Karnataka J. Agric. Sci.,23 (4) : (550-553) 2010

Remote sensing, geographic information system and modeling techniques for wheat area and production estimation

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(Received: January, 2010)

Abstract: The major wheat producing countries in the world are India, China, USA, France, Russia, Canada and Australia. Global demand for wheat is growing at 1 per cent per year. Crop growth and productivity are determined by a large number of factors such as genetic potential of crop cultivar, soil, weather and management variables, which vary significantly across time and space. Early prediction of crop yield is important for planning and taking various policy decisions. Many countries use the conventional techniques of data collection for crop monitoring and yield estimation based on ground – based visits and reports. These methods are subjective, costly and time consuming. Empirical models have been developed using weather data which is also associated with a number of problems. With the launching of satellites, satellite data are being used for crop monitoring and yield prediction. Most studies have revealed a strong correlation between remotely sensed NDVI and crop yield. GPS/sensor based on-the-go yield monitors are being used in the developed world for yield mapping. A critical analysis of the diverse techniques helps in identification of the most accurate and useful ones. An effort has been made for comparative assessment of these techniques the details of which are discussed in the paper.

Key words : Remote sensing, geographic information system, modeling, wheat

Introduction

With world commodity markets becoming competitive, prior knowledge of likely production and its geographical distribution at various scales has become highly sought – after information. Generating objective estimates of planted area will allow near real – time production estimates, which can then be used in updating supply chain information at the regional, state and national levels. Crop acreage estimation and early prediction of crop yield is important for planning and taking policy decisions. In many countries, conventional techniques of data collection based on field visits and reports are used for crop inventory. These methods are subjective, very costly and time consuming. For example, the crop acreage estimates of principal agricultural crops in India are usually made through complete enumeration, while the production is estimated as a product of area under the crop and the average yield per unit area of the crop. The crop yield is estimated through General Crop Estimation Surveys (GCES) on the basis of crop cutting experiments conducted on a number of randomly selected fields in sampled villages of the district. However, the crop acreage records maintained by the village revenue officials is not reliable on most occasions. Hence the production estimates which are based on the crop acreage estimates are also not completely reliable. All the rural development plans which are based on such unreliable crop acreage and production estimates become unrealistic leading to faulty decisions and actions and subsequent uncertainties in agricultural sector. In order to improve the accuracy of estimates, empirical models were developed using weather data, which are complex and associated with problems due to scant spatial distribution of weather stations. Advent of Remote sensing (RS) and Geographic Information System (GIS) techniques of great potential have opened up newer avenues of improving agricultural statistics system as they offer accelerated, repetitive spatial and temporal data acquisition possibilities. The objective of this review paper is to document the various RS, GIS and Modeling techniques of wheat area and production estimation.

Use of RS and GIS techniques for wheat area and production estimation

Since the inception of civilian RS programme in the USA in the early 1960s, Large Area Crop Inventory Experiment (LACIE) was the first worldwide experiment to demonstrate the operational capability of RS technology for wheat acreage estimation and production forecasting (MacDonald and Hall, 1980). It featured use of Landsat MSS data for wheat acreage estimation and agro-meteorological models for production estimation. Since then, several attempts to use RS and GIS techniques in crop acreage estimation and production forecasting have been made in many other countries. In India, early studies using space borne data (Landsat MSS data) employed visual interpretation technique for wheat inventory in four districts of Punjab (Munshi,1982). The visual interpretation techniques have not been used for large scale adoption. With the launching of IRS – 1A, studies were initiated under IRS – Utilization Programme in 1983 that used digital analysis of space borne RS data. The promising results from the first satellite based study on wheat acreage estimation in Karnal by Dadhwal and Parihar (1985) led to state level wheat acreage estimation using Landsat MSS data for Haryana and Punjab (Dadhwal, 1986) adopting a sample segment based approach of 10 m x 10 m segments and 10