Proceedings of the Peradeniya University Research Sessions, Sri Lanka, Vol. 15, 16th December 2010

PREDICTION OF RAINFALL INCORPORATING CLIMATIC VARIABILITY

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Introduction

Flooding constitutes the most prevalent and costly natural disaster in the world. With the expected change in global climate, rainfall would vary resulting in changes in the severity and frequency of flood occurrences. The paper presents the prediction of rainfall over Kalu-Ganga river basin in Sri Lanka incorporating expected climatic variability, which could be used to predict floods in the basin based on a rainfall-runoff. Frequency analysis is used to estimate the magnitude of rainfalls with different return periods. Major limitation in frequency analyses is the availability of reliable and long term data and one of the basic assumptions made in frequency analysis is the statistic stationarity of time series data available.

Intergovernmental Panel for Climate Change ((IPCC), 2001) summarized its conclusions concerning the likely increases in globally averaged surface temperatures and sea level, which will be accompanied by increases and decreases in precipitation. According to IPCC [2001], "there would be changes in the variability of climate, and changes in the frequency and intensity of some climate phenomena." Such forecasts, now being made with ever-increasing confidence, imply that the statistical stationarity necessary for many hydrologic analyses can no longer be safely assumed, and the spatial and temporal availability of water resources must be expected to change as and when regional climate changes (Clarke, 2002). Incorporating these climatic trends in rainfall frequency analysis is a question. The paper presents an attempt made to investigate the time trend in extreme rainfall events with the aim of incorporating them in rainfall frequency analysis leading to rainfall runoff estimates.

Study area and data availability

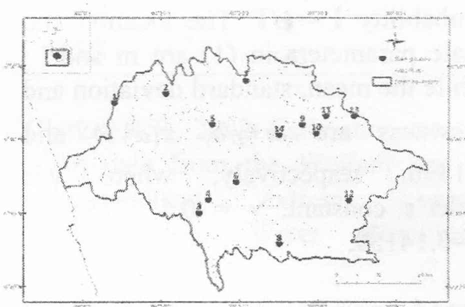

Fig. 1. Basin and rainfall gauging stations

The Kalu-Ganga river catchment covers 2658 km2 and is subjected to frequent floods. Geographically the catchment lies between 6.32°N and 6.90°N latitude and 79.90°E and 80.75°E longitude as per WGS84 coordinate system and the river flows from a height of about 2,250 m MSL (Figure 1).

For this study daily rainfall data at rain gauging station at Ratnapura (No. 14) displayed in Figure 1 were used. At this station, daily rainfall data from January 1901 to December 2009 were available.

Methodology

The Gumbel distribution is extensively used in the study of extreme rainfall intensities. In the absence of time trends, the Gumbel distribution

$F(y;\alpha,m)=\alpha exp\{-\alpha(y-m)-exp[-\alpha(y-m)]\}$ (1)

$-\infty<y<\infty$

with cumulative probability

$F(y;\alpha,m)=exp\{-exp[-\alpha(y-m)]\}$ (2)

has been widely used for estima the magnitudes of floods with different ("T-year") return periods, because of the ease with which its quantiles can be calculated, the flood with return period T years being the quantile corresponding to cumulative probability 1 - 1/T. The location and scale parameters in (1) are m and , while the mean, standard deviation and skewness are $m+\gamma/\alpha$, $\pi(\alpha\sqrt{6})$ and 1.1396, respectively, where γ is Euler's constant, γ = 0.577215 and π =3.14159.

Trend Analysis

Annual maximum values were extracted from the daily rainfall data of all gauging stations. Since long term data are available only at Ratnapura gauging station, the data at that gauging station was used to investigate the existence of a trend. The data series was divided into four intervals. The location and scale parameters of the Gumble distribution were estimated for these four data series. After estimating the Gumbel parameters, the values were analysed to check whether these values can be fitted into a trend. Fitted trend was used to estimate the Gumble parameters for the next 100 years period.

Results

The average and standard deviation of the data series of the four time intervals are displayed in Table 1. It includes scale and location parameters of the Gumbel distributions corresponding to those time four series.

Parameters α and m for the four periods were plotted and trends were fitted as shown in Figures 2 and 3. The variation of the parameters α and m indicates the change in the rainfall with time.

Table 1. Average, Std. dev., α and m of the data series at Ratnapura gauging station

For Ratnapura gauging station	1901-1930 (1)	1931-1960 (2)	1961-1990 (3)	1991-2009 (3)
Average of the data series	150.64	163.66	152.03	158.16
Std. dev. of the data series	40.38	77.15	56.35	81.08441
Scale parameter (α)	0.031	0.016	0.0227	0.015
Location parameter (m)	132.47	128.95	126.68	121.69

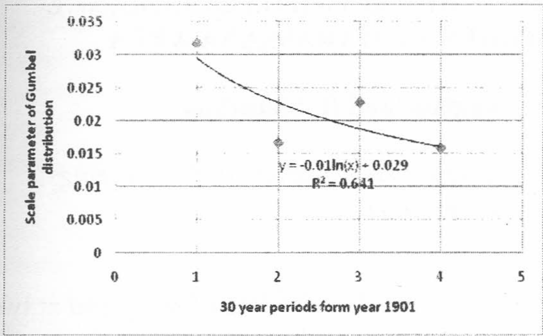

Fig. 2. Trend of scale parameter

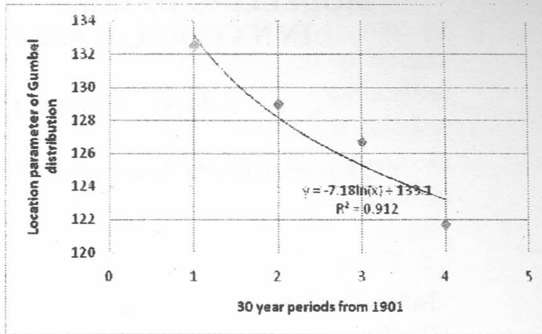

Fig. 3 Trend of location parameter

Table 2. Expected rainfall with 100 year return periods

Periods of years	Predicted Gumbel parameters		Expected 100 year rainfall	Maximum rainfall observed so far
	m	Alpha		
1901-1930	133.10	0.02900	291.7	269.2
1931-1960	128.12	0.02206	336.5	394.4
1961-1990	125.21	0.01801	380.5	294.9
1991-2020	123.14	0.01513	427.0	392.5------
2021-2050	121.54	0.01290	477.9	
2051-2080	120.23	0.01108	536.3	

Discussion and Conclusions

The results indicate that the rainfall has varied in the past. The method used could be used to estimate extreme rainfalls expected to occur if same trend in the climate change exists. The extreme rainfalls over the Kalu-Ganga river basin have been increased and therefore, more severe floods could be expected to occur in the basin in future.

References

(IPCC), I.P.f.C.C., 2001. Climate Change 2001: Impacts, Adaptation and Vulnerability. New York: Cambridge University Press.

Clarke, R.T., 2002. Estimating trends in data from the Weibull and a generalized extreme value distribution. Water Resources Research, 38 (6).