Module
6

MANAGEMENT OF WATER RESOURCES

LESSON 2

DROUGHT AND FLOOD MANAGEMENT

Instructional objectives:

On completion of this lesson, the student shall have learnt:

1. The consequences of abnormal rainfall – drought and floods
2. Drought and flood affected regions of India
3. Definition of drought
4. Tackling drought through water management
5. Flood management measures

6.2.0 Introduction

Water is the essential ingredient of life. Unless it is in balanced quantity, any deficit or excess, may cause physiographic imbalance. Similarly, for an entire region, too, deficit or excess of the normal requirement of water may cause imbalance in the regions physical, social, or economic situation. This chapter discusses the two crucial adverse effects of water imbalance: Droughts and Floods.

Since the beginning of the existence of mankind, drought has affected human activity throughout the world. Historical records of drought confirm the fact that it has occurred in almost every part of the world at sometime or other. Examples galore in the history to show that drought is the chief cause of most famines throughout the history of mankind. Many civilisations have perished due to abnormally long persistent deficiency of rainfall. Syrian Desert is one such example.

In India, drought is a frequent natural calamity which finds in all the great epics of the country. One of the earliest droughts in India has been referred in 'Vayu Purana'. In Ramayana also, there is description of drought during the period of king Dasaratha. In Mahabharata, there is mention of serious drought during the reign of Emperor Mandhata of the race of Iksvakus. Written records also give evidence of occurrence of several famines like the one which occurred about 160 years before Mahabharata war during the reign of King Shantanu, the ruler of Hastinapur. During the reign of king Trishanku, father of famous King Harishchandra, a famine is said to have occurred. King Chandragupta Maurya's reign was also witness to a serious famine.

In pre-Independence period, the large catastrophic effect of frequent droughts and famine caught the attention of the then British rulers in the nineteenth century when a series of famine commissions and an Irrigation Commission were setup to go into the various aspects of the problem and to suggest suitable measures to mitigate the distress of the people. Indian Finance Commission in 1880 has mentioned occurrences of severe famine and drought conditions in the then north-west province and Punjab. In 1942-44, the great Bengal famine occurred.

Despite tremendous developments in almost every field, drought continues to torment our society constantly. Even such areas which normally have sufficient precipitation to meet various needs of the area, are confronted with occurrences of drought of shorter or longer duration at sometime or other. According to an estimate, about 108 million hectare, which works out to about one-third of the total geographical area of 329 million hectare of the country, are affected by drought. It has been estimated that number of people living in drought prone districts is around 263 million which is more than 26 percent of the total population of the country (as estimated in the year 2000). Hence, a major part of our country is in the grip of this natural calamity in spite of crores of rupees being spent by the Government on drought combating measures every year. In view of its impact on a wide spectrum of social concerns, a proper understanding and scientific study of drought is extremely essential so that suitable and effective drought proofing measures are formulated in order to minimize or eliminate the adverse impacts of drought on the economy of the country.

6.2.1 Identification of drought and flood affected areas of India

Drought

Irrigation Commission of India in 1972 identified 67 districts located in 8 states and having an area of 49.73 million hectare as drought-prone. Subsequently, the National Commission on Agriculture in 1976 identified a few more drought districts. The drought identification studies carried out by Central Water Commission during 1975-82 considered 99 districts for the study located in 13 states having an area of about 108 million hectares which included those identified by the above two Commissions. For the purpose of study, a smaller unit viz., taluka, was adopted instead of district as a whole and the number of drought affected talukas were identified as 315 out of a total of 725 talukas in the 99 districts. Thus, out of 108 million hectare, only 51.12 million hectare spread over 74 districts can be considered as drought prone areas.

The criteria adopted for the above study was “Drought is a situation occurring in an area when the annual rainfall is less than 75 percent of the normal in 20 percent of the years examined. Any taluka or equivalent unit where 30 percent or more of the cultivated areas are irrigated, is considered to have reached a stage which enables it to sustain a reasonably stable agriculture and to be reasonably protected against drought”.

Attempts are being made to assess as to how much area has been made drought proof (as per the criteria of 30% or more of the cultivated area brought under irrigation with the irrigation facilities) made available to the people. State Governments are to be emphasised to supply this information to the concerned agencies. But it is a fact that lot of area in the country has been converted from drought to normal since the launching of a systematic programme of irrigation development from first Five Year Plan. Had there been no Bhakra Dam, lot of areas of Punjab and Haryana would have been still reeling under the severity of drought. Similarly, Indira Gandhi Nahar Pariyojana has helped in transforming severe drought prone areas of Rajasthan to areas of abundant greenery and general prosperity.

To cover drought prone areas, storage reservoirs have been created to supply drinking water to far – off distant places e.g. water from Sutlej and Ravi rivers are distributed to dry lands of Thar desert and to villages and towns located even 500 to 800 km away from the source, throughout the year. Otherwise the population of these villages would have suffered due to acute water shortages.

Rabi Cultivation is a gift of storage reservoirs which supplements the production of cereals in a big way. But for this, the country would have had to depend on import of cereals from other countries to supplement its demand. No world market can support the food shortages of India even of the order of 50 percent of food requirement. Self help and natural resource generation is the only solution for sustaining the large population.

Floods

Floods have also been a cause of misery for the country since ages. This is because, major habitation clusters like towns and cities been located near rivers since the beginning of civilization. Of course, for most of the cases, they were located much above the high flood level of the river but once a while a heavy rain caused flooding of these places as had been perhaps for Pataliputra (ancient Patna) by River Ganga or Indraprastha (ancient Delhi) by River Yamuna.

According to the India National Commission on Irrigation and Drainage (INCID), 'Flood' is defined as a relatively high flow or stage in a river, marked by higher than the usual, causing inundation of low land or a body of water, rising, swelling and overflowing land that is not normally covered under water. Further, the damage due to flood, or Flood Damage, may be defined as the destruction or impairment, partial or complete of the value of floods and services or of lines resulting from the action of flood water and the silt and debris that they carry. Flood damages arise primarily due to the occupancy of flood plains, which rightfully belong to the river. This is because the flood plains, so to say, are the playgrounds of a river. The flood plains are the playground of the river. Width of these playgrounds may be roughly four to six times the waterway of dominant discharge for meandering rivers. On the one hand, flood plains provide attractive location for various human activities, notably agriculture and transportation such as in Gangetic alluvial plains in U.P., Bihar, W.Bengal, Bangladesh. With increased economic development activities, more and more of the flood plains are getting occupied.

Flood plain occupancy can be costly and in some cases may lead to disaster. Once in a while the river may overflow its banks and exact a heavy toll of property damages, income loss, and perhaps loss of life as well. In densely populated developing countries of South Asia, South East Asia and China, means of sustenance are already limited and the toll exacted by flood disasters in the flood plains is especially heavy.

The annual precipitation in India, which is the source of water causing floods, is estimated at 4,000 BCM including snowfall. Out of this, the seasonal rainfall in monsoon is of the order of 3,000 BCM. The flood problem in the country is mainly due to southwest monsoon during the months from June to October. The average annual rainfall of India is about 1170 mm, of precipitation takes place in about 15 days and less than 100 hours altogether in a year. The rainy days may be only about five in deserts to 150 in the North East.

The average annual flow of the rivers of India has been estimated to be about 1869 BCM. The Brahmaputra and the Ganga rivers contribute the major part of these flows. The rivers carry major portion of their flows during the southwest monsoon period when heavy and widespread rainfall occurs. It is mainly during this period that floods of varying intensities are experienced in one or the other part of the country, bringing in their wake considerable loss of life and property and disruption of communication network.

Flooding is caused by the inadequate capacity within the banks of the rivers to contain the high flows brought down from the upper catchment due to heavy rainfall. Areas having poor drainage characteristics get flooded by accumulation of water from heavy rainfall. Flooding is accentuated by erosion and silting of the river beds resulting in reduction of carrying capacity of river channel, earthquakes and landslides leading to changes in river courses, obstructions to flow, synchronization of floods in the main and tributary rivers and retardation due to tidal effects. Some parts of the country mainly coastal areas of Andhra Pradesh, Orissa, Tamil Nadu and West Bengal experiences cyclones which often are accompanied by heavy rainfall leading to flooding. There had been a recent case of flood due to a super cyclone combined with heavy rainfall during October 1999 in the coastal belt of Orissa in India.

6.2.2 Characteristics of flooding in specific regions of India

The rivers in India can be broadly divided into the following four regions for a study of flood problems:

1. Brahmaputra River Region
2. Ganga River Region
3. Northwest River Region
4. Central India and Deccan Region

The flood situation in each of these regions are described in the following paragraphs.

Brahmaputra River Region

This region consists of rivers Brahmaputra and Barak and their tributaries and covers the States of Assam, Arunachal Pradesh, Meghalaya, Mizoram, Northern parts of West Bengal, Manipur, Tripura and Nagaland. Catchments of these rivers receive very heavy rainfall ranging from 110 cm to 635 cm a year which occurs mostly during the months of May/June to September. As a result flood in this region are severe and quite frequent. Further, the rocks of the hills, where these rivers originate, are friable and susceptible to erosion and thereby cause exceptionally high silt charge in the rivers. In addition, the region is subject to severe and frequent earthquakes, which cause numerous landslides in the hills and upset the regime of the rivers. The predominant problems in this region are the flooding caused by the spilling of rivers over the banks, drainage congestion and tendency of some of the rivers to change their courses. In recent years, erosion along the banks of Brahmaputra has assumed serious proportions.

Considering the individual States in the region, main problems in Assam are inundation caused by spilling of the Brahmaputra and the Barak and their tributaries and also erosion along the Brahmaputra river. In northern parts of West Bengal, the Teesta, Torsa, Jaldhaka and Mahananda are in floods every year and inundate large areas. These rivers also carry considerable amount of silt and have a tendency to change their courses. Rivers in Manipur spill over their banks frequently. Lakes in this territory get filled up during monsoons and spread over large marginal areas. In Tripura, there are problems of spilling and erosion by rivers.

Ganga River Region

River Ganga and its numerous tributaries, of which some of the important ones are Yamuna, Sone, Ghagra, Gandak, Kosi and Mahananda, constitute this river region. It covers the States of Uttar Pradesh, Bihar, South and central parts of West Bengal, parts of Haryana, Himachal Pradesh, Rajasthan, Madhya Pradesh and Delhi. Normal annual rainfall of this region varies from about 60 cm to 190 cm of which more than 80% occurs during the southwest monsoons. Rainfall increases from west to east and from south to north.

Flood problem is mostly confined to the areas on the northern bank of Ganga River. Damage is caused by the northern tributaries of Ganga by spilling over their banks and changing their courses, inundation and erosion problems are confined to a relatively few places. In general, the flood problem increases from the west to the east and from south to north. In the Northwestern parts of the region, there is the problem of drainage congestion. Drainage problem also exists in the southern parts of West Bengal.

Flooding and erosion problems are serious in the States of Uttar Pradesh, Bihar and West Bengal. In Rajasthan and Madhya Pradesh, the problem is not so serious but in some of the recent years, these States have also experienced some incidents of heavy floods.

In Bihar, floods are largely confined to the rivers of North Bihar and are, more or less, an annual feature. Rivers such as Burhi Gandak, Bagmati, Kamala Balan, other smaller rivers of the Adhwra Group, Kosi in the lower reaches and Mahananda at the eastern end spill over their Ganga in some years causing considerable inundation of the marginal areas in Bihar. During last few years, erosion has also been taking place along Ganga and is now prominent on the right bank immediately downstream of the Mokamah bridge and in the vicinity of Mansi Railway Station on the left bank.

In Uttar Pradesh, flooding is frequent in the eastern districts, mainly due to spilling of Tapti, Sharada, Ghagra and Gandak. Problems of drainage congestion exists in the western and northwestern areas of Uttar Pradesh, particularly in Agra, Mathura and Meerut districts. Erosion is experienced in some places on the left bank of Ganga, on the right bank of Gharga and on the right bank of Gandak.

In Haryana, flooding takes places in the marginal areas along the Yamuna and the problem of poor drainage exists in some of the southwestern districts.

In south and central West Bengal, Mahananda, Bhagirathi, Ajoy, Damodar etc. cause flooding due to inadequate capacity of river channels and tidal effect. There is also the problem of erosion of the banks of rivers and on the left and right banks of Ganga upstream and downstream respectively of the Farakka barrage.

In Delhi, a small area along the banks of the Yamuna is subjected to flooding by river spills. In addition local drainage congestion is experienced in some of the developing colonies during heavy rains.

Northwest River Region

Main rivers in this region are the Sutlej, Beas, Ravi, Chenab and Jhelum, tributaries of Indus, all flowing from the Himalayas. These carry substantial discharges during monsoons and also large volumes of sediment. They changes their courses frequently and leave behind vast tracts of sandy waste. The region covers the States of Jammu and Kashmir, Punjab, parts of Himachal Pradesh, Haryana and Rajasthan.

Compared to Ganga and Brahmaputra River regions, flood problem is relatively less in this region. Major problem is that of inadequate surface which causes inundation and water logging over vast areas.

At present, the problems in the States of Haryana and Punjab are mostly of drainage congestion and water logging. Floods in parts of Rajasthan were rare in the past. Ghaggar River used to disappear in the sand dunes of Rajasthan after flowing through Punjab and Haryana. In recent years, it has become active in Rajasthan territory, occasionally submerging large areas.

Jhelum, floods occur periodically in Kashmir causing rise in the level of the Wullar Lake there by submerging marginal areas of the lake.

Central India and Deccan Region

Important rivers in this region are Narmada, Tapi, Mahanadi, Godavari, Krishna and Cauvery. These rivers have mostly well defined stable courses. They have adequate capacity within the natural banks to carry the flood discharge except in the delta area. The lower reaches of the important rivers on the east coast have been embanked, thus largely eliminating the flood problem.

This region covers all the southern States, namely Andhra Pradesh, Karnataka, Tamil Nadu and Kerala and the States of Orissa, Maharashtra, Gujarat and parts of Madhya Pradesh. The region does not have serious problem except for some of the rivers of Orissa state, namely Brahmani, Baitarni, and Subernarekha. The delta areas of Mahanadi, Godavari and Krishna rivers on the east coast periodically face flood and drainage problems in the wake of cyclonic storms.

Tapi and Narmada are occasionally in high floods affecting areas in the lower reaches in Gujarat.

The flood problem in Andhra Pradesh is confined to spilling by the smaller rivers and submergence of marginal areas along the Kolleru Lake. In addition, there is a drainage problem in the deltaic tracts of the coastal districts.

In Orissa, damage due to floods is caused by Mahanadi, Brahmani and Baitarni which have a common delta where the floodwaters intermingle and when in spate simultaneously cause considerable havoc. The problem is accentuate when the flood synchronizes with high tides. Silt deposited constantly by these rivers in the delta area raises the flood level and the rivers often over-flow their banks or break through new channels causing heavy damage. Lower reaches of Subernarekha are affected by floods and drainage congestion. Small rivers of Kerala when in high floods cause considerable damage occasionally.

Details of annual damage due to floods in any one of the years under consideration is taken as the area liable to flood in that State. Considering all such figures for all the States for the period from 1953 to 1978, Rashtriya Barh Ayog (National Commission on Floods) has assessed the total area liable to flood in the country as 40 m.ha. out of which 32m.ha area could be provided with reasonable degree of protection. The severity of the problem can be seen from the fact that this area constitutes one eighth of total geographical area of the country.

6.2.3 The concept of drought

Drought has many definitions, but mostly it originates from a deficiency of precipitation over an extended period of time, usually a season or more. This deficiency results in a water shortage for some activity, group, or environmental sector. Drought should be considered relative to some long term average condition of balance between precipitation and evapotranspiration (i.e., evaporation+transpiration) in a particular area, a condition often perceived as “normal”. It is also related to the timing (i.e., principal season of occurrence, delays in the start of the rainy season, occurrence of rains in relation to principal crop growth stages) and the effectiveness (i.e., rainfall intensity, number of rainfall events) of the rains. Other climatic factors such as high temperature, high wind, and low relative humidity are often associated with it in many regions of the world and can significantly aggravate its severity. There are four disciplinary definitions of drought, which are as follows:

Meteorological Drought

Meteorological drought is defined usually on the basis of the degree of dryness (in comparison to some “normal” or average amount) and the duration of the dry period. Definitions of meteorological drought must be considered as region specific since the atmospheric conditions that result in deficiencies of precipitation are highly variable from region to region. For example, some definitions of meteorological drought identify periods of drought on the basis of the number of days with precipitation less than some specified threshold.

Agricultural Drought

Agricultural drought links various characteristics of meteorological (or hydrological) drought to agricultural impacts. Focusing on precipitation shortages, differences between actual and potential evapotranspiration. Soil water deficits, reduced ground water or reservoir levels, and so forth. Plant water demand depends on prevailing weather conditions, biological characteristics of the specific plant, its stage of growth, and the physical and biological properties of the soil. A good definition of agricultural drought should be able to account for the variable susceptibility of crops during different stages of crop development, from emergence to maturity. Deficient topsoil moisture at planting may hinder germination, leading to low plant populations per hectare and a reduction of final yield. However, if topsoil moisture is sufficient for early growth requirements, deficiencies in subsoil moisture at this early stage may not affect final yield if subsoil moisture is replenished as the growing season progresses or if rainfall meets plant water needs.

Hydrological Drought

Hydrological drought is associated with the effects of periods of precipitation (including snowfall) shortfalls on surface or subsurface water supply (i.e., streamflow, reservoir and lake levels, ground water). The frequency and severity of hydrological drought is often defined on a watershed or river basin scale. Although all droughts originate with a deficiency of precipitation, hydrologists are more concerned with how this deficiency plays out through the hydrologic system. Hydrological droughts are usually out of phase with or lag the occurrence of meteorological and agricultural droughts. It takes longer for precipitation deficiencies to show up in components of the hydrological system such as soil moisture, streamflow, and ground water and reservoir levels. As a result, these impacts are out of phase with impacts in other economic sectors.

Socioeconomic Drought

Socioeconomic definitions of drought associate the supply and demand of some economic good with elements of meteorological, hydrological, and agricultural drought. It differs from the aforementioned types of drought because its occurrence depends on the time and space processes of supply a demand to identify or classify droughts. The supply of many economic goods, such as water, forage, food grains, fish, and hydroelectric power, depends on weather. Because of the natural variability of climate, water supply is ample in some years but unable to meet human and environmental needs in other years. Socioeconomic drought occurs when the demand for an economic goods exceeds supply as a result of a weather-related shortfall in water supply.

The sequence of impacts associated with meteorological, agricultural, and hydrological drought further emphasizes their differences. When drought begins, the agricultural sector is usually the first to be affected because of its heavy dependence on stored soil water. Soil water can be rapidly depleted during extended dry periods. If precipitation deficiencies continue, then people dependent on other sources of water will begin to feel the effects of the shortage.

6.2.4 Indices for drought monitoring

Drought indices are numbers on a certain scale, which defines drought quantitatively. The most commonly used indices world wide, which are based on a number of data on rainfall, snowpack, streamflow, and other water supply indicators, are discussed in the following paragraphs.

Percent of normal

Percent of normal precipitation is one of the simplest measurements of rainfall for a location. Analyses using the percent of normal are very effective when used for a single region or a single season. Percent of normal is also easily misunderstood and gives different indications of conditions, depending on the location and season. It is calculated by dividing actual precipitation by normal precipitation-typically considered to be a 30 scales range from a single month to a group of months representing a particular season, to an annual or water year. Normal precipitation for a specific location is considered to be 100 percent.

One of the disadvantages of using the percent of normal precipitation is that the mean, or average precipitation is often not the same as the median precipitation, which is the value exceeded by 50 percent of the precipitation occurrences in a long-term climate record. The reason for this is that precipitation on monthly or seasonal scales does not have a normal distribution. Use of the percent of normal comparison implies a normal distribution where the mean and median are considered to be the same.

Standardized Precipitation Index (SPI)

The understanding that a deficit of precipitation has different impacts on groundwater, reservoir storage, soil moisture, snowpack, and streamflow led scientists to develop the Standardized Precipitation Index (SPI). The SPI was designed to quantify the precipitation deficit for multiple time scales. These time scales reflect the impact of drought on the availability of the different water resources. Soil moisture conditions respond to precipitation anomalies on a relatively short scale. Groundwater, streamflow, and reservoir storage reflect the longer-term precipitation anomalies.

The SPI calculation for any location is based on the long-term precipitation record for a desired period. This long-term record is fitted to a probability distribution, which is then transformed into a normal distribution so that the mean SPI for the location and desired period is zero. Positive SPI values indicate greater than median precipitation, and negative values indicate less than median precipitation. Because the SPI is normalized, wetter and drier climates can be represented in the same way, and wet periods can also be monitored using the SPI.

Palmer Drought Severity Index (PDSI)

The PDSI is a meteorological drought index, and it responds to weather conditions that have been abnormally dry to abnormally wet. When conditions change from dry to normal or wet, for example, the drought measured by the PDSI ends without taking into account streamflow, lake and reservoir levels, and other longer-term hydrologic impacts. The PDSI is calculated based on precipitation and temperature data, as well as the local Available Water Content (AWC) of the soil. From the inputs, all the basic terms of the water balance equation can be determined, including evapotranspiration, soil recharge, runoff, and moisture loss from the surface layer. Human impacts on the water balance, such as irrigation, are not considered. The classification of a region according to this index is as follows:

4.0 or more	Extremely wet
3.0 to 3.99	Very wet
2.0 to 2.99	Moderately wet
1.0 to 1.99	Slightly wet
0.5 to 0.99	Incipient wet spell
0.49 to -0.49	Near normal

Crop Moisture Index (CMI)

The Crop Moisture Index (CMI) uses a meteorological approach to monitor week-to-week crop conditions. It was developed from procedures within the calculation of the PDSI. Whereas the PDSI monitors long-term meteorological wet and dry spells, the CMI was designed to evaluate short-term moisture conditions across major crop-producing regions. It is based on the mean temperature and total precipitation for each week within a climate division, as well as the CMI value from the previous week.

Because it is designed to monitor short-term moisture conditions affecting a developing crop, the CMI is not a good long-term drought monitoring tool. The CMI's rapid response to changing short-term conditions may provide misleading information about long-term conditions. For example, a beneficial rainfall during a drought may allow the CMI value to indicate adequate moisture conditions. For example, a beneficial rainfall during a drought may allow the CMI value to indicate adequate moisture conditions, while the long-term drought at that location persists. Another characteristic of the CMI that limits its use as a long-term drought monitoring tool is that the CMI typically begins and ends each growing season near zero. This limitation prevents the CMI from being used to monitor moisture conditions outside the general growing season, especially in droughts that extend over several years. The CMI also may not be applicable during seed germination at the beginning of a specific crop's growing season.

Surface Water Supply Index (SWSI)

The objective of the SWSI was to incorporate both hydrological and climatological features into a single index value resembling the Palmer Index for each major river basin in the state of Colorado in U.S.A. These values would be standardized to allow comparisons between basins. Four inputs are required within the SWSI: snowpack, streamflow, precipitation, and reservoir storage in the winter. During the summer months, streamflow replaces snowpack as a component within the SWSI equation.

The procedure to determine the SWSI for a particular basin is as follows: monthly data are collected and summed for all the precipitation stations, reservoirs, and snowpack/streamflow measuring stations over the basin. Each summed component is normalized using a frequency analysis gathered from a long-term data set. The probability of non-exceedence (the probability that subsequent sums of that component will not be greater than the current sum) is determined for each component based on the frequency analysis. This allows comparisons of the probabilities to be made between the components. Each component has a weight assigned to it depending on its typical contribution to the surface water within that basin, and these weighted components are summed to determine a SWSI value representing the entire basin. Like the Plamer Index, the SWSI is centered on zero and has a range between -4.2 and +4.2.

Reclamation Drought Index (RDI)

Like the SWSI, the RDI is calculated at a river basin level, and it incorporates the supply components of precipitation, snowpack, streamflow, and reservoir levels. The RDI differs from the SWSI in that it builds a temperature-based demand component and a duration into the index. The RDI is adaptable to each particular region and its main strength is its ability to account for both climate and water supply factors.

Deciles

Arranging monthly precipitation data into deciles is another drought-monitoring technique. It was developed to avoid some of the weakness within the “percent of normal” approach. The technique they developed divided the distribution of occurrences over a long-term precipitation record into tenths of the distribution. They called each of these categories a decile. The first decile is the rainfall amount not exceeded by the lowest 10% of the precipitation occurrences. The second decile is the precipitation amount not exceeded by the lowest 20% of occurrences. These deciles continue until the rainfall amount identified by the tenth decile is the largest precipitation amount within the long-term record. By definition, the fifth decile is the median, and it is the precipitation amount not exceeded by 50% of the occurrences over the period of record. The classification of a region according to deciles is as follows:

Deciles 1-2: lowest 20%	Much below normal
Deciles 3-4: next lowest 20%	Below normal
Deciles 5-6: middle 20%	Near normal
Deciles 7-8: next highest	Above normal
Deciles 9-10: highest	Much above normal

6.2.5 Tackling drought through water management

Mean annual rainfall over the country is around 119 centimeters, out of which about 80 percent rainfall occurs only during the 4 monsoon months of the year. However, this rainfall varies widely from region to region, season to season and year to year. While some of the regions of the country receive as much as 10,000 millimetres (mm) or more like the hills of Assam, a major part of Rajasthan gets only 100mm or even less. Low rainfall leads to arid conditions which persist almost throughout the year. Nearly 9 percent area of the country is arid and 40% is semi-arid (annual rainfall between 500 and 1000 mm). Because of large variability of rainfall both in space and time, semi-arid regions are subjected to the problems of drought. The problems of arid areas wherever one good crop is not possible in normal years is quite different from those of semi-arid areas where one good crop is normally expected but it is frequently lost due to scanty rainfall or due to variability of rainfall. Even normally high rainfall areas face failure of rains and consequent upsetting of human water requirements. Water conservation and water management measures are need of the day to achieve a strong and stable economic base, especially in the arid and drought prone areas of the country. There are no general solutions possible. They will have to be area specific, because of the hydrological peculiarities. It has also to be remembered that development of drought prone areas cannot be modelled on the lines of the development of other favourably placed areas. The pattern of development of the drought-prone areas will have to be quite different from that of the others.

Some of the methods that may be suggested as technical strategies to mitigate the adversities of drought are mentioned in the following paragraphs.

Creation of surface storage

Conventional approach to water conservation has been to go in for water development projects – creating reservoirs by building dams, big and small, and diversion canals – to supply water wherever and in whatever amounts desired. The total storage capacity of all the reservoirs (major, medium and minor) in the country has been assessed as 400 cubic kilometer. Central Water Commission is regularly monitoring the storage availability of 70 selected major and medium reservoirs with a storage capacity of about 131 cubic kilometer, out of which reservoirs with storage capacity of about 50 cubic kilometer are located in the drought prone areas. Comparing this with the overall utilisable potential of 690 cubic kilometer of surface water apparently shows that to overcome our water supply problems, we have to go in for creation of more storages. However, this will not solve the main problems raised due to large spatial and temporal variations in rainfall. One is that the overall figure of availability of water resources presents a misleading picture. In some regions there is scope of storage but so much of water is not needed. Many river basins like Cauvery, Sabarmati have already exhausted the available water resources. In many other basins, water is fast becoming scarce. The second problem is that building dams and canals has become an extremely costly proposition. This is partly due to the increase in the basic cost of construction and partly due to the necessity to tackle more complex projects involving difficult foundations etc.

Planning for less dependable yield

In India normally the drinking water supplies are planned for almost 100 percent dependability, hydro-power systems for 90 percent dependability and the irrigation systems for 75 percent dependability. However, for the drought areas, planning of average flows or 50 percent dependability has been recommended by many Commission and Committees to increase the availability of water mainly for the agricultural purposes. Minor irrigation tanks (i.e. which have culturable command area of 2,000 hectare or less) are already being planned for 50 percent dependability.

Prevention of evaporation losses from reservoirs

It is seen that shallow tanks having large surface areas located in the drought affected areas lose nearly half the water storage by evaporation in summer months. To save water in a critically water short region, an application of a layer of chemicals like cetyl, stearyl and fatty alcohol emulsions can effectively retard evaporation and savings in the field can be around 40 percent of the normal evaporation losses.

Adjustment in sanctioned water to a reservoir or its releases

The trend of reservoir filling or the ground water position for a water year gets fairly known by the middle of August. Re-adjustment of sanctions and releases have to be carefully carried out at this time keeping a close watch on the behaviour of the monsoon. The modern management techniques using probability analysis may help in assessing the situations of 'supply-variability' in the drought areas.

Reduction in conveyance losses

Reduction in conveyance losses in the conveyance system is an important facet of the water conservation techniques because losses due to seepage are found to vary widely in an irrigation system ranging from 35 percent to 45 percent of the diverted water. Lining of the canal system could be an appropriate step to conserve this precise resource in such a situation.

Considering the high degree of losses in dry summer months, running a canal system in the drought areas during the hot dry months will not be an economical proposition. As an alternative, it will be better to transport as much water during the wet monsoon months or later during the winter period thereafter and to store water in small tanks or ponds near the point of consumption for later use during the summer months. Similarly, practice usually adopted for releasing water through the river channel itself for transporting over long distances during the dry months should be discouraged. However, in cases where releases have to be made during summer months through the river channel instead of resorting to releasing continuous low flows over long periods it would be better to rush the requisite quantity in a small period and then hold it up in small storages near the points of consumption. Such rush systems are being successfully practiced in Maharashtra.

Equitable distribution

Many of the existing canal systems are not able to supply an adequate and equitable quantum of water to all the farmers in the command areas. A rotational system of supply of water if strictly implemented will not only meet the ends of equity but will also economise use of water. Lack of adequate control arrangements in the canal systems also adds to the problem of equitable distribution of water. Another important aspect of water management is the prevention of loss of water to drains during transit from outlet to field. This can be eliminated by farmers active participation in water distribution and maintenance of distribution network in good shape.

Maintenance of irrigation systems

Over the years, maintenance of irrigation systems has deteriorated mainly due to the fact that water rates charged are not sufficient for carrying out the maintenance for keeping the system fit and efficient. In some States, leave alone the operation and maintenance, the revenue collected from irrigation rates does not even cover the expenses incurred on collection of revenue. Whole range of activities covering operation, routine maintenance, special and major repairs, replacements etc. are now covered under " maintenance" and funds are allocated to it from non-plan. Due to shortages of funds and restrictions on non-plan activities, most of the allotted money under this is being spent on staff salaries. Unless adequate allocations are earmarked for maintenance of irrigation systems, gradual deterioration of the existing irrigation systems cannot be controlled.

Better irrigation practice

On farm irrigation practices prevailing in the country also result in wastage of water leading to poor irrigation efficiency. Most farmers still irrigate as their predecessors did hundreds of years ago by flooding or channeling water through parallel furrows. Absence of field channels for adopting to field irrigation adds to the problem. Simple measures like leveling of the fields so that water gets more evenly distributed can greatly improve the performance. Wastage due to absence of field channels and lack of field leveling are now being eliminated through the Command Area Development (CAD) programmes.

Irrigation scheduling

Better irrigation scheduling practices can also improve the irrigation efficiency. For example, it is now well established that water is required more at critical stages of crop growth and water stress during other period has negligible impact on yields. Addition waterings do not add proportionately more to the yield. Greater effort should be made to train farmers in the use of irrigation scheduling methods appropriate to their mode of production. Agricultural extension programmes could help spread the benefits of these water management techniques.

Cropping pattern

Better water management involves all stages i.e. from pre-project formulation to operation and maintenance. In the project formulation stage, a suitable cropping pattern in conformity with soil and climatic conditions taking into account the farmers preferences should be evolved. While designing the canal capacities, peak demand of water in critical periods by the high yielding varieties of crops should be kept in view.

Conjunctive use of surface and ground water

The concept of conjunctive use of surface and ground water resources is very essential especially in drought areas in order to increase the production per unit of water. The manner of using ground water and surface water varies considerably from region to region. Where ground water quality is not good, canal water can be mixed in suitable proportion. Conjunctive use makes possible same flexible of cropping pattern and multicropping in the canal command. For the proper water management, it is necessary to treat command areas as one composite unit and two resources should be judiciously managed to achieve optimization of benefits. Costs of exploiting the two sources vary considerably and efforts are necessary to lay uniform charges for providing irrigation to serve the area in an optimal manner and to achieve maximum food production. The concept of conjunctive use has been successfully implemented in various States. Conjunctive use of surface and ground water supplies needs careful planning on more scientific lines to achieve full benefits particularly in all drought management programmes. Suitable legislation is called for to regulate over-exploitation of ground water, which at present is developed and used on individual ownership basis.

Watershed development

Planning of watershed development involves an integrated approach upon physiographic and hydrologic characteristics which include construction of soil conservation works on crop lands; Construction of structures, like check dams, Nalla bunding, contour bunds, Gully plugging, percolation tanks, development of rainwater harvesting and construction of wells etc.

Ministry of Agriculture's proposal of National Watershed Development Projects focuses on aspects from the angle of agriculture environment, forests and rural development and heavy investment is envisaged for macro level development. Pilot projects for Watershed Development in Rainfed areas in Andhra Pradesh, Karnataka, Madhya Pradesh and Maharashtra have already been implemented with World Bank assistance. This is a long term development, whereas watershed development at micro level will lead to quick results in increasing the water availability and leading to sustainable development. Presently, there are several externally aided projects sponsored by the Central Government and funded by the World Bank and other Organisations which are going on in various parts of the country. Some State Governments namely Andhra Pradesh, Karnataka, Madhya Pradesh, Maharashtra, Orissa and Rajasthan have also started watershed development programmes on their own, with some success as at Jhabua in Madhya Pradesh. In this connection, it is worth mentioning that watershed development in drought prone areas needs involvement of both Government and Non-Government agencies using Non-Government Organisations (NGOs) as an interface between the Government and the local village communities for revival, restoration and development of the watersheds. Examples of Ralegaon-Shindi, Adgaon, Rendhar, Sukhomajri, Tejpura, Nalgaon, Daltonganj, Sidhi, Jawaja and Alwar show that Voluntary organizations and Non-Government Organisations can play a major role in the watershed development and management.

Creation of large storages

While planning various projects particularly in the regions depending on rainfall, it is preferable to go in for large storages rather than a large number of small storages on the tributaries, since small tanks are particularly vulnerable to drought. This is also essential in view of the fact that about 80 percent of the river flow occurs only during the four monsoon months and this flow requires to be stored for irrigation and power generation. The present storage capacity of all the reservoirs including major, medium and minor schemes is 400 cubic kilometer as against the potential of 690 cubic kilometre which means the water scarcity problem may be solved to a great extent by creation of more storages.

Integrating small reservoirs with major reservoirs

Of late, there are persistent demands to abandon the schemes of large storages as it is feared that they cause environmental disaster leading to non-sustainable development of water resources. Instead, number of small reservoirs are being advocated to replace a single large reservoir. However, in many cases, a group of small schemes may not provide the same benefits as a large project can. It is, therefore, very important that minor schemes are integrated with the canal systems of major reservoirs.

Transfer of water from water excess basins to water-deficit basins

A permanent long term solution to drought problem may be found in the basic principles of transfer of water from surplus river basins to areas of deficit. For this purpose, it is essential to take an overall national view for the optimum utilisation of available water resources. With this aim in view, Ministry of Water Resources and Central Water Commission have formulated a national perspective plan for water resources development which consists of two components: Himalayan Rivers Development and Peninsular Rivers Development.

The national perspective of water resources development envisages construction of about 185 cubic kilometre of storages. These storages and the interlinks will enable additional utilisation of nearly 210 cubic kilometre of water for beneficial uses, enabling irrigation over an additional area of 35 million hectare, generation of 34 million kilowatts of hydro power and other multi-purpose benefits.

In order to give concrete shape to these proposals, Government of India has set up National Water Development Agency in 1982 which is carrying out prefeasibility/feasibility level studies of linking of various rivers both in Peninsular as well as Himalayan Rivers Development Components based on internationally accepted norms.

6.2.6 Flood protection measures in India over the years

In India, flood protection measures using embankments were in existence for centuries. This is evident from the old embankments constructed by private individuals for the protection of their lands.

The inadequacy of the individual efforts in the sphere of flood control led to governmental interest in the problem chiefly during the past century. As a result of this, a number of well-planned embankments were constructed on some of the rivers, which were causing recurrent flood damage. These measures were largely to give protection to the commanded areas of the canal systems in northern India, and the deltaic tracts of east flowing rivers in Orissa, Andhra Pradesh and Tamil Nadu.

In the fifties, the Damodar Valley Dams, viz., Tilaiya Dam (1953), Maithon Dam (1957) and Panchet Dam (1959) were constructed for multipurpose development of Damodar Valley, which included flood control also. A barrage at Durgapur downstream of the Maithon and Panchet Dams and an upstream dam at Tenughat were also constructed and are operating as a unified system for flood control apart from other major purposes of irrigation, power generation and water supply requirements. The system has helped to moderate the intensity of the floods in the lower valley considerably and the Damodar is no longer, a ‘river of sorrow’ of the pre-project era.

Kosi Flood Control Schemes (1959) have certainly helped in checking the movement of the river in westward direction and provided better protection to a large area of about 2.5 lakh hectares which used to be ravaged by floods. Large-scale economic development has come up in this area.

Similarly, storage reservoirs such as Hirakud, Ukai, Bhakra, Beas, Chambal Dam and Nagarjunsagar have either protected some areas from floods or have reduced their intensity considerably. In addition to these, Baigal reservoir in Uttar Pradesh, Rengali Dam and Bhimkund project in Orrisa, Multipurpose reservoirs on the Subernarekha for the benefit of Orissa, Bihar and West Bengal, Halai Dam in Madhya Pradesh and Mecharbali Dam in Karnataka have been useful for reduction of flood fury. The Kangasabati Reservoir in West Bengal also takes care of flood problem in the downstream.

A number of drainage schemes have been taken up in the States of Punjab, Haryana, Rajasthan and Gujarat. Such schemes have also benefited the States of Uttar Pradesh and West Bengal and water logged areas in Punjab and Haryana. The Krishna Godavari Delta Drainage Scheme in Andhra Pradesh has also resulted in positive developments.

Similarly, a number of schemes for channel improvements, raising of villages, anti-erosion and town protection works have been taken up towards protection from floods.

In addition to the above for tackling the flood problem in Ganga and its tributaries and to facilitate effective coordination of flood management among the Ganga Basin States, Government of India set up Ganga Flood Control Board and its Secretariat, namely Ganga Flood Control commission in April, 1972. The Ganga Flood Control Commission has prepared comprehensive plans for flood management for all the 23 river systems of Ganga by the year 1990. The Comprehensive Plans have been sent to State Governments for preparing detailed schemes based on actual ground surveys and investigations and implementation. Similarly, Government of India had set up Brahmaputra Board under an Act of Parliament (46 of 1980) in December, 1981. The objective of the Board is mainly to prepare a Master Plan for the control of floods and bank erosion and improvement of drainage in the Brahmaputra and Barak Valley. The Board has prepared Master Plans for Main Brahmaputra River (1986) and Barak Valley (1988) and 38 tributaries. These have been also forwarded to States for taking further action towards their implementation.

Flood management schemes are taken up by respective State Governments in their successive plans. It is estimated that a total of 16,199 km length of embankments and 32,003 km length of drainage channels were constructed; a total of 906 towns were protected and 4,721 villages were provided protection from floods upto the year 1997. From the above works, it is estimated that an area of 14.37m.ha has benefited.

The evolution of flood management policy in India can be summarized as below:

Before 1947	Main emphasis on flood embankment
1954	Policy statement in Parliament: Two document presents “ Floods in India-problems and Remedies” and “The Floods in the Country” - absolute immunity from flood damage is not physically possible even in the distant future.
1957	High level committee on floods -Non structural measures were recommended
1964	Ministerial committee on flood control -Non structural measures were emphasized
1972	Ministers Committee on floods and flood relief -additional storage for flood moderation -Legislation to prevent encroachment of river -Restricting the costly anti erosion works to important locations
1980	Rashtriya Barh Ayog (National flood commission): A comprehensive report 207 recommendations covering entire gamut of flood problems CWC in 1987 reviewed implementation status of these recommendations and found not much progress. even now (in 2005) not much progress.
1987	National water policy -Basin master plans, watershed management catchment area treatment
1999	National commission for integrated water resources development -Efficient management of flood plains and other non structural measures -Performance of embankments to be evaluated -Flood forecasting network to be extended

It may be mentioned here that the organizations that are responsible for the management of flood in the country are the following.

State Flood Control Department	Planning and execution of flood management works
Central Water Commission	(River Management Wing) Coordination and guidance
Ganga Flood Control Commission	Master plans for flood control in 23 sub

	basins of Ganga have been prepared
Ganga Flood Control Commission	(1981) Survey and Investigation, Preparation of plans for flood control and bank erosion in Brahmaputra and Barak Valleys.

6.2.7 Flood management initiatives

Flood management activities can be broadly classified into four major groups:

i. Attempts to modify the flood
ii. Attempts to modify the susceptibility to flood damage
iii. Attempts to modify the loss burden
iv. Bearing the loss

All these measures for flood management can be classified as under:

- Structural measures
- Non-structural measures

Broadly, all measures taken up under the activity of "Modifying the flood" which are in the nature of physical measures are "Structural measures", while the others which are taken up as management tools without major construction activity are grouped as "Non-structural measures". These are explained in the subsequent sections.

6.2.8 Structural measures for flood mitigation

The general approach to tackle the problem of floods in the past has been in the form of physical measures with a view to prevent the flood waters from reaching potential damage centres. This approach had been extensively constructed in the Godavari, Krishna and Cauvery Deltas in South India and also in some areas of Indo-Gangetic plain.

The main thrust of the flood protection programme undertaken in India so far has been in the nature of taking structural measures like:

i) Embankments, flood walls, sea walls.
ii) Dams and reservoir
iii) Natural detention basin
iv) Channel improvement
v) Drainage improvement
vi) Diversion of flood waters

Embankments, flood walls, sea walls

The most common and generally economical form of protection to provide immediate relief from inundation is construction of embankment. The embankment system along the river is planned to restrict the river in its existing course and they are designed to avoid over-flowing of banks by increasing the channel capacity to pass the probable floods. Generally, these are constructed with easily available earth in the nearby area. The embankments of the pre-independence period and those came up after independence through plans have provided considerable protection to life and property of people living in flood plains.

As embankments prevent passage of river water into adjoining area even during high floods which otherwise could have been inundated by silt laden river water, the adjoining land is deprived of the fertilizing effect of silt, But there is no conclusive evidence to establish the so-called fertilizing effect of silt. It is also a fact that sometimes flood waters when spread over the flood plains adversely affect productivity of the land.

Also, in the case of embankments when constructed along the river banks, the flood wave movement becomes restricted which causes general increase in flood stages upstream of the embanked section. In alluvial reach, the embankments are continuously threatened by erosion. The progressive of bed level requires progressive rise of the embankment to ensure protection.

Embankments attract new settlements as a result of protection from floods offered by them. State Governments have been very slow on maintenance of these structures due to inadequacy of funds. Another problem is that due to unprecedented rains, if a breach occurs, the effect of such a flood to the settlements will be unexpected and devastating. Such breaches are reported from the States of Bihar, Assam, U.P. and West Bengal. Proper maintenance of the embankments involving the beneficiaries and educating the masses on the consequences of occupying the flood plains are necessary.

The benefits of embankments and embankment scheme in reducing distress and damage due to floods are very evident. The benefits achieved for the some case of the kosi project is as follows:

Kosi is a perennial river originating from Himalayas in Nepal whose three main streams viz. the Sun Kosi, the Arun Kosi and the Tamur Kosi meet at Triveni in Nepal to form Sapta Kosi or simply called as Kosi in the plains of Bihar. The notorious meandering behaviour of Kosi is apparent from the fact that it has changed its course for a width of about 112 km its lower reach in Bihar in a period of about 250 years, as a result of which the flood problem faced by people living in the area was acute. A barrage was constructed in 1963 for irrigation, power and regulated flow downstream. Flood embankments on both sides of the river were constructed arresting its unique translatory movements giving a great sense of security to the people of the area which is apparent from the fast changing outlook in the districts of Purnea, Saharsa and Darbhanga and, therefore, giving protection to an area of about two lakh ha in Bihar.

The flood embankments on both the banks of Kosi river which were mostly completed as early as 1957 have on an average protected 1.17 lakh acres of land in Darbhanga and 4.11 lakh acres in Saharsa districts of Bihar from the ravages of flooding. Kharif crops on this land were formerly badly damaged and even Rabi sowing was sometimes affected by standing water and excessive moisture. Severe damage was also caused to properties like building, orchards etc. Prevention of flooding in this area on account of the project has rendered following incidental benefits:

i) Construction of a network of metalled roads improved communication and there by addition to the convenience and prosperity of the people.
ii) Communications on the Mansi-Supaul and Saharsa-Purnea sections of the North Eastern Railway, which were formally cut off in the wet season, are now possible throughout the year. The longer running period will mean a rise in railway earnings from fares and freights. Villagers served by these lines will have better facilities for carrying their produce to markets.
iii) Replacement of improvised and temporary thatched houses of private individuals, commercial concerns and govt. Departments by pucca buildings reflecting a better standard of living and sense of security.
iv) Reclamation for cultivation of large areas of land which were formerly infested with 'Kans and Pater'
v) Opening of small-scale industries and even major factories like the sugar factory proposed at Banmankhi.
vi) Reduction of flood and waterlogging and consequential improvement in general health.
vii) Kosi barrage has opened up all weather communication between Saharsa-Purnea district on the bank and Darbhanga district on the other bank.
viii) A metalled road from Bathnaha to Bhimnagar had been constructed by the project. This road provides much-needed means of communication in this locality.

In addition to benefits to Bihar (India) from the project, Nepal is also drawing large benefits from it through protection from flood, stability of river in the upstream to some extent and better communication system at flood time apart from power and irrigation facility.

The Programme Evaluation Organisation of the Planning Commission undertook evaluation of the embankment projects with a view to assess the economic benefits of the projects. They also substantiated benefits from the project.

The embankments, however, have created some potential dangers to the zone inside embankments, which is liable to experience greater threats of floods than before. The area lying within 5 km of left embankment is submerged under water. Besides, the problem of water logging also needs to be separately addressed and necessary measures taken.

Dams and reservoir

Human issues involved in the case of dams and reservoirs are evacuation and resettlement of people in the reservoir area, environmental impacts due to developmental activities and increase in population etc. Consequences of dam failure-possible damages to life and property in the downstream and human encroachment on the flood plains due to the security provided by dams are also to be taken into account. While planning all the above works, impact due to the scheme on its surrounding and on the settlements in the downstream area need be taken into account.

Maximum attention is to be given while framing reservoir regulation policies so that optimum utilisation of water resources is possible and at the same time flood control and issues related to the people living in the downstream of the reservoir are taken care of.

Construction of dams and reservoirs is adopted as a major activity to control floods by storing flood water so that the stored water could be released subsequently when the flood has receded and the downstream river channel is in a position to contain the flow without causing floods. The main advantage reservoirs is that apart from moderating the flood peaks, the stored water can be used for multipurpose uses such as irrigation, power generation, industrial requirements and domestic uses etc. In the case of flood control reservoirs, proper reservoir regulation schedule can be worked out for optimum benefit from the project as a whole from the flood control point of view, and it is advisable that specific flood cushion is allocated in the reservoir although incidental benefit of flood control to some extent is available from any reservoir scheme.

6.2.9 Non-structural measures for flood management

The present trend to reduce the losses incurred by flooding is equally towards non-structural measures. This section examines some such techniques.

Flood plain management and zoning

Heavy encroachment of flood plains has been responsible for increasing trend of damage over the years. The basic concept of flood plain management is to regulate the land use in the flood plains in order to restrict the damage due to floods, while deriving maximum benefits from the same. This is done by determining the locations and the extent of areas likely to be affected by floods of different magnitudes/frequencies and to develop those areas in such a fashion that the resulting damage is minimum in case floods do occur. Flood plain zoning, therefore, aims at disseminating information on a wider basis so as to regulate indiscriminate and unplanned development in flood plains and is relevant both for unprotected as well as protected area. Flood plain zoning recognizes the basic fact that the flood plains are essentially the domain of the river, and as such all developmental activities in flood plains must be compatible with the flood risk involved.

The basic concept of flood plain zoning is to regulate the land use in the flood plains in order to restrict the damage by floods which are bound to occur from time to time. Flood plain zoning, therefore, aims at determining the locations and the extent of areas likely to be affected by floods of different magnitudes/frequencies and to develop those areas in such a fashion that the resulting damage is reduced to the minimum. It, therefore, places limitations on indiscriminate and unplanned development of both the unprotected as well as protected areas. In the former case, boundaries of restricted areas are established to prevent indiscriminate growth; while in the protected areas, only such categories of development can be allowed which will not involve unduly heavy damage in case of failure of the protection provided, while ensuring that the valuable flood plains are simultaneously put to development use.

Flood plain zoning is not only necessary in the case of floods caused by rivers but is also useful in reducing the damage caused by drainage congestion, particularly in urban areas, where on grounds of economy and other considerations, urban drainage system is not designed for the worst possible conditions and presupposes some damage during storms whose magnitude exceeds that for which the drainage system is designed.

The steps involved in implementation of flood plain zoning measures could be broadly indicated as follows:

i) Demarcation of areas liable to floods

ii) Preparation of detailed contour plans of such areas on a large scale (preferably 1:15,000) showing contours at an interval of 0.3 to 0.5 metres

iii) Fixation of reference river gauges and determination of areas likely to be inundated for different water levels and magnitudes of floods

iv) Demarcation of areas liable to flooding by floods of different frequencies like once in two years, ten, twenty, fifty and hundred years. Similarly, area likely to be affected on account of accumulated rainwater for different frequencies of rainfall like 5,10,25 and 50 years

v) Delineation of the types of use to which the flood plains can be put to in the light of (i) to (iv) above with indication of safeguards to be ensured.

The need for flood plain zoning has been recognized in the past also. As far back as 1973-74, Central Water Commission had prepared guidelines for flood plain zoning which were approved by the Central Board. Since the implementation of these guidelines needed statutory backing, CWC also prepared a model draft bill which was circulated in 1957 by the then Ministry of Irrigation, to all the States for enacting legislation.

The Rashtriya Barh Ayog (1980) in its report has recommended that Flood Plain Management measures should be undertaken, wherever necessary legislation enacted in other States. However, the response from States except Manipur has not been encouraging. Manipur enacted a legislation in Sept., 1978 which came into force in Dec., 1985.

One of the reasons advanced by the State Governments for non-implementation of flood plain zoning measures has been the non-availability of survey maps on suitably large scale to enable proper demarcation of flooded areas. To overcome this difficulty, Central Water Commission had initiated in 1978 programme for such surveys under the Central Sector through the Survey of India to assist the State Governments in the preparation of flood risk maps. These surveys cover areas along main Ganga, Yamuna, Ramganga, Roopnarayan, Jalangi and other flood prone rivers of West Bengal, tributaries of Brahmaputra like Burhi Dehing, Desang and Dikhoo, Sutlej and Ravi etc., which were taken up in a phased manner as per the priorities indicated by the States. However, the programme has now been discontinued at Central level. With the available data/maps, it should now be possible for the State Govts. to make a start and demarcate the zones for different flood frequencies.

This is an area where immediate attention of all the State Governments has to be attracted considering the extent of human issues involved. With the availability of remote sensing maps, preparation of flood risk maps has become easier. The need of the hour is to prepare flood risk maps for all the frequently flood prone river plains in the country, enact and enforce laws for implementing the zoning regulations, constant monitoring of the flood situation using remote sensing and to plan mitigating measures accordingly.

Flood Proofing

Flood proofing measures help greatly in the mitigation of distress and provide immediate relief to the population in flood prone areas. It is essentially a combination of structural change and emergency action, not involving any evacuation. The techniques adopted consist of providing raised platforms for flood shelter for men and cattle and raising the public utility installations above flood levels and other facilities to make various essential services flood proof so that the miseries of people can be reduced to minimum even when flooding occurs.

Flood forecasting and warning

Flood forecasting enables forewarning as to when the river is going to use its flood plain, to what extent and for how long. As per strategy of laying more emphasis on non-structural measures, Central Water Commission has established a nationwide flood forecasting and warning system. With reliable advance information/warning about impending floods, loss of human lives and moveable properties, human miseries can be reduced to a considerable extent. People and cattle can be shifted to safer places. Similarly, valuable moveable properties can be removed to safer places beyond area to be inundated. Large number of reservoir schemes to harness water resources for irrigation, power etc. were undertaken in the country during various plan periods. Realising the great potential of reservoirs in impounding floods and regulating the flows downstream for flood moderation, flood control has been sought to be achieved as one of the objectives in multi-purpose dams by providing flood cushion. Inflow forecasting for these reservoirs is very important for optimum reservoir operation.

Present flood forecasting network in India

Flood forecasting and flood warning in the country commenced in a small way in the year 1958 with the establishment of a unit in the Central Water Commission (CWC), New Delhi, for flood forecasting for river Yamuna at Delhi. This has by now grown to cover most of the flood prone interstate river basins in the country. This organization is presently responsible for issuing flood forecasts at 157 stations of which 132 stations are for river stage forecast and 25 for inflow forecast.

The flood forecasting system of CWC functions under Member (River Management). Seven field offices of Chief Engineers, ten offices of Superintending Engineers and nineteen divisional offices are in charge of management of the forecasting work. These offices are responsible for hydrological and hydro meteorological data collections such as gauge, discharge and rainfall data, their transmission from field stations to the central control rooms, formulation of forecasts and dissemination to various concerned Central/State Governments, Media and other users. Forecast about water level in river likely to be attained as a result of flood and volume of inflow to reservoir is issued by concerned officers everyday in the morning. The forecasts are also transmitted to CWC headquarters at New Delhi where daily bulletins are prepared for the country as a whole and sent to all concerned departments of the Government.

According to the present norms of the Central Water Commission, a forecast is considered to be reasonably accurate if the difference between forecast and corresponding observed level of the river lies within ± 15 cm. In case of inflow forecasts, variation within ± 20 percent is considered acceptable. On an average, about 6,000 flood forecasts are issued every year with a maximum of 7,943 forecasts issued during the year 1998. The forecasts issued by CWC have been consistently accurate as a result of which the flood forecasting and warning services have rendered immense benefit to the people in the flood prone areas.

Like the river stage forecasts, the inflow forecasts issued by CWC have also been consistently accurate. This has provided immense benefit to the authorities of concerned dams and barrages for systematic operation of the reservoirs for optimum utilization of the water resources and for the control of floods.

However, proper integration of the flood forecasting system with disaster mitigation works can go a long way to reduce flood damage and alleviate distress to the people affected by flood. Also, where the warning messages are utilized with other non-structural measures like flood plain zoning activity and flood fighting in a comprehensive manner, the outcome of the forecasting and warning system can become more effective.

Flood fighting

Flood fighting covers building temporary dykes along the river, dowel bunds on the banks, closing small breaches immediately, attending to scour, wave wash, sand boils etc. evacuating goods and equipment out of the reach of flood zone, protecting equipment with plastic sheets etc. When floods occur, the existing facilities for water supply and sewerage get disrupted affecting the health of the population. The inundation and deterioration of the quality of food grains, destruction of agricultural crops and health of livestock may lead to famine or at least nutritional deficiencies. Stagnant water becomes the breeding ground for mosquitoes affecting public health. Public health operations should ensure availability of supplies and equipment, co-ordination with other organisations engaged in disaster relief and procedure for immediate mobilisation of personnel to eliminate health hazards. Flood fighting measures normally involve:

- Strengthening of Central, State and District Flood Control Rooms.
- Evacuation of flood victims.
- Air dropping of food packers.
- Close review of flood relief measures.
- Release of emergency funds to local bodies and thence to the flood victims.
- Supply of food and other rations.
- First aid and health operations.
- Supply of essential commodities like Kerosene, oil, petrol etc.
- Plugging of breaches.

- Restoration of road/rail links.
- Restoration of tube wells and other agricultural machinery.
- Pumping out water from ponds and low-lying areas in cities/villages.
- Restoration of public assets such as roads, bridges, irrigation systems and structures, power installations, public buildings, municipal roads, sewerage and water supply schemes, paved streets and drains etc.
- Voluntary efforts by Red-Cross, Home-Guards, Panchayats, local people etc.

Most of the above activities are of immediate nature. Participation by voluntary organisations and local people are necessary for flood fighting. There is a need to give training to voluntary organisations and other non-governmental organisations in the field. All the above issues are directly aimed at reducing the losses due to flood to life and property.

Flood insurance

Flood insurance has several advantages as means of modifying loss burden. The insurance does not reduce the flood loss potential directly, but it provides a mechanism for spreading the loss over large number of individuals. It is advantageous both to the public and the Government.

So far, flood insurance has not been adopted widely in India. Though flood risk has been included in ‘cover’ issued by the General Insurance Companies in India, it is more popular in urban areas and big towns where damage due to inundation caused mostly by excessive rainfall is taken care of. The insurance companies have also not been able to arrive at different rates of insurance premium for different flood prone regions in the country. As such, they continue to charge uniform rate irrespective of the fact that property was located in high flood risk area compared to the other areas. The insurance companies are facted with a difficult choice. If they levy uniform rates in all areas, the people in flood prone areas would most likely take out the policy which may become too large a burden. If an attempt is made to charge rates proportionate to the flood risk, the premium may work out much more than what the property owner might be willing to pay. Another problem being faced by the insurance companies is regarding the assembling of basic data for working out a fair and equitable premium for all areas according to flood risk. The insurance cover works successfully for a class of people who are subjected to such risks more or less equally. In case of floods, the risk of loss even in areas liable to flood is not equal. For example, those owning land or property at lower elevation in a flood plain are subject to higher risk both in magnitude as well as in frequency. Therefore, those living at high levels would not be equally willing to obtain insurance cover, at the same rate. It is quite a difficult task to accurately adjust insurance premium. All these difficulties need to be sorted out and there is an urgent need to make insurance schemes attractive to insures and the insured.