IMPACT OF CLIMATE CHANGE ON NON-STATIONARITY OF EXTREME STREAMFLOWS IN GODAVARI RIVER BASIN, INDIA

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1. Introduction

- As a result of climate change, human-induced changes in land use patterns (urbanization, deforestation, encroachment of flood plains), and faulty reservoir operations, the stationarity of streamflow assumption is questionable in flood frequency analysis.
- The changing climate has continued to alter the intensity, duration, and frequency of extreme events in the region, and the current status of climate change impacts on hydrology calls for the evaluation of a non-stationarity approach for extremes to enhance effective planning.
- This study aims to investigate the non-stationarity of streamflow and hydrologic sensitivity of catchments of the Godavari River basin located in peninsular India to changing climatic circumstances using a multi-model ensemble based on CMIP6 climate models.

2. Study Area

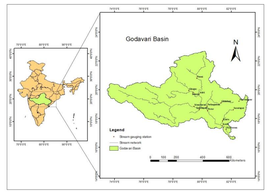


Fig. 1.Godavari River Basin, India.

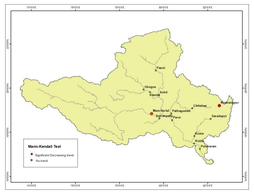


Fig. 2. Observed trends (Mann Kendall) in annual maximum streamflow in the Godavari River basin

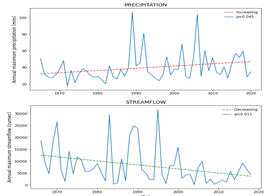


Fig. 3. Observed annual maximum precipitation and streamflow at the Mancherial stream gauging station

Data Collection:

This study was undertaken using only freely available data, including following sources.

- **Terrain Data:** A digital elevation model (DEM) generated from the Shuttle Radar Topography Mission (SRTM) of 30-m resolution was used.
- **Hydrological Data:** India -WRIS has streamflow data for hundreds of CWC-owned stations. From this, 14 stations of Godavari basin region were selected and annual maxima were derived.
- **Land Use:** The Environmental Systems Research Institute (ESRI) offers figures on proportions of Water, Built area, Crops and Forested land.
- **Meteorological Data:** India Meteorological Department (IMD), Pune offers 0.25° × 0.25° resolution daily gridded precipitation data.

3. Methodology

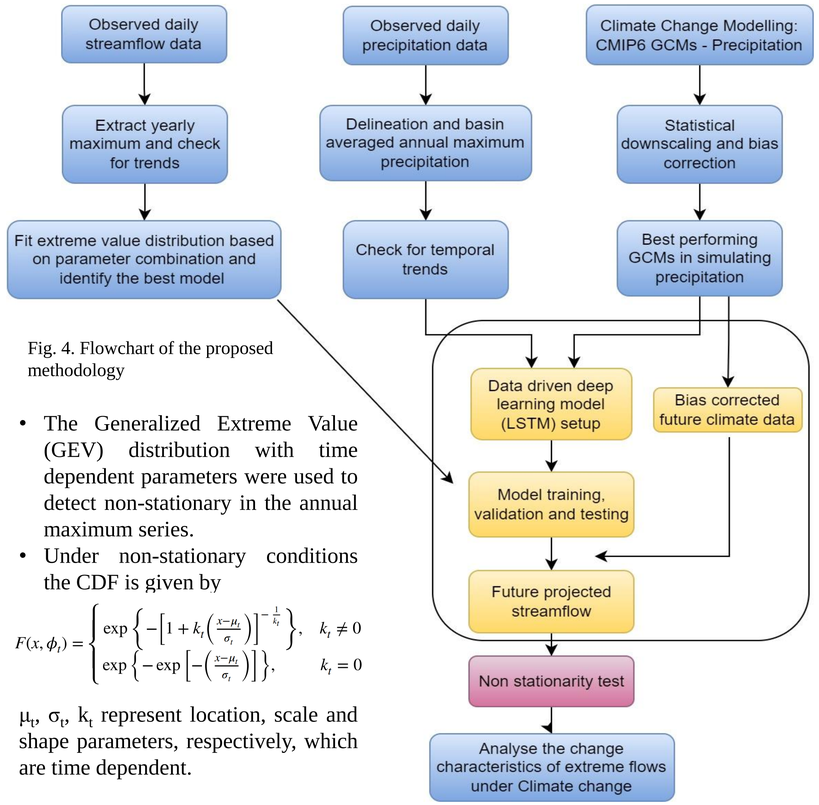


Fig. 4. Flowchart of the proposed methodology

- The Generalized Extreme Value (GEV) distribution with time dependent parameters were used to detect non-stationary in the annual maximum series.
- Under non-stationary conditions the CDF is given by

$$F(x,\phi_t)=\begin{cases}\exp\left\{-\left[1+k_t\left(\frac{x-\mu_t}{\sigma_t}\right)\right]^{-\frac{1}{k_t}}\right\}, & k_t\neq 0\\ \exp\left\{-\exp\left[-\left(\frac{x-\mu_t}{\sigma_t}\right)\right]\right\}, & k_t=0\end{cases}$$

μ_t, σ_t, k_t represent location, scale and shape parameters, respectively, which are time dependent.

4. Results

Goodness of fit of a GEV distribution

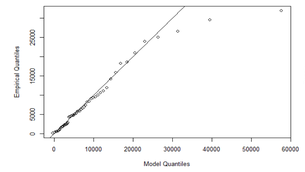


Fig. 5. Quantile – Quantile plot of GEV distribution for annual maximum streamflow at station Mancherial

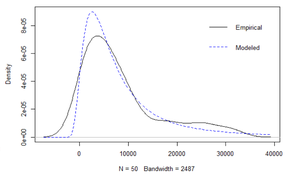
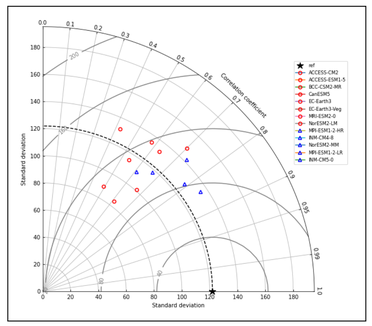


Fig. 6. Density plot of GEV distribution for annual maximum streamflow at station Mancherial

- GEV distribution whose scale and location parameter linearly varies with time is the best fit distribution for streamflow series at Mancherial stream gauging station

Performance of climate models



Taylor diagram integrates three statistical metrics :

- The degree of the correlation coefficient (r) between the observed and CMIP6 GCMs.
- Centered root mean square error (CRMSE).
- Departure of the models' standard deviation (SD) from the observed data.

Fig. 7. Taylor diagram showing comparative skills of 13 CMIP6 GCMs in simulating precipitation over the Godavari River basin

5. Conclusions

- In the Godavari river basin, annual maximum streamflow shows decreasing trend at two stations and no trend is observed at remaining stations whereas annual maximum precipitation shows an increasing trend at three stations.
- GEV distribution fits show that only 2 out of 14 streamflow series show temporal trends, suggesting that using physically based covariates instead of time can provide a better fitting.
- Future work is to analyze the change characteristics of extreme streamflows under climate change using best ranked CMIP-6 GCMs.

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