Precision Farming

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- **Traditional Farming-Here the various crop treatments, such as irrigation, application of fertilisers, pesticides and herbicides were evenly applied to the entire field, ignoring any variability within the field.**
- **Precision Farming - or Precision Agriculture has been defined as an information and technology-based agricultural management system to identify, analyze, and manage site-soil spatial and temporal variability within fields for optimum profitability, sustainability, and protection of the environment**

Issues relating to Precision Farming

Technologies needed

- Accurate GPS system
- Variable rate technology
- Site-specific management services

Economics

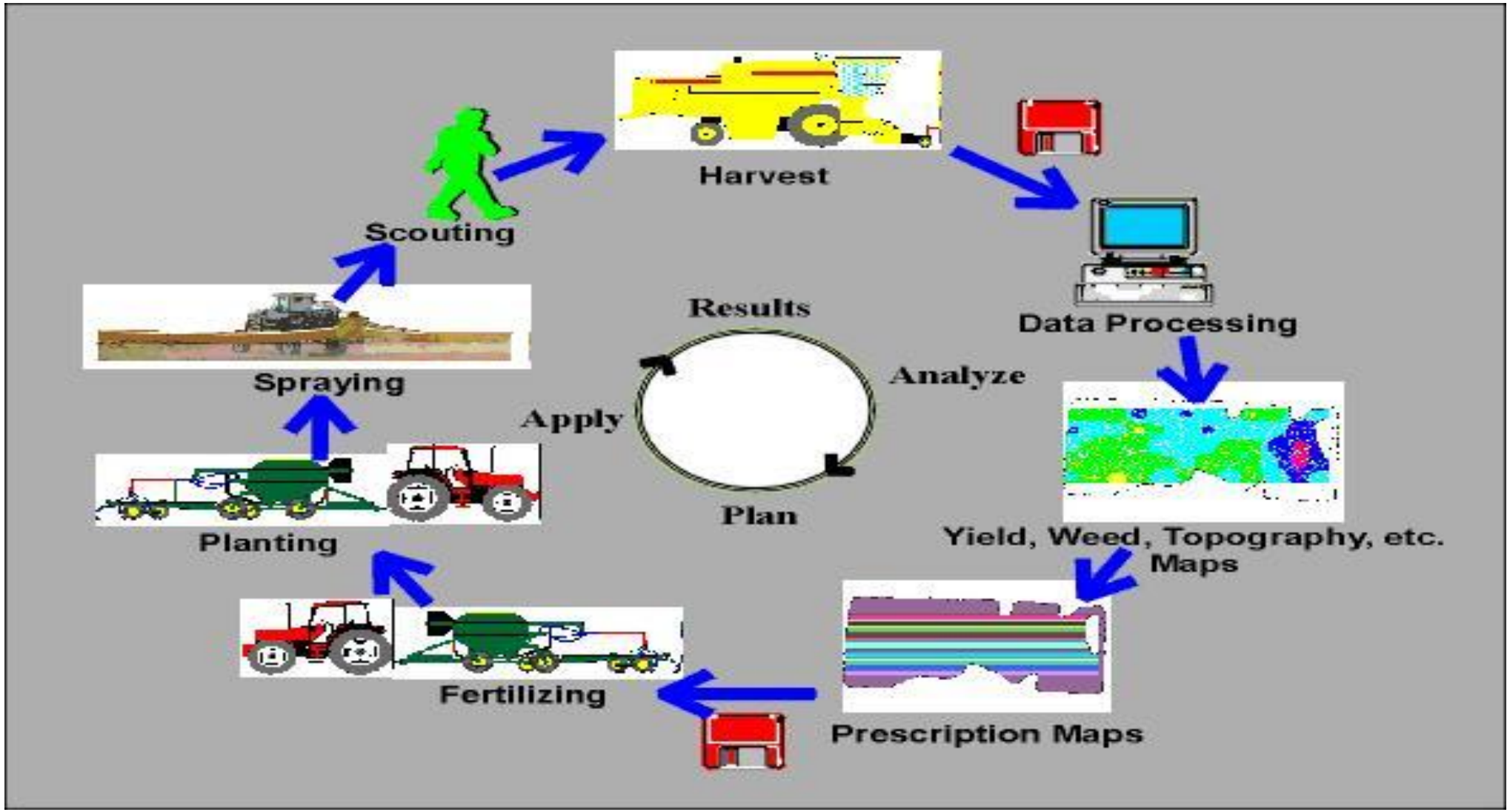
- Initial investments
- Changes in costs
- Changes in revenues
- Cash flow
- Risk

Management

- Data acquisition and analysis
- Decision support systems
- Increased attention to management

Environmental

- Reduce input losses and Increase water and nutrient use efficiency



Pricision farming cycle

Need for Precision Agriculture

- **Economical and environmental benefits through reduced use of water, fertilizers, herbicides and pesticides besides the farm equipments**
- **Precision farming approach recognizes site-specific differences within fields**
- **Fields have variable yields across the landscape**
- **Variations can be traced to management practices, soil properties environmental characteristics.**
- **Soil characteristics that affect yields include texture, structure, moisture, organic matter, nutrients landscape posit**ion.

Need for Precision Agriculture (contd)

- Environmental characteristics include weather, weeds, insects and diseases.
- Management challenge is to optimally manage the areas in the field that have different production capacities.
- Precision agriculture offers potential to automate and simplify the collection and analysis of information
- Allows management decisions to be made and quickly implemented on small areas within larger fields.

Precision Farming Technologies

- The major components of technology used for PF management practices are:
- Geographical Information Systems (GIS),
- Global Positioning Systems (GPS),
- Sensors,
- Variable rate technology (VRT)
- Yield monitoring (YM).
- Spatial Decision Support Systems (SDSS)
- Crop Simulation Models (CSMs)

Near –future high resolution satellites

Mission / Agency	Major specifications
SPOT – 5 CNES, France	PAN (Resolution: 3m, 5m, Swath: 120 km) MSS (Resolution: 10, 20 m, Swath: 120 km) VEGETATION payload (Resolution: 1 km, Swath:2200km)
ORBVIEW -3, Orbital Science Inc., U.S.A	PAN (Resolution: 1m, 2m, Swath: 8 km) MSS (Resolution : 4m, Swath: 36km)
QUICK BIRD, Earthwatch Inc, U.S.A	PAN (Resolution : 1m, 2m, Swath: 36km) MSS (Resolution: 4 m, Swath: 36km)
RESOURCESAT – 1ISRO, India	LISS-IV (Resolution: 6m, Swath: 25km) LISS-III (Resolution: 23m, Swath 140 km) AWiFS (Resolution: 60m, Swath 740km)
CARTOSAT – 1ISRO, India	PAN Stereo (Resolution: 2.5m, Swath: 30km)
CARTOSAT – 2ISRO, India	Panchromatic (Resolution: 1m, Swath: 12km)

Geographic information systems(GIS):

- (GIS) includes computer hardware and software that use feature attributes and location data to produce maps
- An agricultural GIS can store layers of information such as yields, soil survey maps, remotely sensed data crop scouting reports and soil nutrient levels
- Geographically referenced data can be displayed in the GIS, adding a visual perspective for interpretation data storage and display
- Can be used to evaluate and present an alternative management by combining and manipulating data layers to produce an analysis of management scenarios

Global Positioning System(GPS) receivers :

- Global Positioning System satellites broadcast signals that allow GPS receivers to compute their location.
- This information is provided in real time meaning that continuous position/location information is provided while in motion.
- Having precise location information at anytime 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.
- To be useful in agriculture, the corrected position accuracy is typically 63-10 feet.

Differential Global Positioning System (DGPS)

- GPS that utilizes a reference signal to gain more accurate positional data is a differential global positioning system (DGPS)
- DGPS receivers with positional accuracy within 3 to 5 feet are adequate for tracking field positions and are the types of receivers on most agricultural tractors and harvesters.
- Receivers are mounted on the top of the cab or on some high point to get a clear view of the sky.
- More accurate survey grade *DGPS* systems can improve accuracy to within an inch, at a cost increase.
- These highly accurate and more expensive *DGPS* units have been used to develop field topographical maps
- The primary need for a system like *GPS* is the ability to return to a particular location, again and again.
- By obtaining a soil sample, which indicates a fertilizer need, it is essential that the fertilizer spreader place the fertilizer in the proper location and in the right amount.

Spatial Decision Support Systems (SDSS)

- **Designed to help growers to solve complex spatial problems and to make decision concerning irrigation scheduling, fertilization, use of crop growth regulators and other chemicals.**
- **Spatial decision support systems have evolved in parallel with decision support systems (DSS)**

In addition to decision making on complex spatial problems SDSS also :

- **Provide for spatial data input**
- **Allow storage of complex structures common in spatial data**
- **Include analytical techniques that are unique to spatial analysis**
- **Provide output in the form of maps and other spatial forms**

Crop Simulation Models (CSMs)

- **Displays variation in crop yields across a field and provides the best management practice for each part of a field in order to achieve these goals**
- **The need for fertiliser application in areas of varying yield levels can be found out by conventional field experiments which are time consuming and labour intensive**
- **Crop simulation models to predict the likely yield response to different levels of a particular input.**
- **Such models offer a cost effective way in which agronomic knowledge accumulated from numerous previous experiments**

Sensors

- Sensors are being developed to determine crop stress, soil properties, pest incidence etc.
- Sensors can be used to measure soil and crop properties as the tractor passes over the field, as a scout goes over the field on foot, or as an airplane or satellite photographs the field from the sky.
- Measurement of plant and soil properties as the tractor or combine travels over the field is a developing area in precision farming.
- Currently, yield monitors are the primary sensing system that make measurements "on-the-go." Commercial sensing systems are available that claim to measure soil properties and make application rate changes "on the-go."
- Other types of "on-the-go" sensors currently undergoing research and development with some commercial applications are designed to detect weeds, nitrogen levels in plants, and soil properties

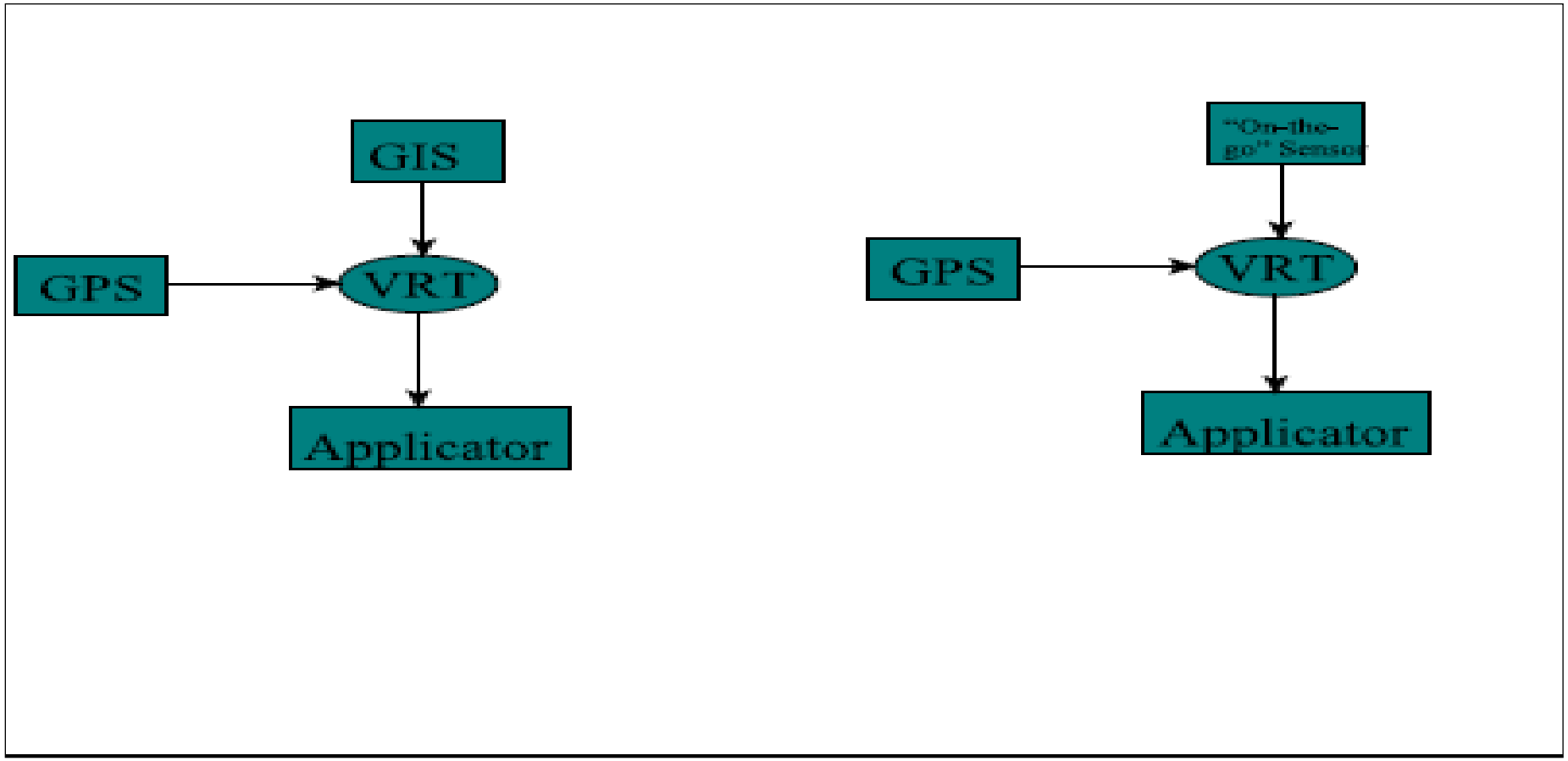
Sensors (Contd)

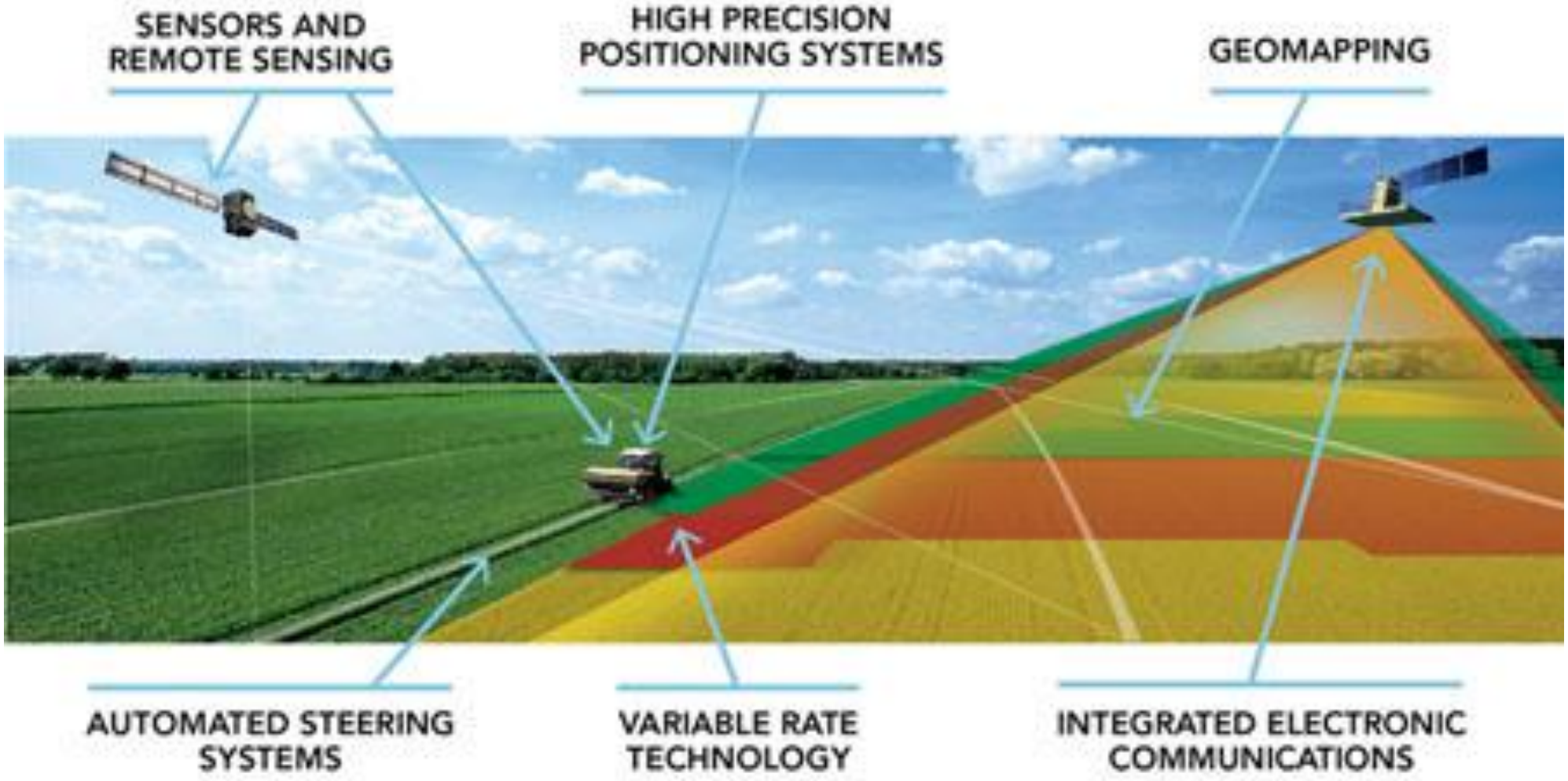
- There are also sensors that can be carried by a scout to the field and used to spot check the health of plants and soil properties.
- They use light reflectance on the leaf to determine chlorophyl levels.
- It has been shown that nitrogen levels in the plant are directly proportional to the chlorophyl production.
- Several soil chemistry kits are also available to measure soil pH, nitrogen, potassium and phosphorus in the field without waiting for soil sample results.
- *Remote sensors* are generally categorized as aerial or satellite sensors that can provide instant maps of field characteristics.
- An aerial photograph is an optical sensor that can show variations in field color
- that correspond to changes in soil type, crop development, field boundaries, roads, water, etc.
- Both aerial and satellite imagery can be processed to provide vegetative indices that also reflect plant health.

Variable Rate Technology

- Variable rate technology (VRT) includes computer controllers and associated hardware to vary the output of fertilizer, lime, and pesticides.
- Controllers are manufactured by several companies and can generally take an application map, along with the *GPS* to locate your field position, and control hardware that varies the application rate.
- One example of variable rate technology is in the application of fertilizers. Variable rate fertilizer application is used as an example because it can be associated with soil sampling,
- The *GPS* tells the operator where on the field the tractor is located.
- The *GPS* links with the *GIS* to tell the controller what the field characteristics are at that location.
- The pre-determined yield goals will then dictate the precise amount of fertilizer to be applied at that spot.
- The controller then manipulates the machinery to apply the correct amount of fertilizer.

Variable rate system using combination of GPS, and GIS.





GIS tools mounted on vehicle

Yield monitoring and Mapping

- Yield Monitoring is the most direct method to assess the field production and how it should be managed.
- Yield monitor measures the crop as it is harvested.
- As the yield is measured, data are stored on a computer along with the *GPS* coordinates at the point where the yield was measured.
- Mapping software can then create a yield map
- The yield map can immediately provide two important pieces of information, yield variability, and yield production
- Yield variability is illustrated on a map by a change in color, where each color represents a range in yield
- Lack of yield variability would mean that the map shows mostly one color.
- Yield production can be found by calculating the yield for the entire field.
- Specific monitors are required for each crop
- Commercially available yield monitors have been introduced for cotton

Profit mapping:

- A profit map can be created using records of field inputs and records of crop yield and sales.
- The profit map is used to determine the areas of the field which are making or losing money for each point where yield was measured in the field,

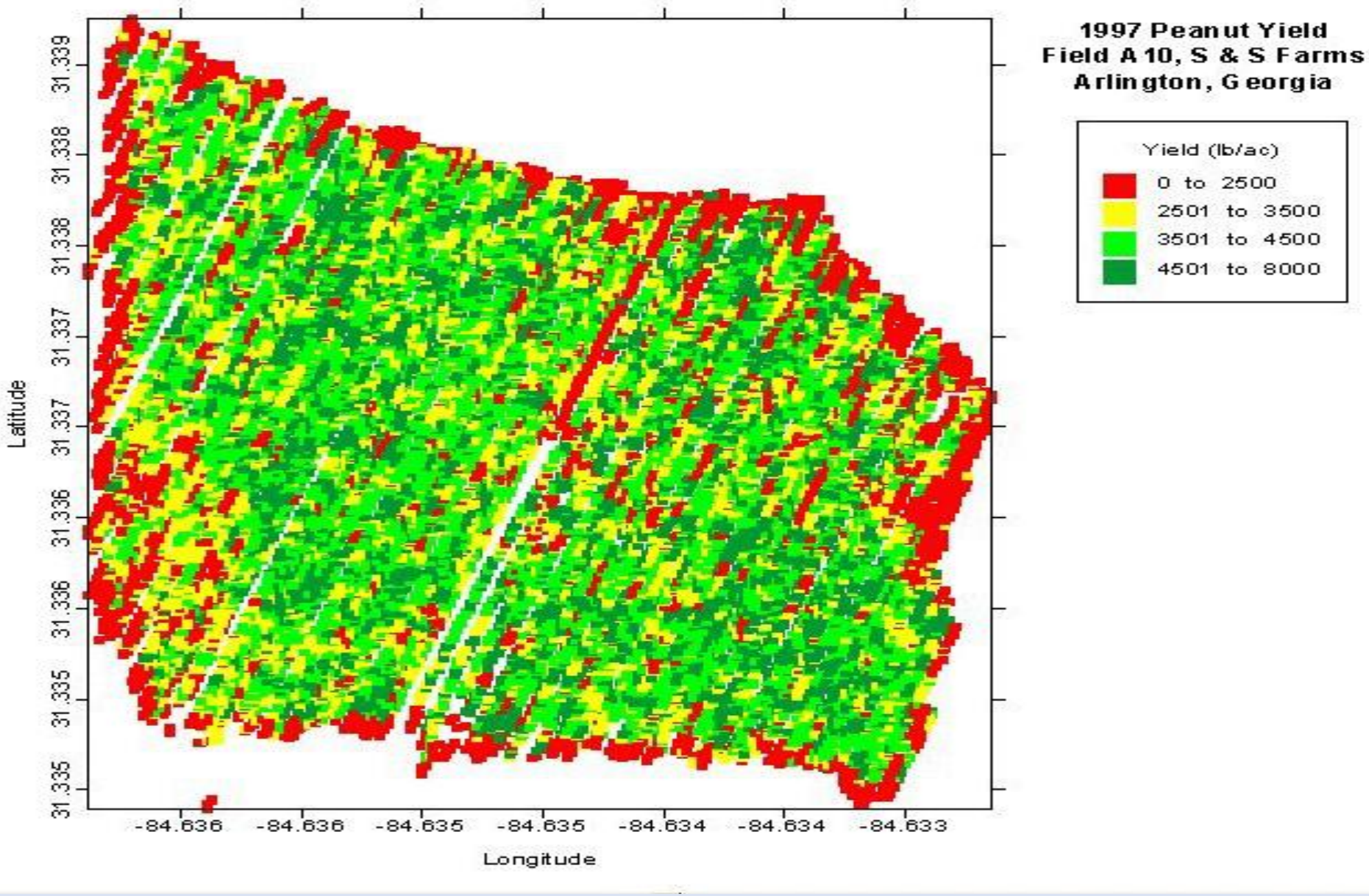
Identifying a precision agriculture service provider

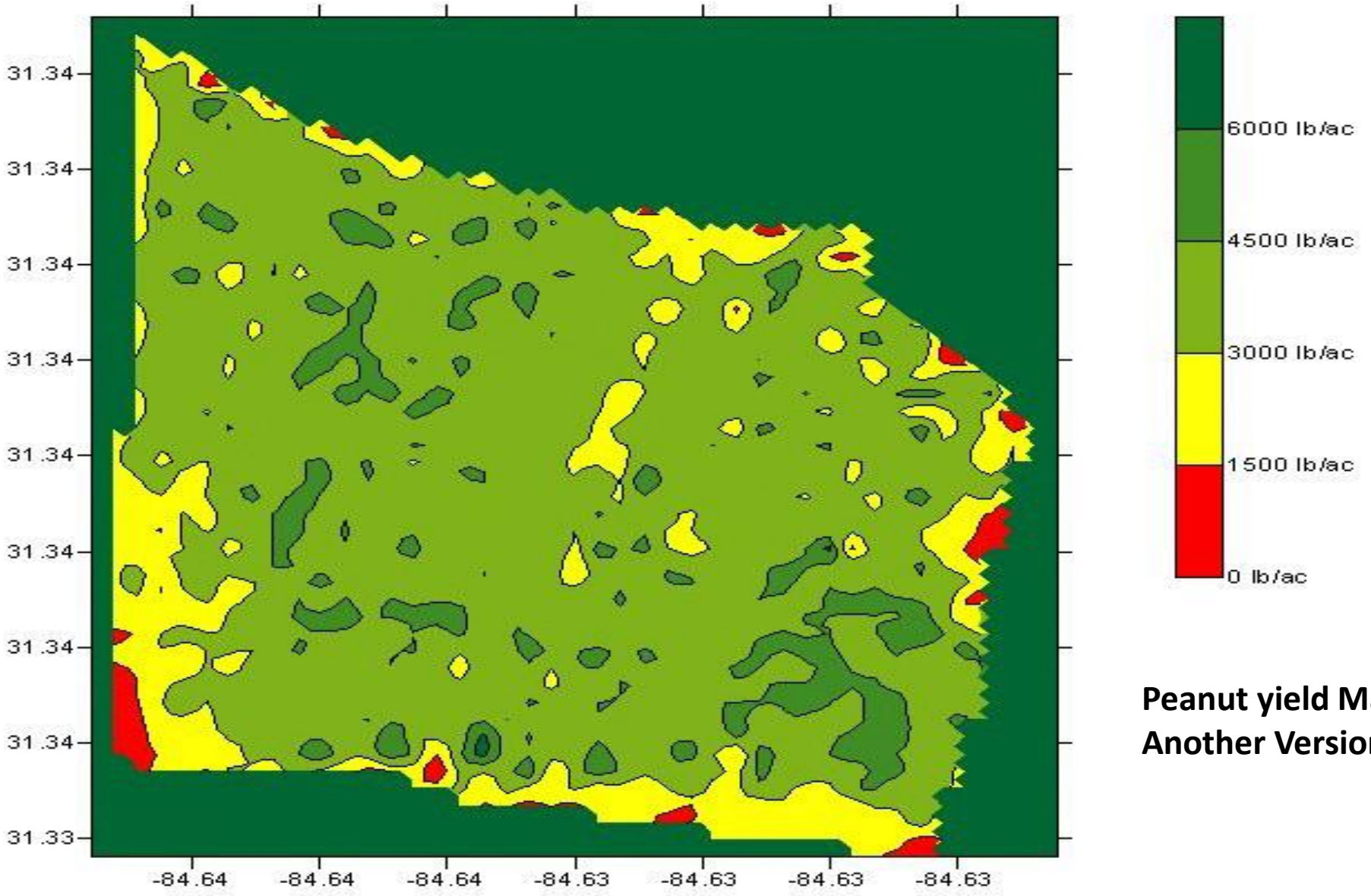
- It is also advisable for farmers to consider the availability of custom services when making decisions about adopting site-specific crop management.
- Agricultural service providers or properly trained extension workers may offer a variety of precision agriculture services to farmers

Prospects of Precision Farming in Indian Agricultural Situation

Precision farming, though in many cases a proven technology is still mostly restricted to developed (American and European) countries. The reasons for limited implementation of PF in Asian countries are following:

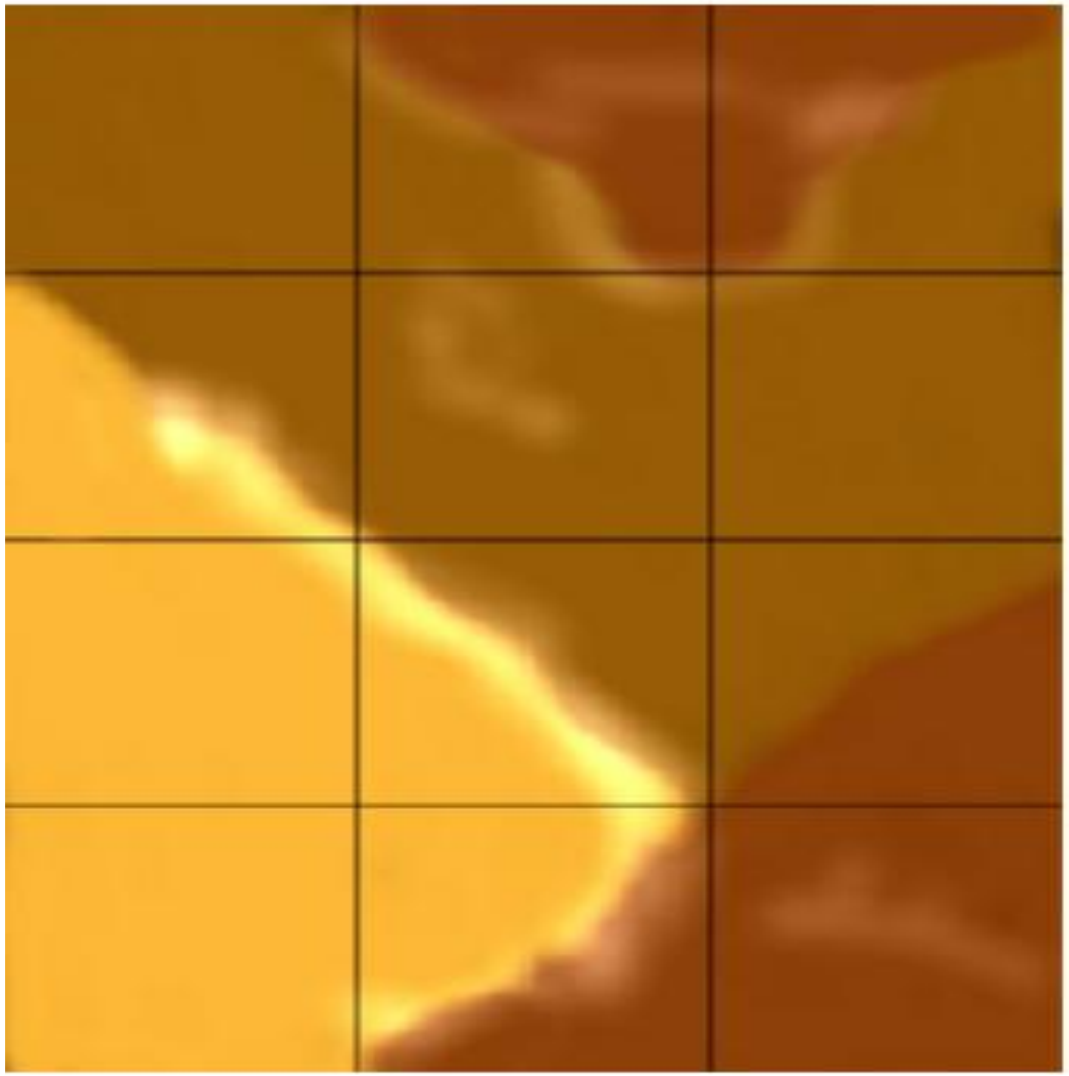
- **Small land holding**
- **Cost / benefit aspect of PF system**
- **Heterogeneity of cropping systems**
- **Lack of local technical expertise**
- **Knowledge and technological gaps**


1997 Peanut Yield
Field A10, S & S Farms
Arlington, Georgia
Yield (lb/ac)
0 to 2500
2501 to 3500
3501 to 4500
4501 to 8000
Latitude
31.339
31.338
31.338
31.337
31.337
31.336
31.336
31.335
31.335
-84.636
-84.636
-84.635
-84.635
-84.634
-84.634
-84.633
Longitude



Peanut yield Map
Another Version

Sample grids for collection of soil samples



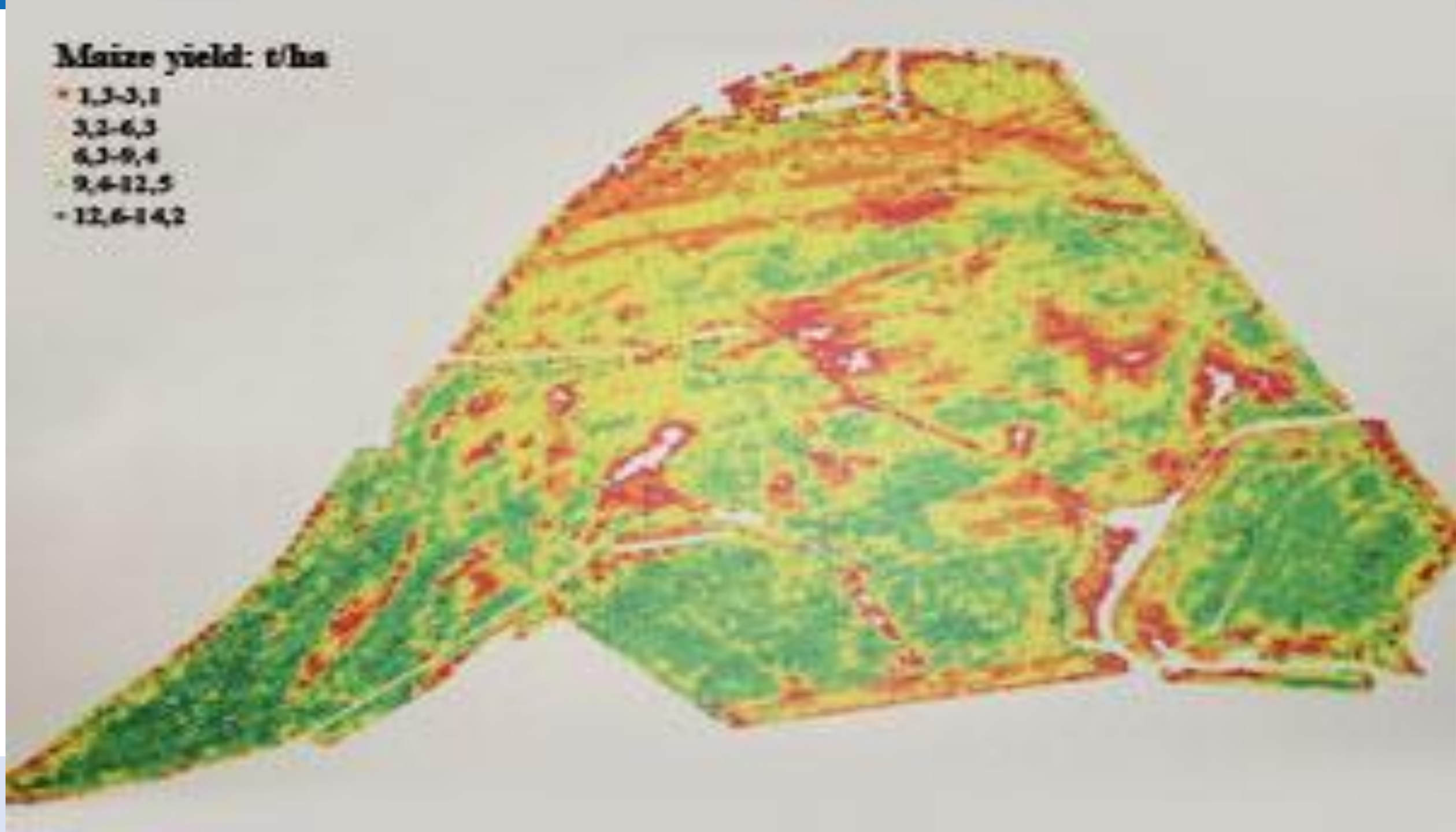
Management zones for collection of soil samples

Soil Sampling in precision Farming

- Soil sampling for precision farming separates the field into smaller segments called grids
- square grids of about 1 to 2.5 acres.
- In grid-sampling method, each grid point/area is sampled in several locations, mixed, and sent into the lab for analysis. Once these samples are analyzed, the nutrients, lime, etc necessary in each particular grid are calculated.
- Soil samples can be collected based on management zones grouped by similar soil types and field conditions identified by the farmer using the aerial photographs, soil surveys or other resources.
- This method is winning favor over grid sampling.

Yield mapping is the first step to determine the precise locations of the highest and lowest yield areas of the field, and to analyze the factors causing yield variation.

- **One way to determine yields map, is to take samples from the land in a 100m x 100m grid pattern to test for nutrient levels, acidity and other factors**
- **The results can then be combined with the yield map (sample as shown) to see if application levels need to be adjusted for more effective yet more economical placement that produces higher crop yields**
- **Map**
- **yield mapping of maize in Durgapur to assess yield variation – case study**
- **Spatial variability in organic carbon and grain yield of IARI Farm**


Maize yield: t/ha
1,3-3,1
3,2-6,3
6,3-9,4
9,4-12,5
12,6-14,2

Spatial variability in organic carbon and grain yield of IARI Farm

- **Methodology used**
- **As against the conventional system an alternate to conventional laboratory soil analysis, hyper spectral remote sensing which is non-destructive, cost effective and capable of spatial prediction for surface soil characterization.**
- **Hyper spectral image data or imaging spectrometry technique provides near-laboratory-quality reflectance information, has the capability to obtain non-visible information over a spatial view in large scales.**

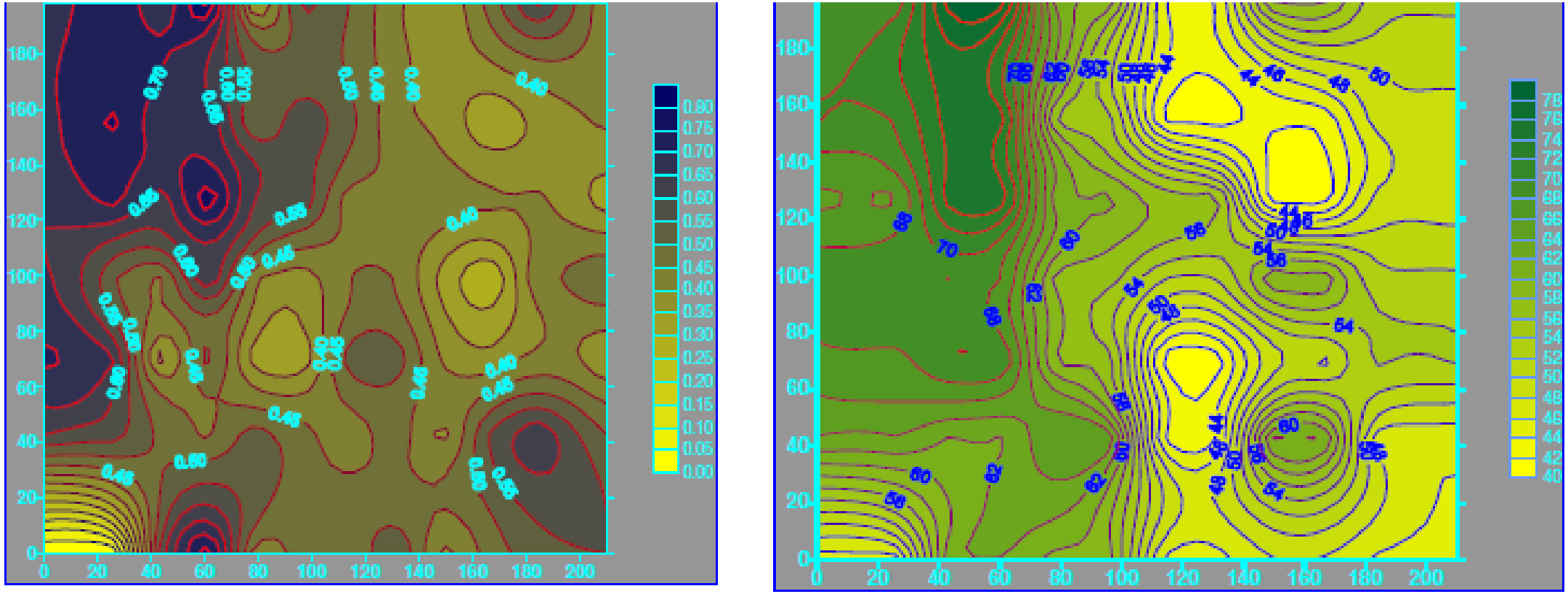


Fig. 1. Spatial variability map of (a) Soil organic carbon and (b) grain yield in (q ha^{-1}) of wheat crop in 4.16ha land in IARI farm.

Case study on soils of Punjab

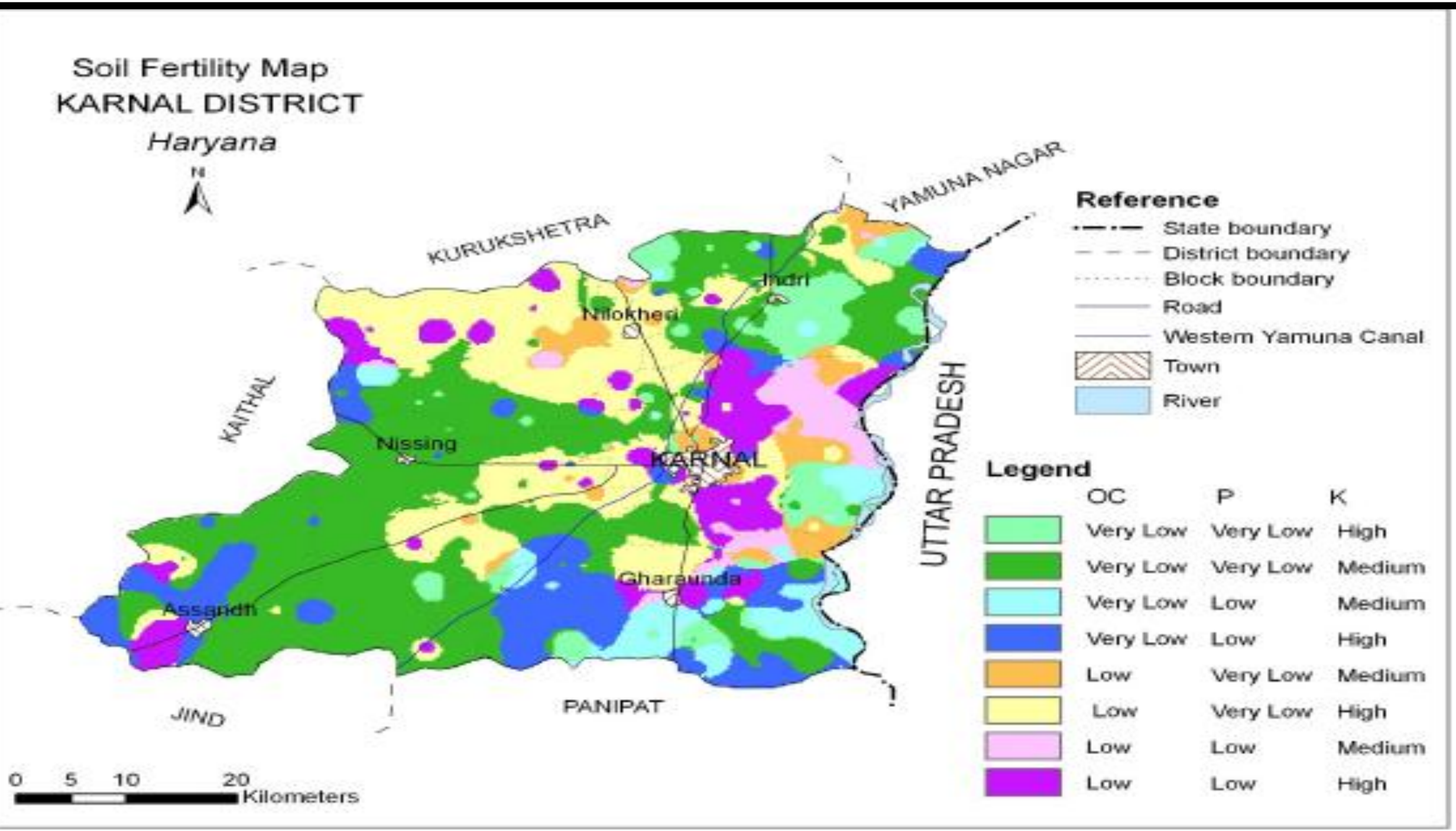
- **A study was carried out for quantitative assessment of 17 physico-chemical parameters such as texture, moisture, colour, organic matter, soil reaction, available N, P and K, exchangeable Ca, Mg, Fe, Mn, Cu and Zn, Calcium carbonate and oxide contents**
- **Hyper spectral remote sensing techniques using both ground based and space based platforms and soil hydraulic properties**
- **Prediction equations were developed for their retrieval from data of ground based sensor spectro radiometer and space based hyper spectral sensor *i.e* hyperion. The highest predictability (adjusted R2) was 0.93 recorded for CaCO3 while lowest 0.68 was for N.**

Site specific nutrient management in Karnal district of Punjab

- **Fertility map was generated by Over laying the generated surface maps of available Phosphorus, potassium and organic carbon.**
- **Based on homogeneity different ranges of P, K and OC, 13 composite fertility units were generated (Fig. 2).**
- **Recommended dose of N: P: K were worked out using QUEFTS model for a targeted yield of rice (6.5 t/ha), wheat (6 t/ha) and maize (6.5 t/ha) crops**
- **The Leaf area Index (LAI) Chlorophyll (Cab) and equivalent water thickness (Cw) of wheat crop in the Gangetic Plain was studied using radiative transfer model (PROSAIL) approach and freely available MODIS data products**
- **LAI has direct relationship with biomass and yield of the crop, Cab is mainly governed by nutrient (mainly nitrogen) which indicates indirectly N stress and Cw, reflects water status in the canopy and thereby water stress.**

The composite indicator considering all these three parameters may provide information about the vegetation health there by the index is named vegetation health index (VHI) which can be used to prioritize zones at regional scale yield enhancing site specific interventions

- **Based on Vegetation Growth Index, (VHI) the wheat areas have been divided into**
- **Very poor growth conditions 0-0.25**
- **Poor growth, 0.25- 0.5**
- **Good 0.5 to 0.75**
- **Very good conditions above 0.75**


Soil Fertility Map
KARNAL DISTRICT
Haryana
N
KURUKSHETRA
YAMUNA NAGAR
UTTAR PRADESH
KAITHAL
JIND
PANIPAT
Indri
Nilokheri
Nissing
KARNAL
Gharaunda
Assandh
Reference
State boundary
District boundary
Block boundary
Road
Western Yamuna Canal
Town
River
Legend
OC P K
Very Low Very Low High
Very Low Very Low Medium
Very Low Low Medium
Very Low Low High
Low Very Low Medium
Low Very Low High
Low Low Medium
Low Low High
0 5 10 20
Kilometers

HIGH-TECH TOOLS FOR SITE-SPECIFIC CROP NUTRIENT MANAGEMENT

Photo Credit: Dealer PROGRESS Magazine

Variable rate fertilizer application can improve efficiency.

Grid sampling guided by GPS gives more accurate soil test data.

Variable rate seeding, variety changes and starter can adjust for soil properties and productivity.

Crop scouting with new technology improves field records.

On-the-go yield monitors can quickly track variability in the field.

PAST YEARS' YIELDS

SOIL TEST (K)

SOIL TEST (P)

SOIL MAP


Thank You