__Mini-review Article__

A REVIEW ON RECENT ADVANCES IN AGRICULTURE AND AGROFORESTRY WITH GPS AND GIS

ABSTRACT

Various researchers, agronomists, scientists, and engineers utilize a variety of technologies every year to boost agricultural productivity at a low cost, but this has a negative influence on the environment. Precision agriculture is the study of the use of technology to enhance agricultural operations in comparison to conventional agricultural methods and lessen negative environmental impacts. Precision agriculture depends heavily on remote sensing technology, and this technology's use in precision agriculture opens up new possibilities for raising agricultural standards. The global positioning system (GPS) enables the geographic Latitude and Longitude data of field data (slope, aspect, nutrients, and yield). Since it has the ability to continuously determine and record the right position, it can build a bigger database for the user. A geographic information system (GIS) that can handle and store these data is needed for further investigation. Despite the limited spatial extent, isolation, and higher structural and functional complexity of agroforestry, the recent development of geospatial technologies, as well as the free availability of spatial data and software, can offer new insights into assessing resources, making decisions, and developing policies. This review has covered the current uses of geospatial technology, along with their restrictions and limits, as well as prospective future uses for agroforestry. This review discusses GPS, GIS, and remote sensing technology and explains how they might be used in precision agriculture and agroforestry.

Keywords: Precision agriculture, Environment, Agroforestry, Remote Sensing, GIS and GPS

1. INTRODUCTION

The world population is expected to reach 10.0 billion people in 2050 as it continues to grow [1]. Everyone cares about the production of agricultural products, and every farmer, large-scale farm manager, and regional agricultural agency strives to produce food as cheaply as possible. A farmer needs to be well-informed in order to be effective, and this includes having the information and understanding necessary to create a workable plan for farming operations. He will be able to use these instruments to better understand the state of his crop, the severity of pest damage or stress, the prospective yield, and the soil's characteristics. Due to the fact that yield estimates for all products-both quantity and quality—control pricing and global trading, commodity brokers are also keenly interested in how well farms are producing. Precision agriculture is the study of the use of technology to produce agricultural products that meet global food demand more efficiently than conventional agricultural methods while also having a lower negative environmental impact. The global positioning system, geographic information systems, and remote sensing are just a few of the technological elements that make up the integrated information and agricultural management system known as precision agriculture. Precision farming aims to reduce the negative impacts of chemical loading on the environment while increasing overall farm output efficiency. Precision farming seeks to maximize the effectiveness of agricultural inputs within restricted sections of the farm field by collecting and analyzing data on the variability of soil and crop conditions. The variability within the field must be under control if we are to achieve this efficiency goal. In order to make informed crop management decisions, precision farming involves gathering timely and accurate information on soil and crop conditions. The perception of the land from which farmers and agribusinesses derive their income is currently changing as a result of precision agriculture. Precision agriculture entails acquiring timely geospatial data on the requirements of the soil, plants, and animals as well as prescribing and applying site-specific treatments in order to maximise agricultural productivity and protect the environment. Remote sensing technologies are actively utilised in precision agriculture, and their significance is increasing constantly. Remote sensing using space-based sensors is the greatest way to obtain repeated (varying from minutes to days) and synoptic (with local to regional coverage) observations on the spectral behaviour of crops as well as their growing environment, such as soil and atmosphere. This information may be used for a wide range of applications, such as crop inventory, crop production estimates, drought and flood damage assessment, range and irrigated land monitoring and management. The use of RS data for crop inventory in India is covered in this review. Before discussing the Indian experience, a quick summary of the traditional methods of agricultural acreage/estimation in India and the justification for using RS for crop inventory is made. According to Sharma et al.,[2] the agroforestry system (AFS) is a well-known land use system that unites agriculture and forestry by generating a more integrated, diverse, productive, profitable, healthy, and sustainable land use system than the agriculture system. It has the potential to significantly improve a variety of social, environmental, and economic issues, including farm productivity and incomes [3], livelihood security [4], soil fertility decline [5], water conservation [6], climate change risk and variability[7], maintaining the atmospheric environment, and water quality[8], severe weather, greenhouse gas emissions[9], improvement of the microclimate [10], weed management [11], and provision of environmental values [12].

Excluding this widespread land use effectively limits landscape improvements, especially in degraded and wastelands with significant potential for climate change prevention and mitigation, which in turn restrains their economic growth [13]. Additionally, these databases are underutilized in SDSS and suitability assessment even though computer-based AFS tree selection database research started before 1991 [14]. Furthermore, nothing is known about the data sources and processing employed to determine the scope and organisation of AFS as well as a number of other applications. Additionally, there hasn't been much research done on how geospatial technologies are used in AFS, covering their current status and future prospects. With the help of IRS III digital data [15], prepared a Rabi (winter) crop inventory for a portion of the Solani River basin (parts of Haridwar and Saharanpur districts, Uttar Pradesh, India). Many academics and agronomists have made significant contributions to the field of crop inventory, such as [16], who forecasted wheat crop yield and production for the 1998–1999 Rabi season using remote sensing and agrometeorological data. Three different varieties of wheat crops, namely wheat-1 (high vigor-normal sown), wheat-2 (mid vigor-late sown), and wheat-3 (low vigor-very late sown), have been found and distinguished from one another using supervised maximum likelihood classification. Based on trend analysis of historical crop yield (actual yield), spectral vegetation indices (RVI and NDVI), agrometeorological parameters (ET max and TD), and historical crop yield (actual yield) data, linear and multiple linear regression models were used to forecast wheat crop production in this study. Singh et al., [17] evaluated the classification and accuracy of wheat crops over central India using digital data from four multi-spectral sensors with different spatial resolutions and spectral channels: LISS-III, LISS-II, LISS-I, and WiFS. These sensors were acquired from two Indian remote sensing satellite platforms (IRS- 1B, IRS-IC). For crop production and corn monitoring [18], used optical and RADARSAT-2 satellite pictures. The main goal of the paper was to establish indicators of crop condition and generate estimates for crop yield using RADARSAT-2 data and optical data to identify cultivated areas and monitor crop condition. From RADARSAT-2 data, corn polarisation signatures were obtained and connected to leaf area index (LAI), photosynthetic active radiation (PAR), crop characteristics, and vegetation indices. In order to anticipate agricultural production for the province of Hubei [19], built crop yield estimation models utilising remote sensing data. First, the productivity zoning approach was used to choose the simulated counties, and then the historical trend was examined to determine the fluctuated yield. Second, the correlation coefficient between the remote sensing index and the fluctuating yield was determined. Then, to construct basic linear regression models to estimate crop yield, the indicator with the highest correlation coefficient was chosen as the important factor. By contrasting the actual crop yield from statistic data with that from the outcomes of the modelling, the error analysis was finally processed. The precision error ranges from -14.38% to 11.31%, according to the results, and the R2 coefficient of determination is 0.872. In the majority of Hubei Province, the findings computed using this method are accurate enough to be used for agricultural yield estimation. With the help of synchronised Landsat and SPOT reflectance data for spring wheat, barley, and oats [20], recently worked on modelling cereal yield in Finland using optical and radar remote sensing. Their study's specific objective was to calibrate optical VGI models (Models I–IV) and validate baseline yield estimates (yb) by comparing them to yield statistics from the MAFF inventory, reflectance data from Landsat, SPOT, NOAA, and the official crop model of MTT Agrifood Research Finland, the CropWatN dynamic crop model. As a starting point, data from trials with an average yield between 1996 and 2006 were used. Finally, employing VGI models to calculate cereal nonpotential baseline yield levels (yb) in growth zones (I-IV) as a yield inventory tool for the annual MAFF inventory statistic.

2. GIS IN AGRICULTURE

A powerful collection of tools, known as GIS, may be used to collect, save, access at any time, modify, and display geographical data from the real world for a variety of purposes [21]. The use of GIS in agriculture is revolutionising planning and management. The applications of remote sensing-based analysis have been greatly expanded by geographic information system (GIS) technology. GIS allows for the overlay of human pressure indices, actual physiognomy, and environmental conditions. Agriculture has a significant role in the economies of both developed and developing countries. Using satellite-based earth observation data, crop inventory was estimated and examined in this study. The grain market became less unpredictable as harvest estimates became more accurate and reliable. The ability of GIS to assess and visualise agricultural landscapes and work processes has shown to be highly beneficial for anyone working in the agriculture business. A farm's production and profitability depend on keeping its inputs and outputs in balance. Topography or other environmental elements are typically represented as layers of spatial data. By combining various map and satellite data sources, GIS technology is rapidly being utilised to develop models that replicate the interactions of complex natural systems. GIS allows for the creation of graphics, animations, and other cartographic products in addition to maps. GIS is playing a more and bigger role in agricultural production all over the world, from mobile GIS in the field to the scientific analysis of production data in the farm manager's office, in order to help farmers, increase productivity, decrease costs, and manage their land more efficiently. While it is hard to completely regulate natural inputs in agriculture, GIS applications including crop yield estimates, evaluations of soil supplements, and erosion detection and correction may be able to help us comprehend and manage them more effectively. to calculate north China's agriculture output. [22], a model of the ecosystem and remotely sensed data were integrated. In his study, he offers a technique for estimating agricultural productivity in North China that blends an ecosystem model with remotely sensed data (the MODIS LAI product) (the spatial EPIC model). Traditional crop models are frequently employed in conjunction with site-specific productivity simulations. The spatial crop model developed in this work uses the Environmental Policy Integrated Climate (EPIC) model and Geographical Information System (GIS) data to simulate regional agricultural production. Bingfng and Chenglin completed the Crop Growth Monitor System for the AVHRR and VGT Data Coupling. [23].

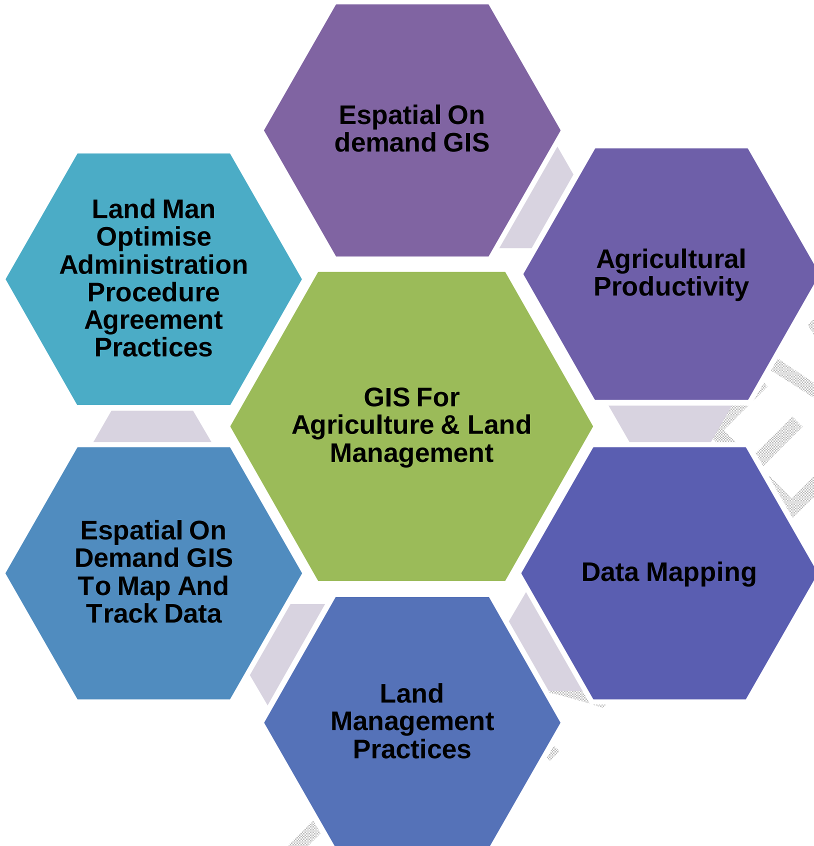

Fig. 1. Uses of GIS For Agriculture and Land Management.

3. GPS IN AGRICULTURE

The global positioning system has the ability to record the in-field variations as regionally encoded data (GPS). It is possible to determine and continuously record the proper location. With this technology, agricultural fields and places are taken into consideration in more detail than in the past, giving the user access to a larger database. Correct yield data can only be provided in the places where GPS position monitoring has been done. The yield monitor data's geographical coordinates are given by GPS receivers collaborating with them. Using this, yield maps for each field may be produced. By combining data from different satellites and referencing it with GPS, field management strategies for chemical application, cultivation, and harvest may be created. [24].

Precision agriculture, also known as site-specific farming, was made possible by fusing the Global Positioning System (GPS) with geographic information systems (GIS). Thanks to these technologies' capacity to link real-time data collection with accurate position data, large amounts of geographic data may be processed and evaluated efficiently. For farm planning, field mapping, soil sampling, tractor navigation, crop scouting, variable rate applications, and yield mapping, GPS-based technologies are utilised in precision farming. All thanks to GPS, farmers can now operate equipment appropriately in poor visibility field conditions including rain, dust, fog, and darkness

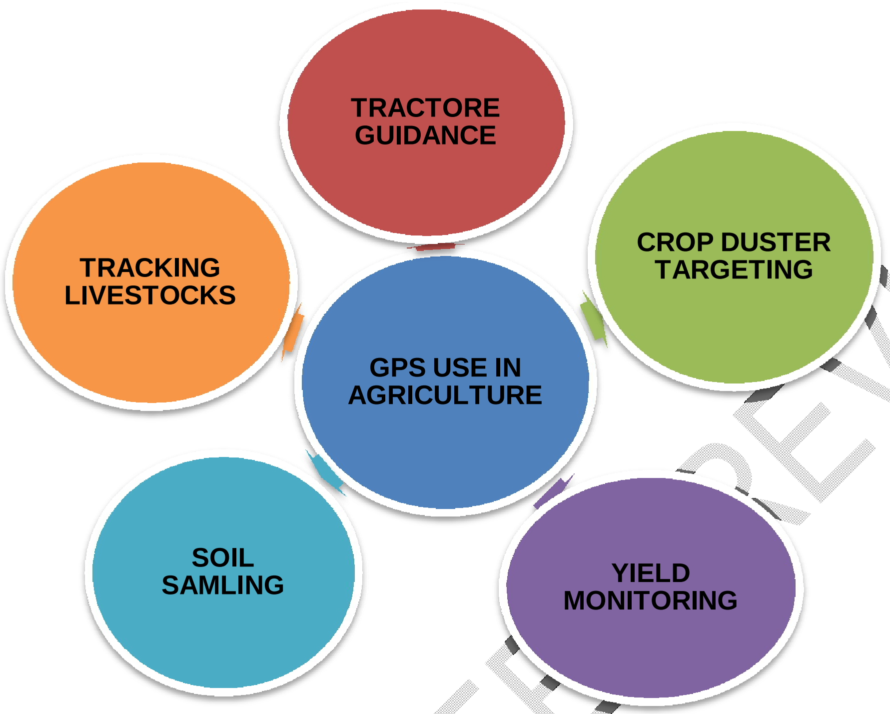

Fig. 2. Uses of Global Positioning System (GPS) in agriculture.

4. REMOTE SENSING AND GIS IN AGROFORESTRY

Natural resource management heavily relies on mapping and resource inventory, and the need for current geospatial data for management, research, and almost real-time decision-making is growing exponentially. This is largely due to the free accessibility and availability of satellite data products as well as geospatial advancement. Geospatial technologies are crucial for AFS and have a lot of promise to offer new perspectives and opportunities for scaling up AFS interventions [25]. AFS characterisation, including species distribution and density patterns, and change in land use patterns at any landscape-level with regard to location, altitude, and topography, are all part of the initial use of the RS-GIS in AFS. For the future development of supporting policies, planning [26], management strategy [27], An accurate and impartial estimation of the magnitude, geographic distribution patterns, and characterisation of AFS are crucial for maximising its contribution to the nation's climate change goals or intended nationally determined contributions (INDCs) under the UNFCCC. [28]. In addition, the AFS extent offers the chance to pinpoint agricultural yield variations [29]. Only if the AFS region is there will even the CS potential of the AFS have any significance [30]. RS is a brand-new, useful, and affordable approach for evaluating and tracking biomass, carbon stock, CS, and related changes of AFS [31];[32] while reducing the uncertainty.

In addition, GIS is crucial for understanding the relationships between physical, biological, and biochemical components as well as for development [33]. It is also crucial for evaluating, monitoring, mapping, and quantifying the socioeconomic value of AFS services [34]. Through the AFS suitability analysis or spatial decision support system, there are potential to adopt various AFS practises in the regions lacking in AFS practises [26]. (SDSS). However, despite the fact that computer-based AFS tree selection database research had started before 1991 [14], SDSS and suitability analyses do not frequently use these databases. A crucial step in helping policymakers decide whether and where to promote AFS is the large-scale scientific evaluation of the land for AFS that combines spatial information from various parameters using GIS [35]. Another important step is the planning of various AFS projects at various scales to achieve the goal of the National AFS policy 2014 [36]. In particular, the spatial decision support system (SDSS) connects the gap and offers a trustworthy resource for wise species choice and subsequent planning [33]. Unmanned aerial vehicle (UAV) platforms have just entered the mainstream and help with extensive mapping and monitoring of systems, particularly complex systems like AFS [37].

5. CONCLUSION

Precision farming allows for accurate tracking and modification of production. Precision farming both makes and increases the difficulty of farm planning. There are many more map data that may be used to decide on long-term crop planning, erosion controls, salinity controls, and evaluation of tillage techniques. But as data volume grows, so does the amount of labour required to analyse it, increasing the risk of incorrect interpretation. Precision farmers are likely to work more closely with a variety of specialists in the fields of computer, GPS, and agriculture. So, GIS, GPS, and remote sensing are the core technologies in precision agriculture. As RS and GIS technology advanced over time, a variety of platforms (satellites and UAVs) and sensor options for gathering AFS data were available. The intrinsic spatial complexity of the AFS may be rapidly and effectively mapped, monitored, and captured in any landscape thanks to geospatial technology (multispectral, hyperspectral, microwave, thermal). Researchers will soon be able to fully utilise this cutting-edge and new technology by gaining access to free software (QGIS, SNAP) and datasets (Landsat, Sentinel), or even by developing these resources expressly for AFS

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