Precision Agriculture: Role of GPS and GIS

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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.

I. INTRODUCTION

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 as shown in figure 1. To meet this efficiency goal the variability within the field must be controllable.

It has long been accepted by agricultural producers that homogeneous treatment of a field gives sub-optimal crop production due to the variability of many factors within the field. To realize optimal crop potential (within the controls of science), these variabilities must be understood and treated accordingly. The major hurdle to achieving this has been the positioning problems that occur when trying to gather the information. If data is too sparse, errors in interpolation may draw researchers to incorrect conclusions. Denser data is very often too time consuming and not cost effective to collect. DGPS has effectively provided accurate positioning capabilities and through integration with other sensors, has allowed much of the necessary data to be collected during normal farming duties.

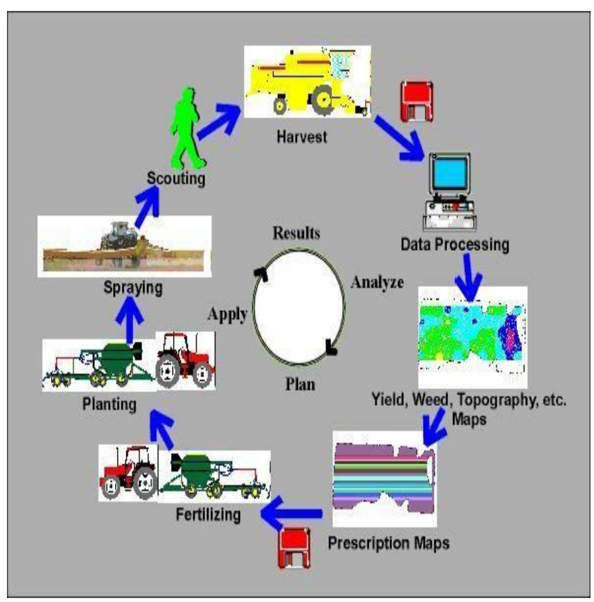

Figure 1. Precision farming cycle

II. FIELD MAPPING WITH GPS AND GIS

GPS technology is used to locate and map regions of fields such as high weed, disease and pest infestations. Rocks, potholes, power lines, tree rows, broken drain tile, poorly drained regions and other landmarks can also be recorded for future reference. GPS is used to locate and map soil sampling locations, allowing growers to develop contour maps showing fertility variations throughout fields. The various datasets are added as map layers in geographic information system (GIS) computer programs. GIS programs are used to analyze and correlate information between GIS layers.

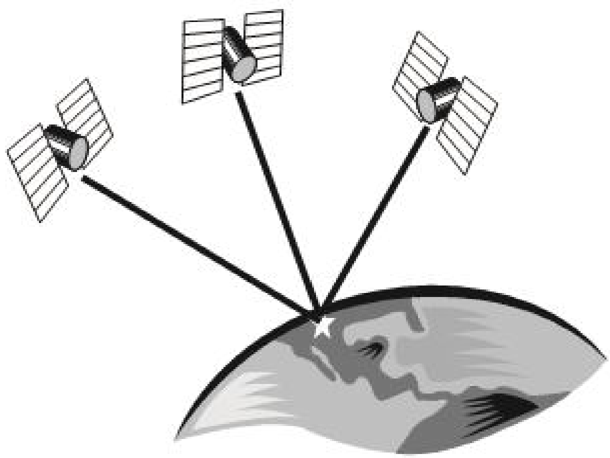

Figure 2. Satellite system

III. PRECISION CROP INPUT APPLICATIONS

GPS technology is used to vary crop inputs throughout a field based on GIS maps or real-time sensing of crop conditions. Variable rate technology requires a GPS receiver, a computer controller, and a regulated drive mechanism mounted on the applicator. Crop input equipment such as planters or chemical applicators can be equipped to vary one or several products simultaneously.

Variable rate technology is used to vary fertilizer, seed, herbicide, fungicide and insecticide rates and for adjusting irrigation applications.

The cost all of the components necessary for variable rate application of several products is approximately $15,000, not including the cost of the GPS receiver. Technology capable of varying just one product costs approximately $4,000.

IV. HOW DOES THE GPS SYSTEM WORK?

The GPS System

Precisely locating positions on Earth is not a new phenomenon. Navigators, sailors, explorers and surveyors have done this for centuries as they traveled about the world. Most maps and globes display longitude and latitude or some other coordinate projection information. Points on Earth are given unique addresses on maps using specific coordinate systems. Agriculturists commonly use either a geographic system of latitude and longitude measured in degrees or a Universal Transverse Mercator coordinate system that locates positions in meters measured from a specific point.

The GPS system uses measured distances to the precisely located GPS satellites to locate positions on Earth. Radio receivers in GPS units monitor radio signals broadcast from the GPS satellites. A GPS position is determined by simultaneously measuring the distance to at least three satellites. The distance to a satellite is measured by the time it takes a radio signal to ravel from the satellite to the GPS receiver. Computers in GPS units use satellites in location without obstructions like buildings or trees.

GPS Errors

The quality of GPS units and operational errors associated with the GPS system determine the accuracy of GPS-located positions. There are several sources of GPS errors. GPS radio signals can “bounce off” objects such as buildings and trees prior to acquisition by the GPS receiver, resulting in lower accuracy. This is called multi-path error. (Figure 4).

The satellites use very accurate information from the radio signals, including broadcast time and unique satellite information, to calculate positions. Information from at least four satellites is needed to calculate elevation. Signal reception from more satellites increases position accuracy.

The global positioning system includes a constellation of 24 systematically arranged satellites orbiting the earth in six orbital planes with four satellites in each plane. The satellite orbits are approximately 12,500 miles above the earth. The constellation is arranged to guarantee radio reception from at least four satellites from any location anytime, anywhere on Earth (Figure 3). GPS receivers normally receive signals from eight to nine atomic clocks to generate the timing data received by the GPS receivers. However, even small errors in timing from clocks in the satellites and GPS units cause errors in GPS positions.

Signal delay errors can be caused by atmospheric interference such as electrically charged particles in the ionosphere. A layer of water vapor located below the troposphere can also alter the speed of travel of radio signals.

Errors from GPS satellites’ orbit and location are also significant. Pressures from solar radiation and gravitational forces of the sun and moon can alter satellite locations.

GPS receiver quality also effects GPS accuracy. More costly GPS units generally provide more accurate GPS positions than less expensive units.

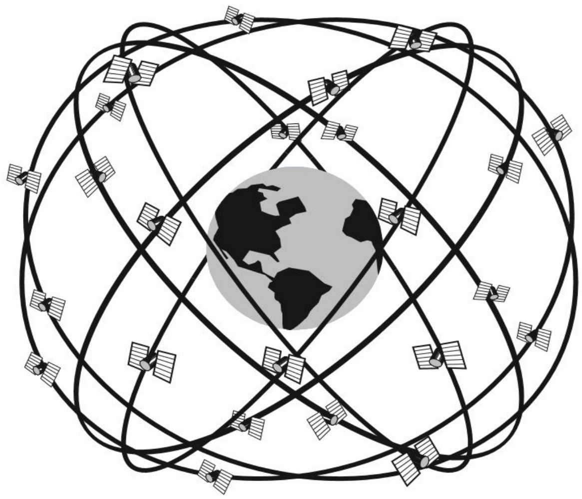

Figure 3. Satellite constellation and

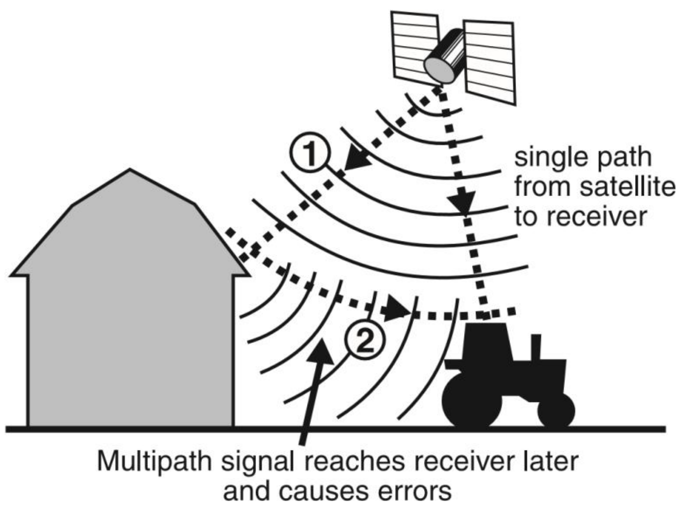

Figure 4. Multipath signal errors

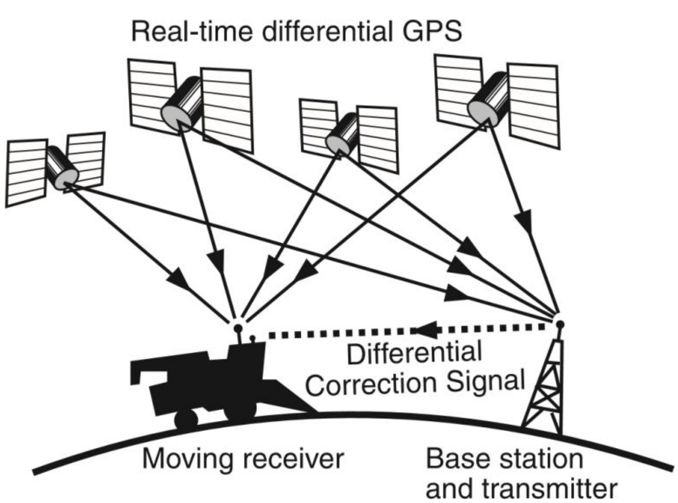

Figure 5. Base station DGPS representation.

V. WHAT IS DIFFERENTIAL CORRECTION?

Types of Correction

Differential global positioning systems (DGPS) reduce GPS errors and provide more accurate and reliable readings. Differential correction uses a radio signal broadcast from known locations on Earth. These Earth-based stations receive radio signals from the GPS satellites and determine the error from their known positions. The error is calculated and transmitted to the GPS receivers (Figure 5). The US government and several commercial companies provide differential correction GPS services.

The US Coast Guard provides a free differential correction beacon signal. The Coast Guard signal is an AM radio signal that is broadcast from several locations, and travels as a “ground wave” over the earth’s terrain. Each station has a radial coverage of approximately 300 miles. As the distance increases, the accuracy of the signal decreases.

VI. 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.

VII. 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.

VIII. 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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