Verification of a Rational Combination Approach for Agricultural Drought Assessment: A Case Study Over Indo-Gangetic Plains in India

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ABSTRACT

Agricultural Drought is characterized by a deficient supply of moisture, resulting either from sub-normal rainfall, erratic rainfall distribution, or higher water with respect to a crop. In spite of technological developments in providing improved crop varieties and better management practices, in India, agriculture has been considered a gamble due to higher spatial and temporal variability. The Rice-Wheat (RW) system is the major cropping system of the Indo-Gangetic Plains (IGP) in India and occupies 10 million hectares. In this paper, the authors have examined the possibility of rationally combining the rainfall anomaly index, a weather-based index, and an agriculture index based on the Crop Growth Simulation Model for a rice-wheat productivity assessment in selected sites of IGP in India. The district average yields of rice varied from 0.9 t/ha at Samastipur to 3.8 t/ha at Ludhiana. Rice yields decreased from the west to east IGP, and farmers in the western IGP harvested more rice-wheat than those in the eastern regions. The productivity gap showed that all the sites were produced only 50% of the potential in RW system productivity during the triennium ending period 2005. This paper may help researchers and planners to take appropriate measures for improving productivity.

Keywords: Agricultural Drought, Crop Growth Simulation Model, Drought Indices, Kharif Rice Productivity Index, Rational Integration, Rice-Wheat Productivity, Wheat Productivity Index

INTRODUCTION

Drought is one of the most severe and extreme weather events affecting more people than any other form of natural disaster (Wilhite, 2000). Drought which is broadly defined as deficient supply of rainwater to meet the water needs of various forms of life in the ecosystem such as water drinking and other uses for both human and animal population, plants and agricultural

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crops water needs and decomposition organic matter in the soil etc. The precise quantification of drought is difficult as no universal drought estimation method (e.g., drought indices, hydrological or soil water balance models) can be defined through the complexity of the problem. Common to all types of drought is a lack of precipitation (WMO, 1993). From a meteorological point of view, drought is associated with dry spells of varying lengths and degrees of dryness. The fundamental measure of drought is inadequate precipitation for a particular commotion viz., crop growth, irrigation supply, reservoir/dam level. The American Meteorological Society (1997) suggests that the time and space processes of supply and demand are the two basic processes that should be included in an objective definition of drought, and thus in the derivation of drought estimation methods. There are four types of droughts are commonly differentiated meteorological or climatological, hydrological, agricultural, and socioeconomic (Rasmussen et al., 1993; Wilhite & Glantz, 1985). Among these, agricultural drought relates to a shortage of available water for plant growth, and is assessed as insufficient soil moisture to replace evapotranspirative losses (WMO, 1975). As agriculture is an important economic factor in many countries, drought can have a number of economic and socio-economic consequences (CAgM, 1992, 1993; WMO, 1995, 2001) such as loss of income in agriculture and food industry, significant higher costs for water and production techniques (e.g., irrigation systems). Most places in the world can be affected by agricultural droughts which reduce the availability of water required in agricultural production, but duration and intensity vary greatly from one climatic zone to another (Wilhite, 1993). Because of climate changes that could change climatic variability including precipitation pattern, extreme weather events such as drought are likely to occur more frequently in different spatial and time scales in future (IPCC, 2007).

The success of drought preparedness and mitigation depends, to a large extent, upon timely information on drought onset, progress, extent and its end. These types of information can be obtained through drought indices which provide decision makers with information on drought severity and can be used to elicit drought contingency plans. Many drought indices such as the Palmer Drought Severity Index (Palmer, 1965), the decile index (Gibbs & Maher, 1967), Bhalme-Mooley Index (Bhalme & Mooley, 1979), the Surface Water Supply Index (Shafer & Dezman, 1982), the China-Z index (CZI) (Wu et al., 2001), Standardized Precipitation Index (SPI) (McKee et al., 1993) are widely used to quantify the drought vulnerability. Most of these indices are normally continuous functions of rainfall and/or temperature. These indices were tested and modified in different parts of the world (Nguyen et al., 1989; Wu et al., 2001; Oza et al., 2002; Ansari, 2003; Ntale & Gan, 2003; Morid et al., 2006; Patel et al., 2007). Generally, meteorological drought in India is defined when rainfall in a month or a season is less than 75% of its long-term mean, if the rainfall is 50-74% of the mean, a moderate drought event is assumed to occur, and when rainfall is less than 50% of its mean a severe drought occurs (Smakhtin & Hughes, 2004).

Agricultural drought occurs when there is inadequate soil moisture to meet the needs of a particular crop at a particular time. Generally refer to situations in which the moisture in the soil is no longer sufficient to meet the demand of the crops. When soil moisture is lacking, this may hinder crops potential development, leading to low growth characters and eventually lower final yield. The production potential of a crop is largely determined by the climatic, edaphic and soil properties and their interactions. Crop Growth Simulation Models (CGSM) deal with interactions of crop growth with climatic factors, soil characteristics, agronomic management, and therefore can be used to estimate climatic limitations to growth and yield (Aggarwal & Kalra, 1994). These are formulated to analyse crop growth using biological and physiological data of the crops and interaction of the plant and the environment (Dorigo et al., 2006). Several studies have been carried out to develop an integrated assessment.
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