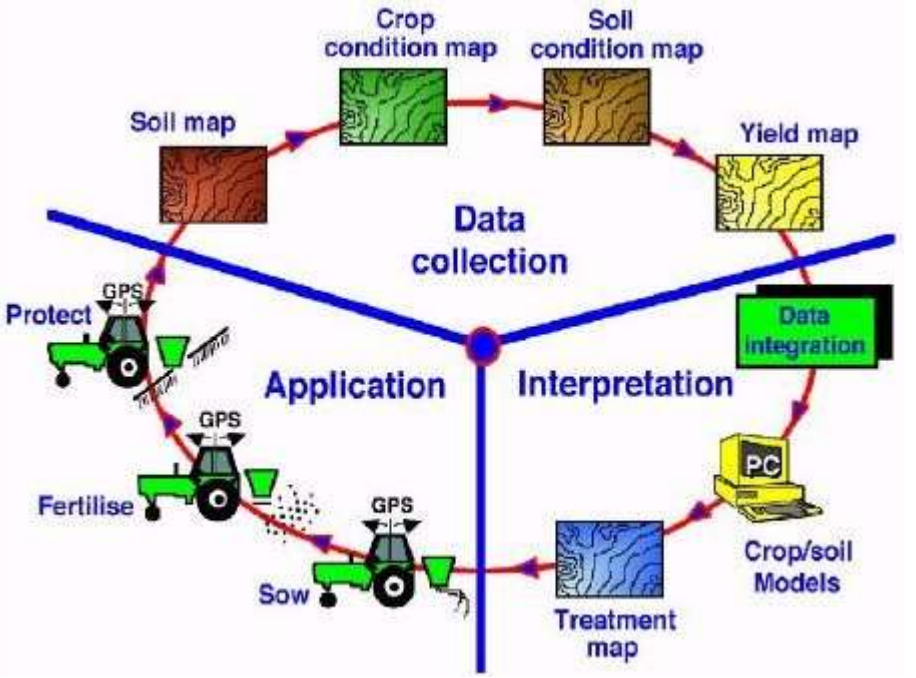
COMPONENTS OF PRECISION FARMING

Precision farming should not be thought of as only yield mapping and variable rate fertilizer application and evaluated on only one or the other. Precision farming technologies will affect the entire production function (and by extension, the management function) of the farm. A brief overview of the components in precision farming is presented in Figure 1 and listed below.



Yield monitoring

Instantaneous yield monitors are currently available from several manufacturers for all recent models of combines. They provide a crop yield by time or distance (e.g. every second or every few metres). They also track other data such as distance and bushels per load, number of loads and fields.

Yield mapping

GPS receivers coupled with yield monitors provide spatial coordinates for the yield monitor data. This can be made into yield maps of each field.

Variable rate fertilizer

Variable rate controllers are available for granular, liquid and gaseous fertilizer materials. Variable rates can either be manually controlled by the driver or automatically controlled by an on board computer with an electronic prescription map.

Weed mapping

A farmer can map weeds while combining, seeding, spraying or field scouting by using a keypad or buttons hooked up to a GPS receiver and datalogger. These occurrences can then be mapped out on a computer and compared to yield maps, fertilizer maps and spray maps.

Variable spraying

By knowing weed locations from weed mapping spot control can be implemented. Controllers are available to electronically turn booms on and off, and alter the amount (and blend) of herbicide applied.

Topography and boundaries

Using high precision DGPS a very accurate topographic map can be made of any field. This is useful when interpreting yield maps and weed maps as well as planning for grassed waterways and field divisions. Field boundaries, roads, yards, tree stands and wetlands can all be accurately mapped to aid in farm planning.

Salinity mapping

GPS can be coupled to a salinity meter sled which is towed behind an ATV (or pickup) across fields affected by salinity. Salinity mapping is valuable in interpreting yield maps and weed maps as well as tracking the change in salinity over time.

Guidance systems

Several manufacturers are currently producing guidance systems using high precision DGPS that can accurately position a moving vehicle within a foot or less. These guidance systems may replace conventional equipment markers for spraying or seeding and may be a valuable field scouting tool.

Records and analyses

Precision farming may produce an explosion in the amount of records available for farm management. Electronic sensors can collect a lot of data in a short period of time. Lots of disk space is needed to store all the data as well as the map graphics resulting from the data. Electronic controllers can also be designed to provide signals that are recorded electronically. It may be useful to record the fertilizer rates actually put down by the application equipment, not just what should have been put down according to a prescription map. A lot of new data is generated every year (yields, weeds, etc). Farmers will want to keep track of the yearly data to study trends in fertility, yields, salinity and numerous other parameters. This means a large database is needed with the capability to archive, and retrieve, data for future analyses.

GROUND BASED SENSORS

What are sensors?

A sensor is a gadget that perceives and responds to certain inputs which could be illumination, locomotion, pressure, heat, or moisture, and transforms it into a representation or signals that can be read by humans for further reading and processing.

They are commonly used in various applications, from detecting motion in security systems to measuring temperature in HVAC systems. They are also used in everyday objects like smartphones, cars, and appliances.

Sensors work by detecting physical or chemical changes in the environment and converting them into electrical signals. The type of sensor used depends on the type of change being detected.

For example, a temperature sensor detects changes in temperature and converts them into electrical signals that can be interpreted by the device it is connected to.

What are the types of sensors used in agriculture?

There are various types of sensors used in agriculture that enable the need for smart agriculture incorporation.

1. Optical Sensors in Agriculture

This is the use of light to evaluate soil materials and track countless light prevalence. These sensors can be positioned on automobiles, satellites, drones, or robots thereby enabling the soil to reflect and the gathering and processing of plant color data.

Optical sensors also have the ability and capacity to condition the clay, natural matter, and humidity properties of the soil.

2. Electrochemical Sensors for Soil Nutrient Detection

The electrochemical sensors aid in the collection, processing, and mapping of the chemical data of the soil. They are usually mounted on specially designed sleds.

They supply accurate details required for agriculture. This includes the nutrient of the soil levels and pH. The soil samples are then sent out to a soil testing lab and standard procedures are carried out.

Error-free measurements especially in the area of determining pH are carried out with the use of an ion-selective electrode. These electrodes notice the pursuit of specified ions, such as hydrogen, nitrate, and potassium.

3. Mechanical Soil Sensors for Agriculture

These types of sensors are used to measure soil compression or mechanical opposition. This sensor uses an application that passes through the soil. This sensor then records the force calculated by pressure scales or load cells.

When a sensor passes through the soil, it documents the holding forces that result from the cutting, smashing, and displacing of soil. Soil mechanical resistance is recorded in a unit of pressure and points out the ratio of the force necessary to go into the soil channel to the frontal area of the tool engaged with the soil.

4. Dielectric Soil Moisture Sensors

This sensor calculates the moisture levels in the soil with the assistance of a dielectric constant. This is an electrical property that substitutes depending on the moisture content in the soil.

The moisture sensors are used in association with precipitation check locations all around the farm. This allows for the scrutiny of soil moisture positioning when vegetation level is low.

5. Location Sensors In Agriculture

They are also known as agricultural weather stations. They are positioned at different places throughout the fields. These precision agriculture sensors are used to determine the variety, distance, and height of any position within the required area. They take the help of GPS satellites for this purpose.

6. Electronic Sensors

They are installed on tractors and other field equipment to check equipment operations. Data are transmitted via cellular and satellite communication systems to computers or mailed to individuals directly. The supervisor in charge can now have access to the information either on their office computer or their personal cell phones.

7. Airflow Sensors

Its measurements can be made at particular locations while on the move. These types of sensors measure soil air penetration. The expected result is the pressure needed to push a decided amount of air into the ground at a prescribed depth. There are various soil properties, including moisture levels, soil type compaction, and structure, which produce a different identifying signature.

8. Agriculture Sensors IoT

With the increase in adoption of the Internet of Things (IoT) the ability to connect various devices have being implemented in virtually every aspect of our life. It only makes great sense that automation also finds its own application in agriculture as it will have a great impact on it.

This sensor provides real-time information on what is happening on the field such information including air temperature, soil temperature at various depths, rainfall, leaf wetness, chlorophyll, wind speed, dew point temperature, wind direction, relative humidity, solar radiation, and atmospheric pressure.

This indicates that farmers are in the know-how of when their crops are due for harvest, the quantity of water being used, the soil health, and if there's a need for any additional input. This is measured and recorded at scheduled intervals.

There is a big list of sensors used in agriculture IOT sensors which means (Solutions for Smart Farming). Making use of precision agriculture sensors will definitely transform the agricultural industry by increasing crop production, adopting a pest-free high yield variety in crops, and keeping up with the increasing demand for food.

Different Forms of Sensors in Agriculture

Although many different types of intelligent farming sensors exist, IoT sensors for agriculture are the most prevalent and widely used.

Farm aspects	**Categories of sensors**
Soil	Soil moisture, soil temperature
Canopy	Leaf wetness
Microclimate	Air humidity, lux meter, wind speed, and direction.

Categories of Farm Sensors

Types of sensors used in agriculture

A. **Soil sensors**

1. Soil moisture sensors

- A soil moisture sensor is a tool **used for measuring the exact moisture amount in the soil near plant root zones.**
- The data collected by these sensors is useful information for precise irrigation practices.
- The soil moisture sensors allow for much more efficient scheduling of water supply and distribution.
- For the best plant growth, such sensors aid in reducing or increasing irrigation.
- The soil moisture sensors can be divided into **primary and secondary sensors.**
- The role of these sensors is to give soil moisture readings at primary and secondary root zones.

Soil moisture sensor

2. Soil temperature sensors

- Soil temperature sensors are used for measuring the real-time temperature of the soil. These temperature readings help predict any possible soil-borne disease infections.
- In agricultural assessment and research, soil temperature sensors are frequently used.
- The soil temperature sensor can operate for an extended period of time in humid conditions with a quick response.

- It has a high measurement accuracy and consistency, allowing it to simultaneously monitor the temperature of the soil, atmosphere, and water in real-time, giving the overall temperature of the soil.

B. Canopy sensors

1. Leaf wetness sensors

- The Leaf Wetness sensor is an innovative and user-friendly tool that makes it possible to detect leaf wetness accurately and affordably.
- Many bacterial and fungal diseases only harm plants when there is moisture on the leaf surface.
- The Sensor detects dampness on the surface of a leaf, allowing researchers and growers to foresee disease & pests and preserve plant canopies.

Leaf wetness sensor

C. Micro-climate sensors

1. Air humidity sensors

- Light, water, soil, and air are the four elements that crops need to survive.
- The impact of water, however, is the most crucial factor in growing healthy crops.
- The amount of water the air can store at any particular temperature is measured by relative humidity.
- Humidity Sensors assist in predicting disease and pest attacks that might attack the farm at a specific relative humidity. This dramatically enhances farmers' efforts and lower expenses.

2. ***Windspeed and direction sensors***

- Wind speed and direction sensors monitor the wind during farming activities like spraying.
- In general, an anemometer is the best tool for measuring wind speed, whereas vane sensors assist in measuring wind direction.
- Farming activities considering the wind speed and direction measurements can draw better outcomes because the wind can impact many factors in the farm.
- The magnitude of the wind speed will influence seed transmission distance and pollination efficiency, which will impact plant reproduction and fruit set.
- In addition to having a positive effect on the environment of farmlands, wind also negatively affects agricultural output by spreading pathogens, causing widespread plant diseases,

assisting pests in migrating, and also by causing crops to fall and trees to break, as well as the phenomenon of falling flowers and fruits.

Wind speed, wind direction sensor

3. ***Rainfall sensors or Rain sensors***

- Rainfall sensors can help with plant health maintenance and water conservation by avoiding the need for frequent irrigation.
- Farmers can schedule their farming activities based on the information provided by the rainfall sensors, which detect the quantity of rainfall that has happened.
- They can decide when to irrigate their crops at the ideal time using rainfall sensors.

- Rainfall sensors can measure the quantity of rainfall that has happened.

4. ***Lux sensor***

- Crop cultivation is a delicate balancing act. To keep plants healthy and in bloom, the ideal sun, water, and soil conditions must be met.
- An instrument known as a lux meter is used to measure brightness, more precisely, the intensity needed for crops.

- Some diseases and pests attack at a specific intensity of sunlight. Farmers are informed whether there is a chance of a disease or pest attack on their farm based on the measurement of solar light intensity provided by lux sensors.

5. ***Temperature sensors***

- The three factors that affect plant growth the most are light, temperature, and moisture.
- By using temperature sensors, farmers can easily keep an eye on the temperature at the plant canopy level, thus reducing the risk of disease and pest infestation for their crops.

Several benefits are achieved from an automated method of capturing, storing and analyzing physical field records. Detailed analyses of the farm production management activities and results can be carried out. Farmers can look at the performance of new varieties by site specific area, measure the effect of different seeding dates or depths and show to their banker the actual yields obtained and the associated risk levels. It is imperative that trends and evaluations are also measured over longer time spans. Cropping strategies to control salinity may take several years to evaluate while herbicide control of an annual weed should only take one season. Precision farming can be approached in stages, in order to ease into a more complex level of management.

Precision farming allows for improved economic analyses. The variability of crop yield in a field allows for the accurate assessment of risk. For example, a farmer could verify that for 70 % of the time, 75 % of the barley grown in field "A" will yield 50 bushels. By knowing the cost of inputs, farmers can also calculate return over cash costs for each acre. Certain parts of the field which always produce below the break even line can then be isolated for the development of a site-specific management plan. Precision farming allows the precise tracking and tuning of production.

Precision farming makes farm planning both easier and more complex. There is much more map data to utilize in determining long term cropping plans, erosion controls, salinity controls and assessment of tillage systems. But as the amount of data grows, more work is needed to interpret the data and this increases the risk of misinterpretation. Farmers implementing precision farming will likely work closer with several professionals in the agricultural, GPS and computing sciences.