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# Application of GIS and GPS in Precision Agriculture (A Review)

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## Abstract

Agriculture is a complex system science and the knowledge of it is consisting of much concepts and relationships. Examinations in connection with site-specific farming have been carried out by our institute since 1998. Precision farming is a way of agricultural production, which takes into account the in-field variability, a technology where the application-seeding, nutrient replacement, spraying, etc. has taken place to act on the local circumstances of a given field. The geographic information system (GIS) created by computing background makes possible to generate complex view about our fields and to make valid agro technological decisions. With the advent of the satellite-based Global Positioning System, farmers gained the potential to take account of spatial variability. Our goal was to compare two systems for marking out further research tasks, because in some cases there have been misunderstandings among the researchers, and the information provided by given companies seems to be complicated for potential users. This article provides an overview of worldwide development and current status of precision agriculture technologies and Application of GIS and GPS in Precision agriculture.

**Keywords:** GPS, GIS, Computer Application, Precision Agriculture.

## Introduction

Agriculture production systems have benefited from incorporation of technological advances primarily developed for other industries. The industrial age brought mechanization and synthesized fertilizers to agriculture. The technology age offered genetic engineering and automation. The information age brings the potential for integrating the technological advances into precision agriculture (PA) (Whelan et al., 1997).

PA is conceptualized by a system approach to re-organize the total system of agriculture towards a low-input, high-efficiency, sustainable agriculture (Shibusawa, 1998). This new approach mainly benefits from the emergence and convergence of several technologies, including the Global Positioning System (GPS), geographic information system (GIS), miniaturized computer components, automatic control, in-field and remote sensing, mobile computing, advanced information processing, and telecommunications (Gibbons, 2000). Agricultural industry is now capable of gathering more comprehensive data on production variability in both space and time. The desire to respond to such variability on a fine-scale has become the goal of PA (Whelan et al., 1997). After more than 10 years of development, PA has reached a crossroad with much of the necessary technology available but with the environmental and economic

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benefits yet unproven (Stafford, 2000). Many technological innovations have been presented but development of agronomic and ecological principles for optimized recommendations for inputs at the localized level is generally lagging. Many farmers are uncertain as to whether to adopt available PA technologies on their farms. Motivations for widespread uptake of PA technologies may come from strict environment legislation, public concern over excessive use of agro-chemicals, and economic gain from reduced agricultural inputs and improved farm management efficiency. After all, success of PA technologies will have to be measured by economic and environmental gains (Naiqian et al., 2002).
This article provides an overview of worldwide development and current status of precision agriculture technologies and Application of GIS and GPS in Precision agriculture.

## What Is GPS?

The Navigation Satellite Timing And Range Global Positioning System, or NAVSTAR GPS, is a satellite based radio-navigation system that is capable of providing extremely accurate worldwide, 24 hour, 3-dimensional location data (latitude, longitude, and elevation). The system was designed and is maintained by the US Department of Defense (DoD) as an accurate, all weather, navigation system. Though designed as a military system, it is freely available with certain restrictions to civilians for positioning. The system has reached the full operational capability with a complete set of at least 24 satellites orbiting the earth in a carefully designed pattern (Gelian et al., 2012).
GPS equipment manufacturers have developed several tools to help farmers and agribusinesses become more productive and efficient in their precision farming activities. Today, many farmers use GPS-derived products to enhance operations in their farming businesses. Location information is collected by GPS receivers for mapping field boundaries, roads, irrigation systems, and problem areas in crops such as weeds or disease. The accuracy of GPS allows farmers to create farm maps with precise acreage for field areas, road locations and distances between points of interest. GPS allows farmers to accurately navigate to specific locations in the field, year after year, to collect soil samples or monitor crop conditions (Qian and Zheng, 2006).

## What Is GIS?

General-purpose GIS packages, such as ARCVIEW, IDRISI, and SURFER, provide many functions, some of which offer little value to PA applications. Most of these packages are expensive and require computer platforms that are not usually possessed by farmers. To address the urgent need for PA applications at the field level, many commercial GIS packages, such as the software packages introduced by AGRIS Corporation, Farm Works TM, Agri-Logic, Inc., John Deere Precision Farming Group, Case Corporation, Rockwell International, and RDI Technologies, Inc., have been developed (Ess et al., 1997). Some systems directly interact with DGPS devices or yield sensors to acquire location and yield data in real time. Runquist et al. (2001) developed a field-level GIS (FIS) containing analytical functions for spatial data analysis in PA research.

## GIS for Precise Farm Management

Monitoring market trends, improving yields, and predicting weather are among the many responsibilities required to reduce the risk of loss and increase profitability. The Farmer’s Almanac has been replaced with geospatial analysis and predictive modeling. With these tools at their disposal, farmers now have the ability to visualize their land, crops, and management practices in unprecedented ways for precise management of their businesses. Today, accessing spatial data has become an essential farm practice. Government agencies such as the U.S. Department of Agriculture (USDA) and the European Union host Web sites that deliver valuable information to help farmers better understand their land and make more informed decisions. This data can be accessed on the Internet and used to create intelligent maps for better farm business practices (Xie and Wang, 2007).

**Worldwide applications**

PA research started in the US, Canada, Australia, and Western Europe in mid-tolate 1980s. Although a considerable research effort has been expended, it is still only a portion of farmers who have practiced any type of PA technologies. Implementation of PA has mainly been through utilization of existing field machinery by adding controllers and GPS to enable spatially-variable applications. To date, the leading application of PA still is the site-specific application of fertilizers (Naiqian et al., 2002).

Despite the fact that most PA experiments were concentrated on VRT applications of fertilizers and herbicides, diverse types of PA technologies have been experimented throughout the world (Hendrickson et al, 2000).

Every GIS database must be referenced to a base map or base data layer. Ideally, the database should be referenced to a large scale, very accurate base map. If instead the base map is smaller scale (quad scale or smaller) there could be problems when attempting to view the true spatial relationships between features digitized from a small scale map and features whose coordinates were captured with GPS. This can be a real problem if a grower decides to use a particular GIS data layer that was originally generated using small scale base maps as a base to which all new data generated is referenced. The best way to avoid such incompatibility one should consider developing an accurate base data layer, based on geodetic control and photogrammetric mapping (erstegen, 1998).

**GPS and GIS is an important (future) tool for Precision Agriculture**

Field portable GPS and GIS receivers are available for rapidly mapping insect infestations and this data can be accurately communicated to the field manager who may employ a custom spray operator to apply the correct chemicals only where they are needed. In addition, the spray operator will be able to provide a permanent record back to the field manager with GPS data of where and when the treatment took place. Yield monitors will be connected to GPS receivers to map yield. The resultant yield maps will help identify areas of the field requiring different treatments (Smith, 2002).

**Conclusions**

The mentioned method has an additional advantage. This advantage is that the Agrocom ACT system involves an Arc View-based GIS application called AgroMap Professional, which has the capability to receive objects from the AgroMap Basic. Using this software, it is possible to insert our precision farming data into any Arc View compatible GIS.

Both availability and cost of management time appear to be issues for the adoption of precision farming technology. Some precision farming technologies appear to use very little management time under US conditions, either because they are usually out-sourced (e.g. grid soil sampling and VRA P & K), or because they mainly affect logistics and do not require data analysis or decision making (e.g. GPS guidance). Some stand alone precision farming technologies yield low returns even without charging for management time (e.g. VRT seeding maize and soybeans). They would look even worse if management time were charged. Though little data is available on them, integrated systems seem to fare better. An example of the Sauder farm trials indicates that the annual benefits could support the average U.S. managerial salary for almost three month, probably enough time to handle the managerial tasks involved. The willingness of traditional U.S. producers to undertake the computer analysis and decision making is probably greater constraint than the opportunity cost of the time because many of those producers chose agriculture for the active outdoor lifestyle that it offered and are reluctant to spend time in front of a computer. The unwillingness of U.S. producers to commit management time to precision agriculture may signal an opportunity for out-sourcing the data analysis and recommendation development.

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