

Flood Problems

1.1 INTRODUCTION

In Webster's New International Dictionary, a 'flood' is defined as a 'great flow of water... especially, a body of water, rising, swelling, and over-flowing land not usually thus covered; a deluge; a freshet; an inundation'. Commonly, it is considered to be a phenomenon associated with an unusually high stage or flow over land or coastal area, which results in severe detrimental effects. 'Flood control' implies all measures taken to reduce the detrimental effects of flood.

There exist several types of flooding such as:

- **River Flooding:** This is the major cause of flooding extensive areas as a result of heavy rains in the catchment areas as well as local areas thereby increasing the river levels.
- **Flash Floods:** This results due to heavy rains in hilly areas which cause local rivers and small streams to rise to dangerous level within a short period of time say 6 to 12 hours. Heavy and continuous rains in local areas can cause flash floods.
- **Urban Flooding:** Local heavy rains up to 100 mm or more in a day over the city and larger towns can cause damaging and disruptive flooding due to poor or choked drainage and rapid runoff.
- **Strom Surge or Tidal Flooding:** This results mostly due to tropical disturbances, developing to cyclones and crossing surrounding coastlines. Cyclone induced storm surges have devastating consequences in coastal areas and such surge induced floods may extend many kilometers inland.
- **Floods Arising due to failure of Dam:** A large number of large and small dams are constructed to store water for various purposes. Due to poor maintenance and due to exceptionally high precipitation a severe flood may result causing failure of the dam. This causes a surging water front travelling with high velocity causing destruction of properties and loss of life.

Floods result from a number of causes as mentioned above. However, one due to heavy and prolonged rainfall is the most frequent one. For systematic studies it is necessary to classify such flood events as flash floods, single event floods, multiple event floods and seasonal floods. Flash floods have sharp peak, the rise and fall are almost equal and rapid. Single event floods have a single main peak and have more duration than flash floods. Multiple event flood are caused by more severe complex weather situations where successive flood peaks follow closely. The floods occurring during rainy season are known as seasonal floods. Excessive snow melt also results in frequent flooding in many countries. Floods not directly connected to rainfall may result due to failure of dam causing thereby sudden escape of huge volume of water stored in the reservoir. When a dam fails it causes severe flooding of the down stream areas resulting in heavy damages and loss of lives. Floods may also result due to landslides, which may temporarily block the water passage and later on gives away as a result of built up pressure etc. The landslides may trigger of due to tectonic movement of earthen surface or instability of soil mass.

2 Flood Control and Drainage Engineering

In nature, the problems associated with floods are diverse and extremely complicated. Floods inundate built-in property, endanger lives, and prolonged high flood stages delay rail and highway traffic. Further, it interferes with efficient drainage and economic use of lands for agricultural or industrial purposes. Due to high rate of flow or runoff from the catchment areas of the streams, there occurs large-scale erosion of lands and consequently to sediment deposition problems downstream. Floods also cause damages to drainage channels, bridge abutments, sewer outfalls and other structures. It further interferes with navigation as well as hydroelectric power generation. In short, floods cause severe strain and hardship to the civilised life of a community. Apart from loss of human lives, economic losses associated with the above combined effects, run to several thousands billions of dollars on a global basis.

Coming to our country India, flood is an almost annual feature of our life which is to a large extent due to its geographical location and its natural drainage system. The Indian peninsula presents striking contrasts of meteorological conditions as it faces severe floods and acute droughts. There is also the problem of unequal distribution of water both in time and space. Almost eighty per cent of the rainfall in the entire country occurs during the south-west monsoon which lasts from June to September. Whereas the annual average precipitation over the country as a whole is of the order of 110 cm, rainfall of the order of 25 to 40 cm in a particular day is not uncommon during the monsoon. The south-west monsoon causes most of the rainfall in the country and it moves in two main streams, one entering from the Bay of Bengal and the other from the Arabian Sea. The areas of heavy precipitation under its influence are the windward side of Western Ghats, the hills of Assam, the great Himalayan range containing the watersheds of the principal river systems of Northern India, namely the Ganges, Brahmaputra and their tributaries. Apart from the above, the tropical cyclone storms occurring in the pre and post-monsoon periods during the months of May, and October to December affect the coastal belt on the east and cause floods in the estuaries of the rivers Mahanadi, Godavari, Krishna and Hooghly.

1.2 INDIAN RIVERS AND FLOOD

All the rivers in India start in the high mountains. First, they have the stage called boulder stage and then they jump into the alluvial areas. And it is there that they cover most of the areas of the country. For example, the Ganga runs hardly 320 km in the hilly region but runs about 1600 km in the alluvial reach. Same is the case with many other rivers. The characteristics of these rivers which flow through the alluvial soil are most important for India, as well as for many other countries, especially because in the alluvial reaches these rivers cause damage by way of flooding extensive areas, waterlogging, prevention of the growing of crops and so on. Secondly, they meander, and take different courses, especially augmented by the sediment—huge amount of sediment is carried by which their behaviour becomes very erratic. Therefore, we are anxious to know the characteristics of these rivers and how to control them. For example, on account of floods during the year 1971—one of the worst years in India, the country lost by way of direct damages alone, something like 600 crore rupees; resulting in untold suffering to the people. Crops were lost, lives were lost, and so on. The flood problem is therefore, grave. Apart from this the other problem is the question of the behaviour of rivers, which tend to change. An important contributing factor is the sediment that is carried by these rivers, especially by Himalayan rivers. They carry a very heavy amount of sediment. For example, about 190 km (120 miles) from Delhi, the Ganga emerges out of the mountains. There is a canal constructed about 140 years back to irrigate about a million acres. That place is called Hardwar and the canal is called the Upper Ganga Canal. This is a magnificent irrigation work. It has removed famine since from the area and it has been in use from more than 120 years. But in 1970, due to some complex reasons, there was a landslide in

the hills, and the debris was carried by the river and the concentration of sediment was 3.6 per cent—usual average is about 0.3 per cent. With this high percentage of sediment, the gates of the canal were opened. The whole debris went into the canal and instantaneously the canal got filled up—11 km (7 miles) shoaling—becoming one solid block of sediment right up to the full supply level of the canal. And that spoiled the first crop, of a million acres. One could not supply water. The whole canal was completely filled with soil and then one had to take energetic steps, put in all labour, and all the machines that one could command, and it took six months to remove that material. This was about two million cubic metres of soil. It took six months because the soil was wet and it was very difficult to remove that sediment. At the end, nearly 15 million rupees were spent to remove the silt and, only after this one could give water for the second crop. Similarly the rivers under the Brahmaputra river system have their origin either in Sikkim or Bhutan, except for the Torsa which originates from Tibet before approaching West Bengal and, travels through Bhutan. These rivers drain the steep slopes of the Himalayas, where the copious downpour during monsoon causes occasional flooding of the rivers. During rains these rivers carry discharge much in excess of their channel capacity and bring down, colossal quantity of debris and sediment from the erodible outer ranges of the Himalayas. On emerging from the hills the rivers travel through steep slopes. Further lower down the slopes become comparatively flat and with decreasing velocity more and more silt and sediment are deposited. Frequent landslides also occur in the steep hills of the Himalayas during rains and they ultimately find their way into the river system, thereby raising their beds and choking their channel systems.

A study of the available statistics from 1953 onwards indicates that India suffered an annual loss of Rs. 365 crores as a result of floods between 1963 and 1981. In 1981–82 flood damage amounted to Rs. 1132 crores and the next year it was estimated at Rs. 1410 crores. The irrigation authorities have estimated that 80 per cent of the 40×10^6 hectares of flood-prone areas are protectable but only 12×10^6 hectares have been protected so far.

1.3 CAUSES OF FLOODING AND ECONOMIC LOSSES

With the Independence of India, flood control activities received considerable attention from the Government of India. This saw the creation of Central Water and Power Commission with the important task of formulation of the various multipurpose river valley projects, such as Hirakud Dam Project to lower the maximum flood levels in the Mahanadi Delta, Damodar Valley Project to cut down the flood peaks from about $28317 \text{ m}^3/\text{sec}$ to $7079 \text{ m}^3/\text{sec}$, Bhakra Dam Project on river Sutlej to achieve appreciable lowering of flood levels down below the dam. The Government of India has simultaneously instituted the River Commissions for the Brahmaputra, Ganga and other rivers.

The causes of flooding in all the major river systems, therefore, are more or less the same. They are: (a) spilling over the banks, resulting in flooding other areas; (b) bank erosion; (c) rising of river beds caused by deposition of silt; and (d) changing of the river course from time to time. Figure 1.1 indicates the regions in the country that are prone to frequent flood damages.

Generally speaking, a quantitative estimate of the losses is rather difficult to provide since the intangible component of the flood losses is a dominating factor. On an average several crore people are affected annually and a few hundred lives are lost. Besides, there occur huge losses from the death of domestic animals. Overall several hundred crores worth of property is lost which does not take into account the losses and privations arising out of break-down of communications, disruption of essential services, environmental deterioration, etc.

The expected annual damages are normally computed in probabilistic terms. The procedure followed includes routing of the reaches from the dam site to the downstream control point where the

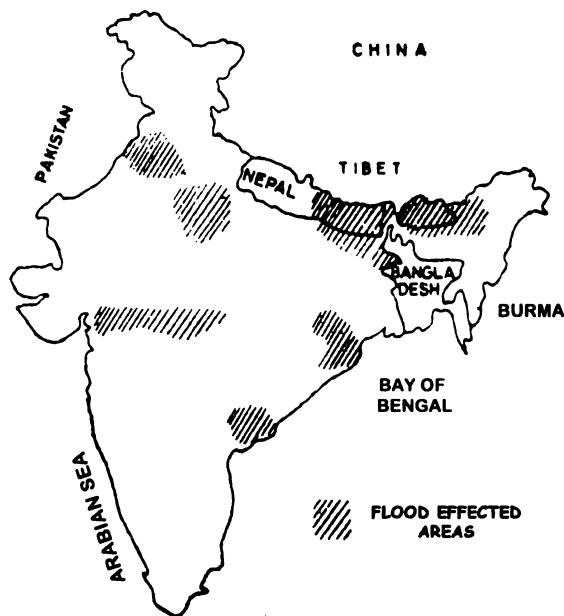


Fig. 1.1 Flood-prone areas in India.

computed discharge is converted to respective elevations using rating curve made at the control point cross section. The inundated areas corresponding to the computed elevation are marked on the map. Now a days this can be done with the help of data collected through remote sensing and GIS technology. An exhaustive survey is made in the delineated areas for the census of inhabitants, live stock, valuable properties including valuable agricultural lands and the important structures such as bridges, culverts etc. An assessment on the likely damages is made for several flood events and elevation vs annual flood damage curve is plotted. Using long term historical annual flood series a frequency analysis is carried out and probabilities are assigned to the above flood events observed at the control point. Then a plot between elevation and probability of exceedence is prepared. It is then converted to the plot between probability of exceedence and annual flood damages and non-dimensionalised using the potential damage. The probabilistic damage curve thus prepared is then used for making financial compensation decision by appropriate authorities.

Despite flood hazards mankind has always shown preference to settle near the reaches due to assured supply of water, facility of navigation and fertility of river valleys. A considerable portion of world population lives in areas adjacent to rivers and often becomes victim of misery due to devastating nature of floods. Floods are always a part of mankind's life throughout the history and extensive literature exists giving accounts of man's struggle to cope with this natural phenomena.

1.4 FLOOD MANAGEMENT MEASURES

Flood management measures can be classified as (i) short term and (ii) long term measures. The nature and extent of flood damages as well as local conditions determine the measures to be taken up. However short term measures are dependent for their effectiveness on long-term measures.

Short-term measures

These measures are adopted for giving quick results when immediate relief to some pockets or locations is felt necessary and they are respectively:

- Construction of embankments along the low level banks that are subject to frequent flood spells.
- Construction of raised platforms for temporary shelter during flood.
- Dewatering by pumps of flooded pockets, towns when gravity discharge of floodwater is not possible.
- Construction of floodwalls near congested areas of cities, towns and industrial belts.

Long-term measures

- Construction of storage reservoirs to moderate the flow peak thereby ensuring regulation of flood downstream.
- Integrated watershed management in the hilly area catchment, which ensures reduction in surface runoff, erosion and increase of infiltration capacity thereby reducing the impact of flood.
- Flood forecasts and warning based on hydro-geomorphological studies which can be given with some lead period, thereby ensuring minimization of property loss and loss of human life by shifting them to safer places.

1.5 FLOOD CONTROL STRATEGIES

To reduce losses due to flood the strategies to be followed can be stated as follows:

I. Modify flooding by structural means:

Herein the strategies to be followed involves construction of dams, dikes, levees, channel alterations, high flow diversions and land treatment. The main idea is to keep water away from the potential damage areas.

II. Flood forecasting: This is a non structural measure:

Here forecast of flooding is provided at the potential damage points. The population both human as well as livestock and the movable properties are shifted to a safer place if there is a chance of flood damage. Herein the objective is to keep people away from inundated areas.

III. Modify susceptibility to flood damage:

Regulations are framed to avoid undesirable or unwise rise of flood plains. Necessary steps are taken to modify the impact of flooding through individual or group action designed for assisting people in the preparatory, survival and recovery phase of floods which are namely through education and information on floods, flood insurance, taxation relief etc.

Structural Measures

The structural measures are aimed to mitigate flood damage by regulating the movement of flood water and these include:

- Dams, reservoirs and high flow diversions, their purpose is to store flood water temporarily or to divert it from the area to be protected.
- Channel improvement works to increase the carrying capacity of a river channel and to pass the flood water quickly through the channel reach.
- Embankments, levees and flood walls to stop the flood water from entering the areas to be protected.
- Catchment treatments to induce holding of water in the catchment temporarily.

Non-structural Measures

The main idea is to keep the general civil and industrial activities undiminished during flood which can be ensured by flood forecasting warning systems, flood regulation through zoning, emergency plans, modifying building codes, flood proofing, disaster preparedness and assistance.

Automatic rain gauge stations provide reliable picture of the rainfall events in the basin. Radar data provide details with regard to movement and dynamic characteristics of storms on a large scale. A useful input to the forecast is the meteorological satellite data. Real time forecasts are issued nowadays in many countries including India for important rivers. The data requirements for forecast are for flood arising out of rainfall: rainfall details, catchment details, river geometry, discharge, water, level.

1.6 ALLEVIATION OF FLOODING

It would thus be apparent that flood control is and will continue to remain one of the major requirements of a comprehensive water resources development project.

Voluminous and extensive literature is available on different methods of flood control. These can be divided mainly under the following categories:

- (a) Detention and storage or use of existing lakes or construction of a number of tanks in the catchments for the purpose of flood moderation.
- (b) Or ring bunds around important towns, properties and estates to prevent flooding.
- (c) **(i) Enlargement of existing channels or rivers:** Training of rivers to provide local protection at critical points from erosion, scour or flooding by spurs, revetment, dykes, etc. to form artificial cuts to lower the flood level and improve the river regime, widen and deepen the river bed artificially by dredging or by other training measures such as bandalling; groynes, etc.
- (ii) Construction of by-pass channels on rivers:** Natural or artificial flood diversion through subsidiary channels of the parent river or in another river system, to selected depressions, lakes, etc. with the aim of relieving intensity of floods in the main rivers. Flood water can also be diverted by constructing overflow weirs in the flood embankment at a predetermined flow stage.
- (d) By flood plain zoning which is purely an administrative measure.
- (e) By provision of spreading grounds.
- (f) By providing suitable drainage arrangement by installing pumping facilities which comes under drainage engineering.
- (g) Soil conservation measures in the catchments by various known methods.
- (h) Preparation of detailed action plans for mobilisation of the local resources for supervision of embankments during flood, flood relief works and other emergency measures. Further plan for collection of materials such as earth bags, stones, brushwood mattresses to reinforce or add to the protection works including mobilisation of local people for execution of such works.
- (i) Flood forecasting and warning system to keep alert all concerned people in advance and to take timely action for evacuation in case of impending danger.

The above methods can be used either singly or in combination. This, however, requires knowledge of the capabilities, limitations and relative advantage of such measure singly or in combination. Associated with this is an economic study to determine the potential damages averted by the projected works and whether the benefits justify the cost.

Finally this chapter ends by providing the reader the various methods of flood management in a nutshell as proposed by the National Commission on Floods, 1980.

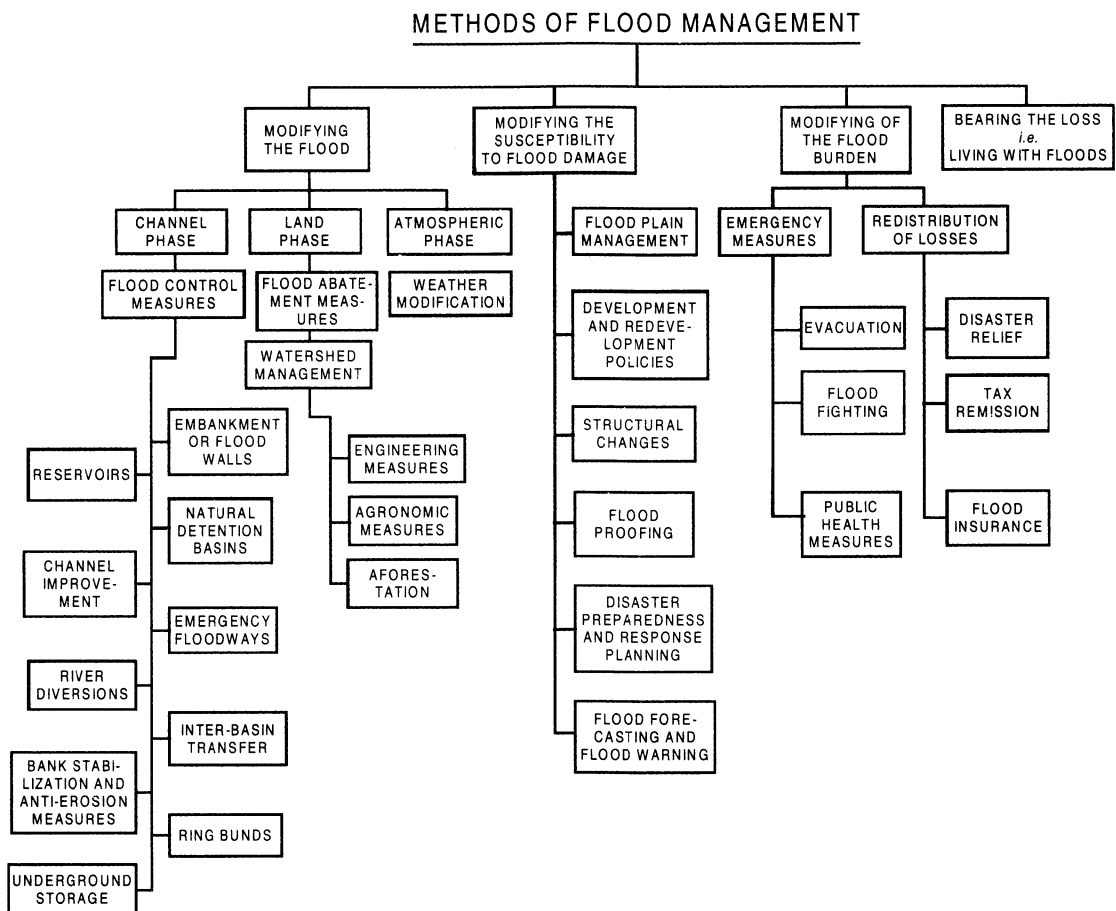


Fig. 1.2 Method of flood management (National Commission on Floods, 1980).