A Review: The application of Remote Sensing, GIS and GPS in Precision Agriculture

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ABSTRACT

Every year copious technologies have been applied by many researchers, agronomies, scientist and engineers to increase agricultural production with low cast, but it has adverse impact on environment. Precision agriculture deals with the study of the application of technology to improve agricultural practices as compare to conventional agricultural method and lower adverse impact on environment. Remote sensing technology plays an important role in precision agriculture and its application in the precision agriculture introduces new opportunities for improving agricultural practices. With the help of global positioning system (GPS), it is possible to record field data (slope, aspect, nutrients, and yield) as geographically Latitude and longitude data. It has capability to determine and record the correct position continuously, so therefore, it can create a larger database for the user. For the further analysis geographic information system (GIS) is required, which can store and handling these data. This review highlights about remote sensing technology, GIS, GPS and give you an idea about, how it can be valuable in precision agriculture.

Keywords: Precision agriculture, environment, Remote Sensing, GIS and GPS

1. Introduction

The world population continues to increase and is projected to reach 10.0 billion in the year 2050 (Lutz et al., 1997). The production of agricultural product is important to everyone and producing food in a cost-effective manner is the goal of every farmer, large-scale farm manager and regional agricultural agency. A farmer needs to be informed to be efficient, and that includes having the knowledge and information products to forge a viable strategy for farming operations. These tools will help him understand the health of his crop, extent of infestation or stress damage, or potential yield and soil conditions. Commodity brokers are also very interested in how well farms are producing, as yield (both quantity and quality) estimates for all products control price and worldwide trading. Precision agriculture deals with the study of the application of technology to produce agricultural product to fulfill world-wide food requirement as compare to conventional agricultural method and lower adverse impact on environment.

Precision agricultural is an integrated, information and agricultural management system that is based on several technical tools such as global positioning system, geographical information system and remote sensing. Precision farming is designed to increase whole farm production efficiency with low cast effect while avoiding the unwanted effects of chemical loading to the environment.

The goal of precision farming is to gather and analyze information about the variability of soil and crop conditions in order to maximize the efficiency of crop inputs within small areas of the farm field. To meet this efficiency goal the variability within the field must be controllable.

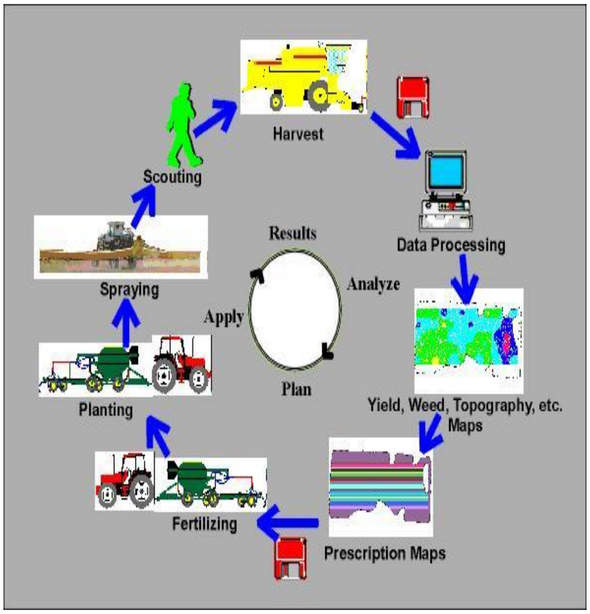

Figure 1. Precision farming cycle

Precision farming is the getting hold of in sequence on soil and crop conditions at the temporal frequency and spatial resolution required for making crop management decisions. Precision agriculture is now changing the way farmers and agribusinesses view the land from which they reap their profits. Precision agriculture is about collecting timely geospatial information on soil-plant-animal requirements and prescribing and applying site-specific treatments to increase agricultural production and protect the environment.

Remote sensing technology play an important role in precision agriculture and its significant increasing day by day. Remote Sensing using space-borne sensors is a tool, par excellence, for obtaining repetitive (with a range from minutes to days) and synoptic (with local to regional coverage) observations on spectral behavior of crops as well as their growing environment, i.e., soil and atmosphere. Use of this data could be made for a number of applications such as crop inventory, crop production forecasts, drought and flood damage assessment, range and irrigated land monitoring and management. This review covers Indian experience on RS data use for crop inventory. A brief mention of conventional procedures of crop acreage /estimation in India and the rationale of use of RS for crop inventory is made before reviewing the Indian experience. Salam et al. (1998) worked on crop discrimination and acreage estimation using IRS III digital data to prepare Rabi (winter) crop inventory of part of Solani river watershed (parts of Haridwar and Saharanpur districts, Uttar Pradesh, India). Many researchers and agronomist has done adequate work in the field of crop inventory like Bairagi and Hassan (2002) has used remote sensing and agrometeorological data for the 1998-99 Rabi season for yield and production forecasting of wheat crop. By using supervised maximum likelihood classification three types of wheat crop viz. wheat-1 (high vigour-normal sown), wheat-2 (moderate vigour-late sown) and wheat-3 (low vigour-very late sown) have been identified and discriminated from each other. There work reported yield prediction of wheat crop spectral vegetation indices (RVI and NDVI), agro meteorological parameters (ET max and TD) and historical crop yield (actual yield) trend analysis based linear and multiple linear regression models. Singh et al. (2002) has used digital data from four multi spectral sensors having different spatial resolution and spectral channel, LISS-III, LISS-II, LISS-I and WiFS acquired from two Indian Remote Sensing satellite platform (IRS- 1B, IRS-IC) and evaluated wheat crop classification and accuracy over central India. Ruiz et al. (2007) has used optical and RADARSAT-2 satellite images for corn monitoring and crop yield. The basic objective of the paper was to use RADARSAT-2 data and optical data to determine cultivated areas and monitor crop condition for obtaining better estimations of crop yield and obtain polarization signatures from RADARSAT-2 data for corn and relate these to Leaf Area Index (LAI) and photosynthetic active radiation (PAR) crop parameters and vegetation indexes, to establish indicators of crop condition and produce estimates for crop yield. Junying et al. (2009) worked on crop yield estimation models using remote sensing data were developed to forecast crop yield for Hubei province. Firstly, simulated counties were chosen using productivity zoning method and the fluctuated yield was obtained by analyzing history trend. Secondly, the correlation coefficient between fluctuated yield and remote sensing index was calculated. Then, the index with the highest correlation coefficient was selected as key factor to build simple linear regression models to estimate the crop yield. Finally, the error analysis was processed by comparing the actual crop yield from statistic data with that from modeling results. The results indicate that the precision error ranges from -14.38% to 11.31% compared with statistics data, and the coefficient of determination R2 is 0.872. The results calculated by this method meet the accuracy requirements for the crop yield estimation in most part of Hubei province. Recently last year, Laurila et al. (2010) worked on cereal yield modeling in Finland using optical and radar remote sensing the specific objective of their study was the Calibration of the optical VGI models (Models I-IV) by using phenologically classified Optical Minimum Datasets containing harmonized Landsat and SPOT reflectance data for spring wheat, barley and oats (Avena Sativa L.) and validation comparison of optical VGI model baseline yield estimates (yb) vs. CropWatN dynamic crop model yield estimates using Landsat, SPOT, NOAA reflectance data and MAFF inventory yield statistics and MTT Agrifood Research Finland Official Variety Trial averaged yield results (1996–2006) were used as a ground truth reference.And finally estimation of cereal non-potential baseline yield levels (yb) in growing zones (I–IV) using VGI models as a yield inventory tool for the annual MAFF inventory statistics.

II- GIS in agriculture

Burrough and McDonnell (1998) has defined GIS as a powerful set of tools for collecting, storing, retrieving at will, transforming and displaying spatial data from the real world for a particular set of purposes. Application of GIS is revolutionizing planning and management in the field of agriculture. The technology that has given vast scope to the applicability of remote sensing-based analysis is 'Geographic Information System (GIS)'. GIS provides ways to overlay different 'layers' of data: the ecological conditions, the actual physiognomy and human pressure indices. Agriculture always plays an important role in economies of both developed and undeveloped countries. Here in this study, we have used satellite based earth observation data to analyze and calculate crop inventory. More accurate and reliable crop estimates helped to reduce uncertainty in the grain industry. The ability of GIS to analyze and visualize agricultural environments and work flows has proved to be very beneficial to those involved in the farming industry. Balancing the inputs and outputs on a farm is fundamental to its success and profitability. Spatial data are commonly in the form of layers that may depict topography or environmental elements. Nowadays, GIS technology is becoming an essential tool for combining various map and satellite information sources in models that simulate the interactions of complex natural systems. GIS can be used to produce images, not just maps, but drawings, animations, and other cartographic products.

From mobile GIS in the field to the scientific analysis of production data at the farm manager's office, GIS is playing an increasing role in agriculture production throughout the world by helping farmers increase production, reduce costs, and manage their land more efficiently. While natural inputs in farming cannot be controlled, they can be better understood and managed with GIS applications such as crop yield estimates, soil amendment analyses, and erosion identification and remediation. Yang et al. (2004) has integrated remotely sensed data with an ecosystem model to estimate crop yield in north china. His paper describes a method of integrating remotely sensed data (the MODIS LAI product) with an ecosystem model (the spatial EPIC model) to estimate crop yield in North China. The traditional productivity simulations based on crop models are normally site specific. To simulate regional crop productivity, the spatial crop model is developed firstly in this study by integrating Geographical Information System (GIS) with Environmental Policy Integrated Climate (EPIC) model. (Wu Bingfng and Liu Chenglin .2000) worked on Crop Growth Monitor System with Coupling of AVHRR and VGT data.

III- GPS in agriculture

The global positioning system (GPS) makes possible to record the in-field variability as geographically encoded data. It is possible to determine and record the correct position continuously. This technology considers the agricultural areas, fields more detailed than previously; therefore, a larger database is available for the user. The accurate yield data can be reported only in the points where GPS position recording has happened.GPS receivers coupled with yield monitors provide spatial coordinates for the yield monitor data. This can be made into yield maps of each field. Information collected from different satellite data and referenced with the help of GPS can be integrated to create field management strategies for chemical application, cultivation and harvest. (Liaghat and Balasundram 2010). The development and implementation of precision agriculture or site-specific farming has been made possible by combining the Global Positioning System (GPS) and geographic information systems (GIS). These technologies enable the coupling of real-time data collection with accurate position information, leading to the efficient manipulation and analysis of large amounts of geospatial data. GPS-based applications in precision farming are being used for farm planning, field mapping, soil sampling, tractor guidance, crop scouting, variable rate applications, and yield mapping. GPS allows farmers to work during low visibility field conditions such as rain, dust, fog, and darkness.

IV-Conclusion

Precision farming allows the precise tracking and tuning of production. Precision farming makes farm planning both easier and more complex. There is much more map data to utilize in determining long term cropping plans, erosion controls, salinity controls and assessment of tillage systems. But as the amount of data grows, more work is needed to interpret the data and this increases the risk of misinterpretation.Farmers implementing precision farming will likely work closer with several professionals in the agricultural, GPS and computing sciences. Hence, the foundation technologies in precision agriculture are GIS, GPS and remote sensing.

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