CLIMATE CHANGE IMPACT ON THE SPATIAL DISTRIBUTION OF DROUGHTS IN KIRINDI OYA AND MADURU OYA DRY ZONE RIVER BASINS IN SRI LANKA

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Degree of Master of Science

Department of Civil Engineering

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Thesis submitted in partial fulfillment of the requirements for the degree
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DECLARATION

I declare that this is my own work and this thesis/dissertation does not incorporate without acknowledgement any material previously submitted for a degree or diploma in any other University or Institute of higher learning and to the best of my knowledge and belief it does not contain any material previously published or written by another person except where the acknowledgement is made in the text. I retain the right to use this content in whole or part in future works (such as articles or books).

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The above candidate has carried out research for the PhD/MPhil/Masters thesis/dissertation under my supervision. I confirm that the declaration made above by the student is true and correct.

Name of Supervisor: Prof. R. L. H. L. Rajapakse

Signature of the Supervisor: Date: 18/12/2023

Abstract

Climate Change Impact on the Spatial Distribution of Droughts in Kirindi Oya and Maduru Oya Dry Zone River Basins in Sri Lanka

Drought, a consequence of prolonged precipitation deficiencies, is a significant hazard exacerbated by climate change. Sri Lanka, highly susceptible to extreme climatic events, faces drought as its most prominent hazard, necessitating a comprehensive assessment of its impact. This study focuses on the escalating impact of drought intensified by climate change on the Maduru Oya and Kirindi Oya dry zone basins, crucial due to their vulnerability to altered hydroclimatic dynamics. With the substantial contribution of the dry zone to the paddy cultivation of the country, early detection of agricultural droughts is crucial for effective water allocation planning. Recognizing the importance of meteorological droughts as precursors to physical droughts, proactive monitoring and forecasting are essential for planning against subsequent agricultural droughts, while monitoring hydrological droughts is imperative for ensuring a reliable water supply for irrigation and other purposes. Thus, this research primarily focuses on evaluating meteorological and hydrological droughts.

The research employs the Standardized Precipitation Index (SPI) and the Streamflow Drought Index (SDI) for the monitoring of meteorological and hydrological droughts, respectively. It considers six CMIP6 (sixth Phase of the Coupled Model Inter Comparison Project) Global Climate Models (GCMs), and the CNRM-HR-1 model was selected as the preferred model. The two future projection scenarios, SSP1-2.6 and SSP5-8.5, were selected for the analysis. In the meteorological drought assessment, maps illustrating the spatial distribution of meteorological droughts were generated for both current and future climate scenarios. In order to generate maps, a future gridded rainfall dataset was developed by developing statistical relationships with the Climate Hazards Group InfraRed Precipitation with Station data (CHIRPS) set and observed precipitation data. For the hydrological drought assessment, machine learning methods, including Recurrent Neural Network and Random Forest Algorithm, were used to predict future streamflow at specific gauging stations, with the Random Forest model selected for its superior performance. Additionally, the climatic indices formulated by the Expert Team on Climate Change Detection and Indices (ETCCDI) were used in this study to monitor the occurrence of climate extremes of precipitation in the past.

The meteorological and hydrological drought assessments reveal significant insights into the anticipated impacts of climate change. In the Maduru Oya basin, meteorological droughts exhibit varying percentage increases under SSP1-2.6 and SSP5-8.5 scenarios. Extreme and severe droughts experience increases of 18%, and 16%, respectively, under SSP1-2.6, and 31%, and 2%, under SSP5-8.5. Conversely, the Kirindi Oya basin displays significant susceptibility to extreme meteorological droughts, with increases of 49% under SSP1-2.6 and 37% under SSP5-8.5, particularly with extreme droughts surging by over 35% under both scenarios. Furthermore, the hydrological drought assessment highlights the heightened vulnerability of the Padiyathalawa sub-basin in the Maduru Oya basin, indicating a significant increase in the occurrence of moderate hydrological droughts at the 12-month timescale under both future scenarios. Conversely, the Wellawaya sub-basin in the Kirindi Oya basin also shows susceptibility to frequent moderate hydrological droughts along with an 80% increase in the occurrence of severe hydrological droughts under the SSP5-8.5 scenario at the 12-month scale. Therefore, both basins are expected to face water scarcity in the future, emphasizing the importance of implementing measures to ensure a reliable water supply for irrigation and domestic purposes, given the substantial impact of climate change on watershed hydrology.

Keywords: Climate-driven water stress, CMIP6 GCM projections, Drought resilience in water resources, Drought vulnerability

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