended the establishment of an international centre on early detection and warning of approaching cyclones. The Ministerial Declaration also welcomed the establishment of institutes/centres for research, training, and policy formulation related environment and development, activities with a view to promoting exchange of information, technical assistance and regional co-operation. In fulfilling the objectives of such centres, ESCAP should play an important role.

VIII. IMPACT OF NATURAL DISASTERS ON THE LEAST DEVELOPED AND ISLAND COUNTRIES OF THE ESCAP REGION

A. Problems

Natural environment is the most critical factor in the life and livelihood of the people in developing countries in general and the least development countries, in particular. It is their most important resource and endowment. Even at the best of times, the people in the least developed countries located in the Himalayan region and in the small islands and atolls, eke out livelihood from highly fragile soils and vegetation. The ecological systems in least developed countries—the rich diversity of plants, animals and bird life, the swamps, the marshes, the little streams—are fast vanishing. Growth of population has doubled in the last three decades. Traditional practices cannot cope with new emerging situations. Rains, droughts and floods have become an established pattern.

The forest cover is being depleted at a fast pace; the soil is being degraded from over-cultivation and over-grazing, and water is getting scarcer than ever before. Agricultural productivity is therefore seriously threatened. The livestock industry has declined due to degradation of pastoral fields in these countries.

Over 80 per cent of the energy supply of the people is met by fuelwood which is obtained primarily from the forests and jungles around their villages and nearby hills. Now in almost all these countries, fuelwood has become scarce. The fragile soils especially of the upper Himalayas are being washed away down the rivers. Global warming, the depletion of the ozone layer, the greenhouse effect and industrial pollution are a more immediate and urgent concern for these countries.

Almost all the least developed countries are characterized by at least one of the following types of geophysical handicap: aridity, mountainous topography or atoll structure. The mountainous least developed countries of Asia, namely Afghanistan, Bhutan and Nepal, face similar obstacles to development. With growing populations making increasing demands on the environment, there is a massive deforestation going on in these areas, and conditions of cultivation are getting worse, as soil is washed away from the slopes. The broken terrain imposes high costs on communication, and divides the population into small isolated communities which are costly to equip with infrastructure and social services.

The scope for the land-based agriculture on small island countries in the Pacific region is also extremely limited, since the natural soil consists of coral sand containing more or less no organic matter. Furthermore, the very small areas of continuous land and the shortage of fresh water impose severe limits on the development of urban concentrations.

Rising demands for food, water, land, fuelwood and other natural resources have further aggravated the precarious environmental balance in many of these countries during the 1980s. The United Nations Conference on Trade and Development (UNCTAD) has identified the problems which have become worse are as follows:[1]

(1) Depletion of forests. Forests occupy only 21 per cent of the land area of least development countries compared to the 30 per cent average for developing countries. These forests are being depleted at a rate of 0.6 per cent per annum. In a number of these countries the rate of destruction is much higher, ranging from 2 to 4 per cent a year.

(2) Soil degradation. The loss of vegetative cover, through pressure of population on land, exposes the soil to wind and rain.

(3) Water scarcity. Lakes, swamps, rivers and coastal waters are increasingly polluted. The capacity of fresh water to replenish its supplies is now under threat in several least developed and island countries.

(4) Extinction of biological resources and diversity. Wild plants and animals are also a source of food for poor people, apart from their scientific and ecological value.

The least developed countries are also increasingly being exposed to environmental damages caused mainly by industrial activities elsewhere. The phenomenon of global warming is of particular concern to many of these countries, since the predicted change in climate would aggravate the problems which already beset their ecology.

[1] UNCTAD, The Least Developed Countries 1989 Report, Geneva.

The effect of diminished rainfall in arid least developed countries is obvious. If rainfall increases in wetter areas, erosion on the deforested slopes of mountainous least developed countries is likely to be aggravated, as is flooding in the lower reaches of rivers. A rise in the sea level would also threaten the very existence of least developed atoll countries in the Pacific region, as well as the densely populated low lying area of Bangladesh.

The least developed and island developing countries of the ESCAP region have been adversely affected by various environmental phenomena. In Bangladesh, monsoon floods reportedly destroyed 2 million tons of rice during the 1986/87 harvest. The country was again severely hit by a devastating flood in 1988. Apart from the tragic loss of life and property, crops on about 4 million hectares of land were destroyed and on a further 3.2 million hectares damaged. The total loss of foodgrain output was estimated at 2-2.5 million tons, equivalent to 12-15 per cent of the normal output. About 25 million people were made homeless and several hundred deaths were reported. In addition, the flood inflicted extensive damage to livestock and fisheries, and infrastructure. Hundreds of kilometres of roads and flood embankments and hundreds of schools and forestry buildings were damaged. The total cost of reconstruction and rehabilitation of physical and social infrastructure was estimated to be around 4.4 per cent of the country's GDP. As a result, the Government was prompted to declare state of emergency in the country. Again in early 1989, the country suffered from a prolonged drought.[2]

The rapid pace of development in the 1980s has exposed the Maldives to new environmental problems such as the destruction of reefs through coral mining (leading to increased wave damage to the shore), deforestation, waste disposal questions, the depletion of water supplies, and inadequate sanitation (especially on the atolls). An additional source of concern is the appearance of a crack in the substructure of Male island.[3] Moreover, a tidal wave inundated Male and the adjacent islands in April 1987. It was the first tidal wave in the recent history of the country, and it destroyed much of the reclaimed land area on Male Island, and damaged the Male International Airport as well. High waves in subsequent months also affected other islands. According to some environmentalists, the Maldives and other countries lying close to sea level are threatened by the rise in its level due to melting of the polar ice-cap because of the long-term "greenhouse effect" of the earth's increasing temperature.

In late August 1988, a severe earthquake struck eastern and central Nepal. Twenty-seven districts of the country were affected. Several hundred persons were killed and many more seriously injured. Private property, cattle and infrastructure, including highways, bridges, schools, and hospitals, suffered considerable damage estimated at NRs 2 000 million. As many as 20 000 homes were destroyed. Hillside erosion and subsequent mudslides and floods exacerbated the earthquake impact and increased the death toll further.

Many of the Pacific islands lie in the track of hurricanes, typhoons and cyclones and have been struck repeatedly in recent years. Vanuatu, for example, sustained considerable damage from cyclones in three consecutive years. Of these, cyclone Uma (February 1987) was the most destructive, killing at least several dozen people, leaving thousands homeless, and destroying infrastructure and housing in the central and southern areas of Vanuatu and the capital city, Port Vila. In parts of Tanna Island, farmers lost their subsistence crops. Since the island economy is based on agriculture, the impact of each cyclone was most extensive and visible on that sector. Copra production fell by 80 per cent in the affected areas. Subsistence gardens were devastated, depriving households of vegetables, tubers and fruit.

B. Past experiences and measures

Disaster preparedness has assumed greater importance in least developed and island countries, calling for the total mobilization of national effort. In this regard, action taken includes the build-up of adequate foodgrain reserves and their stocking in remote areas of the country, the mobilization of the armed forces and civil administration in relief operation, the formation of teams to provide basic medical services, and the involvement of NGOs and social organizations in relief operations. At the same time, high priority is being given to forestry conservation and management in a number of the least developed countries of the region.

The creation of the Natural Disaster Preparedness Council in Bangladesh after the devastating flood of 1988 is a step towards disaster preparedness. The Government announced measures to strengthen existing programmes for forestry development and the protection of the environment. Currently only about 10 per cent of the total land area of the country is covered by forests, compared with 24 per cent in 1947. According to an estimate, it is necessary

[2] ESCAP, Economic and Social Survey, 1988.

[3] United Nations Conference on the Least Developed Countries: Maldives 1990 (UNLDC II/CP.29).

for the ecological balance of a country to have 25 per cent of the total area under forest. The existing 20 point programme gives priority to the protection and preservation of the environment.[4]

Although soil erosion in Bhutan is not yet a serious problem, there is moderate to severe erosion in eastern Bhutan and in the Punakha-Wangdi area. The resulting land degradation has given rise to loss of productivity. The effect of over-grazing is the major cause of erosion, as large parts of the country, whether in designated grazing areas or forests, are subject to over-grazing by livestock. Landslides are quite common along roads and irrigation canals. The existence of shifting cultivation particularly in the eastern part of Bhutan, illegal encroachment and clearing of forests are among the major problems in the country at present.

Programmes of afforestation, social forestry and land terracing have been undertaken in an effort to reduce the danger of environmental damage that can arise out of population growth and increase in the number of livestock. Efforts are also being made to find alternatives to shifting cultivation. Rigorous rules against felling of trees and encroachment on forest land exist. Roughly 20 per cent of forest land has been reserved for parks and sanctuaries to protect flora and fauna.

However, further efforts will be needed, in areas such as soil conservation, river training and screening of projects for their environmental impact. The Government has established a Coordinating Body to implement the National Environment Conservation Strategy (NECS). In this regard, an "Endowment Fund" of $US 100 million is proposed to be set up with financial assistance from the bilateral and multilateral donors.[5]

Nepal has initiated plans to address the environmental and other related problems in a concerted and integrated fashion through the formulation of an Environmental Action Plan for implementation in the 1990s. The Action Plan will also assess environmental problems as well as identify appropriate measures for dealing with them and monitor their results from time to time.

C. Policy considerations for the 1990s

During the 1980s, least developed countries became more aware both of the environmental risks they were facing and of the economic and social benefits of environmental protection and sound policies for improving the natural environment. Environmental aspects are increasingly being reflected in national development plans, although in view of the costs involved, specific programmes and measures have been slow to emerge. These developments need to be strengthened in the 1990s to protect the environment from further decline in the decade ahead.

The protection and improvement of the natural environment will require several categories of measures: education and mobilization of the entire population, in both rural and urban areas, aimed at enhancing awareness of the economic benefits of environmental protection; economic incentives to motivate better environmental management, and higher efficiency of energy use; linking programmes of social development, including poverty alleviation and participation of economically disadvantaged groups, to programmes of environmental improvement and management; and programmes aimed at both preserving the environment and meeting the specific concerns of women, such as energy-efficient technologies for cooking.

To this end, there is a need to build up least developed countries' capacities to identify environmental problems, assess mutual links between development and environmental trends and prepare national environment management plans. The latter should aim at providing sustainable solutions to the specific ecological problems faced by least developed countries at the national and/or regional level. Furthermore, in close collaboration with relevant international institutions and bilateral and multilateral donors, the least developed countries should strengthen their early warning and forecasting mechanisms.

As for mitigating the effects of natural disasters, the least developed countries should improve their capacity to identify the most probable future disaster scenarios, to establish appropriate protective measures and contingency plans, and to ensure that local community leaders and the population in general know how and when to apply these measures. While disaster mitigation activities should be integrated into new development projects from their inception, disaster assistance should be designed to help bring about development activities in affected areas, rather than merely to restore the status quo ante.

Natural disaster has now become an issue of global concern. Over the past two decades, natural disasters have claimed about 3 million lives globally, and adversely affected the lives of 800 million people. Immediate damage has been estimated to exceed $23 billion. In many of the above instances the natural disasters are thought to

[4] (EIU) Country Report No. 3. 1990 (Bangladesh), p.16.
[5] United Nations Conference on the Least Developed Countries: Bhutan 1990 (UNCLDC II/CP. 20), p. 25.

have a common cause: environmental degradation including deforestation and the so-called "greenhouse" effect, caused by the long-term rise in the earth's average temperature due to large-scale burning of fossil fuels and damage to the ozone layers of the stratosphere.

The United Nations General Assembly in its resolution 42/169 has designated the 1990s as the International Decade for Natural Disaster Reduction with the objective of improving the capacity of each country to mitigate the effects of natural disasters, paying special attention to: assisting developing countries in the establishment of early warning systems; fostering scientific and engineering research aimed at closing critical gaps in knowledge, in order to reduce loss to life and property; and promoting programmes of technical assistance and technology transfer, demonstration projects, and education and training, tailored to specific hazards and locations.

In pursuance of the United Nations General Assembly Resolution 42/177 of 11 December 1990, the Second United Nations Conference on Least Developed Countries was convened in Paris in September 1990. The Conference reviewed the socio-economic situations in the least developed countries in the 1980s and adopted a comprehensive Programme of Action for the Least Developed Countries for the 1990s. Recognizing that there exists a close linkage between poverty and environmental degradation, the Conference recommended that these twin problems should be tackled simultaneously to provide a basis for long-term sustained growth and development to enhance the capacity of the least development countries to protect the environment. The Programme contains, inter alia, measures and recommendations on environment, and disaster mitigation, preparedness and prevention for implementation at both national and international levels. Relevant paragraphs of the text of the Programme of Action are included in the appendix.

Appendix. Environment and disaster mitigation, preparedness and prevention[1]

1. Environment and development in the least developed countries

While the current threats to the global environment are of common concern to all countries, the LDCs' vulnerability is further exacerbated by a specific set of environmental problems such as soil degradation and erosion, drought and desertification, which impair prospects for their development. These environmental problems are closely linked to a number of complex and interrelated factors: these include poverty, underdevelopment, poverty-linked population pressure placing further demands on the natural resource base in a number of LDCs, a narrow technological base, geographical disadvantages, unregulated industrial operations, as well as the illegal transboundary dumping of hazardous waste and radioactive waste, The twin problems of poverty and environmental degradation have to be tackled simultaneously to provide a basis for long-term sustained growth and sustainable development, which are essential and will enhance the capacity of LDCs to protect the environment. One of the main endeavours by LDCs should be to achieve an optimum balance between human demands and the natural resource base for future generations as well as for the present generation and at the same time to maximize the ability of the environment to meet these demands on a sustainable basis. To achieve these objectives, however, due attention needs to be given to these problems in domestic policy-making and additional resources, both in terms of concessional finance and access to environmentally sound technology, should be channelled to LDCs in accordance with General Assembly resolution 44/228 to assist in avoiding further degradation of the local eco-systems, in overcoming environmental problems crucial for development, in combating the negative impact of global environmental problems, and in implementing the measures listed in the following two paragraphs.

An integrated and multi-disciplinary approach in this regard should cover, inter alia: (i) incentives to motivate better environmental management and to ensure efficiency of energy use, as well as to discourage environmental degradation; (ii) education of the local communities in both urban and rural areas, aimed at enhancing awareness of the economic and social benefits of environmental protection; (iii) developing human resources to deal with environmental problems, as an important component of capacity-building in the LDCs; (iv) addressing the intertwined problems of poverty eradication and improvement and management of the environment in an integrated way; (v) facilitating the access to and the transfer of environmentally sound technology to the least developed countries; and (vi) developing new techniques to rationalize the use of traditional energy resources, and developing low-cost alternative fuel sources, in particular new and renewable sources, which could provide an alternative to the use of fuelwood, thus alleviating pressure on the environment.

Special consideration should be given to LDCs which are prone to drought and desertification. Improved natural resources management and productivity increases in agriculture and livestock on a sustainable ecologically sound basis are needed in order to protect the productive basis of these countries.

There is a need to strengthen human, institutional and technological capacities of LDCs to identify environmental problems, assess the relationship between development and environment trends and prepare national environmental management plans for conservation and protection strategies. Women should be involved in these plans, especially in forest and land management programmes. They should also be involved in the choice and dissemination of appropriate technologies which would facilitate their household and productive activities while respecting the rhythm of renewal of the natural resource base. National early-warning and forecasting mechanisms, included as part of a wider regional effort, should be strengthened. Women should be associated with the establishment of warning systems and follow-up on natural calamities, as well as of programmes aimed at reducing post-harvest losses and food wastage. The United Nations organizations, including UNEP, WMO, and FAO should give priority attention to the LDCs in their programmes and mechanisms relating to the environment.

The United Nations Conference on the Environment and Development, scheduled for 1992, should address, in accordance with its mandate, the environmental and developmental problems of the least developed countries. The

[1] The Programme of Action for the Least Developed Countries for the 1990s adopted by the Second United Nations Conference on Least Developed Countries, held in Paris from 3 to 14 September 1990.

Conference should provide for measures to enable the least developed countries to pursue their efforts to incorporate the environmental dimension into their development objectives and policies. Moreover, the Conference should be an opportunity to renew the international community's commitment to support, technically and financially, major projects designed to avoid the recurrence of natural disasters due to environmental degradation.

Appropriate and adequate international support is also needed to explore possibilities to protect the least developed countries against the effects of new environmentally negative phenomena, such as climate change, marine pollution and the transboundary movement of wastes.

2. Disaster mitigation, preparedness and prevention

Natural and man-made disasters continue to cause heavy losses of human lives and property, with particularly severe and lasting impact on the national economies of the least developed countries. Furthermore, the magnitude of future losses will inevitably increase as population pressure leads to the occupation of even more vulnerable areas. Considerable knowledge exists of techniques for minimizing the impact of disasters that have not yet been systemically applied in the majority of the least developed countries. Each country will need assistance to increase or improve its capacity to identify scenarios, to establish appropriate protective measures and contingency plans, and to ensure that local community leaders and the population in general know how and when to apply these measures. LDCs would continue to undertake measures within their available capacity and with appropriate international cooperation: (i) to alleviate and mitigate the consequences of such disasters; (ii) to limit the extent of their damage; and (iii) to undertake feasible preventive measures. Activities in this regard should be integrated into new development projects.

It would be necessary for LDCs to continue efforts to stimulate among their population in general a clear perception of the benefits of disaster preparedness and prevention. Pilot projects to promote a coherent approach to disaster preparedness, mitigation and prevention should be initiated in the disaster-prone least developed countries, in line with the General Assembly guidelines on the International Decade for Natural Disaster Reduction (IDNDR), with adequate international support. Special attention should be given to women and children because of their vulnerability during disasters. LDCs should receive priority attention in the activities of the IDNDR. In particular, the international community will provide support to Bangladesh, as well as to the project for the establishment of an environment-surveillance mechanism in the Sahara and the Sahel, aimed at the control of desertification in sub-Saharan African.

Several of the LDCs are or have been affected by refugee and migration problems. In view of the adverse impact of the presence of refugees and displaced persons on the socio-economic infrastructure and development process, the international community and competent international organizations should support the LDCs' efforts in facing these problems.

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