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Dismantling barriers to urgent climate adaptation action

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PARTNERS

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Development and Use of Agronomic Weather Indices in Assessing Intra-Seasonal Climate Change Risks to Rainfed Cropping Systems.

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To answer the fundamental question of "adapt to what" within the context of climate-smart agriculture investments, staff and partners of the Food and Agriculture Organization of the United Nations (FAO) have developed and applied a set of 69 agronomic weather indices to identify trends in the frequency and intensity of intra-seasonal weather events associated with climate change. These indices, when applied to daily historical and downscaled projected temperature and precipitation data, provide a robust, empirically-driven means of identifying the principal attributes of climate change to which crop agriculture must adapt. Research completed with national teams in Malawi and Zambia used the indices with the daily weather station records from the National Meteorological and Hydrological Services and gridded climate data. Individually, and in combination, the indices allow the identification of important trends in seasonality, the crossing of critical crop tolerance thresholds, extreme weather events and the responsiveness of some adaptation options. The projection of these trends into the near-term future helps to guide climate-smart agricultural investments in research programmes, extension field activities and climate change adaptation efforts more broadly. Using daily temperature and precipitation data, the established indices can be used with any crop for which a basic physiological understanding exists, covering spatial scales ranging from individual weather stations to national and regional coverage.

Background

In the context of climate change research, climatological indices have been developed and used as observational benchmarks to detect and track changes to key weather parameters (e.g., those of the ETCCDI). Historically, agricultural applications of indices-based research have predominantly focused on discrete weather phenomenon, most notably determining the start of the rainy season [1][4], and more recently the crossing of crop-specific temperature thresholds [2] and the impact of major weather anomalies such as el Nino, with lesser attention given to those associated with outbreaks of certain crop diseases.

To extend the use of weather indices in assessing climate change impacts on crop agriculture, staff of the FAO developed an initial set of 38 agronomic weather indices in 2014. The indices were created to support analysis of historical daily temperature and precipitation records for trends in weather patterns associated with climate change that impact rainfed agriculture. These indices have undergone subsequent refinements, expansion and testing, resulting in the current set of 69 indices that have been used in assessing the historical and projected downscaled weather records at national scale [3]. The indices are organized into three levels of increasing specificity – general climatological indices (e.g., annual and monthly means); general agronomic (e.g., seasonality, intra-seasonal extreme events); and crop specific indices (e.g., related to crop phenology). The indices effectively serve as search terms used to interrogate historical and projected daily weather records for the occurrence of specific anomalies. Each of the indices includes one or more default values regarding the magnitude and/or temporal occurrence of a specific precipitation (mm) or temperature (°C) attribute, and are written to allow the user to replace default values to carry out more advanced types of analysis.

Within the context of capacity strengthening efforts in Malawi and Zambia, part of FAO Modeling System for Agricultural Impacts of Climate Change (MOSIACC) supported and associated projects, the agronomic weather indices were introduced and sub-sets selected in each country to assess specific weather features. A beta-version of an on-line global agronomic indices tool was released in July 2019 at a Southeast Asia regional workshop organized by FAO a in Bangkok, Thailand, and is being refined for general release prior to the end of 2019.

Methods

The initial coding of the indices used Matlab software, and is under conversion to R for greater accessibility. In both countries, historical daily weather data were used in the analysis. In Malawi the indices were directly applied to the national archive of weather station records, with 41 stations reporting precipitation, and 21 and 19 stations reporting maximum and minimum temperature data respectively, covering the period from 1960 to 2012. In Zambia, a 3km grid cell data layer for daily precipitation and temperatures, covering the period 1981 to 2014, was resampled to 50km and used in the analysis. A validation of the grid cell data layer was conducted comparing a sample of individual station records with data in the corresponding grid cells and deemed acceptable (R values of > 0.7 and > 0.8 for precipitation and temperature respectively). For the future projections, two emission scenarios, RCP 4.5 and 8.5, were considered over three time-periods: near future (2011-2040); medium future (2041-2070); and far future (2071-2100). Statistical downscaling techniques were used comparing four global circulation models: GFDL, MIROC, IPSL and NORESM. The analysis is both countries produced means, covering the date range of weather data, historical and projected, as well as year-to-year trends (Man-Kendall) for all of the indices used in each country.

Results

Analysis involving the 28 indices selected for use in Malawi on the national precipitation and temperature station data provided a number of insights on how changing weather patterns are impacting agriculture. In key locations in the country significant trends are observed in the increasing frequency of large storm events (>50mm) associated with high rates of soil erosion, the crossing of high temperature thresholds for important economic crops (e.g., Arabica coffee) and increased consistency in some locations to the start to the agriculture season. The indices also proved useful as a tool in assessing the potential of adaptation responses to avoid detected climate change stressors, such as the use of shorter maturing varieties to avoid the occurrence of dry-spells during reproductive period of maize.

In Zambia, using the national gridded dataset, analysis focused on assessing changes to the start, end and length of the growing season, as well as the number of days of with average temperatures over 30 °C affecting maize productivity. Results of the analysis (below) detected a trend in an increasingly early start to the growing season, a later ending, with an overall lengthening of the growing period, yet with increasing variability.

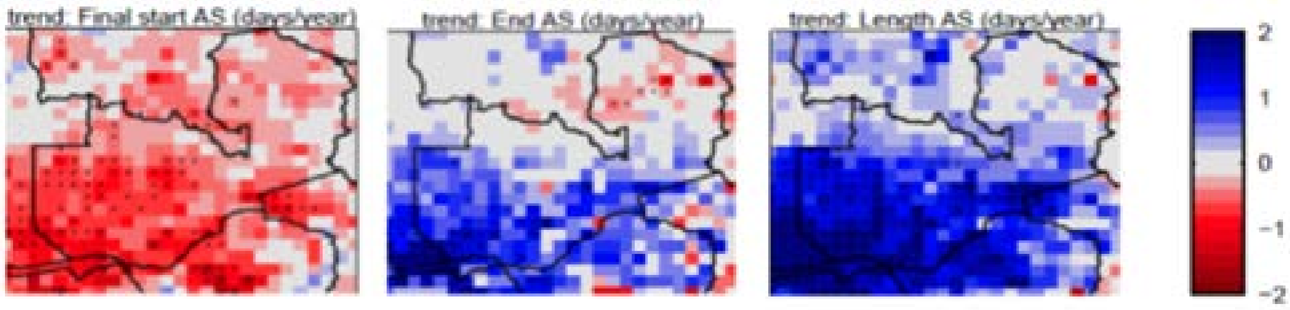

Figure 2. Start/End/Length of the Maize Growing Season (days/year)

The analysis also detected an important trend in the number of days within the maize growing season with temperatures exceeding 30 °C. The findings of Lobel et al., (2011) show a physiological response of maize to temperatures above this threshold leading to a nearly one percent decline in maize yields for each day above 30 °C, assuming the absence of other stressors[2]. The trends detects by the indices, in terms of geographic location and year-to-year change, indicate that a serious decline in the productive potential of maize is occurring within the country. Such trends will continue as temperatures continue to rise.

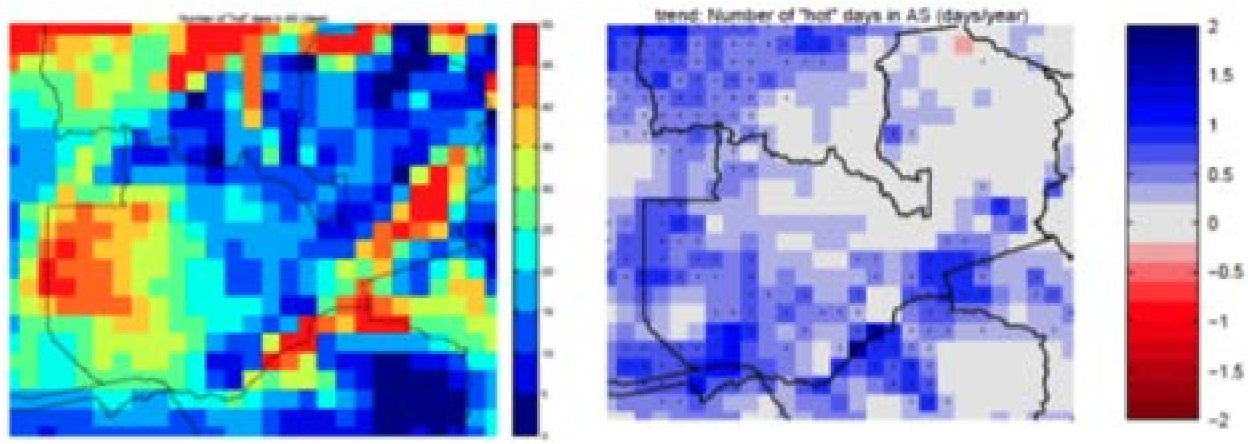

Figure 3. Average and Trend in the Number of Days > 30 °C During the Maize Growing Season

Conclusions

The agronomic weather indices have proved successful in detecting changes to important intra-seasonal weather parameters (precipitation and temperature) affecting agriculture at sub-national scales. The ability to look within the agricultural season at changes to weather patterns allows the identification of specific weather stressors where adaptive responses are required. The indices, through user defined adjustments to threshold values, also allowed the initial screening of certain adaptive responses for their potential of avoiding or responding to the stressors identified.

Use of the indices to detect climate change impacts on agriculture requires agronomic interpretation in at least three ways. First, is in setting the basic default and user determined parameters of the indices search terms (e.g., conditions defining the start of the agricultural season). Second, is the interpretation of the results for potential impacts on specific crops (e.g., number of days with high temperatures above critical thresholds), and agricultural systems more generally where adaptive actions may be required, such as the potential impact of increased frequency in large storm events exacerbating soil erosion in areas already subject to erosion threats. Third, is the ability to conduct an initial screening of adaptive responses to observed trends in specific weather threats (e.g., avoiding dry-spells during the reproductive period of maize through use of shorter maturing varieties). When applied to downscaled weather projections, use of the indices also provides the ability to assess the future prospects of the key food and cash crops in contributing to national food security and economic growth objectives.

The ability to conduct detailed, agriculture specific analysis of changes to weather patterns provides critical information and guidance for national research efforts, agricultural extension field programmes and national policy planning. The established indices can be used with any crop for which a basic physiological understanding exists, and for any location for which daily precipitation and temperature data is available, covering spatial scales ranging from individual weather stations to national and regional coverage.

An initial set of the agronomic indices is included in an on-line platform launched by FAO and partners in Bangkok, Thailand, July 2019. The platform currently covers 28 countries in South and Southeast Asia. Global coverage, including the full range of agronomic weather indices, will be available before the end of 2019. FAO staff will continue to support the future development, maintenance and expanded use of the agronomic weather indices.

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Estimation of Flood damage for housing in flood-prone areas in ouagadougou (Burkina FASO)

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Floods regularly cause huge damages to population, environment and socio-economic infrastructures in West Africa. Burkina Faso experiences a variety of natural hazards, including floods with significant socio-economic impacts across the country and in Ouagadougou in particular. Flood management is now based on a good knowledge of the phenomenon. Due to the significant costs of building flood protection, policy-makers need an estimate of the potential damages in order to evaluate the relevance of investments. The objective of this research is to estimate the cost of flood damage by first estimating the potential damages in terms of flood depth. A survey of two hundred and forty-three (243) households located in flood-prone areas in Ouagadougou commune allowed to construct some empirical relations of damages depending on submersion. Thus, three relationships between flood depth and likely damage are established depending on the housing building material (poor material, semi concrete and concrete). The results indicate that the cost of damages for the major flood of 2009 (1st September) is amounted to over 329 million XOF corresponding to a mean flood depth of 0.6 m. The estimated cost