Geographic information systems Application in Natural Resource Management

Dr Mrs Sadhna Tyagi
Associate Professor and Head Geography Department, CRA College, Sonepat, Haryana

Abstract-The socio-economic development of any country is based on natural resources. The natural resources are essential to the economy of the nation since they play a critical role in the provision of employment, they are a source of raw materials for various industries, act as the source of food and income, medicine as well as energy. Due to increase in population, these resources are over stretched often leading to resource depletion. Ultimately the depletion of natural resources has led to increase in the cost of living ,changes in weather pattern and decline in economic , social and cultural benefits that were accrued as a result of their utilisation .It is essential for nations to learn how to use these resources in sustainable manner to ensure that benefits are enjoyed in present as well as future generations There is need to prudently manage these delicate resources with the current trend in the advancement in the field of information technology, natural resources managers have now laid a lot of emphasis on the use of remote sensing and GIS technology in the management of natural resources,. These technologies provide a platform through which managers can generate informative data and the information that can be used to make sound decisions for sustainable development. This study is based on secondary data and information which includes research papers, reports, workshop outputs and information published in the websites of the related organizations .Thus, this paper presents an overview of the GIS and Remote Sensing applications in natural resources management and sustainable development.

INTRODUCTION

National Natural Resources Management System (NNRMS) is a national level inter-agency system for integrated natural resources management in the country. NNRMS supports the optimal utilization of country's natural resources by providing for a proper and systematic inventory of natural resources available using remote sensing data in conjunction with conventional data/techniques. In doing so, NNRMS adopts various advanced technologies of satellite and aerial remote sensing; Geographical Information Systems (GIS); precise Positioning Systems; database and networking infrastructure and advanced ground-based survey techniques.

Agriculture plays a vital role in every nation economy. It represents a substantial trading industry for an economically strong country. Production of food in a cost-effective manner is the essential goal of every farmer, large-scale farm manager and regional agricultural agency. Remote sensing and Geographic information system used to analyze and visualize agricultural environments has proved to be very beneficial to farming community as well as industry. It plays great role in agriculture throughout the world by helping farmers in increasing production, reducing costs and managing their land more efficiently. Geographic information systems (GIS) has been widely applied and been recognized as effective and powerful tool in detecting land cover and land use change. Using remote sensing and GIS are important to understand the health of crop, extent of infestation, potential yield and soil conditions. It applied to explore agricultural applications such as crop identification, area estimation, crop condition assessment, soil moisture estimation, yield estimation, agriculture water management, agro meteorological etc.

Applications of remote sensing in agriculture including major important things such as; biomass and yield estimation, vegetation vigor and drought stress monitoring, assessment of crop phenological development, crop acreage estimation and cropland mapping, mapping of disturbances and land use land cover changes in addition to precision agriculture and irrigation management. GIS based mapping application can help to identify location of crops growing across the country and to adapt different variables, monitor the health of individual crops, estimate yields from a given field, and maximize crop

production. By using land-use and primary food crop statistics, along with data collected by different tools including mobile devices able to identify areas in need and underlying causes of food insecurity, GIS is an instrumental in the efforts to end global hunger and it is an integral part of automated field operations.

Using data collected from remote sensors, and from sensors mounted directly on farm machinery, farmers have improved decision-making capabilities for planning their cultivation to maximize yields. Previous crop yields, terrain specifics, organic matter content, pH, moisture, and nutrient levels of the soil all aid in proper preparation for precise farming. Combine harvesters equipped with GPS tracking units can measure crop yields along with crop quality values like plant water content and chlorophyll levels in real time and at the exact location in the field from which they are harvested. Rapidly emerging remote sensing and geospatial technology can play vital role for crop growth monitoring, identification and management of different types of stresses, regional yield estimations, to sustain the natural resources and agricultural productivity.

GIS APPLICATION IN AGRICULTURE

Crop inventory Remote sensing (RS) and Geographical Information System (GIS) play a crucial role for identification of crops and areas where changes in cropping patterns and useful tool to carry out crop surveys and mapping. Reliable and timely information on types of crops grown, their area and expected yield is importance for government for agriculturally based country. The spectral information is the important aspect of remote sensing data for crop modeling and it is strongly related with canopy parameters which are the representative of crop health and crop growth stages. Crop-specific maps created by combining satellite image, survey data and provide the layout of the land and owners (farmers) which are helpful to agribusinesses such as seed and fertilizer companies. The science of remote sensing can play a significant role in inventorying data base on different crops. Several studies using aerial photographs and digital image processing techniques have been reported in literature. It helps in reducing the amount of the field data to be collected and provides higher precision of the estimate.

Table Major Fields and Areas of GIS/RS Applications

Major Fields	Area of GIS/Remote sensing application
Land Resources	Land use planning, land inventories, land survey, land use and land cover mapping
Agricultural Resources	Agricultural planning and management, National Agro-Ecological Zone (AEZ) database, soil resources database, soil survey, soil data analysis, characterization of soil, soil erosion assessment and prediction, climate change impact on agriculture
Forest Resources	Planning and management, forest inventory, afforestation, climate change impact on forests
Water Resources	Water resources management, watershed analysis, fisheries resources development planning, river bank erosion and accretion, monitoring morphological changes and hydrology of rivers, navigation and dredging, construction and maintenance of embankments, flood forecasting and management, water pollution.
Coastal zone resources	Management and development planning, land erosion, construction and maintenance of embankments, salinity, water logging, shrimp culture, marine fisheries, Sundarban mangrove forest, coastal afforestation, sea level rise

ANALYSIS OF CROP YIELD, DAMAGED CROP REGION AND FORECASTING

Moisture stress and flood is a common occurrence in rain fed areas to damage crops, particularly rice growing regions. Different information on crop yield is an important input for production estimation. Every crop genotype has certain yield potential, which can be achieved in experimental field with optimal conditions. However, in the real world, the crop yield is conditioned by various parameters like soil, weather and cultivation practices, like date of sowing, irrigation and fertilizer. Crop yield is also influenced by biotic stresses like disease and pest. Satellite based remote sensing provides a suitable alternative for crop condition and yield assessment/forecasting, as it gives a timely, accurate, synoptic and objective estimation of various crop parameters. Remote sensing data has one of an important tool for yield modeling.

The crop vigor is an indication of crop yield. It can be assessed using vegetation indices derived from different parts of the spectrum. Plant growth simulation models have been used for monitoring crop growth, health and predicting yield. However, their use in large areas has been limited because most plant growth models were developed at the field scales. Synthetic Aperture Radar technology integrated with crop modeling approach to estimate and forecast yield [6]. Crop health condition and identification can be detected with remote sensing data by estimating the loss of leaf area. The symptoms of pest attacks usually cause the break-down of chlorophyll, and one can identify the reduction of chlorophyll concentration in the plants through remote sensing.

NUTRIENT AND WATER STRESS

Plants require water, sunlight and adequate nutrients for proper growth and vitality. In plant cell and tissue development macronutrients acquired in greater amount than micronutrient as fundamental substances. One of the most important fields where we can opt for application of remote sensing and GIS through the application of precision farming is nutrient and water stress management. Detecting nutrient stresses using remote sensing and GIS are important in site specific nutrient management and thereby can reduce the cost of cultivation as well as increase the fertilizer use efficiency. In the arid regions, judicious use of water can be possible through adaptation of precision technologies. For example, drip irrigation coupled with information from remotely sensed data such canopy temperature difference can be used to increase the water use efficiency by reducing the runoff and percolation losses.

By using multispectral and hyperspectral image nutrient deficiency is detected. Spectral reflectance measurements can help to select wavelengths sensitive to different types of nutrient and water stress. Detection of crop water stress is important for efficient irrigation water management. Vegetation water stress by using satellite monitoring is important for precision agriculture, timing of irrigation to ensure crops will not grieve from water stress and produce yield under limited water conditions. Satellite data has potential to provide spatial and temporal dynamics of crop growth conditions under water stress and its impact over productivity.

FLOOD MONITORING

Remote sensing technology allows measurements particularly from space to be obtained over spatial scales much larger than may be covered by field-based instruments and methods. Satellite data of inundation have been used to gather information about flooding across different temporal and spatial scales, especially in the form of flooded area. Automated spacecraft technology has reduced the time to detect and react to flood events in a few hours. using satellite image of floods are important to demonstrate the potential and to improve our understanding of flood processes and even speculated on the value. It is possible to increase the spatial coverage of river discharge estimations globally by using remote sensing approach, several surface water hydraulic characteristics of large rivers can be measured or evaluated from remote-sensing data, which include average river width over certain reach length, water surface slope, water surface elevation and channel morphology.

Hydrological data assimilation and modeling through river flow measurements are important in flood forecasting and other water resource management issues. Observations of river, precipitation and surface topography into early warning systems by employing satellite microwave sensors to gauge discharge from rivers by measuring changes in river widths and satellite based estimates of rainfall to improve warning systems. Optimization methods were also used to minimize discrepancies between simulations and observations of flood extent fields to estimate river discharge. By using remotely sensing information, estimation of spatial variability in evapo-transpiration is possible over a wide area coupled with surface energy balance algorithms. The energy emitted from cropped area temperature of most plant leaves are mediated by soil water and crop evapotranspiration.

LAND USE AND LAND COVER

Land use/ land cover mapping involves identifying surface features at various scales and their hierarchical classification and it play a major role in the study of global change. Human activity causes environmental problems resulted in deforestation, biodiversity loss, global warming largely affects land use / land cover. Therefore, critical input for decision-making of environmental management and planning the future

can be provided by available data on land use /land cover. Growing population and increasing socio-economic results unplanned and uncontrolled changes in land use /land cover. The land use /land cover alterations are generally caused by mismanagement of agricultural, range and forest lands which lead to severe environmental problems such as floods, landslides etc. Pixel by pixel change detection comparison technique was applied to the Land use\land cover maps derived from satellite imagery. Surface features existing naturally (forests, hills, rivers, etc.) are termed as land cover whereas features modified by human beings are classified as land use (urban, rural settlement, canal, orchards, etc.). Land use and land cover mapping has always remained very important in all geographical studies as it composed of basic information of feature existing on surface along with their information on area, location, shape and pattern.

Digital detection is the process that are essential to identify variation associated with land use and land cover properties throughout geo-registered multi temporal remote sensing data. Remote sensing and GIS have extensively used in preparing land use and land cover information of an area. So, it is better than manual surveys of extensive regions in terms of cost, accuracy and manual errors. In addition imagery or aerial photographs capture synoptic view of an area; hence nothing can be remained unobserved while in surveys there are ample chances of negligence of some features, satellite imaginaries can be acquired at some interval while surveys can't be conducted regularly or over a short period monitoring of surface features or phenomena (floods, deforestations, forest fires, etc.) become easy and cost effective, different geographical, socio-economical aspects can be analyzed by incorporation of one information with other. Digital detection is the changes related with land use and land cover properties with reference to geo-registered multi temporal remote sensing data. Remotely sensed data and field observations collaboration can accomplish land cover classification, change detection, faster and cheaper than either alone.

AGRO METROLOGICAL APPLICATION

Agriculture highly influenced by climatic and metrological phenomena. The metrological data are collected by different spatial network of point station observation. Conventional agro-metrological techniques have severe limitation to use their data for real time agricultural monitoring and yield forecasting. Satellite metrology has allowed obtaining accurate and frequent measurements of several basic agro metrological parameters (example surface albedo, surface temperature, evapotranspiration, solar radiation, rain fall). The agro meteorology inputs were predominantly significant rainfall at fortnightly intervals, minimum and maximum temperatures etc. that would form part of correlation weighted regression model.

Geostationary satellites remote-sensing of weather and climate is regarded as the single most significant breakthrough for monitoring the Earth's vegetation, weather and climate in the last quarter of a century, these satellites collect data on ocean temperature and terrestrial vegetation. Information on meteorology and vegetation are the two major important inputs into agricultural meteorology. Two broad meteorological satellite types are in common use. One is the Geosynchronous Meteorological Satellite (GMS), which orbit at an altitude of some 36 000km and the second is polar orbiting satellite which placed on a low Earth orbit of 750km.

WATER RESOURCE MANAGEMENT

In the recent decades, the scarcity of water resources is being experienced at global and regional level and, therefore, needs to be managed judiciously by applying the state-of-theart technologies. Remote sensing is one of the effective tools for assessing and monitoring the water resources. Hyperspectral remote sensing is emerging as the more in-depth means of investigating spatial, spectral and temporal variations in order to derive more accurate estimates of information required for water resource applications. The advent of microwave remote sensing has made possible the assessment of soil moisture availability from remote sensing data. One of the most valuable natural resources is groundwater, which supports human health, ecological diversity and economic development. Overexploitation of this vital resource is threatening our ecosystems and the life of future generations.

The applications of Geographic information system (GIS) and remote sensing (RS) technologies in

groundwater hydrology have received cursor treatment. A good understanding of the geographical space and related spatial information like water sources, watershed, terrain surface, land use, land cover, rainfall, temperature, humidity, soil condition and composition, geology, conditions on the atmosphere, human activities, environmental data, etc. are important for water management. Geographic information system (GIS) and remote sensing (RS) technologies also describes the problems, significance, and sustainable management of groundwater and freshwater . The integration of geographic information system and remote sensing techniques has enabled assessments of aquatic vegetation growth, salt marsh quality and floodplain disturbances over time and provided careful consideration is given to source materials and database construction.

CONCLUSION

India faces many problems in management of natural and man-made resources. So the applications of GIS and Remote Sensing tools have become inevitable. Even International Development partners are encouraging the application of GIS and Remote Sensing in the applications in all spheres of natural resource management. Most of the organizations (government and private) are using GIS and Remote Sensing in the management of the resources from the past few years, and with the advancement of technology the application in the other fields is also going to increase with time.

REFERENCES

[1] Kumar N, Yamaç SS, Velmurugan A (2015) Applications of Remote Sensing and GIS in Natural Resource Management 20(1): 1-6.

[2] Atzberger C (2013) Advances in Remote Sensing of Agriculture: Context Description, Existing Operational Monitoring Systems and Major Information Needs. Remote Sens 5(2): 949-981.

[3] Kingra PK, Majumder D, Chandra B, Viswavidyalaya K, Singh SP (2016) Application of Remote Sensing and GIS in Agriculture and Natural Resource Management Under Changing Climatic Conditions. Agricultural Research Journal 53(3): 295-302.

[4] Profile SEE (2016) Remote Sensing and GIS Applications in Agriculture Some of the authors of this publication are also working on these related projects: Assessment of Climate change effect on mustard yield in western Haryana View project Computation of agro-meteorological indices in Barley cultivars under different growing environments at Hisar View project.

[5] Dadhwal VK Applications S, Isro C Crop growth and productivity monitoring and simulation using remote sensing and GIS. Satellite Remote Sensing and GIS Applications in Agricultural Meteorology pp. 263-289.

[6] Setiyono T, Nelson A, Holecz F (2014) Remote Sensing based Crop Yield Monitoring and Forecasting.

[7] Mee CY, Balasundram SK, Hanif AHM (2017) Detecting and monitoring plant nutrient stress using remote sensing approaches: A review. Asian Journal of Plant Sciences 16(1): 1-8.

[8] Shanmugapriya P, Rathika S, Ramesh T, Janaki P (2019) Applications of Remote Sensing in Agriculture - A Review. Int J Curr Microbiol App Sci 8(1): 2270-2283.

[9] Schumann GJ, Brakenridge GR, Kettner AJ, Kashif R, Niebuhr E (2018) Assisting Flood Disaster Response with Earth Observation Data and Products: A Critical Assessment. Remote Sens 10(8): 1-19.

[10] Sun WC, Ishidaira H, Bastola S (2011) Towards improving river discharge estimation in ungauged basins: calibration of rainfall-runoff models based on satellite observations of river flow width at basin outlet. Hydrol Earth Syst Sci 14: 2011-2022.

[11] Acharya SM, Pawar SS, Wable NB (2018) Application of Remote Sensing & GIS in Agriculture. 6495(4): 63-65.

[12] Reis S (2008) Analyzing Land Use/Land Cover Changes Using Remote Sensing and GIS in Rize, North-East Turkey. Sensors 8(10): 6188-6202.

[13] Diallo Y, Hu G, Wen X (2009) Applications of Remote Sensing in Land Use / Land Cover Change Detection in Puer and Simao Counties, Yunnan Province. 5(4): 157-166.

[14] Of R (1994) Remote-Sensing and GIS Applications in Agrometeorology. pp. 1-35.

[15] Joshi C, Leeuw J De, Duren I C Van (2002) Remote Sensing and GIS Applications, (Graph 1).

[16] Huang Y, Lan Y, Hoffmann WC (2008) Use of Airborne Multi-Spectral Imagery in Pest Management Systems. Agricultural Engineering International: the CIGR Ejournal X: 1-14.
[17] Rani DS, Venkatesh MN, Naga C, Sri S, Kumar KA (2018) Remote Sensing as Pest Forecasting Model in Agriculture. Int J Curr Microbiol App Sci 7(3): 2680-2689.
[18] Welch R, Remillard M (1991) Remote sensing / GIS for water resource management applications in the southeast. pp. 282-284.