International Archive of Applied Sciences and Technology
Int. Arch. App. Sci. Technol; Vol 8 [4] December 2017: 04-09

[ISO9001: 2008 Certified Organization]
www.soeagra.com/iaast.html

IAAST
ONLINE ISSN 2277- 1565
PRINT ISSN 0976 - 4828

CODEN: IAASCA REVIEW ARTICLE

DOI: .10.15515/iaast.0976-4828.8.4.49

Precision Farming, Remote Sensing, Geographical Information System: A New Paradigm for Agricultural Production in India.

Rajendra Madhav Wagh
Assistant Professor
School of Agricultural Sciences
Yashwantrao Chavan Maharashtra Open University
Dnyangangotri Near Gangapur Dam, Nashik-422222, Maharashtra(India).
Email: wagh_rm@ycmou.digitaluniversity.ac

ABSTRACT
Every year copious technologies have been applied by many researchers, agronomies, scientist and engineers to increase agricultural production with low cast, but it has adverse impact on environment. Precision agriculture deals with the study of the application of technology to improve agricultural practices as compare to conventional agricultural method and lower adverse impact on environment. Remote sensing technology plays an important role in precision agriculture and its application in the precision agriculture introduces new opportunities for improving agricultural practices. With the help of global positioning system (GPS), it is possible to record field data (slope, aspect, nutrients, and yield) as geographically Latitude and longitude data. It has capability to determine and record the correct position continuously, so therefore, it can create a larger database for the user. For the further analysis geographic information system (GIS) is required, which can store and handling these data. This review highlights about remote sensing technology, GIS, GPS and give you an idea about, how it can be valuable in precision agriculture.
Keywords: *remote sensing; geographic information system; precision farming*

Received 28.09.2017 **Revised 17.10.2017** **Accepted 30.10.2017**

Citation of this article
Rajendra Madhav Wagh. Precision Farming, Remote Sensing, Geographical Information System: A New Paradigm for Agricultural Production in India.. Int. Arch. App. Sci. Technol; Vol 8 [4] December 2017 : 04-09.

INTRODUCTION

Accurate and timely information is necessary to evolve strategies for sustainable management of natural resources. Today's "Space Age" supported by computer and communication technologies offer great scope for efficient planning and management of agricultural resources on scientific principles. The satellite data hitherto was considered as sensitive and used mostly for defence purposes. However, the space scientists are now willing to share the satellite data, although on a high cost basis, for civilian use. Remote sensing (RS) and geographic information system (GIS) technologies have been of great use to planners in planning for efficient use of natural resources at national, state and district levels. Application of these technologies in the management of natural resources are increasing rapidly due to great strides made in space borne remote sensing satellites in terms of spatial, temporal, spectral and radiometric resolutions. Many of the conventional approaches of handling multi thematic information to arrive at optimal solutions are being computerized using GIS utilities.

Precision farming has been confined to developed countries. Land tenure system smaller farm size (<1ha) and crop diversity limit the scope for precision farming in India. However, there is wide scope for precision farming in irrigated areas/commercial crops/fruit and vegetable crops/high value crops. It is apparent from the foregoing that there is tremendous scope for use of RS, GIS and precision farming techniques in developing a data base of natural resources and decision support systems at the farm (<1ha !) level. This will be a stupendous task and a threatening challenge to space and agricultural scientists alike both of whom are currently remotely placed from the ground truth of Indian farming. However, the speed of these transformations depends very much on the level of commitment of politicians, bureaucrats, technocrats and scientists in addition to financial resources available. Indian Agriculture is known for its multi-functionalities of providing food, employment, livelihood, nutritional and ecological securities.

The agriculture sector alone sustains the livelihood of around 64 per cent of the population and contributes nearly 26 per cent to the gross domestic product. Of course, there has been substantial increase in food grain production from about 51 million tonnes in 1950 to about 210 million tonnes in 2001. However the rate of increase in population demands much higher rate of increase in food production while maintaining harmony with the environment-the core concept of sustainable agriculture. The agriculture in the WTO era has to be more competitive and cost effective. The farming technologies followed in India need to be constantly updated to meet these challenges. In this context, comprehensive and reliable information on land use/cover, soils (extent of wastelands and degraded lands), agricultural crops, water resources (both surface and underground), natural hazards/ calamities like drought and floods and agro meteorology is essential. Season-wise information on crops, their acreage, vigour and production enables the country to adopt suitable measures to meet shortages if any, and implement proper support and procurement policies.

Objectives – following are the objectives of this study

1. To discuss the Present Scenario of Remote Sensing in Agriculture
2. To discuss about Crop Acreage and Production Estimation,
3. To discuss about concepts of Geographical Information System (GIS) in Agriculture, Precision farming and its Opportunities & Challenges

RESEARCH METHODOLOGY

This is descriptive study based on secondary data. Various Research Journals, Books, Websites & various reports which is related to Present Scenario of Remote Sensing in Agriculture, Crop Acreage and Production Estimation, Geographical Information System (GIS) in Agriculture, Precision farming and its Opportunities & Challenges were studied to draw the conclusions.

RESULTS AND DISCUSSIONS

In this paper different factual information related to Present Scenario of Remote Sensing in Agriculture, Crop Acreage and Production Estimation, Geographical Information System (GIS) in Agriculture, Precision farming and its Opportunities & Challenges are discussed as follows.

1. Remote Sensing in Agriculture: Present Scenario

Remote sensing techniques play an important role in crop identification, acreage and production estimation, disease and stress detection, soil and water resources characterisation and also by providing required inputs for the following: generation of land and water resources developmental plans, bringing additional land into cultivation through mapping and reclaiming wastelands, increasing the irrigation potential through ground-water prospects mapping; crop-yield and crop-weather models, integrated pest management, command area management, watershed management, agrometeorological services, precision farming, etc. Remote sensing applications to agriculture have grown to a stage where such inputs are being used for number of policy level decisions related to food security, poverty alleviation and sustainable development in the country. Decision on buffer stock of food grains could be based on pre-harvest crop acreage and production estimation while the ground water prospects maps serve as the major source of information in ensuring drinking water and other needs in rainfed and less favoured areas. Nation wide wasteland, land use, land cover and soil mapping has helped in expanding and intensification of agricultural activities and also in identifying the land capability classes and crop suitability indices.

2. Crop Acreage and Production Estimation

In India the use of space-borne remote sensing data for crop acreage estimation and production forecasting was experimented in early 1980s in selected districts for wheat, rice and groundnut. The promising and encouraging results of this initial study led to an attempt to estimate state-level wheat acreage using Landsat MSS data for Haryana and Punjab in 1985-86. The results were encouraging and the project, namely, 'Crop Acreage and Production Estimation' (CAPE) was launched covering wheat, rice, groundnut and rabi sorghum in selected major growing states/districts. Since availability of optical data is a concern in monsoon seasons, the use of data from active sensors, such as SAR of RADARSAT was operationally used for kharif rice in 12 districts of Karnataka.

The microwave data, which has all weather capabilities, has shown that the rice crop can be discriminated at better than 90% accuracy, which can aid in early detection with multiple forecasting.

Apart from using the single-date high-resolution satellite data to provide crop acreage estimates at district-level under CAPE, the multidate WiFS data (coarse resolution and high receptivity) is used to explore the possibility of making national-level forecasts. The procedure uses a national-level sampling frame and coarse sample segment grids to make multiple forecasts as well as inter-seasonal crop growth differences using multi-year WiFS data. A comprehensive software package called 'CAPEWORKS/CAPEMAN' has been developed enabling end-to-end analysis culminating in generation of production statistics. The remote sensing techniques have also been deployed in assessing the horticultural crops. For example, acreage estimation of mango and banana plantations in Krishna district of AP and Thiruchirapalli district in Tamil Nadu, respectively has also been successfully carried out with an accuracy of 94% in a joint venture with the Indian Institute of Horticultural Research. Mapping of sugarcane has been carried out to aid various users and cooperative sugar mills in accurately estimating the acreage.

This is also done at cadastral level enabling the government to identify those beneficiaries (farmers) who are not paying the tax. Efforts made on estimating the onion acreage in Nasik district, Maharashtra yielded results to an accuracy of 75% because of smaller field size, peculiar leaf structure, continuous cultivation and spectral mixing with other crops. From the experience gained on implementation of CAPE project and also to meet the requirements of timeliness, accuracy and coverage of crops, an integrated concept of Forecasting Agricultural output using Space, Agrometeorology and Land based observation (FASAL) has been evolved. A National Crop Forecasting Centre is being established by the Department of Agriculture and Cooperation, Govt. of India to execute the project. (As remote sensing, weather and field observation provide complementary & supplementary information for making crop forecasts, FASAL proposes an approach which integrates in pulses from these three types of observation on to make forecasts of desired coverage, accuracy and timeliness).

The concept of FASAL, thus strengthens the current capabilities of early crop season estimation from econometric and weather-based techniques with remote sensing mid-season assessments that can be supplemented with multi-temporal coarse resolution data based analysis. In the later half of crop growth period, direct contribution of remote sensing in the form of acreage estimates and yield forecasts is available. However, in this case also, the addition of more extensive field information and weather inputs would increase the forecast accuracy. India is also planning for some exclusive satellites to provide data specific to agriculture.

3. Geographical Information System (GIS): in Agriculture

Integration of the land and water resources and identification of the constraints/ecological problems at the micro level will help in identifying the location specific solutions through the effective use of remote sensing based resource information combined with other socio-economic data using GIS. This is being done by survey of resources at different scales using traditional and remote sensing techniques, collection of collateral information like slope, topography etc, preparation of a set of resource maps (hydrogeomorphology, soils, land use / cover, surface water/drainage/watershed etc.) and generation of action plan maps giving site specific recommendations for development and management of agriculture, ground water recharge, fuel and fodder as well as for soil conservation / reclamation and afforestation.

In one of the experiments at NRSA, sustainable action plan for upper Machkund Watershed falling in tribal areas of Visakhapatnam district, Andhra Pradesh has been generated through GIS techniques. GRAM ++ is an indigenously developed Geographical Information System (GIS) software package for storage, analysis and retrieval of geographic information relevant to the task of local level planning (GRAM++ - Geo-referenced Area Management Package A Tool For Local Level Planning, Natural Resources Data Management System, Department of Science & Technology, Government of India).

The package has been put to use in a variety of applications like watershed management, waste land reclamation, land capability analysis, soil erosion assessment, energy budgeting, location/ allocation of facilities, and hazard zonation studies. These applications have been conducted and functionalities tested by Karnataka State Council for Science and Technology, Bangalore; Technology Informatics Design Endeavour, Bangalore, National Atlas and Thematic Mapping Organization, Calcutta, National Water Development Agency, New Delhi and several other universities and R&D institutions. Under NNRMS, Dept. of Space, a Natural Resources Information System (NRIS) is being developed for policy makers to ensure the optimum utilization of natural resource information. This information system will enable to update existing natural resource information and integrate with socioeconomic data.

GIS forms the core of NRIS for data storage, retrieval, data integration and analysis. It will also be linked with other existing information systems at district/state level to provide an efficient and powerful tool for management of resources. NNRMS (2000) has prepared a document on the node design and standards to be adopted under NRIS for all themes like soil, land use, water, geomorphology, socioeconomic data, infrastructure facilities, etc. Thus, the potential of the GIS is vast to improve the resource management for enhancing the productivity on a sustainable basis in an eco-friendly manner. This involves collection and formatting large database with co-operation from line departments/institutions for deriving the maximum benefits out of this technology.

4. Precision farming

Précising farming is an emerging concept in modern agriculture. It is a micro management system to arrive at improved agricultural and land management decisions that result from using information delivered by geospatial technologies. In other words it is "Digital Agriculture" involving very large scale farm level mapping, comprehensive data base creation on required resources generated through space based inputs and field observations and making a detailed plan of work for maximizing the yield and reducing the cost on inputs using the decision support system.

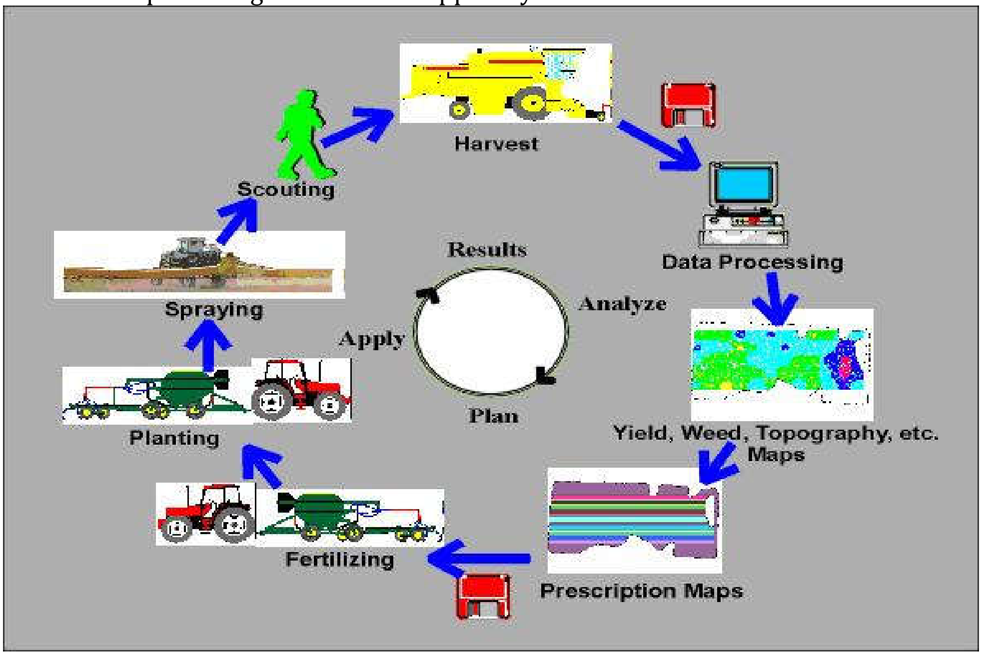

Figure 1. Precision farming cycle

The precision farming data base generally includes:

I. Crop characteristics like, stage of the crop, crop health, nutrient requirement, etc;

II. Detailed soil layer with physical and chemical properties, depth, texture, nutrient status, salinity and toxicity, soil temperature, productivity potential, etc.,

III. Microclimate data (seasonal and daily) about the canopy temperature, wind direction and speed, humidity etc.,

IV. Surface and sub surface drainage conditions;

V. Irrigation facilities, water availability, and other planning inputs of interest.

With the advent of differential Global Positioning System (GPS) with high accuracy, there are possibilities of automating the farm operations like tillage, planting, fertilizer applications, pesticide/herbicide spraying, irrigation, harvesting and other mechanized cultural operations. High resolution Digital Elevation Models (DEM) may also form a component of the database, which provides the appropriate description of the topography to support soil moisture and fertility models for decision making.

Precision farming enables micro-management concepts that include the ability to appropriately manage every field operation at each location in the field, if it is technically and economically advantageous to manage at that level. The concept of precision farming is picking up very fast in developed countries due to large farm holdings and fully mechanized agricultural operations. With the present day technological developments and further availability of higher resolution multi spectral sensor data, there is scope for adopting precision farming for cultivation of high value / Commercial / fruits / flowers/ vegetables etc. in developing countries including India. The application of remote sensing and GIS techniques in the management of agricultural resource are increasing rapidly due to improvement in space borne remote sensing satellites in terms of spatial, spectral, temporal and radiometric resolutions.

Many of conventional approaches of handling multithematic information to arrive at optimal solutions are being computerized using GIS utilities. Keeping in view the development in satellite, computer and communications technologies, the following opportunities and challenges exist in the application of remote sensing GIS and precision farming technologies in India.

Opportunities

1) Prioritization of macro/micro watersheds for implementation and impact assessment of watershed projects at national, state, district, taluka and hobli levels.
2) Forecasting of outbreak of pests and diseases based on soil water status and plant stress indicators in crops such as paddy, wheat, sugarcane, cotton, chilli, & pigeonpea, etc.
3) Development of decision support system for precise management of resources at farm level at least in commercial / fruit / flower crops to begin with.
4) Airborne SAR data utilization for identification of kharif crops and development of procedures for canopy backscatter models for identification and yield prediction.
5) Soil mapping at cadastral scale using high resolution spatial, spectral and radiometric resolutions.
6) Quantification of soil loss.
7) Detection of water logging due to rising ground water table.
8) Delineation of salt-affected soils in black soil and sandy regions.
9) Soil moisture estimation and mapping using micro wave/optical/thermal remote sensing techniques in surface and root zone depth.
10) Land surface temperature estimation using thermal and microwave remote sensing techniques.
11) Hyper spectral studies on soils to establish quantitative relationship between spectral reflectance and soil properties.
12) Development of digital techniques for a variety of applications using GIS techniques. For e.g., soil suitability to crops, land capability classification and land irrigability assessment etc.
13) Preparatory activities towards hyper spectral data utilization for understanding the plant processes and development of spectral response models for stress detection.
14) Improved yield models by integration of biophysical simulation and regional level crop models.

Challenges

The application of Remote Sensing, GIS and precision farming techniques in the management of agricultural resources are increasing rapidly due to improvements in space science supported by computer and communication technologies. The following challenges need to be addressed in the application of these technologies.

1) Identification of crops and estimation of area and production of short duration crops grown in fragmented land holdings, in particular during kharif season.
2) Forecasting of droughts/floods.
3) Detection of crop stress due to nutrients, pests and diseases and quantification of their effects on crop yield.
4) Automation of land evaluation procedures for a variety of applications using GIS techniques.
5) Information on sub-surface soil horizons.
6) Extending precision farming database to smaller farm size and / or diverse crops/cropping systems.
7) Developing decision support systems for management of biotic and abiotic stresses at the farm level.
8) More accurate yield models
9) Estimation of depth of water in reservoirs and quality assessment of ground water.
10) Better than 1m contours for watershed development plan at the micro level.
11) Use of remote sensing and precision farming technologies in intercropping/multiple cropping situations.
12) Identifying ways and means of reducing the cost of RS, GIS and precision farming technologies and time gap in collection, interpretation and dissemination of data to enable their usage on a large scale. A successful example in this direction is that of hand-held radiometer developed by Optomech Engineers Hyderabad in collaboration with space application center, ISRO Ahmedabad for standardizing the spectral signature insitu for inter pressing the RS Data.
13) Convincing evidence to prove the utility and economic viability of these technologies so as to mobilize support for R & D work.
14) Human resource development to hasten the process of large scale use of unexplained and cutting edge technologies that have tremendous scope and potential.

CONCLUSION

The interest in precision farming (PF) and its introduction has resulted in a gap between the technological capabilities and scientific understanding of the relationship between the input supplies and output products.Agriculture, the dynamic system governed by several biotic and abiotic factors, needs to be sustained, as it is the major player in Indian economy. Though we are self sufficient in food grain production, there are several gray areas which need to be improved for achieving ever-green revolution.

There is a need to transform low-yielding food production systems in to high yielding ones through the convergences of agrotech (mainly production related), biotech (productivity related) with space technology (RS and GIS)

Launching of satellites like IKONOS-II Quick Bird-2, TES and planned indigenous earth observation mission, namely Resourcesat-1 Cartosat-1 and Cartosat 2, Orbriew-3, SPOT-5 and Advance Land Observation Satellite (ALOS) may enable generating detailed and more specific information on land and water resources. To facilitate deriving information on crops during the Kharif season, India has proposed to launch a dedicated microwave mission viz., Radar Imaging Satellite (RISAT) with a c-band SAR. Generation of DEM with fine resolution is another important requirement for watershed development.

Translation of remote sensing data, GIS techniques and precision farming database information in to implementable schemes at the field level and absorption of technology at the grass root level by the actual beneficiaries still remains a greater challenge. These technologies should infiltrate in to agricultural sector at micro level for greater and sustainable benefits.

REFERENCES

1. Agro-Informatics (2001). Proceedings of the first National Conference on Agro-Informatics (NCAI) (V.C.Patil, G.S.Dasog, A.R.Alagawadi, K.C.Shashidhara and D.P.Biradar), INSAIT. Dharwad
2. Aziz FAA, Shariff ARM, Amin BM, Mohd S, Rahim AA, Jahanshiri E, Nik Norasma Che' Ya. GIS based System for Paddy Precision Farming. Iaald Afita WCCA2008 World Conference on Agricultural Information and IT, Tokyo University of Agriculture, Tokyo, Japan, August 24 – 27, 2008;417-422.
3. Bairagi, G.D., Hassan, Z., (2002), Wheat Crop Production Estimation Using Satellite Data. Journal of the Indian Society of Remote Sensing, 30(4), pp 213–219.
4. Bingfng, W., Chenglin L., (2000), Crop Growth Monitor System with Coupling of AVHRR and VGT Data, vegetation 2000, conference, Lake Maggiore – Italy.
5. Burrough, P.A., McDonnell, R.A., (1998), Principles of geographic information systems. Oxford University Press, Oxford, UK, pp 10–16.
6. FICCI. Agriculture overview; (2012). Accessed 26.5.2012. Available: http://www.ficci- b2b.com/sector-overview-pdf/Sector-agri.pdf.
7. Gowrisankar, D. and Adiga, S., (2001), Remote sensing in agricultural applications: An overview. PP: 9-14, In: Proc, The First National Conference on Agro-Informatics (NCAI), INSAIT. Dharwad.
8. Joubert R. Precision farming – suitable for large or small farms. (2012). Accessed 26.6.2012. Available: http://www.farmersweekly.co.za/article.aspx?id=30367&h=Precision-farming- %E2%80%93-suitable-for--large-or-small-farms.
9. Junying, S, Jinliang, H., Jing, C., Lihui, W., (2009), Grain Yield Estimating for Hubei Province Using Remote Sensing Data –Take Semilate Rice as an Example, 2009 International Conference on Environmental Science and Information Application Technology, pp 497-500.
10. Laurila, H., Karjalainen, M., Kleemola, J., Hyyppa, J., (2010), Application of Remote Sensing Technology in crop acreage and yield statistical survey in china Lutz, W., Sanderson, W. and Scherbov, S., 1997, Doubling of world population unlikely. Nature 387, pp 803–805.
11. Liaghat, S., and Balasundram S.K., (2010), A Review: The Role of Remote Sensing in Precision Agriculture. American Journal of Agricultural and Biological Sciences 5(1): 50-55.
12. Mackay D. Precision Farming: connecting the pieces. (2012). Accessed 26.6.2012. Available: http://www.personal.psu.edu/pwl5119/blogs/bill_lim/assets/Limpisathian,%20P.%20GI S%20Paper.pdf.
13. Ryu C, Suguri M, Iida M, Umeda M, Lee C. Integrating remote sensing and GIS for prediction of rice protein contents. Precision Agric. 2011;12:378–394.
14. Salam, M.A., and Saha S.K., 1998, Crop Inventory using remote sensing and Geographical Information System (GIS) Techniques. Journal of Remote Sensing and Environment
15. Singh AK. Precision Farming. (2012). Accessed 25 June 2012. Available: http://www.iasri.res.in /ebook/EBADAT/6-Other%20Useful%20Techniques/14- Precision%20Farming%20Lecture.pdf.
16. Soria-Ruiz, J., Fernandez-Ordonez, Y., McNairm, H., Bugden-Storie, J., 2007, Geoscience and Remote Sensing Symposium, IGARSS, IEEE International, pp 3655–3658.
17. Venkataratnam, L., (2001), Remote sensing and GIS in Agricultural Resources Management. pp: 20-29. In: Proc, The First National Conference on Agro-Informatics (NCAI), INSAIT. Dharwad.
18. Yang, P., Tan G.X., Zha, Y., Shibasaki, R., (2004), Integrating remotely sensed data with an ecosystem model to estimate crop yield in North China. In: The International Archives of the Photogrammetry, Remote Sensing and Spatial Information Sciences, Istanbul, Turkey, Vol. XXXV, Part B7, pp 150-155.