PRECISION AGRICULTURE: AN OVERVIEW

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Soil is a three-dimensional heterogeneous body that formed in response to the physical, chemical and biological weathering of rocks. Varied nature and intensity of weathering forces along with different types of parent materials resulted in the spatial variability of soil properties. In other words, the spatial variability of soil properties is attributed to the complex interaction of climatic (Temperature, Humidity, rainfall), edaphic (relative proportion of sand silt clay, organic matter, salinity, acidity), topographic (slope, elevation), anthropogenic (tillage, compaction) and biological (microbes, earthworm) factors. Ignoring the spatial variability may result in poor land and crop management, and also lead to yield losses or inefficient use of agricultural inputs like chemical fertilizers, pesticides and herbicides. Excessive use of agricultural chemicals has negative environmental impact on water resources. In order to minimize the environmental impacts of agriculture, popularization of technologies for site-specific land management practices like Precision Agriculture (PA) is inevitable. PA advocates farm management activities like tillage, application of farm inputs such as fertilizers, irrigation, pesticide, tillage etc. precisely after analyzing various factors that affect crop growth in a particular farm field. A pictorial representation of various components of the PA system and how they work to produce site specific recommendation for farm fields is given in figure 1.

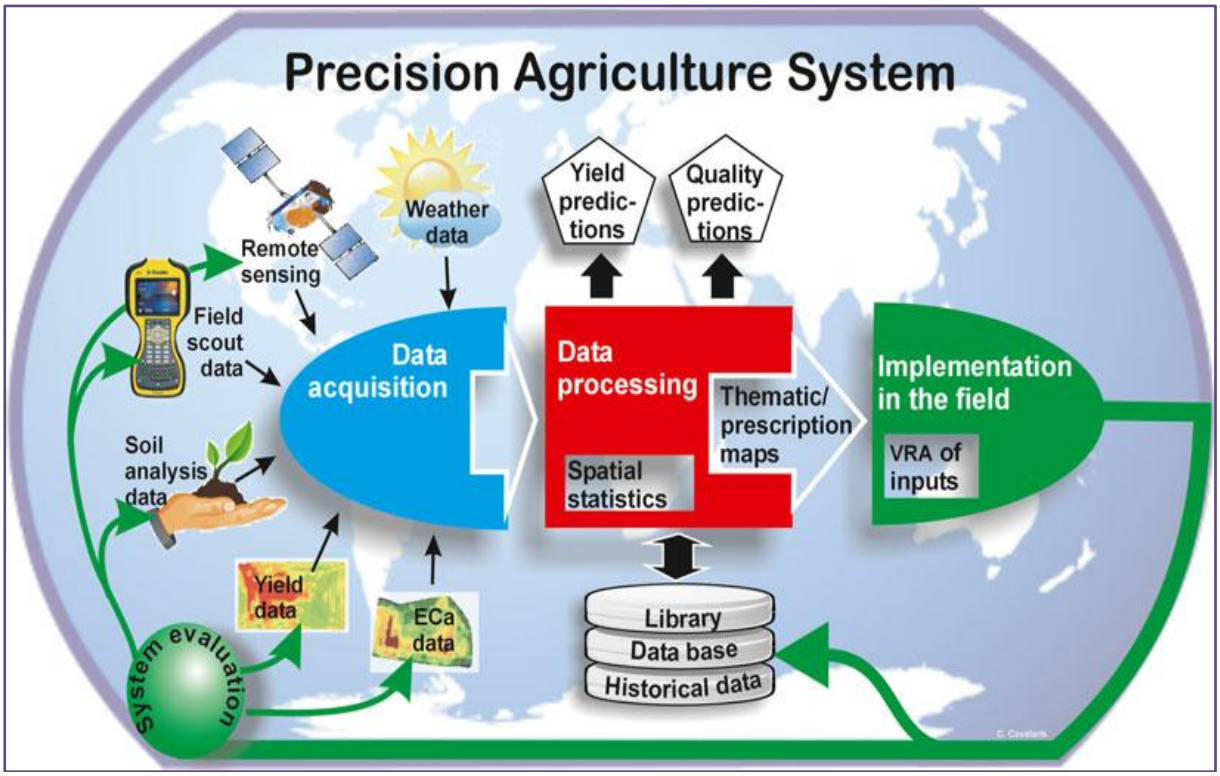

Figure 1. An overview of precision agriculture system (University of Thessaly,Volos, Greece)

DEFINITION AND IMPORTANCE OF PRECISION AGRICULTURE

PA is also known in other names like prescription farming, site-specific crop management and variable rate technology. The Home Grown Cereals Authority (HGCA) defined PA as 'management of farm practices that use computers, satellite positioning systems and remote sensing devices to provide information on which enhanced decisions can be made. More explicitly, it is an information and technology-based agricultural management system to identify, analyze, and manage soil spatial and temporal variability within fields for higher profitability, sustainability, and protection of the environment (Tiziano*Gomiero, 2019).*

Site-specific management requires detailed information about the heterogeneity of fields to adapt soil cultivation, seeding, fertilizer, fungicide and herbicide application to the locally varying conditions. Previously existing soil and plant information seldom match the requirements either for the intensity of the required information or with respect to the quality of the derived maps to delineate management units. Conventional methods are cost intensive and time-consuming. Therefore, fast, non-contacting and non-destructive methods should be available to obtain the required information such as soil, plant and weather parameters simultaneously. Recent advances in remote sensing and sensor technology have taken a leap and aid in PA. The schematic diagram (Figure 2) explains how different technologies contribute to site-specific management practices. There are several benefits of adopting PA over the conventional agriculture. Some of them are summarised in Table 1.

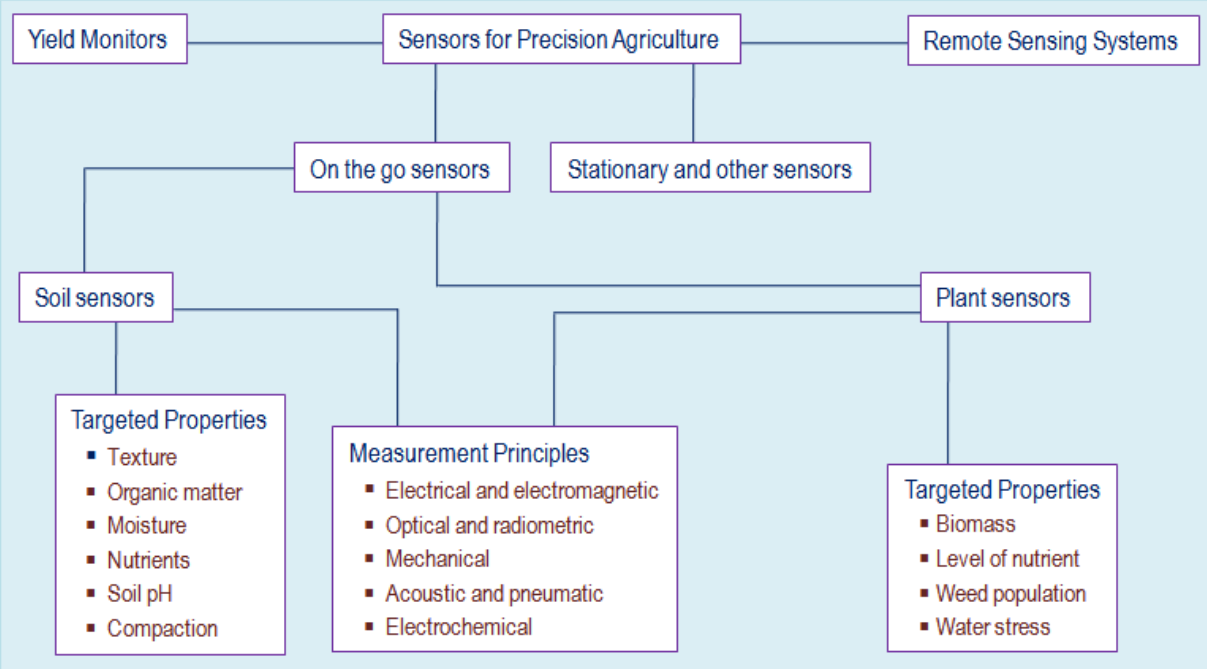

Figure 2: On-the-go soil and plant sensors used in precision agriculture (Dobermann et al., 2004)

Table 1. Major Differences between Conventional Agriculture and Precision Agriculture

CONVENTIONAL AGRICULTURE	PRECISION AGRICULTURE
• Agricultural farms are viewed as an agricultural management and organizational unit that have homogenous properties as production site. • Averaged sampling-based nutrient management • Averaged plant protection damage assessment and intervention • Same plant density, variety	• Production site is viewed as an agricultural and organizational unit that is having heterogeneous propertied on each and every point at field level. • Satellite positioning-based point wise sampling and data collection. • Infield production site blocks delimited as "homogenous" by geo-statistical interpolation.

• Homogenous water management • Same machine operation • Unified crop in space and time on field level • The base of the economic evaluation is the cost based on the average crop on field level/income relationships. • The number of decision alternatives **is relatively** low during the analysis, which has a limited capacity to take into account the spatial relationships. • Low information technology use in decision making, generally advocate blanket recommendation	• Variable machine operation by production sites. • Unified machine operation by the production sites • Unified crop in space and time organized to homogenous block on production site level • The base of the economic evaluation is the cost based on crop division/income relationships. • The number of decision alternatives during the analysis is capable to take into account emphatically the spatial relationships by GIS tools. • Information technology is present in all phases of production, forming a single system.

Adapted from János (2008)

TOOLS OF PRECISION AGRICULTURE

Production issues can easily be addressed through PA if it is taken care of properly. Farmers need to identify their specific needs beforehand so that the identification of ideal tools to suit their needs will follow. The following tools are inevitable in creating efficiency, more accurate records, and ease farm management under the PA.

AUTO-GUIDANCE EQUIPMENT

This type of technology allows farmers to cover larger fields more accurately and faster. It essentially eliminates overlaps, skips, and gaps from any product that farmers apply. As a result, fertilizer, insecticides, pesticides and other crop protection products are only applied at the right amount and places that are in need. Time is money and thus, auto-guidance tools save on both. Auto-guidance tools also minimises accidents that are usually caused by these machines.

GEOGRAPHICAL INFORMATION SYSTEM (GIS)

A geographical information system (GIS) consists of a computer software database system used to input, store, retrieve, analyze and display, in map-like form, spatially referenced geographical information.

GRID SAMPLING

Grid sampling is a method of breaking a field into blocks of about 0.5-5 ha. Sampling of soils should be done within those grids to determine appropriate application rates. Several samples are taken from each grid, mixed and sent into the laboratory for further analysis.

VARIABLE RATE TECHNOLOGY

Variable-rate technology (VRT) consists of farm field equipment with the ability to precisely control the rate of application of crop inputs that can be varied in their application commonly include tillage, fertilizer, weed control, insect control, plant population and irrigation.

YIELD MONITORS

Yield monitors are crop yield measuring devices installed on harvesting equipment. The yield data from the monitor is recorded and stored at regular intervals along with geo-coded data received from GPS unit. GIS software takes the yield data and produces yield maps.

YIELD MAPS

Yield maps are produced by processing data from adopted combine harvester that is equipped with a GPS that is integrated with a yield recording system. Yield mapping involves the recording of the grain flow through the combine harvester while recording the actual in the field at the same time.

PROXIMATE SENSORS TECHNOLOGY

There are different types of sensors. Moisture and temperature sensors are some of them. These sensors can help the farmer to detect any problem experienced

by the crops, or stress that livestock might be undergoing. It then helps the farmer to fix the problems easily with fewer resources.

REMOTE SENSORS

Remote sensors are generally categorized as aerial or satellite sensors. They can indicate variations in field color that corresponds to changes in soil type, crop development, field boundaries, roads, water etc. Remote science can be explained in agricultural terms as viewing crops from overhead (from a satellite or low flying aircraft) without actual contact, recording what is viewed and displaying the image and provide the map to pinpoint the field problems earlier and more effectively.

FUTURE TREND

Earlier days, in PA the spatial and temporal resolutions of remote sensing satellites used were expressed in terms of 30 meter and week to months respectively. Today, spatial resolutions are as good as several centimeters, while temporal resolutions are as good as a few days. With this level of spatial and temporal resolution, it is likely that PA practitioners will be able in the near future to develop customized management recommendations on a weekly basis for every single plant growing in their field.

SUGGESTED FURTHER READING

https://precisionagricultu.re/tools-of-precision-farming/

https://precisionagricultu.re/important-tools-to-succeed-in-precision-farming/

https://www.tankonyvtar.hu/en/tartalom/tamop425/0032_precizios_mezogazdasag/ch01.html

Soil-specific farming precision agriculture (Edited by Rattan Lal and B. A. Stewart)

Precision Farming: Challenges and Future Directions (Dobermann et al., 2004)

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