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THEORY NOTES FOR MID TERM EXAM

Title: - Geo-informatics and Nano-technology and Precision Farming

Prepared by,

Prof. Waghmode B.R.

Assistant Professor (Department of Agronomy)

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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 farming for maximizing the effectiveness of crop inputs.
- **Precision agriculture (PA)** is an approach to farm management that uses information technology (IT) 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 to deal with every possible variation found in fields and field sections. .
- When implemented correctly, precision farming is a process that allows users to deal with 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 within 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 be extrapolated 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 modern, 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 flowing 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 land:-

The use of PA techniques on arable land is the most widely 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 farming 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 with 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 wine 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 inputs and, therefore, greater economic and environmental benefit in comparison with uniform management.

14. Precision livestock farming (PLF):-

Precision livestock farming (PLF) is defined as the management of livestock production using the principles and technology from precision agriculture. Processes suitable for the precision livestock farming approach include animal growth, milk and egg production, detection and monitoring of diseases and aspects related to animal behaviour and the physical environment such as the thermal micro-environment and emissions of gaseous pollutants. Systems include milk monitoring to check fat and microbial levels, helping to indicate potential infections, as well as new robotic feeding systems, weighing systems, robotic cleaners, feed pushers and other aids for the stockman such as imaging systems to avoid direct contact with animals. New systems for data monitoring for feed and water consumption can be used to the early detection of infections is available now. Other developments include the monitoring on the growing herd where measurement of growth in real time is important to provide producers with feed conversion and growth rates.

15. On-line resources for precision agriculture :-

There is a wealth of information available over the internet on new technology for farm production. Most
manufacturers of farm equipment, GPS receivers, sensors, and other PA technologies use this media to inform growers on new products, technical specifications, trouble-shooting information, software upgrades, and a variety of services.

16. Remote Sensors:-

These are generally categories of aerial or satellite sensors. They can indicate variations in the colours of the field that corresponds to changes in soil type, crop development, field boundaries, roads, water, etc. Arial and satellite imagery can be processed to provide vegetative indices, which reflect the health of the plant.

- **ADVANTAGES OF PRECISION FARMING (PF)/PRECISION AGRICULTURE (PA):-**

1. Precision agriculture can contribute to reduced waste,
2. It help to increase total profit from agriculture
3. Help to protect the environment by precise application of inputs.
4. Precision agriculture can provide both environmental and economic benefits as consequences from reduced or targeted placement of crop inputs that include water, pesticides, and nutrients.

- **Precise nutrient applications** can give important environmental and economic benefits. The aim is to apply only the nutrients that the plants require and can use. Rates of application will differ within the field based on the type of soils, levels of fertility, and sensitivity to the environment. There is some type of soils in a field that does not have the potential to validate maximum rates of nutrient application. On the other hand, there might be areas that need to be reduced rates because of sensitivity to the environment.
- **Precise pesticide applications** can offer both economic and environmental benefits. One of the cheapest and fastest environmental payoffs for applications of pesticides is the use of light bar guidance systems. These affordable light bar guidance systems offer an easy method to lead equipment across a field to prevent overlapping when pesticides are being sprayed.
- **Precision Soil preparation :- Soil preparation** is the first step before growing a crop. The ultimate objective is to produce a firm and weed-free seedbed for rapid germination and emergence of the crop. One of the most important tasks in soil preparation is tilling (or ploughing): turning the soil and loosening it.

❖ **Precision Seeding :-**

- **Seeding (or: sowing)** is a critical step in crop growing. For a successful seeding process, two challenges need to be overcome:
- **Correct depth:** if sown too deep into the soil, roots will not be able to breath. If sown on the surface, birds may damage the seeds.
- **Proper distance:** if plants are overcrowded, they will not to get enough water, nutrients and sunlight, resulting in yield loss. If they are planted too far from each other, valuable land is left unused.

❖ **Precision Crop Management :-**

During their growth phase plants need:

- The right amount of nutrients - **FERTILISATION**
- Adequate protection from pests and diseases - **CROP PROTECTION / SPRAYING**
- The right amounts of water - **IRRIGATION**
- In all three areas, precision farming solutions help farmers to **produce more with less.**

❖ **Precision Harvesting :-**

- For the farmer, **harvesting** is a critical point in time. Speed, accuracy, and timing determine whether the harvest will be successful. Until recently, harvesting was the most burdensome and laborious activity of the entire growing season. Today, the task is taken over by some of the most sophisticated farm machines such as:

❖ **Precision Livestock Farming :-**

- **Livestock farming is facing tremendous challenges today:**
- **Increasing production:** over the next 15 years, global demand for meat is expected to increase by 40% triggered by a growing number of people adopting protein-richer diets. According to the UN's Food and Agriculture Organisation (FAO), technology solutions in agricultural and livestock production systems will play a key role to address this challenge and ensure an adequate food supply for an expected population of 9.7 billion by 2050
- **Promoting sustainability & animal welfare:** while increasing production, it will be important to find ways to minimize the environmental footprint of livestock farming and ensure high levels of welfare and health for animals.
- **Alleviating farmers' workload and ensuring economic viability of farm operations:** it will be important find solutions that will enable farmers to manage large number of animals in an adequate and profitable manner.

➢ **Precision Livestock Farming (PLF) systems** :-

❖ **PLF systems:**

➢ help farmers to increase livestock production and quality of production in a sustainable manner
➢ offer tailored care for the animals in terms of feeding, milking and housing
➢ make many of the farmer's daily tasks much easier to handle

- **Examples of PLF systems include:**

Precision feeding systems: feeding systems allow farmers to feed their cows accurately, precisely and with minimal expenditure of work at all times (24/7).

Precision milking robot: a good example of large adoption of PLF systems are automatic milking machines. These robotic systems can handle up to 65 cows on an average of 2.7 times per day.

Stable and farm management systems: various PLF support and monitoring systems exist, which use cameras and microphones and thus act as the eyes and ears of the farmer at all times.

- **Benefits of PLF systems:**

a. **Greater sustainability & higher productivity:** recent studies show PLF management systems can raise milk yields, while also increasing cows' life expectancy and reducing their methane emissions by up to 30%.
b. **Increased animal welfare through an individual 'per animal' approach:** PLF systems allow farmers to follow and manage the individual animal's status and well-being closely at all times. They can detect diseases at an early stage, for instance, acoustic sensors can pick up an increase in coughing of pigs. PLF systems can also alert farmers of specific needs of animals by sending an SMS.
c. **Easier farm operations:** PLF systems enable livestock farmers to take care of a large number of animals per farm, while providing individual attention to each animal and complying – and documenting compliance – with high quality and welfare standards.

➢ DISADVANTAGES

1. Precision farming cannot be utilized completely in every crop.
2. Precision farming needs the good economic condition of the farmer for adoption
3. It requires technical and skilled persons
4. Initial cost is very high as well as maintenance cost also high
5. For adoption of precision farming farmers must have a technical knowledge.

➢ DIFFERENCE BETWEEN TRADITIONAL FARMING AND PRECISION FARMING

Traditional farming	**Precision farming**
Unit of treatment and organisation: the **field** that is regarded as a homogenous arable site	Unit of treatment and organisation: **arable site** that is regarded as different from one point to the other and at "field level" as heterogeneous
Nutrient management based on average sample taking	Nutrient management based on GPS and point-like sample taking
Average survey on plant deceases and damage and intervention if necessary	Plant protection treatments based on GPS and point-like plant survey
Sowing with same plant number and variety	Plant species and plant variety-specific sowing
Same machine operation practice	Machine-operation adjusted to the arable site
Unified plant stock in space and time	Unified plant stock organised into homogeneous blocks at arable sites
Few data influencing decision preparation	A lot of data influencing decision preparation

- **BENEFITS OF PRECISION FARMING :-**

  a) Precision farming not only is potentially more economical, but it also reduces the amounts of chemicals released into the environment.

  b) Improves crop yield and profit

  c) Provides better information for making management decision.

  d) Provides more details and useful farm records.

  e) Reduces fertilizer costs.

  f) Reduces pesticide costs.

  g) Reduces pollution.

- **COMPONENTS OF PRECISION FARMING :-**

  1. Remote sensing (RS)
  2. Geographical information system (GIS)
  3. Global Positioning System (GPS)
  4. Soil testing
  5. Yield monitors
  6. Variable Rate technology (VRT)

- ✓ **ADVANTAGES OF PRECISION FARMING SYSTEM (PFS) TO FARMERS** :-
- ✓ **Overall yield increase :-** Precise selection of crop varieties, application of exact types and doses of fertilizers, pesticides and herbicides and appropriate irrigation meet the demands of crops for optimum growth and development.
- ✓ **Efficiency improvement :-** Advanced technologies, including machinery, tools and information, help farmers to increase the efficiency of labour, land and time in farming.
- ✓ **Reduced production cost :-** Application of exact quantities at the appropriate time reduces the cost of agrochemical inputs in crop production.
- ✓ **Better decision making in agricultural management** :- Agricultural machinery, equipment and tools help farmers acquire accurate information which is processes and analysed for appropriate decision making.

- ✓ **Reduced environmental impact :-** Timely application of agrochemicals at an accurate rate avoids excessive residues in soils and water and thus reduces environmental pollution.
- ✓ **Accumulation of farmers knowledge for better management with time :-** All PFS field activities produce valuable field and management information and data are stored in tools and computers. Farmers can thus accumulate knowledge about their farms and production systems to achieve better management.

➢ STEPS IN PRECISION FARMING :-

- There are **two basic steps** in precision agriculture.

1. Identification and Assessment of Variability :-

a) Grid soil sampling :-

- Grid soil sampling uses the same principles of soil sampling but increases the intensity of sampling compared to the traditional 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 to generate a map of nutrient/water requirement called an **application map**

b.) Yield map:-

- Yield mapping is the first step to determine the precise locations of the highest and lowest yield areas of the field and to analyse the factors causing yield variation.
- One way to determine yields map is to take samples from the land in a 100 x 100 m grid pattern to test for nutrient levels, acidity and other factors.

c) Crop Scouting: - In season observations of crop conditions like weed patches (weed type and intensity), insect or fungal infestation (species and intensity) and crop tissue nutrient status can be helpful for explaining the variations in yield maps.

d) Use of precision technologies for assessing variability: - Faster and real time assessment of variability is possible only through advanced tools of precision agriculture.

2. Management of Variability:-

a) **Variable rate application :-**

- Grid soil samples are analyzed in the laboratory and an interpretation of crop input (nutrient/water) needs is made for each soil sample.
- Then the input application map is plotted using the entire set of soil samples.
- The input application map is loaded into a computer mounted on a variable rate input applicator.
- The computer uses the input application map and GPS receiver to direct a product delivery controller that changes the amount and kind of input according to the application map.

b) Yield monitoring and mapping :-

- Yield measurements are essential for making sound management decisions.
- However, soil landscape and other environmental factors should also be weighed when interpreting a yield map.
- Yield information provides important feedback in determining the effects of managed inputs such as fertilizer amendments, seed, pesticides and cultural practices.

c) Quantifying farm variability: - Every farm presents a unique management. Not all the tools described above will help determine the causes of variability in a field and it would be cost prohibitive to implement all of them immediately.

d) Flexibility: - All farms can be managed precisely. Small scale farmers often have highly detailed knowledge of their lands based on personal observations and could already be modifying their management accordingly. Appropriate technologies here might make this task easier or more efficient.

❖ SCOPE AND ADOPTION OF PRECISION FARMING IN INDIA:

PA for small farms can use small farm machinery and robots which will not compact the soil and may also run on renewable fuels like bio oil, compressed biogas and electricity produced on farms by agricultural residues. For small farms, precision agriculture may include sub-surface drip irrigation for precise water and fertilizer application, weed removal, harvesting and other cultural operations. Some of these robots are already being used on small farms in the US and Europe and it is expected that they may be deployed in large scale in the near future. For small farms, precision agriculture may help in sub-surface drip irrigation for precise water and fertilizer application and robots for weed control, harvesting and other operations. Similarly, drones have also been introduced in Japan and the U.S. for mapping the farms, identifying diseases and so on. Most robotic machines and drones are compact and thus suitable for small farms. India's small farms, therefore, are ideal for the large-scale application of precision agriculture.

➢ SCOPE AND LIMITATION IN ADOPTION OF PRECISION FARMING IN INDIA

1. Precision Farming concepts are applicable to all agricultural sectors like animal farming, fisheries and forestry. Precision Agriculture (PA) can be classified into two categories namely 'Soft' PA and 'Hard' PA.
2. 'Soft' Precision Agriculture mainly depends on visual observation of crop and soil and management decision based on experience and intuition, rather than statistical and scientific analysis.
3. Whereas, 'Hard' PA utilizes all modern technologies like GPS, GIS, VRT, etc.
4. In India 96 million farms out of a total 105.3 million farms have less than 4 hectares (ha) area.
5. Though only fragmented lands are cultivated, the present food grain production in India is nearly 200 Million Tone, which has made India self sufficient in food production.
6. To compete with the world production, the crop yield per hectare must be economic and without environment degradation.
7. In India, overall fertilizer consume-tion rate is 84.3 Kg/ha, which must be reduced by systematic soil testing and creating nutrient maps along with fertilizer recommendations.
8. Along with nutrient zones pest control, disease and weed management also plays an important role in high yield of crop. Using advance technology, it is possible to monitor and control the pest and disease at lower costs.
9. Some states like Punjab, Haryana use high doses of fertilizer and pesticides.
10. For example, the state of Punjab has 1.5% of total geographical area of India, but uses 1.38 million tones (nearly 10% of all India fertilizer consumption) of NPK fertilizer along with 60% of weedicides used in India.
11. Overall exploitation of land as well as excessive use of agriculture input are typical problems of these areas.

12. Stress management is another area where Precision Framing can help Indian farmers in scheduling irrigation more profitably by varying the timing, quantity and placement of water.
13. Mechanization of farming helps the farmers to reduce the labor cost and to improve the accuracy of farming including quality seed selection, weed removing, pesticide and fertilizer application, harvesting and sorting of the crop as per the quality.
14. There are many limitations to adoption of Precision Farming in developing countries in general and India in particular.
15. Some of these limitations are common to those in other regions; however, following are specific to Indian conditions: 1. The culture and perceptions of the users, 2. Small farm size, 3. Lack of success stories, 4. Heterogeneity of cropping systems and market imperfections, 5. Land ownership, infrastructure and institutional constraints, 6. Lack of local technical expertise, 7. Availability, quality and cost of data.

- **KEY CHALLENGES TO PRECISION FARMING IN INDIA**

Though widely adopted in developed countries, the adoption of precision farming in India is yet in infancy primarily due to its unique pattern of land holdings, poor infrastructure, lack of farmers' inclination to take risk, socio-economic and demographic conditions. The small size of farms and fields in most of Indian agriculture limits economic gains from currently available precision farming technology, while the population density, and public concerns for the environment, food safety and animal welfare means that those potential benefits are being given more attention.

➢ OPPORTUNITIES AND CHALLENGES

Precision Agriculture can have a positive impact on environmental quality. The opportunity exists to show producers how changing production practices will not place crops at risk and produce positive economic and environmental benefits. Conducting experiments on precision agriculture will require field or farmscale studies and perhaps watershed-scale adoption of new management practices.

Completing this type of study will require:

1. Appropriate questions that can be addressed at the field scale.
2. Methods for measuring environmental endpoints that will demonstrate the efficacy of management practices.
3. Commitment to multiple years of study to overcome meteorological variation.
4. Adequate monitoring equipment for crop production, soil properties, and environmental quality in order to understand the changes occurring due to the management practices.
5. Use of comparison fields or farms in which no changes are made to provide a validation of the improved practices.
6. Cooperation of producers to implement the practices with minor modifications across years so that variations can be isolated to the management practice and not producer influence.
7. Data base structure that includes geographic information layers and accurate global positioning system equipment to position any treatments in the same area across years.
8. Funding sources that will allow for long-term studies across large areas.
9. Interdisciplinary teams that will address the critical problems in experimental design, implementation, and evaluation of results.

10. Commitment from the scientists, producers, and educators involved to maintain interest in the project over a sufficient period of time to allow the original objectives to be achieved.

➢ PRECISION FARMING CONCERNS FOR INDIAN AGRICULTURE :-

1. Farmers in developed countries typically own large farms (10-1000 ha or more) and crop production systems are highly mechanized in most cases.
2. Large farms may comprise several fields in differing conditions.
3. Even within a relatively small field (<30 ha) the degree of pest infestation, disease infection and weed competition may differ from one area to another.
4. In conventional agriculture, although a soil map of the region may exist, farmers still tend to practice the same crop management throughout their fields: Crop varieties, land preparation, fertilizers, pesticides and herbicides are uniformly applied in spite of variation.
5. Optimum growth and development are thus not achieved.
6. Furthermore, there is inefficient use of inputs and lab Labour.
7. Availability of information technology since the 1980s provides farmers with new tools and approaches to characterize the nature and extent of variation in the fields, enabling them to develop the most appropriate management strategy for a specific location, increasing the efficiency of input application.

➢ PRACTICAL PROBLEMS/ISSUES IN PRECISION AGRICULTURE/FARMING :-

1. Small land holdings.
2. Heterogeneity of cropping systems and market imperfections.
3. Complexity of tools and techniques requiring new skills.
4. Lack of technical expertise knowledge and technology.
5. Infrastructure and institutional constraints including market imperfections.

➢ **STEPS TO BE TAKEN FOR IMPLEMENTING PF IN INDIA :-**

a) Creation of multidisciplinary teams involving agricultural scientists in various fields, engineers, manufacturers and economists to study the overall scope of PA.
b) Formation of farmer's co-operatives since many of the precision agriculture tools (GIS, GPS etc) are costly.
c) Government legislation restraining farmers using indiscriminate farm inputs and thereby causing ecological/environmental imbalance would induce the farmer to go for alternative approach.
d) Pilot study should be conducted on farmer's field to show the results of PA implementation.
e) Creating awareness amongst farmers about consequences of applying imbalanced doses of farm inputs like irrigation, fertilizers, insecticides and pesticides.

Lecture 2. GEO-INFORMATICS SYSTEM- DEFINITION, CONCEPTS, TOOL AND TECHNIQUES; THEIR USE IN PRECISION FARMING.

- **"Geoinformatics"** deal with handling digital geoinformation such as collecting, processing, storing, archiving, preservation, retrieving, transmitting, accessing, visualization, analysing, synthesizing, presenting and disseminating geoinformation.
- **"Geoinformatics"** is "the science of the gathering, processing and dissemination of information which is spatially defined within the Earth's system".
- **"Geoinformatics"** as "the art, science or technology dealing with the acquisition, storage, processing, production, presentation and dissemination of geoinformation".
- **"Geoinformatics"** is the combination of technology and science dealing by means of the spatial (location, place, space, field) information, its acquisition, its qualification and classification, its processing, storage and dissemination.
- **"Geoinformatics"** is an integrated tool to collect process and generate information from spatial and non-spatial data.
- The term geo informatics consists of two words, geo (Earth) and informatics (the study of information processing).
- Geoinformatics is an appropriate blending of modules like RS, GPS, GIS, RDBMS

❖ CONCEPT OF GEO-INFORMATICS (GI) :-

- ✓ Geo-informatics is integrated technology for collection, transformation and generation of information from integrated spatial and non-spatial data bases.
- ✓ Remote sensing, Geographical Information Sciences (GIS), Global Positioning Systems (GPS), Relational Data Base Management Systems (RDBMS) are some of its important ingredients.
- ✓ It is a powerful tool for assessment, monitoring, planning and management of agricultural research and development.

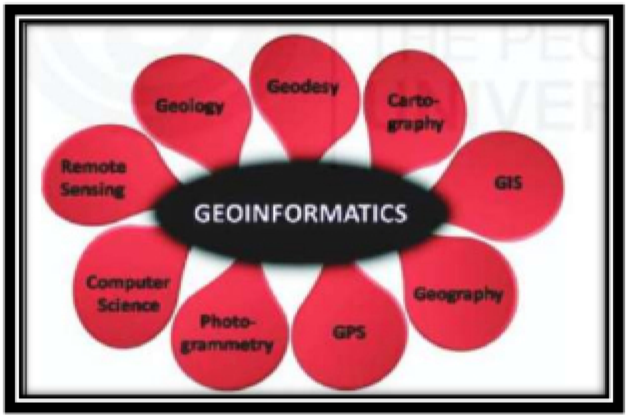
- ✓ Management of agricultural resources & its conservation practices and land/water resources aimed at increasing the food production.
- ✓ GI involves study of i) existing land use and acreage under various crops, ii) soil types and extent of problem soils, iii) monitoring of surface water bodies (to determine water availability in irrigation systems) for ground water development and (iv) management of natural calamities.
- ✓ It is a multidisciplinary science that integrates the technologies and principles of digital cartography, remote sensing, photogrammetry, surveying, Global Positioning Systems (GPS), Geographic Information Systems (GIS), and automated data capture systems using high-resolution geo-referenced spatial information from aerospace remote sensing platforms.

➢ **PRINCIPLES OF GEO-INFORMATICS (GI) :-**

1. **Cartographic principles** involve map compilation, map design, and map visualisation and production in analogue or digital computer environment.
2. **Remote sensing** involves the acquisition of spatial data of the environment without physical contact with the objects or features being sensed by using electromagnetic energy radiation, interaction and detection principles in analogue or digital formats.
3. **Photogrammetric principles** involve the art and scientific processes of obtaining reliable information about the physical environment by interpreting remotely sensed aerospace data (aerial photographs and satellite imageries) in analogue or digital formats.
4. **Surveying principles** involve the adroit use of fundamental methods (processes) and technologies (instruments) to determine the precise position and dimensions of points (features) on the earth's surface and the presentation of the results in analogue or digital format.
5. **Global Positioning Systems (GPS)** involve precise surveying (determination of position and dimensions of points) by applying resection and satellite constellation principles and the presentation of the results in analogue (maps, tables) or digital formats.

6. **Geographic Information Systems (GIS)** principles involve data gathering, data processing, database management, data modelling and visualisation in a digital computer environment.
7. **Automated data capture systems** include multi-spectral remote sensing processes, GPS data, map digitisation and scanning, and computer input and output technologies.

- **TOOLS AND TECHNIQUES OF GEO INFORMATICS (GI) :-**
  - i. Computer Science
  - ii. Geodesy
  - iii. Cartography
  - iv. Photogrammetry
  - v. Remote Sensing (RS)
  - vi. Global Positioning System (GPS)
  - vii. Geographic Information System (GIS)



1. **Computer Science:-**

- ✓ Informatics, as a discipline, comprises of both the computer technologies, i.e. hardware and software.
- ✓ The important role of information derives from our necessity to manage more and more numerous and complex data in every field.

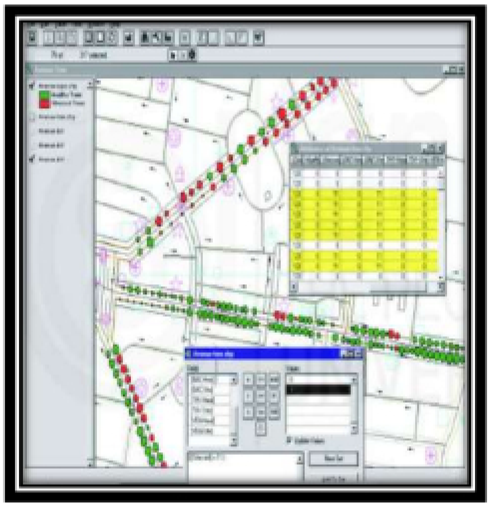
- ✓ The knowledge of computer science is a pre-requisite to represent and process applicable information through the development of hardware and software.
- ✓ Computer science culture is now more prevalent contributing in improvement of our activities and research.

2. Geodesy: -

- ✓ Geodesy also known as geodetics is the discipline that deals with the measurement and representation of the Earth.
- ✓ Geodesy is defined as the science concerned with the study of shape and area of the Earth.
- ✓ Geodesy defines the shape and dimensions of the Earth through its two branches: gravimetry and positioning astronomy.
- ✓ Gravimetry deals with the determination of Earth’s gravity and its anomalies and the gravity determines the shape of the Earth.

3. Cartography:-

- ✓ Cartography is generally considered to be the science and art of designing, constructing and producing maps.
- ✓ It includes almost every operation from original field work to final printing and marketing of maps.



4. Photogrammetry:-

- ✓ Photogrammetry is the technology developed for determining the geometric properties of objects from their photographic images.
- ✓ Photogrammetry is concerned with making measurements about position and shape of objects with the help of photographs.
- ✓ The American Society for Photogrammetry and Remote Sensing (ASPRS) has defined Photogrammetry as "the art, science, and technology of obtaining reliable information about physical objects and the environment through processes of recording, measuring and interpreting photographic images and patterns of recorded radiant electromagnetic energy and other phenomena".
- ✓ Photogrammetry is useful in various fields including topographic mapping, architecture, engineering, manufacturing, quality control, police investigation, and geology.

5. Remote Sensing:-

- ✓ Remote sensing is the collection of data about an object from a distance.
- ✓ Scientists use the technique of remote sensing to monitor or measure phenomena found in the Earth's lithosphere, biosphere, hydrosphere, and atmosphere.
- ✓ Humans and many other types of animals accomplish this task with aid of eyes or by the sense of smell or hearing.
- ✓ Remote sensing is usually done with the help of mechanical device known as remote sensor.
- ✓ This device as greatly improved ability to receive and record information about an object without having any physical contact with them by using electromagnetic energy radiation.

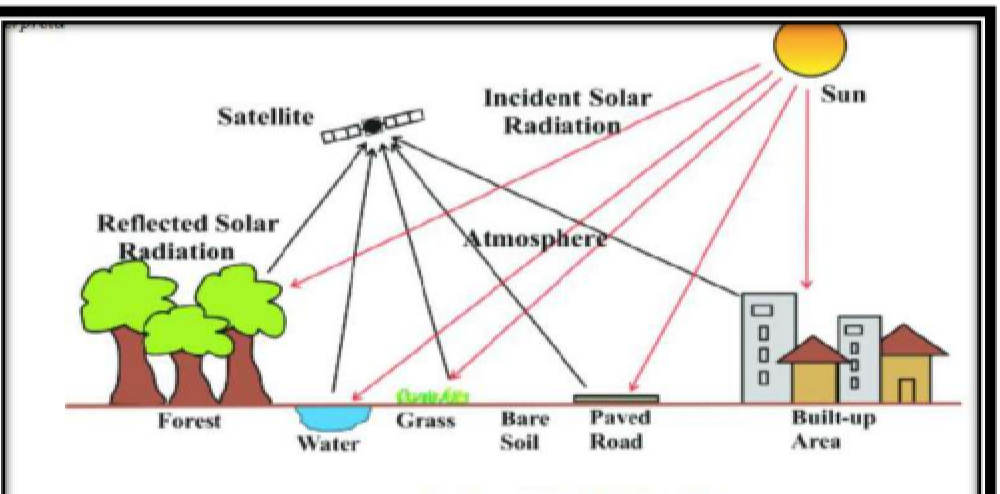


Fig. 1.5: Concept of remote sensing

6. Global Positioning System:-

- ✓ Another important Geoinformatics tool required for agricultural development.
- ✓ Global Positioning System enables positional accuracy in the location of terrain features.
- ✓ It receives signals and positioning information from a series of satellites in space.
- ✓ Global Positioning System capability is necessary in the integration of the diverse agricultural data sets from diverse sources, in Geographic Information System environment.
- ✓ In addition the use of Global Positioning System allows for the accurate location of soil sample points within a field, and hence the determination of physical, chemical and biological characteristics of the soil at different locations.
- ✓ The Global Positioning System is also required to establish the accurate location of yield data collected.

- **Real world applications of GPS fall into following five broad categories:**
- **Location:** determining a basic position
- **Navigation:** getting from one location to another
- **Tracking:** monitoring the movement of people, animals and goods
- **Mapping:** creating maps of the world

✓ Applications of GPS based **Location Based Services (LBS)**

✓ **GAGAN (GPS Aided Geo Augmented Navigation or GPS and Geo Augmented Navigation system)** is a planned implementation of a regional Satellite Based Augmentation System (SBAS) by the Indian government.

✓ The project is being implemented by the Airport Authority of India with the help of the **Indian Space Research Organization's (ISRO)** technology and space support.

7. Geographic Information System:-

✓ Geographic Information System as a system for capturing, storing, checking, manipulating, analysing and displaying data, which are spatially referenced to the earth.

✓ Thus, a true Geographic Information System is designed to accept, organise, statistically analyse and display diverse types of spatial information that are geographically referenced to a common coordinate system of a particular projection and scale.

✓ Recently, GIS has been used for emergency planning, logistics and transportation related analysis, crime analysis, business and service planning, government and public services, analysis of genome sequences on DNA.

✓ Internet has also been exploited to disseminate geographic information to the general public resulting into a new breed of specialized GIS generally known as **Web GIS.**

✓ Geographic Information System comprises **five major components** and **three main subsystems**

➢ **Five major Components of GIS :-**

1. **The hardware** which include a host computer, data acquisition device(s) such as digitiser, scanner, digital image processing system.
2. **The spatial database** which involves position and spatial relationships.
3. **Software** for the acquisition, manipulation and management of data in the database.
4. **Procedures** which invloves conventions and algorithms to guide its operations.
5. **Expertise** in terms of skilled human operators.

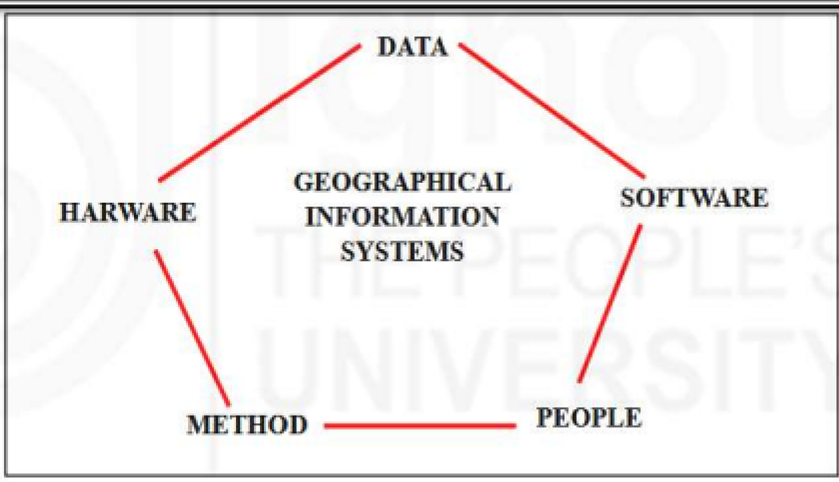


Fig. 1.8: Components of GIS.

➢ **Three main subsystems of GIS :-**

1. **Data acquisition subsystem** for collecting and or processing spatial data from existing maps, remotely sensed data, aerial photography, land survey among others.
2. **Database management subsystem** for the storage, retrieval, manipulation and analysis of data.
3. **Visualization and reporting subsystem** for displaying database query results in graphic and/or alphanumeric form.

- **RELEVANCE OF GEOINFORMATICS IN AGRICULTURE** :-

  - ✓ Geoinformatics, and in particular remote sensing, Geographic Information Systems and Global Positioning Systems technologies have become popular in modern agriculture.

1. **Remote sensing system :-**

   Advances in remote sensing have revolutionized the gathering of information on agricultural activities, including land use, soil condition, weather condition etc that are essential for site characterisation and consequent site selection for farming.

   - ✓ Since remote sensing techniques have the unique capability of recording data in visible as well as invisible (including ultra violet, reflected infrared, thermal infrared and microwave) parts of the electromagnetic spectrum, it enables us see beyond the capability of the human eye.
   - ✓ For instance trees or plants, which are affected by diseases or insect attack, can be detected by remote sensing technique much before human eye sees them. Such early detection is vital for the application of remedial measures.
   - ✓ Remote sensing techniques are also useful in the determination of the spatial distribution of plant status and expected yield by measuring the greenness of the field.
   - ✓ Detection, identification, measurement and monitoring of agricultural phenomena are predicated on the assumption that agricultural landscape features (such as crops, livestock, crop infestation and soil anomalies) have consistently identifiable signatures on the type of remote sensing data.
   - ✓ These identifiable signatures are a reflection of crop type, state of maturity, crop density, crop geometry, crop vigour, crop moisture, crop temperature, and soil moisture as well as soil temperature.

- **AREAS OF SPECIFIC APPLICATION OF REMOTE SENSING IN AGRICULTURAL SURVEYS**

a) **Applicable to Crop Survey :-**

Crop identification; Crop acreage; Crop vigour; Crop density; Crop maturity; Growth rates; Yield forecasting; Actual yield; Soil fertility; Effects of fertilisers; Soil toxicity; Water quality; Irrigation requirement; Insect infestations; Water availability; Location of canals.

b) **Applicable to Range Survey :-**

Delineation of forest types; Condition of range; Carrying capacity; Forage; Time of seasonal change; Location of water; Water quality; Soil fertility; Soil moisture; Insect infestations; Wildlife inventory.

c) **Applicable to Livestock Survey**

Cattle population; Sheep population; Pig population; Poultry population; Age sex distribution; Distribution of animals; Animal behaviour; Disease identification; Types of farm buildings.

- **Use of wavelength region for agricultural survey Area of agricultural phenomena Wavelength employed** :-

1. Plant diseases and insect infestation - **0.4-0.9 mm and 6-10 mm**
2. Natural vegetation, types of crop and fresh inventories - **0.4-0.9 mm and 6-10 mm**
3. Soil moisture content (Radar) - **0.4-0.8 mm and 3-100 mm**
4. Study of arable and non-arable land - **0.4-0.9 mm**

5. Assessment of plant growth and vigour for forecasting crop yield - **0.4-0.9 mm**

6. Soil type and characteristics - **0.4-1.0 mm**

7. Flood control and water management - **0.4-1.0 mm and 6-12 mm**

8. Surface water inventories and water quality - **0.4-1.0 mm and 6-12 mm**

9. Soil and rock type & mineral deposits -**0.4-1.0 mm & 7-12 mm**

2. Geographic Information System:-

- ✓ Geographic Information System as a system for **capturing, storing, checking, manipulating, analysing and displaying data, which are spatially referenced to the earth.**
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➢ ADVANTAGES OF GEOINFORMATICS (GI) :-

a) Can acquire geospatial data in time and cost effective manner

b) Can provide synoptic view and multi date information of an area in different parts of electromagnetic spectrum

c) It helps in collecting data of an area without disturbing or destroying it

d) It can answer where, when, what and why scenarios which is not possible with any other software system

e) It assists in predicting events/outcomes based on multi-criteria analyses

f) It helps in visualizing the scenarios under a given situation, and its consequences. Such scenarios greatly assist disaster managers to plan for future and save human lives

g) It helps to create a comprehensive solution to a problem in hand particularly assisting the decision and policy makers to arrive at inappropriate decision/solution

h) It assists in planning strategies and is especially useful in cases where disastrous events demand quick decision making.

➢ APPLICATIONS/USE OF GEOINFORMATICS IN PRECISION FARMING:-

- Precision farming employs a system engineering approach to crop production where inputs are made on an "as needed basis," and was made possible by recent innovation in information and technology such as microcomputers, geographic information systems, remote sensing, positioning technologies viz., GPS (Global Positioning System), DGPS (Differential global positioning system), VRT (Variable Rate Technology), VRA (Variable Rate Applicator) and automatic control of farm machinery.

1. Application of Remote Sensing (RS) :

- It is a Pivotal role /holistic approach to manage spatial and temporal variability in agricultural lands at micro level based on integrated soil, plant, information, and engineering management technologies as well as economics.
- Sensors provides data on soil properties, crop condition and yield, fertilizer flow rate as weed detection.

2. Application of Differential Global Positioning System (DGPS) :-

- Is used for precise location of activities.
- Make the corrections in error of GPS signal.

3. Application of Global Positioning System (GPS) :-

- Device identifies the location of farm equipment within a meter of an actual site in the field.

- This is required to accurately link location and result of soil samples to a soil map, prescribe farm inputs to fit soil properties, adjust tillage to suit field conditions.

4. Application of Variable Rate Application (VRA) :-

- Is used to operationalise precision farming at the farm level.
- Here **Applicator** are used to accurate rate/desired rate of fertilizers, pesticides, fungicides, herbicides and water supply.

5. Application of Variable Rate Technology (VRT):-

- VRT consists of the machines and systems used to apply a desired rate of crop production inputs/materials at a specific time and specific location.
- The control computer co-ordinates field operations with the data base of its memory.
- Based on the desired activity, the computer from **locator** (holds a GPS) receives the current location of equipment and issue command to the **actuator** which does the input application.

CHAPTER NO. 3 CROP DISCRIMINATION AND YIELD MONITORING

➢ **Crop Discrimination (differentiation/classification) :-**

- **Crop discrimination** is a necessary step for most agricultural monitoring systems in which differentiate/classification of crops as per season, phonological stages, pigmentation, spatial arrangement/architecture as well as spectral features is called as crop discrimination.
- Crop discrimination is usually an important step for development and management of crop monitoring systems.
- Since remote sensing technology is used for crop discrimination, both the theory and the technological tools have been in constant development, this has led to a remarkable increased in the range of applications and scope of crop discrimination techniques.
- Crop discrimination types using remote sensing techniques are based on the characterization and understanding of the electromagnetic behavior of target.
- This behavior depends on the wavelength at which the crop observation is performed, due to this, remote sensors for Earth observation are designed to operate at wavelengths in which the response of each target (crop type) is characterized and known, facilitating on this way the target identification in the scene.
- It is important to note that the electromagnetic response of the different parts of a crop cover not only depend on the wavelength used for observation, it also shows variations depending on the season, angle of incidence of the sensor, crop's features, illumination intensity, weather phenomenon and topography among other external factors.

- Recently, GIS and RST (Remote sensing Technology) has come up with a capable role in agricultural research, predominantly in crop yield prediction in addition to crop suitability studies and site specific resource allocation.
- Role of GI to discriminate different crops at various levels of classification, monitoring crop growth and prediction of the crop yield.

➢ **Technologies are used for Crop Discrimination :-**

1. Remote sensing (RS) :-

✓ Remote sensing (RS) is an efficient technology and worthy source of earth surface information, as it can capture images of reasonably large area on the earth.

✓ Due to advancement in the sensor technologies, there is availability of high spatial as well as spectral resolutions imageries and also non-imaging spectroradiometer.

✓ With the use of these imaging and non-imaging data, we can easily characterize the different species.

✓ Different crops shows distinct phonological characteristics (plant life cycle events) and timings according to their nature of germination, tillering, flowering, boll formation (cotton), ripening etc.

✓ Even for the same crop and growing season, the duration and magnitude of each phonological stage can differ between the varieties which introduce data variability for crop type discrimination.

✓ Agricultural crops are significantly better characterized, classified, modelled and mapped using hyper spectral data.

2. Feature Extraction:-

- **Feature Extraction** is the process of defining image characteristics or features which effectively provides meaningful information for image interpretation or classification called as feature extraction.
- **Goals of Feature extraction are** :-

  a) Effectiveness and efficiency in classification

  b) Avoiding redundancy/extra space of data

  c) Identifying useful spatial as well as spectral features

  d) Maximizing the pattern of crop discrimination

  - For crop discrimination, spatial features are useful.
  - Crops are planted in rows, either multiple or single rows as per crop type to maximize yield.
  - Different spatial arrangement of the crops gives better spatial information but it requires high spatial resolution images.
  - In spatial image classification, spatial image elements are combined with spectral properties in crop classification decision.

3. Role of Texture in Classification:-

- ✓ Texture means information in spatial (space) arrangement of colors/intensity of images
- ✓ In general, it is possible to distinguish between the regular textures manifested by manmade objects from the irregular manner that natural objects exhibit texture.
- ✓ Hence, the texture characteristics/classification can be used for discriminate crops.

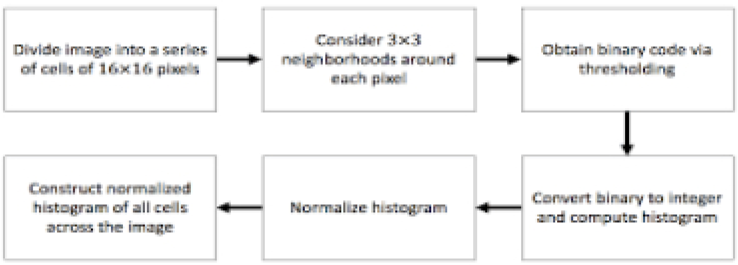
- ✓ For crop discrimination, remotely sensed data, conventional texture analysis and grey level co-occurrence matrix (GLCM) methods are used.

a. Grey Level Co-Occurrence Matrix (GLCM) :-

- ✓ In GLCM method describing the grey value relationships.
- ✓ GLCM is a statistical method of examining texture.
- ✓ GLCM can be viewed as a two dimensional histogram (rectangles) of the frequency with which pairs of grey level pixels/images occur in a given spatial relationship.
- ✓ GLCM method is a way of extracting texture features
- ✓ Image composed of pixels each with an intensity (a specific gray level), the GLCM is a tabulation of how often different combinations of gray levels co-occur in an image or image section.

b. Local Binary Pattern (LBP) :-

- ✓ LBP is powerful feature for texture classification.
- ✓ Local Binary Pattern (LBP) is an effective texture which thresholds (applied for all pixels of the image) the neighboring pixels (smallest unit of image) descriptor for images based on the value of the current pixel.
- ✓ Local Binary Pattern (LBP) is a simple yet very efficient texture operator which labels the pixels of an image by thresholding the neighborhood of each pixel and considers the result as a binary number.
- ✓ Due to discriminative power, LBP texture operator has become a popular approach in various applications.



Steps in LBP

4. Spectral features for crop classification/discrimination :-

- ✓ Spectral characteristics of green vegetation have very noticeable features.
- ✓ Visible portion of the spectrum are determined by the pigments contained in the plant.
- ✓ Chlorophyll absorbs strongly in the blue (0.4-0.5 nm) and red (0.68 nm) regions also known as the chlorophyll absorption bands.
- ✓ Chlorophyll is the primary photosynthetic pigment in green plants.
- ✓ The spectral reflectance signature has a dramatic increase in the reflection for healthy vegetation at around 0.7 nm.
- ✓ In the near infrared (NIR) between 0.7 nm and 1.3 nm, a plant leaf will naturally reflect between 40 and 60 %, the rest is transmitted with only about 5 % being absorbed.
- ✓ Three strong water absorption bands are noted at around 1.4, 1.9 and 2.7 nm can be used for plant-water estimation.

1. Band selection:-

- ✓ Band selection is one of the important steps in hyper spectral (hundreds or thousands of bands) remote sensing.
- ✓ There are two types of spectral bands (make only pass desired wavelength) viz., multispectral i.e. 3 to 10 bands and hyper spectral i.e. 100 or 1000 bands remote sensing
- ✓ There are two conceptually different approaches of band selection like unsupervised and supervised.
- ✓ Due to availability of hundreds of spectral bands, there may be same values in several bands which increases the data redundancy (additional space).
- ✓ To avoid the data redundancy and get distinct features from available hundreds of bands, we have to choose the specific bands by studying the reflectance behavior of crops.

2. Narrowband Vegetation Indices:-

- ✓ **Spectral indices :-** Assume that the combined interaction between a small numbers of wavelengths is adequate to describe the biochemical or biophysical interaction between light and matter.
- ✓ **Hyper spectral system :-** is their ability to create new indices that integrate wavelengths not sampled by any broadband system and to quantify absorptions that are specific to important biochemical and biophysical quantities of vegetation.
- ✓ Vegetation properties measured with hyperspectral vegetation indices (HVI).
- ✓ **HVI can be divided into four main categories**

1. **Structural properties :-** These properties include green leaf biomass, LAI (Leaf Area Index) and Fraction absorbed Photo synthetically Active Radiation (FPAR)
2. **Biochemical properties :-** It includes water, pigments (***Chlorophyll, carotenoides, amthocyanins***), other nitrogen rich compounds (protein) and plant structural materials (Lignin and cellulose)
3. **Physiological and stress indices :-** It measure delicate changes due to a stress induced change in the state of xanthophylls changes in chlorophyll content, change in soil moisture.
4. **Narrowband vegetation indices :-**

- ✓ Can be used as potential variables for crop type discrimination.
- ✓ Best vegetation indices of different category to discriminate the crop types which are greenness/leaf pigment indices, Chlorophyll red edge indices, light use efficiency indices and leaf water indices

➢ **Importance of hyper spectral Remote sensing** :-

- HRS is an advanced tool that provides high spatial/spectral resolution data from a distance, with the aim of providing near-laboratory-quality radiance for each picture element (pixel) from a distance.
- Recent advances in remote sensing and geographic information has led the way for the development of hyper spectral sensors.
- Hyper spectral remote sensing, also known as imaging spectroscopy (study of visible light), is a relatively new technology that is currently being investigated

by researchers and scientists with regard to the detection and identification of minerals, terrestrial vegetation, and man-made materials and backgrounds.

- Hyper spectral remote sensing combines imaging and spectroscopy in a single system which often includes large data sets and require new processing methods.
- Hyper spectral data sets are generally composed of about 100 to 200 spectral bands of relatively narrow bandwidths (5-10 nm), whereas, multispectral data sets are usually composed of about 5 to 10 bands of relatively large bandwidths (70-400 nm).
- Hyper spectral Remote Sensing (HRS) and Imaging Spectroscopy (IS), are two technologies that can provide detailed spectral information from every pixel in an image.

➢ **Applications/Advantages of HRS** :-

✓ There are many applications which can take advantage of hyperspectral remotesensing.

i. **Atmosphere:** water vapor, cloud properties, aerosols
ii. **Ecology:** chlorophyll, leaf water, cellulose, pigmemts, lignin
iii. **Geology:** mineral and soil types
iv. **Coastal Waters:** chlorophyll, phytoplankton, dissolved organic materials, suspended sediments
v. **Snow/Ice:** snow cover fraction, grainsize, melting
vi. **Biomass Burning**: subpixel temperatures, smoke
vii. **Commercial:** mineral exploration, agriculture and forest production

Yield Monitoring and Mapping

- **Yield monitoring: -** is the estimation of crop yield well before the harvest at regional and national scale is imperative for planning at micro-level and predominantly the demand for crop insurance.
- Crop yield estimation is plays a significant role in economy development.
- Currently, it is being done by extensive field surveys and crop experimentation.
- **Yield monitoring equipment** was introduced in the **early 1990s** and is increasingly considered a conventional practice in modern agriculture.

❖ **Different approaches and technologies used for yield monitoring (crop inventory)** :-

1. Aerial Photography (AP) :-

✓ There are two distinct aspects of yield estimation a) forecast of yield based on characteristics of the plant or crop b) Estimates of the crop yield based actual weight of the harvest crop

✓ After World War II, various researchers used the emerged concept of **Aerial Photography** for optimized use of resources for agriculture and crop inventory.

✓ **Black and white photography** has been used for crop identification, primarily based on ground appearance, photographs of selected fields and growing seasons of crops.

2. Multispectral Scanners (MSS) :-

✓ MSS – have 0.3-14 nm or more bands

✓ MSS have certain advantages and disadvantages compared to photography**.**

✓ Ability to differentiate wheat from other agricultural crops using MSS data in a computer format.

✓ An important consideration in the task of species identification is the any stage of growth of the crop.

3. Radar (Radio Detection and Ranging):-

- ✓ Radar sensors are able to capture plant structure and soil moisture content.
- ✓ Radar sensors can contribute to measuring crop condition at different phonological stages that are useful to estimation of crop yields.
- ✓ Air borne or space borne Radar are used crop identification/discrimination.
- ✓ Radar studies have concentrated on seasonal yield data estimation of crops.

4. Satellite Data/Remote sensing data:-

- ✓ Remote sensing data has been proved effective in predicting crop yields and provide reprehensive and spatially information of crop yield estimation.
- ✓ In India remarkable in the remote sensing activities has started with the launch of **IRS (Indian Remote Sensing Satellite) in year 1988.**
- ✓ India launched variety of satellites such as **ResourceSat, CartoSat, OceanSat**

➢ **Yield Mapping :-**

- ➢ **Yield mapping** refers to the process of collecting georeferenced data on crop yield and characteristics, such as moisture content, while the crop is being harvested.
- ➢ Yield mapping is one of the most widely used precision farming technologies.
- ➢ Yield monitor data contain systematic and random sources of measured yield variation, including (i) more stable yield variability related to climate and soil-landscape features, (ii) variable management-induced yield variability, and (iii) measurement errors associated with the yield mapping process itself .
- ➢ Various methods, using a range of sensors, have been developed for mapping crop yields.
- ➢ **The <u>basic components of a grain yield mapping</u> system include:**

a. **Grain flow sensor** - determines grain volume harvested

b. **Grain moisture sensor** - compensates for grain moisture variability

c. **Clean grain elevator speed sensor** - used by some mapping systems to improve accuracy of grain flow measurements

d. **GPS antenna** - receives satellite signal

e. **Yield monitor display with a GPS receiver** - georeference and record data

f. **Header position sensor** - distinguishes measurements logged during turns

g. **Travel speed sensor** - determines the distance the combine travels during a certain logging interval (Sometimes travel speed is measured with a GPS receiver or a radar or ultrasonic sensor.)

- **Processing of Yield Maps** :-

  - The yield calculated at each field location can be displayed on a map using a Geographic Information System (GIS) software package.
  - **Steps for processing of yield maps**

1. Raw data screening
2. Standardization of data
3. Interpretation of data
4. Classification of multi-year yield maps
5. Statistical evaluation of classification results.

- **Potential Applications of Yield maps/mapping** :-

a) Yield maps represent the output of crop production.
b) On one hand this information can be used to investigate the existence of spatially variable yield limiting factors.
c) On the other hand, the yield history can be used to define spatially variable yield goals that may allow varying inputs according to expected field productivity.
d) Yield maps are one of the most valuable sources of spatial data for precision agriculture.
e) In developing these maps it is essential to identifying the points/locations where get the higher and lower crop yields.

CHAPTER NO. 6. REMOTE SENSING CONCEPTS AND APPLICATION IN AGRICULTURE

- **Remote Sensing :-**It is the collection of information relating to objects without being in physical contact with them.
- **Remote Sensing : -** Is the science of acquiring information about the earth's surface without actually being in contact with it.
- **Remote Sensing :-** is the process of acquiring data/information about objects/substances not in direct contact with the sensor, by gathering its inputs using **electromagnetic radiation** that emanate from the targets of interest.
- **Remote Sensing** is **defined** as the science and technology by which the characteristics of objects of interest can be identified, measured or analyzed the characteristics without direct contact.

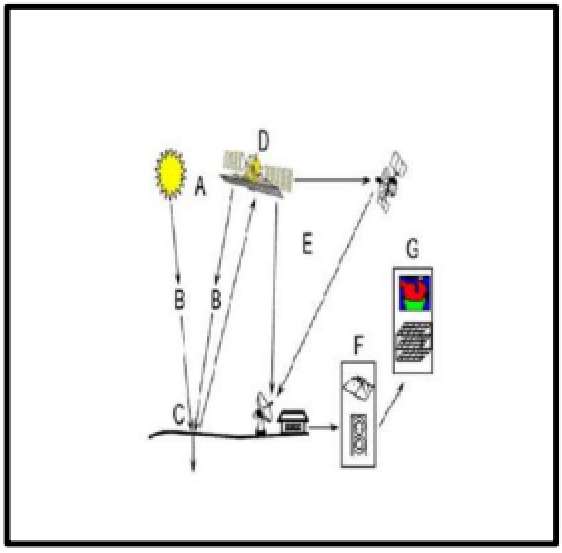
- ✓ A device to detect the electro-magnetic radiation reflected or emitted from an object is called a "**remote sensor**" or "**sensor**".
- ✓ An aerial photograph is a common example of a remotely sensed (by camera and film, or now digital) product.
- ✓ The sun is a source of energy or radiation, which provides a very convenient source of energy for remote sensing.
- ✓ The sun's energy is either **reflected**, as it is for visible wavelengths, or absorbed and then **reemitted**, as it is for thermal infrared wavelengths.
- ✓ Remote sensing techniques play an important role in **crop identification, crop area production estimation, disease and stress detection, soil and water resources.**
- ✓ Remote sensing applications have become very important for making **macroeconomics decisions related to food security, poverty and sustainable development in the country.**
- ✓ **Pisharoth Rama Pisharoty** is considered to be the **father of remote sensing** in India.

➢ REMOTE SENSING : CONCEPTS

i. The most useful electromagnetic radiation in remote sensing includes visible light (VIS), near infra red (NIR) and shortwave infrared (SWIR), to thermal infrared (TIR) and microwave bands.
ii. The path through the atmosphere
iii. The interaction with the object
iv. The recording of the radiation by a sensor

➢ **PRINCIPLES AND PROCESS OF REMOTE SENSING** :-

➢ In much of remote sensing, the process involves an interaction between incident radiation and the targets of interest. This is exemplified by the use of imaging systems where the following seven elements are involved.



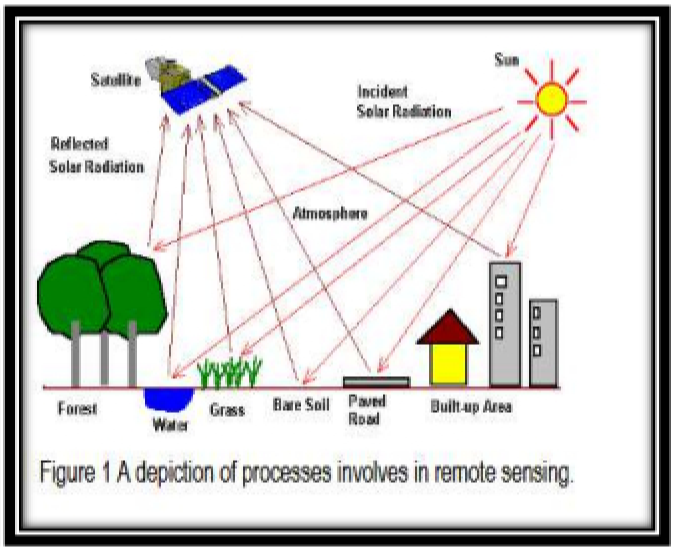


Figure 1 A depiction of processes involves in remote sensing.

i. **Energy Source or Illumination (A) –** the first requirement for remote sensing is to have an energy source which illuminates or provides electromagnetic energy to the target of interest.

ii. **Radiation and the Atmosphere (B) -** As the energy travels from its source to the target, it will come in contact with and interact with the atmosphere it passes through. This interaction may take place a second time as the energy travels from the target to the sensor.

iii. **Interaction with the Target (C) -** Once the energy makes its way to the target through the atmosphere, it interacts with the target depending on the properties of both the target and the radiation.

iv. Recording of Energy by the Sensor (D) - After the energy has been scattered by, or emitted from the target, we require a sensor (remote - not in contact with the target) to collect and record the electromagnetic radiation.

v. Transmission, Reception, and Processing (E) - The energy recorded by the sensor has to be transmitted, often in electronic form, to a receiving and processing station where the data are processed.

vi. Interpretation and Analysis (F) - The processed image is interpreted, visually and/or digitally or electronically, to extract information about the target, which was illuminated.

vii. Application (G) - The final element of the remote sensing process is achieved when we apply the information we have been able to extract from the imagery about the target in order to better understand it, reveal some new information, or assist in solving a particular problem.

- **TYPES OF REMOTE SENSING/SENSORS** :-

- There are **two main types** of remote sensing: **Passive remote sensing and Active remote sensing.**

1. **Passive remote sensors/sensing**
   - ✓ Detect natural radiation that is emitted or reflected by the object or surrounding area being observed.
   - ✓ Reflected sunlight is the most common source of radiation measured by passive sensors.
   - ✓ Examples of passive remote sensors include film photography, infrared, and radiometers.

2. **Active remote sensors/sensing:-**
   - ✓ On the other hand, emits energy in order to scan objects and areas where upon a sensor then detects and measures the radiation that is reflected or backscattered from the target.
   - ✓ RADAR is an example of active remote sensing where the time delay between emission and return is measured, establishing the location, height, speeds and direction of an object.

- **APPLICATIONS OF REMOTE SENSING IN DIFFERENT SECTORS/FIELDS** :-

1. **Meteorology** - Study of atmospheric temperature, pressure, water vapour, and wind velocity.
2. **Agriculture** Monitoring the biomass of land vegetation
3. **Forest-** monitoring the health of crops, mapping soil moisture
4. **Botany**- forecasting crop yields.
5. **Hydrology-** Assessing water resources from snow, rainfall and underground aquifers.
6. **Planning applications -** Mapping ecological zones, monitoring deforestation, monitoring urban land use.
7. **Topography and cartography** - Improving digital elevation models.
8. **Disaster warning and assessment -** Monitoring of floods and landslides, monitoring volcanic activity, assessing damage zones from natural disasters.
9. **Climate**- the effects of climate change on glaciers and Arctic and Antarctic regions

10. **Oceanography**: Measuring sea surface temperature, mapping ocean currents, and wave energy spectra and depth sounding of coastal and ocean depths
11. **Glaciology**- Measuring ice cap volumes, ice stream velocity, and sea ice distribution. **(Glacial)**
12. **Geology**- Identification of rock type, mapping faults and structure.
13. **Geodesy**- Measuring the figure of the Earth and its gravity field.
14. **Oil and mineral exploration-** Locating natural oil seeps and slicks, mapping geological structures, monitoring oil field subsidence.
15. **Military-** developing precise maps for planning, monitoring military infrastructure, monitoring ship and troop movements
16. **Urban**- determining the status of a growing crop
17. **Sea**- Monitoring the extent of flooding
18. **Rock-** Recognizing rock types
19. **Space program**- is the backbone of the space program
20. **Seismology:** as a premonition.

➢ **REMOTE SENSING APPLICATIONS IN AGRICULTURE** :-

1. **Crop production forecasting:** Remote sensing is used to forecast the expected crop production and yield over a given area and determine how much of the crop will be harvested under specific conditions. Researchers can be able to predict the quantity of crop that will be produced in a given farmland over a given period of time.

2. **Assessment of crop damage and crop progress:** In the event of crop damage or crop progress, remote sensing technology can be used to penetrate the farmland and determine exactly how much of a given crop has been damaged and the progress of the remaining crop in the farm.

3. **Horticulture, Cropping Systems Analysis:** Remote sensing technology has also been instrumental in the analysis of various crop planting systems. This technology has mainly been in use in the horticulture industry where flower growth patterns can be analyzed and a prediction made out of the analysis.

4. **Crop Identification:** Remote sensing has also played an important role in crop identification especially in cases where the crop under observation is mysterious or shows some mysterious characteristics. The data from the crop is collected and taken to the labs where various aspects of the crop including the crop culture are studied.

5. Crop acreage estimation: Remote sensing has also played a very important role in the estimation of the farmland on which a crop has been planted. This is usually a cumbersome procedure if it is carried out manually because of the vast sizes of the lands being estimated.

6. Crop condition assessment and stress detection: Remote sensing technology plays an important role in the assessment of the health condition of each crop and the extent to which the crop has withstood stress. This data is then used to determine the quality of the crop.

7. Identification of planting and harvesting dates: Because of the predictive nature of the remote sensing technology, farmers can now use remote sensing to observe a variety of factors including the weather patterns and the soil types to predict the planting and harvesting seasons of each crop.

8. Crop yield modelling and estimation: Remote sensing also allows farmers and experts to predict the expected crop yield from a given farmland by estimating the quality of the crop and the extent of the farmland. This is then used to determine the overall expected yield of the crop.

9. Identification of pests and disease infestation: Remote sensing technology also plays a significant role in the identification of pests in farmland and gives data on the right pests control mechanism to be used to get rid of the pests and diseases on the farm.

10. Soil moisture estimation: Soil moisture can be difficult to measure without the help of remote sensing technology. Remote sensing gives the soil moisture data and helps in determining the quantity of moisture in the soil and hence the type of crop that can be grown in the soil.

11. Irrigation monitoring and management: Remote sensing gives information on the moisture quantity of soils. This information is used to determine whether a particular soil is moisture deficient or not and helps in planning the irrigation needs of the soil.

12. Soil mapping: Soil mapping is one of the most common yet most important uses of remote sensing. Through soil mapping, farmers are able to tell what soils are ideal for which crops and what soil require irrigation and which ones do not. This information helps in precision agriculture.

13. Monitoring of droughts: Remote sensing technology is used to monitor the weather patterns including the drought patterns over a given area. The information can be used to predict the rainfall patterns of an area and also tell the time difference between the current rainfall and the next rainfall which helps to keep track of the drought.

14. **Land cover and land degradation mapping:** Remote sensing has been used by experts to map out the land cover of a given area. Experts can now tell what areas of the land have been degraded and which areas are still intact. This also helps them in implementing measures to curb land degradation.

15. **Identification of problematic soils:** Remote sensing has also played a very important role in the identification of problematic soils that have a problem in sustaining optimum crop yield throughout a planting season.

16. **Crop nutrient deficiency detection:** Remote sensing technology has also helped farmers and other agricultural experts to determine the extent of crop nutrients deficiency and come up with remedies that would increase the nutrients level in crops hence increasing the overall crop yield.

17. **Reflectance modeling:** Remote sensing technology is just about the only technology that can provide data on crop reflectance. Crop reflectance will depend on the amount of moisture in the soil and the nutrients in the crop which may also have a significant impact on the overall crop yield.

18. **Determination of water content of field crops:** Apart from determining the soil moisture content, remote sensing also plays an important role in the estimation of the water content in the field crops.

19. **Crop yield forecasting:** Remote sensing technology can give accurate estimates of the expected crop yield in a planting season using various crop information such as the crop quality, the moisture level in the soil and in the crop and the crop cover of the land. When all of this data is combined it gives almost accurate estimates of the crop yield.

20. **Flood mapping and monitoring:** Using remote sensing technology, farmers and agricultural experts can be able to map out the areas that are likely to be hit by floods and the areas that lack proper drainage. This data can then be used to avert any flood disaster in future.

21. **Collection of past and current weather data:** Remote sensing technology is ideal for collection and storing of past and current weather data which can be used for future decision making and prediction.

22. Crop intensification: Remote sensing can be used for crop intensification that includes collection of important crop data such as the cropping pattern, crop rotation needs and crop diversity over a given soil.

23. Water resources mapping: Remote sensing is instrumental in the mapping of water resources that can be used for agriculture over a given farmland. Through remote sensing, farmers can tell what water resources are available for use over a given land and whether the resources are adequate.

24. Precision farming: Remote sensing has played a very vital role in precision agriculture. Precision agriculture has resulted in the cultivation of healthy crops that guarantees farmers optimum harvests over a given period of time.

25. Climate change monitoring: Remote sensing technology is important in monitoring of climate change and keeping track of the climatic conditions which play an important role in the determination of what crops can be grown where.

26. Compliance monitoring: For the agricultural experts and other farmers, remote sensing is important in keeping track of the farming practices by all farmers and ensuring compliance by all farmers. This helps in ensuring that all farmers follow the correct procedures when planting and when harvesting crops.

27. Soil management practices: Remote sensing technology is important in the determination of soil management practices based on the data collected from the farms.

28. Air moisture estimation: Remote sensing technology is used in the estimation of air moisture which determines the humidity of the area. The level of humidity determines the type of crops to be grown within the area.

29. Crop health analysis: Remote sensing technology plays an important role in the analysis of crop health which determines the overall crop yield.

30. Land mapping: Remote sensing helps in mapping land for use for various purposes such as crop growing and landscaping. The mapping technology used helps in precision agriculture where specific land soils are used for specific purposes.

➢ IMPORTANCE OF REMOTE SENSING IN AGRICULTURAL SURVEY :-

- The specific application of remote sensing techniques can be used for

i) Detection ii) Identification iii) Measurement iv) Monitoring of agricultural phenomena.

- **Area of specific applications :-**
- **a) Applicable to crop survey**

1. Crop identification
2. Crop acreage
3. Crop vigor
4. Crop density
5. Crop maturity
6. Growth rates
7. Yield forecasting
8. Actual yield
9. Soil fertility 10. Effects of fertilizes
11. Soil toxicity
12. Soil moisture
13. Water quality
14. Irrigation requirement
15. Insect infestations
16. Disease infestations
17. Water availability
18. Location of canals

b) Applicable to range survey

1. Delineation of forest types
2. Condition of range
3. Carrying capacity
4. Forage
5. Time of seasonal change
6. Location of water
7. Water quality
8. Soil fertility
9. Soil moisture
10. Insect infestations
11. Wildlife inventory

c) Applicable to livestock survey

1. Cattle population
2. Sheep population
3. Pig population
4. Poultry Population
5. Age sex distribution
6. Distribution of animals
7. Animal behavior
8. Disease identification
9. Types of farm buildings

➢ **ADVANTAGES OF REMOTE SENSING TECHNIQUES IN AGRICULTURAL SURVEY** :-

1. **Vantage point**
   Because the agricultural landscape depends upon the sun as a source of energy, it is exposed to the aerial view and, consequently, is ideally suited or remote sensing techniques.
2. **Coverage**
   With the use of high-altitude sensor platforms, it is now possible to record extensive areas on a single image. The advent of high-flying aircraft and satellites, single high quality images covering thousands of square miles
3. **Permanent record**
   After an image is obtained, it serves as a permanent record of a landscape at a point in time which agriculture changes can be monitored and evaluated.
4. **Mapping Base**
   Certain types of remote sensing imagery are, in essence, pictorial maps of the landscape and after rectification (if needed), allow for precise measurement (such as field acreages) to be made on the imagery, obviating time-consuming on the ground surveys. These images may also aid ground data sampling by serving as a base map for location agriculture features while in the field, and also as a base for the selection of ground sampling point or areas.
5. **Cost savings**
   The costs are relatively small when compared with the benefits, which can be obtained form interpretation of satellite imagery.
6. **Real-time capability**
   The rapidly with which imagery can be obtained and interpreted may help to eliminate the lock of timeliness which plagues, so many agricultural survey.

- **OTHER ADVANTAGES OF REMOTE SENSING**
- Easy data acquisition over inaccessible area.
- Data acquisition at different scales and resolutions
- The images are analyzed in the laboratory, thus reducing the amount of fieldwork.
- Colour composites can be produced from three individual band images, which provide better details of the area then a single band image or aerial photograph.
- Stereo-satellite data may be used for three-dimensional studies.

- **PRESENT SYSTEM OF GENERATING AGRICULTURAL DATA AND ITS PROBLEMS**:-
  - ✓ The present system of agricultural data is collected throughout the nation.
  - ✓ The main responsibility of collection agricultural survey lies on the Director of Land Records, Director of agriculture and District Statistical Office under the Ministry of Agriculture.
  - ✓ These data are collected not only on a local but also some extent of district and state level.
  - ✓ The associate of agricultural survey on crops (crop production, type of crop and crop yield), range land (condition of range, forest type, water quality, types of irrigation system and soil characteristics) and livestock (livestock population, sex of animal, types of farm and distribution of animals).
- The **basic problems in this survey** are :-

i. Reliability of data
ii. Cost and benefits
iii. Timeless
iv. Incomplete sample frame and sample size
v. Methods of selection
vi. Measurement of area
vii. Non sampling errors
viii. Gap in geographical coverage
ix. Non availability of statistics at disaggregated level.

Chapter No. 8. Global Positioning System (GPS), Components and its functions

- **Meaning of Positioning System** :-
- **Positioning System: -** A position information system enables the user to determine absolute or relative location of a feature on or above the earth's surface.

- ✓ Position data is reported in geo referenced format.
- ✓ Latitude-longitude State plane UTM (Universal Transverse Mercators).
- ✓ Position Information System Requirements
- ✓ Provide position data with acceptable degree of accuracy.
- ✓ Must be available on demand at any time.
- ✓ Must be available at any location.
- ✓ Must be able to interface with other equipment.

- **Types of Position Information Systems :-**

a) There are **six main types of position information systems**, which are as follows
b) Dead Reckoning
c) Laser Systems
d) Global Navigation Satellite System (GNSS)
e) Global Positioning System (GPS) - US
f) GLONASS (Globalnaya Navigatsionnaya Sputnikovaya Sistema)- Russia
g) Galileo - Europe

- **Global Positioning System (GPS)-**

- **GPS: -** Automatic computer based device used for Space and land based information system to determine precise position data.

- **GPS: -** The Global Positioning System (GPS) is a space-based satellite navigation system that provides location and time information in all weather conditions.

- **GPS: -** is a satellite navigation system used to determine the ground position of an object.

- **GPS: -** It is a global navigation satellite system (GNSS) that provides geolocation and time information to a GPS receiver anywhere on or near the Earth where there is an unobstructed line of sight to four or more GPS satellites.

- **GPS :-** is a satellite-based navigation system, consisting of more than 20 satellites and several supporting ground facilities, which provides accurate, three dimensional position, velocity and time, 24 hours a day, everywhere in the world and in all weather conditions.

- The GPS project was started by the **U.S. Department of Defense** in 1973.

- In the late 1980s a new technology, the Global Positioning System (GPS) became a valuable tool in spatial data acquisition.

- The global positioning system (GPS) makes possible to record the in-field variability as geographically data.

- It is possible to determine and record the correct position continuously.

❖ **GPS (Global Positioning System) : Concept**

✓ GPS is a satellite based navigation system that can be used to locate positions anywhere on earth.

✓ GPS designed and operated by the U.S. Department of Defense, it consists of satellites, control and monitor stations and receivers.

- **Components of GPS system** :-

1) GPS Antenna
2) GPS Receivers
3) GPS Display and Storage
4) Interface
5) DGPS
6) GPS Ground Control Stations
7) GPS Satellites

- **Functions of GPS components** :-

a) **GPS Antenna:** Antennae come in many shapes and sizes and its basic function is to receive the GPS Signal. Position data is interpreted based on antenna location.

b) **GPS Receivers:** Receiver is used for collection of geographical data of specific area. In differential GPS signal is corrected as data is acquired, requires an additional satellite or second receiver. Basic function of GPS receiver is to decode the signal retrieved by the antenna.

c) **GPS Display and Storage:** Records and reports are displayed and stored by GPS display and storage components. GPS data is available to the user numerically and graphically. Data can be integrated with the receiver or provided by handheld or laptop, computer.

d) **Interface:** Proprietary protocol is unique to receiver manufacturer. Standardized protocol allows data exchange between many devices or interfacing with other devices. For example NMEA 0183 ASCII code, Consists of Data Sentences.

e) **DGPS: -** is essentially a system to provide positional corrections to GPS signals.

f) **GPS Ground Control Stations/Control Segment: -** uses measurements collected by the monitor stations to predict the behavior of each satellites orbit and atomic clocks. Prediction data is linked up to the satellites for transmission to users.

g) **GPS Satellites/Space segment :-** The space segment includes the satellites and the rockets that launch the satellites from Cape Canaveral in Florida, U.S. Satellite are orientate the points of solar panels towards the sun and antennas towards the earth. Each satellite contains four atomic clocks.

- **Type of GPS receivers for Agriculture** :-

Sr. No.	**Configuration**	**Accuracy**
1	GPS	10 meters
2	DGPS Beacon	1 meter (within range)
	WAAS	2 to 5 meters
	Satellite Subscription	1 meter
3	Dual Frequency GPS	2 to 4 inches
4	RTK GPS	1 to 2 inches

- **FUNCTIONS OF GPS** :-
  - The **GPS functions includes** :

1. **Giving a location :-**

- ✓ This is the whole point of a navigation system.
- ✓ Its ability to accurately triangulate your position based on the data transmissions from multiple satellites.
- ✓ It will give your location in coordinates, either latitude and longitude or UTMs (Universal Transverse Mercators)
- ✓ Developed by the military, UTMs are used to pinpoint a location on a map.
- ✓ Most topographical maps have UTM gridlines printed on them.

2. Point –to-point Navigation:-

- ✓ This GPS navigation feature allows you to add waypoints to your trips.
- ✓ By using a map, the co-ordinates of a road or the point where you are standing, you can create a point to point route to the place where you are headed.

3. Plot Navigation:-

- ✓ This feature in a GPS allows you to combine multiple waypoints and move point to point.
- ✓ Once you reach the first waypoint, the GPS can automatically point you on your way to the next one.

4. Keeping track of your track:-

- ✓ Tracks are some of the most useful functions of Portable Navigation Systems.
- ✓ You can map where you have already been.
- ✓ This virtual map is called a track and you can programme the GPS system to automatically drop track-points as you travel, either over intervals of time or distance.

- **APPLICATIONS OF GPS** :-
  - The **GPS applications includes :**

A) Guidance :-

i. **Point guidance:-**Target point selected on map screen. Cursor location indicates present position, target position highlighted. Cursor provides guidance to target.

ii. **Swath guidance: -** Anchor points established to create base line on map screen. Parallel lines generated at desired swath spacing which can be used for straight or contour swaths. Light bar or similar device used to provide guidance along line. Automatic steering possible.

B. Control:-

i. Variable rate application
ii. Variable tillage depth
iii. Variable irrigation

C. Mapping:-

i. Soil properties
ii. Chemical application
iii. Chemical prescriptions
iv. Tillage maps
v. Yield mapping
vi. Pest mapping
vii. Topographic maps
viii. Planting maps

- **Field Mapping:** Position data (georeference data) recorded at predetermined intervals. Other data recorded manually or automatically by monitor, computer, or data logger. Data displayed by geographic information system (GIS) in thematic map format.
- **Soil Sampling:** Georeferenced soil samples can be collected by grid sampling or direct sampling methods. GPS used to locate sample points. Areas of interest intensely sampled, others lightly sampled.
- **Yield Maps:** Record of spatial yield variability within a field or farm.GPS data coupled with yield data to produce map. On field two types of yield data available i.e. mechanically harvested or Hand harvested. Yield maps are very useful tool for decision making.
- **Field Scouting:** Fields can be scouted for a variety of pests. Pest populations recorded on maps. Decision tools can be applied on a site specific basis.

- **Need for Global Positioning System (GPS)** :-

- ✓ Global positioning system has revolutionized positioning concept, though it started primarily as a navigation system.
- ✓ Today, the Global Positioning System (GPS) has become an international utility.
- ✓ In addition to its ease of use and worldwide all-weather operation, GPS owes its popularity to the dependable high accuracy with which position, time and direction can be determined.
- ✓ As a tool of precision Agriculture, Global Positioning System satellites broadcast signals that allow GPS receivers to calculate their position.
- ✓ This information is provided in real time, meaning that continuous position information is provided while in motion.
- ✓ Having precise location information at anytime allows crop, soil and water measurements to be mapped.
- ✓ GPS receivers, either carry to the field or mounted on implements allow users to return to specific locations to sample or treat those areas.

- **Role of GPS in Precision Agriculture** :-

i. Precision Agriculture is doing the right thing, at the right place, at the right time.

ii. Knowing the right thing to do may involve all kinds of high tech equipment's and other analysis.

iii. Doing the right thing however starts with good managers and good operators doing a good job of using common tools such as planters, fertilizer applicators, harvesters and whatever else might be needed.

iv. In this context, GPS becomes part and parcel of precision agriculture.

v. For analysis and processing of remote Sensed images requires ground truth information, collected in the field, at a variety of sites and often at various times throughout the crop production season.

vi. For image analysis the ground data must be digitized in order to create a mask for training the software to recognize different conditions and classify the remote sensing imagery.

- **Future prospects of precision agriculture and GPS in India:**

a) Advances in GIS, GPS and Remote Sensing technologies are changing the way we will look at precision farming.

b) The success of precision farming will be measured by the type of information that is provided to the farmer, how quickly the farmers were convinced.

c) Competition for the farmers business should help in making the success a reality.

d) The study on precision agriculture has been initiated in many research institutions.

e) For Instance Space Application Center (ISRO), Ahmedabad has started experiment in the Central Potato Research Station farm at Jalandhar, Punjab to study the role of remote sensing, GIS and GPS in mapping the variability.

f) M.S. Swaminathan foundation, Chennai, in collaboration with NABARD, has adopted a village in Dindugal district of Tamilnadu for variable rate input application.

g) Directorate for Cropping Systems Research (PDCSR), Modipuram, and Meerut (UP) has initiated a project on precision agriculture in collaboration with Central Institute of Agriculture Engineering (CIAE), Bhopal.