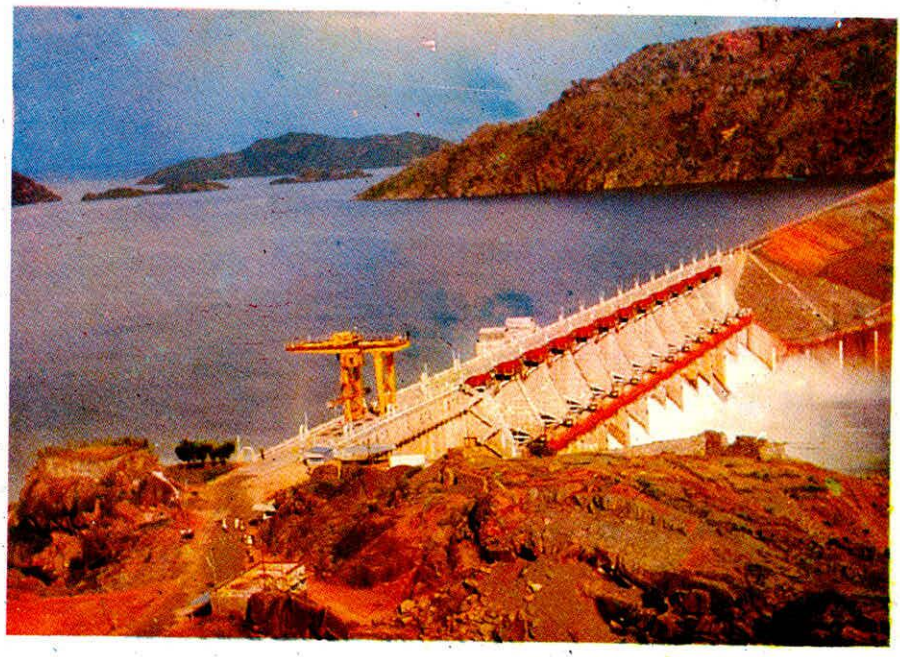
FLOOD AND ITS MANAGEMENT



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INTRODUCTION

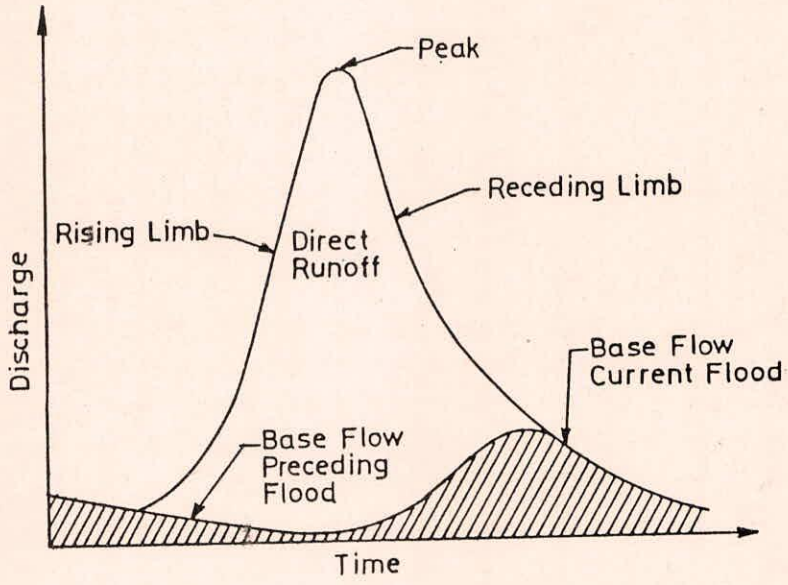
The flow in a river varies from day-to-day and year to year. The volume of water carried is not the same every year due to complex meteorological factors and varying characteristics of the ground on which the rainfall occurs. The river is stated to be in flood when the flow exceeds the capacity within the banks. The magnitude of the floods depends upon the intensity of the rainfall, its duration and also the ground conditions when the heavy spell of rainfall occurs. Arid and semi-arid regions where the rainfall is scanty and infrequent have poor drainage characteristics. Consequently, whenever there is a heavy spell of rainfall, such as a case of cloud burst, water accumulation and flooding occurs. Other factors which tend to increase the flooding are erosion and silting which lead to decrease in the capacity of river channels and increased meandering. Earthquakes and land slides, synchronisation of the floods in the main tributary rivers and retardation of flood flow due to tidal effects and cyclones further aggravate the changes caused by floods.

Floods are repeatedly in the headlines of local, national and international media. The problem of floods and their computation is one of the main and most complex problems facing the hydrologists. The optimal development of water resources depends to a considerable extent on flood flow control, design and construction of structural measures and taking proper measures for flood mitigation including non-structural measures like flood plain zoning, flood forecasting and warning, etc.

All such hydrologic analysis and design problems require accurate and reliable data for flood estimation using statistical and/or deterministic methods. The estimation of design flood for safety of structures under flood conditions has also to take into consideration cost aspects and to avoid over design.

DEFINITION

Defining a flood is somewhat difficult, partly because floods are complex phenomena and partly because they are viewed differently by different people. A meaningful definition of flood should incorporate the notions of damage and inundation. Some typical definitions are as follows:



TYPICAL SINGLE STORM HYDROGRAPH

At present, in most of the river systems, the forecasts are formulated with the help of multiple correlation diagrams in which the actual river stages at the base and the forecasting stations, the rainfall in the intervening catchment with appropriate antecedent precipitation index and the stages of the tributaries joining the river between base and the forecast stations are the parameters.

In the last two decades, significant progress in flood forecasting in India has been made. All major inter-state rivers in the country have been covered by a flood forecasting programme. At present, data from nearly 340 hydrological sites and the 500 meteorological stations are included in the programme for collecting data for forecasting. Data are mostly transmitted to analysis centers over radio-telephones by a network of 450 wireless sets most of which are 15 watts, single side band radio sets. Land line communication including telex and teleprinter circuits provide support where-ever they are available.

As of now, data transmission via High Frequency Radio (HF) sets and manual operators, errors in vocal transmission are possible. Reliance is placed on correlation techniques and forecasts are, however, scrutinized carefully by experienced officers, before release.

options by way of mathematical packages can be used after duly adopting them to each situation;

(v) Software packages (models) calibrated at one point of time are related to experience gained upto that time. They need improvement by way of updating as further data become available. For this work, a R & D wing is needed continuously to update and improve the procedures.

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

FORECASTING IN INDIA

In our country the systematic forecasting programme started in 1959 by Central Water Commission on the river Yamuna. Slowly this programme was extended to all major rivers and their tributaries. Now forecasts for 145 centres in the country are issued covering various river basins. An UNDP assisted project for 'Improvement of River and Flood Forecasting System in India' was taken up on the river Yamuna as a pilot scheme in 1980. This project was completed and the system put to test during 1985 monsoon season. Under the set up, the data are being collected automatically at different sites and transmitted to Central Station at Delhi through VHF links. The data are further processe by HP 1000 F series computer installed at CWC, Delhi and the forecast issued by application of hydrological models such as SSARR, HEC-1F, NAM and Non-linear Cascade Model.

is possible and adequate time to organise alleviation measures is available.

REAL TIME FLOOD FORECASTING

As mentioned earlier, forecasting needs meteorological data from the catchment, river flow data in reaches or stretches of river at the analysis points at the earliest. A network of hydrometeorological stations to obtain such data at sufficiently fast sampling rates and on real time basis has to be organised to make it available for suitable computations. The data collection and transmission network and computational procedure have to meet the following:

i) Such a system of stations will need suitable sensing instruments that can cope with highest and lowest observed variable or rates of variables with accuracy at sampling rates envisaged;

(ii) Measurements which make such data have to be transmitted to the analysis centre with the least possible delay, i.e. system needs good telecommunication linkage;

(iii) Processing of such collected data to spot absurd values, errors in measurement and check continuity and consistency between meteorological and hydrological variables by using high speed computers through suitable software;

(iv) Computer (Hardware) facility to carry out speedy and accurate computations. Software

The application of remote sensing and hydrological analysis is mainly involved in delineation of flood plain area and deciding about limits of flood plains. Surveys have to be carried out for determining the nature and extent of flood plains of rivers. Such surveys form the basis of establishing flood plain zones. This includes delineation of the areas which are subject to flooding including classification of land with reference to relative risk of flood plain use intended to safeguard the health, safety and property of the general public.

FLOOD FORECASTING

Flood forecasting is a process of estimating future stages of flows and their time sequence at selected places along a river during floods. The estimates or predictions required generally are:

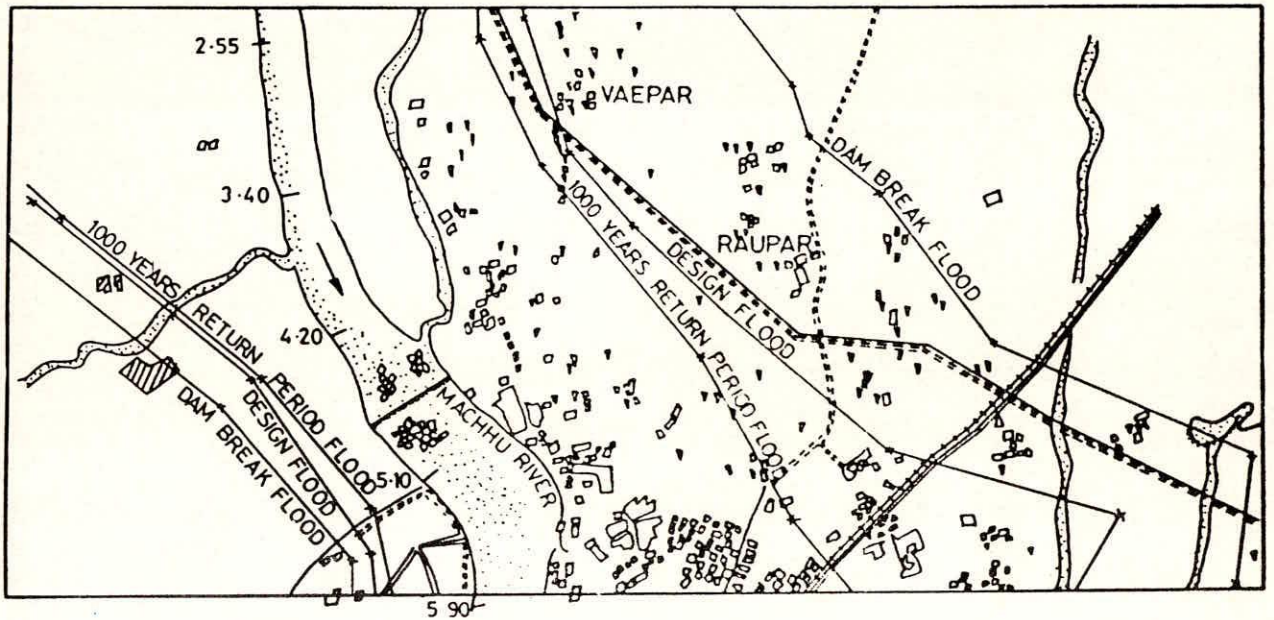
(i) Maximum discharge and its time of occupancy

(the crest of a flood hydrograph)

(ii) The levels expected at various points of time during rising and falling stages of flood in a river above a specified water level or the warning level

(shape of discharge hydrograph above a discharge level)

Utility of forecast is very much dependent on its timeliness and accuracy. If the forecast is not available sufficiently before the event occurs, its value is nil. The entire forecasting service has to be planned around a time factor. This time factor should be large enough so that efficient dissemination of the forecast



AREA INUNDATED FOR RIVER REACH 2·30-5·90 km. OF MACHHU RIVER D/S OF MACHHU II DAM

For developing appropriate flood management measures a proper understanding of factors affecting hydrological aspects of floods with regard to intensity and duration of flood is necessary. In addition to the natural factors, increasing human activities over the catchment such as deforestation, flood protection works, dams, urbanization, etc. have profound influence on the hydrology of floods of the catchments.

FLOOD PLAIN ZONING

Flood plain zoning means restricting any human activity in the flood plains of a river where the plains are created by overflow of water from the channels of rivers and streams. Generally the term flood plain includes water channel, flood channel and area of nearby low land susceptible to flooding by inundation. The activity of flood plain zoning has the short term objective of preventing more damage from flooding and in the long term to reduce and even eliminate such damage. A model bill for flood plain zoning circulated by the then Ministry of Agriculture and Irrigation (Department of Irrigation), Govt. of India, to the State Governments in July 1975, included the following aspects:

(a) Flood zoning authority and its power;

(b) Surveys and delineation of flood plain area;

(c) Notification of limits of flood plains;

(d) Prohibition or restriction on the use of the flood plains;

(e) Compensation;

(f) Power to remove constructions after prohibition.

(ii) Reducing the Susceptibility to Damag

Under this strategy, the following measures have been adopted in our country:

a) Flood forecasting and warning, and b) Raising of Villages

Reduction in the susceptibility to damages can be achieved by keeping people and development away from flood hazard area. The important measures involved in this strategy are flood plain regulations, development and re-development, flood forecasting and warning with an evacuation plan, and flood proofing.

(iii) Reducing the Impact of Flooding

This strategy is achieved in our country through the following measures:

a) Flood fighting, and b) Redistribution of losses through disaster relief and tax remission.

The strategy of reducing the impact of flooding is meant to reduce the distress of the individuals and communities at the time of flooding or after the experience of flood problem, through emergency measures such as evacuation, flood fighting, public health measures, flood insurance and provision of relief and recovery.

All these three strategies briefly mentioned herein are adopted in our country with more emphasis for the strategies of modifying the flood and reducing the impact of flooding. The strategy of reducing the susceptibility to damages is not very popular although it deserves more attention in the near future.

strike a balance between the values obtainable from the use of flood plains and the potential losses to individuals and society arising from such use. The three general strategies for reducing flood losses are:

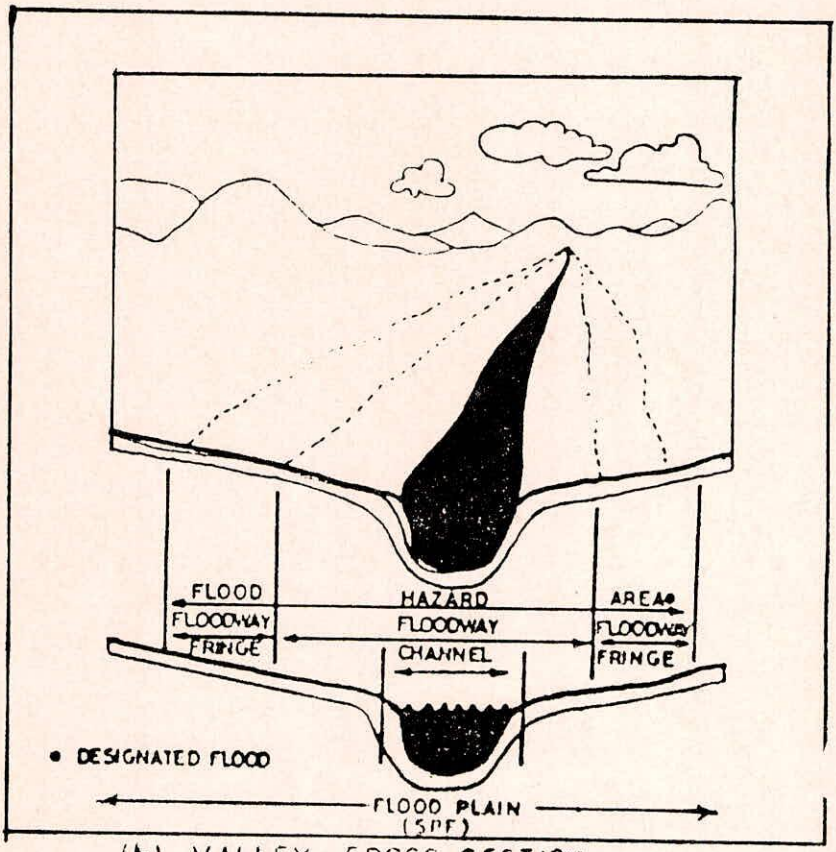
(i) Modifying the Flood

Under this category the following measures have been adopted in our country:

a) Reservoirs, b) Flood embankments, c) Diversions,

d) Channel improvements, and e) River training works.

Modifying the flood in order to keep flood water away from development and populated areas may be achieved through flood protection and flood abatement measures. Flood protection can be achieved through construction of flood levees, flood walls, channel improvements, diversion schemes, reservoirs, etc. These measures are also known as structural measures of flood control. Abatement of floods involves modifying the characteristics of the factors affecting runoff of the catchment in such a manner that runoff is delayed. As such it involves actions to be taken on the catchment. These actions may comprise of afforestation, modifying the land use, regulating flow from urban areas, etc. These actions may be combinedly known as watershed management. While this strategy may be suitable for controlling runoff responses from small catchments, its effectiveness for large catchments seems to be small because the watershed management practices are not very much reflected in the much downstream area of large catchments.



(b) VALLEY CROSS SECTION

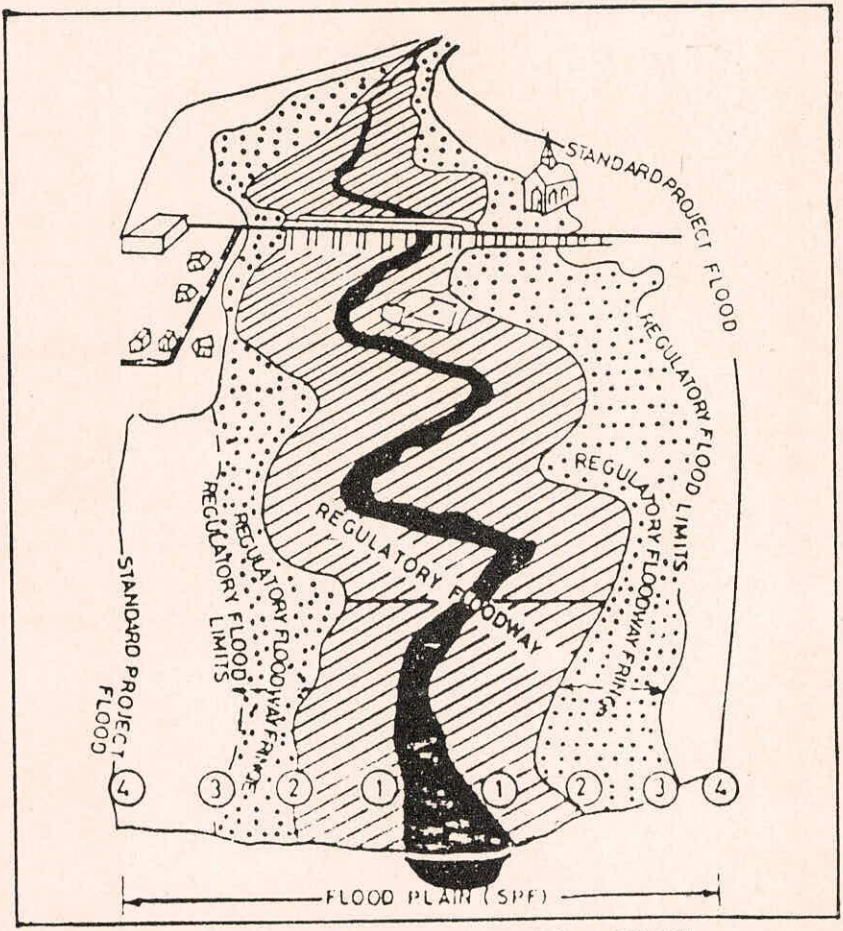
The viability and appropriateness of alternate measures must be worked out in relation to the nature of hazards.

Flood plain management includes all planning and actions needed to determine, implement and revise plans for the best use of flood plains and their water resources for the welfare of the country. Its goal is to

development on the flood fringe that would be unacceptable within the flood way.

The Rashtriya Barh Ayog has assessed that an area of 40 million hectare is prone to floods in the country. However, due to limitations of topographic and economic factors, it has been estimated that around 32 million hectare area is capable of being provided with some flood protection, through structural measures mainly embankments. Besides this, a number of flood forecasting stations of Central Water Commission have been established to provide advance warning to the authorities concerned and the people in general about the impending floods, so that preventive and protective measures can be taken. Inspite of various measures, the annual flood damages have increased from less than Rs.100 crore during 1953 to 1964 to around Rs.5,000 crore in year 1988. This calls for increased emphasis on flood management and regulation of development in flood prone areas.

It is generally seen in our country like in many countries that the flood affected areas and flood damages are on increase despite massive investments made on flood control measures. Further, human activities in the catchments such as urbanization, construction of dams for utilization of water resources, flood control levees, etc. have increased the nature of flood hazard. In view of this fact there have been major attempts to improve knowledge of the flood hazard and of the possible responses to it. As a result it is being realised that total elimination of flood hazard is not possible and alternative approaches to reduce the flood hazard are necessary.



(a) RIVERINE FLOOD HAZARD AREAS

portion of flood flow are termed as 'floodway'. While, the remaining areas of floodplain which get inundated, but contribute very little to the passage of the flood water, are termed as 'flood fringe'. It is possible to allow

Dam failures may also be caused by seepage or piping through the dam or along internal conduits, slope embankment slides, earthquake damage and liquefaction of earthen dams from earthquakes and land slide generated waves in the reservoir. Usually the response time available for warning is much shorter than for precipitation-runoff-floods. The protection of the public from the consequences of dam failures has taken an increasing importance as population have concentrated in areas vulnerable to dam break disasters.

One of the preventive measure in avoiding dam disaster is by issuing flood warning to the public of downstream where there is a dam failure. However, it is quite difficult to conduct analysis and determine the warning time regarding dam break flood at the time of disaster.The method used for such analysis gains more credibility and one can simulate the past dam break failure scenario using that method with reference to failure mode and flood wave movement downstream of the dam.

FLOOD PLAIN MANAGEMENT

The general objectives of a flood plain management strategy can be broadly stated as the enhancement of economic efficiency, social well-being and environmental quality within the area. It aims at establishment of a framework for future decision making on land use and development within the floodplain and identification of necessary river management works and programme for their execution. During the passage of significant floods certain areas of floodplain which carry the major

NECESSITY OF FLOOD HYDROLOGY STUDIES

There are several situations in which an estimate of future flood conditions is required by many different categories of individual investigation, industry, government agency or other group. Essentially, however, this information is needed for either design or forecasting purposes. In the design situation engineers and planners involved in the design of dams, spillway, river channel improvements, storm sewers bridges and culverts need information on flood magnitude and frequency. In the forecasting situation, local government agencies, industrialists, farmers, etc. require more immediate information on flood magnitude and timing so that on appropriate action may be taken. In view of these, a thorough understanding through mathematical modelling of flood formation beginning from sub-basin routing, combining sub-basin floods in the main channel, routing along channel and establishing the flood at the required point is necessary. Therefore, taking up the detailed flood hydrology studies is a must for understanding the runoff process involved in the catchment and stream channel in order to develop general and better methods, for accurate flood forecasts and design flood predictions. Flood studies dealing with flood plain zoning and economic analysis for assessing the actual flood damages are useful for the planners and government agencies involved in flood relief and flood protection activities.

DAM BREAK FLOOD

Dam failures are often caused by over-topping of the dam due to inadequate spillway capacity during large inflow to the reservoir from heavy precipitation runoff.

period 1953-85 that on an average about 7.93 million hectares of area was affected by floods annually which included 3.65 million hectares of cropped area, i.e., 46 percent of the area affected.

To minimise loss of human lives and cattle as also movable assets, a high priority has been given by the Government for flood forecasting and warning systems on major flood prone rivers operated by the Central Water Commission.

The need for flood control and management has been given increasing importance in evolving national water policy. Various measures being suggested include:

(i) Sound watershed management through extensive soil conservation, catchment area treatment, preservation of forests and increasing the forest area and the construction of check dams;

(ii) Adequate flood cushion to be provided in water storage projects;

(iii) Establishment of an extensive forecasting network, alongwith regulation of settlements and economic activity in the flood plain zones.

(iv) Use of structural measures like embankments and dykes as well as non-structural measures like flood forecasting and warning, flood plain zoning, etc. for the minimisation of losses and reduction in expenditure on flood relief.

predictable in their behaviour. Their flow is characterised by heavy discharges during the monsoon followed by very low discharges during the rainless months.

From the point of view of the flood problem, the rivers can also be grouped under the four regions as below:

1. Brahmaputra region;
2. Ganga region;
3. Northwest region;
4. Central India & Deccan region.

The problem of floods varies from basin to basin, so also the magnitude of damages caused by floods. The most flood prone areas are in the Brahmaputra basin and the northern sub-basins in the Ganga basin. The annual flood damages in the Ganga basin States account for about 60 per cent of the total in the country.

Considering total of the protected and unprotected areas floods in any year and failure of protection works, etc. Rashtriya Barh Ayog (RBA) estimated the area liable to floods as 40 million ha. The RBA estimated that during the period 1953-78, on an average about 8.2 million hectares of area was affected by floods every year of which 3.5 million hectares, i.e. 42.7 percent were cropped area. The RBA had further observed that the annual average flood affected area for the period 1970-1978 worked out to be 11.9 million hectares of which 5.4 million hectares were cropped area indicating a increasing trend in the flood affected area. Recently it has been assessed, based on the data available during the

infiltration, and transmissibility of soil and bedrock.

(ii) Network characteristics

(a) Stable - pattern of network

(b) Variable - surface storage, channel length/ contributing or source area, under-drainage

(iii) Channel characteristics

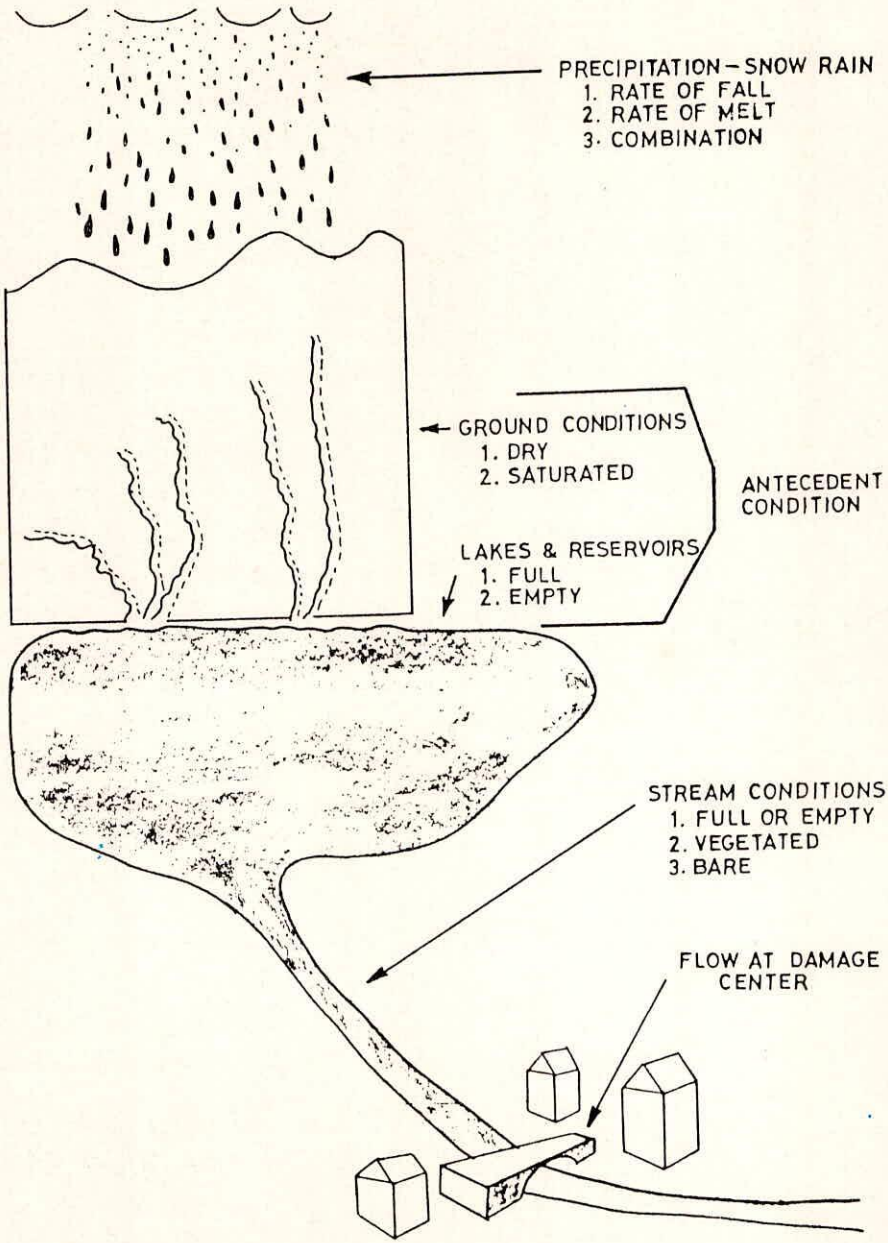
(a) Stable -slope, flood control and river regulation works

(b) Variable - roughness, load, shape, storage.

One of the most important of all flood producing conditions is the total area of interconnected water and water logged surface within the catchment where the effective infiltration capacity is zero and on which, therefore, all falling precipitation contributes directly to streamflow.

FLOODS IN INDIA

The major river systems in the country can be broadly classified into two groups, viz. rivers of the Himalayan region and rivers of peninsular India. The Himalayan rivers are fed by the melting snows and glaciers of the great Himalayan range during spring and summer, and also from rains during monsoon. They are often uncertain and capricious in their behaviour. They carry significant flows during the dry weather due to snowmelt and carry minimum flows, during winter. On the other hand, the peninsular rivers originate at much lower altitudes, flow through more stable areas and are more



FLOOD FLOW FACTORS

(ii) Part climatological

(a) Estuarine interactions between streamflow and tidal conditions; (b) Coastal storm surges;

(iii) Other natural factors

(a) Earthquakes, (b) Landslides, etc.

(iv) Failure of dams and other control works

However, it is to be noted that the identical flood generating mechanisms, particularly those associated with climatological factors may result in very different floods from one catchment to another, or even within a given catchment from time to time. These differences are due to a number of flood intensifying factors/conditions as listed below, which tend to speed up the movement of water within the catchment. Their effect is to reduce the time of concentration (which is defined as the time required for water falling on the most remote part of the catchment to contribute to stream flow at the outlet) either directly as a flow mechanism or indirectly as a push through mechanism of infiltrating water in the higher parts of the basin.

FLOOD INTENSIFYING CONDITIONS

(i) Basin characteristics

(a) Stable - area, shape, slope, aspect, altitude

(b) Variable-interactions between climate, geology, soil type, vegetation cover, wild life, man's activities causing important differences in storage capacity of soil and bed rock.

The overtopping of the banks results in spreading of water over the flood plains which generally comes under conflict with man and his activities. It is, therefore, necessary to study the characteristics of floods so that they could be controlled.

The report of Rashtriya Barh Ayog lists various situations related to floods as follows:

(i) Streams carrying flows in excess of the transporting capacity within their banks, thus overflowing adjoining land;

(ii) Backing up of waters in tributaries at their outfalls into the main river with or without synchronisation of peak floods in them.

(iii) Heavy rainfall synchronising with river spills; (iv) Ice jams or landslides blocking stream courses resulting in the backwater overflowing river banks;

(v) Synchronisation of upland floods with high tides; (vi) Heavy local rainfall; (vii) Typhoons and cyclones; and (viii) Inadequate drainage to carry away surface water with the desired quickness.

CAUSES OF FLOODING

Floods result from a number of basic causes as listed below:

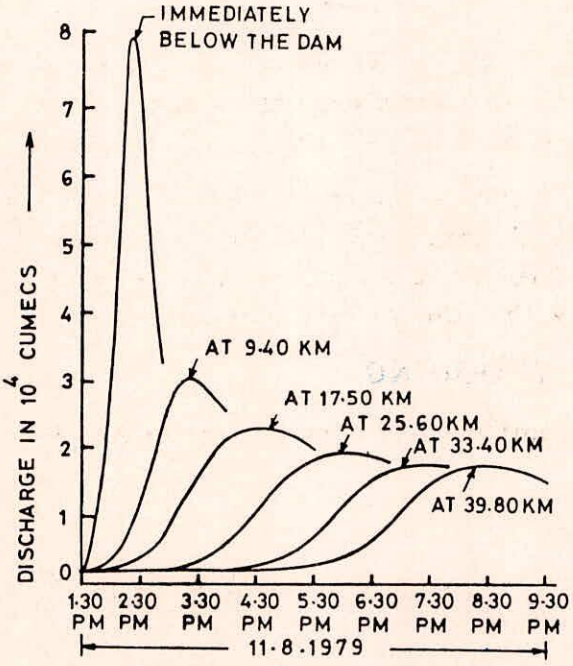
(i) Climatological

(a) Rain, (b) Snowmelt, (c) Icemelt, (d) Combined rain and snowmelt;

(i) A flood is a relatively high flow which over taxes the natural channel provided for the runoff;

(ii) A flood is a body of water which rises to overflow land which is not normally submerged.

(iii) A flood is any relatively high streamflow that overtops the natural or artificial banks in any reach of a stream.



Computed Discharge Hydrograph
Downstream of Machhu Dam II after Dam Bre

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