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Use of Geoinformatics for Agricultural Sector in the State of Andhra Pradesh

ABSTRACT

Agriculture is the backbone of Indian economy and plays a vital role in ensuring the food security. The near real time availability of information on the dynamic parameters like - extent of crop sown, their condition, seasonal crop prospects influences the major policy decisions. The information on soils - their potentials and limitations like degradation problems enables the planners to use the resources optimally. The application of remote sensing and GIS to these areas is discussed in this article.

Keywords: *Crop type map and condition assessment, GIS, Remote Sensing, Soil Resource and Land Degradation Mapping*

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Agriculture is the backbone of Andhra Pradesh, with over 62 per cent of the rural households depending on agriculture as their principal means of livelihood and Agriculture, contributes about 27 % of the state GDP. The state is bestowed with a total geographical area of 1,60,200 sq km spread over in 13 districts of six agroclimatic zones and broadly five different soil types to cultivate a wide range of crops. The remarkable developments in space borne remote sensing (RS) technology and its applications during the last four decades have firmly established its immense potential for mapping and monitoring of various natural resources. Since the 1972 launch of MSS sensor onboard Landsat 1, and IRS 1 in 1988, and subsequent improvements in the sensor specifications - spectral, spatial, radiometric and revisit periods, the scope for applications in agriculture and their use in near real time has increase manifold. Some of the common applications with the use of current satellites IRS - LISS III, LISS-IV, AWiFS, Landsat OLI and Microwave sensors - RISAT and Radarsat1/2 and Sentinnel are given hereunder:

Crop Inventory

The intrinsic ability of spectral reflectance data to identify and distinguish crops is helpful in deriving crop acreages, production estimates, to monitor and assess the crop condition. Remote sensing based crop identification and discrimination is centered around the concept that each crop has a unique spectral signature due to its own architecture, growing period etc., when two crops with similar spectral signatures occur in a given date, multi date data is required to identify them.

Acreage Estimation

The acreage estimation procedure broadly involves 1) selection of single date data corresponding to the maximum vegetative growth stage of crop 2) identification of representative sites of various crops and their heterogeneity on image based on ground truth 3) generation of representative signatures for the training sites 4) classification of image using training statistics and 5) estimation of area of the crop using administrative boundary like district mask.

The estimation can be done on sampling basis or by means of total enumeration approach. In the cases of estimation of crop acreages for large areas like states wherein analysis of large amount data and ground data collection are involved, stratified sampling procedure is being used operationally. The study area is divided into homogenous strata based on crop proportion and vigor as manifested on the satellite data and each strata is subdivided into segments of required size usually 5 X 5 km. About 10-15 percent of the sample segments are randomly selected for digital analysis and standard statistical methods are employed to aggregate crop estimates at district / state levels.

In order to choose most optimum bio-window, it is necessary to obtain the crop calendar and sowing progression of different crops cultivated in the study area for better crop discrimination. Based on the sowing date and its phenology, ideal bio window should be choosen for data selection. Using single date, cloud free optical data during the maximum vegetative stage of the crop growth, district level pre-harvest acreage and production of large area covering crops viz., paddy, wheat, sorghum, ground nut, rapeseed-mustard and cotton is being estimated on operational basis under the crop acreage and production estimation (CAPE) project. An extended project viz., forecasting agricultural output satellite, Agro-meteorological and Land Observations (FASAL) is in progress to provide multiple forecasts at district, state and national level (Navalgund *et. al*. 1991, Dadhwal V K. 1999, Sesha Sai *et al*. 2010 and Ramana K V. *et al*. 2017) Fig. 1 shows the spatial distribution of *kharif* rice in Andhra Pradesh during 2017. With the launch of AWiFS, the high temporal revisit period has been exploited for discrimination of early and late rice crop transplantations.

Inventory of commercially important crops and high value crops has the unique applications in making strategic decisions for enhancing the use efficiency of the economic resources. The technology permits the discrimination and mapping of sugarcane, chillie and horticuture plantations like mango and oilpalm. The Ministry of Agriculture has recently started a nation wide programme on horticulture crop inventory under the programme CHAMAN.

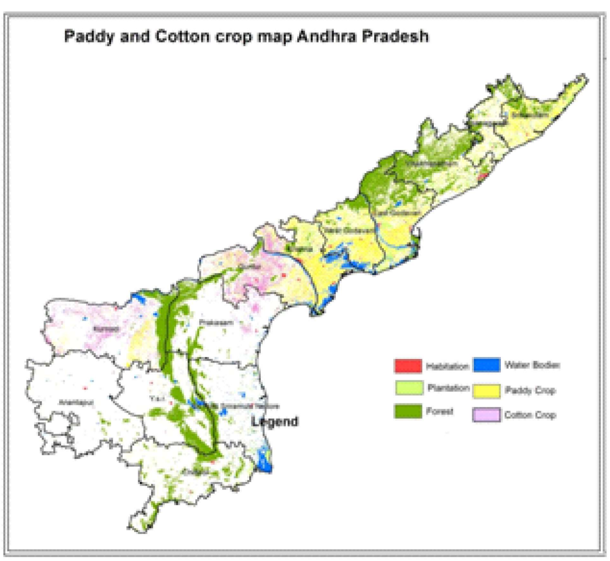

Fig 1. Crop inventory - Paddy and Cotton using satellite data during *kharif* 2017-18

Cropping System Analysis

Remote sensing provides valuable information on the distribution and condition of crops at different spatial hierarchies and has the highest compatibility for analysis in GIS environment. Information on other natural resources that are of significant importance towards agricultural production can be integrated to generate information for sustainable agriculture. Integration of soil suitability for the cultivation of cotton crop along with the spatial distribution of cotton crop, as derived from remote sensing data through a conformity analysis enabled to delineate cotton crop grown under different suitability regimes. This information is useful towards planning for efficient production of cotton crop by apportioning those land parcels that are highly suitable for cultivation of cotton.

Rice is the major food grain cereal crop grown in South Asia and is cultivated mostly during the monsoon (rainy) season. Since the scope is limited for horizontal expansion, increased cropping intensity on the existing agricultural lands is one of the best crop management options. In this context, post kharif rice fallows offer a considerable scope for achieving sustainable production by introduction of short duration leguminous crops. The distribution of rice crop and kharif and rabi season along with pulse crops is shown in Figure 2.

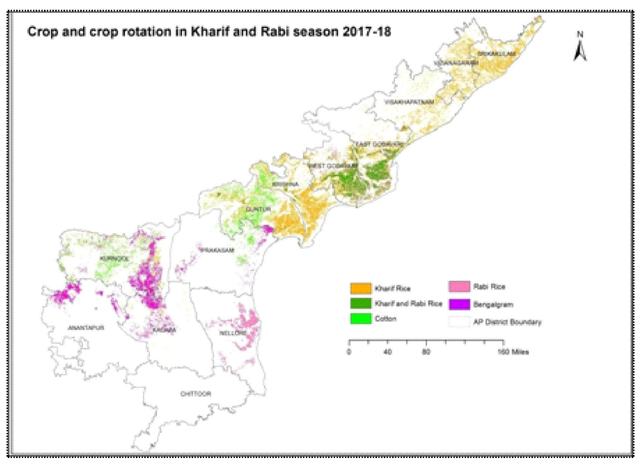

Fig 2. Distribution of *kharif* and *rabi* crops (2017-18) in AP

Production Estimation

Crop yield is influenced by many factors such as genotype, soil characteristics, cultural practices adopted, metrological conditions and influence of pests and diseases. Spectral data of a crop is the integrated manifestation of the effect of all theses factors. Development of reliable crop yield models with minimal data is a major thrust area.

A major challenge often confronted in agricultural crop production, despite the development of advanced agricultural technology, is the damage caused to agricultural crops by pest and diseases. Crop losses can be due to biotic factors like pests, diseases, weeds and abiotic factors like flood, drought, cyclones hailstorms etc. damages is known only after considerable damage has been occurred.

Statistical, meteorological and / or spectral models are used for crop yield estimation. Remote sensing based models adopt two approaches viz., single date spectral index and multi-date spectral index-growth profile are in vogue. The single date data spectral index approach relies solely upon the data acquisition within a narrow critical period of maximum vegetation growth phase while multi-date approach depends spectral data at different stages of crop growth within the season. In addition, attempts are also underway to incorporate the spectral information in the process-based models and crop simulation models to improve the predictive capabilities of the remote sensing based crop production estimation.

Crop Monitoring and Condition assessment

Condition of the crop is affected by factors such as availability of water and nutrients, pest attack, disease outbreak and weather conditions. These stresses cause physiological changes which alter the optical and thermal properties of the leaves and bring about the changes in canopy geometry and reflectance / emission. Monitoring and assessment of crop condition at regular intervals during the crop growth cycle is essential to take appropriate curative measures and to assess the probable loss in production.

The variations in the progression of NDVI, in terms of the magnitude and rate of progression, in relation to its respective normal NDVI provide information of the prevailing status of the vegetation. Exclusion of the permanent non-agricultural features like forests, wastelands, water bodies and settlements, reveal the status of the agricultural situation. In order to circumvent the problem of non-availability of cloud free optical data, time composited NDVI over an aggregated period of a fortnight or a month is generated, covering the entire crop growth season.

In India, National Agricultural Drought Assessment and Monitoring System (NADAMS) was initiated towards the end of 1986, with the participation of National Remote Sensing Agency, Dept. of Space, Government of India, as nodal agency for execution, with the support of India Meteorological Department (IMD) and various state departments of agriculture. NADAMS was made operational in 1990 and has been providing agricultural drought information in terms of prevalence, severity and persistence at state, district and sub-district level.

In Andhra Pradesh, the Integrated Seasonal Crop Monitoring Systems is based on the analysis on Fourteen year historical NDVI, NDWI, VCI and Rainfall and daily Soil Moisture derived from soil water balance model. The project aims at Concurrent monitoring of seasonal conditions using remote sensing, extensive weather network data and continuous ground truth. Using the combination of rainfall deviation, NDVI, NDWI and the duration of the dryspell, the mandals prone for drought are being identified in near real time (Annonymous, 2018a). The temporal status of NDVI for kharif 2017-18 is shown in Fig 3.

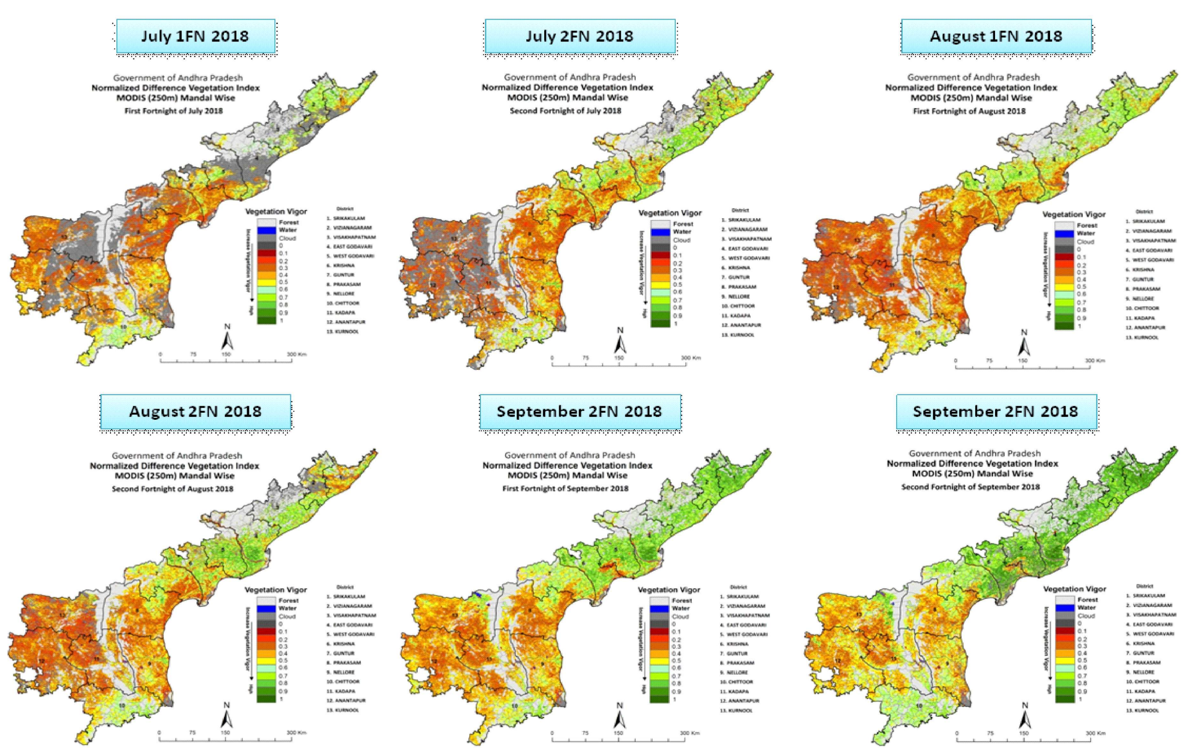

Fig 3. Spatial variations of NDVI (July - Sep 2018)

Soil Resource Mapping

The information on soils with regard to their nature, physical –chemical characteristics and spatial distribution is of paramount importance in formulating any optimal land use plan. Hitherto such information had been generated through traditional soil surveys using topographical sheets or cadastral maps as database. This approach is not only costly and cost- prohibitive but at the same time impractical for inaccessible terrain. The availability of aerial photographs and subsequent development of air photo interpretation techniques in the 1960's augmented the soil survey programmed substantially. With the advancement in the sensor technology, ground – based studies of the spectral reflectance characteristics were made to study the contribution of various soil parameters, namely soil texture, organic matter, iron oxide, soil moisture, etc. (Baumgardner *et al*. 1970; Stoner *et al*. 1980, Rao *et al*. 2001 Seghal *et al*. 1985, Dwivedi *et al*. 2000). The understanding of the spectral response pattern of soils, thus developed, was utilized in the analysis of space-borne multi-spectral data from Earth Resources Satellite (ERTS-1) later renamed as Land sat 1 , for generating information on soil resources.

The relationship between physiography of an area and soils has been widely recognized as the factors involved in the physiographic processes corresponds close to that of soil formation. The relation ship between landscape features and soil conditions makes possible for prediction about nature and distribution pattern of different kind of soils. For mapping soils identification of litho logy and physiography of the area is very important. For deriving the information on parent material, the spectral signature in the analog multi-spectral satellite data is correlated with the data available in the published geological maps. The correlation, thus observed is validated in the field. Information about the relief is available in the topographic maps and field observations, reasonably reliable data on terrain physiography could be generated. Having delineated broad physiographic units and the underlying parent material, the next step is to further categorize the physiographic units based on surface drainage pattern, soil erosion status and land use/ land cover. These features are manifested in the multi-spectral images as individual or combinations of various image elements namely; tone, texture, size, shape and association. Each subdivision of the broad physigraphic unit comprises a unique soil category. The soil mapping has been carried out at 1:50000 scale and the soil units were classified upto family as per the USDA taxonomic classification. The distribution of the soils is depicted in Fig-4 along with their extent.

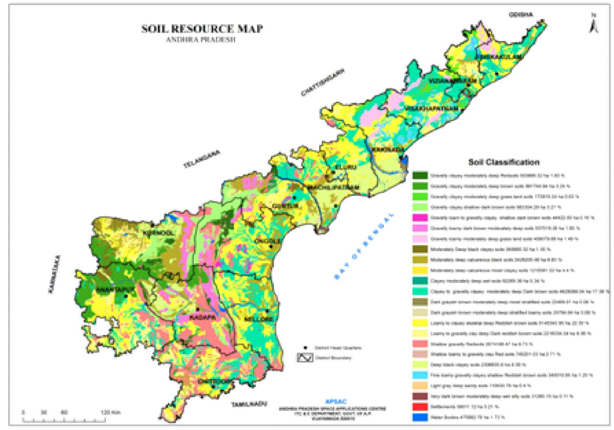

Fig 4. Spatial distribution of soil resources in the state of A.P.

Land Degradation Mapping and Monitoring

Land degradation, generally, signifies a loss or reduction of land productivity as a result of human activity (UNEP, 1993). The term 'land' includes land and local water resources, the land surface and its natural vegetation. Land degradation is a natural process, and is accelerated by human activities on land. The major processes of land degradation namely - Erosion, Waterlogging, Salinity, Areas affected by Industrial effluents and minig were mapped at 1:50000 scale.

The major category other than erosions is areas affected by salinity. Spaceborne spectral measurements with moderate spatial resolution have been used at operational level for deriving information on salt-affected soils and to study their temporal behaviour, which is useful for planning and monitoring reclamation programmes.(Singh.A.N. and Dwivedi.R.S, 1989, Dwivedi, R.S *et al*. 2001. Annonymous, 2018b).

Salt-affected soils with salt encrustation at the surface are, generally, smoother in image texture than non-saline surface and cause high reflectance in the visible and near infrared bands. Strongly saline-sodic

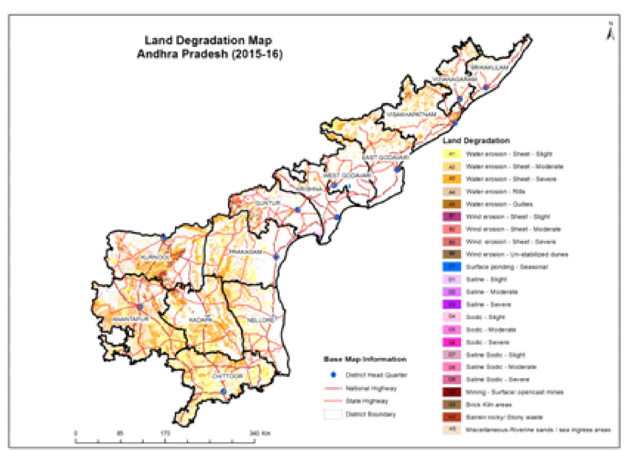

Fig 5. Land Degradation Status map of Andhra Pradesh(2015-16)

soils with pH, ECe and ESP values of>9.5, >30 and>40, respectively reflect more incident radiation (35-60%) as compared to moderately saline-sodic soils (pH:9.0-9.8, ECe:8.30 and ESP:15-40). The Fig-5 depicts the land degradation scenario as on the year 2015-16.

Soil Fertillity Mapping

The soil fertility parameters that can be addressed with satellite data indices are soil mineralogy, organic carbon status and nitrogen. The plant nitrogen levels had a direct effect on the cholorophyll componenet that can be detected with the optical remote sensing region of 400 -900 nm region. The full potential of the hyperspectral data for identificationof macro and micro nutrients is yet to be explored. Few case studies have reported the relation between the narrow spectral bands and the micronutrients (Fe, Mn, Zn, Cu) levels. The field data coupled with geo-statistics brings out the spatial variability of nutrients and an example of Potassium is shown below in Fig 6. Further, the methodology for state wide mapping of major and micro nutrient using the soil health card information and geo-statistics is under development.

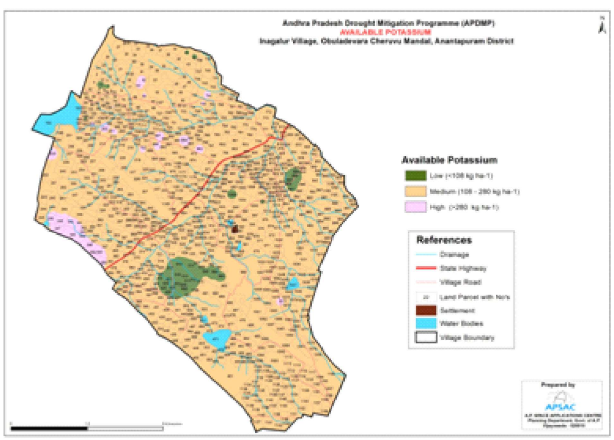

Fig 6. Spatial variability of Potassium generated from grid sample overlaid with cadastral maps in Inagalur village, Anantapur dt., AP.

CONCLUSION

Satellite Remote sensing techniques are being operationally used to provide information on the spatial distribution of crops at different levels. Analysis of satellite data for crops along with the information on other natural resources in GIS environment provides valuable information towards sustainable agriculture. The continuous improvements in the satellite technology in terms of providing improved spatial and spectral resolutions and re-visit periods will greatly enhance the capabilities of mapping and monitoring of crop - type and condition, problematic soils and environmental pollution etc. The miniarization of sensors and their feasibility to place them on board UAV/Drones coupled with improved computational algorithms will enable farm level information generation in future.

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LITERATURE CITED

Annonymous 2018 Integrated Seasonal Condition Monitoring System Andhra Pradesh - Technical Report - APSAC - September 2018. (http://apsac.ap.gov.in:8090/downloads/Consolidated_Report_ Kharif _2018_ISMS _AP_v2.pdf)

Annonymous 2018 Land Degradation Report (2nd Cycle) using three seasons satellite of 2015-16: Andhra Pradesh. November, 2018 (http://apsac.ap.gov.in/downloads/ Land%20 degradation %2050K%20Report%202018.pdf)

Baumgardner M F, Kristof S J, Johannsen C J, and Zachery A L 1970 Effects of organic matter on the multispectral properties of soils . Proceedings of Indiana Academy of science, Vol. 79, pp. 413 – 422

Dadhwal V K 1999 Remote sensing and GIS for agricultural crop acreage and yield estimation, pp. 58-67, International Archives of Photogrammetry and Remote Sensing, XXXII, 7-W9, (ISPRS Commission VII/ WG 2 Symposium on Application of Remote Sensing and GIS for Sustainable Development), March 11, Dehradun, India.

Dwivedi R S, Ramana K V and Sreenivas K 2000 Mapping soil resources in part of Northern India using spaceborne multispectral data. Geocarto International. 15(1):77-82p

Dwivedi R S, Ramana K V, Thammappa S S and Singh A N 2001 The utility of IRS-1C LISS-III and PAN merged data for mapping salt-affected soils. Photogrammetric Engineering and Remote Sensing . 67(10):1167-1175p

Dwivedi R S, Ramana K V, Thammappa S S and Singh A N 2001 The utility of IRS-1C LISS-III and PAN merged data for mapping salt-affected soils. Photogrammetric Engineering and Remote Sensing . 67(10):1167-1175p

Navalgund R R, Parihar J S, Ajai and Nageshwar Rao P P 199 Crop inventory using remotely sensed data, Current Science, 61: 162–171.

Ramana K V, Srikanth P, Sesha Sai M V R, Annapurna G, Das P K, Ramani A V, Aparna N, Diwakar P G, Dadhwal V K and Singh K R P 2017 Multi-incidence angle RISAT-1 Hybrid Polarimetric SAR data for large area mapping of maize crop – a case study in Khagaria district, Bihar, India. International Journal of Remote Sensing Vol. 38, Iss. 20.

Rao B R M, Fyzee M A. Thammappa S S and K V Ramana 2001 Utility of space borne multispectral data for soil and land irrigability assessment – A case study from Southern part of India. Geocarto International Journal, Vol. 16 (2) pp31 – 36.

Sehgal J L, Sharma P K and Karale R L 1985 Soil resource inventory of Punjab using remote sensing technology. Proc. Of the sixth asian Conference on remote sensing, NRSA, Hyderabad, pp298-301.

Sesha Sai M V R, Ramana K V and Hebbar K R 2010 "Remote Sensing for Agricultural Applications" In Remote Sensing Applications – Compiled and Ed. P.S Roy, R.S.Dwivedi and D Vijayan. NRSC. p. 1-21

Singh A N and Dwivedi R S 1989 Delineation of salt affected soils through digital analysis of Landsat-MSS data. . International Journal of Remote Sensing.10 (1):83-92.

Stoner E R, Baumgardner M F, Weismiller R A, Biehl L I and Robinson B F 1980 Extension of laboratory measured soil spectra to field conditions. Soil science Soc. Am. J. 44: 572-574

U N E P 1993 Environmental report 1993-1994. Blackwell Oxford, U.S.A, Cambridge, UK.

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