Eco. Env. & Cons. 28 (October Suppl. Issue) : 2022; pp. (S266-S271)
Copyright@ EM International
ISSN 0971–765X

DOI No.: http://doi.org/10.53550/EEC.2022.v28i06s.045

A Short Review on the Emerging Platform of Forest Informatics

Samanpreet Singh, Gurdeep Singh and Wineet Chawla

Baba Farid College, Bathinda (P.B.), India

(Received 1 February, 2022; Accepted 28 March, 2022)

ABSTRACT

Forest informatics, which integrates forestry with information technology, may be viewed as having a broader scope and potential. The scope of forest informatics in the forestry industry is presented in this article. The most significant developments in the use of informatics in forestry are discussed in this review, together with their prospective benefits and difficulties for forest management and planning. This will shed light on the forestry sector's growth via the use of information technology. A variety of intrinsic and connected issues of forest informatics in many areas and sectors are examined.

***Key words**: Natural, Technology, Management, Information, Sectors*

Introduction

Forest informatics is an interdisciplinary scientific field that "harnesses the power of computational and information technologies to organize and analyze biological data from research collections, remote sensing, experiments, modeling, database searches and instrumentation and deliver them to users throughout the world" (Shanmughavel and Kannaiyan, 2008). Mathematical modeling software, decision support systems, statistical and algorithmic analysis tools, global positioning systems, geographic data systems, and shared databases are examples of computational and information management technologies used to support decision-making activities in the field of forest informatics (Vogt *et al.*, 2007). Forestry informatics can assist in the resolution of problems and tasks such as the calculation of wildfire risk indices, the optimization of harvest scheduling and crew assignment, the evaluation of forestry management guidelines, the treatment of log bucking problems, and the development and optimization of mathematical algorithms for ecological modeling. Various contemporary technologies, such as remote sensing technology, geographic information systems, and global positioning systems, aid in delivering more exact forestry data. Remote sensing technology provides a suitable and cost-effective means of monitoring highly scattered natural resources such as forests. While giving a synoptic picture of a wide area, it also collects biophysical characteristics of land features using reflected electro-magnetic radiations, which are commonly referred to as fingerprints in remote sensing terminology (Sandhya and Mudaliar, 2012). Geographic information system (GIS) offers us with new ways to broaden the scope and improve the accuracy of our investigation of tree diversity change through several inherent capabilities (Iliadis and Betsidou, 2014 and Jansen *et al.*, 2002).

Various contemporary technologies, such as remote sensing, Geographic Information System (GIS), and Global Positioning System (GPS), can be used to improve forest management practices. Precision forestry practices, in line with the SFM (Sustainable forest management) philosophy, may be carried out with the help of these technologies. For example, in order to prepare for Forest Certification and practice sustainable forest management, the forest managers need more detailed, precise and recorded information on forest resources, landscape characteristics and qualities, which may be obtained via remote sensing and GIS tools.

Forest surveys, which include inventory evaluations and compartment maps, are essential for achieving long-term sustainable forest management planning goals. Using GPS technology, this can be done more accurately and conveniently. All of this has been part of precision forestry techniques.

Applications of GIS: Globally, the use of spatial data for forest resource management and planning is widely recognized. Geographic data, on the other hand, will be less useful if it cannot be converted into data that can be studied and comprehended in a systematic and timely manner. As a result, forestry-related geographical data must be transmitted and kept in a standard computer format, ideally in a GIS context.

Remote sensing in forestry: Remote sensing applications in forestry include mapping forest cover types (Khali, 1999), detecting forest fires, monitoring forests, measuring forest cover area, and identifying deforestation and forest degradation (Hussin, 2000). However, in order to accurately use the technology, ongoing research on many elements of remote sensing techniques for forestry applications employing alternative sensor systems (optical or microwave) is being performed. This is done in order to create the best remote sensing information technology for diverse forestry applications. The Forest Canopy Density model is one method for efficiently mapping forest conditions implementing remote sensing information (FCD Mapper). The International Tropical Timber Organization (ITTO) created FCD Mapper, a semi-expert system. Forest canopy density is used as an essential component in the model to characterize forest ecosystems. As a result, it is able to trace forest conditions over time using multi-temporal satellite images based on this model. The model employs Landsat TM data as its primary input, and the analysis focuses on four indices: the Advanced Vegetation Index (AVI), the Bare Soil Index (BI), the Thermal Index (TI), and the Shadow Index or Scaled Shadow Index (SI, SSI). These three variables are inextricably linked to forest conditions. The model produces a map of forest canopy density, which may indicate the degree of rehabilitation therapy necessary in a certain location. This is highly useful in the planning and implementation of any forest restoration endeavor.

Applications of GPS: Global Positioning System (GPS) is a radio navigation system positioned on satellites that provides 3-D positioning, mobility, and information of time. The GPS unit transmitter must recognize at least four satellites in order to obtain GPS co-ordinate readings. The more satellites that the transmitter recognizes, the more exact the readings. The usage of differential GPS (DGPS) can increase accuracy as well. DGPS's goal is to correct bias errors at one place by measuring bias errors at another known location. Corrections for each satellite signal were computed by a reference receiver, often known as a base station. Some of the feasible and advantageous GPS applications in forestry are tree position mapping, forest road survey, forest compartment border survey, ground truth activities (remote sensing), and resource inventory.

GIS: Its applications are categorized based on the degree to which they communicate with other financial and forest management systems. Data collection and maintenance, data viewing and query, map generation, and decision support systems are examples of these areas.

GIS for strategic planning and modeling: Drawing conclusions about how the future forest will seem in relation to various management actions is a component of forest management planning. This expertise is essential for nearly all aspects of management forecasting, particularly long-term wood and wildlife supplies. According to Kane (1997), GIS tracks both the numerical and geographic pattern of forest stands, linking the spatial database for planning models. It helps the manager to properly include both essential temporal and spatial components into the management planning process. Management may then estimate what the forest might seem like in the following 5, 10, 25, or 100 years, as in limitations of the inventory and model.

Production of maps: Foresters rely on a variety of maps to aid them with their daily responsibilities. Plantation maps are often used for location, but they may also include important information such as roads, rivers, compartment boundaries, plant types, and block size. Topography (contours), infrastructure, fire breaks, water points, neighbors, and conservation areas are some of the other variables that may be used in the map (Kane, 1997).

Management of fire: Another important management issue is the impact of fire on forest resources. Fire prevention, controlled burning, animal control, and post-fire recovery operations are illustrations of management activities. GIS modeling skills turn out to be very crucial in this situation. Forest fire managers have utilized GIS for meteorological condition mapping, fuel mapping, and fire danger grading. Forest fires have a considerable influence on wildlife, vegetation cover, air quality, plant flow, microclimate, and general climate (Chuvieco *et al.*, 1989). The loss of timber is obvious, as is the damage done to persons and property. Wildfires have the potential to devastate wildlife habitat and diminish the recreational value of the forest.

The potential to predict fire behavior after ignition was critical in controlling allowed burning operations. Fuel designs have been used to develop models for fire behavior that anticipate fire intensity depending on characteristics such as slope, elevation, cloud cover, wind speed, site exposure, relative humidity, temperature, and live and dead fuel moisture (Chuvieco *et al.*, 1989). These models, on the other hand, are not spatial and are often used to anticipate fire behavior across a large area. Forest fire models were tested with a raster-based GIS to enhance their sensitivity to geographical variation inside the park. Following the storing of input layers in the GIS, the mathematical modeling capabilities of the GIS, as well as selected lookup tables, were utilized to build different fuel and fire intensity models. Wells and McKinsey concluded that the GIS implementation of fire behavior models was useful in planning ignition patterns, locating potential control areas, and accommodating sensitive areas that would be adversely affected by high fire intensities by comparing expected fire behavior with actual burn conditions.

Harvest planning: Harvesting activities must be precisely planned in order to be carried out in accordance with best practices in forest management. Harvest planning operations include specifying felling directions, depots, extraction routes, and sensitive zones like as wetlands. Maps are a fundamental planning tool for these operations (Kane, 1997). Additional systematic harvest planning features employ maps to identify scheduled felling across a number of years, as well as to combine felling zones and extraction routes, allowing for more efficient use of harvesting equipment and other resources.

Resource management: According to Wulder and Franklin (2007) collecting forest inventory data and monitoring changes are important in managing forest operations. In addition, GIS may build on these operations by incorporating models to guide, for example, timber harvesting, silviculture, and fire control activities, as well as forecast fuel wood and other resource supplies. Other issues, such as preserving wildlife habitat, ensuring recreational opportunities, and minimizing the aesthetic impacts of harvesting, are becoming increasingly essential. Some examples address single-management issues, such as wood production, while others demonstrate how GIS may be used to address complex management issues, such as timber production paired with habitat conservation.

Previous findings: As a result, it is essential to maintain plant diversity and determine its current status. Index assessments such as Shannon-Weiner, Margalef, and others are local metrics that are difficult to measure at a larger scale. Therefore, the incorporation of Remote Sensing (RS) and Geographic Information System (GIS) technology has offered a method of characterizing such estimates on a larger scale. In this work, an attempt was made not only to assess various indices, but also to use the RS-GIS tool to interpolate one of such indices over a larger territory. The resulting geographical display of diversity indices at the village level can help forest planners. Furthermore, the species diversity map generated using the kriging technique aided in understanding the diversity issue on a broader scale. At an 85 percent confidence level, the accuracy test indicated that the produced outputs were 65-75 percent correct (Sandhya and Mudaliar, 2012).

Environmental Informatics is a new multidisciplinary practice area that is responsible for the use and use of information technology in nature, the environment, and ecology. Other disciplines, such as geology, forestry, oceanography, agriculture, geography, climatology, and so on, are key stakeholders in environmental informatics. The environment informatics links both informational and environmental sciences for the entire natural processes using language that is familiar to both computers and people. There are several opportunities to teach Environmental Informatics as an academic subject due to its broad scope and applications. Professionals in forestry, geography and geology, agriculture, crops and horticulture, ecology and environment and other important work in the field (Paul *et al.,* 2020).

Haryana is heavily agricultural and has a scarcity of natural trees. Afforestation is one of the goals of the Haryana Forest Department (HFD), which aims to restore ecological balance and preserve environmental stability in regions affected by severe depletion of forests, woodlands, and water, as well as to increase the state's tree cover. The National Forest Policy (1988) set the goal of covering one-third of the country's land area with forest and tree cover. To comprehend ecosystem services like as timber and non-wood products as tangible benefits, as well as services such as carbon, water, and weather modification, the stock and dynamics of Trees Outside Forests (TOF) and natural forests must be well understood. This study demonstrates the application of High Resolution Worldview- II (WV) satellite data to the analysis of strip forests in the Hisar area of Haryana, India. The selected approach entails visualizing the Adampur range's strip forest regions onscreen. The approach for forming, identifying, and delineating Trees Outside Forests (TOF) includes forest area as well as roads, streams, rivers, canals, railway lines, and distributaries, among other things. When the area difference between Haryana Forest Department (HFD) notification information and digitized strip forest lands was examined, it was revealed that the surveyed forest area is 1717.37 ha. vs. the notified forest area of 1714.45 ha. As a consequence, the assessed beat boundaries differed by about 2.92 hectares (Kumar *et al*., 2018).

The goal of this study was to look at how remote sensing is currently used in forest management and ecosystem services science, as well as to identify future areas of research on these issues. A bibliometric approach is used to analyze 2066 papers published on these topics between 1976 and 2019. The goal of using bibliometric techniques is to discover discoveries about scientific productivity and important topic areas. Scientific output has grown year after year, with 50.34 percent of all publications published in the previous five years. More publications in the restricted disciplines of agricultural and biological sciences, environmental science, and earth and planetary sciences were linked. This work adds to the academic, institutional, and scientific debate over how to enhance decision-making. As a result, new scenarios and applications of this technology to better forest resource management and administration are proposed (Emilio *et al.,* 2020).

Precision forestry can improve forest management by utilizing information technology and analytical tools to assist economic, environmental, and sustainability analyses. Geospatial information solutions provide highly reproducible measurements, actions, and procedures for managing and harvesting forest stands. As a consequence, information connections between industry and the wood supply chain, which includes resource management and the environmental community, may be formed. Fardusi *et al.* (2017) focused recent advancements in the use of geospatial information technology in forestry, as well as their potential benefits and difficulties for forest management and planning within the context of precision forestry.

Remote sensing can provide valuable insights into urgent environmental issues. It is a necessary tool for driving solutions. In this Primer, the authors have briefly covered the critical role of remote sensing in forest ecology and management, including applications as diverse as tracking the spread of forest ecosystems and defining the three-dimensional structure of forests. The six main reasons why remote sensing has become an important data source, as well as an overview of the various types of sensors (e.g., multispectral and synthetic aperture radar) and platforms (e.g., unmanned aerial vehicles and satellites) that have been used to map a variety of forest variables. The rapid advancement of remote-sensing technology is expected to result in greater democratization of remote-sensing data to aid in forest management and conservation in parts of the world where environmental issues are most acute (Lechner *et al*., 2020).

Forests occupy around three-quarters of Finland's geographical area. It makes a substantial contribution to the nation's biomass, carbon sinks, and carbon reservoirs. In the future, hyperspectral satellite missions may provide data to support the needs of natural resource management approaches such as forestry. This study used remote sensing data from the hyperspectral AISA imager (128 bands, 400–1000 nm, resolution 0.7 m) and Sentinel-2 (10 bands, resolution 10 m) to examine the potential advantages of enhanced spectral resolution. A new nationwide forest resource dataset (stand-level data) was used as reference data, which has a lot of promise in future remote sensor technologies. For validation, a set of unbiased in situ measurements (plot-level data) was also used. The parameters of interest were mean height, leaf area index (LAI), basal area, stem biomass, and core tree species. The regression algorithms were trained using stand-level data. Estimates were validated using holdout sets at the stand and plot levels. Estimate levels of accuracy were calculated using absolute and relative root-mean-square errors. Variable estimations that were successful indicated that kernel-based regression techniques are acceptable tools for predicting forest structure. As a result, the additional utility of hyperspectral remote sensing data in predicting forest characteristics in the Finnish boreal forest is mostly associated with variables containing species-specific information, such as main tree species and LAI. The more relevant forestry sector variables, including as mean height, stem biomass, and basal area, may also be reliably calculated using more typical multispectral remote sensing data (Halme *et al*., 2019).

For sustainable forest management, updated data of fforest inventory on the features of managed and wild forests is needed. It is necessary to inform biodiversity protection and analyze the effects of climate change. Strategic forest inventories are hard to procure across large areas, and due to their long production cycle, these inventories become soon outdated or spatially insufficient. As a result, automated approaches based on remotely sensed data are becoming increasingly popular for providing broad geographical coverage for a set of essential criteria. The purpose of this work was to describe how to map four forest characteristics (stand age, site index, dominant species, and stem density) for a 55 Mha study region in British Columbia, Canada, utilizing current remotely sensed data products and pre-existing jurisdictional inventory data. To begin, image segmentation was applied to Landsat surface-reflectance pixel composites to produce spectrally homogenous objects. Second, a collection of Landsat-based predictors (e.g., disturbance history, spectral indices, forest structure) and auxiliary variables (e.g., topographic, geographic, and climatic) were created and used to build predictive models of target attributes for these units. Two modeling techniques were evaluated for the challenging classification of dominating species: one was a global Random Forests model calibrated using training data gathered over the whole research region, and the other was a grouping of local models trained with spatially limited local samples. The ensemble of local models was proven to be more accurate and efficient for species classification based on independent validation samples. It was finished with a 72 percent accuracy rate for the species that dominate 80 percent of the province's forested regions. The highest agreement between predicted and reference values was found in the site index, followed by stem density and stand age. Shang *et al*., (2020) discovered that spatially localized and accurate characterizations provided by time series of Landsat data combined with additional data may be used to aid strategic inventory efforts across large regions in a multi-source forest monitoring program.

Remote sensing can offer information on tree species composition, which is extremely valuable in forest management. Despite the fact that the topic has been discussed on occasion in recent years, there is currently little research on remote sensing-based identification of tree species over complicated and vast forest landscapes. This review provides a tree species categorization for a major section of Poland's Biaowiea Forest, which spans 62 000 hectares. The categorization of tree species was carried by using aerial hyperspectral HySpex data. The classification method of iterative Support Vector was used. A precise map of seven specific tree species (birch, oak, hornbeam, alder, lime, pine, and spruce) and one additional broadleaf category was obtained. More errors were found in the classification findings of heterogeneous areas. The managed woods were classified with greater accuracy than the reserves. The findings revealed that mapping dominant tree species using airborne hyperspectral data may be done across large areas. Modzelewska *et al*., (2020) reported that forest management and its effects on forest structure have an effect on classification accuracies and should be actively considered as we go towards functional mapping of tree species composition.

Conclusion

Forest informatics is set to perform a growing role as forest management grows more complex as a result of rising environmental and social involvement and expectations. Increased band width, web-based technologies, and wireless communication improvements will provide many more alternatives for information access, even in remote areas. This will enable in-field real-time online data gathering and querying. The range of applications mentioned in this essay illustrates the value of forests and the potential for forest informatics to aid in their management. Remote sensing and image processing technologies have the potential to significantly improve GIS applications. Forests contain a diverse collection of organisms that respond well to large-scale inventory utilizing remote sensing. However, the need for reliable ground truth necessitates attention, and satellite positioning systems such as GPS are projected to play a significant role in augmenting traditional forest survey operations. Forests are a living resource that is impacted by a number of concurrent natural processes as well as acute management actions. Simulation modeling has been utilized considerably more extensively in forestry than in many other disciplines. It is evident that forests are under a variety of stresses all around the world. As a result, many difficulties in forest management are similar to multi-objective planning approaches. For the analytical resolution of opposing appropriateness and resource allocation alternatives, more powerful techniques are necessary. As a result, this study provides an excellent overview of forest informatics technology and its potential as a strategy for natural resource management.

References

Chuvieco, E. and Congalton, R. G. 1989. Application of Remote Sensing and Geographic Information Systems to Forest Fire Hazard Mapping. *Remote Sens Environ.* 29 : 147-159.

Fardusi, M. J., Chianucci, F. and Barbati, A. 2017.Concept to Practices of Geospatial Information Tools to Assist ForestManagement and Planning under Precision Forestry Framework: A review. *Annals of Silvicultural Research.* 17 : 3-14.

Halme, E., Pellikkab, P. and Mottus, M. 2019. Utility of hyperspectral compared to multispectral remote sensing data in estimating forest biomass and structure variables in Finnish boreal forest. *Int J Appl Earth Obs Geoinformation*. 83 : 101942.

Hussin, Y.A. 2000. State of The Art: Remote Sensing Applications for Sustainable Management of Forests. *Proceedings of the 20th ACRS Conference.* pp. 6.

Iliadis, L. and Betsidou, T. 2014. Chapter 53: Soft Computing Modeling of Wild Fire Risk Indices: The Risk Profile of Peloponnesus Region in Greece", *Crisis Management: Concepts, Methodologies, Tools and Applications*, IGI Global, pp. 1073–1087, ISBN 9781466647084.

Jansen, M., Judas, M. and Saborowski, J. 2002. "Chapter 2: Introduction", *Spatial Modelling in Forest Ecology and Management: A Case Study*, Springer, pp. 3–10, ISBN 9783540433576.

Kane, K. 1997. GIS and Forestry.

Khali Aziz, H. 1999. Applications of Remote Sensing in Tropical Rainforest of Malaysia. In: Couturier, S., Lee, G., and Goonasekera, J., (Eds.). *Proceedings of the CRISP Workshop on Tropical Forests and Remote Sensing.* The National University of Singapore. pp. 13.

Kumar, K. E. M., Ritesh Kumar, Rupesh Kumar, Shashikant, Ravikant Bishnoi, Sarika, Pratibha, R.S. Hooda, T.P. Singh. 2018. Mapping of strip forest in Adampur range (Haryana) A Geo-Informatics approach. *Int. Arch. Photogramm. Remote Sens. Spatial Inf. Sci.* XLII-5 : 289-293.

Lechner, A. M., Alex, M., Foody, G. M. and Boyd, D. S. 2020. Applications in Remote Sensing to Forest Ecology and Management. *One Earth*. 2 : 405-412.

Modzelewska, A., Fassnacht, F. E. and Stereñczak, K. 2020. Tree species identification within an extensive forest area with diverse management regimes using airborne hyperspectral data. *Int J Appl Earth Obs Geoinformation*. 84 : 101960

Paul, P. K., Bhuimali, A. and Aithal, P. S. 2020. Environmental Informatics: The Foundation, Allied & Related Branches—Analytical Study. *International Journal of Social Sciences*. 9 : 1-7.

Sandhya, K. G. and Ashwini, M. 2012. Remote sensing & Geo-informatics technology in evaluation of forest tree diversity. *Asian Journal of Plant Science and Research.* 2 : 237-242.

Shang, C., Coops, N. C., Wulder, M. A., White, J. C. and Hermosilla, T. 2020. Update and spatial extension of strategic forest inventories using time series remote sensing and modeling. *Int J Appl Earth Obs Geoinformation*. 84 : 101956.

Shanmughavel, P. and Kannaiyan, S. (ed.). 2008. forest+informatics"&dq="forest+informatics" Biodiversity lnformatics: A Virtual Access to Global Resources. *Forest Biodiversity.* 1, Associated Publishing Company, pp. 40–46, ISBN 9788185211763.

Vogt, K. A., Patel-Weynand, T., Muller, Gretchen, K., Vogt D.J., Honea, J. M., Edmonds, R. L., Sigurdardottir, R. and Andreu, M.G. 2007. Chapter 7: Emerging Issues in Forests. *Forests and Society: Sustainability and Life Cycles of Forests in Human Landscapes*. CABI, pp. 228–283, ISBN 9781845931117.

Wulder, M. A. and Franklin, S. E. 2007. Understanding forest disturbance and spatial pattern: Remote sensing and GIS approaches. CRC press, Boca Raton pp. 1-246