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MODELING KALU-GANGA RIVER BASIN FOR PREDICTING RUNOFF FOR DIFFERENT FREQUENCY RAINFALLS

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Introduction

Rainfall-runoff models are widely used to formulate reliable relationships between precipitation (input of the model) and runoff (output of the model) in catchments. This paper presents a hydrological modelling study carried out for Kalu-Ganga River located on the south west slopes of Sri Lanka. The study area is its most upstream basin upto Ratnapura, which is having a drainage area of 2658 km^2. The presented rainfall-runoff model was calibrated and verified for the basin based on daily rainfall and runoff data. Subsequently, it was used as a tool for forecasting floods for rainfalls of different return periods.

The modelling was carried out by dividing the basin into four sub-basins (Figure 1): SriPada, Ellegawa, Horana and Sinharaja and each sub-basin was modelled with its own parameters, viz., infiltration loss, transformation and base flow. The software HEC-HMS version 3.3, the latest version, (USACE-HEC, 2008) released in October 2008 by US Army corps of Engineers was used in the study.

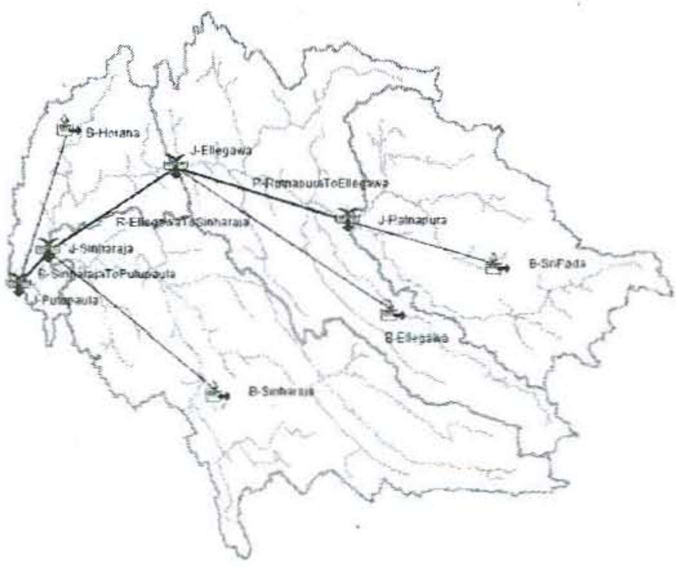

Figure 1. Kalu-Ganga River with four sub-basins

Methodology

Initially event-based daily simulations were carried out to calibrate and verify the HEC-HMS model. After that rainfall intensity-duration-frequency curves were developed for the basin. Then the calibrated model was used to predict the runoff due to rainfalls with return periods of 2, 50, 100 and 1000 years using frequency storm method available in the HEC-HMS software. Finally, peak runoff obtained for these flood events were compared with the available historical discharge records.

Data

The Shuttle Radar Topography Mission (SRTM) Digital Elevation Model (DEM) data, which is freely available on-line (Jarvis et al,. 2008) is used to develop the basin model. Rainfall data within the basin and discharge data at Ratnapura for 4 observed storm events were selected to be used in the study for calibration and verification of the model. The rainfall data were obtained from the Department of Meteorology while the discharge data were collected from the Department of Irrigation.

Modelling the Basin

The HEC-HMS model was calibrated based on one storm event and verified with three other storm events. Results obtained after calibration and validation are shown in Table 1. Subsequently, the calibrated and verified model was used for runoff generation for frequency storms of 24 h duration with different return periods of 2 years 50 years 100 years and 1000 years, respectively. The source of the frequency storms is the Intensity Duration Frequency (IDF) curves that are prepared based on long records of precipitation data within the Kalu-Ganga River basin up to Ratnapura.

Table 1. Results of the calibration and validation using HEC-HMS

	Loss -Initial and constant			Transform - Clarks UH		Base flow - Recession				
Sub-basin	Initial loss mm	Constant rate mm/h	Impervious %	Time of concentration h	Storage Coefficient h	Initial type	Initial discharge m^3/s	Recession Constant	Threshold type	Ratio to peak
Ellegawa	1	0.00	1	72	48	Discharge	65.00	0.90	Ratio to Peak	0.05
Horana	2	0.30	1	72	48	Discharge	25.00	0.80	Ratio to Peak	0.20
Sinharaja	5	3.00	1	96	96	Discharge	30.00	0.80	Ratio to Peak	0.20
Sri Pada	1	0.20	2	24	48	Discharge	15.00	0.80	Ratio to Peak	0.40

Table 2. Intensity of 24 h duration rainfalls with different return periods

Return period (years)	2	50	100	1000
Intensity (mm/day)	139	354	419	716

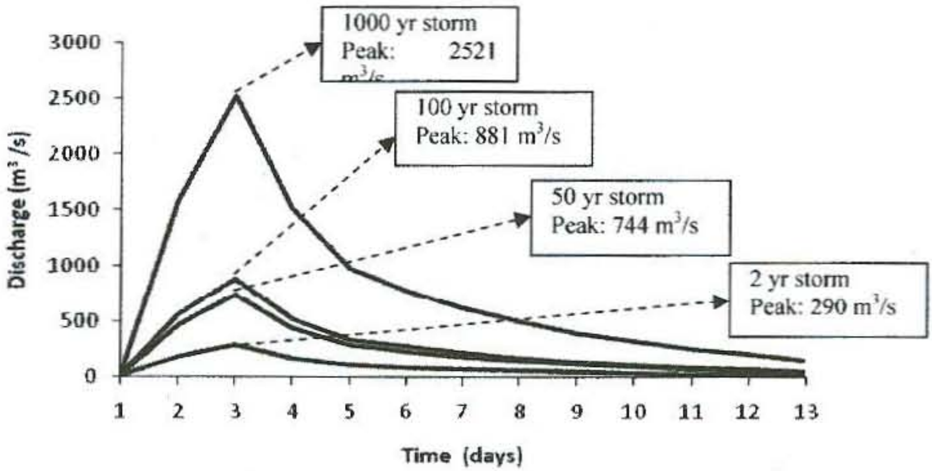

Figure 2. Hydrographs for different return period rainfalls

Table 3. Peak discharge during historical flood events

Year	Discharge (m^3/s)
1913	666
1947	749
2003	676

Results

The rainfall intensities that were used in the study are given in Table 2. Figure 2 presents the hydrographs obtained from the model for the 2, 50, 100 and 1000 years storms. River discharges for three recorded historical flood events are given in Table 3 for comparison purpose. Flood warning is issued when the discharge of the river at Ratnapura reaches 369 m^3/s.

Discussion and Conclusions

Peak discharges of 50 year storm and 100 year storm are very close. However, the differences between the peak discharges of storms for 100 and 1000 year return periods and storms for 2 and 50 year return periods are very large. This may be due to the large time difference between the storms considered. The most severe recorded historical flood event experienced in the Kalu-Ganga River basin in the year 1947 is observed to be due to a 50 year return period rainfall event. The HEC-HMS software is observed to be suitable in modelling the Kalu-Ganga River basin and capable in predicting flood discharges for different frequency rainfall events.

References

United States Army Corps of Engineers, Hydrologic Engineering Center (USACE_HEC). (2008). Hydrologic modeling system HEC-HMS technical user's manual, Davis, California.

Jarvis, A., Reuter, H.I., Nelson, A. and Guevara, E. (2008) Hole-filled seamless SRTM data V4, International Centre for Tropical Agriculture (CIAT), available at http://srtm.csi.cgiar.org.