International Journal of Advanced Research in Engineering Technology & Science ISSN: 2349-2819
Email: editor@ijarets.org Volume-3, Issue-12 December- 2016 www.ijarets.org

A REVIEW OF FLOOD FORECASTING MODELS

Sandeep Devaliya
Department of Civil Engineering
Maulana Azad National Institute of Technology
Bhopal

H.L. Tiwari
Department of Civil Engineering
Maulana Azad National Institute of Technology
Bhopal

Ankit Balvanshi
Department of Civil Engineering
Maulana Azad National Institute of Technology
Bhopal

Bikram Prasad
Department of Civil Engineering
Maulana Azad National Institute of Technology
Bhopal

ABSTRACT: Flood is the excess amount of water or high stage situation in rivers in which water overflows the surrounding areas and bank of the rivers. Some parts of India come under the category of flood prone area so to protect the life and property, proper flood forecasting is needed. This paper gives a review of the various Real time flood forecasting techniques and models that have been employed by the researchers on various Indian basins. The feasibility of models like the Deterministic models, Stochastic and statistical models and more recently used the Artificial Neural Network (ANN) and fuzzy logic techniques are discussed in this paper. It was found that the Stochastic and statistical methods are widely used for flood forecasting but ANN and Fuzzy models are very efficient in comparison to the other models.

KEYWORDS: Flood, Deterministic Model, Statistical model, ANN, fuzzy logic..

1. INTRODUCTION

Natural calamities like floods are responsible for loss of life, property, crops etc in India, as well as in the world. India is having large number of rivers which are responsible for such kind of disasters. In India more than 40 million hectare area comes under the category of flood prone area, flood comes almost every year in one or any other parts of the country. Approximately 33 million people were affected due to flood between 1953 and 2000 in India [1] and this figure may increase in next few years because of urbanization, silting of river beds, snow melt, poor natural drainage, inadequate precipitation and so many other factors if we do not properly take care of the same.

The flood because of change in climate is recognized as one of the most dangerous and important issue for human society and global environment. Most severe impact of a changing climate would be the effect on water cycle. The report suggested that by 2050, an inadequate supply of water could knock down economic growth in some parts of the world a figure as high as 6 percent of GDP, "sending them into sustained negative growth." Areas facing this risk can at least partly be averted by better water management [2].

Proper flood forecasting plays a very important role in planning and implementing measures required to protect living bodies, agricultural land, residential and hydraulic structures. During an approaching flood event hourly flood forecasting is needed because even a one hour flood forecast can save many lives, properties and some more smart action could be taken in that time [3].

2. MAJOR INDIAN BASINS

India is divided in four major basins to make the flood forecasting studies simpler [1,4]. The four basins for flood forecasting in India are named as Ganga river basin, Brahmaputra river basin, North-West river basin and Central India and Deccan river basin.

2.1 THE GANGA RIVER BASIN:

This area covers parts of Haryana, Uttaranchal, Himachal Pradesh, Delhi, Rajasthan, Madhya Pradesh, Uttar Pradesh, Bihar and West Bengal. Normal annual rainfall for this basin varies from 60 cm to

190 cm and river Ganga is having Discharge 57 million liters per second to 85 million liters per second, this data is self explanatory to get an idea about danger of flood in the Ganga river basin [1]. The Yamuna, the Gandak, the Ghaghra, the Kosi and the Mahananda are some major tributaries of Ganga river which are also responsible for numbers of flood occurred in Indian history. Kosi is also known as 'Sorrow of Bihar' because of the frequently occurring flood because of this river, and annual flood affect about 21000 km2 of area.

2.2 THE BRAHMAPUTRA RIVER BASIN:

Almost all the North-East regions like Arunachal Pradesh, Meghalaya, Manipur, Mizoram, Nagaland, Assam, Nagaland, Tripura and some part of West Bengal is affected by the frequently occurring flood in Brahmaputra river basin. This region receives a major part of annual rainfall of India, so the flood in this region is of severe category. Since this area is also subjected to frequent earthquake, landslide and reorientation of the river is also a big problem in this region. Flooding in Manipur and in Assam is because of spilling of water of the Brahmaputra River, the Barak river and their tributaries [1].

2.3 THE NORTH-WEST RIVER BASIN:

The Jhelum, the Chenab, the Ravi, the Beas, the Sutlej and the Ghaggar cover most of the part of Punjab and Haryana. Flood in this region is not so serious but considerable till some extent. The major problem is poor surface drainage and excessive irrigation which causes inundation and water logging which sometimes results in the form of flood in surrounding areas [1].

2.4 THE CENTRAL INDIA AND DECCAN RIVER BASIN:

This region covers mostly south part of India Including Maharashtra, Chhattisgarh, Madhya Pradesh, Gujarat, Andhra Pradesh, Kerala, Karnataka, Tamil Nadu and Orissa. This region is also not having a major problem of flooding except in some important rivers like the Mahanadi, the Godavari and the Krishna at their delta areas. The Tapi and the Narmada are having high stage and high discharge at their Gujarat portion. The Mahanadi, the Brahmani and the Baitarani are having a common delta in Orissa state so the collection of a large amount of water take place which sometimes resulting in the form of flood in that region [1].

3. TYPES OF FLOOD FORECASTING MODELS

Central Flood Forecasting Directorate was created by Government of India in the year 1969 and in 1970 six flood forecasting divisions were set up on inter-state river basin. These covered the Basin of Ganga, the Brahmaputra, the Tapti, the Narmada, the Teesta and coastal rivers of Orissa. Central flood forecasting organization comprised of one chief engineer's office, 3 circles and 11 divisions by the year 1977. Central Water Commission was established in the year 1989, it has 147 flood forecasting and warning sites on various inter-state rivers [1,5].

The selection of an appropriate forecasting model and technique depends on availability of hydrological and meteorological data, warning time required, basin characteristics, rainfall characteristics etc.

3.1 DETERMINISTIC MODEL:

Deterministic models basically work on the concept of relating the rainfall volume to the direct surface runoff volume and then relate the direct surface runoff volume into the accumulation of the excess volume of water.

The deterministic models provides useful information about the extent of hazard exposure and it is possible to combine deterministic extent that depict the impact of storm but deterministic models only delineate a hazard extent do not describe variable risk [6].

3.2 STOCHASTIC AND STATISTICAL MODELS:

These techniques are nothing but finding correlation between discharge and stage between base station and forecasting station or in other words between upstream and downstream of any river with or without considering other factors. Statistical methods are more useful when all data is not available on real time basis for the development of model [7]. The statistical methods are generally graphical or in the form of mathematical relationship, developed with the help of historical data and applying the statistical analysis. Simple gauge to gauge relationships, gauge to gauge relationship with additional parameters and rainfall-peak stage relationship are various techniques under the statistical analysis. The mentioned relationships can be easily developed by relating the hydrological and meteorological data [1]. These relationships are applied for the development of physical models all over the world [4].

3.2.1 CORRELATION BETWEEN UPSTREAM AND DOWNSTREAM DISCHARGE:

To develop relationship between upstream and downstream discharge, some parameters are required like stage and discharge of base station, stage and discharge of forecasting station, change in stage and discharge of base station, travel time at various stages, intensity and duration of rainfall etc, using this data graphical diagram could be made which indicate stage of the river at each station. Using the correlation the diagram made for Yamuna River serves as a very good guide in checking the formulated forecast [1]. Such relations are as follows:

3.2.2 DIRECT RELATION BETWEEN GAUGE AND DISCHARGE BETWEEN UPSTREAM AND DOWNSTREAM:

If gauge and discharge data for base station and forecast station are known then such graphs can be plotted easily. Different kinds of correlation like correlation between N^{th} hours stage of base station and $(N+T)^{th}$ hours of forecast station where T is the travel time for flood or correlation between peaks at base station and forecast station or correlation between change in stage at base station and change in stage at forecast station can be established. Direct relationship was established for river Brahmini, river Subernrekha and for other rivers too [1].

3.2.3 CORRELATION BETWEEN GAUGE AT UPSTREAM AND DOWNSTREAM WITH ADDITIONAL PARAMETERS:

If direct gauge to gauge data relationship does not work effectively due to vary in factors like additional discharge or tributaries and intermediate catchment characteristics like soil moisture or rainfall etc then those additional parameters are taken into the consideration. Such correlations are developed for the flood forecast of Brahmaputra river at Dibrugarh and found that such models take care of aggradations and degradations of the river bed of tributary and main river [1].

In India most of the techniques for formulating the real time flood forecasting are based on statistical approach and also it is more suitable for some Indian basins.

3.3 ARTIFICIAL NEURAL NETWORK MODEL AND FUZZY LOGIC TECHNIQUES:

This is a technique which functions in the same manner as of the human brain and nervous system. It collects knowledge from the process of learning that involves finding for the connections and threshold values for the nervous system [8]. A model was developed using ANN technique on Wainganga river sub basin. The model was validated for one hour to five hour prediction. The model was found to be efficient in simulating the flow [9]. Unlike mathematical models that require upgraded knowledge of all the variables, fuzzy logic, on the other hand, offers a more flexibility and less assumption dependent and self-adaptive approach to modeling flood processes. Fuzzy logic and fuzzy set theory have been widely used to estimate the uncertainty in decision making. However, the main idea for fuzzy logic is to allow the parameters to be partially true rather than fully accurate [10].

The use of Fuzzy logic in the field of flood forecasting is still new and its potential to forecast is still need to be explored and also Artificial Neural Network model is very recent and not fully developed, it is still at its evolution stage [1].

4. CONCLUSIONS

Flood results in heavy losses of lives and properties. In India, most of the techniques for simulating the real time flood forecast are based on statistical approach. In this paper, different types of models named as stochastic and statistical model, deterministic model and ANN and fuzzy logic models were reviewed. Out of these models, Deterministic models provide useful information about the extent of hazard exposure. The ANN and fuzzy logic models are efficient in flood forecasting but needs further improvement to generate more reliable forecasts. The real time flood forecasting systems has more scope of development in India to obtain highly precise forecasts.

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