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Research Paper on Sensing Agriculture from Space through Geospatial Technology

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Abstract :

The use of technology in the development of agriculture is growing tremendously. Geospatial technology is one such technology. In this paper the emphasis is on providing best solutions in agribusiness, improving farm productivity, improving soil and water resources, and ultimately benefiting farmers with the help of geospatial technology. We analyzed two case studies by using this technology. In the first case study, the satellite-based estimated acreage and spatial distribution map helped the end-user in knowing the density of plantation. In the second case, studies were conducted on watershed development by using satellite images without visiting the field. The main objective of sensing agriculture from space is to address the issues of end-user in precision agriculture value chain using remote sensing, Geographic Information System (GIS) and Global Positioning System (GPS).

Keywords: Geospatial Technology, Remote Sensing, GIS, GPS, Precision Agriculture

INTRODUCTION

The use of technology in daily life has increased significantly. Technology has become a significant part of our life. Similarly, the use of technology in the development of agriculture has also grown tremendously. One such technology is “Geospatial technology”. Geospatial means relating to or denoting data that is associated with a particular location. Geospatial technology comprises of three main domains as Remote Sensing, Geographic Information System (GIS) and Global Positioning System (GPS).

Remote Sensing is the process of detecting and monitoring the physical characteristics of an area by measuring its reflected and emitted radiation at a distance (typically from satellite). Special cameras collect remotely sensed images, which help researchers “sense” things about the Earth.

A geographic information system is a type of database containing geographic data, combined with software tools for managing, analyzing, and visualizing those data.

This technology helps in serving the agriculture community towards developing the agribusiness, improving farm productivity, improving soil and water resources, and ultimately benefiting farmers. Geospatial Technology proves handy for small and medium enterprises providing products and services to agriculture industry or any stakeholders from the agriculture value chain, who are looking for data and information for their effective decision-making and business growth.

In this paper the focus will be on four important topics which are, the first topic is PRECISION AGRICULTURE that will include the Agri-Value chain stakeholders and their needs from the input sector, growers to processors. The second is GEOSPATIAL that will include tools of the geographic information system, Satellite remote sensing, Drone, Global Positioning System, etc. The third will be TECHNOLOGY, which will include artificial intelligence, machine learning, internet of things, soil-less agriculture, waterless agriculture, etc. And the fourth topic will be CONSULTING SERVICES wherein we will discuss about building the relationship with industry users and solution providers. These four topics are important, and they should work together for the benefit of any assignment.

DOMAIN

1. AGRICULTURE

In most of the organizations there had been remarkably high skills in GIS, RS, AI, ML, Drone technologies, etc., but with no or limited knowledge in the agriculture domain. In agriculture the business is done directly with clients. In the process of execution due to a gap in the subject, understanding the need assessment of end-user is not done properly, which results in inaccurate result. Similarly, an agriculture expert with limited or no knowledge of geospatial technology and its applications will not result in good output.

As we all know, agriculture is very dynamic and complex. Crops grown in the field depend on multiple factors such as weather, input availability, farmer's financial condition, market for the commodity, buyer's availability, price, etc. This shows that the agriculture value chain has multiple stakeholders for a commodity from its growing till consumed. And hence there is a vast scope of geospatial technology in agricultural domain.

2. GEOSPATIAL TECHNOLOGY

Geospatial technology enables us to acquire data that referenced to the earth and use it for analysis, modeling, simulations, and visualization. An important aspect of a GIS is its ability to assemble the range of geospatial data into a multilayer set of maps which allows complex themes to be analyzed. This technology allows the user to plan the resources and make informed decisions based on the importance and priority of resources. Using web/internet GIS, the technology can be used to create intelligent maps and models that may be interactively queried to get the desired results.

The first information that remote sensing and GIS technique can provide is unbiased crop intelligence information. This includes, where the crop is located, that is, crop spatial distribution, and how much is the crop extent, that is, crop acreage using satellite images. Satellite images covering a large region can be used for a given period. The crop spectral signature and its reflectance value which makes one crop differ from other can be used for mapping the spatial location of crops. Using GIS technique and overlaying with administrative boundaries of a state or district or village, the crop area within the administrative unit can be computed. The accuracy will depend upon the spatial resolution of satellite imageries.

Using satellite images and image processing technique, the crop can be classified, and the crop layer is generated. Further using the GIS platform, administrative unit wise statistics are generated. State-wise crop area, district-wise crop area tehsil-wise crop area is also generated. Since the images are taken on a real time basis by satellite, the images are reliable and unbiased.

GIS and RS can play an especially important role in generating unbiased, timely and accurate information for their effective planning of seed/fertilizer or crop protection chemical production. Satellite-based studies can be cost-effective as it uses images that can cover a large area and only sample survey is required.

3. TECHNOLOGY

Web-based mapping technologies are software programs like Google Earth and web features like Microsoft Virtual Earth that are the emerging ways to view, share and analyze geospatial data. The traditional GIS are slowly getting reserved for specialists.

Using Artificial intelligence and machine learning various crop models can be generated. This will help in generating crop information in a very quick turn-around time. Customized Software applications can be developed for users to view analyzes and generates a report on crops. And can share the data with their representatives.

4. CONSULTING SERVICES

Consulting can be defined as an act of providing expert knowledge to a third party for a fee. Consulting is most often used when a company needs an outside, expert opinion regarding a business decision.

Agriculture consulting can be defined as providing expert subject-specific knowledge to the organization working in agribusiness activities.

The individual subject of remote sensing which includes techniques of image processing, image classification, image analysis, model preparation,

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mapping technique and in GIS about layer creation, integrated analysis, etc are designed for corporate on what they should look for while using geospatial technology to solve their problems, how much they should be dependent on the third-party services and how they can do a part of technology with a little bit of training.

CASE STUDY

Project 1

Cashew Plantation mapping, acreage estimation and change analysis for procurement and processing planning.

This study was done in the year 2016 in west of Africa (Dinesh Kar, 2020)

The West African cashew growing regions are very less populated, forested, and cashew is planted as plantations. The other plantations that could be found in this region are cocoa plantation. The area if cashew plantations have been increasing over a few years. The need of the client is to know the total area under cashew cultivation at the lowest administrative unit level and to analyze the change in plantation areas over the period of the last four years.

Medium resolution satellite images for the year 2013, 2014, 2015 and 2016 were used for cashew plantation mapping. For some areas, field survey points were provided by the client. These points were used as a signature to classify the year 2016 satellite image. Further using the spectral characteristics of the crop of the year 2016, the images of other years were classified. Change detection analysis was performed between the historical year and current year. GIS analysis was performed to generate each administrative unit-wise crop area statistics. The reports were submitted in digital format. The maps were to-the-scale maps so that planning could be done easily. The study area was one complete country in Western Africa. The project was completed in three weeks of time.

The satellite-based estimated acreage and spatial distribution map helped the client in knowing the area where cashew plantation in densely populated and the areas with the least populated. This can support in their procurement planning. The results also helped the client in knowing the areas which were not explored by them and had significantly good area under cashew. The third important information that was generated from the results to change analysis was on the plantation areas which are under production. Any new area that is newly found in the last four years may not be under fruit production and hence those areas can be avoided for procurement. To understand field survey and information collection for the entire country it takes a few months and a large number of resources. The client was benefited by getting the results in short time and filed survey was also planned only on the cashews grown regions. This helped in reducing their field-time significantly and utilizing the resources more effectively.

Project 2

Monitoring and evaluation of implementation of the action plan under watershed-based land and water resources developmental project

This study was done in the year 2015-2016 (Dinesh Kar, 2020)

The client is a bank that would like to monitor and evaluate the work on a periodical basis. There are multiple activities planned in the action plan document, such as the construction of farm ponds, construction of water harvesting structures in the sites identified, creation of contour bunds in hill slopes, plantation of avenue trees along the village roads and in bunds of the ponds, development of social forestry in wastelands of foot slope of hills. The funds are budgeted based on the activities and dimensions of the constructed areas.

Very high-resolution satellite images and drone images were processed during this study. The high-resolution satellite images were procured and processed for the watershed region to monitor the progress of work and evaluate the development work progress. These images were taken two times a year. Images were also a part of the process for pre-project time and change analysis between pre-project and post-implementation is reported every year by the implementing organization to the funding agency. Drone images were taken for the construction areas (farm pond, water harvesting structure and contour bund areas) to evaluate the activities. Drone images were also used in the forestry plantation areas to count trees. The reports were submitted digitally through a dashboard developed for the client. As this was going to be a long-term project, large data can be stored, compared, and analyzed using the dashboard.

The client was able to view, estimate and analyze the developmental activities without visiting the field. The maps and data helped the client is comparing the developmental changes that took place before the start of the project and after the implementation of soil and water conservation structures. Drone images with exceedingly high spatial resolution helped the client in measuring the dimensions of structures such as length of the bunds, length of water harvesting structures, area of farm ponds and also to count the number of trees planted. The temporal images helped in monitoring the growth of trees and their survival rate.

Table No. 1 - Comparison of Project 1 and Project 2

Sr. No	**Parameters**	**Project 1 (Crop Mapping and Estimations)**	**Project 2 (Watershed Management)**
1	INPUTS	Satellite Images and Administrative boundaries are main input for this crop based studies	Satellite images, thematic maps such as Soil, topography, geology, slope, drainage and climatic data) are main inputs for watershed based projects. DEM data (Digital elevation Model) is used to generate contours, slope and topography layers.
2	SATELLITE IMAGE RESOLUTION	The satellite resolution depends on the area of the study. Low resolution for large area and high resolution for small areas.	Medium to low resolution satellite images are only used.
3	SOFTWARE REUIREMENTS AND ANALYSIS TYPES	Image processing software such as (ERDAS Imagine, ENVI etc) are mostly used Number of Pixels (Histogram) based analysis is performed to generate results Artificial Intelligence and Machine Learning are new approach in these studies	GIS software such as QGIS, Arc GIS etc., are used along with Image processing software. Integrated thematic layer analysis, with analytical hierarchical process (weight age assigning method) is done to arrive at suitable zones in water shades for planning Monitoring and evaluation using drones are new trends in such studies
4	TYPE OF STUDY	Crop Intelligence information - such as crop acreage information crop health monitoring, crop yield prediction crop harvest monitoring	Planning and Development - Such as Land evaluation, crop suitability, land resource planning, water resource management.
5	SKILLS AND	Software skills, GIS and remote	Multiple domain experts along with

	RESOURCES	sensing techniques required	GIS and RS experts required to manage such projects.
6	PROGRAMMES	Crop Acreage and Production Estimation (CAPE) "Forecasting Agricultural output using Space, Agro meteorological and Land based observations (FASAL)" Pradhan Mantri Fasal Bima Yojana (PMFBY)	Integrated Watershed Management Programme (IWMP) is implemented by Department of Land Resources of Ministry of Rural Development. INTEGRATED WASTELAND DEVELOPMENT PROGRAMME (IWDP) Pradhan Mantri Krishi Sinchayee Yojna (PMKSY)

CONCLUSION

Remote Sensing and GIS are integral to each other. The development of remote sensing is of no use without the development of GIS and vice versa. Remote Sensing has the capability of providing large amount of data of the whole earth. GIS has the capabilities of analyzing a large amount data within no time. These voluminous data would have become useless without the development of GIS. (*Balaji Waghmare, 2017*)
A number of scientists like geologists, botanists, soil scientists, geographers began the interpretation of the photograph to get information of their interest.
The current trend in Agriculture is its transformation to Agriculture 4.0. This is Digital Agriculture. It includes advance technologies such as use of Drones, Satellite technology, Soil less farming, Driver less tractors, Agriculture robots, vertical farming, digitalization of farms etc. Similarly in Geographic information system, there is transformation to GIS 2.0. In this systems and solutions play important role than services. Computer programs based solution using AI and ML technique are the current trend. This is for fast analytics and more accurate results with less human intervention. The below given projects has major role of computers (Software and Hardware to process large data sets), systems (Agri information system, Decision support system), and machine learning algorithm based solutions.
The comparison study of Project 1 and Project 2 is tabulated in Table No. 1.

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