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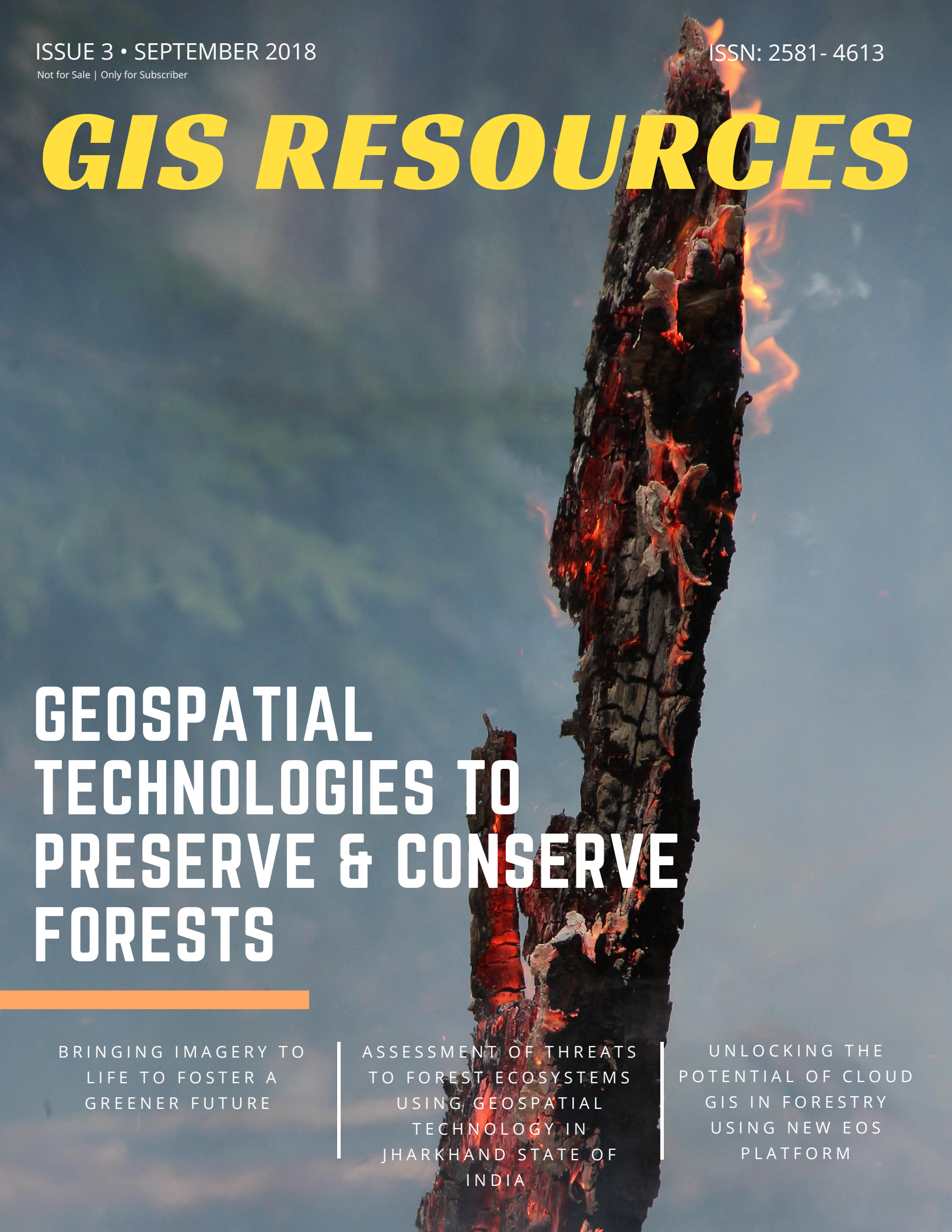
GIS RESOURCES



GEOSPATIAL TECHNOLOGIES TO PRESERVE & CONSERVE FORESTS

BRINGING IMAGERY TO LIFE TO FOSTER A GREENER FUTURE

ASSESSMENT OF THREATS TO FOREST ECOSYSTEMS USING GEOSPATIAL TECHNOLOGY IN JHARKHAND STATE OF INDIA

UNLOCKING THE POTENTIAL OF CLOUD GIS IN FORESTRY USING NEW EOS PLATFORM

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editor's note

PRESERVE & CONSERVE FORESTS FOR HUMAN WELLBEING

Forests are a resource. Minerals are also a resource. Minerals are mined for development hence forests can also be exploited for development. This seems to be the logic that has set the course for development.

Ignoring the recommendations for the conservation and preservation of the Western Ghats has caused the excessive rains in Kerala to cause the kind of damage that Kerala has suffered. If the natural forests and geography of the area had been nurtured, the damage would have certainly been less.

Similar events are taking place in the development of Smart cities. Faridabad is covered by the National Conservation Zone regulations of the National Capital Region regional plans applicable to the Aravallis, forests and rivers. Will Faridabad be developed as a Smart city at the expense of the Aravallis?

In yet another case, the Hon'ble Supreme Court ordered to clear the land by demolishing all structures in an area spread over 425 acres where residential & commercial structures, parks and roads had been constructed in an ecologically sensitive zone of the Aravallis in Faridabad. The Hon'ble Supreme Court came down heavily on the Haryana Government for turning a blind eye to the ecological degradation of the Aravallis over the years and conniving with real estate developers to allow them to exploit protected zones for commercial gains.

The above is surely not isolated cases of a detrimental impact on forests. Such incidences can be found everywhere where there a lack of appreciation of the beneficial role of forests on humankind.

The beneficial influence of forests and the detrimental impact of forest degradation on all forms of life are well known and need not be repeated here. It would be sufficient to say that forests need protection from human greed, development and over exploitation.

In one of my earlier editorial write-ups, I had stressed on a balance between development and environmental preservation. The above incidences of degradation of forests further strengthen the case for better planning for the conservation and preservation of the forests which are an not only an integral part of the ecology but are also instrumental in influencing the environment for human wellbeing.

This is our planet and the only earth we know. Let us preserve and conserve these great forests.

Ashok Prim
Editor

BRINGING IMAGERY TO LIFE TO FOSTER A GREENER FUTURE

Deimos Imaging's high-quality and precisely calibrated sensors are the perfect tool to support the information needs of forestry management and deforestation tracking.

by Ana Isabel Martínez

Deimos Imaging provides reliable monitoring and crucial data about the impact caused by deforestation and its evolution over time, with a focus on protected areas management and sustainable forestry.

Forests cover 31% of the land area on Earth. They produce vital oxygen and provide homes for people and wildlife. The loss and degradation of the world's forests account for around 17% of carbon emissions and could have far-reaching consequences for humanity. According to the Food and Agriculture Organization (FAO), *"current deforestation trends point toward catastrophic and irreversible losses of biodiversity and runaway climate change"*.

The Amazon rainforest has the world's highest deforestation rates. And despite their decline over the last decade, they continue at an alarming rate. The state of Mato Grosso, located in the southern region of the Brazilian Amazon, has one of the highest deforestation rates in Brazil. These land use changes are the result of a complex series of problems, but they can be partly explained by the expansion of pasture and mechanized agriculture, primarily based on soybean crops.

Deforestation is a threat that comes in many forms, including fires, clear-cutting for agriculture, ranching and development, unsustainable logging and degradation due to climate change. And while there are global programmes, such as REDD+, that incentivise sustainability and

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emission reduction, monitoring their progress is still a challenge. It's notoriously difficult to get an accurate picture of the changes in forest cover from the ground and to spot the countless, small-scale logging and forest clearing activities at the hectare level. This is where geospatial information has proved a crucial tool to deliver the much-needed evidence.

Deimos Imaging provides reliable monitoring and crucial data about the impact caused by deforestation and its evolution over time, with a focus on protected areas management and sustainable forestry.

Monitoring the World's Forests With Unprecedented Precision

Deimos Imaging's high-quality and precisely calibrated sensors are the perfect tool to support the information needs of forestry management and deforestation tracking. We provide a wide range of multi-sensor, multi-spectral and multi-resolution imagery that enables frequent monitoring, from global to local scale. You can monitor very vast areas to detect hotspots to 'zoom in' and identify specific and ongoing activities such as small-scale logging and clear-cutting operations. Additionally, our extensive archive imagery allows to detect land cover changes and deforestation trends since 2009.

A feasibility study carried out over the entire Amazon basin showed that, combining our virtual constellation medium and high-resolution sensors, we are capable of imaging the whole region, on average, twice per week. Medium- and high-resolution data are key for vast areas monitoring and to detect changes.

Mapping forests at medium resolution is key to detect large-scale deforestation, but to really understand the changes and to identify what is driving them, you need very much more detailed satellite imagery that reveals what is happening on the ground. Thus, very-high resolution data is the ideal solution for the identification of ongoing and/or illegal activities, such as logging and land clearing. With over 20 sensors at a resolution equal to or better than 1 meter, we guarantee exceptional revisit capabilities.

A feasibility study carried out over a 12 square kilometers parcel near the Xingu Indigenous Park in Brazil's Mato Grosso showed that we can cover this area 15 times per week in average, being able to get a full coverage of it several times per day.

This daily frequency of fresh imagery allows to track deforestation and to manage forest resources with unprecedented precision, especially in areas where cloud cover is common. The status of every hectare can be assessed daily and illegal activities can be identified and tracked, as well as patterns in land cover changes and deforestation. This information is essential to support decision making and the development of integrated policies and concerted action across the region that support sustainable development and management.

Figure 1. Medium resolution image of deforestation near the Xingu Indigenous Park in the state of Mato Grosso, Brazil.

A Greener Future with UrtheDaily™

As a natural evolution from our virtual constellation and given the importance of satellite imagery to monitor and protect our environment, we are developing a new constellation specifically designed for monitoring purposes: UrtheDaily™. This planned constellation will provide high-quality multispectral optical imagery of the Earth's entire landmass (excluding Antarctica) every day, at the same time, from the same altitude, directly into your applications. With these exceptional capabilities, UrtheDaily™ will present a disruptive and problem-solving technology that will bring imagery to life and help fostering a greener future worldwide, daily.

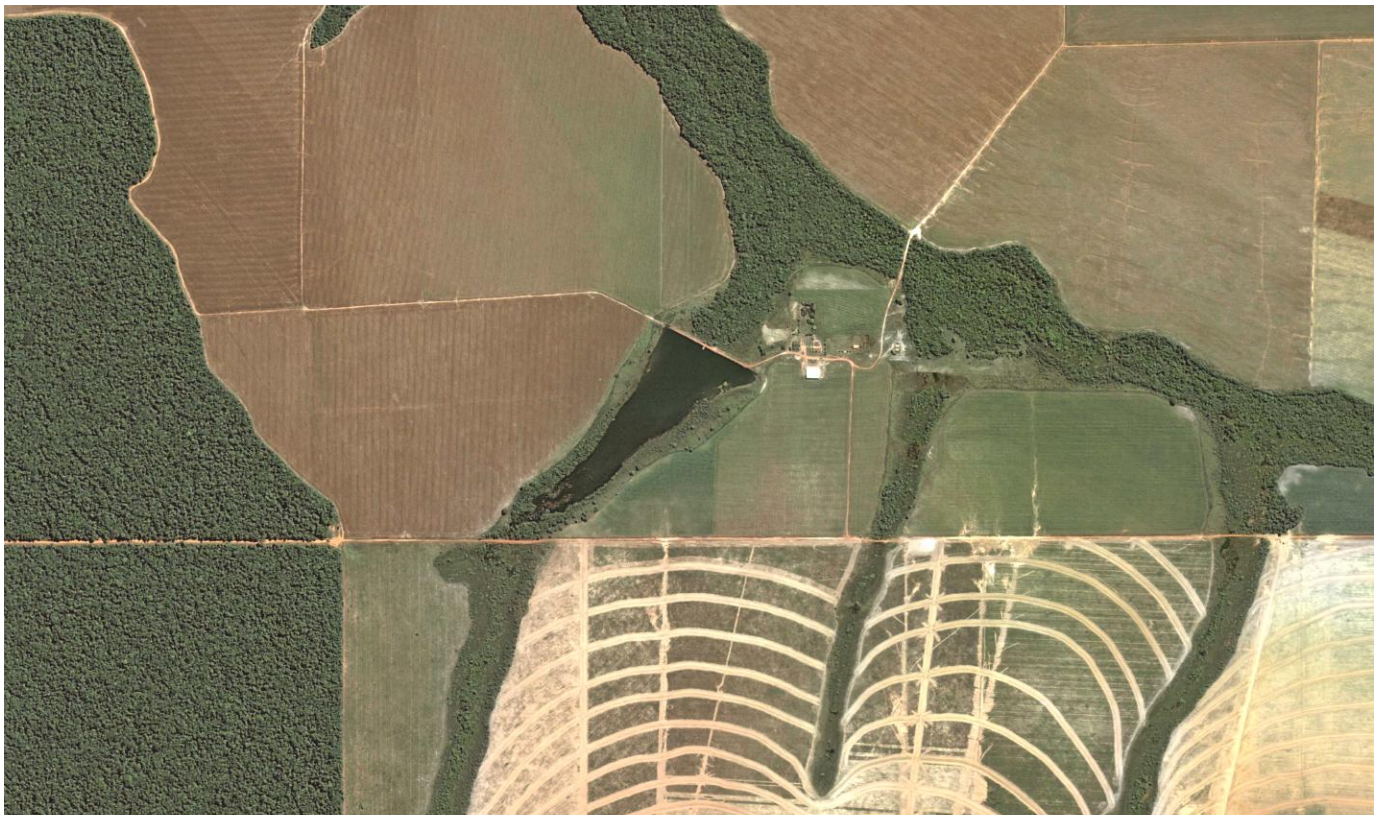


Figure 2. Very-high resolution image of deforestation near the Xingu Indigenous Park in the state of Mato Grosso, Brazil.

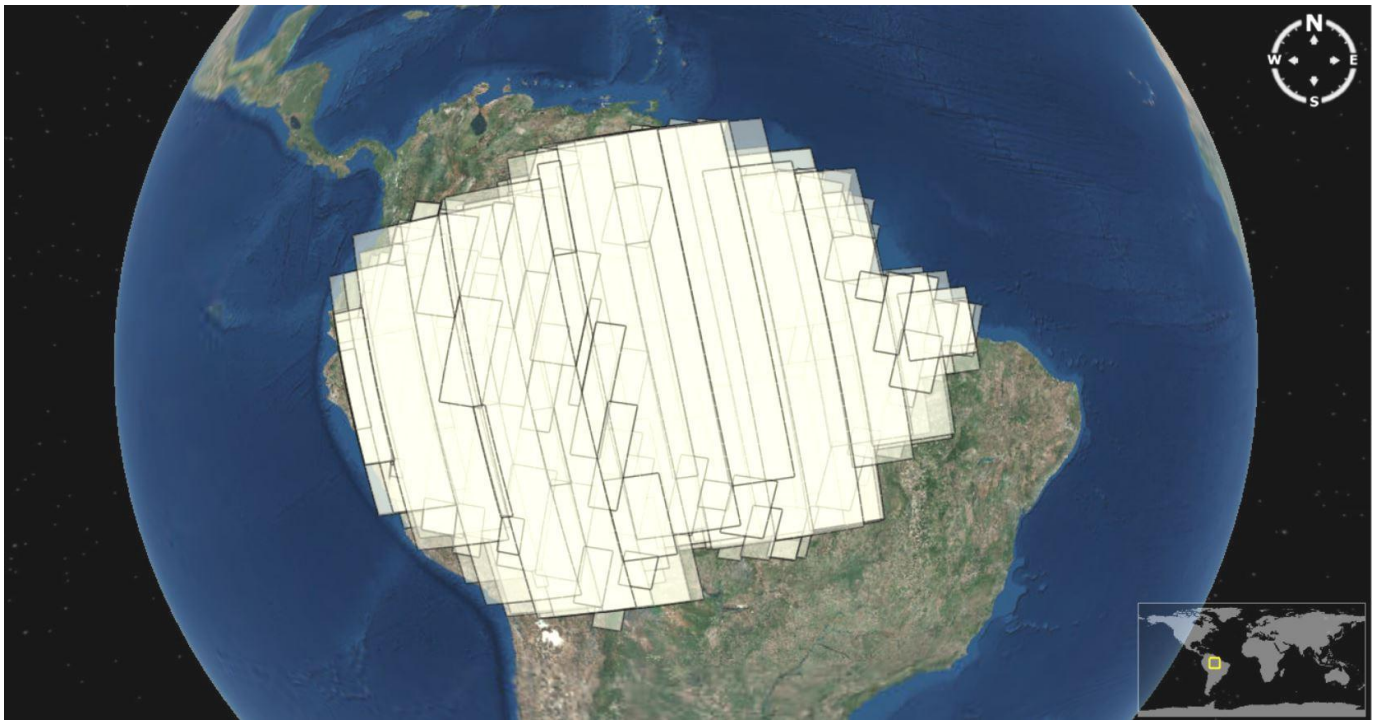
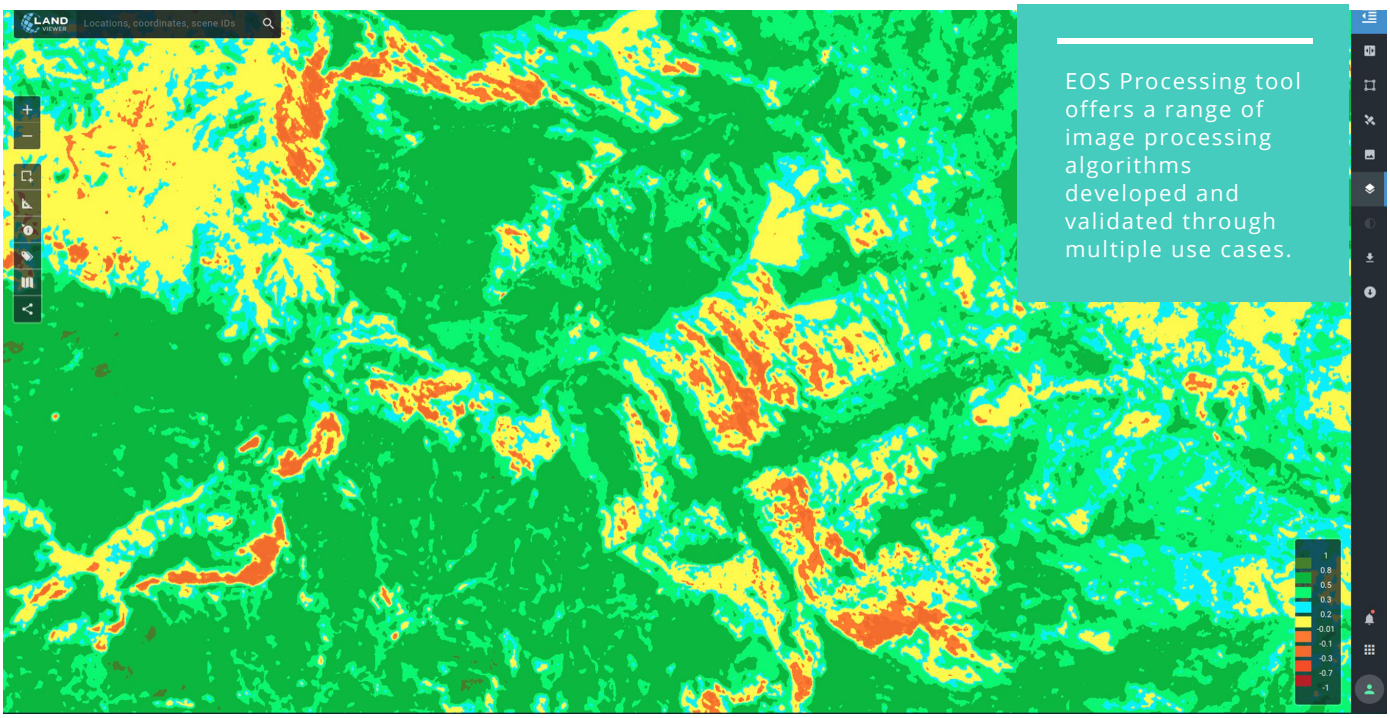


Figure 3. Feasibility study showing the capability of Deimos Imaging's medium and high-resolution sensors to capture the Amazon basin during September 2018.

UNLOCKING THE POTENTIAL OF CLOUD GIS IN FORESTRY USING NEW EOS PLATFORM

EOS' change detection algorithm applied to a pair of satellite or airborne images taken before and after the event will outline the exact contours of deforested or burned area, respectively.

by Earth Observing System (EOS)



EOS Processing tool offers a range of image processing algorithms developed and validated through multiple use cases.

In the era of cloud computing, running a satellite imagery analysis online has become a reality. With cloud solutions like EOS Platform pioneering in the Earth observation market, ENVI and Erdas Imagine software are not the only options anymore.

EOS Data Analytics designed a new GIS platform for all geospatial-data related tasks, from basic remote sensing to cutting-edge image processing. It comprises 4 tools, which together allow for uninterrupted flow of analysis and support most remote sensor types and data formats:

- EOS LandViewer – quick search of low-, medium- and high-resolution imagery and remote sensing analysis;
- EOS Processing – a set of image processing algorithms for automatic feature extraction, change detection, etc.;
- EOS Storage – a cloud space for storing, sharing and distribution of geo-data;
- EOS Vision – a tool for mapping, data visualization and stylization.

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These tools offer solution for individuals and businesses across many industries, most often in agriculture, oil and gas, and forestry. To India, one of the world's most forested countries that is facing severe forest degradation and deforestation, EOS Platform can provide considerable aid in monitoring forest health and logging, tracking illegal forest clearing, and assessing fire damages.

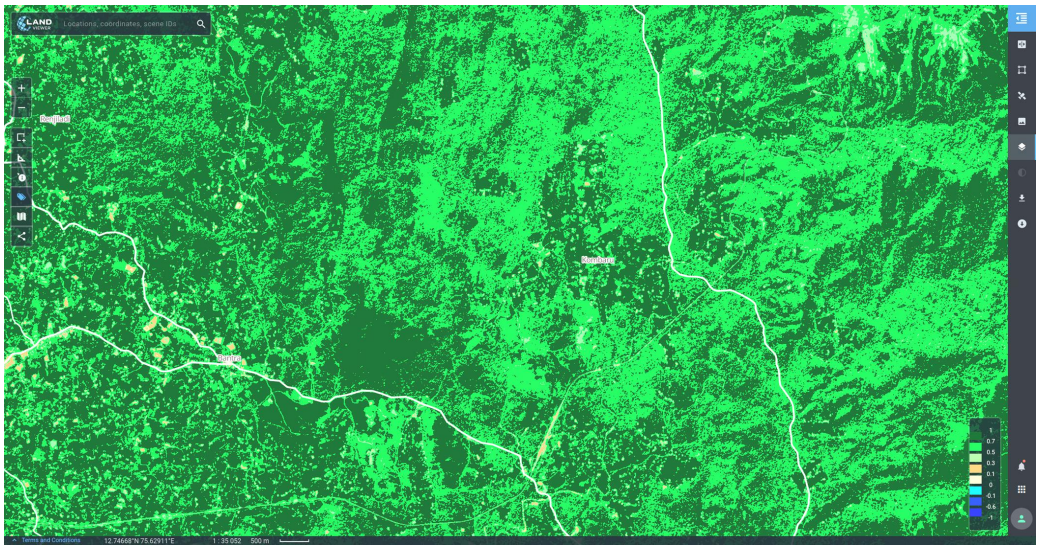

Figure 1. NDVI image of Bantra and Kombaru forest vegetation in 2015.

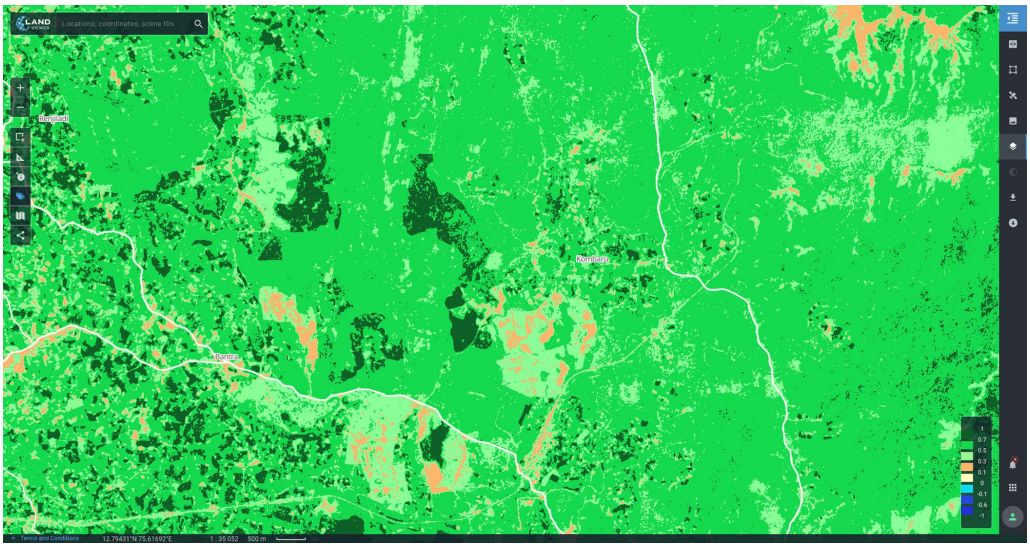

Figure 2. Areas of vegetation loss identified with NDVI analysis of 2018 image.

Monitoring Forest Health With Vegetation Indices

Forest degradation, which results in decrease or loss of forest cover and its productivity, is difficult to be identified from the ground. Satellites play the key role in providing a full picture of the current state of large forested areas, and remote sensing helps to identify vegetation suffering diseases, pest infestations, damaged by human activities.

A common case of GIS application is establishing the state of forest health by calculating the Normalized Difference Vegetation Index (NDVI). One of EOS Platform's tools, LandViewer, can be used to automatically create an online NDVI map. It has a list of instantly calculated indices for landscape, water, vegetation analysis, and gives free access to numerous land-observing satellite datasets (Landsat 7, 8, Sentinel-1, 2, MODIS, etc.). LandViewer also enables users to upload and work with their own satellite data: this can be imagery from Indian (Cartosat, ResourceSat and Indian Remote Sensing series) or other optical/radar satellites (SPOT, WorldView, etc.). Beginner analysts will easily master spectral analysis using LandViewer, as it doesn't require any particular GIS skills.

The growing demand for timber and farming land leads to massive forest clearing and degradation, which boomerangs on people, by causing floods and landslides. Deforestation is considered one of the main factors that triggered the catastrophic Kerala flooding in August, the worst in a century. With remote sensing, environmentalists can monitor the scale of damage caused and identify the forest areas, which need immediate protection.

These Sentinel-2 images show Kombaru and Bantra villages in Karnataka state. Over 80% of Kombaru's area is covered by forests, which looks believable on 2015's Sentinel-2 image, where the overall high NDVI values indicate a healthy forest cover. In 2018, the same area doesn't look same green anymore, demonstrating considerable forest loss in brown-colored areas.

To interpret NDVI values correctly, characteristics of the forest region and local species must be taken into account. According to many scientists, NDVI results' accuracy may also be affected by soil brightness and atmospheric noise. Therefore, skilled specialists may want to correct the analysis with additional VIs (Enhanced Vegetation Index, Wide Dynamic Range Vegetation Index, red edge NDVI, etc.) and validate the results against ground observations.

Experimentators looking for new

discoveries in forest analysis can use LandViewer to play around with spectral bands. The tool allows to apply a single band, create new band combination or an index, and visualize results in real time.

Forest Fire Monitoring

As global air temperatures rise, millions of forest acres are destroyed in severe fires caused by heat waves and humans. For India that has seen a 125% increase in forest fires in the last two years, it's essential to listen to the pulse of the planet and timely identify wildfires, assess damages, and monitor post-fire regeneration.

At national level, such services as ISRO's Indian Forest Fire Response and Assessment System (INFFRAS) enable efficient fire disaster response. Due to constant supply of images generated from MODIS and VIIRS sensors, INFFRAS detects active fires in near real-time, assesses damages and sends fire alerts to forest officers.

This March a severe forest fire outburst in Kurangani Hills, Tamil Nadu, destroying stretches of forest cover and taking 22 lives of trekkers trapped on the hill. To estimate the damage, we took a pair of Sentinel-2 images and calculated the Normalized Burn Ratio (NBR) in LandViewer.

Low NBR values (in dark orange to red) are a sign of recent burning; high values indicate areas of surviving vegetation. This data can be further used to create a burn severity map or measure the exact area using the drawing tool and AOI feature.

NBR-based post-fire analysis can also be performed with other satellite images containing the near-infrared (NIR) and shortwave-infrared (SWIR)

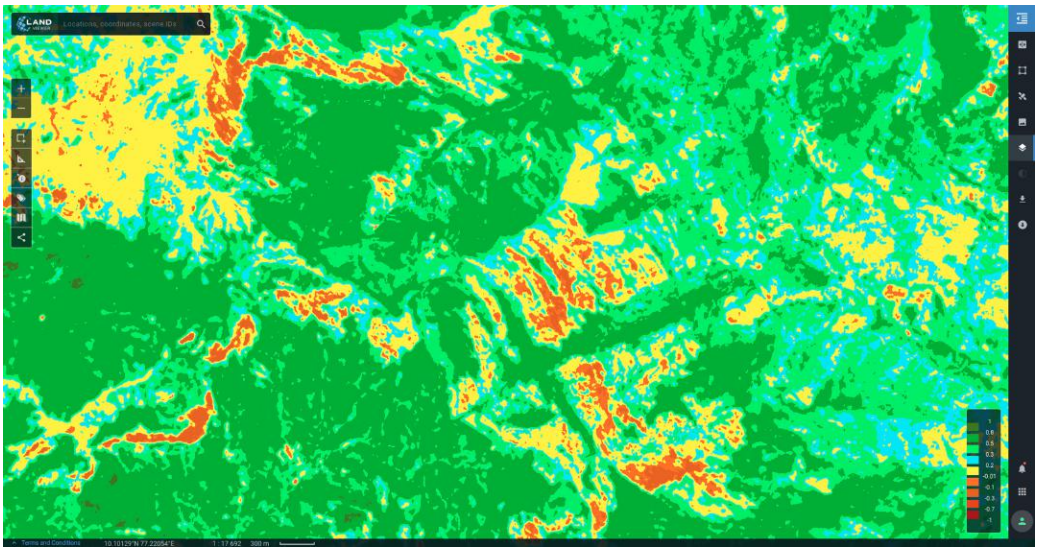

Figure 3. Sentinel-2 image of Kurangani Hills vegetation a week before the fire, with applied NBR.

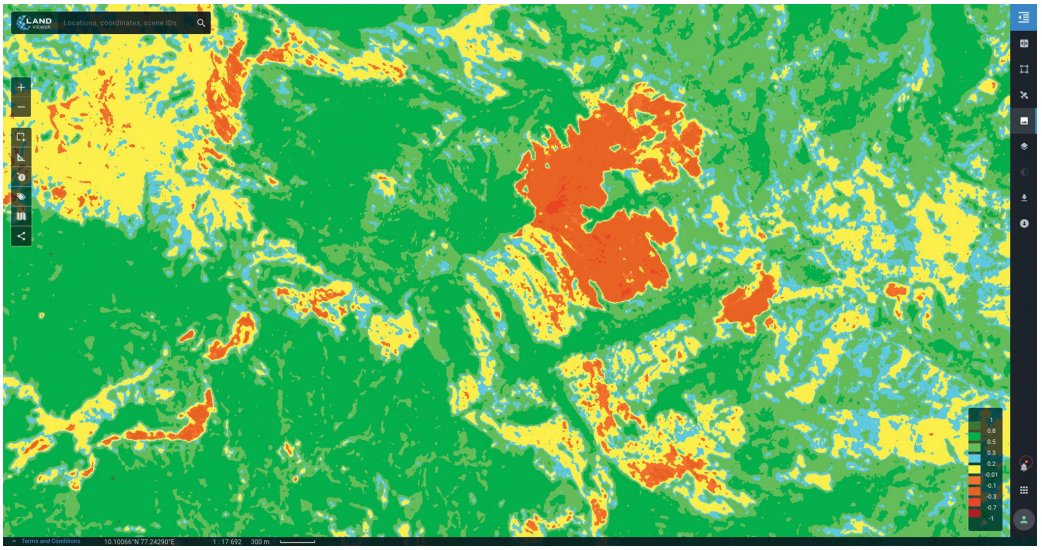

Figure 4. NBR map showing the extent of burn a week after the fire incident.

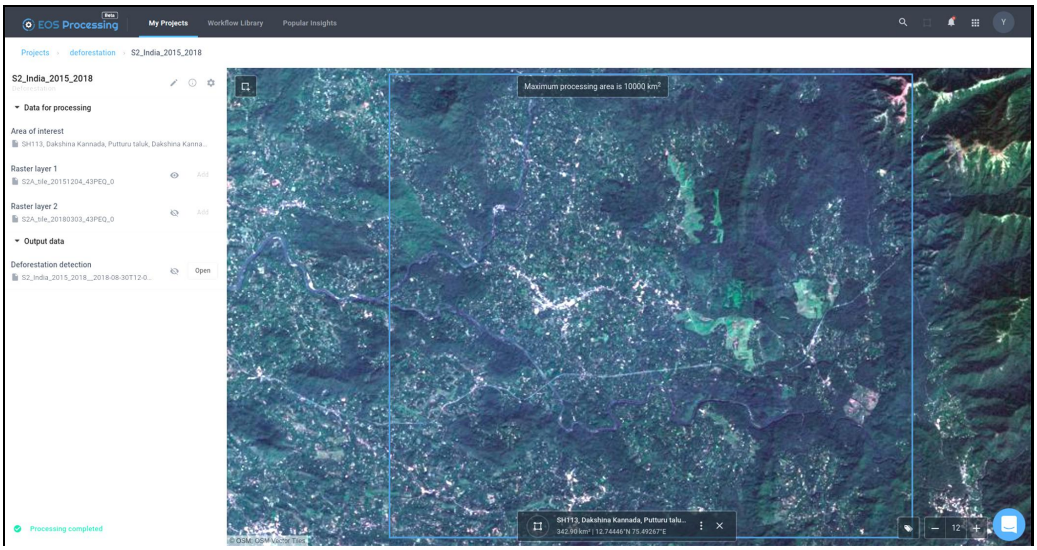

Figure 5. Forests of Dakshina Kannada district in December, 2015.

bands, such as Landsat 7, 8 (available in LandViewer), or IRS ResourceSat-1, 2 (can be uploaded for online analysis). To monitor vegetation recovery and estimate mortality, it's also important to repeat NBR analysis of an area during the next growing seasons.

Deforestation and Fire Damage Assessment

Global climate change is the most dangerous effect of deforestation, which can lead to complete rainforest disappearance in less than 100 years. Environmental organizations all over the world apply GIS techniques to create current maps of forest change and use, and take countermeasures to stop illegal forest clearing.

Forest loss trends can be best observed with multi-temporal analysis of satellite imagery, i.e. by comparing two images of same forest taken at different times. LandViewer's comparison slider can be useful in visualizing the differences between them and eyeball-estimating the scale of deforestation or any other damage.

However, to precisely map and assess forest damage caused by logging, fires or natural degradation, the automatic change detection should be used.

EOS Processing tool offers a range of image processing algorithms developed and validated through multiple use cases. EOS' change detection algorithm applied to a pair of satellite or airborne images taken before and after the event will outline the exact contours of deforested or burned area, respectively.

These are Sentinel-2 images of Dakshina Kannada, which partly lies in the Western Ghats - one of the world's major plant diversity regions. The damage done in 2.5 years is clearly visible in natural color: once green, dense vegetation significantly decreased or completely disappeared (light green and brown areas). With the help of EOS' change detection algorithm that identifies changes from images in RGB and NIR spectrums, we received the third image (raster/vector layer) that highlights the exact areas of deforestation.

The entire analysis can be done in a short span of time, due to mutual integration of all EOS Platform tools: just find images in LandViewer and calculate the index, save them to EOS Storage and proceed directly to EOS Processing for extracting the analytics.

EOS Platform is available for free online use at *https://eos.com/platform*

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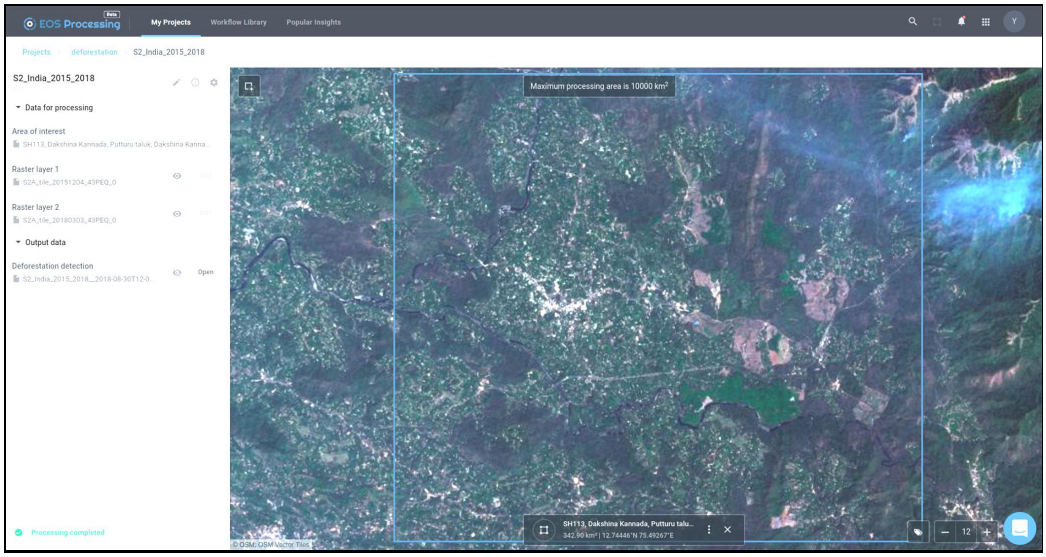

Figure 6. Same area as seen from Sentinel-2 satellite in March, 2018

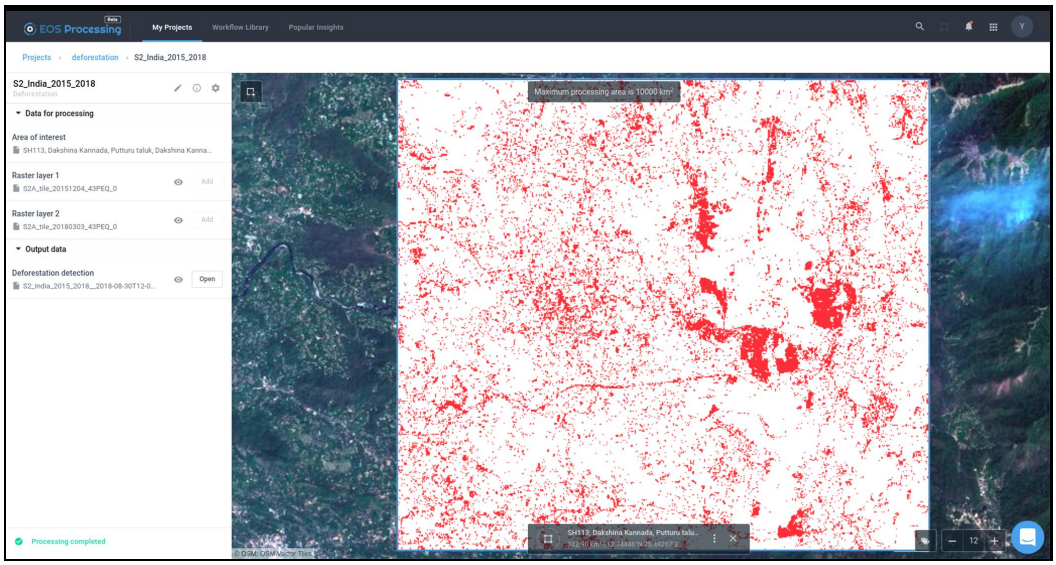

Figure 7. A map of forest cover changes that occured between 2015 and 2018, generated by EOS change detection algorithm.

ASSESSMENT OF THREATS TO FOREST ECOSYSTEMS USING GEOSPATIAL TECHNOLOGY IN JHARKHAND STATE OF INDIA

An integrated approach was adopted to evaluate the three threats that are a forest fire, deforestation and forest fragmentation using remote sensing and GIS data with a synergistic approach for spatial assessment and analysis.

by Firoz Ahmad and Laxmi Goparaju

The study has attempted to generate the spatial information of three forest ecosystem degradation indicators viz. deforestation, forest fragmentation and forest fires using a systematic conceptual approach in the Jharkhand state of India.

Conservation of forest biodiversity is vital for mankind as it provides enormous benefits such as biological resources and ecosystem services. Of late, the forests are facing risk and threats such as fragmentation, degradation and forest fires which are responsible for the deteriorating condition.

The progress in the field of science and technology like satellite remote sensing and GIS since the past few decades in India and the world provide an opportunity to track and monitor the changes taking place on the Earth's surface. Besides, analysis of large spatial data in GIS can also provide insight into the various driving factors which lead to the loss of biodiversity in the threatened ecosystems i.e forests.

The present study has attempted to generate the spatial information of three forest ecosystem degradation indicators viz. deforestation, forest fragmentation and forest fires using a systematic conceptual approach in the Jharkhand state of India. The satellite remote sensing data sets belonging to Landsat were used to analyze the forest cover of Jharkhand state.

To identify the areas of threat, grid cells (5KmX5Km) were generated in GIS domain. The deforestation was

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assessed using multi-source data of 1935 and 2015. Historical evaluation of deforestation reveals that the major changes had occurred in a forest of Jharkhand and identified 1224 extinct, 248 critically endangered, 318 endangered and 396 vulnerable ecosystem grid cells. The fragmentation analysis has identified 148 critically endangered, 296 endangered and 402 vulnerable ecosystem grid cells. Forest fire point's data from the year 2005 to 2016 were utilized and analysis was done. A further frequency of forest fires in each grid was noted. The result indicates that 67.3% of grid cell of Jharkhand forest was affected with a forest fire. Conservation status has been evaluated based on the value of threat of each grid which was the basis for conservation priority hotspot. About 2.1% of Jharkhand forest ecosystem grids had extremely high ecosystem risk stage and had been included under the category of conservation priority hotspot-1 followed by 19.7% conservation priority hotspot-2, 41.3% conservation priority hotspot-3, 27.8% conservation priority hotspot-4, and 9.1% lowest conservation priority hotspot-5. This study highlights the ability to integrate remote sensing and GIS data for mapping the forest degradation, which can be useful in formulating the strategies and policies for protection and conservation of forests.

Introduction

The conservation of forests has become a major concern with the international community ever since the Convention on Biological Diversity (CBD) was drafted in Rio in 1992. Forests and woodlands cover nearly 40 percent of the Earth's land surface, and they are the most biologically diverse ecosystems in most parts of the world (WRI-IUCN-UNEP, 1992). Forests are the single most important banks of global biodiversity (Kapos and Iremonger, 1998). Tropical dry deciduous forests are one of the largely neglected natural resources all over the world. They are the most poorly protected forest categories in the world with only 5% of the area under protection (WCMC, 1996) as cited by Kapos and Iremonger (1998). However, these forests serve the local, tribal communities by meeting their needs for food, fuelwood, fodder, fiber and a range of subsistence products besides performing other functions such as the protection of watersheds, providing opportunities for tribal people, ecotourism and habitats for wildlife.

Forest fragmentation, deforestation, forest fire may negatively influence the forest of its original biodiversity at the levels of genes, species, and communities. The loss of biodiversity was reported by increasing forest fragmentation (Jha et al., 2005). Thus, it is important to evaluate the threats to biodiversity conservation (Reddy et al., 2014). Ancient forest species are important and crucial in terms of nature conservation because they integrate both qualitative (forest quality) and quantitative (diversity) conservation criteria (Peterken 1996). Habitat fragmentation is the process that occurs when a habitat or land cover type is subdivided either by a natural disturbance (e.g. fire or storm) or by human activities e.g. roads or cultivation (Dale and Pearson, 1997). The threats posed by forest disappearance and fragmentation to local biodiversity have been well recognized for nearly two (few) decades (Harris, 1984). Although spatial heterogeneity is a natural phenomenon, human activities are altering the natural landscapes by changing the abundance and spatial pattern of habitats. The two most significant effects of forest fragmentation are a decrease in population sizes and reduction of species diversity (Goparaju et al., 2005; Goparaju and Jha, 2010).

Deforestation implies clearing the forest cover by falling trees or removing the plantations to make way for agricultural, infrastructure and development purposes. A permanent loss of forest cover occurs which cannot be restored to a forest again. According to FAO, it is estimated that the loss in forest cover per year is 18 million acres (7.3 million hectares) - *(http://www.conserve-energy-future.com/various-deforestation-facts.php)*

Removal of trees causes imbalance in the ecosystem and in the long run will affect the environment also. Another major factor which causes loss of trees is forest fire in various parts of the world. It occurs mainly due to the warm summers and mild winters. They may be natural or human-induced but, in both cases, cause large damage to the forest ecosystem. Both the above factors are responsible for increase of carbon in the atmosphere thus causing global climate change. The biogeochemical cycles are altered by deforestation (Potter, 1999).

The World Conservation Strategy (IUCN, 1980) quoted by (McNeely et al.,1990), defines conservation as the management of human use of the biosphere in such a way that it may yield the greatest sustainable benefit to present generations while maintaining its potential to meet the needs and aspirations of the future generation. Since biodiversity is so closely linked with human day today needs, its conservation should rightfully be considered as an element of national security (WRI, IUCN and UNEP 1992). Conservation of biodiversity requires management of entire landscapes, not just protection of individual reserves (Noss, 1990). Core areas managed for the protection of biodiversity could form the backbone for any regional land conservation system surrounded by buffer zones where compatible human uses could be partially allowed.

RS & GIS applications in Forest Conservation Planning

Remote sensing data facilitate as a source of rapid acquisition of any land use information coupled with ground truth of low cost (Pal and

Mather, 2004). In this regard, the Landsat satellite data has been successfully employed for various research activities since 1972 which is the year of its launch. This remote sensing satellite data has a medium spatial resolution and covers worldwide (Hansen and Loveland, 2012). When such data is analysed in GIS (Geographic Information Tool) many of the ecosystems could be studied spatially and temporally (Ahmad and Goparjau, 2017a, b). Some of them were used to study the changing levels of biodiversity with respect to changing forest fragment size (Goparaju et al., 2005). Further it has been utilized for inventorying, monitoring and assessing the terrestrial biodiversity at regional (Shi and Singh, 2002); landscape (Roy and Behera, 2002) level. Besides, it can employ to identify gaps in the protection network which is a GIS-based method (Scott et al., 1993). In a gap analysis of Western Ghats in India, Ramesh et al., 1997; Jha et al., 2000 found that several areas of high biodiversity were excluded from the highest levels of protection.

Few pieces of research have addressed the issue of evaluating the threats and determining the conservation priority hotspot. Reddy et al., 2014 have evaluated the forest ecosystem of the Orissa state of India using the five threats viz. deforestation, forest degradation, fragmentation index, forest fire risk map, and invasive species abundance. The study used 5kmX 5km grid. Further, by integrating various threats by providing equal weights to all, conservation priority hotspot was achieved. A similar study was conducted by Reddy et al., 2015 who have evaluated the forest ecosystem of Telangana state of India using three threats viz. deforestation, fragmentation index and forest fire risk map. Kanga and Singh 2017 studied the forest fire in the Taradevi forest of Himachal Pradesh (India). The study analyzes the forest fire spread analysis and loss assessment using simulation modeling techniques using FARISTE. Findings of the study are helpful in the development of forest fire management and planning.

Apart from Orissa and Telangana states of India, such studies have not been conducted for any other state of India thus this is potential research gap at the state level. The present study has been conducted in the Jharkhand state. It is a land of forest and tribal. A symbiotic relationship persists between the tribals and the forests (Dungdung, 2015). Of late, the forest is threatened due to human and anthropogenic activities, which has deteriorated the condition of forests as well as threatened the livelihood of the tribal people who are mainly dependent on them. The forests have not only witnessed the degradation in forest quality but also in quantity in the recent past. The problem regarding food and livelihood insecurity has escalated due to deforestation. It has further accelerated the displacement, migration and breaking away from the natural environment, also social ambiguity among the tribals.

The present study has attempted to prepare a spatial database for the state of Jharkhand, India to assess the value or quality of the status of the forest ecosystems and identify conservation priority hotspots. In this regard, an integrated approach was adopted to evaluate the three threats that are a forest fire, deforestation and forest fragmentation using remote sensing and GIS data with a synergistic approach for spatial assessment and analysis.

The Study Area

The geographical coordinates of the study area of Jharkhand comprise of latitude 21 ° 58' 02'' N to 25 ° 08' 32''N and longitude 83° 19' 05''E to 87° 55' 03 '' E, whereas total geographical area is 79,714 km² accounted for nearly 2.4 % of total geographical area of the country (Figure 1).

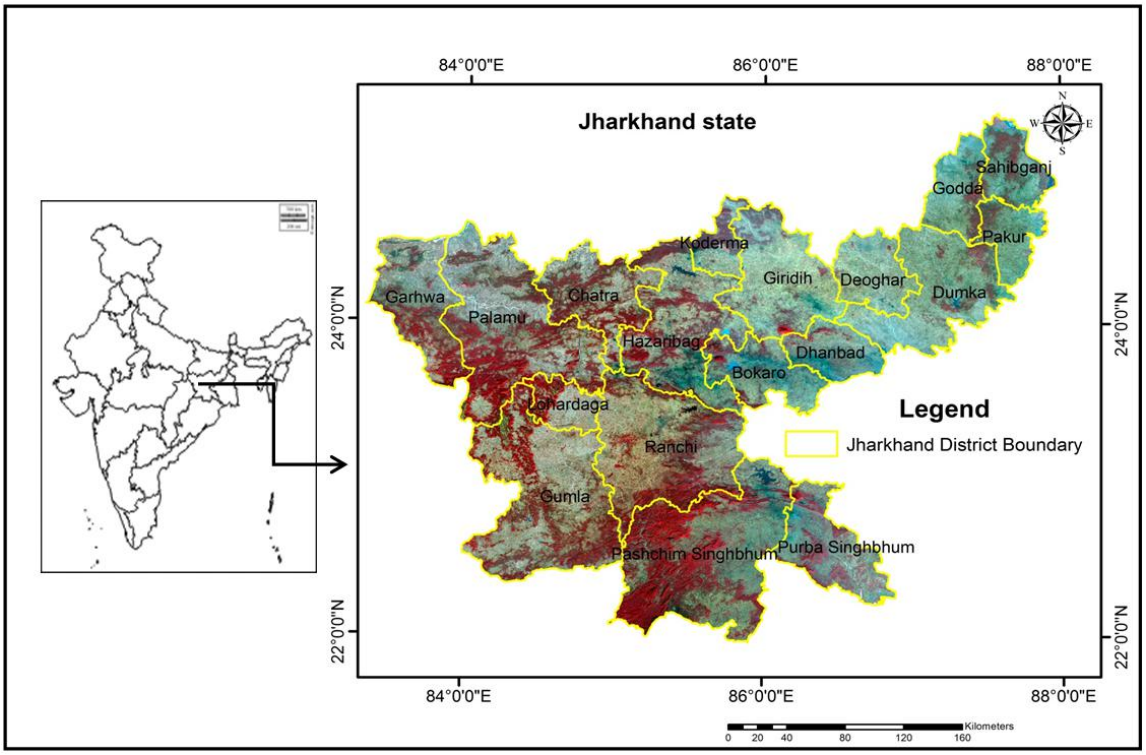

Figure 1. The location of the study area.

The word 'Jharkhand' implies as an 'area of land mass covered with forests'. The state is a home to 30 different tribal groups. Some of the aboriginal races are Santhals, Mundas, Oraons, Hos, Kharia, Bhumij, Birhors, etc. They have a close association with nature. They are commonly known as "adivasis" which means that they are the original settlers of the land. Their livelihood revolves around these forests. They begin their day by collecting edible fruits, roots, flowers, mushroom, tubers, wild vegetables, honey, birds, animals, fuelwood etc. for their daily requirement. Medicinal herbs, fruits, grasses, and leaves etc. serve the purpose of curing diseases and common ailments. Besides, they also preserve the sacred groove in the vicinity of the forest known as Sarna. The forests of this region are tropical dry deciduous with elevation varies from 6 m to 1366 m from the mean sea level. Jharkhand average moderate rainfall varies from 945 mm to 1297 mm with a temperature variation of 6°C in winter to 47°C in summer.

Materials and Methods

- **Data Preprocessing and Analysis**

The identified indicators viz. deforestation, fragmentation, forest fires have been used for the assessment of threatened forest ecosystem in Jharkhand. The flowchart describing the methodology has been furnished in Figure 2. The geospatial evaluation for the threats in forest ecosystem in Jharkhand was analysed using various criteria which are briefly described in Table 1. The forests in the present case have been defined as the area of land with more than 1% of grid area dominated with indigenous tree species with overstory canopy greater than 10%. In order to comprehend the condition of threats, a grid of 5 km × 5 km (each 25 km2) size has been prepared. Historical/long-term changes of forest cover have been expressed in quantitative terms. Only the terminology recommended by IUCN for Red list status of species has been used for the ecosystems, but the criteria for each category of threatened ecosystem has been developed by Reddy et al., (2014) which is used for this study. Forest ecosystems are considered as Least Concern/low risk if no threat identified as per the selected parameters.

- **Processing of the Satellite Data**

The software used was ERDAS IMAGINE 11 for digital image processing and ArcGIS for GRID analyses and presenting the results in the geospatial domain. The nine Landsat images (Table 1) of the time period December 2015 were downloaded from USGS website. The data were mosaicked and resampled using nearest neighbord resampling method in order to preserve the radiometry and spectral information in the imagery. For classification, we have used hybrid classification techniques (combination of visual, Supervised and Normalized Difference Vegetation Index) to map the forest cover with two classes viz. forest and non-forest class. In order to remove the noise and to smoothen the classified image, a 3X3 filter was executed. To evaluate the accuracy of the forest cover map, around 250 random sampling points were generated. They were assigned to the respective classes after confirming them against ground truth data and literature sources. Overall accuracy and Kappa statistic were computed using the error matrix.

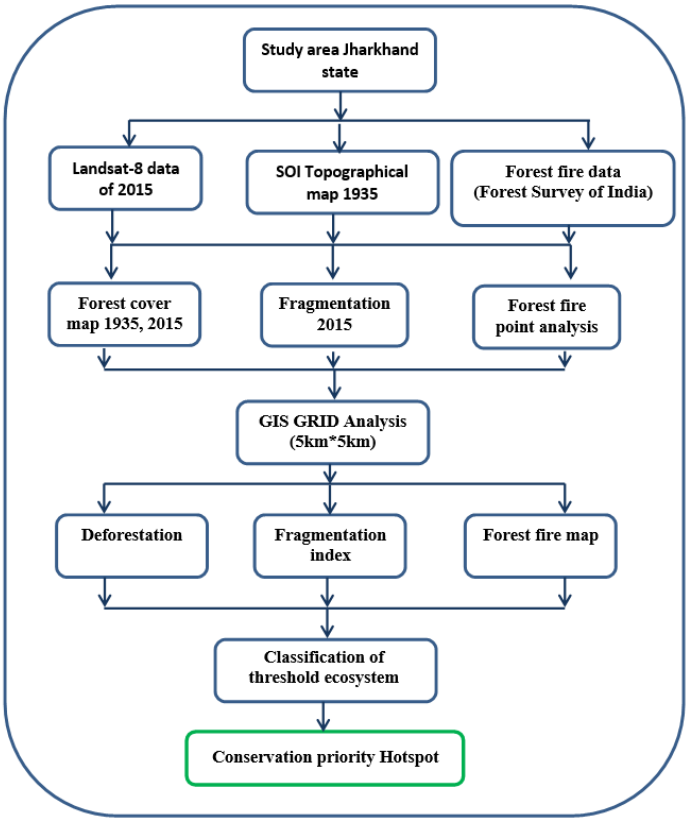

Figure 2. Flow chart showing the methodology adopted.

Satellite	Sensor	Path/ Row	Dates
Landsat 8	OLI_TIRS	142/43	01-12-2015
Landsat 8	OLI_TIRS	141/43 141/44	26-12-2015 26-12-2015
Landsat 8	OLI_TIRS	140/43 140/44 140/45	19-12-2015 19-12-2015 19-12-2015
Landsat 8	OLI_TIRS	139/43 139/44 139/45	28-12-2015 28-12-2015 28-12-2015

Table1. Satellite data details.

- **Threatened Forest Ecosystem Indicator**

1. Deforestation: The spatial distribution of forest cover during the last 80 years has been mapped. Survey of India topographical maps of 1924–1935 (say 1935) were downloaded from - *http://www.lib.utexas.edu/maps/ams/india/* and interpreted visually to generate spatial data on 1:250,000 scale. Remote Sensing data pertaining to Landsat 8 (2015) was used to see the changes with respect to the year 1935. The change in land cover with depletion of tree crown cover to less than 10% was considered as deforestation following the

definition of FAO (FAO, 2011).

On comparing the spatial data on forests in the time series 1935–2015 the forest cover change for the period of 1935–2015 has been considered for assessment of the historical decline wherein if the reduction in geographical distribution of forest cover exceeds >90% considered as Critically Endangered, >70% as Endangered and >50% as Vulnerable (Keith et al., 2013). In long-term decline, if the reduction in the geographical distribution of forest cover exceeds >80% considered as Critically Endangered, >50% as Endangered and >30% as Vulnerable (Keith et al., 2013). In our study we have used the criteria for identification of threatened forest ecosystem based on deforestation were based on a reduction in forest cover exceeds >80% considered as Critically Endangered, >50% as Endangered, >30% as Vulnerable, >10% as near threatened and <10% as least concern.

The analysis of the results has taken these three main points into consideration: firstly, grid cell size of 5 km × 5 km was taken for assessment of threatened ecosystems; secondly, as the analysis was based on multi-time frame data (1935–2015) there is a change in number and distribution of threatened ecosystems, thirdly, the assessment was carried out on 1:250,000 scale.

2. Fragmentation

Habitat fragmentation can be simply characterized as a break up of a continuous landscape containing large patches into smaller, usually more numerous and less-connected patches. In the present study, analysis of fragmentation has been quantified using geospatial analysis in terms of a number of patches of forest and non-forest per unit area. The number of forest patch per unit grid was evaluated based on the forest cover map prepared for the year 2015, it was converted to a vector which was used for spatial grid wise analysis. The criteria for recognization of the threatened forest ecosystem is based on fragmentation were identified by a number of forest fragmented patch. The forest fragmentation index > 70% as critical endangered, > 50% as endangered, > 40% as vulnerable, > 30% as near threatened and < 30% as least concern.

3. Forest Fires

To analyze the forest fires analysis in the state of Jharkhand, the forest fire data was downloaded from Forest Survey of India - *http://fsi.nic.in/forest-fire.php* from 2005 to 2016. The forest fire point file downloaded was in MS-EXCEL file with latitude and longitude. It was exported into shape file year wise using ARC/ GIS Software. The number of forest fires per unit grid was evaluated based on decadal forest fire data. The criteria for identification of forest fire ecosystem were based on number of forest fires. The number of fires >21 as critical endangered, 20-12 as endangered, 11-6 as vulnerable, 5-1 as near threatened and 0 as least concern.

- ***Conservation Priority Hotspots***

The analysis so far has considered as a single potential threat factor. Here, we focus on threatened forest ecosystems which are facing multiple threats like deforestation, fire, and fragmentation rather than single threat factor, as the most prominent, readily useful and identifiable zones for high conservation priority. Conservation status of ecosystems is recorded based on numbers 1–5 are given depending on values of category from deforestation, fragmentation and forest fires. These factors carry equal weight so that they can be combined into various levels of conservation ranking and classified into five categories. Conservation priority hotspot-1 has the highest threat value based on evaluation was in the range of 12–13 followed by conservation priority hotspot-2 with threat value of 10–11, conservation priority hotspot-3 with threat value of 8–9, conservation priority hotspot-4 with threat value of 6–7, conservation priority hotspot-5 with threat value of 3–5.

Results

- **Deforestation**

A comparative evaluation revealed that major changes in forest cover occurred during 1935–2015 (Table 2 and Figure 3). Based on this, the study identified 1224 extinct, 248 Critically Endangered, 318 Endangered, 396 Vulnerable, 284 nearly threatened and 126 least concern ecosystems. Most of the least concern ecosystem is in the middle of the forest surrounded by less dense forest highly inaccessible due to complexity of terrain and mostly away from population. The driving factors of deforestation between the period 1935 and 2015 were industrialization, urbanization, mining activity and conversion of forest land to other land use purpose viz. dam construction, agriculture purpose etc. Within the state, the losses of forest ecosystems are more pronounced in those areas where population was high resulted into forest loss by various their anthropogenic activity. The overall classification accuracy of the forest cover map of 2015 was 94.1%. The Kappa statistic value was 0.91. Validation of maps for 1935 was done based on forest cover map of 2015.

- **Fragmentation**

The geospatial analysis has identified a pattern of fragmentation across the state of Jharkhand. Based on this, the study identified 148 grids under high fragmentation index and categorized as Critically Endangered, followed by 296 Endangered, 402 Vulnerable, 296 nearly threatened and 230 least concern ecosystems (Table 2 and Figure 4). The severe forest fragmentation was found in

southern part of Ranchi, the eastern part of Garhwa, the western part of Palamu and southern part of Gumla district require immediate conservation efforts in order to arrest further deterioration due to land use practices.

- **Forest Fires**

The average of 12 years (2005-2016) indicates Jharkhand face 452 number of forest fire every year. In the year 2010, the forest fire frequency was roughly 3 times higher with the annual average, the same year was also declared as drought year - *http://nidm.gov.in/PDF/DP/JHARKHAND.pdf*. The forest fire analysis reveals the very high identified 27 grids is under high forest fire impact and categorized as Critically Endangered, followed by 85 Endangered,184 Vulnerable, 628 nearly threatened and 448 least concern ecosystems (Figure 5). Study reveals 67.3% of grid cell of Jharkhand forest was affected with fire. Very highly forest fire grid falls in South of Jharkhand (Pachim Singhbhum district area), North west of Jharkhand (south of Palamu and Garhwa district area) and Northeast of Jharkhand (at the junction of Pakur, Sahabganj and Godda district area). The Paschim Singhbhum and Palamu district together roughly receive 50 % of the annual forest fire. Therefore, immediate conservation efforts are required in severe forest fire grids of Paschim Singhbhum and Palamu district to arrest further deterioration.

- **Conservation Priority Hotspots**

This analysis complements an assessment of the threatened ecosystems undergoing multiple threats. The high conservation priority in threatened ecosystem is considered as hotspot-1, followed by hotspot-2, hotspot-3, hotspot-4 and lowest conservation priority is for hotspot-5. 2.1% (29 grids) of existing forest had severe ecosystem level risk and included under the category

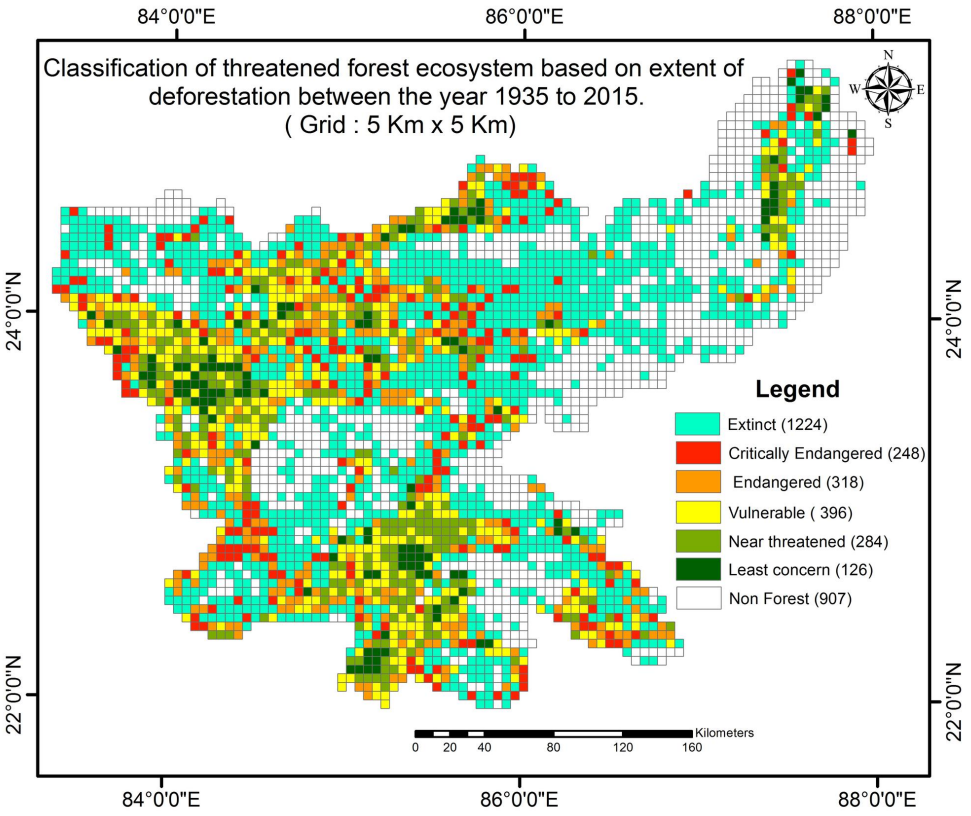

Figure 3. Classification of threatened forest ecosystem based on extent of deforestation.

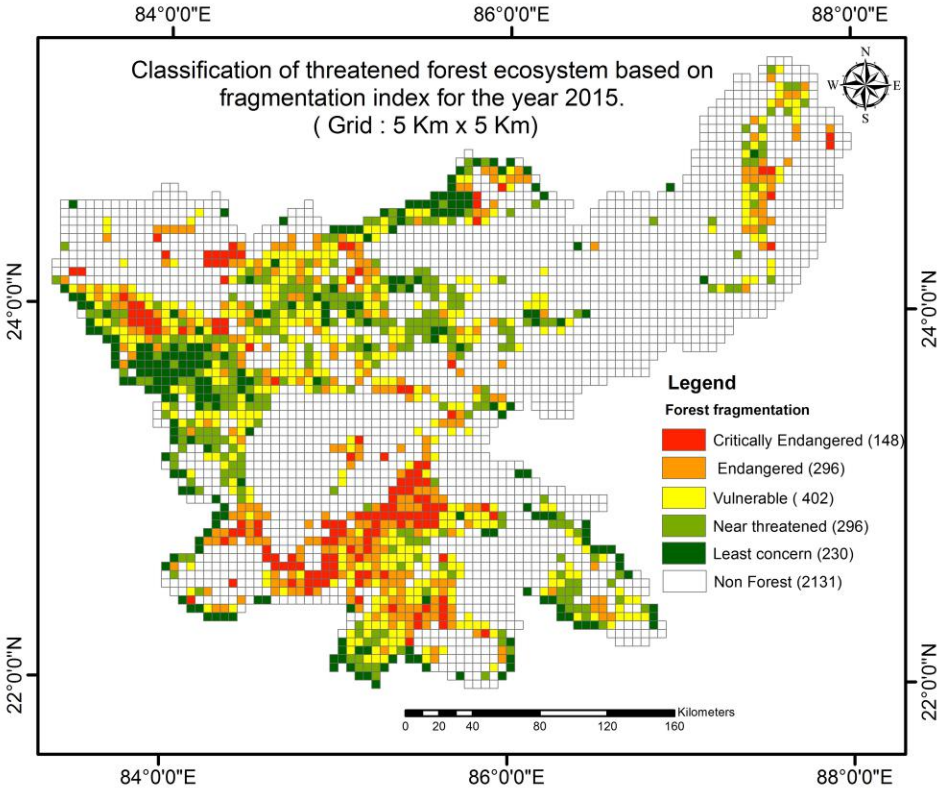

Figure 4. Classification of threatened forest ecosystem based on fragmentation index.

of conservation priority hotspot-1, followed by 19.7% (270 grids) in conservation priority hotspot-2, 41.3% (566 grids) in conservation priority hotspot-3, 27.8 % (382 grids) in conservation priority hotspot-4 and 9.1% (125 grids) in conservation priority hotspot-5, (Figure 6). The majority of conservation priority hotspot-1 mostly falls in West Singhbhum, Ranchi, Palamu and Garhwa district.

The similar study in the state of Orissa and Telangana have also indicated considerable loss of biodiversity at an ecosystem level. The analysis has identified 5.8% (326 grids) of existing forest of Orissa had severe ecosystem level risk and placed under conservation priority hotspot-1 (Reddy et al 2014) whereas the similar study in existing forest of Telangana state identified 2.1% (39 grids) of had severe ecosystem level risk and placed under conservation priority hotspot-I (Reddy et al 2015)

The regions of greater risk have been prioritized since the risk of local extinction is likely to be increased for many species. Thus, understanding the conservation priority hotspots helps directly in conservation programs of forest ecosystems.

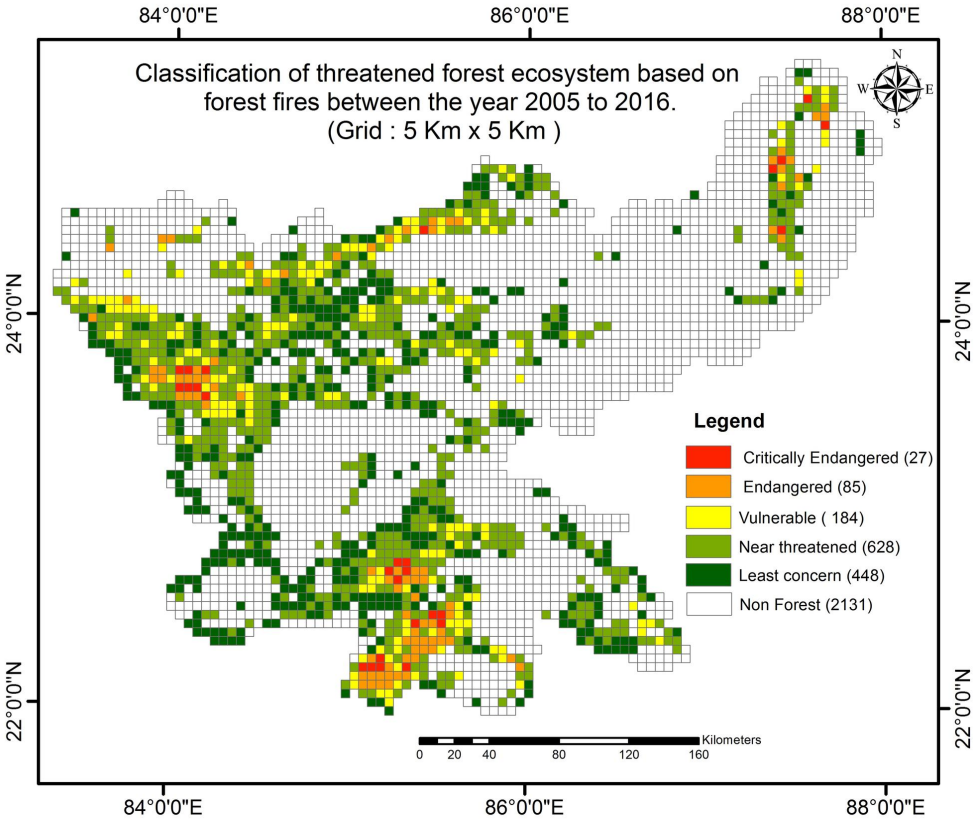

Figure 5. Classification of threatened forest ecosystem based on forest fire.

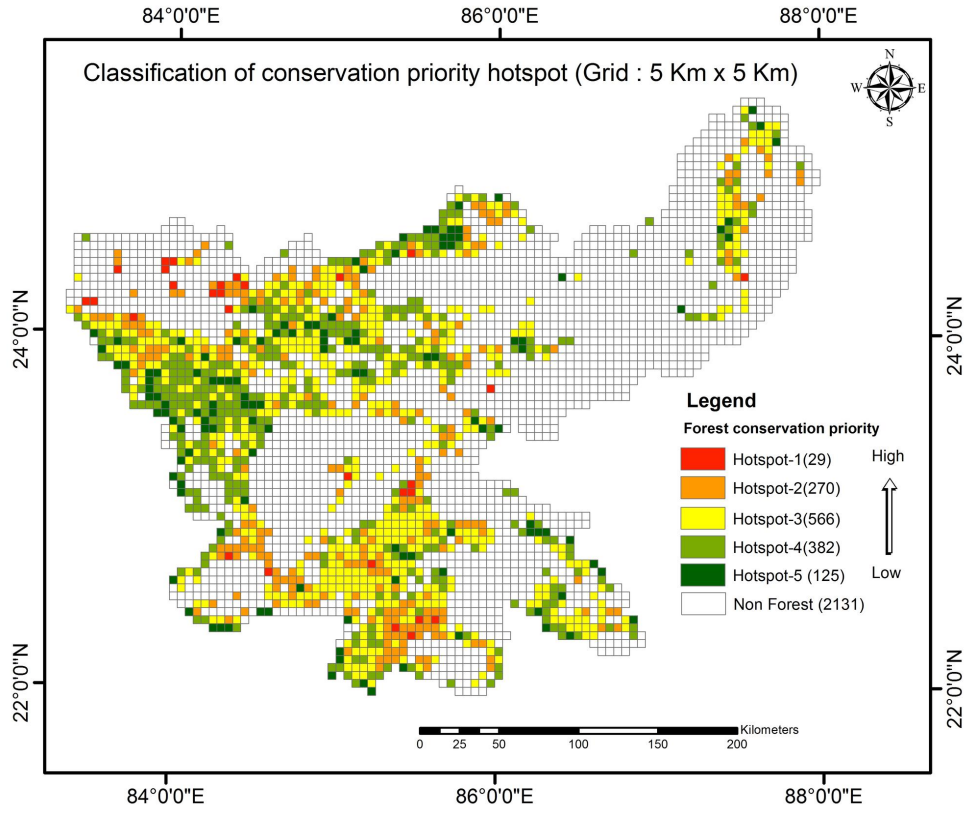

Figure 6. Classification of conservation priority hotspot.

Discussion

The present study has attempted to develop multiple grid-based maps depicting the various threatened categories which are based on ecosystem degradation drivers such as deforestation, fragmentation and forest fire. Such an approach of spatial analysis identifies all the forest ecosystems threats under various categories. They are responsible for the degradation of forests within the state which is a home to the tribes and supports a large number of flora and fauna. Hence, there is an urgent need to formulate the conservation measures and strategies along with

environmental education and people participation which would involve local bodies to manage biodiversity in conservation priority hotspots. It is recommended that an immediate and suitable conservation action plan for the identified hotspots of study area be implemented.

Systematic forest restoration activities are required in conservation priority hotspots-1 followed by conservation priority hotspots-2 and conservation priority hotspots-3. Jharkhand has witnessed severe forest fire in the past and the year 2010 was the worst. In the year 2017 only within 5 days (from 1st April to 5th April) 441 forest fires were recorded in Jharkhand by the Forest Survey of India (FSI). There is a need to formulate the forest fire policies at state and country level to safeguard the forests. Infrastructure development which bifurcates the forests should be discouraged.

Ecosystem	Deforestation		Fragmentation		Forest fire	
	No. of grids	% of grids	No. of grids	% of grids	No. of grids	% of grids
Extinct	1224	34.9				
Critically Endangered	248	7.1	148	4.2	27	0.8
Endangered	318	9.1	296	8.4	85	2.4
Vulnerable	396	11.3	402	11.5	184	5.3
Near Threatened	284	8.1	296	8.4	628	17.9
Least Concern	126	3.6	230	6.6	448	12.8
Non-forest	907	25.9	2131	60.8	2131	60.8
Total	3503	100	3503	100	3503	100

Table 2. Analysis of threatened forest ecosystems based on deforestation, fragmentation and fire.

Authors' Contribution

FA proposed the idea and analyzed the satellite and ancillary data in GIS domain and drafted the manuscript, LG supervised the analysis and improved the manuscript. All authors read and approved the final manuscript.

Competing Interests

The authors declare that they have no competing interests.

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UNIVERSITY OF ZAGREB ENGINEERING GEOLOGISTS PERFORM FORECASTING AND PROTECTIVE MONITORING OF THE KOSTANJEK LANDSLIDE USING TRIMBLE MONITORING SOLUTIONS

The real-time transmission of data from each monitoring location within the landslide observation area was critical to the success of the project.

by Christian Breuer

Kostanjek Monitoring Station

Comprehensive landslide monitoring systems using GNSS receivers and geotechnical sensors to continuously monitor landslide movement in real-time to predict landslide behavior and establish values used for the development of an early warning system (EWS).

Overview

Customer Profile: Engineering geologists from the Faculty of Mining, Geology and Petroleum Engineering of the University of Zagreb are the team of scientists who monitor the Kostanjek landslide, located in the City of Zagreb, capital of Croatia. The monitoring equipment was donated in the period from 2009 to 2014 by the Japanese Government through SATREPS (Science and Technology Research Partnership for Sustainable Development) scientific project with the main purpose to enable landslide risk reduction from the threat of the Kostanjek landslide.

Business Challenge: To enable development of risk reduction solutions, it was essential to establish reliable, automated, continuous, real-time monitoring system network customized to specificity of the Kostanjek landslide. It is a reactivated, deep-seated, large translational landslide (landslide area about 1 sq. km) located in the populated hilly area of the City of Zagreb. Development of the

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forecasting models by scientists also required extensive monitoring of causes of landslide movement (precipitation and groundwater level).

Solution

Trimble 4D Control™ monitoring software, Trimble NetR9™ GNSS reference receivers.

Results

- **Precise GNSS monitoring** - Sixteen Trimble NetR9 receivers collect GNSS data and deliver it in real time via routers to Trimble 4D Control software for real-time landslide monitoring.
- **Remote sensor management and visualization** - City authorities, scientists and other project stakeholders can monitor and visualize the landslide movement, remotely from a web portal using Trimble 4D Control software.
- **Building more reliable landslide movement model** - The landslide monitoring system aids in the development of more accurate movement models which enable forecasting of landslide movements. Kostanjek landslide movement predictions are based on empirical models, combining landslide movement parameters with other parameters of landslide causes such as groundwater levels and precipitation.

Mining Activities Caused Slope Instability

The Kostanjek landslide is the largest landslide in the Republic of Croatia. It is activated by mining activities in 1963, i.e., undercutting of the marly slopes and uncontrolled blasting. Excavation of the total volume of 5.1*106 cubic m. in the marl quarry caused slope instability of 32*106 sq. m. volume and superficial movement in the wider residential area placed around abandoned open pit. Scientists report the width of the displaced mass is some 960 meters, and the total length of the landslide is 1.26 kilometers. The depth of the sliding surface is 62.5 meters in the central part of landslide. Today there are still more than 300 homes and associated infrastructure on the moving landslide mass. Since the movement started, it has resulted in significant damage to both residential and commercial buildings and properties.

Martin Krkač, assistant professor at the Faculty of Mining, Geology and Petroleum Engineering of the University of Zagreb, explains that despite extremely slow landslide movements over the past 50 plus years, the risk surrounding the landslide is still high. Since 2011, scientists have been working to estimate these risks by acquiring new knowledge about landslide movements.

Figure 1. Trimble NetR9™ GNSS reference receiver.

"We analyze its displacements, velocities and accelerations depending on influence of precipitation and groundwater level changes," said Dr. Krkač. "The analyses of continuous time series of landslide displacements obtained by GNSS revealed unambiguous sliding of the huge landslide mass in the direction of 60-meter-high cuts in abandoned open pit. Moreover, we identified two movement patterns, slower and faster movements which corresponds to periods of higher precipitation and higher groundwater levels. High quality data enabled quantitative comparison of the relationship between sliding and its causes using advanced statistical models."

With these observations the goal is to better predict the displacement based on meteorological prognosis of precipitation. Dr. Krkač explains that the prediction of landslide displacement 24 hour in advance is necessary for early warning of civil protection that are responsible to activate measures of evacuation in case of threatening sliding.

There are several unique characteristics of the Kostanjek landslide that made monitoring challenging including finding adequate positions to monitor within the landslide, providing adequate electrical power supply, gaining permission from local citizens and city authorities to monitor the area. Cheaper solutions, such as total station, were not possible, because landslide morphology disable the line-of-sight visibility between total station and prisms.

Precise GNSS Monitoring Data

Between 2011 and 2014 the landslide scientists from Zagreb, Rijeka and Japan, Geomatika Smolčak Ltd. and Trimble Inc. developed and implemented a real-time monitoring system to monitor and predict the movement of the landslide that got around the problem of line-of-sight. GNSS receivers and various types of geotechnical sensors have been installed. All movement sensors are connected to the core of the monitoring system, the Trimble 4D Control monitoring software. The software processes, visualizes and

analyzes the monitoring data in real-time and issues alarms automatically whenever the system detects movement. Trimble 4D Control is a very versatile monitoring software which is also perfect for the use in other monitoring applications such as mines, dams and construction related monitoring.

In total, 15 Trimble NetR9 TI-2 GNSS reference stations with Zephyr Geodetic 2 GNSS antennas have been installed on site. Dr. Krkač explains that the Kostanjek landslide GNSS receivers are mounted on 4-meter-high poles with 1-meter-deep reinforced foundations. One GNSS reference station, located in a stable area approximately 7 kilometers (4.3 miles) south of the landslide, is used as a base station. In addition to the GNSS receivers the monitoring system also uses various geotechnical sensors such as long- and short-span extensometers, pore pressure gauges in boreholes, water level gauges in wells, and a weather station including a rain gauge.

Trimble 4D Control and GNSS Provide Daily Monitoring

"T4D is an essential tool for monitoring the Kostanjek landslide movement," said Dr. Krkač. "It allows multiple GNSS processing options in parallel. For our project we used 60 minute and 24-hour post-processing intervals as well as 1 Hz RTK results. We also calculated precision of GNSS measurements and proved that they correspond to Trimble specifications which means that measurements at the Kostanjek landslide gives reliable data about antenna positions. Besides, daily monitoring of movement with high precision enable measurements of small displacements which is particularly important for analysis of slowly moving landslides, such as the Kostanjek landslide.

"Among high temporal resolution of GNSS monitoring data, high spatial resolution of movement data is achieved by good coverage of the whole landslide area by 15 GNSS stations. Donation through SATREPS project, financed by Japanese government, make it possible for the Kostanjek landslide to be equipped by densely spaced GNSS stations, comparing to other world-wide known landslide monitoring systems," Dr. Krkač said. "Geomatika Smolčak, together with Trimble Support helped to setup the GNSS monitoring system, and even now, five years after deployment of the solution, they help to solve different kinds of issues that arise related to data measurements and data transmission, which has been a tremendous asset."

Real-time Data Transmission

The Trimble NetR9 receivers collect GNSS data and deliver it in real-time via wireless routers to Trimble 4D Control software, installed on an application server in a data center at the Faculty of Mining, Geology and Petroleum Engineering of the University of Zagreb. GNSS network is stable and average loss of data from particular GNSS station during monitoring period is only 3%, or

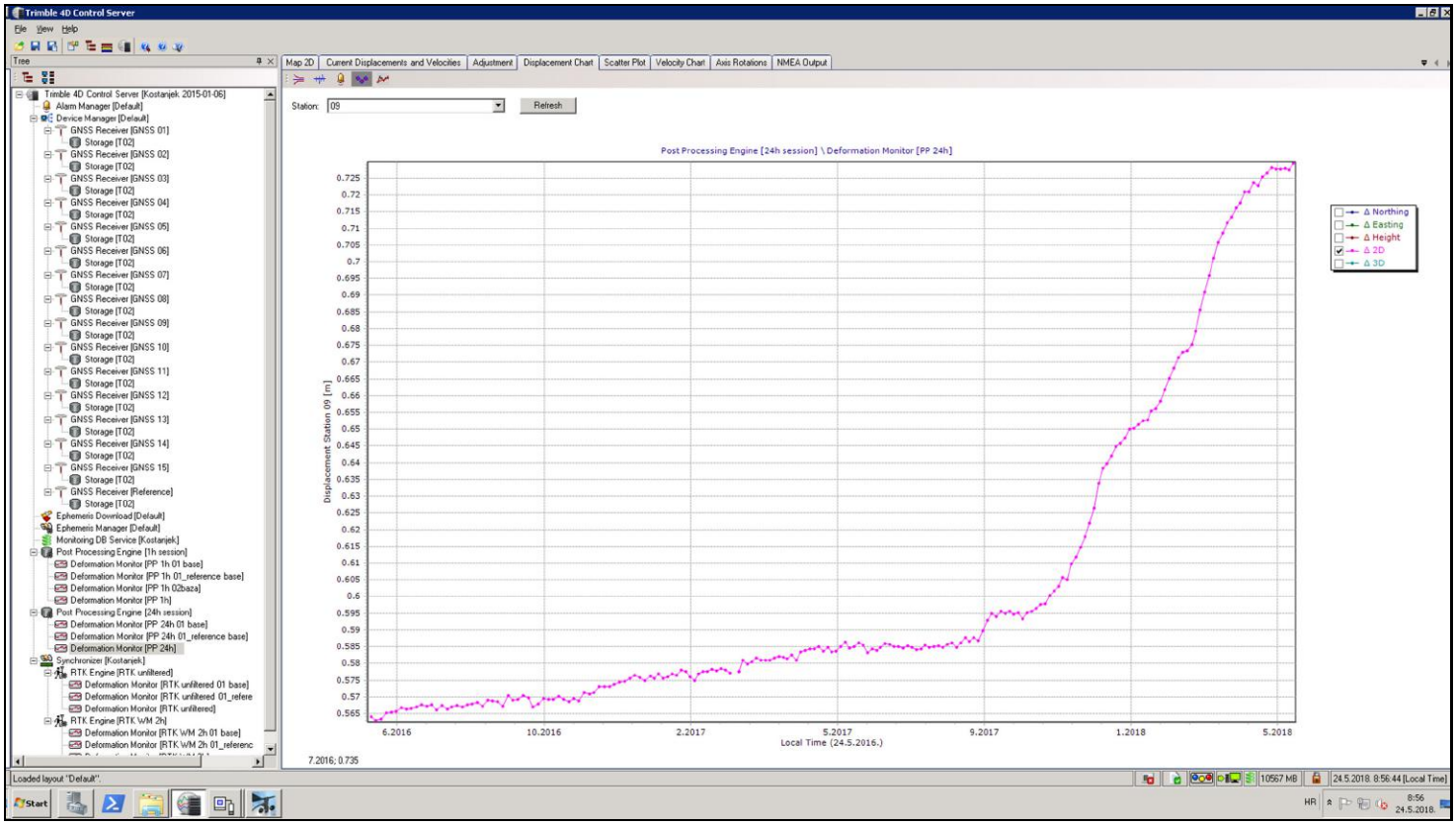

Figure 2. Trimble T4D Displacement Chart

about 20 daily measurements for the period of two years. All losses are caused due to data transmission and human factor.

"The real-time transmission of data from each monitoring location within the landslide observation area was critical to the success of the project," said Dr. Krkač. "Wireless internet at each of the monitoring locations enabled fast and high-quality transmission of large amounts of data being collected continuously, not just from 16 GNSS sensors, but also from weather station and the geotechnical sensors – such as pore pressure gauges. Wireless internet eliminated our need for the line-of-site that is required for traditional monitoring projects."

Looking Ahead - More Automated Data Processing and Analysis Aid in Protective Predictions

The data collected from the GNSS receivers and other equipment is processed by a variety of specialized software for analysis and modeling. Zagreb city officers and other scientists can use the Trimble 4D web user interface as a portal to observe landslide movement behavior remotely.

Dr. Krkač explains that results obtained by the GNSS monitoring system showed multiple reactivations of the Kostanjek landslide during the period between 2013 and 2018. Observations revealed maximum displacements in the central parts of the landslide of approximately 70 centimeters.

Japanese researchers guided by Kyoji Sassa, professor emeritus of the Kyoto University, applied failure predictions based on velocity monitoring, i.e., on the Fokozuno's method of inverse velocities. They also proved high risk of the Kostanjek landslide due to long period of movement, over 50 years, which resulted in large total displacement. Professor Sassa, as technical director of the International Consortium on Landslides (ICL), said that ICL supports applied scientific research of landslide monitoring as one of important risk reduction measure.

Integrating Research Results for More Insight into Landslide Movements

By integrating monitoring research results from different sensor types, scientists are more clearly defining landslide models and evaluating critical landslide triggers. Professor Željko Arbanas from the University of Rijeka, head of the Croatian Landslide Group and Vice president of the International Consortium on Landslides, stresses that observing activity of large and deep-seated landslides continuously is of utmost importance for development of an early warning system for extreme conditions for support authorities responsible for emergency preparedness. He also stresses that data and knowledge gathered by monitoring of the Kostanjek landslide will aid in the development of more effective and protective slope stabilization measures.

"High frequency meteorological, hydrogeological and movement data obtained by continuous monitoring enabled us to establish a new, more accurate method to predict landslide movements," said Dr. Krkač.

Professor Snježana Mihalić Arbanas from the University of Zagreb, head of the Kostanjek Landslide Observatory explains: "We have established the Kostanjek Landslide Observatory to focus on the disaster risk factors and scenarios, including emerging risks in the medium and long term changes of precipitation pattern. The main component of the Observatory is precise GNSS monitoring, that is vital and it will continue to have tremendous benefits for scientists, local authorities and residents when it comes to public safety and remediation efforts."

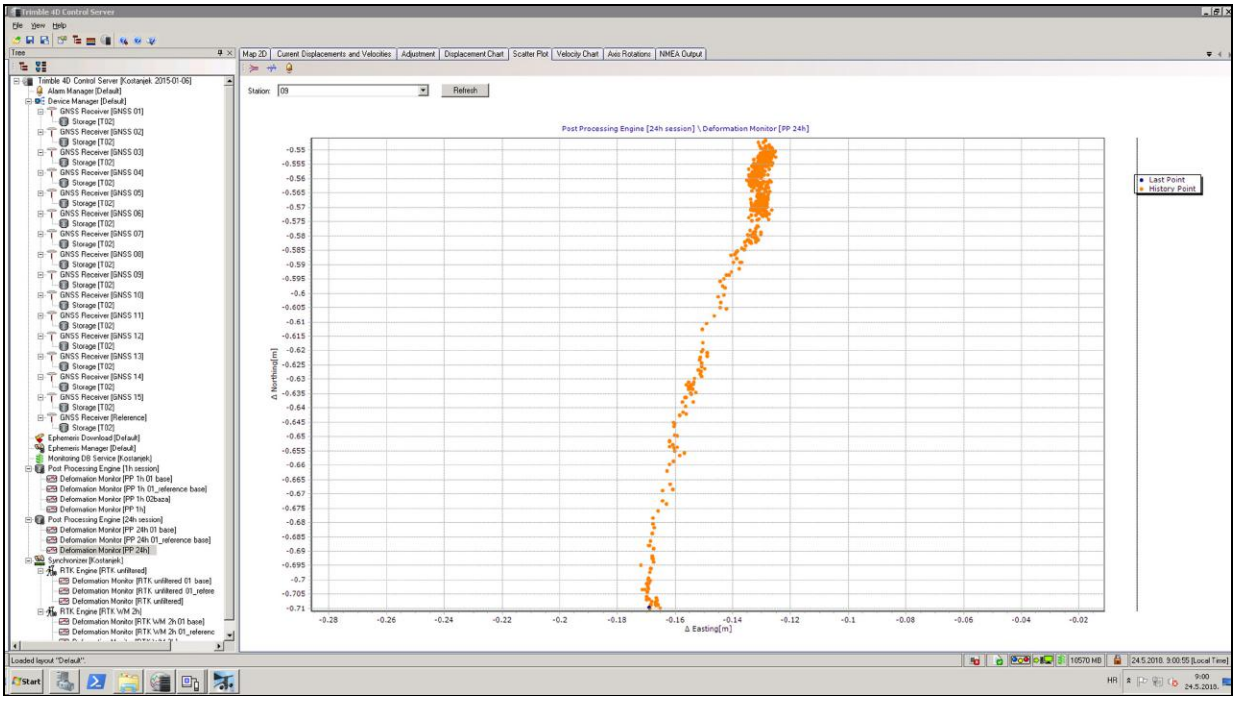

Figure 3. Trimble T4D Scatter Plot

FOREST MONITORING IN URBAN AGGLOMERATION USING GOOGLE EARTH SATELLITE IMAGE – A CASE OF BHUBANESWAR CITY, ODISHA

Combining several remote sensing technologies to estimate forest cover attributes will greatly improve resource assessment.

by Dr. Jajnaseni Rout and Dr. Adikanda Ojha

Image Courtesy: Public Radio International

Remotely sensed data provide advantages like synoptic coverage, consistency in data, global reach and readability, precision and maximum accuracy in data provision.

Forest provides goods and services including water, shelter, flood, folder, nutrient cycling, cultural and recreation value. Forest also helps in providing habitat for wildlife and also improves the socio-economic condition of the local community. Most people depend on forest resources and obtain for fodder for maintenances, wood for houses and fuelwood for the fire. Additionally, local people gather various NTFPs from forests for household use and cash income. The use of GIS and remotely sensed data in mapping different natural resources management and environmental modeling are gaining mass momentum in recent years. Majority work in Remote Sensing was mainly focused on environmental studies in the last few decades. The implication of Remote Sensing and Geographic Information System to forest cover change and urban planning is now getting attention and interest among GIS and Remote Sensing professionals. The techniques are becoming an important part of watershed management, urban planning, hydrological modeling, drought prediction, and forest cover mapping. Remotely sensed data provide advantages like synoptic coverage, consistency in data, global reach and readability, precision and maximum accuracy in data provision. Large areas of land are acquired for agricultural practices, which results in deforestation.

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Deforestation is a reduction of forest cover i.e. from dense forests to fragmentation of forests, open forests, scrubs or degradation of land use. Deforestation is caused by agriculture, degradation of forests, pollution, shifting agriculture, expansion of cities etc. Deforestation can cause many problems like the extinction of endemic species (plant and animal), loss of biodiversity, flooding, soil erosion, increase in greenhouse gases, climate change, and global warming to name a few (C. Sudhakar Reddy et al., 2009). National economies are dependent on the consumption of their natural renewable and non-renewable resources. Deforestation has become a global concern. The study area is adjacent to Nandankanan Zoo, during the year 2006 and 2018 most of the greenery area has cleaned. The stone query has abolished the greenery and also some years after the hilly areas will be abolished. During 12 years of study, the 'A', 'B' and 'D' site has totally deforested for stone quarry. The government should implement strict rule and regulations for maintaining the greenery areas which somehow reduce the global warming and climate change. It's an emergency to ameliorate the environmental conditions. Promote measures to prevent soil erosion and enable soils to retain more moisture regenerate more greenery and contribute to increased biomass production. Afforestation of the protected lands with plantation and their protection and restore the ecological balance of the region at least to some extent.

Figure 1. Google Earth imagery of year 2006, showing forest cover.

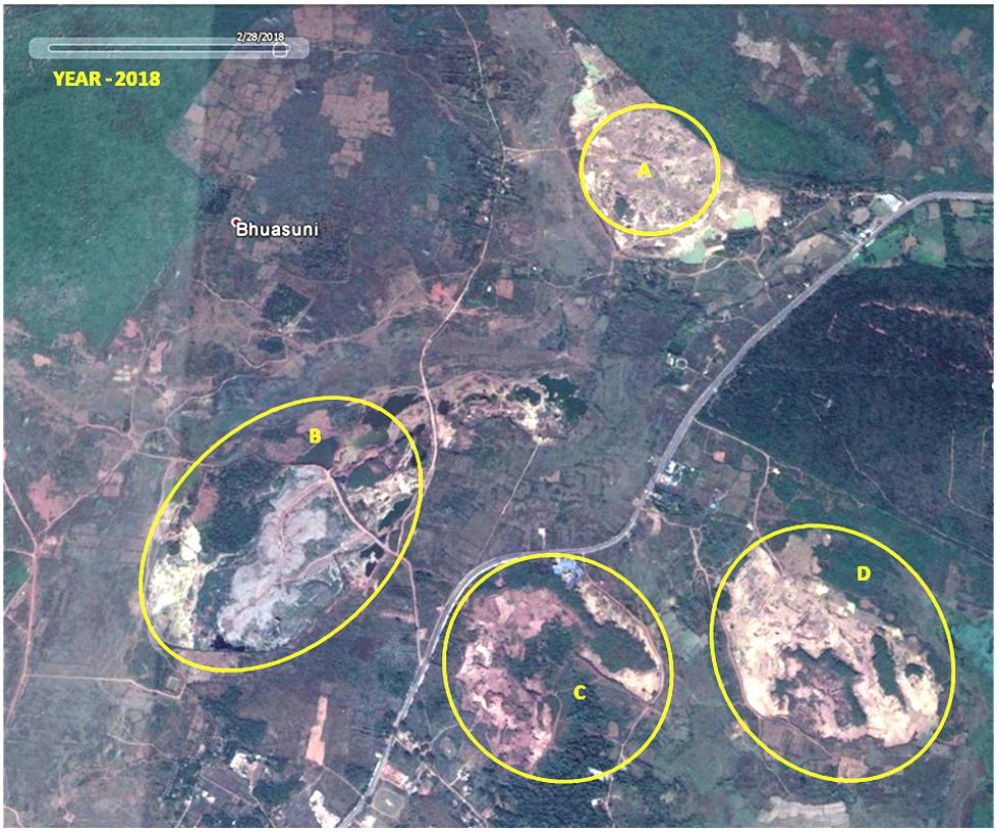

Figure 2. Google Earth imagery of year 2018, showing decrease in forest cover.

As per the report of the Forest Survey of India using Remote Sensing Techniques, the forest cover in the State is 48,855 sq. kms. of which 7,073 sq. kms. is a very dense forest. The moderately dense forest extends over 21,394 sq. kms. while the open forest is over 20,388 sq. kms. The forest cover in the State constitutes 31.38% of the geographical area. Besides this, there exists tree cover outside the forest over 2.85% of the geographical area of the State. The National Forest Policy 1988, Orissa Forest Sector Vision, 2020 and Joint Forest Management Resolution, 2011 provide guiding principles for forest management in the State.

BUSINESS

June 16 - September 15, 2018

KeyW Wins Award on GSA's $135 Million Remote Sensing, Command Control Communications and Computer IDIQ Contract

KeyW Holding Corporation has announced that the General Services Administration awarded the company a Blanket Purchase Agreement under the Professional Support Services Schedule to support the Department of Defense and Defense agencies. The multiple award BPA has an estimated value of $135 million over five years. Under the contract, KeyW will provide professional engineering services across the Remote Sensing, Command Control Communications and Computer (RS&C4) mission areas to develop, evaluate and operate innovative capabilities for Joint Service needs.

UrtheCast and Land O'Lakes, Inc. Announce Term Sheet for Purchase of Geosys

UrtheCast Corp. ("UrtheCast") and Land O'Lakes, Inc. has announced they have entered a binding term sheet for the purchase of Geosys Technology Holding LLC ("Geosys"), a wholly owned subsidiary of Land O'Lakes, for a purchase price of US$20 million. This landmark deal is expected to bring unprecedented value to agribusinesses worldwide through the enhanced relationship between imagery data and geoanalytical solutions.

RMSI Appoints Mark Jorgensen as Managing Director, RMSI Australia Pty Ltd.

RMSI, a leading geospatial solutions provider announced the expansion of its leadership team with the appointment of Mark Jorgensen as Managing Director of RMSI Australia Pty Ltd.

Mark will be responsible for leading the growth and managing the RMSI business in Australia and New Zealand. He will execute growth strategies and go to market plans to develop new business opportunities across verticals. He will also actively engage with our existing clients to define strategies for operational excellence and capability development.

Amar Nayegandhi Appointed to Director of ASPRS LiDAR Division

The American Society for Photogrammetry and Remote Sensing (ASPRS) appointed Amar Nayegandhi, CP, CMS, GISP, as director of the lidar division. He was previously elected to the role of assistant director in 2016.

TCarta Wins National Science Foundation Grant to Enhance Satellite-Derived Bathymetry Technology

TCarta Marine, a global provider of marine geospatial products, has been awarded a research and development grant by the National Science Foundation (NSF) to enhance and automate multiple techniques for deriving seafloor depth measurements from optical satellite imagery. The 'Project Trident' research seeks to transform existing satellite derived bathymetry (SDB) techniques by leveraging machine learning and computer vision technology to enable accurate depth retrieval in variable water conditions.

Geospatial Intelligence Startup Ursa Announces $5.7 Million in New Funding

Ursa Space Systems, a provider of geospatial intelligence solutions, has recently announced $5.7 million in new venture funding, led by RRE Ventures and including participation from S&P Global and Paladin Capital Group. The company will use the funds to develop new products in response to strong customer demand, as well as expand current offerings to serve new customers and markets.

USGIF Announces Two New Board Members

The United States Geospatial Intelligence Foundation (USGIF) has announced the addition of Al Di Leonardo and Patty Mims to the Foundation's Board of Directors. USGIF's Board includes 26 directors representing the many aspects of the broad and expanding GEOINT Community. Di Leonardo is an experienced intelligence and special operations officer and is widely recognized as a subject matter expert in analytical tradecraft, and Mims is currently director of Global National Government at USGIF Organizational Member Esri. Di Leonardo has more than 25 years of government experience centered at the National Security Agency.

3D Laser Mapping & GeoSLAM Global Merger Announcement

Leading UK laser scanning and monitoring companies' 3D Laser Mapping Ltd and GeoSLAM Ltd have merged to create one of the world's most innovative mobile mapping and monitoring technology providers. 3D Laser Mapping is a world leading geospatial technology supplier and innovator. Working alongside some of the world's biggest mining companies, governments, universities, blue-chip firms and operators of highways, power lines and railways. 3D Laser Mapping helps its customers to capture and understand their world in 3D.

Kenyan Startup Apollo Agriculture Secures US$500,000 Funding

Kenyan startup Apollo Agriculture has secured US$500,000 in funding from Dutch Development Bank FMO and the Rabobank Foundation to fund harvesting cycles, further develop its credit model, and expand geographically. The funding comes in the form of a US$250,000 convertible grant from the FMO MASSIF Fund and a US$250,000 loan from the Rabobank Foundation.

Bentley Systems Acquires Synchro Software to Extend Digital Workflows for Infrastructure Project Delivery Through 4D Construction Modeling

Bentley Systems, Incorporated has announced the acquisition ofSynchro Software, headquartered in London, leader (and the market creator) in 4D construction modeling software or scheduling and project management. Synchro, "construction's time machine," has been globally adopted, in particular, for building and civil infrastructure projects.

NGA Selects Hexagon US Federal as a Prime Contractor for a Role on Two Programs Totaling $1.17 Billion

The National Geospatial-Intelligence Agency (NGA) has selected Hexagon US Federal as a prime contractor on two multiple award, indefinite delivery/indefinite quantity contracts for amounts totaling $1.17 billion. Hexagon was selected as one of multiple vendors for the JANUS Geography and JANUS Elevation contracts.

SwRI Investigates New Techniques To Estimate Groundwater Recharge

Southwest Research Institute scientists are investigating using the latest remote-sensing technology to assess groundwater recharge more accurately. This information is critical for water resource managers, especially in arid regions. Groundwater collects in the cracks and spaces in soil, sand and rock. Resources are replenished or recharged by precipitation moving slowly through geologic formations called aquifers. Groundwater supplies drinking water for about half of the U.S. population, including 99 percent of the rural population.

LiDAR Aerial Photo Bluesky Aerial Survey Helps Malta Develop GeoSpatial Infrastructure

Aerial mapping company Bluesky has captured aerial photography and 3D map coverage of Malta. Working alongside tender lead IIC Technologies and Ordnance Survey, Bluesky captured ultra-high resolution aerial photography together with high density LiDAR measurements. Part of project SIntegraM – Spatial Data Integration for the Maltese Islands, the data will be used across various government departments and entities as part of the ERDF.02.030; a Maltese Government project led by the Planning through ERDF Funding.

Woolpert Achieves the Location-Based Services Partner Specialization in the Google Cloud Partner Specialization Program

Woolpert has achieved the Location-Based Services Partner Specialization in the Google Cloud Partner Specialization Program. By earning this Partner Specialization, Google recognizes Woolpert's proven expertise and success in building customer solutions in the Location-Based Services field using Google Cloud Platform technology.
The Google Cloud Partner Specialization Program is designed to provide Google Cloud customers with qualified partners who have demonstrated technical proficiency and proven success in specialized solution and service areas.

India Approved Guidelines to Use of Drones Under a Legal Framework

Directorate General of Central Aviation has announced India's policy on the use of drones. The government has permitted commercial flying of drones from December 1, 2018. There are two key restrictions that have been put in place for safe use of drones. The drones will be allowed to fly only along visual line-of-sight and only during day-time with a maximum altitude of 400 feet.

Russia, China Agreed to Hold Experiments to Increase Satellite Data Accuracy

Russia's State Space Corporation Roscosmos and the China National Space Administration (CNSA) have agreed to hold an experiment before October 1 to use testing grounds for raising the quality of assessing Earth's remote sensing data, the Roscosmos press office reported. Both sides also noted their effective interaction in the mutual provision of the Earth's remote sensing data from the Russian and Chinese satellites under the International Charter on Space and Major Disasters upon the onset of emergency situations on the territories of Russia and China.

Permafrost Monitoring with Latest Radar Technology in German-Canadian Cooperation

Scientists from the German Aerospace Center (Deutsches Zentrum fuer Luft- und Raumfahrt;DLR) Microwaves and Radar Institute are developing special radar technologies and analytical methods that enable the highly accurate observation of permafrost. As part of DLR's Permafrost Airborne SAR Experiment (PermASAR), they are carrying out extensive measurement over the permafrost region of Canada. In the first measuring campaign, surveyed 10 test sites along a 2000-KM-long North-South gradient – from boreal forests in Northern Saskatchewan up to the Canadian Arctic coastline – has now been successfully completed. For millennia, permafrost has been shaping the subsoil of the Arctic and subarctic latitudes, ranging from a few meters to more than one KM deep into the interior of the Earth.

Indian Space Research Organisation (ISRO) Successfully Launches NovaSAR and S1-4 Satellite

The Polar Satellite Launch Vehicle (PSLV-C42) of ISRO has successfully launched two satellites - NovaSAR and S1-4 - from the Satish Dhawan Space Centre (SDSC) SHAR, Sriharikota. The satellites belong to UK-based Surrey Satellite Technology Limited, which has a contract with Antrix Corporation Ltd, the commercial arm of ISRO. NovaSAR carries S-band Synthetic Aperture Radar and an Automatic Identification Receiver payloads. NovaSAR-S provides medium resolution (6-30 m) imagery. S1-4 is a high resolution earth observation satellite. It has a mass of 440kg and is capable of acquiring multiple targets in one pass and will utilise spot, strip and mosaic imaging modes.

China Launches Two Satellites for Pakistan

China has successfully launched two remote sensing satellites for Pakistan, marking the first international commercial launch for the Long March-2C rocket in about 19 years. The satellites -PRSS-1 and PakTES-1A were launched from the Jiuquan Satellite Launch Center. The Pakistan Remote Sensing Satellite (PRSS-1), commercially known as Remote Sensing Satellite System (RSSS), is a dual-purpose Earth observational and optical satellite. PakTES 1A (Pakistan Technology Evaluation Satellite) is a 300 kg low to medium resolution earth observation remote sensing satellite indigenously developed by Pakistan's SUPARCO but with much of the payload subcontracted to South Africa's Space Advisory Company.

Airbus to Provide an End-to-end Geo-Information System to Thailand

The Geo-Informatics and Space Technology Development Agency of Thailand (GISTDA) has selected Airbus as partner for its next-generation national geoinformation system. The end-to-end system will make Thailand one of the few nations able to fully exploit geo-information for societal benefits. Fully in line with Thailand's 4.0 policy, the THEOS-2 programme will constitute a major milestone in the development of Space in the Eastern Economic Corridor and its Digital Park.

UAV

June 16 - September 15, 2018

SimActive for Mining: Drones & Volume Calculation

SimActive Inc. has announced new features to improve volumetric calculation. Correlator3D™ now has integrated tools for users to generate precise statistics on mining activities. Applications like mineral extraction monitoring can all be done seamlessly within the software. Users can process raw drone data, produce point clouds and DSMs, and perform volumetric calculations, all in the same Correlator3D™ workflow.

Pix4D Accelerates Growth with A New Office in Madrid

Pix4D opens a new R&D office in Madrid. It is the company's fifth office after Lausanne, San Francisco, Shanghai and Berlin. As a centre of innovation, research and development, Pix4D Madrid will continue to expand and develop Pix4D's knowledge of photogrammetry and machine learning, with the goal of creating an entirely new solution for the professional drone market.

DroneDeploy Releases Intelligent Cloud Photogrammetry

DroneDeploy, a drone software platform with the largest drone data repository in the world, has announced the release of Map Engine— the industry's first machine learning-driven photogrammetry software. This release comes after a successful beta period where it processed 30K maps per month for more than 4,000 clients across 180 countries. DroneDeploy's Map Engine generates high-resolution maps and 3D models from drone imagery collected in the construction, energy, agriculture, and surveying sectors. The new processing engine leverages the latest cloud infrastructure and machine learning technology to deliver high-quality results and help customers reduce on-prem hardware and maintenance costs. The Map Engine codebase integration began two years ago with DroneDeploy's acquisition of leading photogrammetry solution 3DN, which had already been in development for five years. Since launching in Beta last January, Map Engine has processed 100M gigapixels of drone imagery. Its machine learning capabilities enable customers to gather better data, drive faster insights, and automate time-consuming workflows - helping drones become an essential tool on every job site.

senseFly Launches The eBee X Fixed-wing Drone, Allowing Operators to Map Without Limits

senseFly has sets a new standard in mapping tools with the launch of the eBee X. The eBee X includes a range of revolutionary new camera options to suit every mapping job—from land surveying and topographic mapping to urban planning, crop mapping, thermal mapping, environmental monitoring and many more. Its unique Endurance Extension option unlocks a flight time of up to 90 minutes. With this capability activated, the drone is able to achieve vast single-flight coverage of up to 500 ha (1,235 ac) at 122 m (400 ft), while the eBee X's built-in High-Precision on Demand (RTK/PPK) function helps operators to achieve absolute accuracy of down to 3 cm (1.2 in)—without ground control points.

GNSS & SURVEYING

June 16 - September 15, 2018

Trimble Catalyst Now Supports GLONASS, Delivering Faster, More Accurate and Reliable Positioning Performance

Trimble has announced that its Trimble® Catalyst™ software-defined Global Navigation Satellite System (GNSS) receiver for Android phones and tablets has been updated to support GLONASS. The update demonstrates the advantages of software GNSS for delivering new functionality faster and easier.

Trimble RTX Correction Technology Now Delivers Two Centimeter Accuracy for a Broad Range of Positioning Applications

Trimble has announced that its Trimble RTX™ GNSS corrections technology can now achieve horizontal accuracies of better than two centimeters. Start-up times, commonly referred to as convergence, have also improved. Users can now achieve full accuracy in less than 15 minutes, and as fast as one minute in select areas where RTX Fast network infrastructure is available. This performance is achievable using Trimble's premier correction service, CenterPoint® RTX, delivering RTK-level accuracy outside traditional Virtual Reference Station (VRS) networks, considered the gold standard for high-accuracy corrections.

Swift Navigation Announces Full BeiDou and Galileo Support for Piksi Multi

Swift Navigation, a San Francisco-based tech firm building centimeter-accurate GNSS technology and a Cloud-based Corrections Service to power a world of autonomous vehicles, has announced the latest firmware upgrade to its flagship product—the Piksi® Multi GNSS Receiver. This marks the sixth major release to Piksi Multi since it was launched in February 2017 and the upgrade is available free of charge to Swift customers. The firmware release also enhances Duro®, the ruggedized version of the Piksi Multi receiver housed in a military-grade, weatherproof enclosure ideal for long-term outdoor deployments.

Chennai Metro Rail in Southern India Selects Trimble Rail Solutions for Remote Diagnostics, Condition Monitoring and Analytics

Trimble has announced that Chennai Metro Rail Ltd. (CMRL), operated by the Tamil Nadu State Government and the Government of India, will implement Trimble® Nexala rail asset management solutions. Deploying the Trimble solutions will enable CMRL to improve its real-time status monitoring and analytics capability by accessing up-to-date fleet status, which can improve overall fleet availability and reliability while reducing costs and improving safety. Once implemented by Trimble and its Chennai-based partner KKM SOFT, the project will be one of the first examples of digital real-time, condition-based monitoring rolled out by an Indian rail operator.

PRODUCT LAUNCH

June 16 - September 15, 2018

GIS & EO

Esri
- Esri Announces New Indoor Mapping Product - ArcGIS Indoors

Kongsberg Geospatial
- Kongsberg Geospatial Concludes Final Trials of Drone Airspace Management System with Transport Canada, RCMP, and Defence Research and Development Canada

FARO
- FARO® Introduces As-Built™ Software Platform For 3D Digital Modeling

Boundless
- Boundless Introduces Managed Service Offerings for State and Local Governments

Novara Geospatial
- Novara GeoSolutions Unveils New Geospatial Product in Oil & Gas Industry - StationNav Widget

Maptitude
- Free Point of Interest Data by Type for Use with Maptitude Mapping Software

Global Mapper
- Global Mapper v.20 Now Available with Improved 3D Model Functionality and New Map Layout Options

LiDAR

FARO
- FARO® Announces SCENE 2018 with FARO Laser-HDR™ and High Detail Scanning

Hexagon
- Hexagon Introduces the Leica BLK3D for Real-time, In-picture 3D Measurement
- Hexagon Introduces the Leica RTC360 - World's First 3D Laser Scanner With Automatic In-field Pre-registration

Orbit GT
- Orbit GT Releases Free ESRI ArcOnline Widget for 3D Mapping Cloud and 3DMPublisher

GNSS & SURVEYING

Trimble
- Trimble Launches New Model of its R10 GNSS System for Land Surveyors.

Leica Geosystems
- Leica Geosystems Introduces New Detection Solution for Utility Construction - the Leica DD SMART utility locator series, signal transmitters and DX Shield software.

Sokkia
- Sokkia introduces T-18 Field Controller with Advanced Performance for Diverse Applications

Hemisphere GNSS
- Hemisphere GNSS Announces All-New Rugged Atlas®-Capable UAV GNSS Antenna

TRX Systems
- TRX Systems Enhances 3D Mapping and Indoor Location within Complex Buildings and Other GPS-Denied Environments with Release of NEON 10

DRONE/UAV

PrecisionHawk
- PrecisionHawk Launches the First Long-Range, Beyond Visual Line of Sight (BVLOS) Multi-Rotor Drone Platform

Topcon
- Topcon Introduces New Software for UAV Inspection Applications - MAGNET Inspect

TatukGIS
- Tatuk Release ObliMapper to Transform Drone Imagery into Actionable Visual Intelligence

Insitu
- Insitu Announces New Advancements in High Accuracy Photogrammetry Payload

GEO EVENTS

October 01 - 03, 2018
Commercial UAV Expo
Las Vegas, USA
https://www.expouav.com

October 09 – 12, 2018
GIS-Pro & CalGIS 2018
Palm Springs, CA, USA
https://www.urisa.org/education-events/gis-pro-annual-conference/

October 15 – 19, 2018
39th Asian Conference on Remote Sensing (ACRS 2018)
Kuala Lumpur, Malaysia
https://acrs2018.mrsa.gov.my/

November 05 - 08, 2018
Esri GeoConX Conference
Dallas, TX, U.S.A.
http://www.esri.com/events/geoconx

November 20 -22, 2018
GIS4SmartGrid 2018
Amsterdam, The Netherlands
https://www.smartgrid-forums.com/forums/gis4smartgrid-2018/

November 28 - December 01, 2018
16th World Congress of the International Association of Institutes of Navigation (IAIN)
GI_Forum Symposium 2018
Salzburg, Austria
http://www.gi-forum.org

December 02 – 05, 2018
FOSS4G Asia 2018
Moratuwa – Sri Lanka
http://www.foss4g-asia.org/2018/

Science, Technology and Practice to Resilient Navigation

Date 2018 Nov 28 (Wed.) - Dec 1 (Sat.)

Venue Makuhari Messe
2, Nakase, Mihama-ku, Chiba-city, 261-0023 JAPAN
https://www.m-messe.co.jp/en/index.html

Host Institute
Japan Institute of Navigation (JIN)

Image of Sail Training Ship NIPPON MARU is credited to MEMORIAL FOUNDATION OF SAIL TRAINING SHIP "NIPPON MARU".

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Managing Director of North America, DJI

Exhibitors *as of June 1:*

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