FLOOD MANAGEMENT




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1. INTRODUCTION

Among all natural disasters, floods are the most frequent to be faced in India. Flood is a relatively high stream-flow that overtops the natural and artificial banks in any reach of a stream resulting in inundation of flood plains. Floods occur in almost all river basins of our country; however, they are more frequent and severe in Eastern and North-Eastern part of the country. As per the information published by different government agencies, the tangible and intangible losses due to floods in India are increasing at alarming rate. As reported by Central Water Commission (CWC) under Ministry of Water Resources, Government of India, the annual average area affected by floods is 7.563 million ha. This observation is based on the data for the period 1953 to 2000 with variability ranging from 1.26 million ha in 1965 to 17.5 million ha in 1978. On an average, floods have affected about 33 million persons during 1953 to 2000. There is every possibility that this figure may increase due to rapid growth of population and increased encroachments of the flood plains for habitation, cultivation and other activities. This calls for increased emphasis on flood management and regulating the various development activities in flood prone areas.

Flood management aims at providing a reasonable degree of protection against flood damage at economic costs. The total elimination or control of floods is neither practically possible nor economically viable. Hence, different methods of flood protection have been adopted in different states depending upon the nature of the problem and local conditions. These include structural and non-structural methods as well as the judicious combination of these approaches. Structural measures include reservoirs,

flood embankments, drainage channels, anti-erosion works, channel improvement works, detention basins etc. and non-structural measures include flood forecasting, flood plain zoning, flood proofing, disaster preparedness etc. In addition, flood management also calls for community participation.

For developing appropriate flood management measures, a proper understanding of factors affecting hydrological aspects of floods with regard to intensity and duration is necessary. In addition to the natural factors, understanding the effects of man-made changes (deforestation, flood protection works, dams, urbanization, etc.) on the flood hydrology of the catchment is also important for effective management of floods. The subsequent sections look into various causes of flooding and discuss the flood problems in India and different measures taken for their management. Future needs in flood management in India are also discussed.

2. CAUSES OF FLOODING

Floods are mainly caused by excessive rainfall in the catchment area. The magnitude and severity of floods depend upon the intensity and duration of rainfall. The inadequate capacity of rivers to carry large discharges during such events is mainly responsible for inundation of adjoining areas. The silting of river-beds and bank erosion further decrease the channel capacity to carry such large discharge thereby increase the chances of overtopping of river banks. In addition, other factors such as poor natural drainage in the flood prone area, cyclone and associated heavy rain-storms or cloud bursts, snowmelt and glacial outbursts as well as dam break flows also create flooding. Sometimes land slides (during earthquake) leading to obstruction of flow and

change of the river course are also responsible for flooding. Floods are also resulted by retardation of flow due to tidal and back water effects in costal areas. Following situations related to flood are reported by Rashtriya Barh Ayog:

(i) Streams carrying flows in excess of the transporting capacity within their banks, thus overflowing adjoining land.
(ii) Backing up of waters in tributaries at their outfalls into the main river with or without synchronization of peak floods in them.
(iii) Heavy rainfall synchronizing with river spills.
(iv) Ice jams or landslides blocking stream courses resulting in the backwater overflowing river banks.
(v) Synchronization of upland floods with high tides.
(vi) Heavy local rainfall.
(vii) Typhoons and cyclones, and
(viii) Inadequate drainage to carry away surface water with the desired quickness.

However, it is to be noted that the drainage characteristics of the basin determine the response of a basin to a given rainfall event, which is different for different basins. Even the response of a catchment changes with time i.e. the catchment characteristics are dynamic in nature.

3. FLOOD PROBLEMS IN INDIA

The flood problems in India vary from basin to basin depending upon the river system, topology of the place and flow phenomenon. However the main problems in India with respect to floods are inundation and drainage congestion. Being a vast country the flood problem in India may be visualized on regional basis and can be divided into four zones of flooding. These flood zones are as follows:

(a) Brahmaputra River Basin
(b) Ganga River Basin
(c) North-West River Basin
(d) Central India and Deccan River Basin

The flood-prone areas of India are shown in Figure 1.

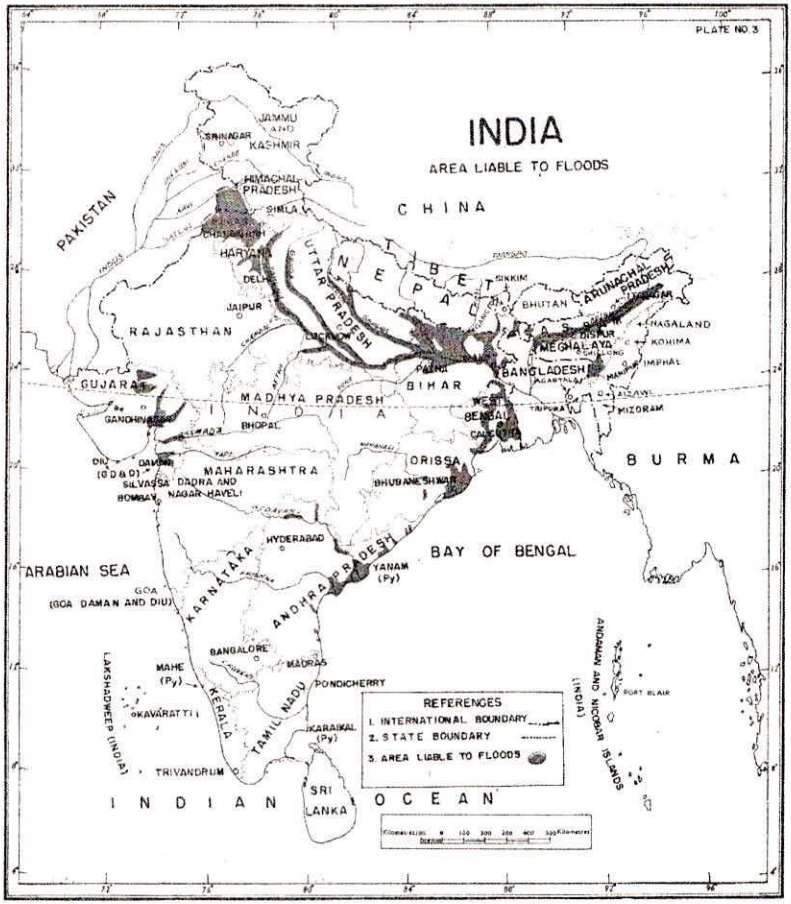

Figure 1: Flood-prone areas of India

The flooding problems in these four zones are summarized as follows:

Brahmaputra River Basin

The first zone belongs to the Brahmaputra and Barak river system. This covers the States of Assam, Arunachal Pradesh, Meghalaya, Mizoram, northern part of West Bengal, Manipur, Sikkim, Tripura and Nagaland. It is the highest rainfall intensity zone of the country and receives large amount of rainfall. Mousinram, (a village, 16 km west of Cherrapunjee) record the highest rainfall of about 1169 cm. Therefore, floods in this region are frequent and severe in nature. Important problems in this region are flood inundation, drainage congestion due to natural and man-made structures and change of river flow. In addition the region is subject to severe and frequent earthquakes causing numerous landslides, which upset the regime of the rivers. During flooding these rivers carry large amount of silt and have a tendency to change their courses. In Assam, the main problems of flooding are inundation caused by the spilling of the river Brahmaputra and Barak as well as their tributaries. In addition, the erosion along the Brahmaputra is a serious problem. In northern part of West Bengal, the river Teesta, Torsa and Jaldakha are in floods every year and inundate large areas. During flooding these rivers carry large silt and have a tendency to change their course. In Manipur the rivers spill over their bank frequently.

Ganga River Basin

The Ganga and its tributaries i.e. Yamuna, Sone, Ghaghra, Gandak, Kosi and Mahananda constitute the second zone. This zone covers Uttaranchal, Uttar Pradesh, Bihar, south and central part of West Bengal, Part of Haryana, Himachal Pradesh, Rajasthan, Madhya Pradesh, and Delhi. The normal annual rainfall of this region varies from about 60 cm to 190 cm. About 80 percent of this rainfall occurs during the South-West monsoon. The flood

problem is mostly confined to the areas on the northern bank of the Ganga river. The damage is caused by the northern tributaries of the Ganga by spilling over their banks and changing their courses. In Bihar, the floods are largely confined to the rivers of North Bihar and are an annual feature. Most of the rivers in this region spill over their banks causing considerable damage to crops. In Uttar Pradesh the flooding is frequent in the eastern districts mainly because of spilling of the Rapti, Sarada, Ghaghra and Gandak. In the south and central part of West Bengal, Mahananda, Bhagirathi, Ajoy and Damodar cause flooding due to inadequacy in river channels and tidal effects.

North-West River Basin

This zone comprises of basins of North-West rivers such as the Sutlej, Ravi, Beas, Jhelum and Ghaggar. The flood problem in this zone is relatively less in comparison of the above two zones. The major problem is that of inadequate surface drainage which causes inundation and water logging. At present, the problems in Haryana and Punjab are mostly of drainage congestion and water logging. The Jhelum floods occur frequently in Kashmir causing a rise in the level of the Wullar Lake thereby submerging marginal area of the lake.

Central India and Deccan River Basin

The important rivers in this zone are the Narmada, Tapi, Mahanadi, Godavari, Krishna and Cauvery. These rivers have mostly well defined stable courses and have adequate capacity within the natural banks to carry the flood discharge except in their lower reaches and in the delta area, where the bed slope is very flat. The lower reaches of the important rivers on the East Coast have been embanked. This region covers all southern States namely Andhra Pradesh,

Chhattisgarh, Karnataka, Tamil Nadu, Kerala, Orissa, Maharashtra, Gujarat and part of Madhya Pradesh. This region does not have very serious problems except for some of the rivers of Orissa (Brahmani & Baitarni, Subarnarekha). The delta areas of the Mahanadi, Godavari and Krishna rivers periodically face flood and drainage problems, in wake of the cyclonic storms. The silt deposited constantly by these rivers in the delta area raises the flood water level and the river often overflows their banks causing heavy damage. The small rivers of Kerala when in high floods often cause considerable damages. In addition there is also the problem of mud-flow from hills, which results in severe losses.

4. FLOOD MANAGEMENT IN INDIA

In India the systematic planning for flood management started with Five Year plans, with the launching of National Programme of Flood Management in 1954. The government of India has taken a number of steps for flood management. Some of the important policies on flood management include: policy statement (1954); high level committee on flood (1957); policy statement (1958); ministerial committee on flood control (1964); ministers committee on flood and flood relief (1972); working groups on flood control for five year plans; Rashtriya Barh Ayog; National Water Policy (1987); National Commission for Integrated Water Resource Development (1996); Regional Task Force (1996). These committees and commissions constituted by the government have given valuable recommendations on different issues of flood management. In the initial policy statement of September 1954 the implementation programme was outlined as follows:

(a) Immediate Phase (within two years)

(i) Embankment at related sites

(ii) Construction of spurs etc. for the protection of towns against river erosion.

(b) Short Term Phase (three to seven year)

(i) Embankments

(ii) Channel improvement

(c) Long Term Phase (eight to twelve year)

(i) Construction of selected storage reservoirs

(ii) Additional embankments wherever necessary

(d) Beyond Long Term Phase (after twelve years)

(i) Other long term measures

(e) Inter-se priority in the programme

Besides the programme indicated in the policy statement, flood warning and watershed management were also to be added as important measures. Subsequently, other committees and commissions both at official and Ministers level recommended implementation of the programme from time to time and gave proper directions for its success.

During various plan periods, different methods of flood protection, both long term and short term have been exercised in different states. Different structural measures through the construction of flood levees, flood walls, channel improvement, diversion schemes and reservoir have been taken for flood protection. In addition different non-structural measures have also been taken for flood management. These measures rather than aiming to mitigate the flood damage by trying to keep the flood water away from people strive to keep the people away from floods. In view of the cost effectiveness of the non-structural measures and their usefulness in managing the flood plains, the main thrust is now on the non-structural flood management measures. In addition, to reduce the impact of flooding at the time of flood or after the experience of flood, different

emergency measures such as evacuation, flood fighting, provision of relief and recovery, health measure, flood insurance are generally exercised in flood affected areas. These non-structural measures, which are being exercised are broadly classified under two categories.

(a) Modifying the Susceptibility to the Flood Damage
    (i) Flood Plain Zoning
    (ii) Flood Forecasting and Warning
    (iii) Flood Proofing
(b) Modifying the Loss Burden
    (i) Disaster Relief
    (ii) Flood Fighting
    (iii) Flood Insurance

4.1 FLOOD PLAIN ZONING

The basic concept in flood plain zoning is to regulate the land use in flood plains in order to reduce/restrict the damage potential of floods. For regulating the land use in different flood zones (as shown in Figure 2), the following priorities are envisaged:

First Priority

Important installation like Defense installations, Industries, Public utilities like Hospitals, Electricity installations, Water supply, Telephone exchanges, Aerodromes, Railway stations, Commercial centers etc. should be located in such a way that they are above the levels corresponding to 1 in 100 year flood or maximum observed flood levels. They should be above the levels corresponding to a 50-year rainfall and likely submergence due to drainage congestion.

Second Priority

Installation like Public institutions, Government offices, Universities, Public Libraries and Residential areas could be located above 25 year flood zones with the stipulation that they are built on stilts or far higher levels as indicated above

Third priority

Parks, Play grounds, Parking places could be located in areas vulnerable to frequent floods.

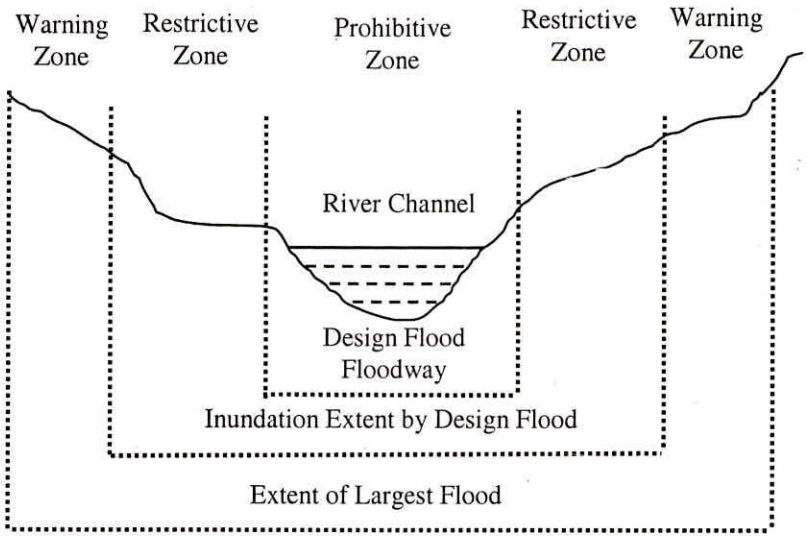

Figure 2: Flood-plain zoning

A model bill for flood plain zoning was circulated by the then Ministry of Agriculture and Irrigation (Department of Irrigation), Govt. of India, in July 1975 to all the State Governments advising them for enactment of legislation for regulating different activities in flood plains. In order to help the States to properly demarcate the flood prone areas according to various flow frequencies, CWC also initiated

(through Survey of India), preparation of flood risk maps to a scale of 1:15,000 with a contour interval of 25 cm. The matter is in different stages of consideration in various States.

4.2 FLOOD FORECASTING

The flood forecasting and warning is gaining increased attention of the planners and acceptance of the public as a nonstructural measure of reducing the flood damages. It involves estimating the future stages of flows and their time sequence at selected places along a river, during floods. This includes estimates (or predictions) of (i) maximum discharge and its time of occurrence (the crest of a flood hydrograph) and (ii) The levels expected at various points of time during rising and falling stages of flood in a river above the warning level. Based on this information different measures could be planned in advance to reduce the impact of the incoming flood. However, the utility of the forecast is dependent on its timeliness and accuracy. Different types of modeling approaches are currently in use to model the flood events depending upon the availability of the hydrological and hydro-meteorological data, basin characteristics, computational facilities available at forecast centers, warning time required and purpose of the forecast.

Considering the importance of flood forecasting and warning system in flood management, CWC has setup about 157 flood forecasting and warning centers to cover most of the flood prone interstate river basins in the country. These river basins are indicated as below.

(a) The Ganga and its tributaries.
(b) The Brahmaputra, Barak and their tributaries.
(c) West flowing rivers, the Narmada, the Tapi, the Daman Ganga, the Sabarmati, the Banas and Mahi.

(d) Krishna, Godavari and their tributaries.
(e) East flowing rivers, the Mahanadi, the Subernarekha, the Baitarni etc.

For improving the reliability of forecasts further (in term of accuracy and timeliness) modernization of existing networks has been taken up with the assistance of UNDP, USAID etc. Cooperative programmes with the friendly neighboring countries such as Nepal , Bhutan have also been taken up to provide better forecasts in these countries and also in India particularly for those rivers which originate from these countries.

4.2.1 Real Time Flood Forecasting

Since the formulation of the flood forecast is based on the hydrological and hydro-meteorologicai conditions in the upstream catchment, it is imperative that such real time information or data in the form of water levels, discharges, rainfall, runoff etc. relating to the base stations be made available to the flood forecasting stations through the quickest possible channel of communication. Any avoidable loss of time in the transmission of the data from base stations would reduce the lead-time to forecast and severely affect the other relief and rehabilitation works. Thus, it is important to observe the hydro-meteorological data in the upstream catchment on real time basis and make it available for suitable computations at the forecasting station in the quickest possible time. Development in the field of communication has played a vital role in better management of such monitoring and decision-making mechanism. The data collection and transmission network and computational procedure for real time flood forecasting have to meet the following:

(a) The observation stations should have suitable sensing instruments that can cope with highest and lowest observed variables or rates of variables with accuracy.

(b) The observed data should be transmitted to the forecast stations on real time basis, using reliable telecommunication linkage.

(c) Preliminary processing of such collected data to spot absurd values, errors in measurement and check continuity and consistency between meteorological and hydrological variables, using high-speed computers.

(d) Computer (Hardware) facility at forecast stations to carry out speedy and accurate computations

(e) Forecasting models (or software packages) calibrated at one point of time and updating algorithm for on line updating of these forecast models.

Thus, a forecasting and warning system should have a data network, an efficient transmission system, computational facilities and an analysis wing.

5. FLOOD MANAGEMENT: CURRENT STATUS

5.1 STRUCTURAL MEASURES

The Rashtriya Barh Ayog had assessed that an area of around 40 million ha was prone to floods in the country. However, due to topographical and economic factors protection against floods can be provided only to 32 million ha. The flood management measures undertaken so far have provided reasonable degree of protection to an area of 15.81 million ha. through out the country. The total length of embankment structures is about 16,800 km and drainage channels are of 32,500 km. A total of 1,040 towns and 4,760

villages are currently protected against floods. Major embankment projects taken up and completed are on the following rivers: Kosi and Gandak (Bihar), Krishna and Godavari (Andra Pradesh), Mahanadi (Orissa), Tapi (Gujarat), Lower Damodar (West Bengal), Brahmaputra (Assam). Barring occasional breaches these embankments have played important role in providing reasonable protection to the affected areas. A large number of reservoirs were also constructed in India during various five-year plans. These reservoirs have helped greatly in reducing the intensity of flooding downstream of reservoir.

5.2 NON-STRUCTURAL MEASURES

The response of the State Governments towards enactment of flood plain zoning bill is not encouraging. Major flood affected states have not considered such legislation. Main requirement for implementing the flood plain zoning, as an effective flood management measure is availability of Survey maps on suitable large scale to enable proper zoning of flooded areas. An area of about 55,000 km^2 of flood plains was surveyed against the total area of 100,000 km^2 identified by the States. These surveys cover areas along the Ganga, Yamuna, Ramganga, Roopnarayan, Jalangi and other flood prone rivers of West Bengal, tributaries of Brahmaputra, Sutlej and Ravi. In total, 570 maps were prepared. The working Group of National Natural Resources Management System (NNRMS) recommended flood risk zoning using satellite based remote sensing with a view to give thrust towards implementation of flood plain zoning measures in India.

Flood proofing measures taken in the past in India consisted of raising of a few flood prone villages. Under this programme, several villages in West Bengal, Uttar Pradesh

and Assam were raised. Flood forecasting and flood warning in India were commenced for the Yamuna River at Delhi in a small way in 1958. Over the years, the Central Water Commission has established a number of flood forecasting systems covering all major rivers and flood prone regions of India. Presently, the Central Water Commission is responsible for issuing flood forecast at 157 stations. Out of these, 132 stations are for water stage forecast and 25 stations are for inflow forecast. Inflow forecast stations are used for optimum operation of certain major reservoirs.

Ministry of Agriculture, government of India has prepared a contingency action plan for all natural disasters including floods. The relief Commissioner and Additional Secretary of the above ministry is the nodal officer at the center. He receives all information from States and other agencies from the affected areas. There is a National Crisis Management Committee (NCMC) with the cabinet secretary as chairman. There is also a Crisis Management Group (CMG) with Relief Commissioner as the Chairman. When situation is to be handled by NCMC, it gives necessary direction to CMG.

6. FLOOD MANAGEMENT: FUTURE NEEDS

Though there is a considerable progress in various flood management measures in India, the problems due to floods still persist. This is because flood plains in India are not being developed in a regulated manner. Therefore, flood management measures have to be more focused and targeted towards the decided goals within a stipulated time frame. A flood management measure needs the river basin as a whole to be considered as unit for integrated planning for optimum utilization of the resources. For flood plain zoning, methods have to be evolved in consultation of the local bodies so that

the legislation on flood plain zoning is adopted. As suggested by the Working Group of tenth five year plan, the possible apprehensions of difficulties in drafting a legislation should not become a bar to the idea of the approach of flood plain zoning itself. Flood forecasting constitutes one of the most important actions of flood disaster preparedness. Technical advancement in a well planned flood forecasting and warning system can help in providing higher lead time for timely action. It is well recognized that long term solution of flood problems lies in creating appropriate flood storage in reservoirs. The total live storage capacity of completed projects in India is about 174 km^3. A large flood storage space in reservoirs is required for a successful flood management programme. Flood management also calls for community participation. Farmers, professional bodies, industries and voluntary organizations have to be aware about flood management. People's participation in preparedness, flood fighting and disaster response is required. Media like radio, TV, newspapers can also play an important role in flood management. As India shares river systems with six neighboring countries viz. Nepal, China, Bhutan, Pakistan, Bangladesh and Myanmar; hence, bilateral cooperation for flood management is necessary for India and the concerned countries. The Government of India has taken some initiatives in this regard.

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