Chapter 1
Forest Management with Advance Geoscience: Future Prospects

Gouri Sankar Bhunia and Pravat Kumar Shit

Abstract The creation and implementation, involving key stakeholders, of context-specific forest management practices plays a significant role in the achievements of sustainable forest management. A number of site-growth modelling studies have been funded in recent years with the goal of developing quantitative relations between the site Index and specific biophysical indicators. With considerable time period, the role of forests in meeting the requirements for minor resources and ecological services has been recognized beyond the mere supply of forest. Present chapter describes advance geoscience application in forest management and also suggesting present research work to be adopted in future forest management plan. Counter-measures and recommendations were suggested on different forest management aspects, including developing consolidated structured data sets, designing top-ranking model monitoring and analysis and creating a multi-scenario decision support network. Finally, we proposed the main field of research in forestry research by incorporating and developing the participatory method, crowd sourcing, crisis mapping models and simulation systems and by linking data integration framework of geospatial technology, evaluation system and decision support system, to enhance forestry management by systematically and efficiently.

Keywords Forestry · Geospatial science · Crowd sourcing · Crisis mapping · Participatory mapping · Sustainable management

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P. K. Shit et al. (eds.), *Spatial Modeling in Forest Resources Management*, Environmental Science and Engineering,
https://doi.org/10.1007/978-3-030-56542-8_1

1.1 Introduction

Forest resource modelling and its status are very important economically and ecologically. Scientific community and policy makers are becoming increasingly aware of the fact that sustainable forest management is affected by several factors linked to global change. Between 1999 and 2012, the rapid rise in population contributed to the increase of €1 trillion, leading to an over 7 trillion people worldwide that need to be maintained by Earth resources. Forests are important to humanity because they provide a broader range of critical ecosystem resources, but the increasing depletion of forest cover means that the need for an ever-shrinking resource must be met with increased demand (Brockerhoff et al. 2013). Today, forest cover is about 31 percent of the land area or 4 billion ha. About half of the Earth's largest forests have been destroyed from land development, with the remaining 16 million hectares losing annually. At the same time, forests became more and more popular as sources of water and food, drugs, wood goods, and other leisure, economic, artistic, and spiritual advantages. Forests have been adequately or abusively exploited, but more effort to make sustainable use of them has been made. Forests are assessed annually at the global and country levels in terms of their scale, quality, usage and importance. In fact, as trees greatly add to the Earth's carbon balance. International interest in the identification of biomass is closely related to the protection of trees, photosynthetic development, and other carbon cycle processes and climatic variation (Houghton et al. 2009). In fact, the inventory of forests gives information on forest activities, conservation of forests and associated decision-making. Forest canopy and booth information was retrieved mainly by remote sensing and space-borne technologies (Tomppo et al. 2008) for wide areas of the world. Other environmental changes caused by human beings, such as increase in low ozone levels, deposition of nitrogenic contaminants, introduction of exotic insect pests and pathagogens, the fragmentation of ecosystems, and increased destruction such as fire may worsen these consequences (Bernier and Schöne 2009). Forestry can also have other consequences of climate change.

Some forest surveillance currently relies on data on development, i.e. improvements to forest cover, and two methods are used (DeVries and Herold 2013). Most environmental regulations are currently focussed on details on environmental operations, i.e. changes in land cover, and two methods are applied: top-down and bottom-up. The top-down approach utilizes satellite systems, while the bottom-up approach employs ground observation by government agencies, community-based surveillance (CBM), participatory surveillance or voluntary data (Danielsen et al. 2009). Satellite data provide global coverage and improved acquisition speed at a low cost, necessary for near-real-time forest surveillance (NRT) (Lynch et al. 2013). The scientific community is now generally recognized as major factors to latest increases in greenhouse gasses in the atmosphere and changes in the global hydrological cycle deforestation and degradation of forests (Hansen et al. 2013). The sample plot data reference data is still obtained largely through manual measurements while significant work is underway for, for example, terrestrial laser scanning, mobile laser scanning (MLS). The characteristics calculated in the inventories of operating forests are primarily the number of trees, tree types and breast height diameters (BHDs). Satellite Observations (SOs)—including Earth Observation (EOs) surveillance of the Earth's home planet; International Space Station (ISS) calculation, experiment and photo surveys; observations of the space science (SS); and Global Satellite Navigation System (GNSS) observations—are the basis for research to better understand our atmosphere and our environment.

The globalization of global trading networks and an increase in the volume of traded goods have been a contributing factor to population growth (Hulme 2009). Climate change can exacerbate invasions and impacts of forest pests. Climate change may, for example, promote the spread of both native pests and exotic ones (insects and pathogens) or affect tree pest resistance (Jactel et al. 2012) and there is growing evidence of an increasingly widely used phenomenon (Anderegg et al. 2015). Trumbore et al. (2015) described invasive species and diseases, as well as climate change, and deforestation as the major stressors in today's world's forests. The ongoing escalation and mechanization of forest management, which has increased forest vulnerability to biological invasion, climate change and other stressors, is an additional contributory to the forest health issue (Seidl et al. 2011). There have been several shifts in the forests in recent global warming (Lucier et al. 2009). Climate change effects can be beneficial in certain areas for certain tree species. In some areas, the growth of trees is increasing in longer growing seasons, hotter temperatures and higher CO_2 rates. Many of the expected climate changes and their indirect impacts are likely to adversely impact forests. Observed changes in vegetation (Lenoir et al. 2010) or increased mortality from drought and heat in forests around the world (Allen et al. 2010) may not be caused by climate change triggered by human beings but may demonstrate the potential consequences of the rapid environment. However, the vulnerability of tropical humid forests has been discussed recently (Huntingford et al. 2013) and temperate forests may be at greater threat in areas subject to a more extreme climate (Choat et al. 2012). A variety of viewpoints are available to consider adjusting to these changing and unpredictable future circumstances (McEvoy et al. 2013). Forest management would have to prepare on a variety of spatial and time levels in order to resolve potential problems and implement more flexible and collaborative management strategies. The tacit belief that local climate conditions will continue to be constant is often the basis of local forest activities (Guariguata et al. 2008). Additional social and economic developments in forest management will also continue to push transition (Ince et al. 2011). A growing global population, rapid economic growth, and increased wealth, for example, are driving demand in multiple developing countries for food and fiber crops and forest conversions into agriculture (Gibbs et al. 2010). The goals of climate change mitigation are to raise demand for biomass-based bioenergy and biomass in construction and manufacturing systems. Increasing urbanization shifts the essence of social demands for forests, and a reduction in rural communities decreases the supply of labor and capacity for intensive initiatives on forest management.

Regional climate, biodiversity, domestic environmental protection, even global environmental changes are strongly affected by the change in forestry area. The further squandering of ecological building space and the greater demands for strict forest red line expansion and industrialisation. In current land use and ecological cultures, how forest resource management is optimized and improved by complex monitoring for change in forest areas has become an extremely significant and urgent mission. Dynamic surveillance needs database tools have been developed to direct forest area surveillance capacity building (Gillis et al. 2005). For dynamic monitoring, a georeferenced digital database is commonly used as a basis of capacity building monitoring work. As an indicator of changes to forest area (Illera et al. 1996), temporary evolution of vegetation indices may be possible. With the exponential growth of earth observation technology (EO) and the continuing launch of remote sensing satellites, the Earth observation data resolution is growing and the number and range of data are rising as well, indicating that EO data are increasingly entering the age of big data (Xia et al. 2018). The Earth Observation Satellites Committee's (CEOS) figures indicate that over the last half century in 500 EO satellites were deployed, and more than 150 satellites will be launched in the next 12 years (Guo 2017). The Big Earth Observation Data (BEOD) slowly supported the growth of the world industries, research institutions, and application sectors which had a profound effect upon the Earth system science, contributing to human activities, environmental monitoring, and climate change (Yao et al. 2020). Furthermore, Web-based Geographic Information Systems (WGIS) is accessible in order to allow access to digital maps and geographic models. The reports are available publicly. It is a significant step in democratizing exposure for various users to geographical information. There are no spatial analysis resources available in current WGIS programs for this area, which use specific data sources, and easy access to reports with maps, graphs, text and table data.

In particular for data collection, for the production of a technical model and for research platform construction there remain many defects and limitations in technology and capacity building. Failure to coordinate forest land knowledge resulted from a lack of inventory requirements (Managi et al. 2019). Forest region adjustments are difficult to incorporate details based on the different forest land inventory and land grading requirements. There are significant issues with the uniformity of reporting practices in the reporting implementation process. Further development is required in conjunction with an integrated research model and a dynamic monitoring of forestry change. Systematic analysis for forestry area changes includes comprehensive data bases and models, and a system development tool is also required to help the conversion process from data analysis to application decision-making study. Spatial data items for the Multi-Period and Multi-Scenario Forest Region must be routinely analyzed and planned. The current state and rising forest area patterns combine with environmental and socio-economic influences interacting with each other. By using methods of GIS and Space Economics, the findings of the analyzes can be better adapted to natural change and better decision-making data for the optimal management of forest lands and other land types, using methodological methodologies. The findings of such research are focused on the effects of the natural changes. In addition, it is necessary for forest change to be improved in prediction and dynamic analysis, for development paths to be framed and regional development objectives to be recognized. The basic project to improve the study of forest dynamic change is the perfecting of data integration—model study—policy modelling Integrated development and the realization of scenarios for forest land changes under various systems. Restrictive factors influencing the growth of forestry areas must be identified, forest growth adaptive management measures examined and transition and strategies for development based on different stages promoted. The essential pre-conditions under the current climate change, urbanization growth, industrial system transformation, environmental protection and so on are the identification of the major contradictions in the cycle of forest growth and the main factors restricting development and implementing adaptive management.

1.2 Geosciences to Improve Forest Assessment

Through technical and statistical advancement, the processing of forestry data and their analyzes have steadily progressed (Kleinn 2002). Of starters, field dimensions, such as diameter or height scales, usually measured using tape or wood compasses and relascopes are now being improved with the use of emerging technology, including laser scope discoverers. In addition, the technology of remote sensing has been used rapidly to enhance soil sampling (Maniatis and Mollicone 2010), to measure improvements in vegetation and areas and to monitor other value variables, including forest fires, rodents and trees outside forest (Barducci et al. 2002). The usage, along with ground-based observations, of remote sensed data has gained considerable interest in estimating greenhouse gas emissions and forest-related removals, especially in the context of REDD+ (GFOI 2014). Recently a free Landsat satellite sample has been used by Food and Agriculture Organization of the United Nations (UN-FAO) to record forest land and area changes figures for the period 1990–2005 (FAO and JRC 2012) for woodland, other forested land and other ecosystem services. Therefore, a specific challenge for enhancing forest cover projections, carbon reserves and complexities is to efficiently integrate numerous top-down and ground-up strategies, a suggestion issued by the United Nations Framework Convention on Climate Change in the sense of emission reduction from deforestation and forest loss (REDD+) (UNFCCC 2009).

In the last few years, major changes have been made in LiDAR's systems leading to a boost in LiDAR position precision and surface density. LiDAR technology applies to a vast range of laser measurement devices, three primary approaches to the sensing of forest structures being terrestrial, airborne and space-borne approaches (Yao et al. 2011). Terrestrial laser scanning (TLS) has the ability to estimate tree diameters, height of the tree, tree volume and thus biomass in a structured and automatic manner (Hosoi et al. 2013). There is still an overview of these massive, three-dimensional datasets, but many ongoing methodological advances will make this technology useful soon. A digital elevation model (DEM) can be created from the point-cloud data created with LiDAR from the points reaching the ground and a canopy height-model from those intercepted by the upper canopy can be made. LiDAR's precision, combined with high spatial and point density, makes airborne LiDAR systems an enticing data acquisition method for estimating a large array of tree and forest parameters (Laes et al. 2011) like tree height (Detto et al. 2013), tree biomass (Li et al. 2008), leaf area index (Morsdorf et al. 2006) or stem volume (Heurich and Thoma 2008). Spaceborne data like LiDAR enables forest structures to be mapped globally with a vertical structure (e.g. by the Geoscience Laser Altimeter System (GLAS)) (Simard et al. 2011). In 2018, a similar sensor, ICESat2, has a smaller footprint than the previous GLAS instrument. Finally, the Global Ecosystem Dynamics Investigation (GEDI) project aims to make a high-resolution observation of a forest vertical structure at the global level using a LiDAR-backed instrument embarked on the International Space Station (https://science.nasa.gov/missions/gedi/). Moreover, a system called Synthetic Aperture Radar (SAR) is used to improve resolution beyond physical antenna aperture limits in order to achieve a high radar spatial resolution. For example, since it has a wavelength (5–6 cm), a C-band SAR signal is known to quick saturate with forest biomass (Thurner et al. 2014). In April 2014, Sentinel-1A was successfully launched with C-Band Radar as part of the European Space Agency's Copernicus Mission (ESA). Nonetheless, a loss of sensitivity at values greater than 100–150 Mg ha^{-1}, sometimes interpreted as signal saturation, was also observed in several studies (Woodhouse et al. 2012). Mermoz et al. (2015) have shown recently that L-band scatters appear to attenuate, rather than saturate, over and above this biomass threshold which could result in new opportunities in the mapping of L-band SARs. Currently, the L-band ALOS PALSAR is the single, wavelength radar sensor for monitoring the structure of forests, and in 2014, its sequel—ALOS2—was launched. In the case of forest-carbon evaluation, LiDAR, radar, textural and stereo-photogrammetry analysis have made considerable progress and allow the measurement (LVG 2012), over a significant shorter duration than conventional field sampling campaigns, of several variables of interests—for example, the diameter of tree, the height of tree and crown size (Table 1.1).

However, it is currently little understood how precise additional forestry characteristics such as timber volume per hectare are modellable by high-resolution data (almost 1.0 m and < 5 m) and high-resolution satellite stereo data (<1.0 m). For forestry survey methods, such as the extraction of quantitative information on canopy structure and forest biomass estimates, also in a setting of high biomass (Bastin et al. 2014). Therefore, it was possible for researchers to study ecologic structures with far greater detail than those provided by the start of high-resolution satellite sensors such as CARTOSAT (Spatial Resolution: 2.5 m), IKONOS, (spatial resolution in MS: 4 m), Quickbird (spatial resolution in MS: 2.88 m), and OrbView-3, (spatial resolution in the MS: 4 m),GEOEYE (Straub et al. 2013; Goward et al. 2003; Gibbs et al. 2007). For the calculation of the heights of individual pine trees and lading stands at Appomattox-Buckingham State Forest in Virginia, USA Popescu and Wynne (2004) used LiDAR and ATlAS multi-spectral (visible, near-IR and mid-IR) optical data with spatial resolution of 4 m. Table 1.2 illustrated the high spatial resolution satellite data in forestry mapping and monitoring. They showed that combined multi-spectrum imaging and LiDAR data can reliably predict forest inventory and evaluation tree heights of value. Nagendra (2001) assessed 'remote sensing capacity for determining the diversity of the ecosystem.' He concluded that a decade ago it was

Table 1.1 Satellite data and methods for forestry resources mapping and monitoring

Satellite/sensor	Aims	Methods	Reference
Synthetic aperture radar (SAR) and/or LiDAR	To detect and map forest degradation; Estimates above ground biomass	Spectral fractions, unmixing or classification	Mitchell et al. (2017)
Airborne X-band SAR data	To enhance discriminability of the forest types and features	Leaf Area Index; Spatial textural analysis	Roy et al. (1994)
Japanese Earth Resource Satellite (JERS)-1 Synthetic Aperture Radar (SAR)	Assesses the feasibility of forest cover mapping and the delineation of deforestation	Multi-image segmentation, post-classification detection	Thiel et al. (2006)
JERS-1, ERS-1 SAR and RADARSAT	Objectives are biomass estimation, forest and land-cover-type recognition in boreal forests	Textural measures, multitemporal approach, mixed pixel approach	Kurvonen et al. (2002)
Passive Microwave Remote Sensing (C-band, L-band and X-bands)	To compute the emissivity e of forests	Radiative transfer theory, matrix doubling algorithm	Ferrazzoli and Guerriero (1996)
Synthetic aperture radar (SAR); airborne and terrestrial LiDAR	Degradation and forest change assessment	Random forest (RF), REDD+ mechanism	Calders et al. (2020)
Synthetic Aperture Radar (SAR)	Quantification of spatial and temporal changes in forest cover	Random Forests, Extremely Randomised Trees	Devaney et al. (2015)

not yet possible to delineate a large number of species with spectral data. However, a 2-m spatial resolution was launched in 2009 for WorldView-2 (WV2) (Coastal, Blue, Green, Red, Red-Edge, near infrared (NIR)—1 and NIR—2) with a high resolution of 0.5 m (Coastal, Blue, Green, Yellow and NIR). Several studies in recent years have used WV2 images for the study of tree habitats. The accuracy of mapping six species/groups of trees improved with WV2 imagery by 16–18% compared to IKONOS satellite images. The research, however, covered trees/groups with sparse vegetation and not in a forest, within a dense urban area. Carter's (2013) use of multitemporal data from June and September 2010 in a multi-temporal forest mix in Upstate New York from two WV2 images for classifying ash, maple, oak, beech, evergreen and 6 other tree classifications. This would also promote the grouping of tree species into mixed near-nature, natural, urban forests with a wide variety of tree species. Very high spectral resolution imaging often mounted on aerial systems offers important, unreviewed eye information on forest function with a greater number

Table 1.2 Use of high spatial resolution satellite data in forest mapping and monitoring

Satellite/sensor	Region of study	Aims	Methods	Outcome	Reference
IKONOS II	Italy	Forest Inventory and Mapping	Supervised classification, Object-based approach	Forest cover density and dominant tree species composition	Giannetti et al. (2003)
IKONOS; QuickBird	Costa Rica, Central America	To evaluate tree death rates	Calibration factor	Calculated a landscape-scale annual exponential death rate	Clark et al. (2004)
QuickBird	Tully, New York	Tree identification and tree crown delineation	Rule-based classification; segmentation algorithm	Classification trees were built and results were evaluated using a cross-validation approach; spectral metrics, texture, elevation features, and geometric features were calculated for each image object	Ke and Quackenbush (2007)
WorldView-2, LiDAR	Ljubljana	Tree species inventory	Object-based image analysis; Digital elevation model (DEM); Principal component analysis (PCA)	The accuracy of the proportions of individual tree species that form the forest stand canopy was lower than in some other studies. The distinction between deciduous and coniferous tree species was the most reliable	Verlič et al. (2014)
QuickBird, IKONOS	Nepal	Forest Condition Monitoring	Geographic object-based image analysis (GEOBIA)	Tree crown detection, delineation, and change assessment	Uddin et al. (2015)

(continued)

Table 1.2 (continued)

Satellite/sensor	Region of study	Aims	Methods	Outcome	Reference
LiDAR,WorldView-2	Victoria, Australia	Characterisation and classification of forest communities	k-means clustering algorithm; TreeVaW algorithm; support vector machines (SVMs) and decision trees	Identified individual trees, including locations and crown sizes identification of Myrtle Beech and adjacent tree species—notably at individual tree level	Zhang (2017)
WorldView-2	Long Island, New York (US)	Assessment of forest fire	Multiple Endmember Spectral Mixture Analysis (MESMA) fraction; spectral indices	Forest burn severity mapping from VHR data	Meng et al. (2017)
Unmanned aerial vehicles (UAVs), Pléiades	Czech Republic	Estimation of basic tree attributes, such as tree height, crown diameter, diameter at breast height (DBH), and stem volume	Structure from motion (SfM) algorithms; spectral Correlation	Predict tree characteristics with high accuracy (i.e., crown projection, stem volume, cross-sectional area (CSA), and height)	Abdollahnejad et al. (2018)
Airborne LiDAR	Peru	measure and monitor carbon stocks and emissions; measurements of top-of-canopy height	Random forest machine learning regression	Aboveground carbon stocks and emissions	Csillik et al. (2019)

of narrow spectral bands (up to 200 or more contiguous spectral bands). Imaging spectroscopy, for example, may relay valuable information on variability in canopy chemistry (Baccini and Asner 2013) and thus provide direct information on the functioning of the Ecosystem. The taxonomic and functional structure of canopy trees can also be described in a highly successful way.

For research and development, the bulk of the above technological methods are still considered. Technology development, modifying and implementing existing systems in accordance with country circumstances, has the possibility, as necessary, of improving field measurement alertness, reducing time and expense of field sampling campaigns and improving forest extrapolation estimates over broad spatial scales including remote or conflict areas. The implementation of transparent national forest surveillance systems can also be assisted by new technologies. However, national and subnational corporations, private businesses, research and academic institutions, NGOs and civil society face a great many constraints in implementing, adapting and activating these technologies. Of these, minimal technical skills are possibly the most critical when using these new technologies; thus, training and capacity building are necessary and must be expected.

1.3 Cloud Computing and Forest Management

The rapid advancement of cloud computing technology in recent years provides strong computing power, especially for the efficiency of big geospatial data management and processing, which makes it possible to perform complex simulations on a global scale. Cloud computing is used as a framework to allow users to access a common community of computational tools that is configurable and can easily be supplied and published with minimal management effort and/or interference between service providers (Li and Huang 2017). Cloud computing has transformed the conventional information technology model entirely by offering at least three types of services: infrastructure as a service (IaaS), platform as a service (PaaaS) and software as a service (SaaS). In order to address persistent spatial data model problems spatial cloud computing (SCC), a data layer as a service (DaaS) was proposed (Yang et al. 2011). The discrete global grid systems (DGGS) have had a fairly flawless theoretical statistical history and basic functions over the last two decades (Zhao et al. 2016). DGGS is known as an Earth reference system (ERS) which uses cells to divide and address the globe (Bauer-Marschallinger et al. 2014). The DGGS Standards Working Group was set up in 2014 and an international specification was adopted by the Open Geospatial Consortium.

Cloud technologies, and particularly in the field of data storage, have begun to infiltrate all facets of life. Cloud computing cannot make use of itself explicitly for the visualization and maintenance of forest resources, because it essentially lacks the functionality of the spatial data collection. This effort aims to address four strength issues in the geospace, namely data, machine, competitor and space-time. After several years of growth, cloud-related computing technology and forest observation tools are also increasingly being developed, for example Google Earth Engine and Esri Geospatial Software (Yao et al. 2020).

Figure 1.1 shows that cloud computing provides some services for forest observation mapping and monitoring including spatial data infrastructure (SDI), EO data resource, algorithm or model library, processing and computation, systems and applications. The easiest approach is to provide a wide variety of nodes, computers, and servers which can provide customers with on-demand network resources such as the AWS, Google Cloud or Aliyun space storage network. The second is to provide forest

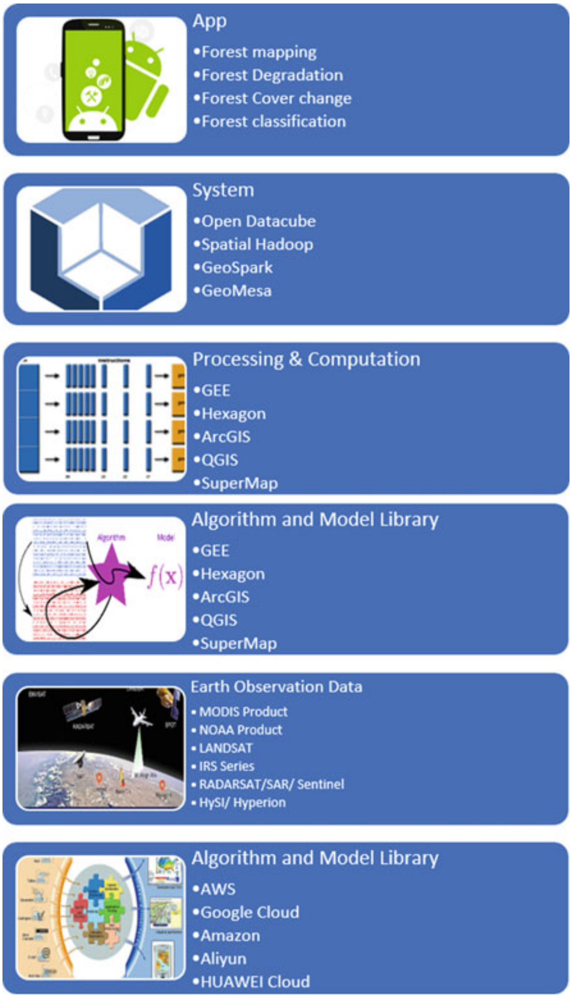


Fig. 1.1 Cloud computing for forest observation mapping and monitoring

resource mapping and tracking computer services for Earth observation, known as the EO computer cloud. The data cloud is actually the most sophisticated and simple form of cloud computing. The Global Earth Observation System of Systems (GEOSS) for example has developed a scalable platform for regional and multidisciplinary data exchange in EO sector, with its cloud-based exploration and access solutions. An algorithm or a software database, processing and computational power is given for the third and fourth versions. The two pieces are comparatively more professional and are only open to a few study teams or industrial firms. They are the most growing trends for structures and applications.

1.4 Integration of Participatory Approach and Geospatial Technology

Rambaldi et al. (2006) states that PGIS "combines a variety of geospatial knowledge and methods, such as maps of drawings, participatory 3D modeling, community-based air and visual analysis of satellite images, GPS transect walks and cognitive GIS mapping." GIS (Participatory GIS) was widely used to support group mapping to ensure subsistence sources and their cultural areas (such as holy sites, historical sites, ancestor routes) Corbett et al. (2006) stated, "this participatory concept implies a degree of control over decision-making, managerial authority and accountability by the group at all levels." In the last two decades the number of companies and advocacy groups interested in natural resource management has dramatically grown. In promoting engagement preparation systems, ICT has the ability to play a significant role. Engagement forms include either one-on-one (in an anonymous interview) or group interaction (individual forums such as public juries, round tables, research circles, and collective advisory groups). The ability of the local people to participate largely depends on the sort of opportunity they may anticipate (Robiglio and Mala 2005). Learning and sharing experiences with local community organizations have helped us recognize the conditions required for effective measurement and reporting at local level. Measuring, documenting and testing involves cost-effective and accurate testing methods. We researched conditions for a fairly easy and cost-effective method to gather information concerning land use (LU) and land cover changes (LCC) using remote sensing and geographical information systems. We have identified land use and drivers of deforestation and forest destruction, and their effects, using satellite imagery analysis and knowledge from local people (Fig. 1.2). GIS technology and the maps remain primarily focused on characterising, evaluating characteristics of places instead of communities and livelihoods given these efforts and the rapid growth of new research areas Participatory GIS (PGIS) and Public Participation GIS (PPGIS). Sulistyawan et al. (2018) demonstrate how participatory mapping results can be integrated into Spatial Planning Regulation. The integration of PGIS and Space Planning Control is being carried out in three stages. Throughout the first step, the group and district governments formed a shared vision and dedicated all

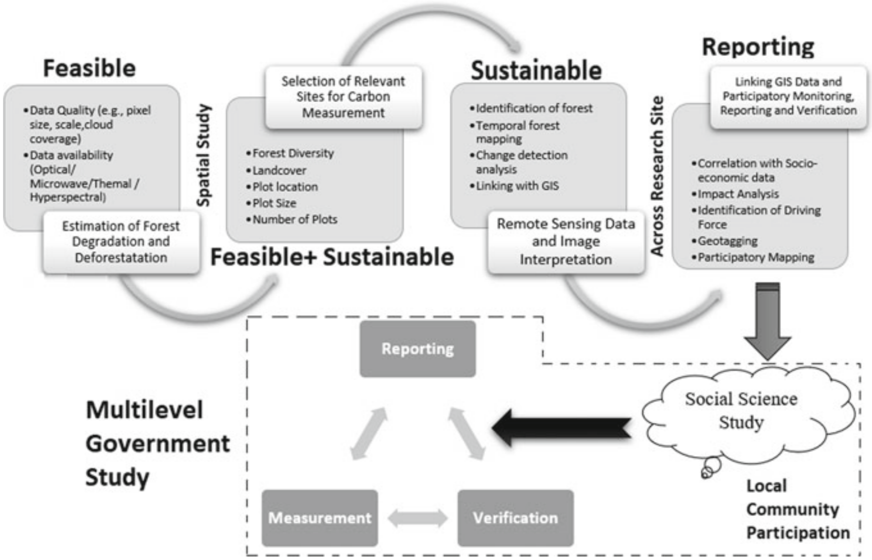


Fig. 1.2 Local Community participation in forest research analysis and participatory mapping. Deforestation and forest degradation scales, still using satellite data and space analyzes, and the knowledge provided by local communities to select appropriate locations for the estimation of carbon stocks and change drivers for forest cover. This figure illustrates how the social science team conducted its investigations in each local context (Modified after Boissière et al. 2014)

parties to embracing the end results of mapping for use in the future planning phase. The second step was to promote the involvement of GIS by the Community and to incorporate the appropriate community areas in the regulation on spatial planning. A clear evaluation of their strengths and limitations for the different applications is required to combine participatory and GIS-mapping approaches and is important for carving practitioners, designers and community members alike (Vajjhala 2005). Within this multidisciplinary approach we incorporated biophysical information and information (carbon stock estimates), social science information and remote sensing information (cards using satellite images and knowledge of the local population). In this multidisciplinary approach. When it is the only tool for biomass assessment, the use of remote sensing is limited. Participatory mapping can also help local people draw maps based on their experiences in the land cover (Mapedza et al. 2003). Vegetation forms for rising land cover can be established in local communities (Abraao et al. 2008). Ground inspections are also needed to validate the discrepancies in remote sensing maps. Without local community engagement, remote sensing and GIS cannot provide too much knowledge about the drivers of transition. They offer a full picture of the changes in forest cover (Mapedza et al. 2003) and thus the reasons for variations in space and time in carbon stocks. Remote sensing experts may also provide information on sensitive areas that need careful attention when working together with local communities for monitoring and plot-measuring (e.g.

high environmental value areas (Balram et al. 2004). New ICT technologies help to close the divide between the general population who will now take their insight into the policy process more efficiently, and experts, academics, and politicians who take action every day on behalf of the country. The social network is a significant piece of knowledge for social capital analysis as it focuses on how social networks promote and restrict incentives, attitudes and cognition (Paletto et al. 2010). Social media enables users to access digital information, upload and distribute content as well. They can not only access digital information. The growth of mobile telephone technologies and the resulting decline in prices have made it easier to access the internet. The Internet has been revolutionized in social media and turned from an information source into a communication platform. The media that expressing our thoughts, emotions and general mental state through social networks such as Twitter, Inc, Facebook, Inc and Reddit Inc. are also a part of our daily lives (Wongkoblap et al. 2017). This website has also become a powerful data bank of advertisers and analysts, who can examine consumer practices, social content and related knowledge, as well as other attitudes and habits to define their interests and tastes. The most popular social media enables knowledge and views to be exchanged by forums or by Wikis in a forum, or more sophisticated ways of gathering information such as MySpace or Facebook (Sweeney 2009).

1.5 Mobile Application in Forest Management

The software, Web App, Online Download, iPhone app or smartphone application may be named a mobile device. Mobile apps are generally available through native distribution platforms, known as app stores, run by mobile operating system owners. The most rising smartphone apps in India include Whatsapp, biking, Instagram, Bookmyshow, Paytm, Indian Rail App Disha. The essential mobile app for forestry is listed below.

1.5.1 Hejje (Pug Mark)

Hejje is an indigenously developed Android-based application. It co-ordinates foot patrolling of forest staff apart from providing the range forest officers live update of their respective anti-poaching activities such as patrol time, water level in lakes, suspicious activities, tree population and forest fires. The staff using the mobile application can take photographs.

1.5.2 Urban Forest Cloud Tree Inventory App

This app allows user to inventory trees in an easy-to-use web map and export the data to an ESRI shapefile or MS Excel/Access file for use in other software applications. It serves as a tool for individuals without tree inventory software and as supplemental, highly accessible tool for those with inventory software.

1.5.3 Tree Sense

The app allows user to quantify and qualify the benefits of trees, including air quality, electricity savings and storm water reduction. Users can also figure out the best placement for future tree plantings in order to maximize their benefits.

1.5.4 Timber Tracker

Timber Tracker, was developed by App Pros, LLC of Springfield, Missouri. Timber Tracker was designed by loggers for loggers. This app allows you to estimate timber harvest, price lumber, and prepare and send a quote PDF to customers.

1.5.5 Leafsnap

This Smartphone App is a North American tree identification guide.

1.5.6 Tree Trails

Tree Trails planned to gather trees knowledge throughout the state of Texas. The app is designed to allow teachers, youth leaders and the general public to trail and learn about these themes and share this knowledge with other people through the corresponding curriculum.

1.5.7 Tree Book

Tree Book is the leading guide to 100 of North America's most famous trees.

1.5.8 Tree Tagger

The Tree Tagger Mobile Forest Health App transforms a smartphone into a device that tracks ill tree and provides scientists and wood management around the world with forest health data.

Nowadays, digital cameras are mostly attached to smartphones. Apps are already used to calculate a forest sample plot or stand using smartphone camera data. Such fast, easy-to-use plot-measurement application for forests has become increasingly popular with foresters and are tested by various forest organisations. To order to consider the impact of constant clearance and irrigation of bushes along the riversides it should better benefit local people including farmers (Pratihast et al. 2012). Under standard boreal forest conditions Melkas et al. (2008) and Vastaranta et al. (2009) were testing a laser camera. It was a digital Canon EOS 400D reflex with an integrated laser line generator from Mitsubishi ML101J27. It measured the diameters of trees without visiting them from the middle of the sampling plot. Forest sample measurements, Vastaranta et al. (2015) tested the TRESTIMATM smartphone software. The software interprets the images from sample images captured on the smartphone using a camera. It then calculates forest inventory attributes including species-specific basal areas (G) as well as basal area medium-tree diameter (DgM) and height (HgM). The smartphone app seeks to assist forest conservationists, government officials and stakeholders in creating, amending and applying an efficacious community-based conservation program that preserves forest protection in real time updates on the status of forests and associated habitats (Fig. 1.3). Satellite images and videos are used by the iOS device to provide in real time information on the situation in certain areas of woodland habituating. India's Natural Resources Department has a free mobile program called "Indiana DNR," for Android as well as Apple iOS. "Forest Watcher" is a US-based charity that monitors changes in forest cover to allow offline

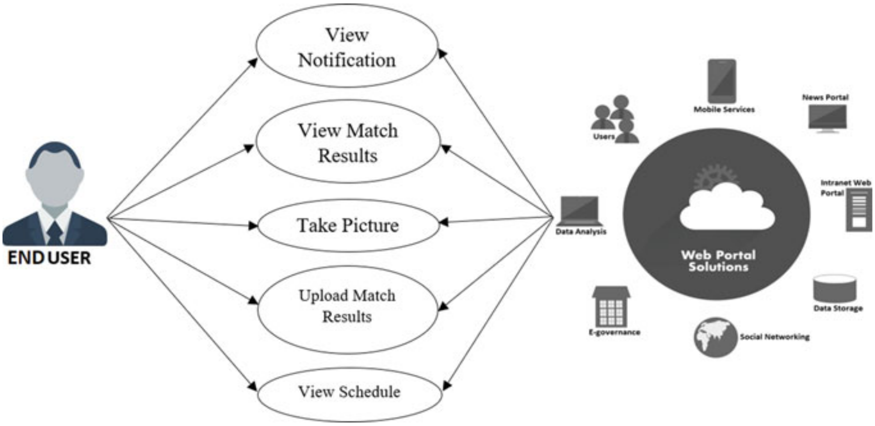


Fig. 1.3 Mobile application use case diagram

access to real-time Satellite Maps and data gathered. The app shows forest shifts on mobile devices via their Global Positioning System (GPS) system, which depends not on internet connection. Moreover, the Forest Survey of India (FSI) adds importance to fire warnings in the field of forests, attaches attributes to a list, prepares map-based items, etc. for example. Fire areas are MODIS 1 km grid centres. The KML file, Google compatible format and sent to the registered end users within 2 h of satellite overpass, is created with forest fire alerts from the active fire locations. Emails and SMS can be used to send warnings to registered users.

Forests used computer technology to adopt best practices. Incorporating computer technology into forestry has reduced the problems of information, expertise and data sharing in order to increase decision-making. It strengthens the openness of forest science. This lead to successful policy making around the world to safeguard the forest and increase the development of forest products through environmental conservation. As the role of computer technology is important for the education of forest scientists and the management of forest science, it is vital that information technology is required to educate forests scientists. This can be done easily through forest information technology.

1.6 Near Real Time Monitoring of the Forest-Sensitive Zones

Thanks to the local community's involvement in the land, forest change may be indicated to the municipality, date, scale, and proximity drivers in NRT transition (deforestation, forest destruction, or reforestation). Digital tools such as smartphones for mobile correspondence ease data storage and delivery activities (Pratihast et al. 2016). The incorporation of community-based monitoring (CBM) data into national forest monitoring system (NFMS) has, however, caused some problems, including: (1) lack of trust in the method of data collection, (2) incoherently controlled size, (3) restricted geographical coverage, (4) variable data quality and (5) a lack of confidence in data providers. Recent advances in technology like cloud 2.0 have provided potential solutions to such problems such as GIS, remote sensing, big data analytics, smart apps and social media (Conrad and Hilchey 2011; Skarlatidou et al. 2011). Given this ability, for many reasons there are currently a lack of successful implementation of the integrated NRT forest monitoring program. Secondly, forestry transition research results from multisource data sources (i.e. satellite and CBM in NRT) cannot be managed by organizational processes. Second, no device can archive, envision and provide local actors with information on forest change across the Internet. Fourth, there is the absence of the quest capabilities for spatial and temporal forest transition. Ultimately, in the sense that individuals do not provide input about the information submitted the interaction among users and the program is usually "passive." The integrated forest surveillance network is shown by Fig. 1.4. The architecture is scalable and extensible, enabling the application to easily add additional functionality or map

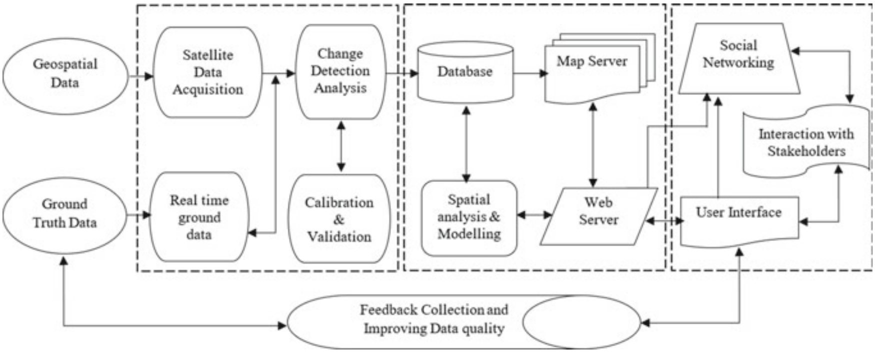
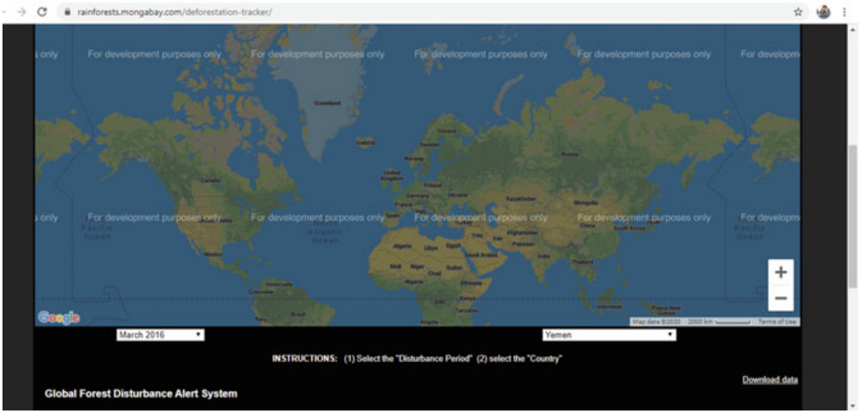


Fig. 1.4 Interactive web-based near real-time forest monitoring

layers of external data sources. The server conducts the necessary spatial analysis and provides input, interactions and visualization of the findings for the client.

The GIS virtual support program is accessible on the Internet. The key goal is to make the forest information on the spatial and non-spatial datasets on land cover and vegetation type and other forestry layers in the country accessible freely available to existing, accurate and reliable land resource users. NSDI is intended to facilitate the compilation, aggregation and dissemination by different mapping agencies of geographic datasets on various issues in a shared set of specified standards and formats. The national forest fire program is coordinated to locate fire areas through its “Easy Reading Out” service. Modest Resolution Imaging Spectroradiometer (MODIS) Data transmission and analysis is performed (Tang et al. 2019). The stakeholders are sent within 90 min to designated emergency areas (hot spots). The Indian Space Research Organization (ISRO) along with Forest Survey of India (FSI) has been conducted spatial scale and patterns in forest cover shifts in India using multi-source and multi-date data (1930–2013). This research has evaluated the spatial scale and patterns in forest cover shifts in India using multi-source and multi-date data (1930–2013). As a guide for classifying the other four periods (1975, 1985, 1995, 2005), visual interpretations have been used to evaluate the forest cover map created from the Resourcesat-2 AWiFS 2013 image for transition between forest and non-forest cover. For time series evaluation and analysis of trends in forest distribution (1930–1975, 1975–1985, 1985–1995, 1995–2005 and 2005–2013), a grid cell measuring 5 km by 5 km were developed. The e-planning program of these two American federal agencies aims to offer advanced, immersive, internet-based planning papers with similarly smart backend technologies for public commentary delivery Pratihast et al. (2016). developed an interactive web-based near real-time (NRT) forest monitoring system in Ethiopia. The functionality of the program comprises (1) the download, store, and analysis of NRT forestry changes identification by means of Landsat time series images; (2) the possibility to submit land observations and collection positions for forest change on request; (3) the ability to monitor and display the hotspot for forest changes in time. The spatial database framework was built to allow various types of data to be processed, managed and accessed via structured query language (SQL), including basic geographic data, ground observation data, and distance sensing information. This problem is tackled by a new, 80-year-old technology—radar—the Monitoring of the Andean Amazon Project (MAAP), with the use of remote sensing data to identify hotspots in the West Amazon and the activities triggered by forest depletion (https://maaproject.org/en/). In order to allow its team to track deforestation during Peru's entire year in almost real-time, MAAP now integrates high-resolution optical data with the capacity for radar imagery. Inspired by the DETER and SAD forest surveillance programs protecting Brazil's Amazon, the FORMA project originated at the World Development Center and entered the Data Lab at the World Resources Institute (https://www.globalforestwatch.org/). Such devices easily generate maps of hotspots for forest destruction. These also allowed police, civil society groups and the media to respond quickly to criminal crime and to reduce the deforestation rate in Brazil. The FORMA network consists of several components: wildfire extreme and fire data from the MODIS instrument on NASA Terra satellite, NOAA weather data and forest clearance historical data. In relation to dryness or other seasonal variability—see Fig. 1.5—a mathematical model uses increasing pixel background to identify relevant signs of the failure for wood cover. The end result is a map displaying regions of interest based on the new satellite images. The Indonesian version of Mongabay.com (mongabay.co.id) launched recently over the coming month aims to create a pilot program to investigate some deforestation hotspots in Indonesia, found by the GloF-DAS in local correspondents. The ground-based project, which is witnessing high rates of mining deforestation, the conversion to the oil palm assets and to pulp and paper plantations and agriculture, could boost forest transparency in Indonesia (Fig. 1.5). The GloF-DAS is based on a new NASA Moderate Resolution Imaging Spectroradiometer (MODIS) satellite data product.



March 2016

Yemen

INSTRUCTIONS: (1) Select the "Disturbance Period" (2) select the "Country"

Global Forest Disturbance Alert System

Fig. 1.5 The Global Forest Disturbance Alert System (GloFDAS) provides data on forest disturbance globally on a quarterly basis. GloF-DAS is freelyavailable at rainforests.mongabay.com/deforestation-tracker/

1.7 Crowd Sourcing in Forest Management

Jeff Howe and Mark Robinson, editors of the Wired Journal, coined the word ‘crowdsourcing’ in 2005 for the purpose of representing the activities of a global band of people for information, ideas and services (World Meteorological Organization 2017). The terms “crowd” and “outsource” were a mixture of phrases. Crowdsourcing is the type of participatory online operation that provides a community of people with diverse skills, complexity and number with ample resources to volunteer their work through a scalable, accessible request. The generation of geosphere data by volunteer people, who are untrained in astronomy, mapping or related fields is spatial crowdsourcing (Heipke 2010).

Crowdsourcing was introduced in the forest industry to test urban trees even though there have been some concerns about their durability (Fritz et al. 2009). Current technology makes it possible for machines to identify the forest area automatically by means of satellite data and chart most forestry worldwide accurately. The forest cover in a pixel is observed by conventional remote sensing techniques instead of trapping individual trees in the landscape. Within the less dense woodland or in individual trees, as is the essence of the drylands most commonly, the approach can be overlooked. Google Earth receives satellite data from many satellites with various technological capacities and resolutions (Fig. 1.6). The array of Google’s dryland satellite imagery from a variety of providers like Digital Globe is especially high, as deserts are cloud-free. While the identification of non-dominant ground cover is difficult for algorithms, the human eyes do not have a problem identifying trees in landscapes.

A program that supports organizations involved in REDD+ and forest discussion was created during the second half of 2015 by the European Space Agency (ESA). The REDD+ is a global initiative to encourage countries to reduce CO_2 emissions, encourage forest restoration and sustainable land management, and increase the sum of land carbon stocks. Emissions from forest destruction is a global initiative. To order to figure out illicit deforestation and to monitor the condition of trees, forest management is important for REDD+. The monitoring of forests from the land, however, requires time. Certain regions, particularly in locations where the resources and records are scarce, are also difficult to protect.

1.8 Crisis Mapping of Forest Cover

The crisis map is a real-time data collection, view and review of a crisis of specific severity of growth, including financial, social and environmental data. Crisis mapping allows a vast range of individuals, even indirectly, to monitor crisis response by sharing information. “Crisis mapping can be defined as the three-part combinations—information compilation, display and analysis—as defined by Patrick Meier (Meyer 2011). All are stored in a dynamic, interactive map. Disaster maps are used for the

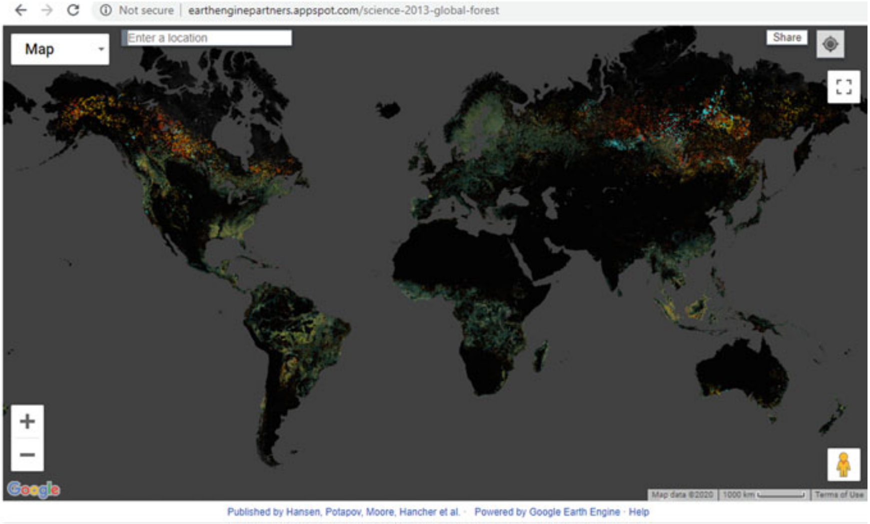
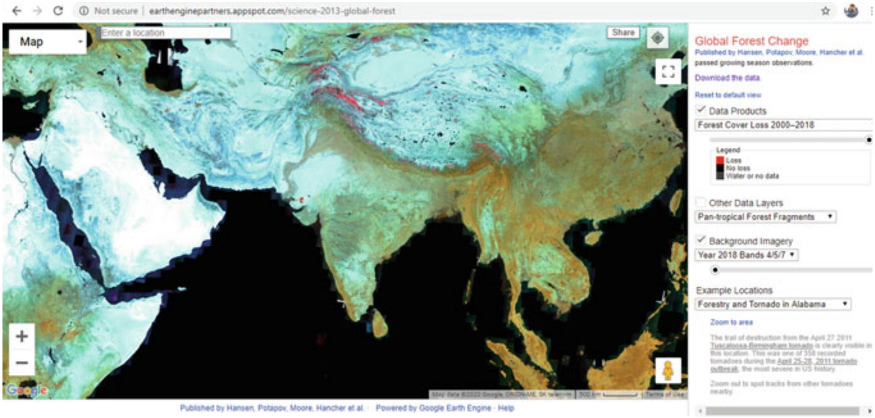


Fig. 1.6 Forest map showing Forest Loss in the World in 2018. Reference 2000 and 2018 imagery are median observations from a set of quality assessment-passed growing season observations. Trees are defined as vegetation taller than 5 m in height and are expressed as a percentage per output grid cell as '2000 Percent Tree Cover'. 'Forest Cover Loss' is defined as a stand-replacement disturbance, or a change from a forest to non-forest state, during the period 2000–2018. 'Forest Cover Gain' is defined as the inverse of loss, or a non-forest to forest change entirely within the period 2000–2012. 'Forest Loss Year' is a disaggregation of total 'Forest Loss' to annual time scales (*Source* https://earthenginepartners.appspot.com/science-2013-global-forest)

development in the field of early warning systems and disaster-response services by means of real-time, crowd-sourced crisis data, satellite imagery, data analytics, computer analysis and web-based applications. A non-profit, open-source development organization, for instance, is building the Ushahidi Web site. Ushahidi will disseminate and gather data on a situation in any region of the world. Users can provide information through email, e-mail or web pages, and the data can be aggregated to form a map or timeline. Google Crisis Response is a Google.org department that "sees to make knowledge critical of natural disasters and humanitarian emergencies more available." Google that respond: updating the disaster area satellite imagery, developing an emergency information and resources web page, hosting a crisis map featuring accurate and crowd-based geographic information, contributing charity to on site organisations, engineering products and information services, such as Google's person-based Finder and landing pages. The humanitarian OpenStreet Map Team (HOT) manages free mapping tools in several locations worldwide to develop, produce and distribute them. The HOT delivers "free, up-to-date maps" as a "critical resource for emergency relief agencies and global emergencies". Although the dataset is available in a format which the technically knowledgeable can most probably use, users will generate derivative charts, views and aggregations.

More than 50 football fields of the forest are damaged every minute, as per the World Community Institute. 20.8 million acres of woodland were overlooked in 2012 alone (over 80,000 square miles).Global Forest Monitor is a program that combines satellite technologies, open data, and crowdfunding to enhance policymaking in real time. Global Forest Watch (https://www.globalforestwatch.org/) was originally founded by the World Bank Institute as an initiative in 2007. This was a way of combining the latest up-to-day technologies with collaborations between various countries to create a global forest surveillance network. In an attempt to foster global forest accessibility, Global Forest Watch merges real-time satellite technologies, web devices, crowd-sourced info, forest maps, protected area maps and on-the-ground networks. For example, Global Forest Watch (GFW) is an immersive global forest monitoring and alert program that offers updates on forests all over the world in real time. Forest image processing and cloud storage capability, GFW using satellite technologies in building exchanging distributed data sets on trees (Fig. 1.7). Forest data collection, it was also developed as a resource for crowd sourcing that allows users to share their own findings directly from the ground.

Rapid growth in ICT (Internet), cloud computing, social networks (including mobile telephony) in recent years has revolutionized people's way of communicating and sharing knowledge with one another. The emergence of smartphones and open Internet connectivity has contributed significantly to the availability of vast information for the public. The ability of crowd-sourced knowledge to provide consumers with a better view of the importance of shopping plans is used by popular webpages such as TripAdvisor, Amazon, eBay and the new e-commerce sites. At the other hand, Wikipedia, Flickr and OpenStreetMap provide an outstanding example of the modern world where crowdsourcing has provided a huge resource of resources for organisations and people all over the globe to continue to use. The concept of the digital world also reveals how important people are as data sources and participants to daily life. The importance of citizen-generated crowd-data is expressed in Digital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Global Forest Change

Published by Hansen, Potapov, Moore, Hancher et al.

passed growing season observations

☑ Data Products: Forest Cover Loss 2000–2018

☐ Other Data Layers: Pan-tropical Forest Fragments

☑ Background Imagery: Year 2018 Bands 4/5/7

Example Locations: Forestry and Tornado in Alabama

Published by Hansen, Potapov, Moore, Hancher et al. · Powered by Google Earth Engine · Help

Fig. 1.7 Forest change of Indian sub-continent (*Source* Hansen et al. 2013)

World (Craglia et al. 2012). The Digital Earth vision addresses the key government, science and social forces that make it possible to locate, imagine and interpret vast quantities of data from a "DigitalEarth" as a multi-resolution, three-dimensional image of the earth.

1.9 Conclusion

Forests and forest ecosystems are evolving more as a result of natural and human transition. And if individuals will not participate, they are still subject to tangible improvements. Conservation importance can be established by the use of multiple ecological landscape criteria, as well as stringent soil monitoring for areas with biological value, highlights, warm spots and hot specks. In global efforts to mitigate greenhouse gas emissions, the protection of carbon stocks, particularly in peat bog forests and mangrove areas, should be a key priority. In the current phase of global economic growth, afforestation, reforestation and the restoration of the natural environment will concurrently provide jobs. Specific challenges are compounded by the geographical and temporal aspects of sustainable forest management. A global and multidisciplinary initiative is required to minimize habitat degradation and to boost public consciousness, increase forestry law enforcement initiatives, increase support for conservation areas and introduce environmental protections in tandem with construction activities. Nevertheless, for the broader application of sustainable forestry management, the relative weakness of the forest legislation to tackle equity concerns remains a major problem. The roles of forest habitats and the use of wood in Anthropocene are evolving. Land managers need new method to understand and change management strategies using revised information. The rapid speed of transition will intensify the need in both natural and managed forests to identify ecological responses over broad scales. There is a commitment to track forest conditions in near real time that substantial progress is being made with the remote sensing-based change detection and Tracking system; it is, however, unclear if this tool is sufficient for quantification and review of the efficacy of management activities. New insights must also be easily incorporated into management decisions and user-friendly predictive model. The level of experiential awareness, insights and data collection can be increased by emerging approaches to gathering and dissemination of information such as citizen science networks and 'crowd sourcing' methods in order to complement written information. Eventually, over the past few decades, upgrades to data acquisition, storage, and access processes have provided vast volumes of readily accessible data, allowing large-scale "big data" biogeochemical pattern analyses. For potential control of forest resources, forest ecosystem services and mixed natural-human processes will be considered for trade-offs. With the purposes of prevention and transition to the adverse impacts of natural and anthropogenic disturbances that will escalate in Anthropocene, current best management practices (BMPs) should have been reviewed.

Acknowledgements We are grateful to the PG Department of Geography, Raja N. L. Khan Women's College (Autonomous), affiliated to Vidyasagar University, Midnapore, West Bengal, India for supporting this research. The author (P. K. Shit) acknowledged West Bengal DSTBT for financial support through R&D Research Project Memo no. 104(Sanc.)/ST/P/S&T/10G-5/2018).

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