

Indus Basin River System - Flooding and Flood Mitigation

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Abstract

The Indus Basin River System drains one of the largest river basins in Asia. Its main tributary, the Indus River, originates in Tibet in the northern Himalayas, snakes through Himalayan mountain ranges before appearing on the plains of Punjab in Pakistan. The river has a number of major tributaries of which Kabul, Jhelum, Chenab and Ravi Rivers are prominent. The river finally joins the Arabian Sea in Indian Ocean near the port city of Karachi. There are a number of barrages and several major dams constructed on this river system, which provides the backbone to one of the largest irrigation systems of the world. A number of major Pakistani cities and several rural communities are established along its banks. The river system is mainly snow-fed but during monsoons carries major floods. The floods are a regular phenomenon with losses running into millions. Fatalities due to flooding are also common. A number of flood control measures have been adopted to relieve the flood impact of the river. This paper describes the magnitude of the flood problem along with the measures adopted to deal with the adverse impacts of the floods. In this context, the flood forecasting system is described. A number of other possible flood mitigation measures are suggested along with the areas of improvements within the existing system.

Keywords

Indus; flood management; flood mitigation, Pakistan

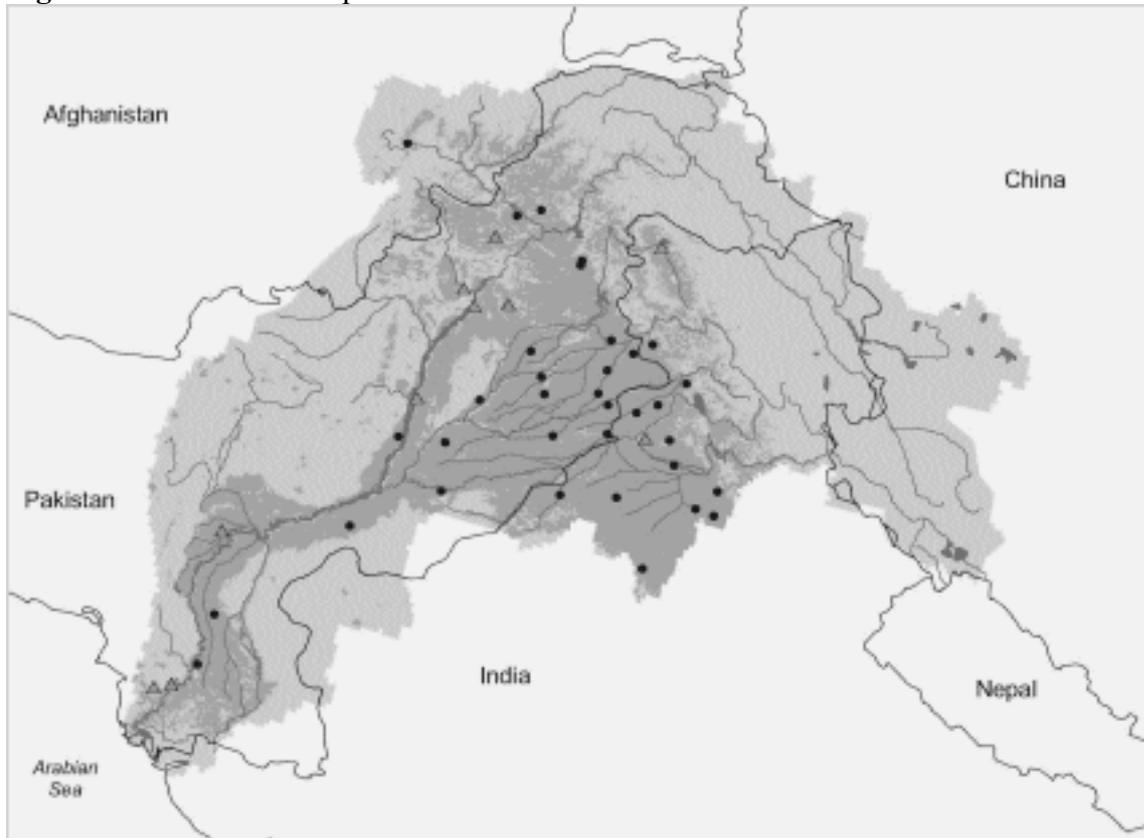
INTRODUCTION

The Indus Basin is one of the largest river basins in Asia with an approximate area of 1 million km². It extends over four countries in South Asia including China in the north-east, India in the east, Afghanistan in the north-west and the vast majority of the plains of the Punjab, Sindh and North West Frontier Province in Pakistan. 56% of the Indus Basin lies in Pakistan and covers approximately 70% of the country area (IUCN, 2005). The geographical location of the basin is shown in Figure 1. According to a 2001 estimate (UNESCO, 2001) the population of the basin is 150 million. However, a 1991 estimate places the population at 196 million (Fahlbusch et al., 2004).

The largest river in the basin is the Indus River with Chenab, Jhelum, Kabul, Ravi and Sutlej Rivers as major tributaries (Figure 2). The major component of the annual flow for these rivers is derived from snowmelt, originating in the Hindukush-Himalayan region. All of the Indus Basin rivers either originate or pass through India before flowing into Pakistan. A riparian dispute erupted soon after the independence of the two countries in 1947, which was settled in a landmark water sharing treaty brokered by the United Nations. This treaty, called the Indus Waters Treaty, was signed in 1960 and has withstood the test of numerous political conflicts between the two countries.

Although the Indus Basin River System spans a number of countries, the major flood impacts are almost entirely felt in Pakistan. This paper therefore concentrates on flooding issues related to Pakistan. The magnitude and causes of flooding are discussed followed by discussion on current flood management arrangements and possible improvements in the existing system.

Figure 1. Indus Basin Map



Courtesy: World Resources Institute

THE FLOOD PROBLEM

Economic damages resulting from annual flooding is a major burden on the country. Floods have wreaked havoc over the years, threatening country's vital agricultural and communication infrastructure, with damages worth Rs 225 billion (US \$ 4 billion) recorded for the ten largest floods since country's independence in 1947. Almost 8000 lives have been lost during these floods. A breakdown of losses for these floods is provided in Table 1.

Table 1. Major Floods of Indus Basin in Pakistan

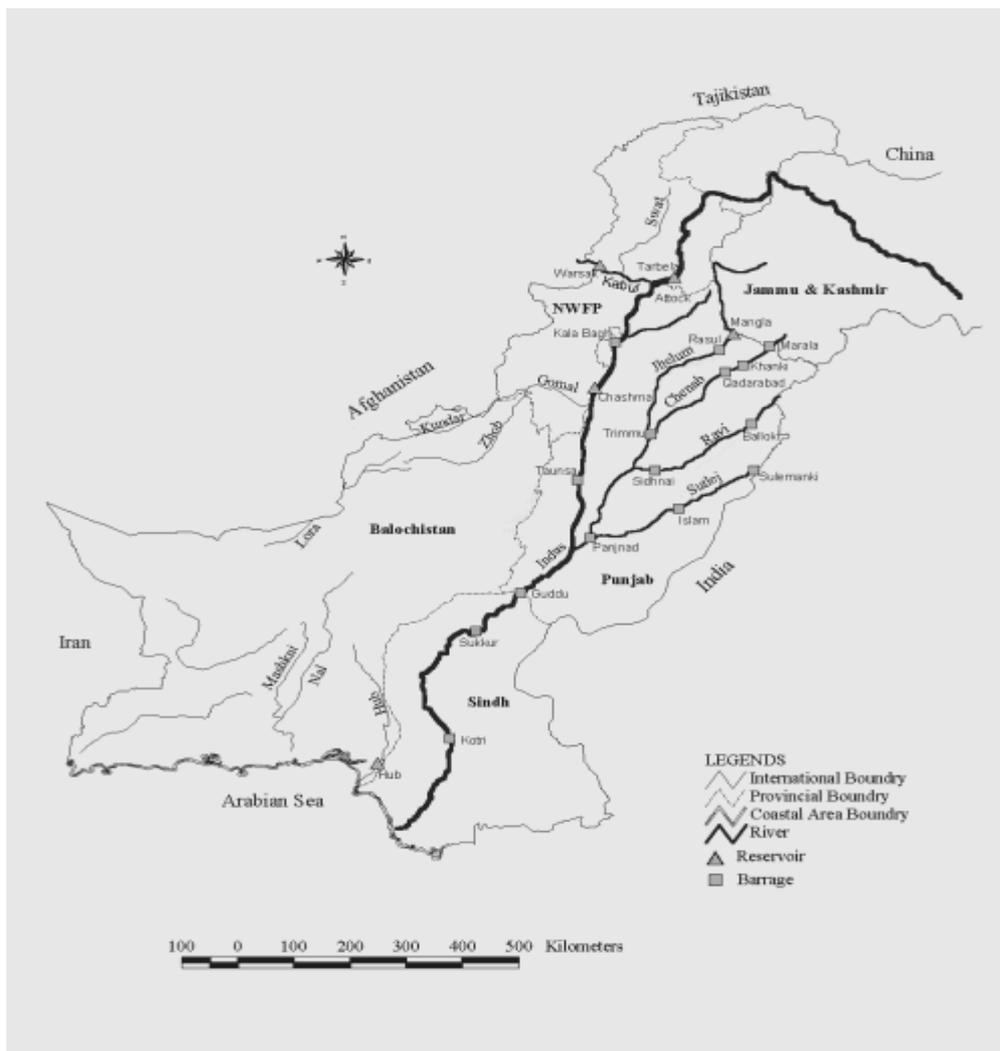
Year	Monetary Losses (Billion Rs.)	Lives Lost (No.)	Villages Affected (No.)	Area Flooded (miles ²)
1950	9.08	2,910	10,000	7,000
1955	7.04	679	6,945	8,000
1956	5.92	160	11,609	29,065
1973	5.52	474	9,719	16,200
1975	12.72	126	8,628	13,645
1976	64.84	425	18,390	32,000
1978	41.44	393	9,199	11,952
1988	15.96	508	100	4,400
1992	56.00	1,008	13,208	15,140
1995	7.00	591	6,852	6,518

Flooding causes massive damage to infrastructure facilities and agricultural lands in the country. The annual disruption in economic activity in many areas of the floodplain hamper steady socio-economic progress of the area. Loss of life and property in the flooding season is an annual phenomenon, diverting limited national resources to the flood relief operations.

FLOODING MECHANISMS

Generally major floods in the Indus Basin occur in late summer (July to September) when the South Asian region is subjected to heavy monsoonal rains. In the upper to mid reaches of the Basin, it is generally the tributaries like Jhelum and Chenab Rivers, which are the cause of flooding rather than the Indus River itself. Since many rivers are also snow-fed, an early monsoon may combine with peak snowmelt runoff to exacerbate flooding.

Figure 2. Indus Basin River System



The monsoon low or depression that causes intense rain develops either in Arabian Sea or Bay of Bengal. Major flooding is generally associated with the depression from the Bay of Bengal moving across India in west/north-westerly direction and then turning north at the border with Pakistan. Heavy rains occur due to orographic lifting at the high mountain ranges in the river catchments. Generally the heavy rainfalls are limited to the Chenab, Jhelum, Ravi and Sutlej River catchments, however, occasionally, the depression can cross further north into the Indus River catchment.

The intense rainfall in the catchments can produce exceptionally high flood peaks. The 33280 km² catchment of Jhelum River has produced three recorded floods in excess of 28000 m³/s (cumecs) in the last 75 years, with the latest one occurring in September 1992. To put these

historic floods in perspective, the estimated Probable Maximum Flood (PMF) for the river varies between 48000 to 70000 m³/s at the recording station.

Indus and other snowfed rivers are also likely to cause flooding due to a heat wave in early summer. This phenomenon recently occurred in June 2005 which was followed by early monsoon rains that caused wide spread flooding in the North West Frontier Province in the country.

Another likely flooding scenario that can come into play by heat waves is the bursting of glacial lakes, a phenomenon termed as Glacial Lake Outburst Flood or GLOF. A recent study (ICIMOD, 2005) found that of the 2420 glacial lakes in the Indus Basin, 52 lakes are potentially dangerous and can result in GLOF with serious damages to life and property. The study has also indicated that global warming can increase the potential of GLOF in the future.

Occasionally, floods have also occurred due to collapse of temporary natural dams formed by landslides or glacial movements.

FLOOD MANAGEMENT

Historic Perspective

The major floods of 1955 and 1956 in the early years of country's history did not create enough momentum for tackling the flood problem in the country primarily due to inadequate institutional arrangements. The unstable political climate combined with limited resources of the country also played a part in sidelining the flood problem.

Up until 1976, flood protection and management was the preserve of provincial governments. However, after the devastating floods of 1973 and 1975, it was realised that the existing arrangements for flood management were inadequate and a unified countrywide approach was required to manage the flood problem. As a result, the Federal Government established the Federal Flood Commission (FFC) in 1977 with a mandate to

- Prepare flood protection plans for the country
- Review and approve flood control / protection schemes prepared by Provincial Governments and concerned Federal Agencies
- Make recommendations regarding principles of regulation of reservoirs for flood control
- Review damage to flood protection works and review plans for restoration and reconstruction works
- Measure improvement of flood forecasting and warning system
- Prepare a research program for flood control and protection
- Standardise designs and specifications for flood protection works
- Evaluate and monitor progress of the National Flood Protection Plan implementation
- Monitor the provincial government's implementation of the national Flood Protection Plan. (The Federal Government to provide the resources for meeting the capital cost of the projects).

FFC is the leading institution for flood planning and control in Pakistan and soon after its inception prepared the National Flood Protection Plan in 1978. The plan envisaged reducing the flood losses, prioritising flood protection for areas of greatest economic risk, providing flood protection for areas outside the major floodplains ie. cities and vital infrastructure, improving existing flood protection facilities, etc. A second stage of the Plan was initiated in 1988. Under this plan, two major projects were envisaged, The Flood Protection Sector

Project (FPSP) Phase I and II. Phase I is complete and Phase II which was delayed due to funding shortage is currently underway. The emphasis in FPSP-II is to improve the flood forecasting process in the country.

Flood Forecasting

Historically the Flood Forecasting Division (FFD) of Pakistan Meteorological Department has undertaken flood forecasting and warning based on traditional methods and communication systems. Following the destructive floods of 1992, a comprehensive program for strengthening the flood forecasting and warning capability was initiated with the help of Asian Development Bank under the auspices of FFC. International expertise was sought to prepare a comprehensive Indus Flood Forecasting System (IFFS). Under this program, which is currently under way, weather radars were installed for rainfall estimation in upper catchments and a decision support system was developed for improved flood management. The program also emphasized the need for better communication among various government agencies/departments involved in flood management. This objective was achieved by acquiring and installing HF radio sets in various agencies/departments.

Better coordination among different departments was also a goal of the IFFS project. To achieve this goal, a Flood Warning Manual has been prepared that defines the tasks of various government departments in the event of flood emergency. The manual also spells out the measures that are to be undertaken by various departments for prompt and efficient management of flood events. An important aspect that has been addressed in the Manual is the dissemination of flood forecasts to the public in an orderly and coordinated approach to avoid confusion of statements being issued by various departments.

In addition, the improvement in Flood Forecasting System is being achieved by preparing computer models for the simulation of runoff from the rainfall data acquired in real-time and routing this runoff through the river system. These models are essential in providing the necessary lead time for activating the necessary flood management measures including evacuation.

Structural Measures

The flood management strategy has traditionally relied heavily on the provision of structural measures for flood containment. Structural measures include construction of embankments, spurs/battery of spurs, dikes/gabion walls/flood walls, dispersion/diversion structures, delay action dam, bypass structures and channelisation of floodwaters. Approximately 5,600 km of embankments have been constructed along major rivers and their tributaries in Pakistan along with more than 600 spurs to protect these embankments.

FLOOD POLICY

A number of provincial and federal acts drive the flood policy in the country. The major provincial acts are Punjab Irrigation Act 1873, Sindh Irrigation Act 1879, NWFP Act 1873, Balochistan Ordinance 1980, Punjab Soil Reclamation Act 1952, Water Users Association Ordinances 1981, Provincial Irrigation and Drainage Authority (PIDA) Acts 1997, etc. At the federal level the relevant acts are WAPDA Act 1958, Indus River System Authority (IRSA) Act 1992 and Environment Protection Act 1997. Additionally a Provincial Water Accord was signed in 1991 for apportionment of Indus River Waters between the four provinces.

A recent report on disaster management policies in Pakistan (WCDR, 2005) highlighted the following issues:

- Disaster management in Pakistan basically revolves around flood disasters with a primary focus on rescue and relief. After each disaster episode the government incurs considerable expenditure directed at rescue, relief and rehabilitation.
- Applied disaster management policy sometimes carries strategic biases that are aimed at protecting locations and infrastructure of greater economic, political and strategic significance at the cost of areas and communities with lesser influence and importance.
- Within disaster management bodies in Pakistan, there is a dearth of knowledge and information about hazard identification, risk assessment & management, and linkages between livelihoods and disaster preparedness. Disaster management policy responses are not generally influenced by methods and tools for cost-effective and sustainable interventions.
- There are no long-term, inclusive and coherent institutional arrangements to address disaster issues with a long-term vision. For instance, the Emergency Relief Cell is mandated to deal only with post-disaster scenarios.
- Disasters are viewed in isolation from the processes of mainstream development and poverty alleviation planning. Some of the large-scale development projects are bringing new forms of disaster and adding to the vulnerability of at-risk communities. The Left Bank Outfall Drainage (LBOD) project and link canals are significant examples in Pakistan.
- Disaster Management, development planning and environmental management institutions operate in isolation and integrated planning between these sectors is almost lacking.
- Absence of a central authority for integrated disaster management and lack of coordination within and between disaster related organizations is responsible for inefficient disaster management in the country.
- State-level disaster preparedness and mitigation measures are heavily tilted towards structural aspects and undermine non-structural elements such as the knowledge and capacities of local people, and the related livelihood protection issues.
- Disaster and relief departments and organizations largely remain under-resourced, untrained, and not given required importance within administrative hierarchy. A dedicated fund for disaster management at the federal level has never been a part of the overall development planning. The officials of two important organizations engaged in disaster management e.g. Emergency Relief Cell and Federal Flood Commission are not provided with adequate training. A great deal of uncertainty prevails among government employees about their stay in any disaster related organization / department, which contributes towards working with less interest and efficiency.
- Given the frequent incidence of floods during monsoon season the government has taken adequate measures for flood control and management down to district level. The Pakistan Army plays a significant role in flood management by providing search and rescue services and emergency relief in affected areas. Flood Commission commences flood fighting plans every year in April and monitors the discharge of water at strategically important barrages and dams, and maintains a regular interaction with all provincial governments in pre, during and post flood situations. The district, provincial and federal governments prepare flood fighting plans annually and ensure timely dissemination of early warning through indigenous and modern modes of communication.

National Water Policy

A Draft National Water Policy has recently been prepared that addresses all the water related issues in the country, including the flooding issue. The Policy provides a framework whereby flood management in the country can be improved through necessary institutional and legal reforms. The National Water Policy is a landmark document and can go a long way in

improving the whole gambit of flood management in Pakistan. It addresses most of the shortcomings identified in the above-mentioned report (WCDR, 2005).

The Policy acknowledges gaps in the existing policy framework and recommends rationalising various pieces of legislature to minimise overlap and redundancy. It proposes to create a Federal Water Commission incorporating FFC, part of Planning Wing of WAPDA and Office of the Chief Engineering Advisor. It also recommends replacement of various water related provincial acts with a simple unified law that enables clearer understanding and subsequent application of the law.

The Policy has been prepared on modern lines and emphasises all the necessary structural and non-structural measures for flood management. It emphasises the need of stakeholder participation in the flood management process and enhancing flood awareness in the community.

A step forward would be to acknowledge the floods as a 'resource' and harness the numerous benefits that are associated with the regular flooding. In this regard flood mitigation measures need to be developed that acknowledge the floodwaters as a resource and ensure that the best possible outcome is achieved in terms of socio-economic and environmental benefits in any proposed structural measures.

The Policy also recommends strengthening of information management and research in the area of flood management. In this regard the Policy calls for promotion and support of public and private research in the fields of weather forecasting, rainfall predictions and flood forecasting.

INSTITUTIONAL ARRANGEMENTS FOR FLOOD MANAGEMENT

Although flood management is the responsibility of the provinces, a number of federal departments are also involved with Federal Flood Commission acting as the coordinating body with all the provincial departments and technical agencies. A brief description of the role of various departments is provided below:

Flood Forecasting Division. The Flood Forecasting Division (FFD) of the Pakistan Meteorological Department plays a central role in the flood forecasting and warning in the country. The department sources hydrometeorological data from various national and international sources including satellite data to prepare flood forecasts, which are disseminated to various flood management and relief organisations.

Provincial Irrigation and Drainage Authority. The Authority plays a prominent role in flood management through planning, design, construction and maintenance of flood protection works. It also undertakes flow measurements at specific rivers and irrigation canal sites.

Water and Power Development Authority. The authority is the custodian of Tarbela and Mangla dams and undertakes the day to day reservoir management for irrigation flow releases. The authority helps FFD in providing rainfall data from telemetric rain gauge stations and flood data at various locations in the Indus River system.

Provincial Relief Department. The relief departments are headed by the Relief Commissioner who coordinates relief efforts during and after the floods. The Commissioner also undertakes flood preparatory actions such as inspections of flood protection measures and establishment of flood warning and flood relief centres at the local government level.

Pakistan Army. The army carries out search and rescue missions during the flood emergency. It also mobilises necessary resources to fill the breaches that often occur in the protective embankments during the flood events. Provincial governments provide the material support for its operation.

Emergency Relief Cell. The Emergency Relief Cell has been established in the Cabinet Division of Federal Government. The relief cell plans for major disasters including floods by stockpiling basic life necessities required by the population affected by the flooding.

Civil Defence Organisation. This organisation assist local administration / Army in rescue, evacuation and relief measures and provide personnel for flood management training in rescue and relief work.

Federal Flood Commission. Federal Flood Commission is the lead federal agency in providing the necessary institutional framework to support the provincial flood management measures. The Commission has been successful in modernizing the flood management policy of the country through two major projects, Flood Protection Sector Project I and II. The second project is currently underway and is expected to vastly increase the flood forecasting capabilities of the Flood Forecasting Division. In addition, further construction of embankments and spurs along major rivers will be undertaken under this project. The Commission has also been instrumental in preparing the National Water Policy.

In addition, the provincial departments of Health, Agriculture and Livestock, Food, Communication and Works and Planning and Development play an important role in flood management in the country.

CONCLUSIONS AND RECOMMENDATIONS

Flood management in the Indus Basin is a multi-dimensional process that demands intensive resources and requires efficient coordination between various government agencies. However, even advanced flood management systems are no guarantee against flood disasters as has often been proved in the more developed countries. Pakistan being an agricultural economy can ill afford to risk its agricultural infrastructure consisting of dams, barrages and irrigation canals, which can be under severe stress in major flood events.

Currently, the flood management policy of the country is more reactive than proactive in dealing with the flood issues. However, with the preparation of National Water Policy, the situation is likely to change with far reaching effects on the flood management process in the country. The National Water Policy provides the necessary legal and institutional framework to improve the flood management process in Pakistan.

Although the National Water Policy provides the necessary guidelines for flood management, there is a need for a separate national policy for flood management to deal specifically with the flood issues in the country. Such a policy may be called National Flood Policy that may outline the details of policy framework for flood management. It is worth noting here that a new paradigm in flood management that considers flood as a resource rather than a menace can be highly beneficial in achieving the environmental objectives of the government, which are set under various international conventions to which Pakistan is a signatory.

It is envisaged that the flood forecasting capabilities would be improved considerably under the second Flood Protection Sector Project being undertaken by the Federal Flood

Commission. The task of quantification of flood risk thorough detailed studies and subsequent measures required in minimizing the risk should be taken on priority basis.

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