## Lecture 1 Precision agriculture: concepts and techniques; their issues and concerns reference for Indian agriculture

- **Precision Agriculture:** - An information and technology based farm management system to identify, analyze and manage variability within fields by doing all practices of crop production in right place, at right time and in right way for optimum profitability, sustainability and protection of the land resource. Precision agriculture is a systems approach to fanning for maximizing the effectiveness of crop inputs.
- **Precision agriculture (PA)** is an approach to farm management that uses information technology (II) to ensure that the crops and soil receive exactly what they need for optimum health and productivity.
- The **goal of PA** is to ensure **profitability, sustainability and protection of the environment.**
- PA is also known as **satellite agriculture, as-needed farming and site-specific crop management (SSCM).**
- **Precision Farming or Precision Agriculture** is generally defined as information and technology based farm management system to identify, analyse and manage spatial and temporal variability within fields for optimum productivity and profitability, sustainability and protection of the land resource by minimizing the production costs.
- The concept of **precision agriculture** offers the promise of increasing productivity while decreasing production cost and minimizing environmental impacts.
- **Precision Agriculture:** - is the technique of applying the right amount of input (fertilizer, pesticide, water etc.) at ***the right location at the right time*** to enhance production, decrease input, and/or protect the environment.
- **Precision farming** is defined as the application of technologies and principles to manage spatial and temporal variability associated with all aspects of agricultural production (Pierce and Nowak, 1999).

- **Precision farming** is an integrated, information and agricultural management system that is designed to improve the whole farm production efficiency with the low cost effect while avoiding the unwanted or harmful effects of chemicals in the environment. The focus under Precision Farming is to gather information regarding the soil and crop condition and capture the sequence on the soil and crop conditions at spatial level.

- **Precision agriculture** relies upon specialized equipment, software and IT services. The approach includes accessing real-time data about the conditions of the crops, soil and ambient air, along with other relevant information such as hyper-local weather predictions, labor costs and equipment availability.

## PRECISION AGRICULTURE: CONCEPT

**Concept is simple**

i) Right input
ii) At right time
iii) In right amount
iv) At right place
v) In right manner

The concept of precision farming is strictly based on the Global Positioning System (GPS), which was initially developed by U.S. (United States of America) defense scientists for the exclusive use of the U.S. Defense Department. The unique character of GPS is precision in time and space. Precision agriculture (PA), as the name implies, refers to the application of precise and correct amounts of inputs like water, fertilizers, pesticides etc. at the correct time to the crop for increasing its productivity and maximizing its yields. The use of inputs (i.e. chemical fertilizers and pesticides) based on the right quantity, at the right time and in the right place. This type of management is commonly known as "Site-Specific Management".

Precision Farming or Precision Agriculture is generally defined as information and technology based farm management system to identify,

analyze and manage spatial and temporal variability within fields for optimum productivity and profitability, sustainability and protection of the land resources by minimizing the production costs. The productivity gain in global food supply have increasingly relied on expansion of irrigation schemes over recent decades, with more than a third of the world's food now requiring irrigation for production. Rapid socio-economic changes in some developing countries, including India, are creating new scopes for application of precision agriculture (PA). All-together, market-based global competition in agricultural products is challenging economic viability of the traditional agricultural systems, and requires the development of new and dynamic production systems.

**Precision farming / satellite farming**

- When implemented correctly, **precision farming** is a process that allows users todeal with every possible variation found in fields and field sections..
- When implemented correctly, precision farming is a process that allows users to deal ,vith every possible variation found in fields and field sections. Just as no two fields are exactly the same, no two sections of any field will be the same.
- Your soil's ability to use and retain nutrients is affected by the its texture and composition, the pH levels, and the various amounts of organic matter present. Field work practices, weeds, cover crops, drainage, and previous years' yields can all cause nutrient levels to fluctuate.
- As you gain more knowledge with respect to your fields and its variances, along with implementation of well-planned precision farming, your farm will benefit from increased yields and higher profits.

**Farm management and optimizing returns**

- Two things are worth immediate consideration: farm management and optimizing returns on inputs. What does that mean? The best path to optimization of your returns is by applying the appropriate inputs in the right place and in the correct amounts.

## NEED OF PRECISION FARMING

- The global food system faces formidable challenges today that will increase markedly over the next 40 years.
- Much can be achieved immediately with current technologies and knowledge, given sufficient will and investment.
- But coping with future challenges will require more radical changes to the food system and investment in research to provide new solutions to novel problems.
- The decline in the total productivity, diminishing and degrading natural resources, stagnating farm incomes, lack of eco-regional approach, declining and fragmented land holdings, trade liberalization on agriculture, limited employment opportunities in non-farm sector, and global climatic variation have become major concerns in agricultural growth and development.
- Therefore, the use of newly emerged technology adoption is seen as one key to increase agriculture productivity in the future.
- Instead of managing an entire field based upon some hypothetical average condition, which may not exist anywhere in the field, a precision farming approach recognizes site-specific differences ,vithin fields and adjusts management actions accordingly.
- Farmers usually are aware that their fields have variable yields across the landscape.
- These variations can be traced to management practices, soil properties and/or environmental characteristics.
- The level of knowledge of field conditions is difficult to maintain because of the large sizes and changes due to annual shifts in leasing arrangements in the farm area.
- So the entire farm area has to be divided into small farm units of 50 cents or less. Precision agriculture offers the potential to automate and simplify the collection and analysis of information.

- It allows management decisions to be made and quickly implemented on small areas within larger fields.

**TOOLS AND EQUIPMENT/TECHNIQUES IN PRECISION AGRICULTURE:-**

1. **Global positioning system (GPS)** :- GPS is a navigation system based on a network of satellites that helps users to record positional information (latitude, longitude and elevation) with an accuracy of between 100 and 0.01 m. GPS allows farmers to locate the exact position of field information, such as soil type, pest occurrence, weed invasion, water holes, boundaries and obstructions. There is an automatic controlling system, with light or sound guiding panel (DGPS), antenna and receiver. GPS satellites broadcast signals that allow GPS receivers to calculate their position. The system allows farmers to reliably identify field locations so that inputs (seeds, fertilizers, pesticides, herbicides and irrigation water) can be applied to an individual field, based on performance criteria and previous input applications.
2. **Sensor technologies:-Various** technologies such as electromagnetic, conductivity, photo electricity and ultra sound are used to measure humidity, vegetation, temperature, texture, structure, physical character, humidity, nutrient level, vapour, air etc. Remote sensing data are used to distinguish crop species, locate stress conditions, identify pests and weeds, and monitor drought, soil and plant conditions. Sensors enable the collection of immense quantities of data without laboratory analysis.
3. **Geographic information system (GIS)** :-This system comprises hardware, software and procedures designed to support the compilation, storage, retrieval and analysis of feature attributes and location data to produce maps. GIS links information in one place so that it can beextrapolated when needed. Computerized GIS maps are different from conventional maps and contain various layers of information (e.g. yield, soil survey maps, rainfall, crops, soil nutrient levels and pests). GIS is a kind of computerized map, but its real role is using statistics and spatial methods to analyze characters and geography. A farming GIS database can provide information on filed

topography, soil types, surface drainage, subsurface drainage, soil testing, irrigation, chemical application rates and crop yield. Once analyzed, this information is used to understand the relationships between the various elements affecting a crop on a specific site. In addition to data storage and display, the GIS can be used to evaluate present and alternative management by combining and manipulating data layers to produce an analysis of management scenarios.

**4. Grid soil sampling and variable-rate fertilizer (VRT) application:-**

**Variable-rate technologies (VRT)** are automatic and may be applied to numerous farming operations. VRT systems set the rate of delivery of farm inputs depending on the soil type noted in a soil map. Information extrapolated from the GIS can control processes, such as seeding, fertilizer and pesticide application, herbicide selection and application at a variable rate in the right place at the right time. VRT is perhaps the most widely used PFS technology in the United States.

**Grid soil sampling** uses the same principles of soil sampling but increases the intensity of sampling. Soil samples collected in a systematic grid also have location information that allows the data to be mapped. The goal of grid soil sampling is a map of nutrient needs, called an application map. Samples may be collected for more than one area of a field which fall in to the same range of yield, soil colour, etc. and thus the same zone. Grid soil samples are analyzed in the laboratory, and an interpretation of crop nutrient needs is made for each soil sample. Then the fertilizer application map is plotted using the entire set of soil samples. The application map is loaded into a computer mounted on a variable-rate fertilizer spreader. The computer uses the application map and a GPS receiver to direct a product-delivery controller that changes the amount and/or kind of fertilizer product, according to the application map.

5. **Crop management:-**

Satellite data provide farmers a better understanding of the variation in soil conditions and topography that influence crop performance within the field. Farmers can, therefore, precisely manage production factors, such as seeds, fertilizers, pesticides, herbicides and water control, to increase yield and efficiency.

6. **Soil and plant sensors** :-

Sensor technology is an important component of precision agriculture technology and their use has been widely reported to provide information on soil properties and plant fertility/water status. A comprehensive list of current sensors as well as desirable features for new sensors to be developed in the future. One of the most popular ways to characterize soil variability is surveying the field with soil apparent electrical conductivity (ECa) sensors that collect information continuously when pulled over the field surface. Because ECa is sensitive to changes in soil texture and salinity, these sensors provide an excellent baseline to implement site-specific management.

7. **Global Positioning System (GPS)** :-

Global Positioning System satellites broadcast signals that allow GPS receivers to calculate their position. This position information is provided while in motion. Having precise location information at any time allows soil and crop measurements to be mapped. GPS receivers, either carried to the field or mounted on implements allow users to return to specific locations to sample or treat those areas. Uncorrected GPS signals have an accuracy of about 300 feet.

8. **Rate controllers:-**

Rate controllers are devices designed to control the delivery rate of chemical inputs such as fertilizers and pesticides, either liquid or granular. These rate controllers monitor the speed of the tractor/sprayer traveling across the

field, as well as the flow rate and pressure (if liquid) of the material, making delivery adjustments in real-time to apply a target rate. Rate controllers have been available for some time and are frequently used as stand-alone systems.

**9. Precision irrigation in pressurized systems :-**

Recent developments are being released for commercial use in sprinkler irrigation by controlling the irrigation machines motion with GPS based controllers. In addition to motion control, wireless communication and sensor technologies are being developed to monitor soil and ambient conditions, along with operation parameters of the irrigation machines (i.e. flow and pressure) to achieve higher water application efficiency and utilization by the crop. These technologies show remarkable potential but further development is needed before they become commercially available.

**10. Software:-**

Applying precision agriculture technologies will frequently require the use of software to carry out diverse tasks such as display-controller interfacing, information layers mapping, pre and post processing data analysis and interpretation, farm accounting of inputs per field, and many others. The most common are software to generate maps (e.g. yield, soil); software to filtering collected data; software to generate variable rate applications maps (e.g. for fertilizer, lime, chemicals); software to overlay different maps; and software to provide advanced geostatistical features. All are excellent options for precision agriculture farm management and record keeping to keep up with the needs of modem, information-intensive farming systems. There are a few companies that operate world-wide and provide integrated software packages from generating all different types of maps, having statistical analysis tools and also record keeping. The machinery companies that provide yield meters also offer software to generate yield maps and fertilizer companies provide software to generate variable rate applications maps. Some of the packages are very complicated for farmers to use and they are

fairly expensive, while some others are considerably simpler and cheaper with fewer options. The packages are more user-friendly and have many options for the farmer to use.

**11. Yield monitor:-**

Yield monitors are a combination of several components. They typically include several different sensors and other components, including a data storage device, user interface (display and key pad), and a task computer located in the combine cab, which controls the integration and interaction of these components. The sensors measure the mass or the volume of grain flow (grain flow sensors), separator speed, ground speed, grain. In the case of grains, yield is continuously recorded by measuring the force of the grain flow as it impacts a sensible plate in the clean grain elevator of the combine. A recent development of a mass flow sensor works on the principle of transmitting beams of microwave energy and measuring the portion of that energy that bounces back after hitting the stream of seeds flo,ving through the chutes. In all yield monitors, GPS receivers are used to record the location of yield data and create yield maps. Other yield monitoring systems include devices used in forage crops to keep track of weight, moisture, and other information on a per-bale basis.

**12. Precision farming on arable Iand:-**

The use of PA techniques on arable land is the most ,videly used and most advanced amongst farmers. Another important application of precision agriculture in arable land is to optimize the use of fertilizers, starting with the three main nutrients Nitrogen, Phosphorus and Potassium. In conventional farming these fertilizers are applied uniformly over fields at certain times during the year. This leads to over-application in some places and under-application in others. The environmental cost is directly related to over-application which allows nitrogen and phosphorus leaching from the field into ground- and surface waters or to other areas of the field where they are not desired. With the use of precision agriculture methods, fertilizers can

be applied in more precise amounts, with a spatial and temporal component to optimize the application. The technology that allows the farmer to control the amount of inputs in arable lands is the Variable Rate Application (VRA), which combines a variable-rate (VR) control system with application equipment to apply inputs at a precise time and/or location to achieve site-specific application rates of inputs. VRs are decided on the basis of prior measurement, e.g. from remote sensing or machine mounted sensors.

**13. Precision farming within the fruits & vegetables and viticulture sectors:-**

In fruit and vegetable fanning the recent rapid adoption of machine vision methods allows growers to grade products and to monitor food quality and safety, with automation systems recording parameters related to product quality. These include colour, size, shape, external defects, sugar content, acidity, and other internal qualities. Additionally, tracking of field operations such as chemicals sprayed and use of fertilizers can be possible to provide complete fruit and vegetable processing methods. This information can be disclosed to consumers for risk management and for food traceability as well as to producers for precision agriculture to get higher quality and larger yields ,vith optimized inputs. In recent years several new approaches were developed that take into account the actual size of the tree, the condition of the crop, but also the environmental conditions.

The development and adoption of PA technologies and methodologies in viticulture (termed Precision Viticulture, PV) is more recent than in arable land. However, driven by the high value of the crop and the importance of quality, several research projects already exist in wine production areas of the world. Grape quality and yield maps are of great importance during harvest to avoid mixing grapes of different potential ,vine qualities. The parcels with greatest opportunities for PV are those which reveal a high degree of yield variation. A high degree of variation will mean higher VRA of