SEMINAR REPORT

By

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(2018-11-074)

Geospatial technologies and its application in agriculture

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DEPARTMENT OF AGRONOMY

COLLEGE OF HORTICULTURE

KERALA AGRICULTURAL UNIVERSITY

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CERTIFICATE

This is to certify that the seminar report entitled**"Geospatial technologies and its application in agriculture"** has been solely prepared By Somanatham Suhas (2018-11-074) under my guidance and has not been copied from seminar reports of any seniors, juniors or fellow students.

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DECLARATION

I, Somanatham Suhas (2018-11-074) declare that the seminar entitled**"Geospatial technologies and its application in agriculture"**has been prepared by me, after going through various references cited at the end and has not been copied from any of my fellow students.

Vellanikkara   Somanatham Suhas
24/01/2020   (2018-11-074)

CERTIFICATE

This is to certify that the seminar report entitled **"Geospatial technologies and its application in agriculture"**is a record of seminar presented by Somanatham Suhas(2018-11-065) on 16st January, 2020 and is submitted for the partial requirement of the course AGRON.591.

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1. Introduction

Food Security in India is best described in million person years of jobs and livelihoods rather than in million tonnes of food grainsDr. M.S. Swaminathan (2001). Food security is only met when all people at all-time have economic access to safe and nutritious food to meet dietary needs for healthy life. To attain food security new technologies must be introduced in precision farming and sustainable agriculture.

Geospatial technology is an information technology field of practise that acquires, manages, interprets, integrates, displays, analyses, or otherwise uses data focusing on the geographic, temporal, and spatial context. In simple terms it is described as Technology relating to the collection or processing of data that is associated with location. It known as geomatics.

The term geospatial technology (GST) refers to geographical information systems (GIS), global positioning systems (GPS), and remote sensing (RS), all emerging technologies that assist the user in the collection, analysis, and interpretation of spatial data. It deals with the relationship and condition of manmade and natural objects within space.

The major sectors using geospatial technology in India are agriculture, telecommunications, oil and gas, environmental management, forestry, public safety, infrastructure and logistics.

In India where agriculture is the prime enterprise, agricultural productivity has become almost stagnant due to unscientific management practices. Precision farming is a scientific approach where inputs are utilised in precise amounts to get increased sustainable yields compared to traditional cultivation techniques.

Geospatial technology tools are used in site specific nutrient management, land use suitability classification, soil fertility mapping, monitoring of drought, forecasting of pests and diseases and crop yield monitoring and estimation, for application in precision agriculture.

1.1 Role of geospatial technology in agriculture

- The application of new and contemporary information, geospatial and communication technologies (ICTs) for rural and agricultural development in the Asia-Pacific region has been advancing quite rapidly over the last decade.
- Geospatial technology is used mostly for surveying and mapping of plantation crops. Mapping of rice is the major activity in countries like Malaysia and Indonesia.
- Australia is among the major users of geospatial technologies, whereas technologies like remote sensing and GIS are most widely used for mapping of crops like sugarcane and oil palms.
- At the micro level implementation of geospatial tools is mainly used for mapping of ground water resources, drainage patterns, variable rate application and management of fertilizers, pesticides and insecticides.
- Geospatial technologies play an influential role in the agriculture sector by increasing yields, managing of resources, prediction of outcomes and improving farm practices.

2. Components of geospatial technology

1. GIS
2. GPS
3. Remote sensing

2.1 Geographic Information System (GIS)

- A GIS is a computer system capable of capturing, storing, analysing, and displaying geographically referenced information; that is, data identified according to location.
- A GIS makes it possible to link, or integrate, information that is difficult to associate through any other means.
- It can use combinations of mapped variables to build and analyse new variables.
- GIS is most useful when used to perform data analysis

2.2Applications of GIS in agriculture

- Farm accounting
- Monitoring the condition of fields and crops
- Agro-technological planning

- Constructing of soil fertility base maps
- Developing a database of equipment’s
- Remote monitoring of equipment’s

GIS tools provide the “big picture” about the resources under your care and assist you in developing long-term supply strategies, forecasting silvicultural stock, determining harvesting system options, etc.

2.3 Global Positioning System(GPS)

- GPS is composed of a constellation of orbiting satellites which in conjunction with ground equipment enable users to determine their exact position anywhere on the surface of the earth at any time.
- GPS and remote sensing imagery are primary GIS data sources.

2.4 Applications of GPS in agriculture

- Field preparation, planting and Cultivation
- Fertilizing and Crop Protection
- Mapping, Scouting, and Sampling
- Harvesting
- Planning and Analysis

2.5 Remote sensing

It is the measurement or acquisition of information of some property of an object or phenomena by a recording device that is not in physical or intimate contact with the object or phenomena under study. Remote sensing has been found to be a valuable tool in evaluation, monitoring and management of land, water and crop resources

2.6Applications of remote sensing in agriculture

- Crop yield estimation
- Crop acreage estimation
- Identification of planting and harvesting dates

- Identification of pest and disease infestation
- Stress detection
- Crop condition assessment

3. Research applications of Geospatial Technology

3.1. Determination of agricultural land use suitability

A study was conducted by Akinci*et al* in 2013 to determine suitable lands for agricultural use in the Yusufeli district of Artvin city (Turkey), where the current agricultural land in the district centre and three villages will be completely inundated while the land in 22 villages will be partially inundated due to three large dams currently being constructed. The Analytic Hierarchy Process (AHP) method, commonly used in land use suitabilityanalysis, was utilized in the study.

In application, the parameters of great soil group, land use capability class, land use capability sub-class, soil depth, slope, aspect, elevation, erosion degree and other soil properties were used. In determining the weights of the parameters, experts' opinions were consulted, and the agricultural land suitability map generated was divided into 5 categories according to the land suitability classification of the United Nations Food and Agriculture Organization (FAO).

After deducting the forests, pastures and reservoir areas from the reclassified suitability map, it was estimated that 0.08% of the study area (177.87 ha) was highly suitable for agricultural production, while 1.55% (3578.33 ha) was moderately suitable and 6.3% (14575.91 ha) was marginally suitable for agricultural production. In addition, it was found that the proportion of land that was currently unsuitable for agricultural production was 2.24% (5183.63 ha), while the amount of land that is permanently unsuitable was 3.42% (7923.39 ha).

It was also determined that the following facts were all effective factors in reaching these results: a substantial portion (approximately 85%) of the study area was covered with forests and pastures, the soil depth was inadequate for agricultural production, the slope in the study area was quite high and, accordingly, the erosion degree was high.

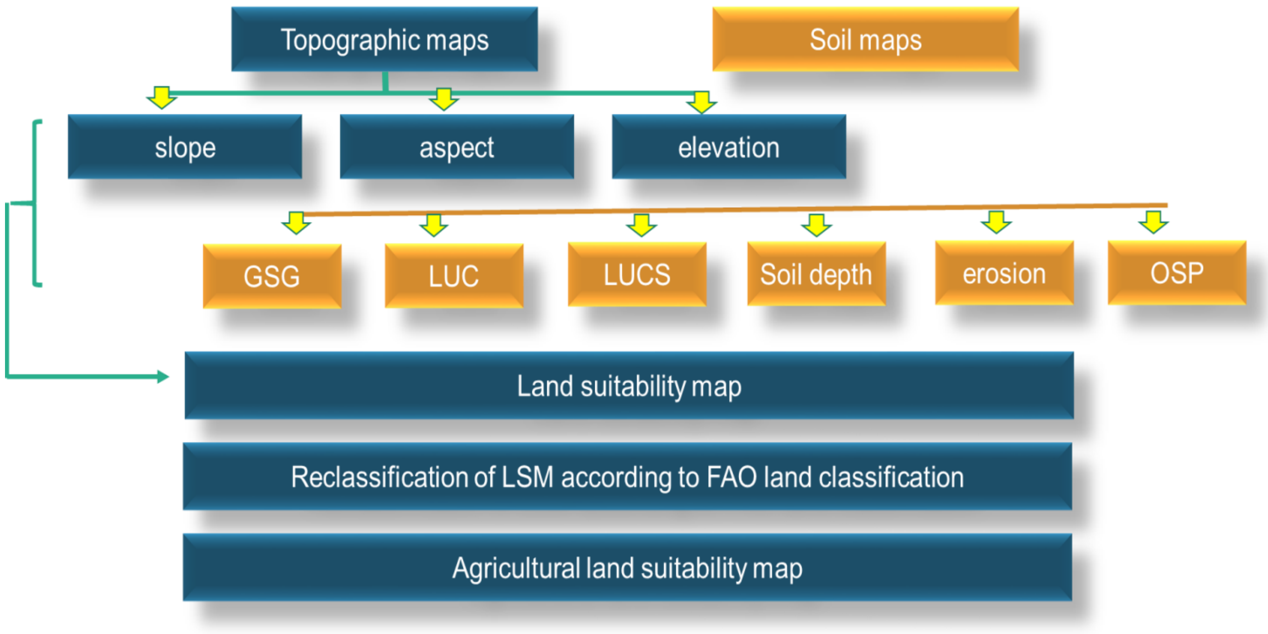


Plate 1: Procedure followed in generating agricultural land use suitability map

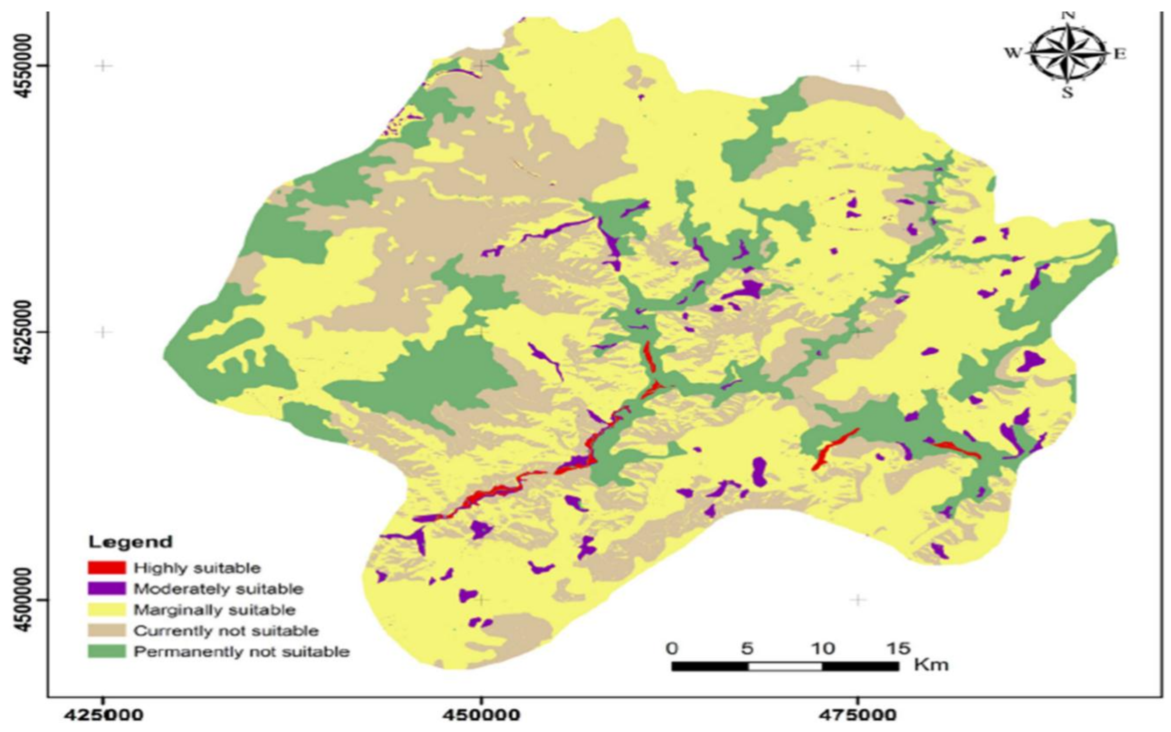


Figure 1: Agriculture suitability map

3.2. Soil fertility estimation

A comprehensive knowledge of the basic soil resources is of fundamental importance for efficient land use planning. The Indian subcontinent possesses widely divergent spectra of changing physiography, climate and vegetation and their combined influence, accentuated by the action of water and wind on the weathering of different types of parent materials, has obviously resulted in soils showing appreciable variations in morphological, physical, chemical and biological characteristics. Thus the soil representing a continuum of diversified genetic processes and being one of the biggest natural heritages of mankind deserves greater consideration than merely as an inert medium for plant growth.

Optimum return on the investment and minimum environmental pollution are the major issues to be addressed while advocating soil test based nutrient recommendations. Fertilizers being the costliest inputs, the scientific approaches towards profitable agriculture would imply the use of plant nutrients according to the actual needs of the soil-crop situations. There is scope to apply the fertilizer as per recommendations superimposing them over the soil fertility maps.

A study was conducted by K.N Singh in 2010to estimate the soil fertility status.Approximately 8% villages from Hoshangabad district were selected using stratified multistage random sampling. From each selected village six farmers were selected for collecting soil samples from their fields. The location of each field was recorded using GPS. The collected samples were analysed for major soil nutrients viz. N, P and K and various soil properties like OC, pH and electrical conductivity (EC) in the institute central laboratory.

Spatial analysis (Kriging) was carried out using sample data in ArcInfo (University Lab Kit).Estimated response surface in case of nitrogen below clearly showed that most of the area in Hoshangabad district was low in Nitrogen (i.e. < 280 kg/ha). To interlinked recommendations, we converted krigged raster surfaces to ACESS database with complete geospatial information. Oncea database was ready, a web interface was designed to access desired information from the database which has been interlinked with the recommendations for optimum use of fertilizer.

Now farmer need to provide only his field geographical location (latitude and longitude) to web interface, and this will suggest him about the soil properties of his field. Moreover, he will also be suggested about the dose of fertilizer application for any desired yield target of any selected crop.

	N (kg/ha)	P (kg/ha)	K(kg/ha)	OC (%)	EC (dS/m)	pH
Mean (actual)	161.75	17.18	433.45	0.60	203.90	7.53
Mean (estimated)	154.68	17.72	429.72	0.57	197.10	7.60

Table 1: Actual and estimated values of soil chemical parameters

3.3. Monitoring drought

Droughts are considered to be one of the major natural hazards causing destructive impact on the environment as well as the economy of countries throughout the world. Drought being attributed to weather conditions cannot be monitored by weather data alone, strictly because these data are most likely to be ill-timed, infrequent and incomplete. Low rainfall has mainly caused droughts and subsequently reduction in agricultural production. Impacts of droughts constitute environmental destruction, economic damage human suffering and loss of lives.

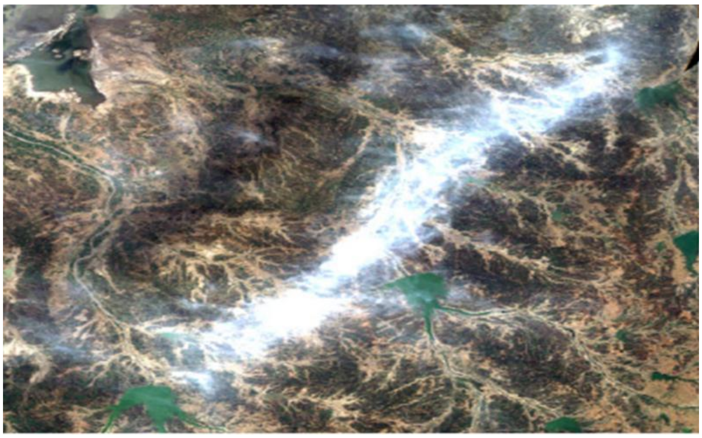
Droughts have been a recurring feature of the Indian climate therefore study of historical droughts may help in the delineation of major areas facing drought risk and thereby management plans can be formulated by the government authorities to cope with the disastrous effects of this hazard.

In recent years, Remote Sensing (RS) and Geographic Information System (GIS) have played a remarkable role in assessment of various types of hazards either natural or man-made. Study conducted by Himanshu*et al*in 2015emphasized the use of RS and GIS in the field of drought risk evaluation. The study area taken was a part of the Jamnagar district of Gujrat. The study was conducted with satellite images of year 1977, 1990 and 1999.

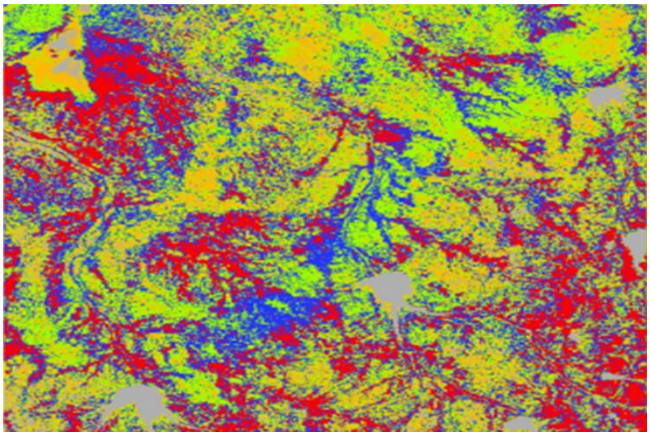
Data used for drought monitoring has been acquired from the following two sources, NDVI obtained from satellite sources and rainfall obtained from ground rainfall stations record. They also attempted to identify and extract drought risk areas encountering agricultural and meteorological drought by using the Normalized Difference Vegetation Index (NDVI) obtained from the LANDSAT images.

The NDVI images generated from LANDSAT data were used to examine large scale drought patterns and their climatic impact on vegetation. NDVI values reflect the different geographical conditions quite well. The NDVI and rainfall was found to be highly correlated. It is therefore concluded that temporal variations of NDVI are convincingly associated with precipitation.

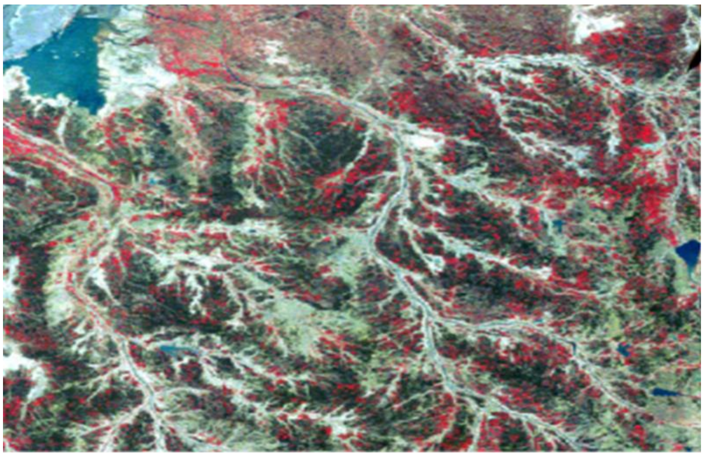
Satellite image (02/11/1990)



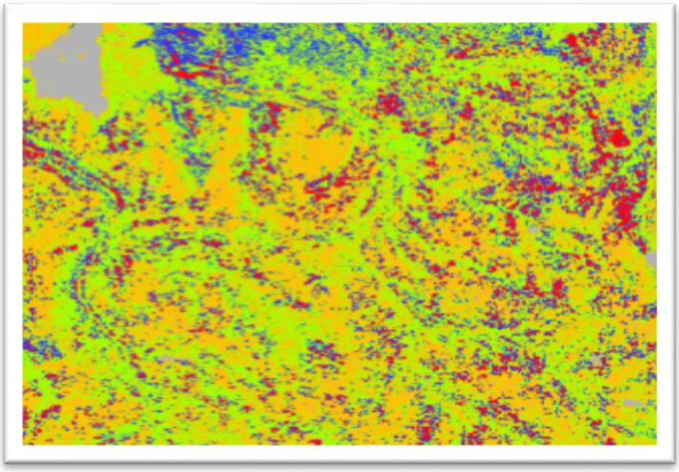
NDVI image (02/11/1990)



Satellite image (17/10/1997)

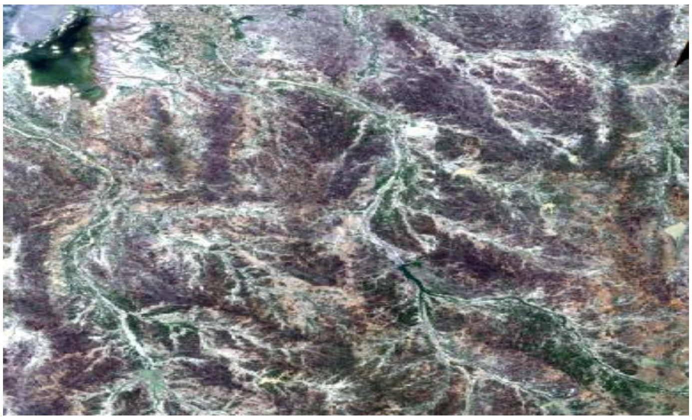


NDVI image (17/10/1997)



Satellite image (18/10/1999)

NDVI image (18/10/1999)



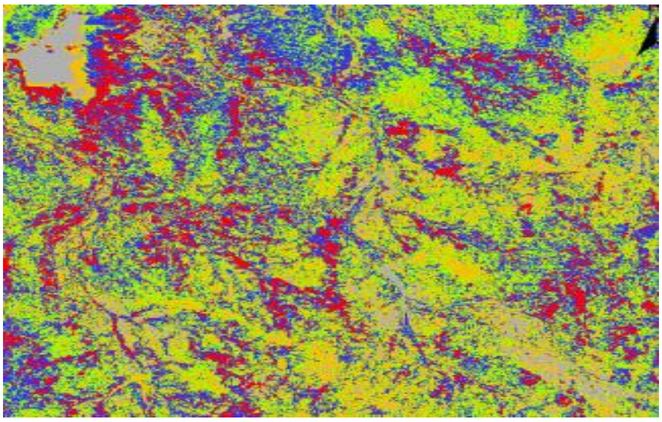


Figure 2: Satellite and NDVI images for 3 years (1990, 1997, and 1999) for drought estimation

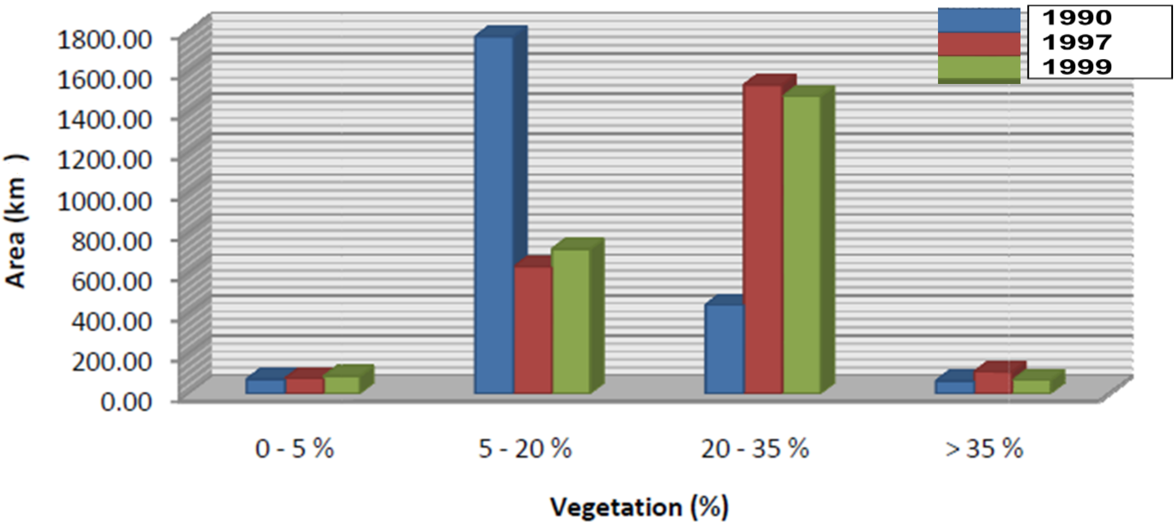


Figure 3.Area under different vegetation class in different years

3.4. Forecasting of pest

The desert locust is potentially the most dangerous of the locust pests because of the ability of swarms to fly rapidly across great distances. The last major desert locust upsurge in 2004 - 05 caused significant crop losses in West Africa. The desert locust (*Schistocercagregaria*) is a species of locust, a swarming short-horned grasshopper in the family Acrididae. Plagues of desert locusts have threatened agricultural production in Africa. Reports show that there are recent pest incidence in India also.

A forecasting model for predicting occurrence of *Schistocercagregaria* was developed by Rani *et al*. in 2018which is given below.

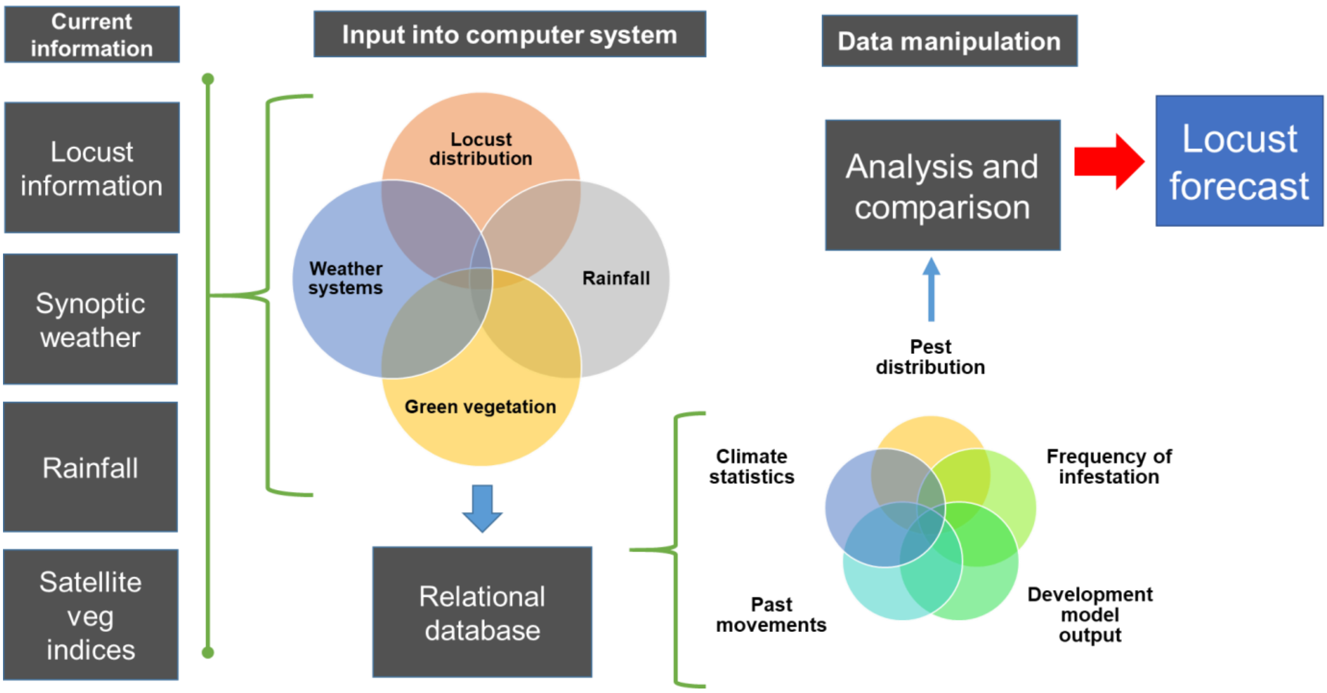


Plate2: Forecasting model for locust incidence

3.5. Monitoring of diseases

Disease is one of the leading factors threatening sustainability of agriculture production, so detecting plant health conditions is of primary importance to agricultural field management. Pathogen can cause severe damage to rice crops, which often leads to crop yield loss and poor quality.

The use of large amounts of fungicide can effectively control many crop diseases and decrease the crop production loss, meanwhile increase the cost of producers and bring a series of environmental problems including the soil, water, and air pollutions and ecological concerns. Thus, the proper characterization and assessment of disease distribution and severity in near-real-time could provide useful information for making decisions regarding the application of fungicide not only when but also where necessary in precise agriculture management.

Large-scale farming of agriculture crops requires real-time detection of disease for field pest management. Hyperspectral remote sensing data generally have high spectral resolution, which could be very useful for detecting disease stress in green vegetation at the leaf and canopy levels.

A study conducted by Liu*et al* in 2008to monitor the disease severity of brown spot of rice. In this study, hyperspectral reflectance of rice in the laboratory and field were measured to characterize the spectral regions and wavebands, which were the most sensitive to rice brown spotinfected by *Bipolarisoryzae(Helminthosporiumoryzae Breda. de Hann*).

When leaf reflectance increased at the ranges of 450 to 500 nm and 630 to 680 nm with the increasing percentage of infected leaf surface, and decreased at the ranges of 520 to 580 nm, 760 to 790 nm, 1550 to 1750 nm, and 2080 to 2350 nm with the increasing percentage of infected leaf surface respectively. The sensitivity analysis and derivative technique were used to select the sensitive wavebands for the detection of rice brown spot infected by *B.oryzae.*

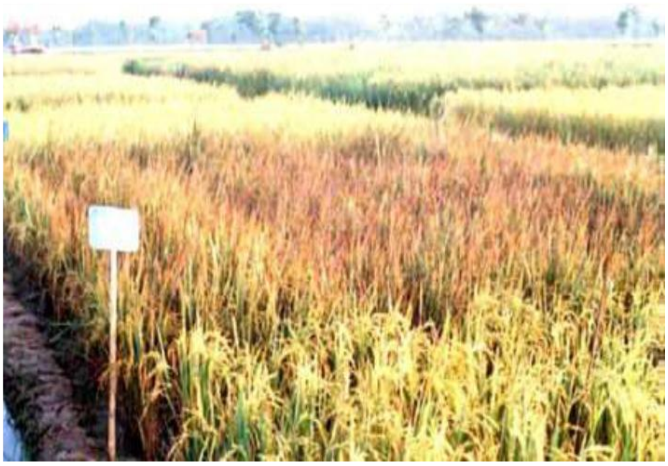


Plate 3: Field affected with brown spot of rice

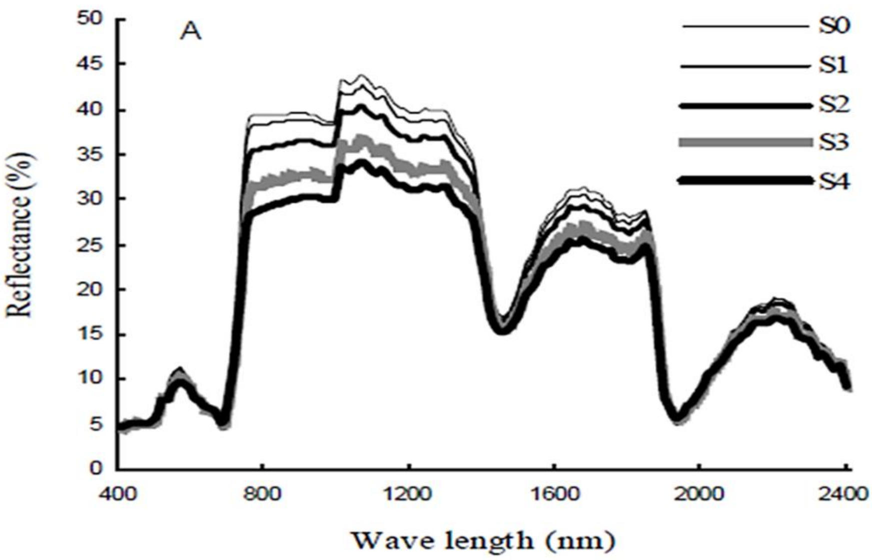


Figure 4: Averagespectral reflectance of rice leaves infected by brown spot fungus (*B. oryzae*) at different disease severities

Ratios of rice leaf reflectance were evaluated as indicators of brown spot. The reflectance at 669 nm divided by the reflectance at 746 nm, increased significantly as the incidence of rice brown spot increased regardless of whether it's at the canopy level or at leaf level. R702/R718, R692/R530, R692/R732 were the best three ratios for estimating the disease severity of rice brown spot at the leaf and canopy levelsThis result not only confirms the capability of hyper spectral remote sensing data in characterizing crop disease for precision pest management in the real world, but also testifiesthat the ratios of crop reflectance is a useful method to estimate crop disease severity.

3.6. Yield analysis and monitoring

Early prediction of crop yield is important for planning and taking various policy decisions. Many countries use the conventional technique of data collection for crop monitoring and yield estimation based on ground-based visits and reports. These methods are subjective, very costly and time consuming.

Empirical models have been developed using weather data, which is also associated with a number of problems due to the spatial distribution of weather stations. These models are complex in terms of data demand and manipulation resulting in information being available very late, usually after harvesting.

Efforts are being done to improve the accuracy and timeliness of yield prediction methods. With the launching of satellites, satellite data is being used for crop monitoring and yield prediction. Many studies have revealed that there is correlation between remotely sensed NDVI and yield. However, most of these studies have been done at regional or national level using low-resolution images, resulting in a lot of generalizations. Studies done at research stations using low flying platforms or hand held equipment to collect spectral data, have also indicated similar relationships.

Sawasawa in 2003used space-borne satellite based NDVI to predict crop yield at field level. Study was carried out in Andhra Pradesh, India. The purpose of the study was to investigate the relationship between space-borne Satellite based NDVI and rice yield in irrigated fields, and combining NDVI with management and land factors for yield prediction at field level.

Data was collected through interviewing farmers on the management practices and yield for the Rabi season, December 2001 - April 2002. Land data for the area was available in form of shape files and tables. Stepwise linear regression was used to relate yield to the management and land factors and the NDVI and to derive a yield estimation model.

Johnson*et al* in 2014 used remote sensed datasets for forecasting county-level corn and soybean yield in the Corn Belt region of the central United States (US). Those datasets were the (1) Normalized Difference Vegetation Index (NDVI) as derived from the Terra satellite's Moderate Resolution Imaging Spectroradiometer (MODIS), (2) daytime and (3) nighttime land surface temperature (LST) as derived from Aqua satellite's MODIS, and (4) precipitation from the National Weather Service (NWS) Nexrad-based gridded data product.

Taking only NDVI and daytime LST as inputs from the 2006–2011 dataset, regression tree-based models were built and county-level, within-sample coefficients of determination (R2) of 0.93 were found for both crops. Limiting the models by systematically removing late season data showed the model performance to remain strong even at mid-season and still viable even earlier. Finally, the derived models were used to predict out-of-sample for the 2012 season, which ended up having an anomalous drought. Yet, the county-level results compared reasonably well against official statistics with R2 = 0.77 for corn. The root-mean-square errors were 1.26 metric tons per hectare.

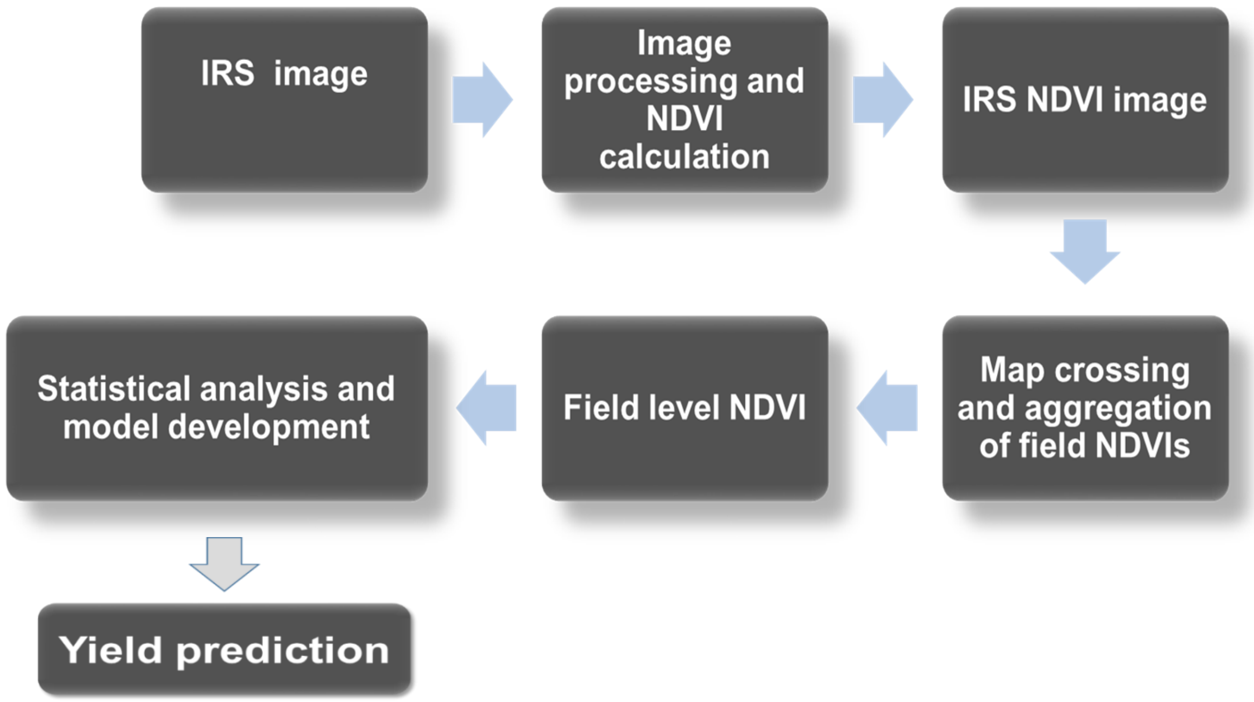


Plate 4: Procedure for NDVI calculation and yield estimation

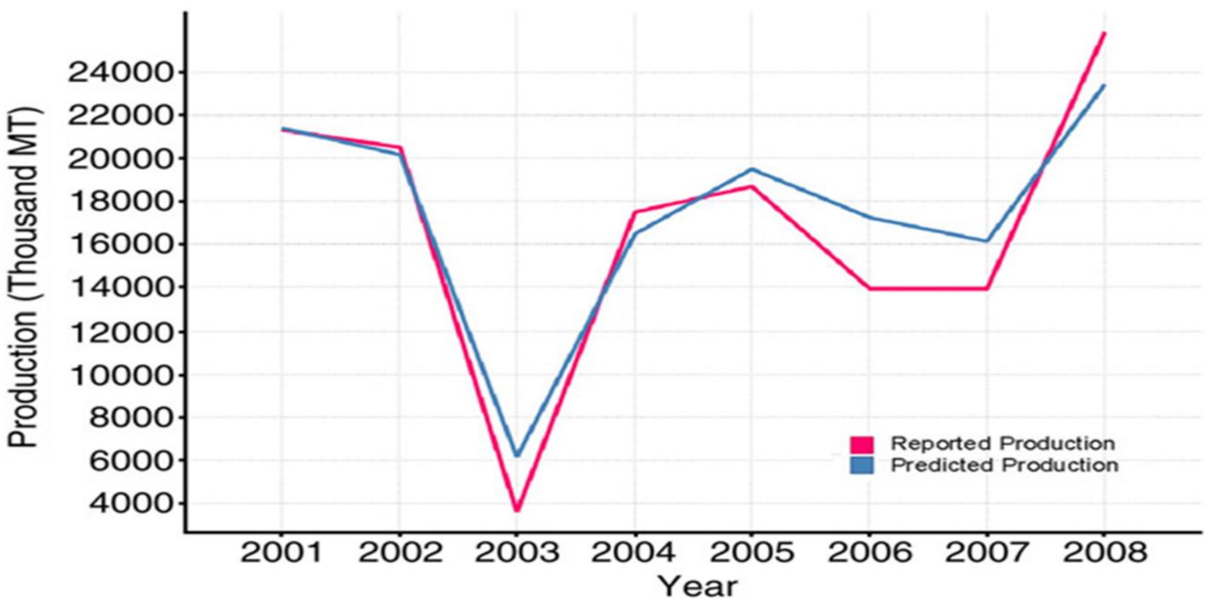


Figure 5: Estimated and predicted yields for corn

4. Advantages of geospatial technology

- Elimination of data redundancy
- Improved allocation of resource and planning
- Layer complex data to drive improved decision making
- Management of natural resources
- Cost savings by improved decision making

5. Limitations of geospatial technology

- GIS technology might be considered as expensive software.
- It requires enormous data inputs
- Only monitoring of droughts/floods, but not forecasting
- Not possible to extend precision farming database to smaller farm and diverse crops/cropping systems
- The biggest constraint of geospatial industry is the lack of awareness about the robustness of the technology

6. Conclusion

- Recent developments in remote sensing and GIS hold much promise to enhance integrated management of all available information and the extraction of desired information to promote sustainable agriculture and development.
- GIS is considered one of the important tools for decision making in problem solving environment dealing with geo-information.
- Remotely sensed images can be used to identify nutrient deficiencies, diseases, water deficiency or surplus, weed infestations, insect damage, hail damage, wind damage, herbicide damage, and plant populations.
- Sustainable utilization of land resources.
- Remote Sensing and GIS technology is very effective tool for suggesting action plans management strategies for agricultural sustainability of any region.

The benefits of geospatial technologies could be better exploited with increase in the level of awareness and understanding of the potential use in the assessment, storage, processing and production of data ranging from site-specific farming systems to global food production and food security issues

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Department of Agronomy

Agron. 591: Masters

Seminar

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Admission No.	: 2018-11-074	Date	: 16-01-2020
Major advisor	: Dr. Sindhu P.V	Time	: 9.15 am

Geospatial technologies and its application in agriculture

Abstract

The term geospatial technology (GST) refers to geographical information systems (GIS), global positioning systems (GPS), and remote sensing (RS), all emerging technologies that assist the user in the collection, analysis, and interpretation of spatial data. It deals with the relationship and condition of man made and natural objects within space. The major sectors using geospatial technology in India are agriculture, telecommunications, oil and gas, environmental management, forestry, public safety, infrastructure and logistics.

In India where agriculture is the prime enterprise, agricultural productivity has become almost stagnant due to unscientific management practices. Precision farming is a scientific approach where inputs are utilised in precise amounts to get increased sustainable yields compared to traditional cultivation techniques. Geospatial technology tools are used in site specific nutrient management, land use suitability classification, soil fertility mapping, monitoring of drought, forecasting of pests and diseases and crop yield monitoring and estimation, for application in precision agriculture.

Geospatial technologies provide direct information on production indicators (such as cultivated area and yield). Using this technology we can analyze the land use suitability of an area. Land use suitability analysis is the process of determining the suitability of a given land area for a certain type of use (agriculture, forest, recreation, etc.)

Geospatial technology helps in preparing soil fertility maps. Once the soil fertility maps are created, it is possible to transform the information from Soil Test Crop Response (STCR) models into spatial fertilizer recommendation maps. Such maps provide site-specific recommendations and validation of soil fertility over the years. The application of fertilizer on the basis of soil test will not only considerably reduce the cost of inputs for fixed targeted yield(s) but also help in the balanced fertilizer application that will lead to better soil health and sustainability of production (Singh *et al*., 2010).

Droughts are considered to be one of the major natural hazards causing destructive impact on the environment as well as the economy of countries throughout the world. Data

for drought monitoring can be acquired from Normalized Difference Vegetation Index (NDVI) obtained from satellite sources and rainfall data obtained from ground rainfall stations. The NDVI images generated from LANDSAT data were used to examine large scale drought patterns and their climatic impact on vegetation (Himanshu*et al*., 2015).

Insect pests and diseases cause enormous losses in agricultural production. The yield losses due to pest population can be suppressed to a greater extent, if their incidence is known well in advance, so that timely adoption of remedial measures is possible. This led to the concept of forecasting. Forecasting methods are based on models that utilize data on weather parameters, farmer's eye estimates, agrometeorological conditions, remote sense crop reflectance observations etc. either separately or in an integrated manner (Rani *et al*., 2018). Early prediction of crop yield is very important for planning and making policy decisions. Geospatial technologies are being used for crop monitoring and yield prediction. Many studies have suggested that there is correlation between NDVI and yield.

The benefits of geospatial technologies could be better exploited with increase in the level of awareness and understanding of the potential use in the assessment, storage, processing and production of data ranging from site-specific farming systems to global food production and food security issues. This technology offers the advantage of generating and synthesizing new information cheaply and quickly over a wide range of areas, as well as over temporal or historical changes resulting from management practices, thus, aiding the ease in decision-making process.

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