**The Analysis of Non-stationarity and Evolution of Droughts**

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**Introduction**

Drought is the costliest natural hazard which destroys human life and property. The devastating effects of drought and its increasing trend in drought intensity and severity have led to research extensively for better understanding, monitoring and prediction of drought. There are different types of droughts based on different hydrological variables and economic conditions. The name of the four main droughts (with their respective drought indices) are like meteorological drought (SPI-Standardized Precipitation Index), agricultural drought (SSI-Standardized Soil moisture Index), hydrological drought (SRI-Standardized Runoff Index) with other types of droughts such as Ground Water drought (SGI- Standardized Groundwater Index) and socioeconomic drought.

There are also some modified Standardized Indices i.e. SPEI (standardized precipitation-evapotranspiration index) and the Self-calibrated Palmer Drought Severity Index (SC-PDSI) which were compared with SPI and a correlation was found among the drought indices( Wang et.al 2017). Because of this correlation between different drought indices, there is a propagation from meteorological drought to agricultural and hydrological drought. Kwon et.al (2016) explored the time-varying joint return periods for drought duration and severity, to assess how the frequency of a significant drought has varied over time to provide a context for the changing climate and drought severity in the region and to investigate relationships between the large-scale climate indices such as the ENSO and PDO on the drought patterns. H. Varikoden et.al(2015),by analyzing droughts in India, suggested that droughts associated with El Niño events brought severe drought conditions over WG region, and there was no considerable difference in cumulative rainfall associated with the two types of droughts(El Niño and non- El Niño) over central India. Jitendra Singh et.al (2016) found the effect of urbanization in changing the character of ISMR (Indian Summer Monsoon Rainfall) extremes by performing a nonstationary frequency analysis. Xiang Zhang et.al (2017) quantified the relationship and evolutionary process among these four types of droughts with impact on crop yield in India and interestingly found there was no time lag between these four kinds of drought, except for the evolution from meteorological to vegetation drought by reconstructing the time series of droughts from 1981 to 2013.

The objective of the study is to find out the reasons of non-stationarity in climate change in India and different non-stationary analysis for drought prediction and its impact on agricultural productivity in India.

**Materials and Methods**

There are different types of non-stationary analysis for the prediction of different types of droughts. A nonstationary, multivariate, Bayesian copula model for drought severity and duration is developed and applied to explore the time-varying joint return periods for drought duration and severity, to assess how the frequency of a unusual drought has varied over time to provide a context for the changing climate and drought severity in the region (Han Kwon et.al 2016). A spatial multi-linear regression approach was used for quantifying the contributions of decadal PET and precipitation variations to drought duration and intensity (Shanlei Sun et.al 2016). Under non-stationarity, Generalized Additive Models for Location, Scale and Shape (GAMLSS ) algorithm was used to fit a time-varying location parameter of lognormal distribution with the initial values (α0) of the traditional Reconnaissance Drought Index (RDI) to establish NRDI for drought monitoring in a climate change (Javad Bazrafshan et.al 2018). And as there is no worldwide accepted parametric distribution for meteorological and hydrologic variables, a nonparametric multivariate Standardised drought index (NMSDI) indicates the reliability and effectiveness by showing the variations of developed NMSDI is well consistent with those of 1-month SPI and SSI (Yuelu Zhu et.al 2015). The modified Mann-Kendall test trend method, Rescaled Range (R/S) analysis, Morlet wavelet analysis were used to capture the trend of severity and duration of historical drought, persistence of drought, to calculate the period of dry and wet condition, to calculate the joint return period of two typical scenarios respectively (Shengzhi Huang et.al 2014).

**Results and Concluding Remarks**

By analysing about different hydrological variables causing different types of droughts, it is concluded that the non-stationarity in climate change plays the main role in drought condition. From some research papers, it was found that in India, the non-stationarity in climate change may be occurred due to urbanisation, human intervention and due to some climatic indices i.e. ENSO, IOD. Because of this non-stationarity in climate change, the occurrence of unusual drought events causes bad impact on agricultural productivity which is the root of the financial source in India. About 72% of the drought years in India are caused by the influence of Pacific Ocean as it is found from historical years (13 of the 18 years) that most of the drought conditions of ISMR are associated with El Niño.

So for better improvement in drought prediction, monitoring and making drought policy to face any extreme drought condition, it is needed to analyze about the direct and tele-connected impacts of the climate indices i.e. ENSO, IOD on the drought condition by selecting the best non-stationary analysis and best drought index.

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