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A Holistic Approach for Determining the Characteristic Flow on Kangsabati Catchment

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ABSTRACT

Kangsabati river rises from the Chotanagpur plateau in the state of West Bengal, India and passes through the districts of Purulia, Bankura and Paschim Medinipur in West Bengal before joining into river Rupnarayan. It is life of these three districts of West Bengal situated in the western part of the state. The river has ephemeral characteristics i.e. it has low flow in the year round and have a high peak on a certain time basis. In the Kangasabati catchment hydrological study gives an evident that during the period every two years there is a chance of drought condition and consecutively after that there is a high flow year. In our study period from 1991 to 2010 there are six low streamflow year i.e. in that year there is less rainfall than the average rainfall on that area. The year 1991, 2002 and 2009 are the drought prone year and above that in 2010 the severe drought condition was seen and this is the lowest rainfall year among the last 20 years and the rainfall on this year is only 766 mm which is in an about 38% less rainfall than the average rainfall of the catchment. And the highest flood peak in the last twenty year is noted on 19th Aug 2007 as 377107.8 Mm^3

Keywords: Hydrological study; rainfall; streamflow; flood; drought; catchment; ephemeral.

I. INTRODUCTION

Western parts of West Bengal are affecting by drought consecutive flood in the next years leads to a poor socio-economic development in that area. For minimizing the losses due to floods, the flood control measures -which should be more correctly be termed as "Flood Management" can be planned either through structural engineering measures or non-structural measures. Wise application of engineering science can afforded a change by mitigating the ravages due to floods and a preventive well plan measure to store the flood water on hydraulic structures comprise multipurpose reservoirs and retarding structures which store flood waters, channel improvements which increase floods carrying capacity of the river and ultimately that can be used in the welfare of the poor people of that area in the drought year.

The lead time available for flash flood forecasts are very small. It makes the implementation of evacuation plan very difficult during the flood. The techniques available for real time flood forecasting may be broadly classified in four groups: (i) deterministic modelling (ii) stochastic modelling (iii) statistical modelling and (iv)computational techniques like Artificial Neural Network (ANN) and fuzzy logic. The deterministic models are based on either index catchment models or conceptual catchment models. Such models tend to simulate the basin response to hydrological events and do not fully utilize information collected during an event. Further the deterministic models were originally developed for design studies, and their formulation has not been influenced by the need to incorporate hydrological information in real time (1).

Depending on the availability of hydrological and hydro-meteorological data basin characteristic, computational facilities available at the forecasting stations, warning time required and purpose of forecast, different flood forecasting techniques are being used in India. Event based hydrological relation based approach is done to find out the flood and drought of a certain year in the catchment (2). Study is carried out in the Kangasabati catchment by considering the holistic development of the catchment considering: the peak flood in each and every year for last 20 years, chances of flood or drought on a given year by taking into consideration of stochastic parameter rainfall.

NEED FOR FLOOD FORECASTING

Warning of the approaching floods provides sufficient time for the authorities:

i) To evacuate the affected people to the safer places.
ii) To make an intense patrolling of the flood protection works such as embankments so as to save them from breaches, failures, etc.
iii) To regulate the floods through the barrages and reservoirs, so that the safety of these structures can be taken care of against the higher return period floods.

iv) To operate the multi-purpose reservoirs in such a way that an encroachment into the power and water conservation storage can be made to control the incoming flood.
v) To operate the city drains (out falling into the river) to prevent bank flow and flooding of the areas drained by them.

DROUGHT MANAGEMENT

Drought is a complex, slow onset phenomenon of ecological challenge that affects people more than any other natural hazards by causing serious economic, social and environmental losses in both developing and developed countries. It is generally considered to be occurring when the principal monsoons, i.e. southwest monsoon and north east monsoon, fail rare deficient or scanty (3). Monsoon failure causing crop failure, drying up ecosystem shortage of drinking water results in undue hardship to the rural and urban communities. Although droughts are still largely unpredictable; they are a recurring feature of the climate (4). Drought varies with regard to the time of occurrence, duration intensity and extent of the area affected from year to year. Over the years, India has developed elaborate governance system of institutionalized drought monitoring, declaration and mitigation at different level (5). India's response to the need for enhanced drought management has contributed to over all development. For example, the drought of 1965–1967encouraged the 'green revolution', after the 1972 drought employment generation programme were developed for the rural poor; the 1987–1988 drought relief effort focused on preserving the quality of life.

HYDROLOGICAL INDICES OF DROUGHT

Droughts are those periods of time when natural or managed water systems fail to provide enough water to meet the established human an environmental uses, due to natural short falls in precipitation or stream flow (6). The persistence of hydrological drought for 20 or more years is due to several land surface feedback combinations (i) Water budget method is used for drought assessment (ii) Surface water supply index is calculated for a river basin, stream flow, precipitation and reservoir storage. It represents water supply conditions Unique to each basin or water management requirements of each basin (iii) Reclamation drought index is calculated at the river basin-level. It is a tool for defining drought severity and duration, in addition to prediction of onset and end of drought periods. It allows states to seek assistance for mitigation measures.

II. METHODOLOGY

A number of techniques are already commonplace in hydrological modelling. Rather than a discussion of existing modelling techniques here, we prefer to suggest new applications of data mining tools. Consider temporal data (7). There are two ways we can characterise temporal data, as time series or as unordered records of the variables collected on a given day. Using both approaches we can borrow from extensive technical bases established for other applications. For example, some tools used for stock-market analysis can be generalised for other time series, or isolated records can be considered as 'market baskets' and analysed using techniques developed for supermarket purchase analysis. A third perspective is a middle way between the two above. When examining any hydrograph, we note that the width of most streamflow peaks and some rainfall events have a length of a few days (8). It seems natural to change the granularity of our time series from days into peaks or events. Daily data, where data mining techniques are perhaps most useful because of the relatively overwhelming quantity of this kind of data and the nature of the information we would like to extract, is usually represented in a sequence of thousands or tens of thousands of records (9). Most established data mining techniques aim to deal with anything up to millions of records, so the computational efficiency is in general very high for large datasets (10). In our case, we can take the simplest method without regard for computation time, as it is not likely to be a restrictive factor with our relatively small quantity of data (of the order thousands to tens of thousands of data points) (11).

The data mining techniques discussed here cannot (generally) help remove systematic errors or correct measurement problems. To circumvent this we will change slightly the form of model under consideration. Instead of aiming to predict stream flow volume from total rainfall over the catchment, we will model what the measured stream flow would be from the measured and interpolated rainfall. Of course this approach does not remove any errors, but it serves to simplify our analysis. We would also like to investigate various methods for dealing with missing data points, a common feature of hydrological data.

COEFFICIENT OF DETERMINATION

Coefficient of determination R^2 is used in the context of statistical models whose main purpose is the prediction of future outcomes on the basis of other related information. It is the proportion of variability in a data set that is accounted for by the statistical model. It provides a measure of how well future outcomes are likely to be predicted by the statistical process. In this case, if an intercept is included then R^2 is simply the square of the sample correlation coefficient between the outcomes and their predicted values, or in the case of simple linear regression, between the outcomes and the values of the single regressor being used for prediction. In such cases, the coefficient of determination ranges from 0 to 1. Important cases where the computational definition of R^2 can yield negative values, depending on the definition used, arise where the predictions which are being compared to the corresponding outcomes have not been derived from a model-fitting procedure using those data, and where linear regression is conducted without including an intercept (12).

III. RESULTS AND DISCUSSION

20 year data for the monsoon period has been analysed to work-out the trend of the streamflow for each and every year and tried to find out a correlation between the streamflow patterns in the various year. It is being analyzed by considering the R^2 value that particularly in the year 1991, 1192, 1994, 1995, 1998, 2000, 2003, 2004 and 2010 rainfall is distributed in well fashion during the entire rainy season whatever the condition of streamflow status in that year.
By considering the streamflow in the river it is analysed that the year 1991, 1994, 1998, 2000, 2003, 2005, 2009 & 2010 are the below rainfall year i.e. drought year. Among that more harsh condition is seen in the year 2010.

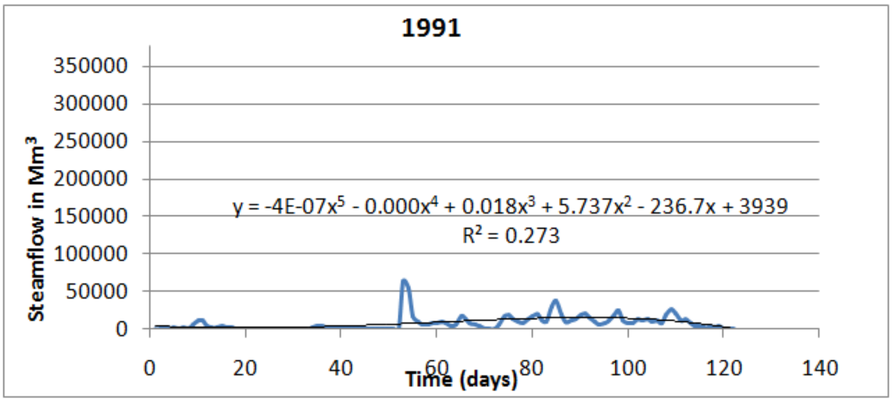

Fig.1 Streamflow pattern of 1991

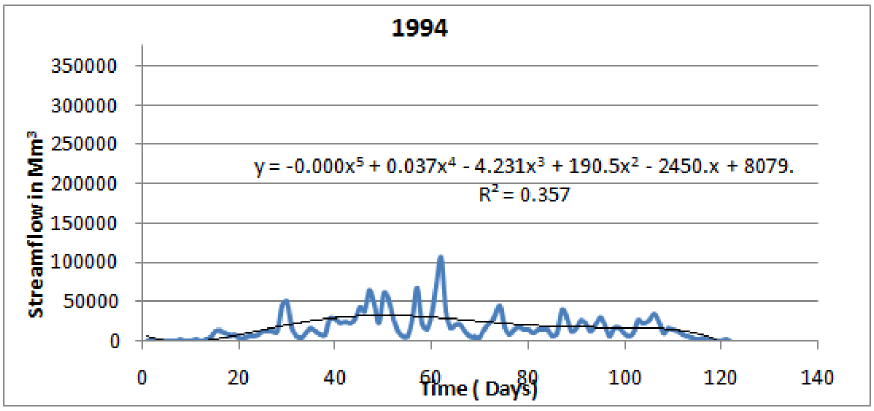

Fig.2 Streamflow pattern of 1994

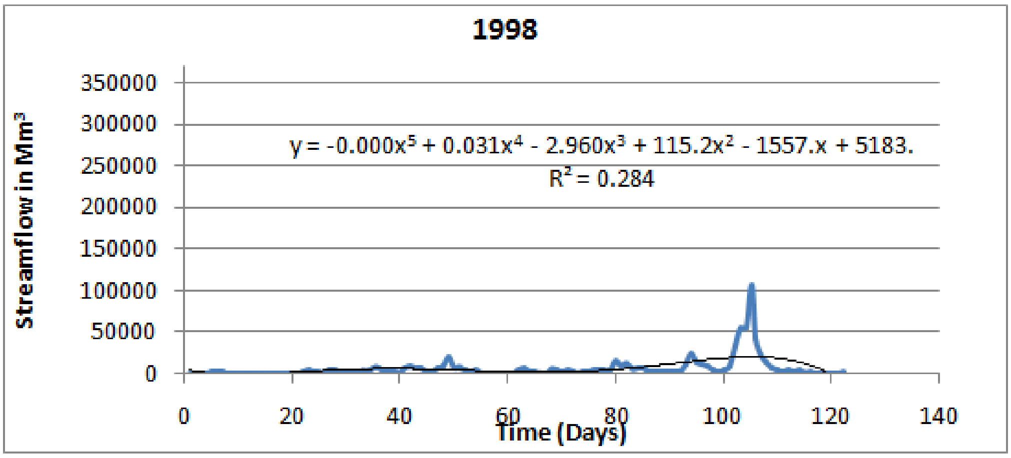

Fig.3 Streamflow pattern of 1998

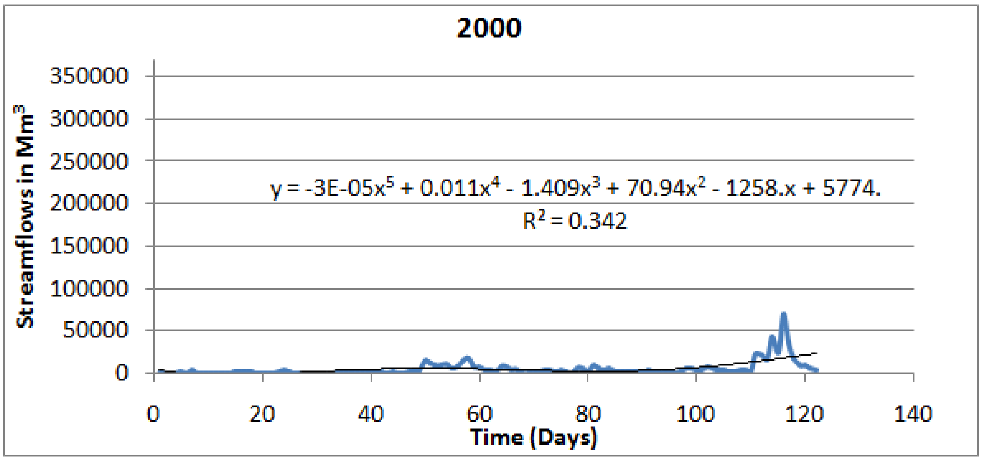

Fig.4 Streamflow pattern of 2000

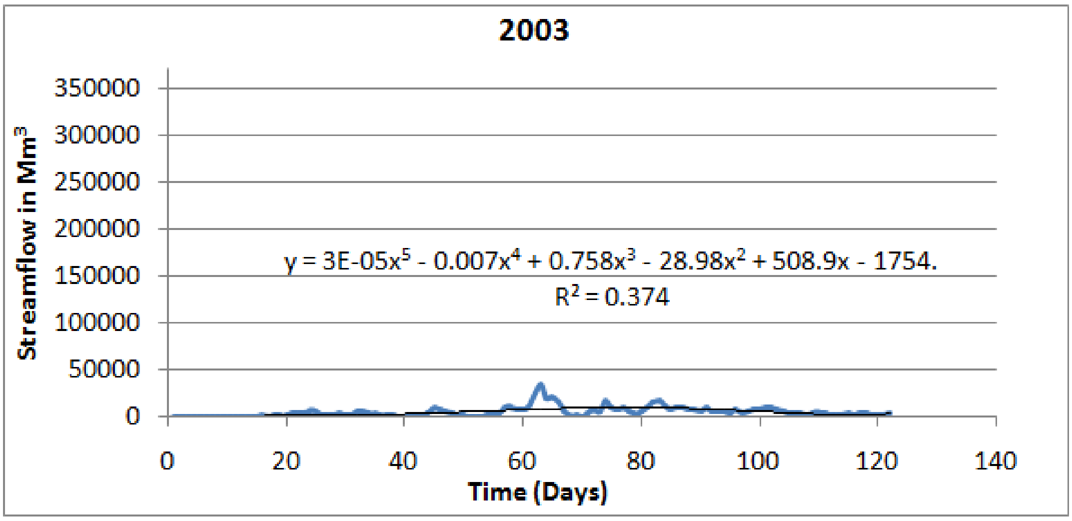

Fig.5 Streamflow pattern of 2003

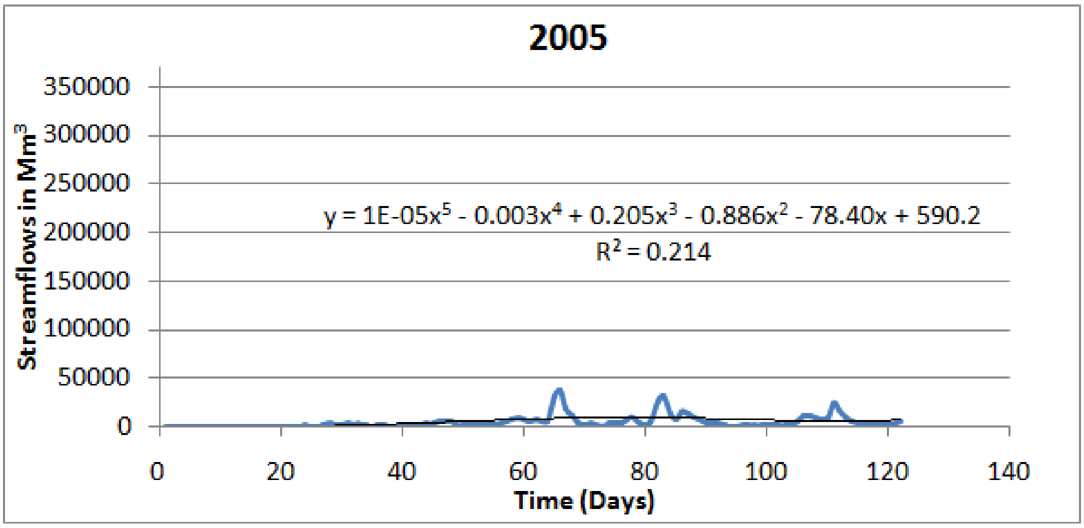

Fig.6 Streamflow pattern of 2005

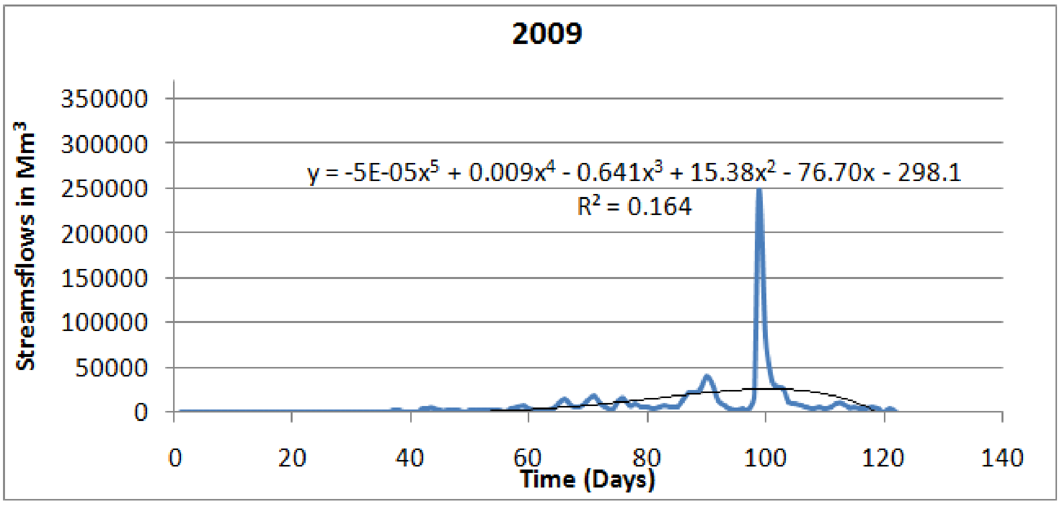

Fig.7 Streamflow pattern of 2009

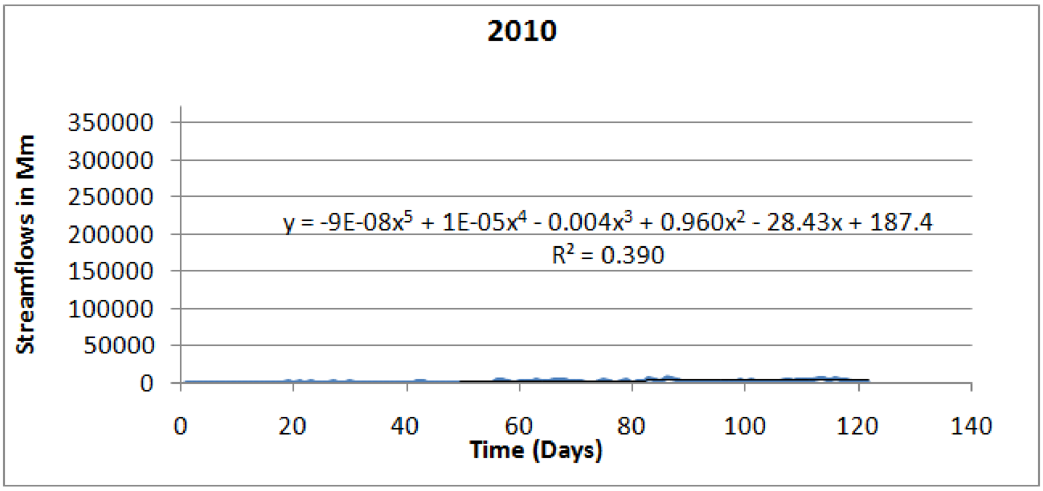

Fig.8 Streamflow pattern of 2010

And the flood prone year are 1993, 1997, 1999 and 2007. Among that 1997 and 2007 causes havoc in the drainage basin.

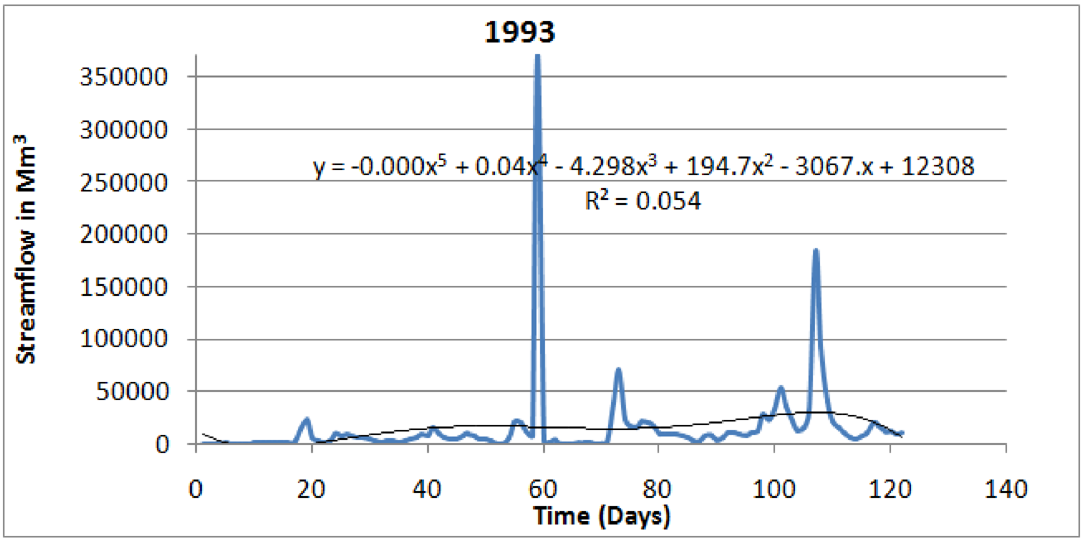

Fig.9 Streamflow pattern of 1993

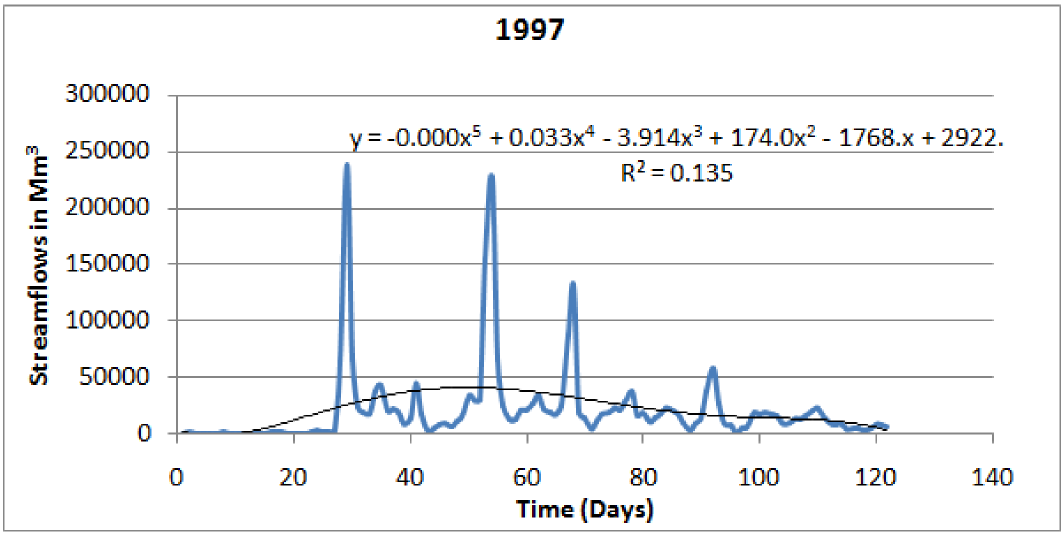

Fig.10 Streamflow pattern of 1997

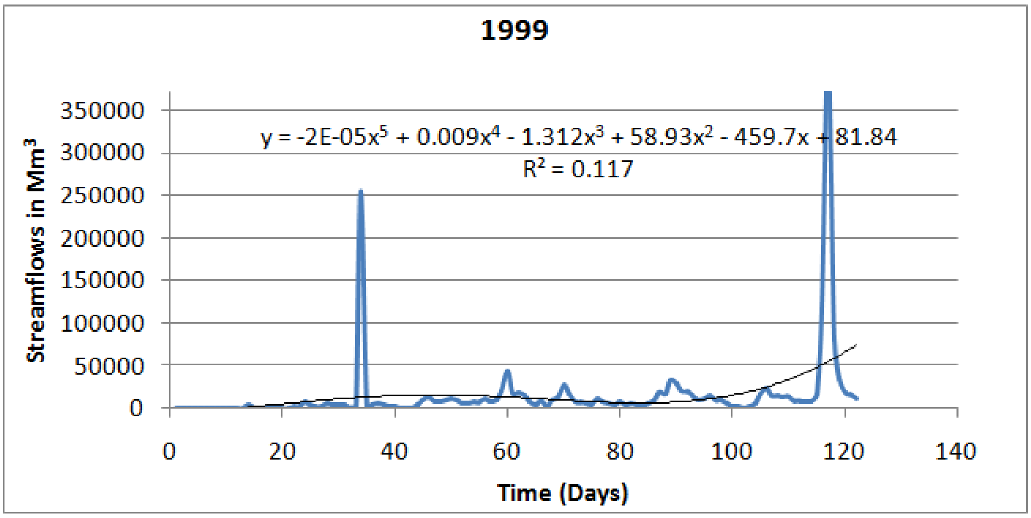

Fig.11 Streamflow pattern of 1999

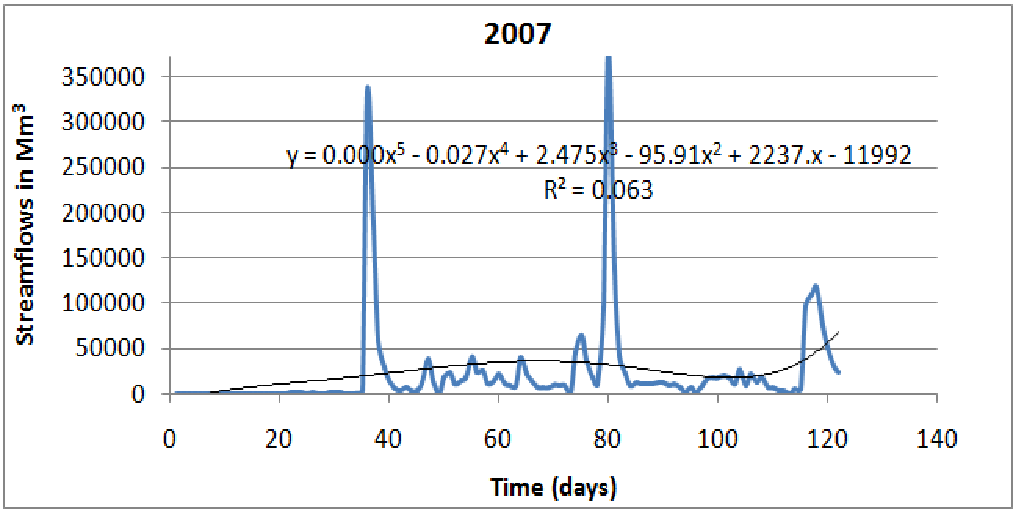

Fig.12 Streamflow pattern of 2007

In Fig: 13 it shows the overall trend of the streamflow in the catchment from 1991 to 2010 and shows the variation of stremflow in a combined interface where R^2 = 0.295 which is an average fit.

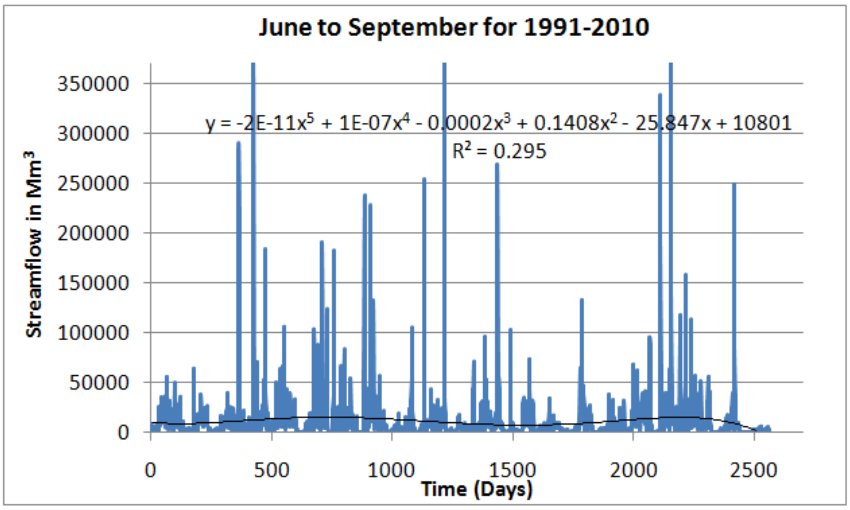

Fig.13 Stream flow pattern of June to September for 1991-2010

The Fig: 14 gives the idea of the stream flow in moving average basis by considering one day delay.

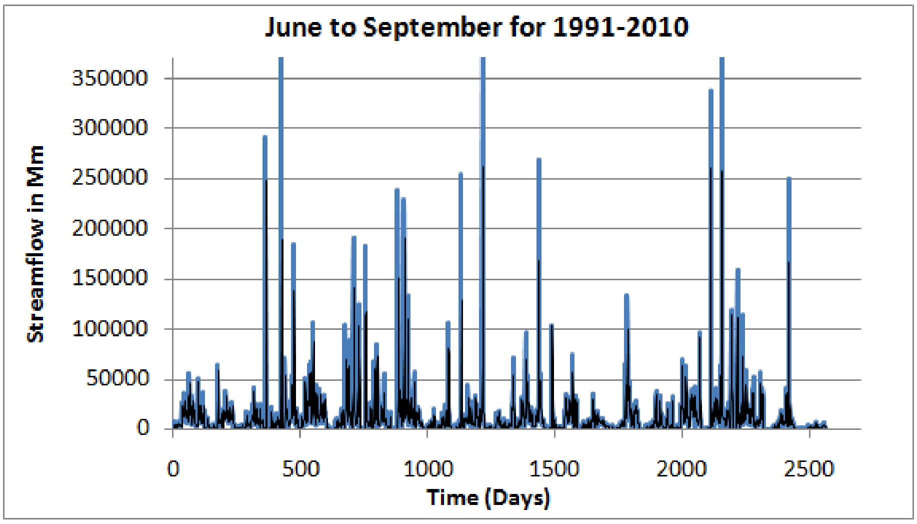

Fig.14 Stream flow on Moving average basis

IV. CONCLUSION

The flood and drought forecasting is not a easy technique. This forecasting technique gives a rough idea about the management practice that is to be implemented in the catchment for the development of the area.

In the Kangasabati catchment it shows a fashion that after every two years there is a chance of drought condition and consecutively after that there is a high flood year. In our study period from 1991 to 2010 there are six low stream flow year i.e. in that year there is less rainfall than the average rainfall on that area.

The year 1991, 2002 and 2009 are the drought prone year and above that in 2010 the severe drought condition was seen and this is the lowest rainfall year among the last 20 years and the rainfall on this year is only 766 mm which is in an about 38% less rainfall than the average rainfall of the catchment. Again on the year 1993, 1999 & 2007 there is havoc in the stream flow and as a result there is a chance of flood in the area. And the highest flood peak in the last twenty year is noted on 19^{th} Aug 2007 as 377107.8 Mm^3.

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