IMPACT OF CLIMATE CHANGE ON DROUGHTS IN MADURU OYA RIVER BASIN IN SRI LANKA OVER THE 21st CENTURY

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ABSTRACT

Impact of Climate Change on Droughts in Maduru Oya River Basin in Sri Lanka over the 21st Century

Drought is an creeping hazard that is least understood and the most complex of all-natural hazards. The drought study requires large historical climatological and meteorological datasets and their complex inter-relationships. Its impacts are prominently observed on a local scale only when the severity becomes high, and the coherent onset and persistence of mild droughts may go unnoticed. The current study investigates the existing drought conditions and future drought risk in the Maduru Oya River Basin over the 21st-century in terms of meteorological and hydrological drought indices (i.e., SPI, SPEI, RDI, EDI and SRI). The future hydrology over the basin is simulated for this research, using bias-corrected precipitation and potential evapotranspiration outputs under RCP 4.5 and 8.5 of the MPI-M-MPI-ESM-MR. The relevant drought-related indices were computed in monthly and seasonal timescales over the 1951-2099 period. The time series have been classified for drought characterization, including drought frequency, severity, trend, and probability computation. Further, to assess the impact of these droughts on the basin's response, a hydrological model (i.e., HEC-HMS) was developed to simulate the discharge at the Padiyathalawa outlet considering 2008-2012 as validation period.

The results of the monthly timescale for SPI (approximately similar drought frequency and severity by RDI and EDI) depicted that the severe and extreme droughts (45) occurred in March (8), August (5), September (4), October (6) and November (9) in the historical period. Severe and extreme droughts (110 under RCP 4.5,104 under RCP 8.5) are projected in January (17), February (12), April (10), May (12) and December (13) under RCP 4.5 and January (12), February (10), April (13), June (13) and August (10) under RCP 8.5 over the 21st-century. The SPEI at monthly timescale identified highest number of severe and extreme drought (67) events in the historical period and projected highest severe and extreme drought (128 under RCP 4.5,122 under RCP 8.5) events over the 21st-century in the study area. The hydrological drought index, SRI projected severe and extreme droughts under RCP 4.5 (65) and RCP 8.5 (62) over the 21st-century that is about 50 % frequency of the meteorological drought indices. The Northeast Monsoon season had the least drought episodes (~20) in the historical period, and on a seasonal time scale, high drought frequency (~30 using meteorological drought indices and ~20 using SRI under RCP 4.5 and RCP 8.5) and severity(severe and extreme droughts) are projected in the Northeast Monsoon. It is also observed that there is a consistent mild drought throughout the mid (~70) and end (~65) century for a maximum duration compared to the historical (~50) period. The accuracy of results obtained from the continuous HEC-HMS model (NSE, RMSE Std. Dev, and R^2 values of 0.59, 0.72, and 0.60 achieved in validation)highlights the efficient way to simulate a basin's hydrological parameters. The model can project the future variation of streamflow of the Maduru Oya River Basin under varied climatic conditions. The discharge is projected to have a decreasing trend (Sen's slope=-0.008) for future years, identified as droughts. It can be concluded that the impact of climate change on meteorological drought will affect the discharge of the basin. Moreover, due to time lag between meteorological and hydrological drought, about 50 % of meteorological droughts may lead to a severe and extreme hydrological drought in the Maduru Oya River Basin over the mid-century (14) under RCP 8.5 and end-century (13) under RCP 4.5 scenarios. This study will begin with quantitative investigations including streamflow variability and climatology over the basin incorporating the application of regional circulation models.

Keywords: Drought Indices, HEC-HMS, Trend Analysis

DEDICATION

This thesis is dedicated to my beloved parents, S. Mohan Singh and Mrs Amardeep Kour, for their encouragement, constant love and endless support.

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LIST OF ABBREVIATIONS

CMIP	Coupled Model Intercomparison Project
CORDEX	Coordinated Regional Climate Downscaling Experiment
DMC	Disaster Management Center
DSD	Divisional Secretariat Division
EDI	Effective Drought Index
EP	Effective Precipitation
ERA	ECMWF Re-Analysis
GCM	General Circulation Model
GDP	Gross Domestic Product
GHG	Greenhouse Gas
HEC-HMS	Hydrologic Engineering Centre - Hydrologic Modeling System
IAM	Integrated Assessment Models
IDW	Inverse Distance Weightage Method
IPCC	Inter-governmental Panel for Climate Change
NSE	Nash Sutcliff Efficiency
PBIAS	Percent Bias
PET	Potential Evapotranspiration
R^2	Coefficient of Determination
RCM	Regional Climate Model
RCP	Representative Concentration Pathways
RDI	Reconnaissance Drought Index
RMSE	Root Mean Square Error
SPEI	Standardized Precipitation Evapotranspiration Index
SPI	Standardized Precipitation Index
SRI	Standardized Runoff Index
SWAT	Soil and Water Analysis Tool
UNFAO	Food and Agriculture Organization of the United Nations
VIC	Variable Infiltration Capacity
WMO	World Meteorological Organization