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Assessment of crop physical drought vulnerability in Sub-Saharan Africa

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Crop yields exhibit known responses to droughts. However, quantifying crop drought vulnerability is often not straightforward, because it is interwoven with different components that are not all known on a practical spatial scale. This study aims to develop a physical Crop Drought Vulnerability Index (CDVI) through linking the Drought Exposure Index (DEI) with the Crop Failure Index (CFI) in Sub-Saharan Africa. Two different DEIs, namely DEI_P and DEI_R, were derived from cumulative distribution functions fitted to precipitation and residual of precipitation and potential evapotranspiration, respectively. The DEI_{P-X} and DEI_{R-X} were calculated for different time scales (i.e., X = 1, 3, 6, 9 and 12 months). Similarly, CFI was calculated by fitting a cumulative distribution function to maize yield simulated using the Environmental Policy Integrated Climate (EPIC) model. Using a power function, curves were fitted to CFI and DEI relations resulting in five different shapes, each explaining a specific class of vulnerability. The results indicated that in Central Africa the highest correlation was found between CFI and DEI_{R-1}, while this was not the case for other parts of Africa, where CFI was strongly correlated to DEI_{P-3} and DEI_{P-6}. Our findings show that some Southern African countries, the West-Sahelian strip, and parts of Eastern Africa are highly vulnerable to drought, whereas CDVI is low in Central Africa because of relatively high rainfall and rare occurrence of crop water stress. The proposed methodology provides complementary information on quantifying different degrees of vulnerabilities and can be applied to different regions and scales.