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Analysing the combined drought index using geospatial technology in the Tigray region, northern Ethiopia

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Abstract

Drought continues to be a significant environmental challenge in Ethiopia's Tigray Region, posing serious threats to agricultural productivity, food security, and the livelihoods of local communities. This study develops and applies a Combined Drought Index (CDI) by merging various satellite data sources, such as vegetation, temperature, precipitation, soil moisture, and hydrological indices on the Google Earth Engine (GEE platform). This study analysed CDI for a period of 25 years (2000–2024) to examine spatial and temporal drought dynamics. The findings show that drought is a frequent hazard, with over 50 % of the Region consistently affected across the years studied. Moderate drought was the most prevalent category, affecting between 26 % and 55 % of the study area for each year. Severe droughts were particularly intense in 2004, 2009, 2010, 2012, and 2013, affecting more than 30 % of the land. Although extreme droughts occurred less often, they caused considerable damage, especially in 2008 and 2009. Moreover, the study validated the findings against the EM-DAT disaster records, which supported the accuracy of the CDI-based assessments. The analysis of crop yields showed a strong correlation with the CDI, especially for teff (MAE = 0.67; RMSE = 0.81) and barley (MAE = 0.74; RMSE = 0.97), highlighting their resilience to water stress. Conversely, maize and sorghum had higher prediction errors (MAE = 1.25 and 1.16), pointing to their vulnerability to variability in rainfall. Additionally, regression models indicated a strong correlation between the CDI and rainfall data from 12 sampled stations (R^2 = 0.72–0.78; r = 0.91–0.95), reinforcing the reliability of the CDI as a comprehensive drought indicator. In summary, these findings emphasise the potential of the CDI to improve early warning systems, guide adaptive agricultural strategies, and inform policy decisions. It is essential to promote resilient crops such as teff and barley in cropping seasons, invest in irrigation development, and work on drought-tolerant varieties to mitigate climate risks and enhance food security in Tigray and similar semi-arid Regions.

Keywords: CDI, climate variability, drought, food security, remote sensing

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