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Remote Sensing and GIS Application in Agriculture and Natural Resource Management

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Abstract

Agriculture plays a vital role in every nation economy every nation. It represents a substantial trading industry for an economically strong country. 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. In this paper I tried to overview application of remote sensing and geographic information system in agriculture and natural resource management. Reliable and timely information on types of crops grown, their area and expected yield is importance for government for agriculturally based country. Applications of different remote sensing techniques are important for crop monitoring, crop condition assessment and yield estimation for sustainability of agriculture and natural resources. 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. Remote sensing and GIS can also be used very effectively in land use / land cover analysis as well as damage assessment because of drought, floods and other extreme weather events. Information on meteorology and vegetation are the two major important inputs into agricultural meteorology Applications of remote sensing technologies are important and effective method to identify pest-infested and disease. It is one of the effective tools for assessing and monitoring the water resources..

Keywords: Crop inventory, Flood monitoring, Nutrient, Geographical information system, Remote sensing

Introduction

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 [1]. 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 [2]. 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 [3].

GIS and Remote Sensing 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 [4]. 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 [3].

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 [5].

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 [7]. 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 [8]. 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 [7]. 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 [9]. 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 [10].

Hydrological data assimilation and modeling through river flow measurements are important in flood forecasting and

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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 [11]. 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 evapo-transpiration.

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 [12]. 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 [10]. 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 [13].

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 [14]. 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.

Pest infestation

Applications of remote sensing technologies are important and effective method to identify pest- infested, diseased and detecting, mapping, monitor Invaders. Spatial heterogeneity complicates the trends of biological invasion study, however, with its broad view remote sensing has the potential to deliver the relevant information [15]. Remote sensing applications provide data has important for detecting and mapping defoliation, characterize pattern disturbances and etc. The remote sensing application in monitoring and assessing insect defoliation has been used to relate variation in spectral responses to chlorosis, yellowing of leaves and foliage reduction over a given time period if these differences can be correlated, classified and interpreted.

Airborne remote sensing with different flight altitudes can achieve different spatial resolutions. Ground-based platforms are typically used in pest management, crop disease, detection of insect damage to crops along with weed infestation and provides valuable information for management planning and decision making [16]. Colour infrared aerial photography with conventional camera have been used effectively to delineate damage caused by several serious pests [17].

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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-the-art 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 (M. Kumar, Kharagpur, & Burchart, 2006). 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 [18].

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