plans. The land along a river is highly desirable for parks and recreational uses, as well as for ecological reserves. Supportive infrastructure such as washrooms, picnic facilities and changing rooms can be flood proofed. Private development of conforming uses such as golf courses can also be considered. The important point here is to integrate the land-use planning for flood-prone lands into the broader plans for the urban and surrounding area.

Zoning of flood-prone lands

The best way to reduce future flood damages is to prevent development from occurring on flood-prone lands. Zoning of such lands is an effective approach, but generally should be coupled with the broader land-use planning mentioned above so that the land has a defined use.

Zoning can be used to reduce damages from flooding and be flexible enough to recognize that other forms of land use are compatible. An example is agricultural use of lands in flood-prone areas where water velocities are low enough not to cause serious erosion. Flood-prone lands can continue to be used for agricultural purposes, particularly in countries where the amount of agricultural land is limited and self-sufficiency in food supply is a national goal. It is important, however, to ensure that the supporting infrastructure such as buildings and houses are located away from the flood-prone area or are flood proofed. It is also important that livestock, machinery or stored crops can be evacuated quickly from the area in the event of a flood. This underscores the importance of a flood forecast, warning and response system.

Zoning of flood-prone lands as ecological reserves or protected wetlands can often help to meet broader environmental or biodiversity goals. In addition, such lands often play an important role in sustaining the fishery, and they can also act as temporary storage and infiltration areas. Riparian buffer strips also reduce the movement of agricultural chemicals and nutrients into the aquatic system.

Redevelopment of flood-prone areas

A major flood disaster is sometimes an opportunity to correct the planning errors of the past. Removal of flood-prone development and conversion of the land to a conforming use is an option to consider. It may be less expensive in the long run to physically relocate flood-prone development, buy it out as part of a disaster assistance programme, or include its purchase in long term planning. The success of the latter approach can be enhanced by measures such as prohibiting improvements not required for health and safety, placing caveats on the land title, and by obtaining rights of first refusal on resale.

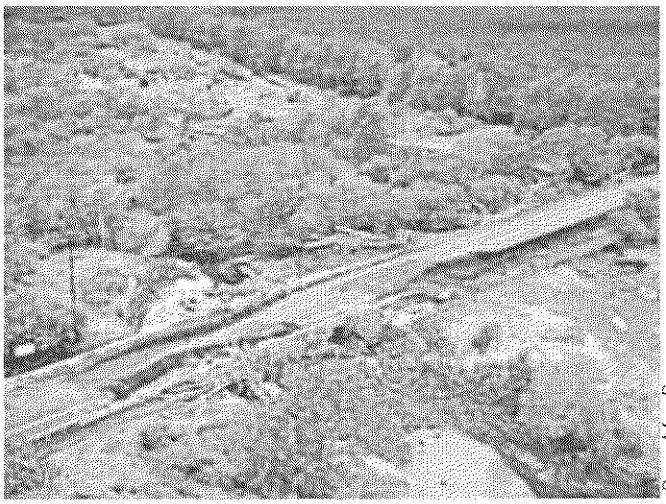

Photo: Ming Press

Compensation and incentives

Compensation as part of disaster assistance should always have as a goal the reduction of future flood damages. Rather than simply paying for damages, the funds should be focused on flood proofing, buyout, relocation and public education on the risks and consequences of living on flood-prone lands.

In a similar manner, incentives can be developed that encourage flood proofing or relocation, and these can be financed through cost-shared programmes. Here the cost of flood proofing can be shared in proportion to the benefits to the various levels of government of not having to compensate for future flood damages. Property owners should also be expected to pay a reasonable share in view of the enhanced value of a flood-proofed structure and the reduced inconvenience after a flood.

Land exchange programmes can be used as an incentive to relocate from flood-prone lands. In such cases a public entity makes alternate land available and disaster assistance is generally used to pay for relocation or replacement of structures, depending on the costs and benefits

Incentives can also take the form of penalties For example, if an individual is aware of the risk of flooding through such programmes as flood plain delineation, or caveats on land titles, and still decides to build on flood-prone land, then that person should bear the consequences of his/her actions and not be eligible for disaster assistance. However this is difficult to enforce and is reliant on strong political will at the time of announcing disaster assistance.

Insurance

Flood disaster insurance forms part of the suite of responses to reducing flood losses in the United States of America. When a prospective homebuyer seeks to purchase a property in a designated flood-prone area with funds obtained through a federally-insured or regulated institution, the lender is required to notify the borrower of the need for flood insurance. The losses covered by flood insurance are paid from the accumulated premiums of policyholders rather than disaster assistance funds. There are some weaknesses in this approach, as not all homeowners in flood-prone areas purchase insurance, and there is the necessity for public funding if losses exceed the accumulated premiums. Flood insurance schemes have been utilized in other countries, including parts of Germany, with varying degrees of success.

For insurance schemes to be successful, there needs to be a clear definition of the risk, as premiums should reflect the degree of risk at a given location. It is also desirable for governments to promote or, when possible, mandate universal insurance coverage and guarantee funding when payouts exceed premiums. Such schemes should be designed to be self-sustaining over the long term An additional problem concerns the information base, which is seldom sufficient to define the degree of risk adequately. It is also difficult to effectively make insurance mandatory. Often those most at risk due to flooding are the least able to pay, or they refuse to pay because of high premiums.

The United States has an advantage from an insurance perspective in that 20,000 communities are at risk from flooding; with such a large number of flood-prone communities, the financial risk can be spread more easily than in smaller countries. Insurance is an option that needs to be considered, but is probably not feasible in many developing countries at this time.

2.4 Watershed Management

The water storage effect of vegetation, soil, shallow groundwater, wetlands and drainage has a direct impact on the flood level in downstream areas. Each of these storage media retain certain quantities of water for various periods of time and can influence the timing of tributary flows and hence their contribution to a flood event. The storage effect can be likened to a sponge and is dependent on the antecedent conditions and the magnitude of the flood.

Impacts of land-use changes

The impacts of land-use changes on flood events can be both positive and negative, so predictions are hard to make for a specific watershed. Generally the removal of forest and other natural cover, and the conversion of land to agricultural uses, compacts the soil and reduces infiltration rates, leading to higher flood peaks. Deforestation is believed to have been a significant cause of the catastrophic flooding in the Yangtze River basin in China and in Central America from Hurricane Mitch, both in 1998. Deforestation and other land-use practices can also lead to greater incidences of landslides and mud flows

Natural water storage is also generally reduced due to the gradual loss of organic material and soil erosion, once an area is converted to agriculture. Additionally, natural vegetation may transpire moisture to the atmosphere at a greater rate than replacement crops, thereby affecting both the amount of storage available in the soil and the amount of local rainfall

Drainage of wetlands and marshes contributes directly to changes in the timing of runoff, the amount of natural storage in the basin, and the vulnerability of the channel to the erosive forces of water. Even road construction can contribute directly to increased runoff rates through improved drainage as well as the effect of reduced infiltration through the road surface.

By far the greatest impact of land-use change is associated with urbanization itself. The paving of surfaces significantly reduces infiltration, natural storage is reduced by improved drainage, and streams are often constricted by development or crossings. A city will frequently have significant flooding problems that are local in nature, but will also be impacted upon by major flood events on larger streams or lakes that are not within the urban zone.

A general rule is that the impacts of land-use change will be greater for smaller basins than for larger ones. Increases in flood peak and runoff volume in the range of 15-25% for medium-sized basins (>5000 square kilometers) have been estimated in temperate climates. However, more detailed studies are required before making predictions for specific basins and their conditions. Scaling small basin results up to larger basins and vice versa remains a major scientific challenge.

2.5 Climate Variability and Change

There is growing concern about the impact of changing concentrations of greenhouse gases on our current climate system and the ramifications these changes might have on water availability. It is believed that further alterations of atmospheric chemistry could lead to increased abnormalities in climatic parameters such as temperature, precipitation and evapotranspiration and might well lead to more dramatic impacts on streamflow patterns and extreme conditions. Some analyses of streamflow over the last 30 to 60 years have shown evidence of increasing and decreasing trends in the low flows, with marked geographic patterns to these trends. Thus far, there has been less evidence of trends in annual flood data for natural pristine basins. However, based on scenarios of projected future atmospheric conditions, it is anticipated that there might be more pronounced alterations to the streamflow regimes in various regions of the world. If these projections are correct, more severe or extreme conditions may prevail.

Climate impacts on extreme events

A number of studies on the potential impacts of climate change on flooding have been carried out as part of the work of the Intergovernmental Panel on Climate Change (IPCC) These studies indicate potential future increases in flood peaks of approximately 15% in temperate zones due to increased storm activity and overall increases in depth of precipitation.

At this point in time, it is not possible to predict potential increases in flood peaks due to climate change for specific basins with the degree of certainty necessary for their incorporation into the design and planning process. However, the freeboard on levees and other works can probably accommodate the potential modifications in extremes due to climate change through modified operating procedures of control structures.

Sea level rise and storm surge

Coastal communities must also deal with the implications of sea level rise, tsunamis, and ocean storm surge in preparing for flooding events.

Sea level rise due to climate change will result in decreased river slopes in reaches above where the river enters the ocean, thereby reducing the capacity of the channel to pass flood flows. This increases the elevation of floods in coastal cities. While the rate of sea-level rise is slow, most protective works or flood plain delineation exercises are sufficiently long term in scope to warrant consideration of the predicted rise.

Some studies have indicated that there is potential for increased frequency of storm surges, which result from high winds and increased barometric pressure. Tsunamis can also be devastating natural disasters and must be considered in a manner similar to flooding. Forecasting and emergency responses to these events must be based on the same principles of acceptable risk and advance planning.

ENSO events

The El Niño Southern Oscillation (ENSO), related to changes in sea-surface temperatures in the Pacific Ocean, can profoundly change the weather patterns in Central and South America. The number of hurricanes that can be expected in a given season is also related Climate predictions of above or below normal storm activity during El Niño and La Niña events can assist with the regulation of reservoirs and other water management activities that can reduce the magnitude of peak storm runoff. Flood forecasting and emergency response activities should also be periodically tested to ensure they meet appropriate levels of readiness.

2.6 Development of Policies, Strategies and Plans

The development of policies, strategies and plans to combat the risks associated with natural disasters should be based on a comprehensive risk assessment. This requires an integrated approach whereby a wide range of mitigation measures should be considered. For example, mitigation activities such as hazardous land mapping (i.e., flood plain mapping plus landslide- and mudslide-prone areas) should be designed so that considerations of other disaster types lead to sounder overall land-use plans. In essence, there would be very little purpose in moving people and goods from one risk zone to another, especially if the other hazard is equally or more apt to occur under the prevailing conditions such as torrential rain. Within this overall process, full consideration needs to be given to the social, environmental and economic impacts of policy and programme development. This chapter provides guidance on aspects of flood hazards that need to be considered within the overall planning process. The aspects contained herein are meant to complement other materials in this guide, such as the development of a flow forecasting and warning system, which are important tools within the range of options to be considered.

Basin wide planning

Reduction of flood losses must be considered, using the basin as the basic planning unit. It is absolutely essential to have knowledge of water uses, diversions, storage, and management practices in all parts of the basin, as well as the antecedent, present, and forecasted meteorological and hydrological conditions.

Transboundary basins represent a special challenge in that international collaboration is required. In such cases consideration should be given to expanding existing bilateral or regional arrangements for exchange of data and information and to the negotiation of treaties or agreements. Agreements can also include the option of projects of mutual advantage funded by all the countries involved, including construction of flood storage or other flood preventative measures at the most advantageous locations in the basin as a whole.

Multijurisdictional issues

Basin-wide planning for reduction of flood losses can involve government at the local, provincial/state and national levels. As such it is desirable to have the national government develop strategies and policies that ensure a consistent framework wherever they are applied. This can extend to matters such as installation and maintenance of data networks, design standards for protective works, flood proofing standards, cost sharing arrangements, and incentive and insurance programmes

In general the national level of government should take the lead in bringing the parties together, but should delegate planning of the details and delivery of the emergency response programmes to the local level. Generally the national and provincial/state governments will play some direct role in operation of forecasting centres, and they will need to provide for emergency response that exceeds the capability of the local level. There should also be a role of higher orders of government in auditing enforcement of policy measures by local levels.

Inter-agency collaboration

Reduction of flood losses will involve a number of government agencies and often

the private sector if, for example, reservoirs are operated by energy utilities. Development of common objectives and definition of a clear role for each of the players can be a major challenge. From a land-use planning perspective, land developers must also be directly involved in the solutions.

Normally some form of inter-agency body will need to be established, and the leadership role assigned to the agency with the greatest involvement or to a strong central agency. There is probably no ideal model for such a structure, as circumstances are quite different in every country.

An independent agency is an attractive option, but in general it is probably better to try and build on the strengths of existing agencies so that supportive resources can be marshalled quickly in case of extreme events. However, within this diverse model, it is imperative that one agency be given the overall lead, and that that agency be held accountable for the overall process.

International collaboration

There are a number of United Nations specialized agencies and programmes that can be of assistance to a country establishing a programme aimed at reducing the losses that result from flooding. Some of these are described herein and could be contacted by interested parties.

The UN Department of Economic and Social Affairs (UNDESA) has been actively involved in providing advice to governments on water resource management during extreme hydrological events in a wide range of environmental and climatic settings from the drought-prone upland plateaus of central Africa through large river basins and aquifer systems in Asia to vulnerable groundwater lenses on Pacific atolls If one principal lesson is to be learnt, it is that managing water resources under conditions of climatic variability and extreme events involves no special approach; it is simply sound water resource management. To this extent, climate change should involve relatively few surprises, and should not be an excuse for poor management. It is only possible to undertake sound management practices, however, if the appropriate and accurate hydro-meteorological data are available to resource managers on a regular basis. One of the critical issues in this area is the breakdown in hydro-meteorological data collection systems and analysis. As funding for water resource organizations declines, monitoring networks and the capacity to collect, store and analyze data break down. Ironically, it is only in times of drought or severe flooding that the political will to fund these activities is revived, by which time it is often too late.

Water resources assessment is a core issue that the UN system is addressing through its technical cooperation activities and the World Water Assessment Programme. UNDESA's technical cooperation with developing countries and economies in transition uses state of the art technologies and software for the assessment of water resources availability as a basis for short-term and long-term planning horizons National capacity has been developed to perform and continue these assessments in countries such as Bahrain, Burkina Faso, Cape Verde, China, Jordan, Madagascar, Mali, Mauritania, Niger, Senegal, and Yemen. This is of particular importance in water-scarce countries, where water has become a limiting factor for economic and social development.

UNDESA has been collaborating with governmental organizations to enhance national capacity to address the problems of water quality assessment and overall water management. Guidelines and recommendations concerning water quality

protection and management are also prepared for national and regional organizations, dealing with monitoring and protection of environment.

The United Nations Development Programme (UNDP) has a programme for strengthening national capacities related to flood mitigation, prevention and preparedness in developing countries. UNDP works in flood reduction and recovery through practical application at the regional and country levels. UNDP has devoted special attention to reducing social and economic vulnerability and loss of lives, and to protecting livelihoods and broad-based development gains.

The World Meteorological Organization (WMO), a specialized agency of the UN, was established in 1950 to facilitate worldwide cooperation in meteorology, hydrology and climatology for the benefit of humanity. WMO promotes the following types of activities. the establishment of the networks of stations for acquiring meteorological, hydrological and related geophysical observations and the standardization of observational methodologies; establishment and maintenance of systems for processing and exchanging data and information; activities in operational hydrology, such as flood forecast and warning systems; multi-agency and interdisciplinary programmes on water resources, climate change, natural disasters, and other environmental issues; and research and training.

The International Strategy for Disaster Reduction (ISDR) was launched by the General Assembly of the United Nations in January 2000, to provide a global framework for action with the objective of reducing human, social, economic and environmental losses due to natural hazards and related technological and environmental phenomena. The ISDR aims at building disaster-resilient communities by promoting awareness of the importance of disaster reduction as an integral component of sustainable development. The General Assembly established two mechanisms for the implementation of the ISDR: the Inter-Agency Secretariat and the Inter-Agency Task Force on Disaster Reduction (IATF/DR).

The ISDR Secretariat serves as a focal point within the United Nations system for co-ordination of strategies and programmes for disaster reduction and to ensure synergy between disaster reduction activities and those in the socio-economic and humanitarian fields. The ISDR Secretariat also serves as an international clearinghouse for the management and the dissemination of information, in particular on current knowledge and status of disaster reduction through the publication of its *Global Review of Disaster Reduction Initiatives*. It develops activities such as advocacy campaigns to promote wider understanding of natural hazards, as well as risk assessment and management to motivate a worldwide commitment to disaster reduction. The ISDR Secretariat has a facilitating role, bringing agencies, organizations and different disciplines together. and providing a common platform and understanding of the scope of disaster risk reduction. In this regard, one main function of the Secretariat is to support the Inter-Agency Task Force for the development of policies on natural disaster.

In particular, the ISDR Secretariat supports activities, such as the development of guidelines, related to reducing the risk from water-related hazards. This requires, on the one hand, support for the development of capacities to monitor the magnitude, duration, timing and location of hazards, such as floods and droughts, as well as landslides, storms, earthquakes, and volcanic eruptions. All of these latter hazards also

have impacts on freshwater resources and infrastructure. On the other hand, this also requires promoting the assessment and reduction of the vulnerability to such extremes. This requires decision-making on issues such as development and planning control, legislation and land-use, environmental management and financial tools (e.g., insurance).

The ISDR, with its focus on disaster and risk reduction, draws its relevance from previous practices in the disaster management fields, where traditionally the focus has been on preparedness for response. Political authorities, professionals from many different fields, commercial interests, public organizations, educational institutions and local community leaders are increasingly recognizing the essential public value of sustained efforts to reduce the social, economic and environmental costs of disasters. There is now increased emphasis placed on risk, and a growing acceptance that disaster, development and environmental problems are inextricably linked.

2.7 Emergency Preparedness and Response

The most critical element in the suite of activities associated with flood-loss reduction is emergency preparedness and response activity. The response to a natural disaster warning must be immediate, comprehensive, and demonstrate very clear lines of command. There must also be a mechanism in place to quickly draw upon external resources available at higher levels of government, or even internationally, when the local level of response will not be sufficient. Many countries have systems in place where a provincial/state wide or national disaster can be declared to bring in the resources needed. The keys to effective emergency response are advance planning, ability to mobilize sufficient resources quickly, and periodic exercises to identify weaknesses and problems.

Collaboration and coordination

Emergency planning and preparedness is first a local responsibility, but one that requires collaboration and coordination with others in a growing circle of like-minded and expert groups that can be drawn upon as events unfold. In particular, there must be strong and reliable communication linkages to storm warning and forecast centers so that the emergency response actions taken are appropriate to the magnitude of the probable event.

The network of linkages from the local level upward must be established in advance and, more importantly, key players must periodically meet to exchange information and become comfortable working together. Information sharing should be bi-directional, both upward and downward, between the levels of government Practice drills are important

Emergency response must include input from the community and political levels but cannot become a collective responsibility. There must be clear lines of authority, even if the lead agency changes dependent on the magnitude of the event.

The community and individuals must have a good understanding of what is expected of them. A good example would be evacuation. Information that defines evacuation routes, identifies emergency shelters, and specifies actions to be taken before leaving, such as removing mobile equipment and removing personal goods and furniture, must be available in advance

Preparedness and response plans

Detailed response plans need to be prepared in advance and reviewed with all of the key agencies and players. There is no one "common" response plan as the linkages will be different in each case. The response to a toxic chemical spill is very different from the response to a major fire or flood.

Not only must the plan be in writing and available to those that will be responding, but also it must be continually reviewed and updated. Some of the key pieces of information are which agency and individuals have the specific responsibility; whom to contact for expert advice; and where to go for information on backup communication systems. This information is constantly changing and needs to be verified periodically and tested in exercises Multiple contact points need to be established as the emergency may occur on a weekend, holiday, or after regular business hours.

Mechanisms for coordination must be included in the plan, including the structure of response committees, where they will meet and sources of resource information available to them. Often this takes the form of something equivalent to a "war room" where maps, plans, other material and support staff are available immediately.

Inventory of resources

A key component of any emergency preparedness plan is an inventory of resources that can be accessed. In the case of flooding this could include items such as emergency vehicles, buses and trucks, earthmoving equipment, pumps, plastic, plywood, emergency generators, supplies of gravel and sand, sandbags, and mobile communications equipment. The inventory should also include access to expertise such as surveyors, levee or slope stability experts, forecasting specialists, the media and community leaders.

Emergency shelters should be designated in advance, their individual capacity defined and plans made for obtaining sufficient supplies of water, food, medicine and medical/social assistance.

If local resources are not sufficient, then the availability circle must be expanded to include adjacent communities, the provincial/state and national government levels.

Triggering emergency action

Advance warning is the key to effective response. It is possible to set up a series of warnings in advance of an actual extreme storm event that can be used as alerts. This could start with long-term climatologic forecasts or more immediate hurricane forecasts that identify potential danger. For specific basins an alert could be issued based on antecedent precipitation and rainfall intensity data in advance of an actual flood forecast. A more detailed forecast would then be issued when all of the data and information required to make a flood forecast became available.

The emergency response to such alerts is very site-specific and should be included in the plan. If, for example, emergency actions such as temporary levees are necessary, then the work could begin based on an alert rather than the specific forecast. The same may hold for emergency evacuation.

The response to an extreme flood forecast should be immediate, and with no uncertainty as to what actions and activities should be taken. The public expects governments to act quickly and in a professional manner under such circumstances. Community leaders should be visible, informed and active right from the start.

Training and response exercises

Emergency response teams need to be well trained in advance and their skills constantly upgraded. Once the disaster strikes, it is too late to train or try to find missing expertise. Trained staff should know their responsibilities, have immediate access to response plans and other critical information, and already have built a working relationship with colleagues in other organizations.

The only meaningful way to test response plans is to carry out periodic emergency exercises. These exercises are meant to simulate real emergency situations and test all aspects of the plan. Costs are significant, but have real payback in an actual emergency. Often critical gaps are identified and appropriate backup strategies developed as part of the exercise.

Advance preparation

Assuming that there is advance warning of a major storm event, a number of steps can be taken to increase readiness. Such steps include: construction of temporary flood protection works; placing emergency response teams on high alert; distribution of critical materials such as stockpiled sandbags to targeted locations; and preparation of emergency shelters and hospitals prepared for occupation.

The population at risk can be informed of what is expected of them in the actuality of an extreme event. As the event becomes more certain, actions such as evacuation of people, goods and machinery can begin. Even if the event is not as extreme as predicted, these preparations help test emergency response plans and inform the public as to the nature of natural hazards.

Media and public information sessions help set the stage as well. The media are key players in the link between public officials and the public. It helps if they are familiar with the terminology used in warnings and forecasts and know whom to contact for more detailed information during an actual flood event.

After the flood event

The emergency response does not end with the event, but continues through cleanup and resettlement stages. People will want to know what assistance will be made available, who is responsible, and how to go about seeking that assistance.

Senior levels of government should develop clearly defined response policies and programmes in advance. In the absence of such policies, the response is often ad hoc, politically and emotionally motivated, and sets precedents that are not wise in the longer run. Often the response is incomplete in that the

obvious and immediate requirements are addressed, but fundamental changes in thinking and sustainable strategies are ignored.

After a major flood it is beneficial to conduct an assessment of the causes and effects of the flood and to make recommendations that would improve preparedness for the next event and reduce future flood losses. Such an assessment can also lead to improvements in flood plain management policies.

The long-term economic and social implications of flooding become evident in the post-disaster period. Governments need to demonstrate leadership and sometimes take bold steps to restore employment, address social issues and move the economy in a new direction. In that sense, natural disasters can be a positive motivator for change.