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The role of meteorological factors in recent advances on drought identification in agricultural and forest ecosystems: A short review

N. Proutsos[1], D. Tigkas[2*], H. Vangelis[2], G. Tsakiris[2]
[1] Institute of Mediterranean & Forest Ecosystems, Hellenic Agricultural Organization "DEMETER", Athens, Greece
[2] Centre for the Assessment of Natural Hazards and Proactive Planning & Lab. of Reclamation Works and Water Resources Management, School of Rural and Surveying Engineering, National Technical University of Athens, Greece
* e-mail: ditigas@mail.ntua.gr

Introduction

Vegetation is particularly vulnerable to extreme events, such as droughts. Several studies indicate that drought events are anticipated to be more frequent and severe in many parts of the globe due to climate change that, in turn, may jeopardise the survival and growth of agricultural and forest ecosystems. Accurate drought characterisation and monitoring is a valuable process for timely evaluation of the risk and responding appropriately for mitigating foreseen damages (yield loss, forest fires, etc.).

Recently, two specialised drought indices were developed, namely the Agricultural Standardised Precipitation Index (aSPI) and the Effective Reconnaissance Drought Index (eRDI), for enhancing the accuracy of well-established drought indices for characterising vegetation-agricultural drought. These indices aim at maintaining the drought characterisation process within a prompt framework through a straightforward and non data-demanding approach. To this end, parameters based on easily accessible meteorological data were used. In this paper, the role of these parameters in characterising drought using the aforementioned indices is examined through a review of recent drought studies in agricultural and forest ecosystems.

Materials and methods

The developed indices focusing on vegetation-agricultural drought are modifications of the broadly used Standardised Precipitation Index (SPI) and Reconnaissance Drought Index (RDI). These indices are relying only on common meteorological parameters (precipitation for both indices and, additionally, potential evapotranspiration for RDI). The aSPI and the eRDI retain the basic structure of the corresponding original index. However, substitute precipitation with effective precipitation (EP), i.e., the portion of the total precipitation that can be used productively by the plants. Data requirements remain the same, since EP is assessed with empirical precipitation-based methods. The concept of EP considers and incorporates additional factors, apart from precipitation, such as evapotranspiration, soil infiltration, runoff, etc. Detailed information on these indices can be found in Tigkas et al. (2017; 2019; 2022).

The performed review analyses studies published within the last 5 years, available in academic databases (Scopus, Google Scholar), using as keywords the names of the indices and similar phrases (e.g. drought, standardised indices). Main criteria for selecting the studies for further evaluation were to include in their objectives the characterisation of drought through these indices and/or the analysis of their outcomes in comparison with the original (SPI, RDI) or other similar drought indices.

Results and concluding remarks

Based on the aforementioned approach, a total of 178 studies were initially collected and, among them, 29 that met the criteria were finally evaluated. The analysis focused on identifying whether the EP parameter used in the modified indices, can enhance the accuracy of vegetation-agricultural drought assessment and/or reduce data demand, having similar performance compared with indices with additional data requirements. An indicative list of selected studies with their main objectives and findings is presented in Table 1.

Table 1. Indicative list of studies with their main objectives and findings.

Study	Main objectives and findings
Nguyen et al. (2023)	Drought impacts on maize and soybean yields in the U.S. during 1979–2019 were assessed. The outcomes showed that the aSPI (using only EP – CropWat method) has similar performance with SPEI (using both P and PET) in assessing drought impacts on crop production.
Teutschbein et al. (2023)	The eRDI was used along with a set of standardized drought indices to represent different nexus sectors (water-energy-food-ecosystem; WEFE) in Sweden. The results examine the propagation of drought through the WEFE nexus, with eRDI indicating the sort of response of the agricultural sector to precipitation deficits in cold climates.
Zarei et al. (2023)	Ten ground-based and remote sensing drought indices have been compared for agricultural drought identification, based on winter wheat yield in Iran. The outcomes indicate that aSPI and eRDI were among the three drought indices that provided the most accurate agricultural drought assessment.
Llanes-Cárdenas et al. (2022)	The sensitivity of SPI, RDI, aSPI and eRDI for the prediction of rainfed maize yield has been evaluated in the region of Sinaloa (Mexico). The outcomes show that aSPI and eRDI for specific reference periods provided the most significant associations, with improved performance compared to the original indices.
Vishwakarma et al. (2022)	Three drought indices (SPI, aSPI, SPEI) have been used to examine their accuracy of representing agricultural drought over Bundelkhand region (India). All indices had similar response, though aSPI appeared to have better performance, also considering the fact that it is using only the EP parameter.
Javed et al. (2021)	The aSPI and the Standardized Vegetation Supply Water Index (SVSWI) were used for agricultural drought characterisation in four regions of China. The results of aSPI, mainly in 3-month timescale which provide similar correlations with SVSWI, revealed the drought effects on winter wheat and corn yield, based on consistent spatiotemporal patterns in the areas of the study region.
Proutsos and Tigkas (2020)	The effect of drought episodes on black pine tree growth is assessed based on SPI, RDI, aSPI and eRDI. The results illustrate that aSPI and eRDI are more sensitive in this task compared to the original indices, indicating their accuracy on drought characterisation in the forest environment.

The analysis of the studies reveals that the use of EP enhances, indeed, the ability of aSPI and eRDI to characterise vegetation-agricultural drought, compared to the corresponding original indices. Regarding aSPI, it seems that the use of only one parameter facilitates the assessment of vegetation-agricultural drought, provided that it has similar performance with indices using additional parameters (e.g. SPEI). Furthermore, it is shown that the selection of the most suitable method for estimating the EP in each region may have a significant role in increasing the accuracy of the utilised index. Overall, based on the analysed studies, both aSPI and eRDI appear to have a satisfactory performance in characterising drought in agricultural and forest environments.

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