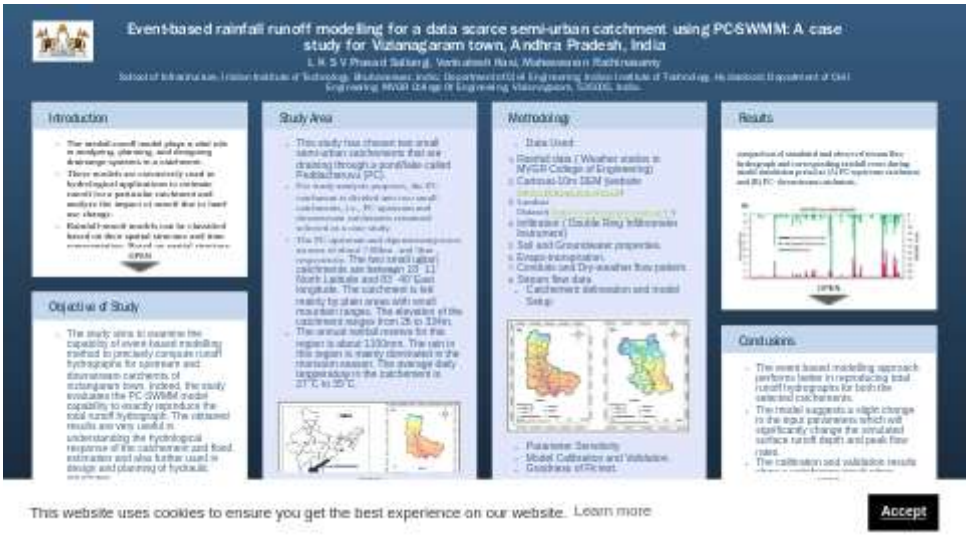
Event-based rainfall runoff modelling for a data scarce semi-urban catchment using PC-SWMM: A case study for Vizianagaram town, Andhra Pradesh, India



L K S V Prasad Sallangi, Venkatesh Kasi, Maheswaran Rathinasamy

School of Infrastructure, Inidan Institute of Technology, Bhubaneswar, India; Department of Civil Engineering, Indian Institute of Technology, Hyderabad; Department of Civil Engineering, MVGR College Of Engineering, Vizianagaram, 535005, India.

PRESENTED AT:

INTRODUCTION

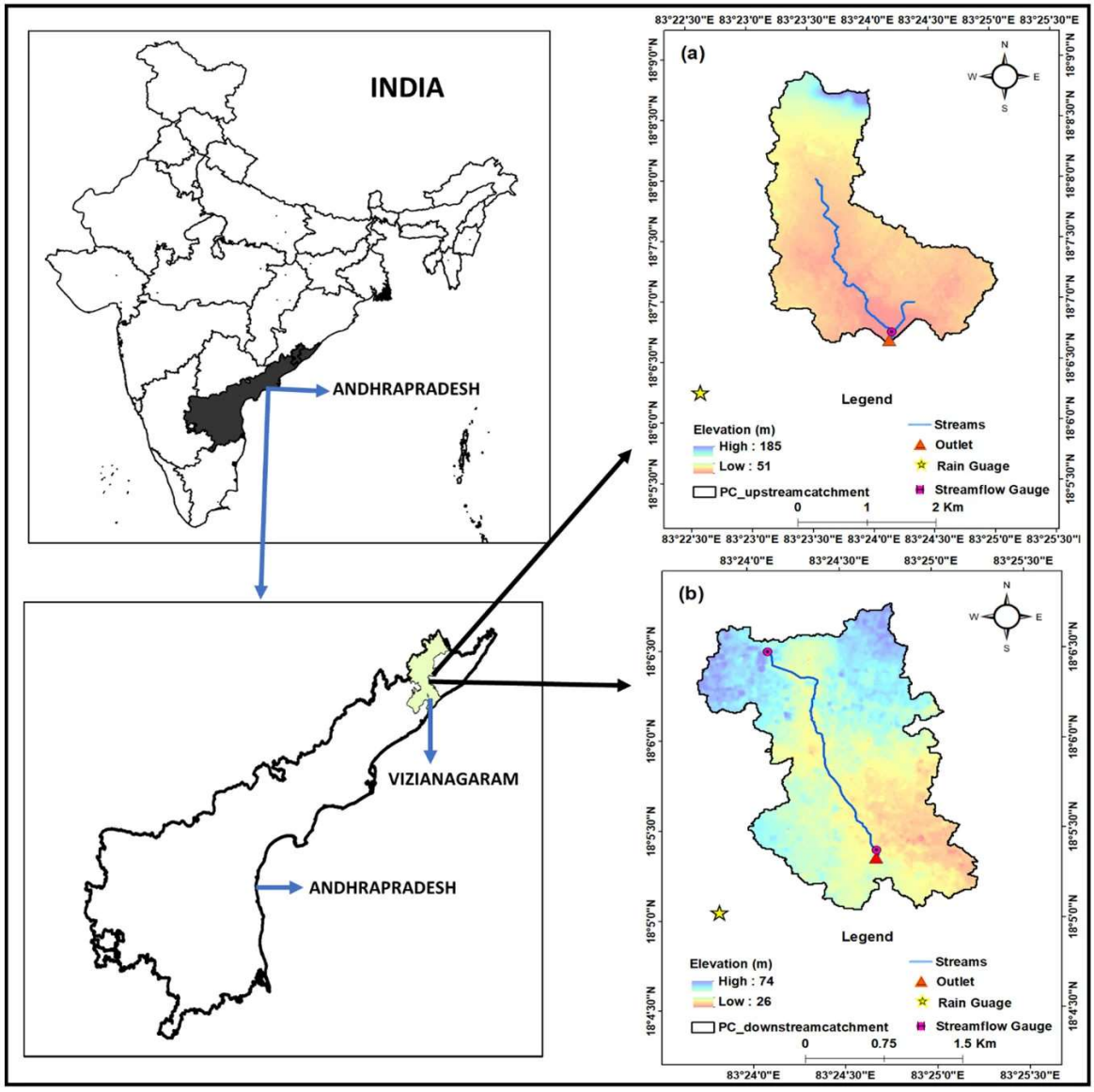
- The rainfall-runoff model plays a vital role in analyzing, planning, and designing drainange systems in a catchment.
- These models are extensively used in hydrological applications to estimate runoff for a particular catchment and analyze the impact of runoff due to land-use change.
- Rainfall-runoff models can be classified based on their spatial structure and time representation. Based on spatial structure, the models are further classified into lumped, semi-distributed and distributed models. Whereas in time representation, models are classified into event based and continous based models.
- There are many advantages and limitations with event-based and continuous simulation models. In event-based modelling, only infiltration loss is taken into consideration, whereas in the continuous simulation modelling, only evapotranspiration loss is accounted.

OBJECTIVE OF STUDY

- The study aims to examine the capability of event-based modelling method to precisely compute runoff hydrographs for upstream and downstream catchemts of viziangaram town. Indeed, the study evaluates the PC-SWMM model capability to exactly reproduce the total runoff hydrograph. The obtianed results are very useful in understanding the hydrological response of the catchement and flood estimation and also further used in design and planning of hydraulic structures.

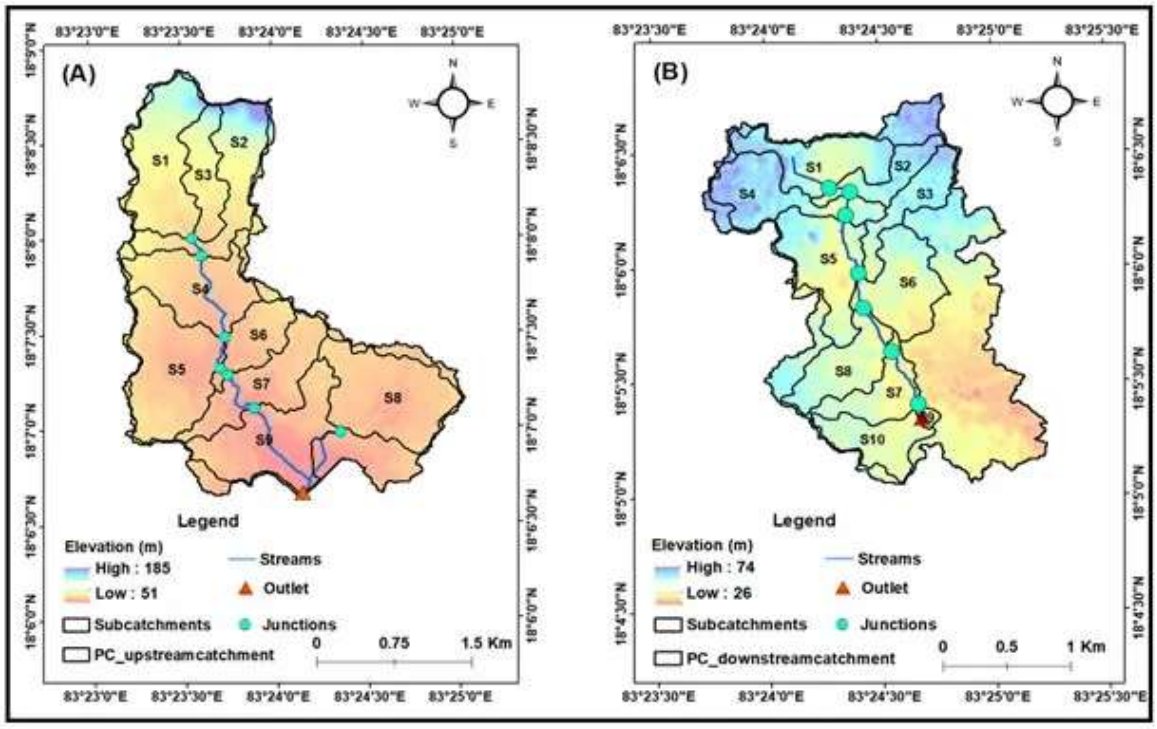
STUDY AREA

- This study has chosen two small semi-urban catchements that are draining through a pond/lake called Peddacheruvu (PC).
- For study analysis purposes, the PC catchment is divided into two small catchments, i.e., PC upstream and downstream catchments remained selected as a case study.
- The PC upstream and downstream covers an area of about 7.08km^2 and 5km^2, respectively. The two small urban catchments are between 18^0 11' North Latitude and 83^0 40' East longitude. The catchment is led mainly by plain areas with small mountain ranges. The elevation of the catchment ranges from 26 to 334m.
- The annual rainfall receive for this region is about 1100mm. The rain in this region is mainly dominated in the monsoon season. The average daily temperature in the catchement is 27^{0}C to 35^{0}C.



METHODOLOGY

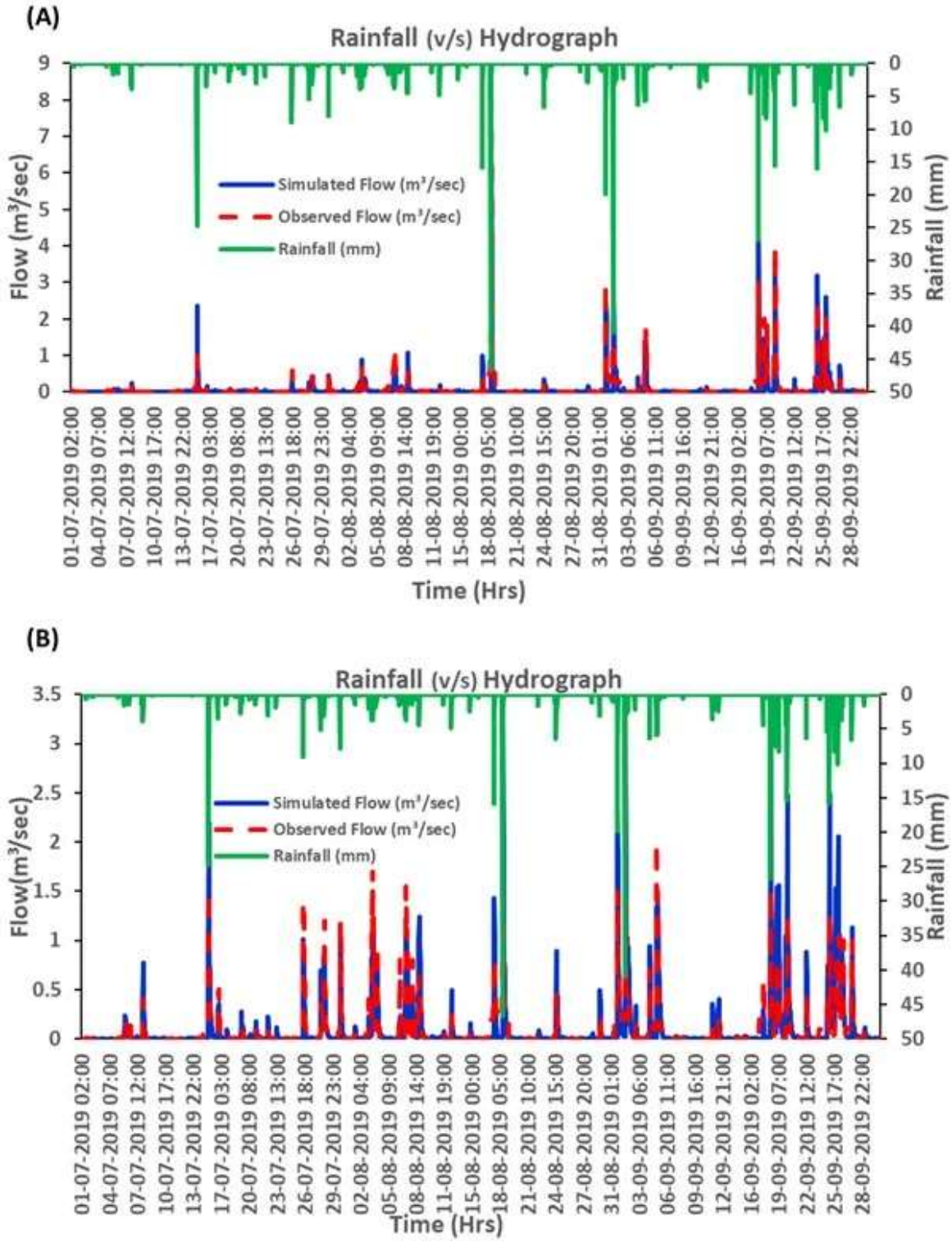
- Data Used:
  1. Rainfall data (Weather station in MVGR College of Engineering)
  2. Cartosat-10m DEM (website https://bhuvan.nrsc.gov.in (https://bhuvan.nrsc.gov.in/))
  3. Landsat Dataset(https://earthexplorer.usgs.gov/ (https://earthexplorer.usgs.gov/))
  4. Infiltration (Double Ring Infiltrometer Instrument)
  5. Soil and Groundwater properties.
  6. Evapo-transpiration.
  7. Conduits and Dry-weather flow pattern.
  8. Stream flow data
- Catchement delineation and model Setup

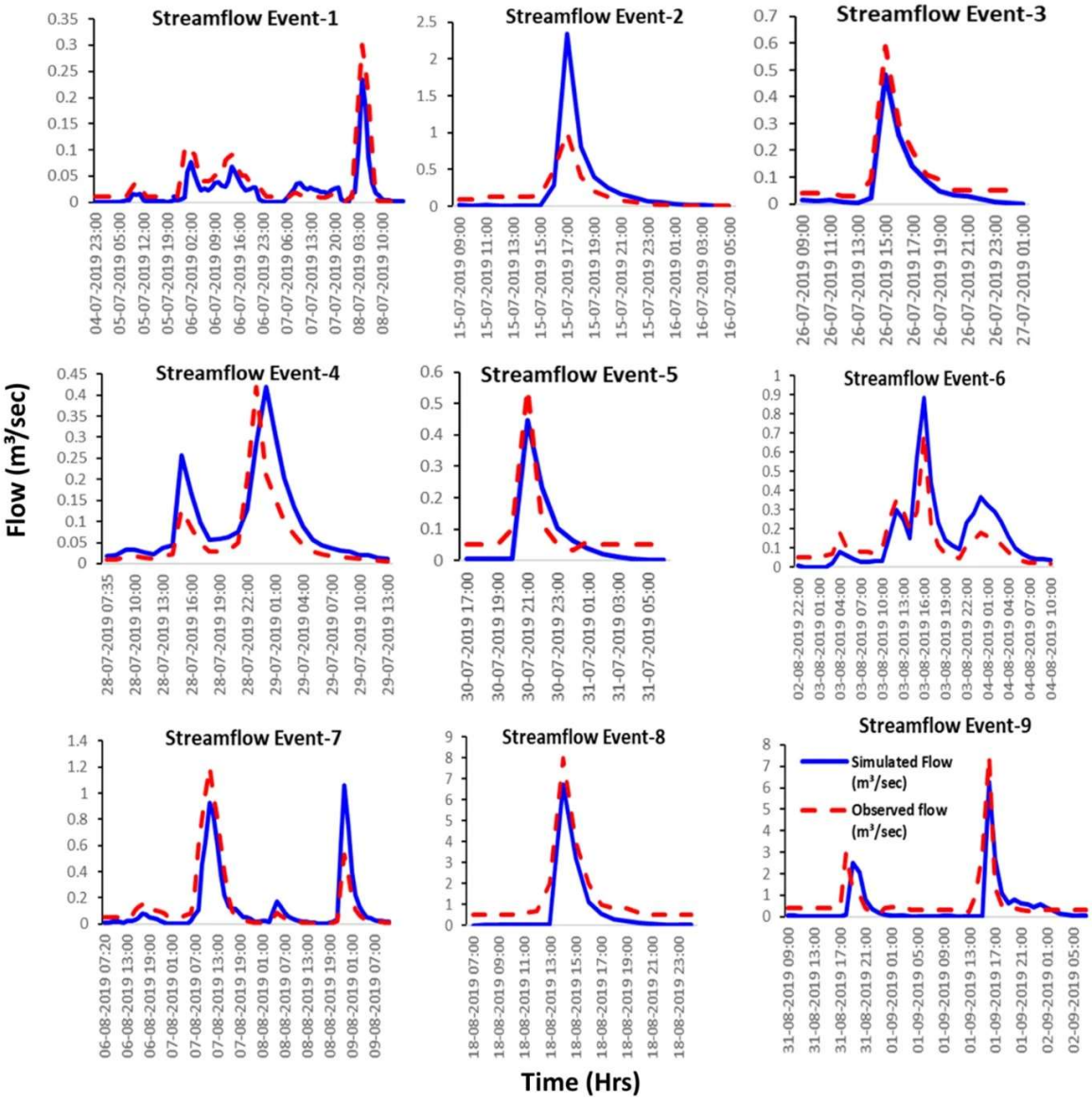


- Parameter Sensitivity
- Model Calibration and Validation.
- Goodness of Fit test.

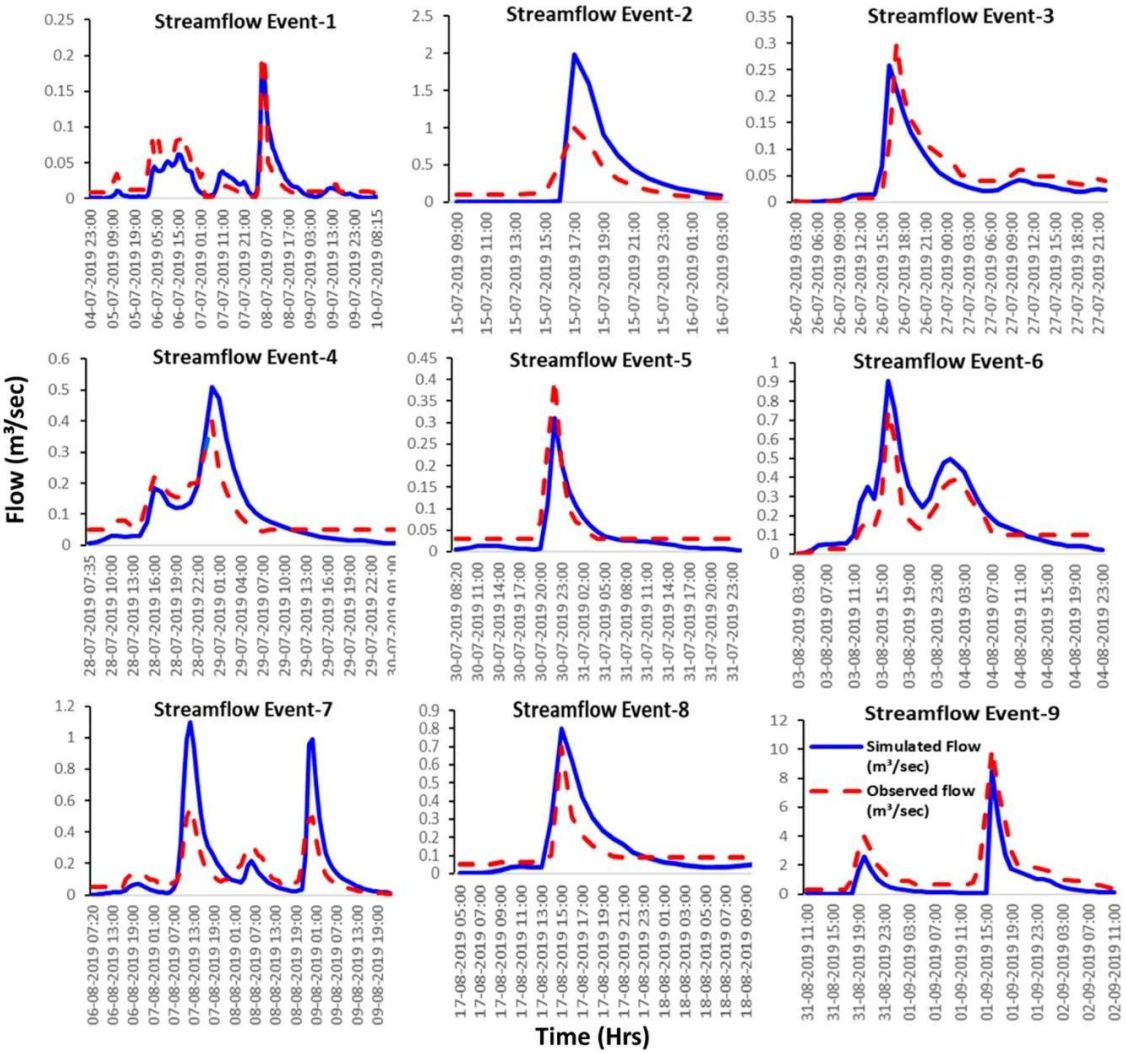
RESULTS

comparison of simulated and observed stream flow hydrograph and corresponding rainfall event during model simulation period at (A) PC-upstream catchment and (B) PC- downstream catchment.

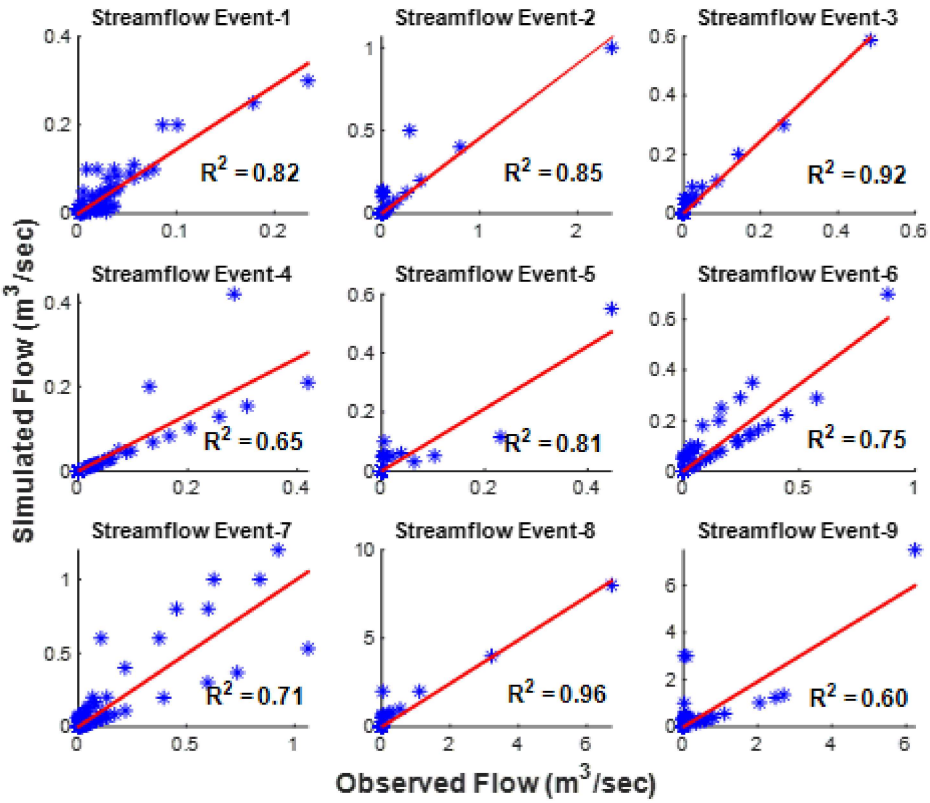




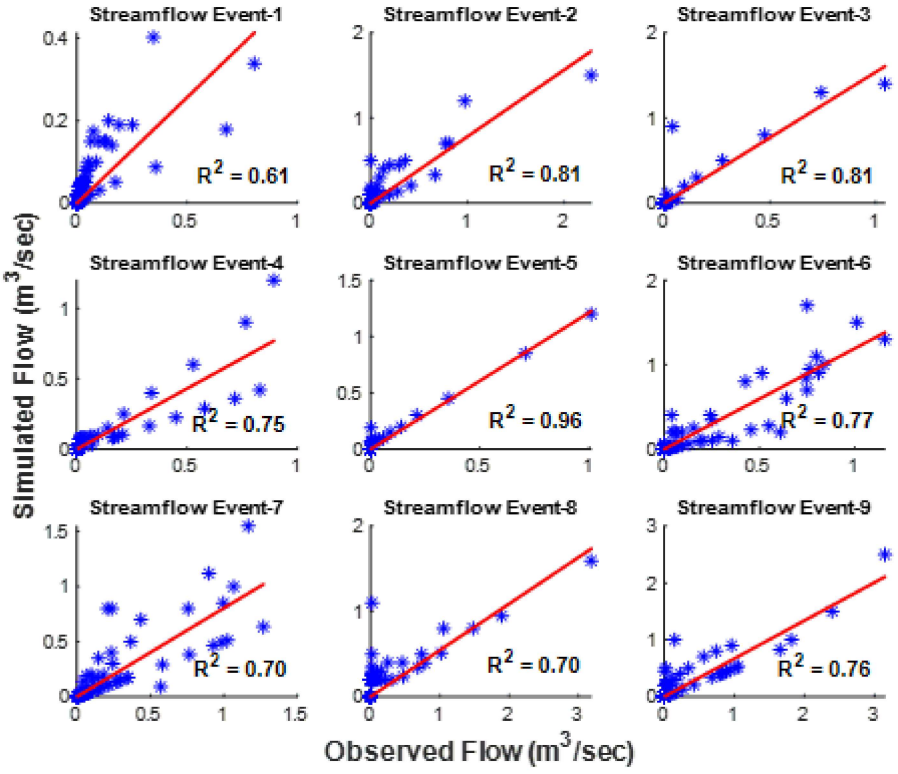
Comparison of event-based model with observed streamflow during the model calibration period for PC upstream catchment



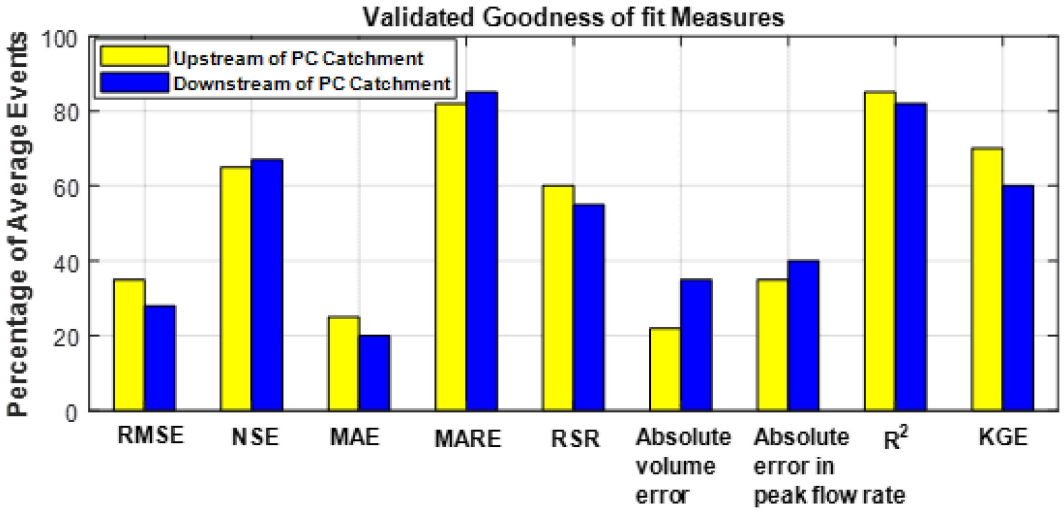
Comparison of event-based model with observed streamflow during the model calibration period for PC Downstream catchment



R^2 values for Upstream Catchement



R^2 values for Downstream Catchement



Validated Goodness of Fit tests measures for PC upstream and downstream catchment.

CONCLUSIONS

- The event based modelling approach performs better in reproducing total runoff hydrographs for both the selected cstchements.
- The model suggests a slight change in the input parameters which will significantly change the simulated surface runoff depth and peak flow rates.
- The calibration and validation results show a satisfactory result when compared to goodness of fit measures for simualted and observed streamflow events.
- The event based modelling approach can highly be implemented on data scarce regions to quantify the runoff that permits the model with more reliable results.
- In conclusion, the event based modelling results can be used for future studies in analyzing the extreme hydrological events such as floods or droughts.

ABSTRACT

Rainfall runoff modelling in a data scarce region has always been challenge and is interest to hydrologist. With increasing flood disasters in urban clusters across the globe, it is pertinent to develop accurate rainfall runoff models for applications such as flood forecasting, inundation modelling. This study investigates the performance of event-based modelling for a data-scarce semi-urban catchment using PC-SWMM in computing the runoff hydrograph. For this purpose, a case study from Vizianagaram, South eastern India is presented. For the model development and calibration, the rainguage data, discharge data and the infiltration characteristics were estimated using simple measurement methods for the period from 1 July 2019 to 31 September 2019 for 12 different events. The model performances are evaluated using five goodness of fit measures like root mean square error (RMSE), Nash Sutcliffe efficiency (NSE), coefficient of determination (R^2), RSR, and Kling Gupta efficiency (KGE) for all the individual events. The model performance is acceptable throughout model calibration as the NSE and R^2 varies between 0.75 to 0.77 and 0.76 to 0.78, respectively. Similarly, the model validation performances (1 September 2019 to 31 September 2019) revealed best fitted with the observed hydrograph for NSE and R^2 were 0.62 to 0.64 and 0.62 to 0.85. KGE for model calibration and validation model varies between 0.65 to 0.75 and 0.62 to 0.75. The results of this study suggest that the PC-SWMM model along with simple methods of measurement can be reliably used for rainfall-runoff modelling in data scarce regions.