Natural Hazard Research

THE EVOLUTION OF FLOOD HAZARDS PROGRAMS IN ASIA: THE CURRENT SITUATION

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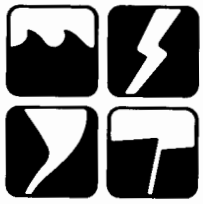

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PREFACE

This paper is one of a series on research in progress in the field of human adjustments to natural hazards. The Natural Hazards Working Paper Series is intended to aid the rapid distribution of research findings and information. Publication in the series is open to all hazards researchers and does not preclude more formal publication. Indeed, reader response to a publication in this series can be used to improve papers for submission to journal or book publishers.

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SUMMARY

In the summer of 1992 the Natural Hazards Research and Applications Information Center sponsored this survey of contemporary flood hazard programs in Asia, which is part of a broader investigation of the evolution of international flood control programs from 1900 to 1992. The geographic scope of the assessment is mainland Asia—from Afghanistan to Korea—with an emphasis on large river basins such as the Indus, Ganges-Brahmaputra, Mekong, Yangtze, and Huang Ho.

The project was initiated because we found through informal discussions that flood planners in each basin had limited awareness of the programs underway in other basins. The overall aim of the project was thus to compile and compare issues and accomplishments of international flood hazards reduction programs in the major river basins of Asia, a region of enormous flood problems and poverty, yet impressive flood mitigation efforts.

As a first step toward that goal, this report describes the current situation in five major basins: current flood problems, programs, organizations, and resources as of the late 1980s and early 90s. It may serve as a useful general reference for flood planners, government officials, and development banks working in the major river basins of the Asian continent. May importantly, it may indicate the importance of increased communication among governments and flood-affected people and organizations in the region, and the role that different organizations can play to facilitate timely and constructive communication.

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INTRODUCTION

Floods give rise to some of the most devastating hazards in mainland Asia (Figure 1). The average annual cost of property damage in Asia due to floods has been estimated at more than $US 3 billion (World Meteorological Organization [WMO], 1986, from Economic and Social Commission for Asia and the Pacific [ESCAP], 1989, p. 40). A significant proportion of the estimated 2.5 billion people living in mainland Asia face a variety of flood hazards (World Resources Institute, 1992). They occupy floodprone lands along rivers and coastal areas in some of the most densely concentrated agricultural and urban settlements of the world. Population growth rates tend to be relatively high, standards of living low, and resource pressures increasing, in the most floodprone regions of Asia.

At the same time, there have been many creative experiments to reduce flood damages in Asia. From the ancient river control works of China to the massive Flood Action Plan in Bangladesh, Asia has been a region of focused concern in flood hazard research and damage reduction.

In addition to surveying current flood problems and programs in Asia, however, this report will show that there are at least two major inadequacies in current flood hazard programs in Asia. First, flood hazards experiences in one region are not widely disseminated to, or sought out by, flood specialists in other regions. The principal flood hazard information dissemination organizations operating today are the U.N.'s ESCAP and the Asian Disaster Preparedness Center, both in Bangkok. However, our informal communication with the planners and engineers developing flood hazards programs in their countries indicated that relatively little practical information was being exchanged among the countries or international organizations of Asia. If correct, this lack of awareness may indicate the difficulty of making practical comparisons and uses of information from other regions, as well as obstacles to information dissemination.

Second, the professional water resources literature on Asia gives relatively little attention to flood hazards compared with other water problems. For example, a bibliography, *Water Resources Management in Asia*, published by the East-West Center, includes only 20 references out of 456 that deal with floods (Cruz et al., 1984, 1986). This neglect may indicate that flood hazards have not received the same level of attention from research scientists as they have from governmental and non-governmental organizations; or it may be

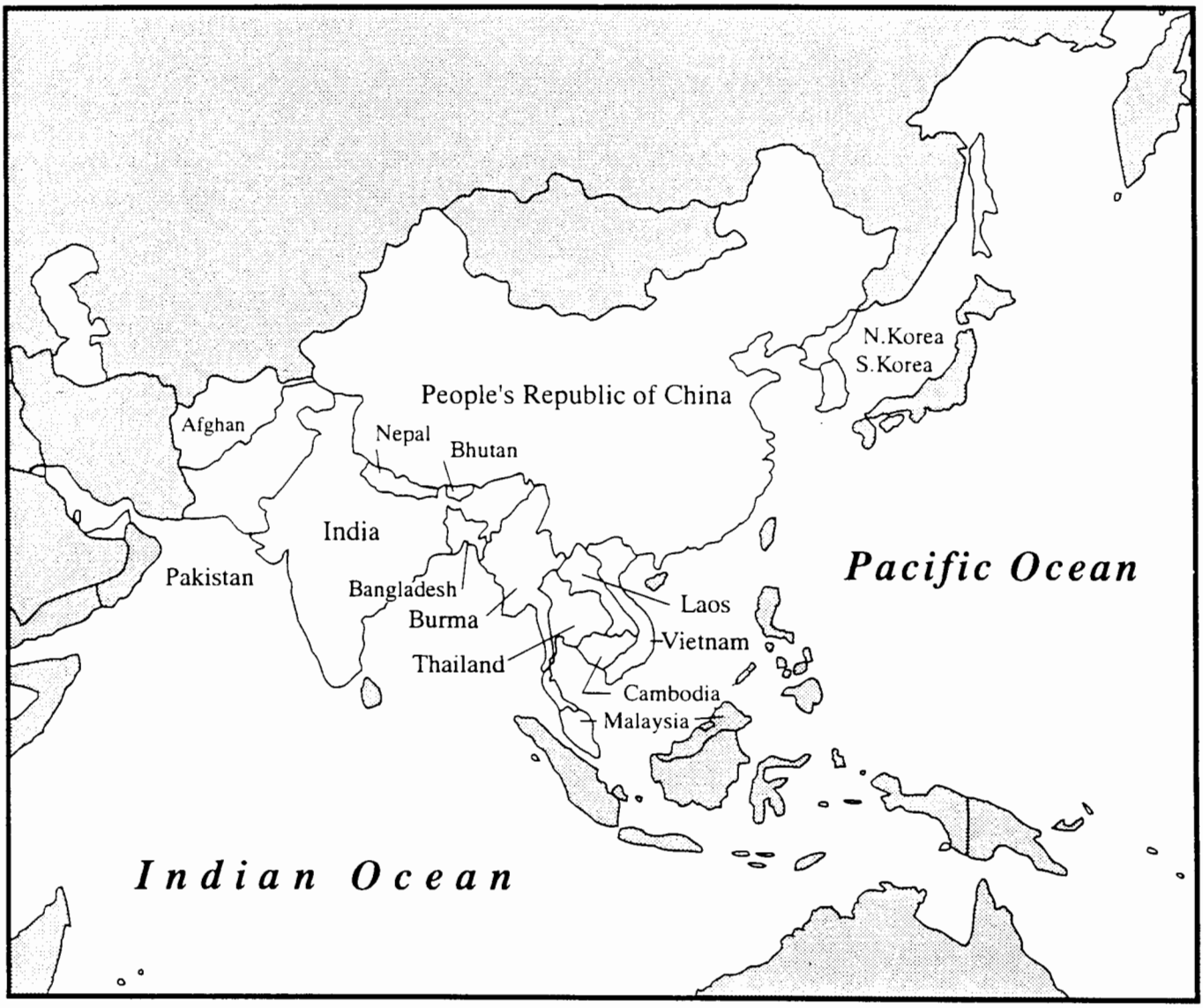

Figure 1. The Study Region

symptomatic of a broader failure to underscore the importance of flood hazards assessment in water sector planning in Asia. Multiobjective water sector planning models used in the Indus and Yellow River basins, for example, do not include flood damages or flood mitigation investment alternatives. Those issues are dealt with in separate, less comprehensive models.

Our aim in this report is to survey the current situation with respect to flood hazards problems and programs in Asia with the aim of facilitating a sharing of experience among regions. A longer term aim, for which this study serves as a benchmark, is to develop a more rigorous basis for making long-term international comparisons of flood problems, programs, and successes in the region. Four basins are studied: 1) the Ganges-Brahmaputra; 2) the Indus; 3) the Huang Ho and Yangtze basins in China; and 4) the Mekong basin. Each basin offers experience and approaches that are potentially relevant in other basins. For example, flood hazards are especially well-integrated with water sector planning in the Mekong River basin. Flood damage reduction programs have been effective in the Huang Ho basin, at least on the time scale of the last several decades. Finally, an enormous amount of scientific information has been prepared, but not always published or distributed, on flood hazards in Bangladesh. To what extent do these experiments in one region have practical relevance for flood hazard reduction in others?

FLOOD PROBLEMS AND PROGRAMS IN ASIA

It may be useful to begin with a brief description of the enormous variety of flood problems in Asia, for it is the differences among regions that make comparisons difficult.

The Bengal Delta, with its very high population density, increasing resource pressures, low-lying coastal position, intense rainfalls, coastal storm surges, and huge river discharges, may be the most floodprone and flood-vulnerable region in the world. In September 1987, some 25 million people of Bangladesh were affected by an intense rainfall event. It has been estimated that some 2,000 lives were lost in that disaster. Floodwaters inundated of 46,620 square km of land, damaged 2 million hectares of crops and some 5 million homes (Bangladesh, 1992; U.S. Department of State [USDS], 1991). The following year (1988) a comparably destructive flood passed through the Bengal delta as the joint result of intense rains and an early peak in river discharge affecting even the capital city of Dhaka

(Dent, 1993). In April 1991, yet a cyclone struck coastal Bangladesh, reconfirming in tragic ways its vulnerability to an array of water-related natural hazards.

Catastrophic flooding on the Ganges-Brahmaputra is not confined to the young nation of Bangladesh. It extends upstream into the states of Bengal, Bihar, and Assam in India. Flooding in the headwaters of Nepal and India also does considerable damage in montane catchments. As this report was written, flash floods struck the southwestern state of Kerala in India, causing landslides that killed more than 50 people (U.N. Disaster Relief Organization [UNDRO], 1992b).

The Kosi River, a tributary of the Ganges in Bihar state, is notorious for its destructive channel changes and flood damages. Massive cyclone damages in 1977-78 in the coastal state of Andhra Pradesh also drew international attention.

In what has now become a familiar line of criticism, some analysts charge that government cyclone mitigation programs in Andhra Pradesh neglect the historical and political-economic dimensions of flood hazard vulnerability (Winchester, 1977, 1981, 1992). They also charge that low-technology (e.g., cyclone shelters) and institutional adjustments receive less support than structural adjustments that reinforce the power of wealthy landowners at the expense of the poor. Finally, they assert that relief money and supplies are rarely distributed as equitably or effectively as intended.

A similar pattern of problems and criticisms occurs in other parts of South Asia. Recent floods have done considerable damage in the Indus River Basin of Pakistan and India. In 1973, flooding in the provinces of Punjab and Sind in Pakistan resulted in almost 500 deaths and the displacement of nearly 5 million people (USDS, 1991). In 1988, an intense monsoon storm in northwest India caused extensive damages in the Punjab region of India and Pakistan.

During the course of this study (1992) there were devastating floods in the Indus and Jhelum basins of Kashmir and Pakistan which resulted in more than 2000 deaths, agricultural and infrastrucutural losses, and over $US 1 billion in economic costs (UNDRO, 1992). A rash of public criticism, political declarations, and government inquiries followed the disaster. It is too early to tell what difference they will make, but there may be useful lessons from other regions as well as from earlier floods on the Indus.

As this report was being written, heavy rains in May 1993 caused flooding in the newly independent states of Central Asia, causing extensive damage to homes, fields, and infrastructure in Kazakhstan and Tajikistan, causing an estimated $US 160 million in damages in the latter country (Department of Humanitarian Affairs/U.N. International Emergency Computer Network [DHA/UNIENET] Situation Report No. 4, 25 May 1993[1]). In April 1993, Iran also experienced intense storms that killed more than 400 people and damaged more than 96,000 structures and 75,000 hectares of land. Losses were estimated to be $US 370 million (DHA/UNIENET Situation Report No. 7, 16 April 1993). Similar torrents occurred in northeastern Iran in June 1992. Afghanistan experienced destructive rainstorms, coupled with earthquakes and landslides in February 1991 which crippled the water, wastewater, and transportation infrastructure (DHA/UNIENET Situation Report No. 9, 19 April 1991).

Even China, with its rich history of riverine civilization and long record of flood programs, has experienced recent damage. The magnitude of historical damages on the extensive, heavily populated plains of China exceeds the modern problems of Bangladesh. As recently as 1931, some 3,700,000 people were killed in Yangtze River flooding (USDS, 1991). Many of these deaths have been attributed to famine and waterborne disease following the floods. In addition, more than 8.5 million acres were inundated. In 1939, an estimated 500,000 people were killed in a dam failure disaster on the Yellow River (USDS, 1991).

It has been a source of pride that China has not suffered riverine flood damages of that magnitude since the revolution. China has a long history of combined structural and non-structural flood abatement approaches which predate the revolution and which deserve close attention from other countries. However, heavy rains in May-July of 1991 in Anhui province caused destructive flooding on the Yangtze and Chu Rivers which will be detailed later in this report (DHA/UNIENET Situation Report No. 6, 25 July 1991). Flooding also occurred in southwest China, Assam (India), and Sylhet (Bangladesh).

The Mekong River Basin of Southeast Asia has its own distinctive set of flood problems on the river's mainstream, ranging from occasional urban flood damages in the

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[1] This and all following situation reports are taken from the UN International Emergency Computer Network.

Laotian capital of Vientiane, to severe erosion and channel changes, to crop damage further downstream in the lower reaches of Cambodia and the delta in Vietnam. Though not of the same magnitude as in other parts of Asia, Mekong flood management is a vital component of integrated water resource use and management program under the auspices of the international Mekong Committee.

In addition to flood problems in these four major basins, a multitude of flood-related hazards affect the smaller river basins and watersheds of Asia. Several recent examples were noted in India, Central Asia, Iran, and Afghanistan. Other recent problems have occurred in Southeast Asia. In October 1992, for example, central Vietnam experienced extensive flash flooding that inundated 80,000 homes and 34,087 hectares of land (DHA/UNIENET Situation Report No. 2, 18 October 1992). Typhoon Fred struck coastal areas of central Vietnam in August 1991, killing 5 people, and destroying more than 3000 homes and 67,000 hectares of paddy (DHA/UNIENET Situation Report No. 1, 20 August 1991). At about the same time, Cambodia suffered floods that left 150,000 homeless and inundated 100,000 hectares of land (UNDRO, Situation Report No. 2, 27 August 1991). And the Ayeyarwaddy and Ngawun rivers of Burma (Myanmar) breached their bunds (embankments) due to a conjunction of heavy rains and high tides (DHA/UNIENET Situation Report No. 3, 4 September 1991).

This report concentrates on large river basins, but it is important to keep in mind the smaller-scale yet devastating problems that can occur in the hill torrents of the Himalaya, coastal areas and islands, and closed basins of the continental interior. It is also important to consider how the scale and geography of flooding affects damages and relief, as well as the comparability of flood hazards in different regions.

PREVIOUS RESEARCH

The published research on flood hazards in the regions mentioned above has tended to focus on either the specific problems of one area or the general principles applicable in all areas. The intermediate regional scale of assessment of countries and large river basins is relatively rare.

There is also uneven coverage of the regions considered here. A great deal has been written about recent floods in Bangladesh. Much less has been written about modern floods in the Indus basin, though there is an interesting literature on the role of flooding in the abandonment of prehistoric cities. Much work has focused on the Mekong; less on the Red and Irrawaddy rivers. Among the many reasons for these differences in coverage, the degree of economic and political support for research and relief operations, both in countries affected and among international organizations, is especially important.

Some important aspects of flood hazards have received little attention in any region of Asia. For example, the institutional and legal dimensions of flood losses, responses, and remedies have not been systematically addressed (Wescoat, 1990). The effects of political instability and cultural conflict on the magnitude of losses and efficacy of coping deserve greater attention. And there has been little formal research on the cultural meanings of flood losses.

We examined the literature on drowning and near-drowning events, some aspects of which presumably cut across cultures while others vary (e.g., by age group, health, experience, etc. See Davis, 1986; French et al., 1983; Modell, 1978; Neal, 1985 for reviews). When reading the more detailed descriptions of flood problems below, however, it will be important to keep in mind questions regarding how different culture groups in different areas experience and adjust to floods. For some social groups, death by drowning may be no different from death by other causes, while for others it has a special significance or horror. The "loss" of a person or a person's body, for example, has different meanings for different cultural groups.

The medical literature deals with flood-related diseases, especially cholera, typhoid, malaria, and dysentery (e.g., Ahmed et al., 1991; Bennish, 1991). However, descriptions of the human experience and meaning of those diseases is eclipsed by efforts to determine their frequency and treatment (cf. the emphasis on cultural aspects of famine-related disease and hunger).

There is, however, a small but significant literature on "flood myths," which notes the persistent link between flood events, social misbehavior, and divine displeasure. Alan Dundes (1988) recounts several Asian variants of these "myths". We do not know the extent

to which such myths guide human action or the interpretation of recent floods in Asia, but the practice of seeking religious explanations for disasters is presumably widespread. One personal example comes to mind: after floods in 1988 resulted in a family death, a man who worked for Wescoat in Pakistan said gloomily, "that's what we poor people are made for."

There are also modern "myths" associated with flood control. Alam (1991a) calls attention to modern myths of flood control in Bangladesh, e.g.: 1) that flooding is caused by deforestation in the Himalaya; 2) that flooding is always caused by high precipitation; 3) that flooding can be controlled with embankments; 4) that mountain reservoirs can regulate downstream floods; 5) that an international approach is absolutely essential for flood damage reduction in Bangladesh; 6) that flood victims always need relief and they panic during disaster; and 7) that relief from NGOs and governments is the best means to succor flood victims. Dent (1993) has suggested that "myths" deflect social attention to issues which seem to lie beyond public control and responsibility. Some scientists are beginning to regard global warming studies in that category (Wescoat, 1993).

Social research on flood hazards in Asia got off to a strong start with the Lower Mekong investigations in the 1950s and 60s, but it became somewhat formulaic in subsequent decades (compared with progress in flood engineering and forecasting and social research on other hazards such as famine). The main exception, in our view, is the Bangladesh Flood Action Plan that has rekindled interest and debates about the range of adjustments to flood hazards (Zaman, 1991a). Because flood planners in other regions may not have studied the programs in Bangladesh closely (and vice versa), we give special attention to those programs in this report.

THE IMPORTANCE OF INTERNATIONAL FLOOD PROGRAMS IN ASIA

Given its long record of riparian settlement, its pressing population and economic needs, and its vulnerability to catastrophic storms and floods, Asia has been a particularly important "laboratory" of human adjustment to flood hazards.

Asian floodplains have supported large agricultural and urban settlement systems that have enormous diversity and longevity. The experience of Asian societies in coping with floods includes millennia of behavioral, as well as scientific and engineering, experiments. At

the same time, population and economic changes have rendered some regions more, rather than less, vulnerable than they were in the past, and the relevance of previous adjustments for future events is not at all certain.

Multinational flood programs were first tested in Asia. The first League of Nations flood relief efforts took place in China in the 1930s (Economic Commission for Asia and the Far East [ECAFE], 1950). A U.N. regional commission established for southeast Asia, ECAFE, (subsequently renamed the Economic and Social Commission for Asia and the Pacific [ESCAP]) focused much of its initial effort on flood control. To this day, ESCAP is the only regional U.N. agency to give any significant emphasis to flood problems.

These international efforts to reduce flood losses also represent an important body of experience in Asia that may also have relevance for other parts of the world. The first step toward assessing this record of experience is to survey the current situation and to explore ways to organize the information to facilitate comparison and dissemination.

AIMS AND METHODS

AIMS

As noted above, the main aim of this report is to survey the current situation, by which we mean: 1) recent experience with major flood events in five major basins; and 2) international programs developed to deal with those events. The geographical scope of the study includes mainland countries of the United Nations' Economic and Social Commission for Asia and the Pacific (ESCAP) (Figure 1). ESCAP provides a coherent geographical region for investigation, and an institutional forum that pioneered international flood hazard and water development programs in the region. A second aim, initiated here for development in future research, is to explore the possibility of more rigorous regional comparison of long-term flood hazards problems and programs.

Because the emphasis of this study is on international programs, we focus on the countries of mainland Asia that belong to ESCAP. This is the largest regional intergovernmental organization for Asia in the United Nations family, and it maintains a unique organizational commitment to flood hazards research. The flood hazard problems of island countries and the industrialized and newly-industrialized economies of Asia (including

Korea) are substantially different from those of the large river basins of mainland Asia, so they are not included within the scope of this report. However, some multilateral programs involving ESCAP and industrialized countries and lending organizations (e.g., the Asian Development Bank) are included.

We define the "current situation" as the period from 1980 to 1993. In some regions where we had field experience or access to unpublished technical reports and government documents, such as the Indus and Mekong river basins, we were able to describe the situation as of 1992. Other countries, such as Bangladesh, which have excellent communication networks about their flood hazards programs also facilitated reporting. Our coverage in other regions is more dated and more data-limited. The coverage is also biased toward English and other European language publications, which posed a special problem for assessing programs in China.

Through the cooperation of experts in the region (contacts are listed in Appendix A), we were able to put together a broad picture of contemporary flood hazards in the ESCAP region. Though floods pose a problem in all ESCAP countries, we focused our efforts on those regions with the most severe problems and the concerted international efforts to alleviate them. We begin with a regional overview.

METHODS

We began with a broad framework for surveying flood programs in Asia. Eight analytical perspectives were identified:

1. An *Events-Based* approach focusing on patterns and trends in flood events that may or may not cause damages.

2. A *Response-Based* perspective focusing on the range of responses and adjustments that have been tried, and on the relative effectiveness of different types of technological, behavioral, and policy adjustments. It is useful to distinguish actions taken prior to the event (i.e., preparedness) and those taken immediately following an event (e.g., relief). Both types of actions are taken in response to flood experience. Although there has been a shift from relief to preparedness in recent decades, it has not measured up to either flood hazards or policy recommendations for the region.

3. A *Vulnerability* perspective that focuses on the social groups most vulnerable to flood-related damages.

4. A *Leadership* perspective that identifies individual leaders and groups that have been effective in dealing with flood hazards and international programs.

5. A *Place-Based* approach that considers the effectiveness of international programs in specific local contexts.

6. An *Organization-Based* approach that examines the programs of international organizations.

7. A *Sectoral* approach that focuses on the degree to which flood control has been integrated with water resources and other government sector programs; the degree to which flood hazards responsibilities are fragmented among sectors; and the level of coordination among responsible agencies.

8. An *International Relations* approach that emphasizes the political and economic context of flood hazard reduction programs at the international level.

These eight perspectives are complementary in nature. Within the scope of this study, we did not pursue all eight perspectives systematically. Instead, we reviewed the available data and literature to identify which perspectives were relatively well-developed and which have been relatively neglected in each region.

Thus, the initial tasks were to compile current literature on flood hazards in Asia and to contact flood hazards researchers working in Asia. It may be underscored that our search did not find any regional directory of scientists, research projects, or organizations focusing on flood hazards. The Asian Disaster Preparedness Center in Bangkok would be in the best position to prepare a directory of that sort if it were deemed useful. We used a variety of partial directories and sources, which are listed in the bibliography and appendices. Sapir and Misson (1992) have recently discussed basic issues of data base construction at the Center for Research on Disaster Epidemiology.

Methodological issues encountered with each of the eight perspectives identified above are briefly mentioned in this section of the report. For comparative information on flood events, we consulted OFDA disaster histories as well as more specific basin studies.

Comparative international data sets on flood events and damages have limitations that have previously been discussed in the hazards literature (Dworkin, 1973; Glickman et al., 1992; Hewitt and Sheehan, 1969; Mitchell, 1989; USDS, 1991; Sapir and Misson, 1992; Flemming, pers. comm, 1992). Flood events on large river systems are especially difficult to measure and observe with conventional hydrologic equipment and methods (Rogers, pers. comm., 1992). International disaster data sets also rely upon a variety of sources that leads to biases in the estimation and reporting of damages. We found that some disaster response agencies are presently working to develop new data bases that include "country disaster profiles," which might help planners assess the context of disaster events, and create disaster networks to facilitate rapid access, analysis, and sharing of information (Flemming, pers. comm., 1992). Quantification of "damages" or costs, and the benefits of different response strategies, including flood preparedness, remains at a very rudimentary level for Asian floods (Dent, 1993).

There exists a relatively large literature that is response-oriented but not context-specific (e.g., Asian Development Bank, 1991; Cuny, 1990). This literature focuses on general models of "vulnerability," "preparedness," "warning," "control," "mitigation," and "response," for applications in a wide range of regional circumstances. This approach is valuable for large-scale hazards (e.g., typhoon monitoring and forecasting) where a common framework is required for international communication and coordination. At the local level, greater concern must be given to community and place-specific approaches that are less well represented in the scientific literature and less effectively compared with local information from other regions. There is little quantitative comparative research on the efficacy of flood hazards responses in large river basins.

Although there was not a ready reference of national organizations involved in flood hazard programs, it was relatively easy to identify intergovernmental organizations and obtain information on their programs. The greatest difficulty was assessing the roles of private voluntary organizations (PVOs), indigenous, and grassroots organizations.

It was possible to identify some flood hazards "leaders," at least in the research field, for each region on the basis of their contributions to the published literature or national and international organizations.

We also found in some regions, such as Bangladesh, a growing literature on vulnerable social groups (e.g., the elderly, sick, young, poor, and in some cases, women). Chinese research was unquestionably under-represented by the emphasis on translated publications. Of all the study areas, Bangladesh has the greatest amount of scientific and published literature on flood hazards. It also has the most detailed social sciences literature on flood hazards. Research in other basins has been of a more technical nature, for example, on issues of flood forecasting, warning, and policy. We were not able to determine, however, how much literature is published in Bengali, the extent to which published materials are sought out or systematically disseminated. In some cases, Bangladesh flood hazards information appears to be more widely available outside Bangladesh than within it!

A methodological difficulty was encountered in trying to identify and compare the sectoral context of flood hazard programs. Flood hazards are not treated as a "sector" as such. Rather flood control is situated within ministries of water, water and power, irrigation, and agriculture. Flood warning programs might be situated in a department of meteorology in the ministry of water or defence; flood prevention responsibilities might reside in a department of flood control under a ministry of water resources; while flood relief might fall under departments of social services, rural development, the military, and a host of other agencies. Even when one has a clear organizational chart, the actual coordination of information and responsibility is rarely clear. Organizational coordination and fragmentation are serious problems. The sectoral context of flood hazard programs affects the effectiveness, communications, and resources available for response.

On a broader level, the international political and economic context of flood disasters and mitigation programs is extremely complex, and cannot be considered in any detail in this paper. The following dimensions of "context" are relevant: 1) local context (economic, political, and ecological situation; presence or absence of cultural conflict); 2) regional context (same); 3) national context (leadership, strength of government, effectiveness of state apparatus; budget situation in re: economic investment or relief; political alignments vis-a-vis flood affected areas); and 4) international context (geopolitical alliances; international economic situation; intergovernmental consensus; degree of international coordination). We found limited coordination among international flood hazards programs.

Information on these eight different perspectives was compiled by river basin, concentrating on international programs in the five basins mentioned. The results of the survey were used to construct a working typology of regional flood hazards and adjustment programs in Asia. This typology was then used to compare flood hazards problems in different regions in the final section of the report.

Several types of comparison were sought. We wanted to know if there were similarities among the problems and approaches of large or highly-regulated river systems. The Yangtze has the third-largest average annual discharge in the world. The Mekong, which experiences less severe flooding problems, is the world's twelfth largest river.

We eventually want to ascertain how such differences among the basins, and their flood management programs, leads to differences in vulnerability and protection. The Indus River Basin contains the world's most extensive and elaborate system of surface irrigated agriculture, while the Mekong is far less regulated. The Ganges-Brahmaputra region experiences upstream-downstream conflicts regarding development and flood control issues to a far greater extent than rivers in China. The Lower Mekong has been the setting for the world's most important experiment in coordinated international river basin planning, which has proven elusive in the Ganges-Brahmaputra. Although the Huang Ho and Yangtze Rivers are managed by the same central government, they have different flood problems and works.

It is worth emphasizing some of the similarities among the basins that warrant comparative assessment:

1. Flood problems in Asia are largely the result of seasonal monsoonal precipitation.
2. The scale of flood hazard and associated water development programs is large.
3. The role of external organizations, both intergovernmental and nongovernmental, has been substantial in addressing flood hazard problems.

In this study we were particularly interested in multilateral programs and those bilateral programs involving the United States of America.

ASIA'S PRINCIPAL FLOOD HAZARD PROBLEMS AND PROGRAMS

A REGIONAL AND GLOBAL PERSPECTIVE

It is useful to begin this survey with comparative information about Asian rivers, including their size, resident populations, riparian countries, and economic situation. The second part of this chapter describes international flood hazards programs.

Table 1 indicates the riparian countries for the five major basins considered here. The number of countries and historical relations among them has influenced the types of international programs that have developed in the basins, as well as the types of cooperation that are presently possible. Whereas the Mekong has six riparians, the Yellow River lies entirely within China. Some boundaries and territories are disputed, as in Kashmir and Tibet, which affects the efficacy of flood hazard warning and mitigation programs.

Table 2 gives basic information about the sizes of the basins, including their ranks among Asian and world rivers. The Yangtze and Huang Ho are the longest rivers examined here, both over 3,000 miles in length. However, the Huang Ho has the smallest drainage area (260,000 mi^2) while that of the Yangtze is three times as large. An even greater disparity exists between the average annual discharges of these rivers—differences that translate into different types of flow, floodplain morphology, and flood hazards.

Table 3 provides demographic and social information about the countries with some territory in each of the major basins. Unfortunately, these data are at the aggregate country level and not for the basins alone. Thus, they are more indicative of country situations that affect national policies toward river development and flood hazards, and not the social situation in the basins themselves. China has the largest population but the lowest population growth rate. Pakistan has the highest population growth rate in the region, while Bangladesh has the highest population density—much of it in the most floodprone lands of Asia. All countries except Thailand have a low gross domestic product (GDP) in world terms. These figures do not reflect the actual population at risk, but may be taken as a surrogate for social pressure on floodprone lands. The percent of GDP that is overseas development assistance (ODA), indicates dependence upon other countries, which ranges from 1 to 31%. Reliance on aid may be a source of vulnerability or buffering, depending upon how outside countries respond after disaster. Thus, these economic indicators can be taken as a rough indicator of

Table 1. Riparian Countries

River Basin	Riparian Countries
Ganges-Brahmaputra	Bangladesh, Bhutan, China, India, Nepal
Huang Ho (Yellow)	China
Indus	Afghanistan, China, India, Pakistan
Mekong	Burma, Cambodia, China, Laos, Thailand, Vietnam
Yangtze	China

Table 2. Principal Hydrologic Characteristics of Major Asian Rivers

River Basin	Length (miles) (world/Asian ranks)	Drainage Area (1000 x sq mi) (Asian rank)	Discharge (1000 x cfs) (world/Asian ranks)
Ganges	1,557 (48) (21)	409 (6)	660 (5) (3)
Brahmaputra	1,800 (31) (14)	361 (7)	700 (4) (2)
Huang Ho (Yellow)	3,011 (7) (4)	260 (10)	116 (31) (14)
Indus	1,800 (31) (14)	358 (8)	196 (23) (10)
Mekong	2,500 (16) (10)	310 (9)	390 (14) (8)
Yangtze	3,716 (4) (1)	750 (4)	770 (3) (1)

Source: van der Leeden, 1975.

Table 3. Social and Demographic Characteristics

River Basin	Country Popultn. (x 10^6) (1990)	Popultn. Growth Rates (1985-90)	GNP Per Capita 1987 $US	ODA as % of GDP
Ganges-Brahmaputra	Bangladesh: 115.6 Bhutan: 1.5 China: 1,135.5 India: 853.4 Nepal: 19.1	Bangladesh: 2.67 Bhutan: 2.15 China: 1.39 India: 2.08 Nepal: 2.48	Bangladesh: 164 Bhutan: 150 China: 294 India: 311 Nepal: 161	Bangladesh: 15 Bhutan: 31 China: 1 India: 2 Nepal: 20
Huang Ho (Yellow)	China: 1,1135.5	China: 1.39	China: 294	China: 1
Indus	Afghanistan: 16.6 China: 1,135.5 India: 853.4 Pakistan: 122.7	Afghanistan: 2.63 China: 1.39 India: 2.08 Pakistan: 3.45	Afghanistan: 220 China: 294 India: 311 Nepal: 161	Afghanistan: 2 China: 1 India: 2 Pakistan: 8
Mekong	Burma: 41.7 Cambodia: 8.2 China: 1,135.5 Laos: 4.1 Thailand: 55.7 Vietnam: 67.2	Burma: 2.09 Cambodia: 2.48 China: 1.39 Laos: 2.49 Thailand: 1.53 Vietnam: 2.24	Burma: 212 Cambodia: n.a. China: 294 Laos: 166 Thailand: 850 Vietnam: 200	Burma: 9 Cambodia: 2 China: 1 Laos: 16 Thailand: 9 Vietnam: 2
Yangtze	China: 1,135.5	China: 1.39	China: 294	China: 1

both the pressure to intensify floodplain use, and the resources available for adjustment to flooding.

Table 4 lists major flood events and damages in five countries. We have not done a quantitative analysis of factors affecting flood damages, in light of the inexactness of damage estimates, but qualitative comparisons are possible. In recent decades, the greatest and most frequent losses of life have occurred in the Bengal delta. A half century ago, comparable losses of life occurred in the Yangtze and Huang Ho valleys. It is very important to account for both the increased deaths in Bangladesh and the decreases in China.

At the same time, as many as 10% of the Chinese population continues to be affected by catastrophic flooding, and the economic losses associated with flooding are substantial, raising questions about continued economic investment in the floodplain. The low number of deaths on the Mekong also deserves close attention. Outside the delta, Vientiane, and the Cambodian lakes, the Mekong river floodplain has relatively low population densities for Asia, and a relatively sophisticated flood forecasting and warning system.

Table 4. Major Asian Flood Events (Source: USDS, 1991)

Country	Year	Deaths	Damages (K$)	People Affected	Comments
Bngdsh.	1970	300,000	86,400	3,648,000	Tropical Cyclone. One of greatest natural disasters in history
Bngdsh.	1987	2,055	330,000	29,700,000	Flooding in most river basins
Bngdsh.	1988	2,379	2,137,000	45,000,000	Worst flood in a century
China	1931	3,700,000	n.a.	1,400,000	Yangtze River
China	1939	500,000	n.a.	n.a.	Dam failure on Yellow R.
China	1989	2,000	2,789,000	100,000,000	Rains and typhoons in E. China
China	1991	1,040	5,800,000	134,000,000	Worst flooding in century; Anhui prov.
Laos	1966	300	15,300	70,000	Mekong Floods
Pakstan	1977	848	n.a.	777,000	Monsoon floods
Pakstan	1978	393	n.a.	2,236,000	Monsoon floods
Vietnam	1978	0	n.a.	4,000,000	Mekong Delta 1 million ha rice flooded

Descriptive Typology of Flood Hazards

Describing flood hazards in a massive region such as Asia is a formidable task. Physical causes and processes of flooding range from intense rainstorms and river discharge to coastal storm surge and human-induced watershed changes. Deforestation and land use intensification is widespread in montane and tributary catchments. An array of secondary physical processes include landslides, river channel changes, and debris flows. Human consequences include loss of life from drowning, flood-swept debris, infectious disease, and accidents. Animals, fish, and plants also suffer in various ways that depend upon their ecosystem context and the flood event. Economic damages include losses of agricultural production, shelter, infrastructure, and industrial production. They have complex temporal and spatial dimensions, which are linked with the situation at local, regional, and international levels. Responsibility for preparedness, crisis management, and adjustment is distributed among private, community, and government parties. Government responsibilities vary from country to country, with the only common trait being fragmentation and poor coordination among the agencies responsible.

In view of these many variables, we have chosen to organize this assessment in terms of the administrative level of flood hazard management. In this typology, emphasis is given to international programs followed by river basin programs, as indicated below:

A. International Flood Programs
    1. United Nations
    2. International Lending Organizations
    3. Regional Intergovernmental Organizations
    4. U.S. Bilateral
    5. International Non-Governmental Organizations
    6. Military
B. River Basin Problems and Programs
    1. The Ganges-Brahmaputra River Basin
    2. The Indus River Basin
    3. The Yangtze and Yellow River Basins of China
    4. The Lower Mekong Basin

This initial survey has two simple aims: to describe current programs, and to point toward more focused comparisons that might systematically employ the eight perspectives indicated on pages 10-11, above. The remainder of this chapter surveys international flood programs in Asia.

INTERNATIONAL FLOOD PROGRAMS IN ASIA

The international programs discussed below include those of specialized agencies of the United Nations; financial banks; and intergovernmental, non-governmental, and private voluntary organizations. Bilateral assistance programs involving the United States and international military organizations are briefly noted, though they have had a less sustained commitment to flood hazards research and assistance in recent years.

United Nations

The United Nations has numerous programs that bear directly or indirectly upon flood hazard reduction in Asia. At the most general level, the U.N. Department of Economic and Social Affairs and the U.N. Department for Technical Cooperation and Development have published international reports and proceedings on flood loss prevention and management (e.g., U.N., 1976). These publications often include case studies in Asia, but they rarely go into depth on the geographical pattern or context of flood losses, or make comparisons among basins, countries, or programs.

1. Recent U.N.-Sponsored Meetings. In 1992, an International Conference on Water and Environment was held in Dublin in preparation for the U.N. Conference on Environment and Development at Rio. One gets a fair sense of the importance attached to flood hazards, relative to other water issues, by reviewing country reports from the Dublin conference (Table 5). Aside from China, surprisingly little emphasis was placed on flood hazards in current water resources position papers. This neglect should raise concern, because the environmental value and damages associated with floods is a major factor in ecological and social well-being.

The U.N. Conference on Environment and Development at Rio de Janeiro in 1992 (UNCED) dealt with a very broad range of issues, including biodiversity, climate change, and forest protection. UNCED devoted little attention to flood hazards. The principal document from UNCED, known as AGENDA 21, briefly referred to floods in its chapters on mountain development, protection of freshwater resources, and climate change. Emphasis was placed on improving flood forecasting and warning systems, and assessing the potential flood impacts of climate change.

One of the most important U.N. initiatives at present is the International Decade for Natural Disaster Reduction (IDNDR). The Decade has organized regional symposia and programs related to meteorological and hydrologic hazards in Asia, particularly tropical cyclones, but to our knowledge the IDNDR has not stimulated regional investigation or comparison of mainland flood hazards in Asia to date (Bruce, 1993). Nor is it clear to what extent these international meetings lead eventually to practical action or policy implementation.

2. U.N. Regional Commissions—ESCAP. More substantial flood control efforts have been underway in the regional commissions of the U.N. especially the Economic and Social Commission for Asia and the Pacific (ESCAP). In fact, international scientific flood hazard assessments began on a sustained basis in Asia under the auspices of ESCAP and its predecessor agency ECAFE. Beginning in 1951, ECAFE published a Flood Control series, which continued up until 1963, when it was renamed the Water Resources series to reflect its joint concern for water resources and hazards. As early as 1955, the flood control series was

Table 5. Asian Country Statements for the ICWE, 1992

Country	Comments
Bangladesh	Discussion of climate impacts, but no discussion of flood hazards under current conditions!
Bhutan	No report available
Burma	" "
Cambodia	" "
China	Strong emphasis on flood hazards, which are described as the most frequent disaster in China. Emphasis placed on mitigation in the middle and lower reaches of 7 rivers and in 25 cities; reinforcing existing reservoirs; improving safety and security management; and soil and water management in smaller basins.
India	No discussion of flood hazards (rather, drinking water, irrigation and integrated development).
Laos	Country Report not available to us.
Malaysia	" "
Mongolia	No mention of flood hazards
Nepal	No mention of flood hazards
Pakistan	" "
Sri Lanka	Brief discussion
Thailand	" "
Vietnam	Brief discussion of Red and Mekong river deltas.

broadening to water resources planning. More recently, the trend is once again shifting, from water sector planning to environmental management.

Although this change in emphasis makes sense in some ways, it may indicate that flood hazard mitigation is receiving less attention. Recent publications, such as the *State of the Environment in Asia and the Pacific* (ESCAP, 1990) contain almost no information on natural hazards.

In 1989, ESCAP (1989) sent a questionnaire on water-related natural disasters to all of its member countries. It received responses from Afghanistan, Bangladesh, Indonesia, Lao People's Democratic Republic (PDR), Maldives, Myanmar, Philippines, Sri Lanka, and several Pacific island states. Most of the mainland countries of Asia did not respond to the survey!

Previously, ESCAP (1984, 1986) has convened expert group meetings to address improvements in risk analysis and typhoon-flood mitigation. Meetings have focused on the use of remote sensing techniques for flood assessment and management, as well as the requirements for sustained development and use of those technologies. ESCAP (1986) has also organized a meeting of experts on risk assessment related to typhoons and heavy rainfall, with particular emphasis on flood risk frequency and risk mapping.

Perhaps the most important regional program is the Typhoon Committee, which was organized in 1965 to deal with the frequent regional storm damages including flooding. The Typhoon Committee (ESCAP and WMO, 1984) has published systematic guidelines for the collection of damage information, as well as provide a regular forum and resources for forecasting, linkage with operational networks, and research. The Typhoon Committee's annual reports analyze specific storms as well as scientific and disaster preparedness programs. In 1990, the committee organized workshops and training courses on flood discharge measurement, storm surge forecasting, typhoon warning, remote sensing, flood forecasting and warning, and dam operations (ESCAP and WMO, 1991). There are several plausible explanations for the Typhoon Committee's success: first, it deals with a serious off-shore hazard beyond the control and sovereignty issues that affect riverine flood programs; second, it concentrates on forecasting and warning technologies of mutual interest to countries in the region; and third, it has continuing financial support from developed nations, both in Asia and the West.

Population and economic growth have contributed to rapid urbanization of floodprone areas and areas with poor drainage. In 1991, ESCAP published a volume focused on *Urban Flood Loss Prevention and Mitigation* (ESCAP, 1991), funded by the Government of Japan. Mainland Asian case studies included the cities of Kuala Lumpur, Bangkok, Hong Kong, Vientiane, Hanoi, and Benxi. The case studies used a common questionnaire and reported their results in a common format to facilitate comparison:

1. Topographical and climatic features
2. Population growth and urbanization
3. Flood problems
4. Flood loss prevention and mitigation
5. Government organizations related to flooding

In Phase II of its urban flood program, ESCAP plans to select four cities as pilot studies for more detailed flood hazard assessment and planning.

More recently, ESCAP (1991b) has issued a *Manual and Guidelines for Comprehensive Flood Loss Prevention and Management* based on expert group meetings from 1987 to 1990, funded by the UNDP "Programme support for the Typhoon Committee." The guidelines are drawn from a variety of sources within and outside mainland Asia (for example, the floodplain management program is based on that of New South Wales, Australia). Although broad in scope and based on general international practice, the guidelines give little attention to differences in approach followed in different regions.

3. World Meteorological Organization—WMO. WMO has several programs underway in Asia that are directly or indirectly relevant for flood hazards abatement. The Monsoon Experiment (MONEX) built upon previous Indo-Soviet (ISMEX-73) and WMO scientific initiatives aimed at modelling and observing systems for the entire monsoon region (WMO, 1987).

The most sustained flood-related program is the Tropical Cyclone Programme (TCP) run by WMO's World Weather Watch (WWW) and ESCAP (WMO, 1988). The TCP includes a technology transfer component and a regional component to develop forecasting and operational centers and to promote regional cooperation. The Typhoon committee publishes an annual review and has produced a *Typhoon Committee Operational Manual* (WMO, 1987).

WMO's Hydrology and Water Resources Programme, and more specifically its Operational Hydrology Programme (OHP), also runs workshops on coastal and river flood forecasting.

4. International Hydrological Programme—IHP. The International Hydrological Programme is coordinated by UNESCO. It has a regional office for South and Central Asia in New Delhi and for Southeast Asia in Jakarta (IHP, 1992). The IHP also has country offices in the mainland Asian countries of Pakistan, India, Nepal, Bangladesh, Thailand, Malaysia, Vietnam, China, and Mongolia. The IHP also launched a Humid Tropics Programme in 1992 with regional administrative centers. Its regional programs for South and Central Asia will include a workshop on coastal zone management with special emphasis on the Bangladesh experience.

5. The U.N. Department of Humanitarian Affairs (DHA)—Disaster Relief Organization (UNDRO). The office of the U.N. Disaster Relief Organization (UNDRO) was created in December 1971. Over the past 20 years, UNDRO has assisted flood-afflicted regions by sending relief assessment teams, coordinating international response, collecting and disbursing financial relief, preparing "situation reports" on a regular basis, and tallying country contributions for relief. In 1992, following a U.N. reorganization, UNDRO was incorporated into the new Department of Humanitarian Affairs (DHA). The organization publishes *DHA News* (formerly *UNDRO News*) on a bimonthly basis, which sometimes includes reports of regional flood and typhoon/cyclone conferences in Asia.

For example, the government of Japan supported an UNDRO-ESCAP joint regional meeting in Bangkok from February 11-15, 1991, that dealt with typhoons, and cyclones (NA, 1991). DHA-UNDRO co-sponsored an "International Workshop on Flood Mitigation, Emergency Preparedness and Flood Disaster Management" in Hanoi, Vietnam with UNDP and the Vietnamese government (proceedings forthcoming).

DHA-UNDRO also operates electronic information systems through the United Nations International Emergency Network (UNIENET), which include news services and disaster situation reports.

6. U.N. Children's Emergency Fund—UNICEF. UNICEF has the largest public health program related to disaster mitigation, but it has, with a few important exceptions, focused

on preventative medicine and human disasters (e.g., civil strife, war, refugee populations). One of the most important exceptions, however, is the provision of medicines, vaccines, and diarrheal control programs in Bangladesh, where flooding has generated outbreaks of waterborne disease.

7. U.N. High Commissioner for Refugees—UNHCR. Flooding is not a major cause of long-distance refugee movement, but in certain geographical circumstances displacement of floodplain occupants does spill over regional or international borders. Conversely, an influx of refugees places greater pressure on floodplain occupance. This latter process is occurring with Burmese Muslim refugees crossing the border into Bangladesh. Although not in the floodplain, per se, refugees do occupy cyclone-vulnerable areas near Chittagong (Dent, 1993). The U.N. High Commission for Refugees has in very recent years dealt with major refugee populations in Pakistan and Bangladesh, but flood vulnerability has not been a significant focus of this agency to date.

8. U.N. Development Programme—UNDP. The U.N. Development Programme provides financial support for many of the programs described above, but it does not have a clearly defined flood hazards program. In 1992, UNDP co-sponsored the "International Workshop on Flood Mitigation and Disaster Preparedness" in Hanoi (22-24 June 1992), the proceedings of which were not available at the time of this report.

9. The International Decade for Natural Disaster Reduction—IDNDR. The IDNDR has facilitated meetings and symposia publications on natural hazards that include a variety of flood hazards case studies in Asia. Additionally, the national committees of the IDNDR vary in their emphasis on different types of hazards. In the course of this study, we did not identify any major new initiative on flood hazards in Asia that was associated with the IDNDR. This preliminary observation may turn out to be incorrect because we did not systematically contact national committees or the IDNDR program office: the lack of well-published flood hazard initiatives associated with IDNDR, however, is not a promising sign.

Summary. The United Nations has been actively concerned with flood hazards in Asia from the early 1950s to the present. It has a wide range of programs with different emphases and accomplishments. As part of the IDNDR and post-UNCED processes, it

would be appropriate to systematically review these programs and to formulate a coordinated, long-term, and practically-oriented flood hazards program for the Asia region.

International Lending Organizations

1. The World Bank. The World Bank Environment Department has a natural hazards coordinator. Regional, sectoral, and mission offices of the Bank also address natural hazards problems on an ad hoc basis, but effectively, there is only one bank officer for all hazards in all member countries. According to that person, response to flood disasters does not follow a set procedure or method, but is instead contingent upon country requests. The Bank, for example, loaned some $40 million to the government of Pakistan for infrastructure repairs in Punjab after the 1988 floods (World Bank, 1989). Flood loan data were not readily available, however, from the World Bank.

2. The Asian Development Bank. The Asian Development Bank (ADB) provides a larger number of loans and grants to flood-affected countries (Table 6). The grant amounts have not been large. They total $US 5.5 million (<2% of loans), two-thirds of which was given to the Philippines in 1988 (ADB, 1992). Loans range in size from $US 5 to 115 million. The largest loans have gone to Pakistan and Bangladesh. It may be noted that ADB loans for flood reconstruction over the past two decades total $US 291.1 million. Economic damages in the 1992 flood in Pakistan alone were estimated at $US 1 billion.

In 1991 the Asian Development Bank published a useful volume on *Disaster Mitigation in Asia and the Pacific*. It included a case study of Bangladesh and a more general chapter on the role of the ADB in hazard mitigation. The ADB also published a more general volume titled *Disaster Management: A Disaster Manager's Handbook* indicating its expanding interest in the field (Carter, 1991). This represents an important step toward formalizing the role of international lending organizations in disaster mitigation, replacing what had previously been an ad hoc approach.

Summary. The international lending organizations have not yet applied their special expertise in project evaluation and economic analysis to flood hazards in Asia. Detailed economic studies of flood damages, the relative benefits of different reconstruction

Table 6. ADB-Supported Flood Loans and Grants

Year	Country	Loan Amount ($US MILLIONS)
1972	Indonesia	5.94
1979	Indonesia	39.0
1979	Maldives	25.4
1987	Pakistan	115.0
1988	Bangladesh	14.3
1991	Bangladesh	91.5
TOTAL		291.14
Year	Country	Grant Amount ($US MILLIONS)
1970	Indonesia	0.181
1977	Indonesia	0.150
1979	Indonesia	0.060
1984	Thailand	0.250
1986	Bangladesh	0.016
1986	Pakistan	0.300
1987	Indonesia	0.650
1988	Philippines	3.753
1989	Philippines	0.100
TOTAL		5.460

Source: ADB, 1992.

approaches, and the economic benefits of flood preparedness are high priorities, and fields in which the banks might make a special contribution.

Regional Intergovernmental Organizations

1. South Asian Association for Regional Cooperation—SAARC. SAARC was established in 1983 and remains, at the present time, a rather fragile regional organization with members from Bangladesh, Bhutan, India, Maldives, Nepal, Pakistan, and Sri Lanka. Although aimed at regional cooperation, it serves primarily as a forum for regular communication. According to Dasgupta (1992), natural disaster reduction is an officially recognized field for cooperation among the SAARC countries. SAARC did facilitate some

relief operations after the 1991 Bangladesh cyclone (Dent, 1993). More broadly, Dasgupta states that SAARC is attempting to integrate natural hazards reduction within a broader array of issues including sea level rise, climate warming, and environmental protection. The results of those "calls" for investigation and cooperation were not available at the time of this review.

2. Association of South East Asian Nations—ASEAN. The principal intergovernmental organization for Southeast Asia, ASEAN, was established in 1967. Its membership includes Brunei, Indonesia, Malaysia, Philippines, Singapore, and Thailand. Although its principal functions are political and economic, ASEAN has a longer history and greater stability than SAARC, and it has officially encouraged regional climate and hydrological hazard reduction programs.

3. Regional Specialized Meteorological Center. On a smaller scale, the Japan Meteorological Agency created a Regional Specialized Meteorological Center (RSMC) Tokyo-Typhoon Center in 1989 that provides scientific, technical, and forecasting services to Typhoon Committee members and the WMO.

U.S. Bilateral Programs

1. Office of Foreign Disaster Assistance—OFDA. OFDA is the principal U.S. agency responsible for monitoring and responding to disasters in Asia. It provides small-scale assistance in the form of grants, loans, and emergency supplies (generally on the order of $US 25,000). In addition, U.S. ambassadors are able to request emergency assistance in the countries where they are posted. OFDA's largest flood hazard program is in Bangladesh, and it is described later in this report. OFDA (USDS, 1979) has occasionally sponsored regional workshops on disaster preparedness in Asia, in which floods are considered.

Of the five disaster priority countries Asia listed in the *OFDA Annual Report* 1991, Bangladesh was the only non-island country. However, OFDA responded in 1991 alone to flood disasters in Bangladesh, Cambodia, Laos, the People's Republic of China, Afghanistan, Burma, and Sri Lanka (Table 7). To our knowledge, there has been no systematic international assessment of the geographic patterns, logic, or coordination of bilateral assistance for the full range of disaster events.

Table 7. OFDA Flood Assistance in Asia, 1991

Country	Amount
Bangladesh	$4,670,702
Cambodia	443,941
Laos	401,251
China	525,000
Afghanistan	25,000
Sri Lanka	25,000

USDS, 1991.

In addition OFDA is supporting the development of an international data base development program, called the International Emergency Readiness and Response Information System (IRRIS). Recognizing that deficiencies in electronic communication among disaster organizations have hampered rapid information sharing and response, the IRRIS program is at-tempting to develop common terminology, technologies, and data bases for rapid communication about the background information, disaster profiles, and responses in developing countries. In the U.S., a PVO called Volunteers in Technical Assistance (VITA) is involved in this electronic data base and disaster profile effort.

2. National Science Foundation (NSF) U.S.-Asia Engineering Conference. NSF has funded research on the physical, engineering, and social aspects of hazards. NSF has not dealt in any large or focused way with flood hazards in Asia. However, it has sponsored two U.S.-Asia conferences on Engineering for Mitigating Natural Hazard Damage in 1987 and 1992 (Karasudhi et al., 1987). The 1987 conference included 14 papers on floods, including one each on the Yellow River and Bangladesh.

3. Other U.S. Agencies. The U.S. Army Corps of Engineers, Tennessee Valley Authority (TVA), National Oceanic and Atmospheric Administration (NOAA), and U.S. Geological Survey (USGS) have contributed to many international conferences and exchanges in Asia, often under the auspices of OFDA (e.g. USDS, 1979) or the U.S. Agency for International Development (USAID). In 1989, a two-volume set of proceedings was

published from a U.S.-China symposium on flood forecasting. As in most workshops of this sort, technical papers focused on either the U.S. or China with no direct attempt to compare experiences or approaches.

International Non-Governmental Organizations

This sector was not surveyed systematically, and although intensively involved in flood response efforts, specific initiatives in Asia are not widely published.

1. International Red Cross/Red Crescent. Non-governmental organizations (NGOs) have played a variety of important roles in responding to Asian flood damages. Historically, the most active organizations have been the International Red Cross, based in Geneva, which has been active in flood relief in Asia for almost a century. Kaur (1992) briefly reviews the activities of the Red Cross in India (Indian Red Cross). The Red Crescent is active in Asian countries with large Muslim populations including Afghanistan, Pakistan, Bangladesh, India, Indonesia, and Malaysia.

2. Asian Disaster Preparedness Center. To our knowledge, the principal international organization focusing on hazards research, training, and information dissemination in the region is the Asian Disaster Preparedness Center, at the Asian Institute of Technology (AIT), Bangkok, Thailand (ADPC, 1992).

Scanlon (1990) describes the ADPC as the "one place with Asia-wide acceptance" and the only regional disaster training center in the world (p. 39). ADPC runs advanced training courses for disaster managers. In 1992-3 there were several training seminars on cyclone preparedness. ADPC maintains a disaster information library and has an association with academic departments at the AIT. A list of some 200 holdings on floods in Asia was available as of September 1992 (unpublished bibliography).

3. Clime Asia. The Bangladesh Flood Action Plan has given rise to, or a new focus for, scores of national non-governmental organizations in that country. Recently, a non-governmental organization involved in the Bangladesh Flood Action Plan has broadened its scope to include climate change in Asia, publishing a newsletter entitled *Clime Asia: Climate Action Network—South Asia.* It focuses, among other things, on flood hazards associated with climate variability and change.

4. Private Voluntary Organizations. DHA-UNDRO disaster situation reports indicate that many international PVOs have been involved in flood relief work in Asia. Those most often listed include Caritas and Care, which provide both contributions and relief workers. Religious organizations involved in relief include the American Friends Service Committee, Mennonite community, and Lutheran World Service. Lutheran World Service (India) Emergency and Rehabilitation Unit has published annual reports on its flood relief activities in India (ADPC, 1992). Unfortunately, we were not able to obtain ready information on the flood relief activities of these organizations for this report.

Military Organizations

Military organizations play an important role in disaster assistance in all of the countries discussed in this report. Although water and irrigation departments are generally situated in civilian sectors of the government (one exception is Iran), meteorology departments are often situated under the Ministry of Defence, as in Pakistan and other countries. Military units are often involved in emergency operations during disasters. They are often the best financed and disciplined organizations in government, though it is not clear to what extent their training includes civilian relief operations in different countries. The Pakistan military and provincial and local police departments, for example, have active though not comprehensive or fully coordinated roles in flood emergencies.

The U.S. military has in recent years provided transport, relief supplies, and emergency infrastructure for flood mitigation in Asia. In 1991, for example, the U.S. Marine Corps became involved distributing flood relief supplies to coastal Bangladesh when ships happened to be returning from the Persian Gulf war. On a more sustained basis, the U.S. Air Force and U.S. Navy operate a Joint Typhoon Warning Center (JTWC) in Guam to provide typhoon information in the North Pacific (ESCAP, 1989).

Walker (1992) has recently discussed the pros and cons of foreign military response to disasters, noting the recent example of U.S. military assistance in Bangladesh. Walker argues that NGOs should adopt a practical case-specific perspective on the pros and cons of military assistance.

RIVER BASIN PROBLEMS AND PROGRAMS

In this section we expand the brief descriptions of problems at the beginning of this report on recent flood losses and mitigation programs in the five case study basins.

THE GANGES-BRAHMAPUTRA BASIN

This river basin covers parts of five countries within and to the south of the Himalayan mountain complex: Bangladesh, Bhutan, China, India, and Nepal (Table 1). For international water management purposes, the principal "basin countries" are Bangladesh, India, and Nepal. Bhutan is a very small mountainous country that contributes a relatively small amount to basin discharge, and the section of China that lies within the basin is very sparsely populated. The upper reaches of the basin, on the northern side of the Himalayas, do not receive heavy monsoon rainfall; hence, any flood control measures taken in that region have limited value for the basin's downstream reaches.

The focus of the basin's flood problems are in the Bengal Plain of Bangladesh and India. There the Ganges, Brahmaputra, and Meghna Rivers meet to form a river two and one-half times the size of the Mississippi River in North America. Though the total area of the Ganges-Brahmaputra watershed is slightly less than one-half the area of the Mississippi Basin, it receives four times the annual rainfall as the latter basin, and approximately 85% of that rainfall occurs in the monsoon season (Rogers et al., 1989, p. 3).

A feeling for the immensity and power of this river system can be gained by a description of its dynamics:

> In a recent "normal" small shift of a lower combined section of the Ganges-Brahmaputra, the river moved its course east in a matter of days by half a mile in front of the port city of Chandpur in Bangladesh. It cut a new east bank channel about 45 meters deep, joining that land to its sediment load and carrying it out to the sea. No embankments or river-training works in the world can control these forces if they are taken head on.
> (Rogers et al., 1989, p. 3)

This large river deposits huge amounts of sediment from the Himalayas onto the Bengal Plain, making it extremely fertile. The plains have for centuries had a high population density, though not always in the coastal mangrove region. Rapid population growth in recent decades has brought the population of Bangladesh to over 115 million people today.

River embankments for flood control have been built in many areas of Bangladesh, but annual flooding continues to claim lives and result in substantial crop and property damage. One of the greatest natural disasters in recent history occurred in 1970 when a combination of coastal storm surge and cyclone flooding claimed an estimated 300,000 to 500,000 lives (USDS, 1991). Some historians regard disputes over the adequacy and urgency of relief by the West Pakistan government as a contributing factor to the political movement that culminated in the independence of Bangladesh in 1972.

The 1970 disaster led to several types of improvements: 1) a cyclone warning system; 2) construction of large cyclone shelters; and 3) construction of tubewells with UNICEF assistance to provide potable water supplies in the wake of flooding (Burton et al., 1978; Bennish, 1991).

Severe floods in 1987 and 1988 caused thousands of deaths and were internationally recognized as major human and ecological catastrophes, though as Brammer (1990a, p. 12) has pointed out, "there were compensatory increases in production in areas not affected by the floods and in the following dry season." Dent (1993) observes that these rainfall events had lower fatalities, and a more rapid rate of agricultural and infrastructural adjustment than those caused by major cyclones.

We begin our discussion of flood policy with a focus on Bangladesh and then consider related problems in upstream countries in the basin. National flood control in the Bengal delta was originally stimulated by a U.N. mission following the 1954-55 floods, and the formation of an East Pakistan Water and Power Development Authority in 1959. A master plan including flood control projects was prepared in 1964 but limited implementation occurred prior to the devastating cyclone and associated floods in 1970. As has been observed in many other contexts, the impact of extreme events is greatly increased in situations of civil conflict and governmental disintegration, as occurred in East Pakistan during the early 1970s. The newly independent country of Bangladesh instituted a flood forecasting and warning center under the Bangladesh Water Development Board, Surface Water Hydrology Directorate, immediately in 1972. The 1970 disaster did not, however, cause a major shift in the water sector plan of 1972 funded by the World Bank, which, in the wake of independence emphasized the expansion of irrigation programs.

The successive floods of 1987-1988, however, did spark a major set of studies and investment programs that are described below. The 1987-88 floods in Bangladesh led to several major international investigations, and to more expanded flood hazard reduction programs than the catastrophic floods of 1970. In 1989, the Government of Bangladesh (Ministry of Planning) and UNDP produced a *Bangladesh Flood Policy Study* (UNDP, 1989). The report summarized recent flood damages and flood policy options, and put forward a set of proposed policies, planning strategies and plan components. The report also noted that the warning network of 34 meteorological stations and 35 water level gauges still relied on telephone communication (UNDP, 1989). Indian storm data are transmitted by teleprinter from seven weather stations and four surface level stations, though there are some problems with the reliability and speed of international transmission. Radar imagery for cloud systems and storm movement is assessed qualitatively (this is also true in the Indus basin). According to the 1989 UNDP report, flood forecasting for major rivers relies on overly simple flood routing models, and the lead times for warning presently average about 72 hours.

Dent (1993) indicates that, in fact, 80% of the warning stations report by radio. Travel time for a river crest from the international border to Dhaka is about 72 hours, and it is not clear in light of existing constraints on bilateral cooperation to what extent communications policies and lead time can be improved. In addition, hydrodynamic river forecast models are used rather than the old flood routing models. The latter adjustment would no doubt be of interest in other parts of Asia.

In contrast with the operational hydrologic forecasting system, cyclone storm tracking and warning by the Bangladesh Meteorology Department is described by UNDP as very efficient. In addition, a less permanent Central Coordinating Committee for flood-relief related activities includes 12 government organizations, chaired by the Vice President of Bangladesh. Flood relief policies are guided by a 1984 Emergency Standing Order for Flood Relief.

At about the same time as the UNDP study, the U.S. Agency for International Development organized an American team that produced a report called the *Eastern Waters Study* (EWI) (Rogers et al., 1989). The EWI was notable for its balanced and sensitive

consideration of scientific, economic, and political dimensions of flood and drought problems in the Ganges-Brahmaputra system. Although it emphasized regional cooperation, it recommended against heavy-handed involvement by organizations outside the region. As a result, subsequent U.S. involvement in the Flood Action Plan, discussed below, was coordinated by the Irrigation Support Program for Asia and the Near East (ISPAN), which has links throughout the region but a national program office in Bangladesh.

These, and related investigations by French (French Engineering Consortium) (Michel et al., 1991) (*Prefeasibility Study for Flood Control in Bangladesh*), Chinese, and Japanese governments (*Report of Survey of Flood Control Planning in Bangladesh*), along with the World Bank led, in contrast, to a massive international water development program known as the Bangladesh Flood Action Plan (FAP). The FAP was organized by the World Bank, UNDP, and a consortium of donors for the period 1990-95 (Nicholas, 1990). It aims to clarify the nature of the flood problem and the range of choices that might be taken to alleviate it. As of 1992, the FAP had 26 parts including 11 "components" and 15 "supporting activities" (Table 8). As might be expected, this scope of work, along with the scope of all previous reports, includes a broad range of flood preparedness and response alternatives. On paper, the range of choice is unprecedented in international flood planning programs. Implementation will require several decades. As both a planning and investment program the FAP represents the world's most ambitious flood hazard program to date.

However, many critics have argued that FAP and Government of Bangladesh (GOB) policies are heavily skewed toward conventional structural embankment programs. Islam et al. (1991), for example, criticized the initial terms of reference (TOR) in a scientific task force report organized by the Government of Bangladesh, which led to some refinements in the TOR. International symposia have facilitated communication and criticism, as well as an expansion of the terms of reference, but the extent to which information dissemination or international meetings have facilitated material changes in policy and human vulnerability is not clear.

A study of the institutional aspects of the FAP prepared by Research and Advisory Services and funded by the Norwegian government noted that access to information by governmental and international agencies remained a problem during the Ershad regime

Table 8. BANGLADESH FLOOD ACTION PLAN COMPONENTS

1. Brahmaputra RB Strengthening
2. Brahmaputra Right Bank
   - Northwest Regional Study
   - NW diversion drain
   - NW interceptor drain
3. Brahmaputra Left Bank
   - North-central Regional Study
   - BL Embankment (N)
   - BL Compartment (N)
4. Ganges Right Bank
   - Southwest area water management study
   - Gorai Intake & GR embankment
   - SW and SC Drainage improvement
5. Meghna Left Bank
   - Southeast regional study
   - Gumti & SE drainage
6. Northeast regional study and rehabilitation
7. Cyclone protection project

8A. Greater Dhaka protection project
8B. Dhaka town protection and environmental improvement project.
9A. Secondary town protection schemes
9B. Meghna bank protection study
10. Flood forecasting and early warning project
11. Flood preparedness

Supporting Activities

12. FCD/I Agricultural review
13. Operation and maintenance study
14. Flood response study—active floodplain
15. Land acquisition and resettlement project
16. Environmental study
17. Fisheries study and pilot project
18. Topographic mapping
19. Geographic Information system
20. Compartmentalization pilot project
21. Bank Protection pilot project
22. River Training/AFPM pilot project
23. Flood proofing pilot project
24. River survey programme
25. Flood modelling-management project
26. Institutional development programme.

(Adnan, 1991a). Some government agencies have reportedly issued instructions to limit the distribution of technical information and have attempted to control reporting on the Flood Action Plan. Adnan's reports stand out for their human and institutional perspective on flood hazards, and for noting the special problems faced by women, children, and other vulnerable social groups. It is distressing to hear informal reports from a range of sources that principles of public participation, dissemination of scientific information, and priority for the most vulnerable social groups are still not fully embraced by politicians and bureaucrats. It is also disturbing if the largest international investment in scientific and policy studies and reports is not leading to dissemination within or among organizations in Bangladesh, and that comprehensive public library collections of the information produced are not being established.

The same Bangladeshi research group has published a regular series of reports from 1990 through 1992, with special coverage of the 1991 cyclone in Bangladesh in which a reported 140,000 persons died in one area, with more than 13 million people affected. Their reports include an analysis of institutional and social response and collations of newspaper clippings about the disaster (Adnan 1991a, 1991b, 1992a, 1992b). Vulnerability during the 1991 cyclone was attributed in a study of the Chittagong area to fear of burglary and disbelief of warnings (Haque and Blair, 1992).

At the same time, Bennish et al. (1991) note some progress in responses to the 1991 disaster, attributable in part to international programs (cf. Taylor, 1979). Oral rehydration therapy kits (consisting of salt crystals that are mixed with drinking water to maintain electrolyte balance) were distributed to counter the effects of diarrhea, and new tubewells were sunk in many areas to limit outbreaks of waterborne infectious disease. The figures reported in the months before and after the cyclone indicate the central importance of waterborne disease associated with flood events (Table 9). Twenty years earlier, flooding along with civil and military disaster, generated health crises of enormous proportion (Chen et al., 1973).

Financial assistance to the most recent flood disaster in Bangladesh is shown in Table 10. It gives a sense of the mix of international organizations that are actively involved in Bangladesh flood hazard response today.

Table 9. Reported Cases of Watery Diarrhea and Bloody Dysentery

Month	Cases reported by field workers
April	74
May	7,027

Source: Bennish et al. 1991, p. 17.

Table 10. Response to the 1991 Cyclone Disaster in Bangladesh (in $US)

International Organizations	
EC	12,195,120
	72,000,000
	30,000,000
FAO	800,000
LRCS	100,000
OPEC	100,000
UNICEF	2,523,000
WFP	1,500,000
UNDP	50,000
WHO	650,000
UNDRO	50,000
U.S. Bilateral	
OFDA	4,670,702
FFP	1,871,500
DOD	19,300,000
Other	2,014,000
Other Bilateral	
Australia	2,216,000
Austria	164,000
Burma	
Canada	2,522,000
China	2,000,000
Denmark	50,000
Egypt	
France	606,000+
Germany	3,081,000
India	5,700,000+
Iran	
Ireland	198,000
Italy	8,000,000
Japan	9,600,000
Korea	100,000

Table 10. Response to the 1991 Cyclone Disaster in Bangladesh (continued)

Nepal	100,000
Netherlands	8,200,000
New Zealand	5,120,000
Norway	367,300
Pakistan	6,185,000
Philippines	
Saudi Arabia	100,000,000
Sweden	3,461,000
Switzerland	494,000
Thailand	75,000+
UK	24,338,000

Non-Governmental Organizations

CARE/Australia	Red Cross and Red Crescent Societies
Caritas International	Secours Catholique
Corps Mondial Secours	South African Muslim Community
Medecins du Monde	World Council of Churches
Oxfam UK	

U.S. Voluntary Associations

Adventist Development and Relief Agency	Food for the Hungry
American Express Foundation	Lutheran World Relief
American Red Cross	Mennonite Central Community
AmeriCares	Save the Children U.S.
AMURTEL	World Concern
CARE	World Relief Corporation
Church World Service	World Vision Relief and Development

USDS, 1991

U.S. bilateral aid components of the Flood Action Plan include FAP14 (Flood response study), FAP16 (Environmental study), and FAP19 (Geographic information systems). These are supervised by the Eastern Waters Initiative of the Irrigation Support Project for Asia and the Near East (ISPAN), which has issued regular bulletins and technical reports on the program (Pitman, pers. comm., 1992; ISPAN, 1992).

An annual meeting of the FAP and interested groups in Dhaka in 1992 drew a very large public audience, estimated by ISPAN representatives to number 500 people. This group was roughly split between governmental representatives (favoring structural measures); and NGOs and members of the scientific community (who generally favored a variety of non-

structural approaches). Scientific writing on Bangladesh flood problems tends to support a mixed strategy (Rogers et al., 1989), though structural approaches are favored by some scientists (Khalil, 1990) and non-structural approaches by others.

The Bangladesh Flood Plan Coordination Organization has recently published *Guidelines for Project Assessment* to be used to assess the 26 FAP components, both in relation to one another and in relation to other sectoral investment alternatives. Impacts to be considered within the multicriteria assessment framework are: agricultural impact, fisheries impact, non-agricultural/fisheries flood damages, social impacts, and ecological impacts (Bangladesh FPCO, 1992).

Many non-governmental organizations have commented upon and sought to become involved in the FAP. Some have specialized concerns, while others are adamantly opposed to the FAP as presently designed. The Bangladesh Center for Advanced Studies stands out for its breadth of perspective as evidenced in a publication entitled *CYCLONE '91: An Environmental and Perceptional Study* (Haider et al., 1991). This study shifts attention from meteorological events toward the perceptions of survivors, the role of NGOs, print media, and relief administration—as a basis for decisionmaking about adjustment policies and infrastructure investment. The oppositional role adopted by some NGO's is partly a reflection of and partly contributing to poor communications and a hardening of opinion by government agencies.

As noted earlier, a large group of interested parties met in 1992 to discuss the progress, balance, and relative promise of the FAP program components (ISPAN, 1992). Dr. Saleemul Huq (1992) raised serious concerns about the seriousness of the environmental assessments required by the FAP. The customary divide between structural and non-structural solutions was also evident, but from ISPAN and other accounts it seems that the latter perspective was the prevailing view among scientists and planners, and that the heavy emphasis on embankments was favored by a declining but highly influential cadre of politicians and officials (ISPAN, 1992). To date, NGO's and grassroots organizations have not been able to gain full participation in the planning and implementation process.

Many flood hazards problems in eastern India are similar to those in Bangladesh, although the overall vulnerability is less and the national and state resources available for

adjustment is greater. At the national level, the Central Water and Power Commission and the Indian Meteorology Department have primary responsibility for all aspects of water resources planning. Specialized flood coordinating committees exist in both central and state governments. The domestic scientific establishment for flood hazards assessment and response in India is substantially greater than that in Bangladesh, though the FAP has increased scientific and agency capabilities in Bangladesh.

On the research side, a volume edited by Sinha (1992) includes several papers on cyclone hazards in India. Those articles reflect the historical emphasis on the natural phenomena and formal planning procedures and do not provide a detailed social, scientific, or policy perspective on the problem. However, India's research resources and capacity are considerable. India has published a *Flood Atlas of India* (India, Central Water Commission, 1987). Indian scientists also publish more scientific articles on floods than the rest of South Asian scientists combined (*Selected Water Resources Abstracts*, Indexes 1980-present).

Further upstream in the Ganges-Brahmaputra basin, there are perennial flash flood problems in the mountain catchments of Nepal and the Himalayan foothills of India. At one point, it was presumed that upstream deforestation in Nepal and the *terai* (foothills) region of India aggravated flood hazards in the Bengal delta. There is little question that deforestation worsens local flooding, erosion, sedimentation, and land degradation problems in the lower portions of mountain catchments and their foothills. However, Ives (1991) and others have argued that mountain-originating flood impacts attenuate rapidly downstream and do *not* constitute the major coastal flood hazards in Bengal. Kattelmann (1990) has challenged the evidence for increased flooding in upland watersheds as well.

U.S. OFDA (USDS, n.d.) flood assistance to the Ganges-Brahmaputra basin in 1988-89 included over $US 5 million to Bangladesh and $42,000 to India. These amounts included a diverse array of goods including cash, seed, blankets, transport, assessment team costs, medicines, and communication supplies and services. Substantial Food for Peace supplies were provided. It should be noted that OFDA grants are generally given in small amounts, e.g. $US 25,000. The Bangladesh flood relief was an unusually large amount from this agency (note, however, that other U.S. government relief expenditures of an ad hoc nature are sometimes provided).

To summarize, recent catastrophic flooding in the Ganges-Brahmaputra basin led in the late 1980s to international flood investigations and hazard mitigation programs on an unprecedented scale. Publications and activities of those programs have been only briefly described in this report, and a full assessment will have an unusually voluminous and varied body of evidence with which to work. The potential lessons for other regions—in terms of the types of materials available, the process of investigation and debate, and the problems of access to information and participation—deserve very close consideration.

THE INDUS RIVER BASIN

The Indus Basin is perhaps the world's most highly developed and regulated river system, with a history of massive inundation canals dating back four millennia (Wescoat and Leichenko, 1992). The present system of perennial canal irrigation was initiated in the 14th century and greatly extended during British colonization of the region in the late 19th and early 20th century. Expansion of irrigated area continues, though offset by salinity, waterlogging, and flood losses.

Flood hazards in the Indus Basin differ in many ways from those in the Ganges-Brahmaputra. Although intense monsoon storms do occur in the headwaters of the Sutlej and Chenab rivers, they are at the tail-end of the monsoon system and are increasingly offset by diversions in India. Although upstream storage and barrage regulation for flood control in the Indus basin is limited, the extensive water distribution system can distribute flood waters. Passage of floodwaters through the canal and drainage system causes extensive economic damage, but it may reduce fatalities and damage to major structures. Damaging floods occur less frequently and with less loss of life on the Indus, but the economic losses can nevertheless be substantial (Bhalme and Mooley, 1980). The most recent floods of September 1992, for example, were the worst floods in living memory in Pakistan. Floodflows resulted from torrential rains in the upper reaches of the Jhelum River in Kashmir, Azad Kashmir, and Punjab; discharging into the Indus mainstem and threatening the major earthen barrages on that river.

Although Mangla Dam is the second largest dam in the Indus system, with a storage capacity of 9.3 million acre feet (MAF), it was little match, volumetrically or operationally,

for the monsoon runoff. Reservoir operations and operating policy became the subject of several inquiries in the wake of the following events:

> On September 8th the water flow into the Mangla reservoir exceeded by a third what the dam could cope with. Its managers released a blast of water from the reservoir. A second wave hit Mangla the next day, forcing engineers to release three times as much as they had the previous day. Within hours, the river surged over its banks and engulfed the city of Jhelum, which lies at the foot of the dam. (NA, 1992)

Total damages were estimated at $US 1 billion, including $US 513 million in public infrastructure damages (UNDRO, 1992a). This tragic event vividly portrays the vulnerability of people in the Indus basin to flood hazards. By October 16, 1992, $US 11.3 million of assistance had been received through UNDRO, which is just over 1% of the estimated damages (UNDRO, 1992a; Table 11). Although inquiries into preparedness and management of the disaster have just begun, there is a familiar pattern of newspaper reporting in Pakistan that blames politicians, dam operators, and military units for losses and inadequate response. Dam operations personnel are subject to the usual pressures of maintaining a high reservoir pool for water supply and power production; conflicting reports about downstream vulnerability to different types and timing of emergency releases; and genuine concern about the consequences of actions taken without documented authorization through the full chain of bureaucratic command.

A similar pattern was observed four years earlier in the Punjab floods of 1988, when an intense monsoon storm in northwestern India caused flooding on the eastern tributaries of the Indus (i.e., the Ravi, Sutlej, and Chenab). Because this event involved India and Pakistan, accusations also went back and forth across the border about the adequacy of data transmission, warning, and response (Wilson, 1989).

The Indus Basin Treaty of 1960 provides for joint flood hazards preparedness, but, in fact, the Flood Forecasting Cell of the Pakistan Meteorology Department in Lahore relies upon a radar station at Sialkot and upon indirect data transmissions from India. This situation bears comparison with bilateral arrangements and procedures on the Ganges river, and represents a sensitive but important field for scientific and policy improvement.

Table 11. Sources of International Assistance for 1992 Indus Flood (in $US)

U.N. System	Amount
DHA-UNDRO	50,000
UNDP	50,000
UNICEF	400,000
WFP	FOOD
WHO	21,000
Governments	
Afghanistan	Helicopters
Australia	35,700
Bangladesh	52,000
Brunei	700,000
Canada	329,000
China	20,000
Denmark	40,000
Egypt	60,400
France	190,000
Germany	310,000+
India	n.r.
Iran	n.r.
Japan	1,000,000
Jordan	n.r.
Korea	30,000
Kuwait	n.r.
Maldives	25,000
New Zealand	27,000
Nigeria	100,000
Saudi Arabia	n.r.
Sri Lanka	tea
Sweden	327,000
Switzerland	250,000
UAE	n.r.
UK	911,000
USA	5,436,000
Intergovernmental	
EC	360,000
NGOs	
Caritas	170,000
Catholic Relief Services	280,000

DHA/UNIENET Situation Report No. 7, October 1992; n.r. = not reported.

The Government of the Punjab in India publishes annual flood statistics and is responsible for the dissemination of forecasts and warnings. Ramaswamy (1985) has reviewed the past 75 years of floods in India, including the catastrophic 1950 and 1955 floods in the Indus Basin tributaries in India. Sinha and Aurani (1984) have evaluated the warning system for cyclones in western India; and Prasad (1992) has analyzed the 1988 rainstorm that produced extensive flooding in the Punjab. Angry citizens murdered an engineer who was responsible for reservoir operations during the flood.

The Kabul River of Afghanistan is also tributary to the Indus Basin and has occasional flooding problems (Economic and Social Commission, 1989, 80-1). However, Afghanistan's Office of Disaster Preparedness (ODP) receives virtually no international assistance and is ill-equipped in terms of personnel, capital, and training to deal with these problems. In the wake of the recent war, reduction of foreign economic development assistance, and continuing civil strife, Afghanistan may be especially vulnerable to flood events.

Dissemination of flood warnings in Pakistan has historically been a weak link in the response system. For example, military decisions to dynamite flood protection bunds in one reach of the river in order to protect heavily populated areas is a drastic measure that is often taken with little or no warning to villagers in the rural areas affected. Flood warnings were historically sent to local police stations (thanas) that then haphazardly relayed the information to local people.

In 1978, Deutsch and Ruggles (1978) proposed that Landsat imagery be used for real time assessment of flood damages and risks, in a manner similar to the Mississippi system, but to our knowledge those techniques are not presently used. Remote sensing imagery, and detailed topographic maps of all sorts are regarded as sensitive; distribution in improving but still severely constrained; and maintenance of computer models and databases suffers from frequent transfers of personnel and inadequate budgets.

Majid (n.d.) describes current forecasting and warning practices, including the equipment and communications system at the Flood Forecasting Center in Lahore. Annual flood reports are prepared by the Center, and increased emphasis is being placed on telemetric communication for warning as well as forecasting. Government of Pakistan flood

protection policies are formulated by a Federal Flood Commission that is directed by a Chief Engineering Adviser in Islamabad (GOP, 1978).

Improving the warning system is a high priority, and is the focus of a study underway by the Delft Hydraulics Institute. But it is also a relatively small component of a more comprehensive and expensive scheme to build structural flood protection levees throughout the Indus main system (Chaudhri, 1981). This international flood protection program is being sponsored by the Asian Development Bank, and the engineering is a joint venture between NESPAK and Harza Engineers (Bhatti, 1990-92), which also prepared the 1978 Flood Protection Plan.

The upper Indus Basin, like the upper Ganges, has flood hazards distinct from those on the plains. Ice dam outburst flooding and landslides are relatively frequent on the Indus main stem and its upper tributaries. Hewitt (1982, 1985, 1989) has identified 29 major outburst floods that have occurred over the past 200 years, the most damaging of which was in 1929. A five-year study completed in 1989 on snow and ice hydrology in the Upper Indus basin began to assess these hazards in five glaciated sub-basins, and a follow-up study is underway (Snow and Ice Hydrology Project [SIHP], 1989).

Constraints on adjustment to upper basin flooding include a weak foundation of basic glaciological research in the Upper Basin, limited topographic maps, inaccessibility (both physical and political), large uncertainties in predicting glacial flood releases, and limited glacial data monitoring and forecasting.

The alternatives for flood damage reduction change as one proceeds downstream. As the river velocity decreases, so do its slope and drainage. Current government policy concentrates on levee protection schemes. Urban settlements and river regulation works are the top flood protection priorities. In the 1992 floods, for example, bunds in rural areas were dynamited by the military to protect major barrages and cities on the middle and lower Indus River. As in other aspects of water management in Pakistan, the upstream-downstream relationships between the provinces of Punjab and Sind are politically sensitive. Sind has, for many social as well as hydrologic reasons, been known as "the unhappy valley".

THE YANGTZE AND HUANG HO RIVERS OF CHINA

The Yangtze and Huang Ho rivers in China are notable for their size, their centralized control by governments for centuries, and their distinctive flood regimes. Construction of flood control dikes on the Yellow River dates back to the third millennium BC (Zezhen, 1983). The combination of large discharge, gentle slopes, heavy sediment loads, high population densities in the floodplains, and strong economic dependence upon these rivers has resulted in some of the largest flood disasters—and flood disaster reduction programs—in the world (ESCAP, 1991b; USDS, 1991).

Huang Ho (Yellow River)

Dikes constructed along the middle and lower Huang Ho have raised the riverbed elevation and lessened its slope (Yellow River Conservancy Commission, n.d.). In addition, the sediment content of the Yellow River is greater than that in all other major rivers of the world (Fuling, 1989). During the past 137 years (since the last major shift of the river) the river's bed has been aggrading rapidly because of silt deposition. These factors greatly increase the risk of catastrophic flooding in alluvial rivers.

However, there have not been catastrophic floods on the Huang Ho in the past half century. According to the Yellow River Conservancy Commission (YRCC), levees were deteriorating in the early 20th century (they were also purposefully breached during the struggles for power in the 1930s).

> In a period of 2,540 years from 602 BC to 1938, there were 543 floods recorded and 26 river course changes with the major 5 changes occurring in years of 602 BC, 11, 1048, 1128, and 1855, causing great disasters. (YRCC, 1991, II-11)

Snow and ice melt coupled with extreme rainfall events tend to trigger flooding on the Yellow River, but vulnerability has also been a function of the maintenance of the levee system, government capacity, and population growth in the north China plain. Following the stabilization of power under the People's Republic of China, sustained flood control works have been undertaken and the massive levee system greatly improved.

However, as the dikes along the riverbanks were raised, the riverbed in the lower reaches became some 3-5 meters higher than adjacent land behind the dikes (Ren and Shu-nan, 1989). Many people are dependent on the river for irrigation, and many bridges,

railways and other river crossing works continue to be constructed. Though Ren and Shu-nan (1989) conclude that the present channel could be securely maintained for an additional 100 years, addressing this precarious situation will be a huge challenge.

Greer (1979) describes in some detail the reliance upon traditional contracting and construction techniques for bank strengthening and enlargement—techniques that require enormous amounts of labor and governmental coordination. Naturally, modern earthmoving and engineering methods have also been integrated with these traditional labor practices in recent decades. According to Greer (1979, p. 112) flood control has been the most successful component of the Yellow River water management program. It should therefore be examined closely for aspects that might work in other regions of Asia.

International flood reduction programs in China have been limited in recent decades, primarily by political considerations. The Yellow River Conservancy District was created after the Boxer rebellion. China was granted the first and only flood protection initiative of the League of Nations in the 1930s, but that initiative was abandoned with the onset of the second World War. Exclusion of the People's Republic of China (PRC) from the United Nations in the post-war era effectively reduced China's participation in international flood programs, which raises questions about the advantages and disadvantages of autonomous development of national flood protection programs.

The Yellow River Water Conservancy Commission continued throughout the century, mobilizing thousands of laborers for "flood fighting" under the direction of the Yellow River Flood Prevention Headquarters. After independence, large dams and reclamation projects reduced certain types of flood hazards; and it is a matter of considerable pride that there has not been a major flood disaster on the Huang Ho since 1949 (Greer, 1979).

It worth noting, however, that in symbolic terms the Huang Ho retains its identity as "China's sorrow" (Xiaokang and Luxiang, 1991). A highly controversial television series titled *He Shang* effectively linked the vagaries and tumultuous cycles of the river with cultural and political-economic difficulties in modern China. As noted earlier, the lower reach of the Indus river in Sind is also known as an "unhappy valley," and no doubt portions of other rivers have similar cultural connotations. To our knowledge, these cultural

associations between natural disasters and human happiness have not been studied for their potential relevance to flood mitigation programs.

During the 1980s, several international conferences of Chinese and American scientists focused on flood hazards. The USGS and Chinese Ministry of Water Resources had a joint "Symposium on Extraordinary Floods" in 1985. A second bilateral conference dealt with flood hazards on the Yellow River, producing a conference volume that was intended to lead to continued collaboration, which did not materialize (Brush et al., 1989). The papers by Chinese and American scientists, though individually interesting, did not explore the prospects or challenges for comparative international research on flood hazards. The most recent bilateral "Flood Forecasting Symposium/Workshop", held in Portland, Oregon on March 29-April 4, 1989, concentrated on three common scientific interests: data collection; hydrologic models; and forecasting. To our knowledge, social and institutional aspects of flood hazards have not been addressed in such forums.

More recently, the World Bank has sponsored a Yellow River Economic Modelling study to be conducted by the Yellow River Conservancy Commission and Water Resources Management, Inc. (YRCC, 1991). That study is primarily concerned with water allocation and with water sector investment planning. In these respects, it follows earlier World Bank modelling efforts on the Indus basin, which focused entirely on the irrigation sector and included flood hazards exogenously in fixed reservoir operating rules and average crop production data that included some years where there were flood losses. According to the project inception report, the economic model for the Huang Ho will not include potential flood losses in the model's objective function.

Sharing of water resources information among government agencies at and between all levels is poor-a problem that seems to occur in bureaucracies everywhere. We did not find any published institutional analysis of the causes, consequences, or potential remedies for this problem in China.

Yangtze River

The Yangtze river experienced its most recent flood damages in 1991, the worst flooding in China in 50 years. Heavy rainfall in eastern China caused extensive flooding in the agricultural provinces of Anhui, Jiangsu, and Henan (as well as 15 neighboring

provinces). UNDRO estimates that 2,470 people died and 18.4 million were seriously affected (note that fatality estimates from different official and unofficial sources range from 1,000 to more than 6,000). Forty-four million of the 320 million people in the affected area suffered losses. UNDRO estimated that over 2 million houses collapsed and 4 million others were damaged (UNDRO Situation Report No. 6, 25 July 1991). Direct economic losses were estimated at $US 3.5 billion.

The Chinese government mobilized a massive response, described by the U.S. government as follows:

> The Chinese army, the Chinese Red Cross, and other local relief organizations were mobilized to combat floods, build dikes, drain flood waters, and deliver relief assistance. The People's Liberation Army and the China Armed Police deployed 360,000 troops, who worked with local citizens to provide relief. An additional 58 medical teams were dispatched to Anhui for relief and disease control, and over 80,000 medical workers were sent to fight the spread of water-borne diseases in the most affected areas (USDS, 1991b).

Red Cross societies in China and 11 other countries were particularly active in responding to this disaster, though it is noteworthy that, in contrast to the role of international NGOs in Bangladesh, most international NGO assistance was turned over for distribution and management to Chinese organizations.

Eighteen governments and seven intergovernmental organizations provided relief. As Table 12 indicates, the greatest contribution greatest contribution for financial relief came from Hong Kong, reinforcing the notion that the economic and political situation of each disaster and each country play a large role in the types of assistance that are delivered.

On the Yangtze River, the controversial Three Gorges Project has drawn renewed international attention with reports that the project will be implemented after decades of controversy, though it is not clear whether the project will receive international financial assistance (LaBounty, 1984; Boxer, 1988). The Three Gorges Project has flood control as a primary objective and hydropower as a secondary objective. The flood control benefits would be offset, however, by displacement of 0.5 to 2.0 million people and permanent destruction of riparian habitat. Dixon et al. (1989) suggest that the benefits are substantial and may outweigh the costs.

Table 12. International Response to 1991 Flooding in China

U.N. System	Amount ($US)
UNHCR (High Commissioner for Refugees)	50,000
Governments	
Hong Kong	77,000,000
Germany	4,700 MT rice
Italy	374,531
Myanmar	1,500 MT rice
Norway	144,080
USA (70 T blankets; and cash)	360,000
Non-Governmental Organizations	
Church World Service	5,000
German Red Cross	1,212,903
Swiss Red Cross	129,032
Private (Canada) 18,000 blankets	

Source: DHA/UNIENET Situation Report No. 7, 2 August 1991; MT = million tons

Summary

The Chinese record of structural adjustment and social mobilization, and the relatively low level of flood damages relative to physical vulnerability, raise important lessons for other areas of Asia. To our knowledge, no comprehensive appraisal of China's flood hazard reduction programs has been carried out or circulated among the international community. The role of China's strong central government in responding to recent Yangtze floods indicates the types of mobilization which are possible, though the level of government authority and control is not comparable in most other countries of Asia. While there is considerable published scientific research in China, only a limited portion of which has been translated (Management Office of Science and Technology, 1991).

THE LOWER MEKONG RIVER BASIN

The Mekong River begins in Tibet and flows through southern China and northeastern Burma before entering the lower Mekong basin. From there, the basin receives substantial

monsoon precipitation and becomes the principal physiographic river basin of mainland southeast Asia.

The Lower Mekong river basin also represents the most comprehensive effort to date to achieve international integrated river basin planning. Responsibility for planning and development of water resources in the Lower Basin is vested in the Mekong Committee. Formed in 1957, the Mekong Committee has made several important contributions in addressing the region's flood problems. The Committee consists of the four lower riparian states: Thailand, Cambodia, Laos and Vietnam. The upper basin riparians that have limited runoff and water development potential are not involved. Although flood hazards in the region are of lower magnitude than those in the other three case study regions, some areas of the basin suffer from such extreme poverty that any losses may be catastrophic compared with the resources available to address them.

The primary flood problems of the Lower Mekong occur in three areas: 1) the Vientiane-Nong Khai floodplain, 2) the area surrounding Cambodia's Great Lake, and 3) the Mekong Delta of Vietnam. In 1966, one of the larger Mekong floods of the past 30 years killed 300 people in Laos and affected 70,000 others (USDS, 1991). In 1991, Laos again suffered flooding along the lower Mekong that affected some 332,000 people and caused extensive agricultural damage. The European Community (EC), World Food Programme (WFP), OFDA, and Australian government gave financial assistance.

Floods might have resulted in more deaths and damages if not for the efforts of the Mekong Committee. The Committee has not been able to build large mainstream flood control structures that might encourage floodplain settlement, but it has operated a flood forecasting and warning system since 1970. That system is credited with saving lives and warning farmers of impending flood hazards (Thammongkol, 1986). Sharing of hydrologic and meteorologic data is important in this floodprone international river, and has not succeeded to the same degree in other parts of Asia. Forecasting and warning systems are regarded as the most important non-structural measure in many regions. Thus, lessons gained from the Mekong experience may be valuable for promoting similar programs in other international basins, such as the Indus and Ganges.

Despite extensive problems in the region, including the Vietnam war, Cambodian civil wars, and erratic international funding, the Committee has continued to function and maintain its engineering and planning capacity. Approaches to mitigation in the Lower Mekong are bound by legal statutes adopted by the riparian states. One of the most important of these documents is the "Joint Declaration of Principles for Utilization of the Waters of the Lower Mekong Basin," signed in 1975. Article 10 states that any "appropriation" of mainstream waters by a riparian state is subject to prior approval of the other basin states, through the Mekong committee. This agreement, along with financial and environmental constraints, has halted the Committee's early plans to build large mainstem reservoirs. Because flood control structures would presumably be designed to serve multiple purposes, including consumptive water diversions that would have substantial upstream and downstream impacts, no mainstem structures have been constructed to date.

Thus, the Committee's flood damage mitigation programs have concentrated on smaller-scale projects and operational hydrology that do not require large structures or capital investment. This has by no means been detrimental to flood hazard mitigation; on the contrary, certain types of flood hazards require a small-scale approach, and all flood hazards programs benefit from advanced operational hydrologic and meteorological capability (Jacobs, 1992). Large mainstem regulatory structures, coupled with effective floodplain management, might reduce flood hazards in some parts of the lower basin, but without floodplain management large structures encourage floodplain settlement and development and result in increased losses from low frequency-high magnitude events.

Flood problems vary considerably within the lower basin. The four riparians have a varied array of ecological, political, and economic circumstances that shape the hazards they face. Laos and Cambodia are two of the poorer nations in the world, with per capita incomes of less than $US 200, deteriorating public infrastructure, and limited governmental or institutional capacity for modern flood planning. In these circumstances, traditional flood hazard mitigation approaches, which to our knowledge have not been surveyed or taken into account by government planners, should be identified and supported.

Vietnam has slightly higher per capita income levels, and is more capable of economic growth due to its coastal location, potential trade position, government institutions,

high literacy levels, and agricultural resources. Vietnam hopes to implement a massive development program in the delta where several factors, including riverine and coastal floods, have reduced rice yields. Deltaic flood protection in monsoon Asia is an extremely difficult problem technically and ecologically, requiring substantial cooperation among the riparian states.

Thailand is by far the wealthiest of the lower Mekong states, with a well-developed system of financial, educational, technological, and scientific institutions. While the other riparians are regarded as developing countries, Thailand is one of a handful of rapidly-industrializing middle-income countries in the world. Thailand's two main interests in the Mekong are hydropower for industrial development and agricultural water supplies for the northeastern plains, the poorest section of the country. But Thai society also includes well-organized non-governmental groups that are adamantly opposed to both large river projects and land development schemes, for both environmental and human rights reasons.

Thailand's main flood problem occurs in the city of Nong Khai, located on the Mekong across the river from the Laotian capital of Vientiane. Flood problems arise in southern Thailand where flood response times are very short. Urban Bangkok also suffers from a combination of escalating flooding, drainage, and subsidence problems.

Government water planners in all of the basin states tend to emphasize revenue generating uses, especially irrigation and hydropower production, over flood preparedness and mitigation. However, the flood warning system of the Mekong committee is also supported. As Thammongkol and Ti (1990) state:

> In the short and medium-term, non-structural measures, such as hydrological forecasting, are cheaper and more practical . . . However, a forecasting system alone cannot be very beneficial unless it is tied to a system for spreading and disseminating forecasts. A comprehensive flood forecasting system, including plans for using the forecasts, might be one of the cost-effective measures in dealing with flood losses. (p. 3)

The Mekong Secretariat uses three flood routing models to generate its forecasts:

1. SSARR (Streamflow Synthesis and Reservoir Regulation) for the upper and middle reaches of the lower basin).

2. DELTA for the lower reaches of the Mekong delta (not including tidal effects).

3. TIDAL for the main channels of the Mekong estuaries, with tidal effects. Forecasting was first initiated in 1970.

Interestingly, the Lao People's Democratic Republic (PDR) was the only Mekong country to respond to the ESCAP questionnaire on flood hazards. As might be expected, flood damages were emphasized, especially those that occurred in the floods of 1966, 1971, and 1978. The Lao PDR receives assistance from the European Economic Community, UNDP, and Mekong Committee with structural and non-structural flood protection programs. National responsibilities are dispersed among the Department of Irrigation and Drainage, the Ministry of Agriculture and Cooperatives, and the Ministry of Posts and Transport—with a Central Coordination Committee responsible for both planning and relief.

The prospect for **long-term** flood damage preparedness and mitigation in the Mekong revolve around four major issues: 1) Cambodian conflict resolution; 2) consensus among environment and development groups in Thailand; 3) donor interest and financial support for the Mekong basin experiment; and 4) economic as well as political cooperation among the lower basin riparian states.

Despite these uncertainties, the Mekong approach stands out as a model for international technical and scientific cooperation in a region with recurring political and economic problems. Mekong planners are now collecting institutional and policy literature on other basins with the aim of improving its river basin management policies. Similar effort in the flood hazard field might prove helpful. With modifications appropriate to the changing international situation, advances in flood hazards planning, and different regional contexts, the Mekong Committee has many lessons to offer other countries in Asia. In our view, it has deserves continued support and close study as one model for international water resources management.

SUMMARY OF FINDINGS AND RECOMMENDATIONS

This study identified the major problems, international organizations, and programs involved in flood hazards reduction in Asia, and it reviewed the scientific literature published in English. Our principle findings and recommendations are:

1. Despite massive efforts to alleviate flood damages in Asia, floods continue to result in a large number of deaths and economic losses in the region. Some countries, such as Bangladesh, have escalating losses, while other ares such as China have had some successes. The explanations for these losses are complex and disputed, but they center around increasing settlement pressures in flood-prone areas (from the combined effects of population growth, social impoverishment, and ineffective or misguided policies), international lending policies which fail to thoroughly deal with environmental hazards, and in all but a few cases governments which cannot keep pace with the hazards their people face.

2. Although the organizations and scientific literature are substantial, there are reasons to doubt that they are being effectively utilized or that experience is shared among regions and organizations. The Mekong Committee, and more recently the Flood Action Plan organizations in Bangladesh, appear to have made the most effort to obtain information and expertise from other areas. There is less evidence that such information is sought or sent from the Indus basin; and there is almost no explicit evidence about whether and how the information obtained from one region is used in any other.

3. This lack of awareness might be understandable international organizations were not so heavily involved in most Asian flood programs; and they must bear substantial responsibility for inadequate dissemination of information and a culture which seems to operate more on the basis of conventional professional approaches than current scientific and technical information. Responsible officials must acquire, read, adapt, and disseminate the information which is available; and they must work against policies that limit the flow of useful information to and from non-governmental groups.

4. In the case of China, language barriers are significant. Translation of Chinese publications and research on Chinese flood hazard programs are high priorities.

5. In light of the populations and risks involved, and in light of the rich record of experiments in flood damage reduction in Asia, flood problems and trends need to be more closely analyzed and compared with one another.

6. Consistent "flood hazard profiles" would facilitate comparisons among countries and basins. Useful international data sets do exist, though they have problems that have been

widely discussed. More detailed data bases on both flood hazards and flood hazard information and expertise might reduce some of those problems.

7. A set of approaches for compiling data on flood hazards was outlined on page *** of this report, which would bring together information about flood events, responses, vulnerability, policy, and priorities.

8. Research on the cultural and political dimensions of flood hazards and flood hazard reduction remains a difficult challenge. However, the Flood Action Plan in Bangladesh will yield an unprecedented record of debate and inquiry that deserves close consideration for the broader insights that might be drawn. Among the many reasons that the FAP has generated this record of debate is the fact that numerous scientific and public organizations are involved, or are demanding to be involved. Their arguments and perspectives are being recorded and internationally disseminated to influence decisions, but the record of their efforts will have longer-term value for flood hazards research internationally. However, even in a well-documented case like the FAP, there is relatively little detailed evidence that has been published to date about the roles of religion, kinship and ethnicity.

9. All persons and agencies working on flood hazards in Asia need to become more familiar with the longer record of flood hazard adjustments in Asia. Those adjustments, especially as practiced by indigenous social groups, have received little attention in the scientific literature and almost no attention in the engineering, planning, and policy literatures.

10. Improved bilateral and multilateral technical and policy coordination among Asian countries is needed. Arrangements between India and Bangladesh bear close comparison with those between India and Pakistan. International cooperation on the Mekong indicates some potential lines of improvement.

11. Regional organizations—such as the Asian Disaster Preparedness Center, the Asian Development Bank, and ESCAP—might build upon their previous efforts and undertake a shared, yet major, role in coordinating the studies called for here, the dissemination of results, and the translation of results into material improvement for the peoples and environments of Asia. The ADB has taken a commendable role in shifting its emphasis from relief to preparedness and in publishing a practical materials.

12. The main regional needs would appear to be: detailed appraisals of what has and has not worked in different contexts; detailed appraisals of the transferability of lessons between regions; the free flow and use of scientific information; and what is currently referred to as "capacity-building" for governmental, technical, and non-governmental organizations.

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Appendix A

CONTACTS IN ASIAN FLOOD HAZARD MITIGATION PROGRAMS (ESCAP REGION)

INTRODUCTION

This section of the report includes persons and organizations contacted and/or identified in this study. Mr. Cengiz Ertuna, ESCAP, generously provided a list of members of the Typhoon Committee. Contacts are organized by country, international organization, and basin commission. Country contacts are listed alphabetically rather than by organizational category; the first reference is to the country representative or office listed in UNIENET, followed by specialized agencies. Although by no means comprehensive, this directory provides an initial starting point for flood hazards specialists in Asia. Additional information and corrections from readers would be appreciated.

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For U.S. natural hazards organizations see also: Hennig, L.M. (editor), 1990, *The Natural Hazards Data Resources Directory*, Special Publication No. 21, Natural Hazards Research and Applications Information Center. Boulder: University of Colorado.

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